

# Design for sustainable well-being and empowerment: selected papers

**Editors :**  
Monto Mani  
Prabhu Kandachar



IISc  
Press



TU Delft  
Delft  
University of  
Technology





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IISc Press  
Indian Institute of Science,  
Bangalore, India

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### Availability

As part of our core mandate of frugality and outreach, to make good ideas and concepts widely available to all those striving to make the world a better place through design, this book has been made freely accessible to all, downloadable from websites at IISc and TU Delft.  
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This book comprises selected papers finally chosen for paper/poster presentation at the Indo-Dutch International Conference on Design for Sustainable Well-being and Empowerment, held at the Indian Institute of Science, Bangalore, India from 12~14 June 2014. Each of the papers was selected following a double-blind peer review, meeting the requirements of a quality research publication, suitably discussing the research methodology or theory adopted, field experiences and/or lessons learnt supported with relevant literature and can complete with proper references and citations. Papers based on field experiences dealt with design problems, solutions, processes or evaluations, while carrying empirical validity with ground realities.

The book marks the crossroads of two interconnected bridges, the first between our two cultures (Dutch and Indian), and the second between academia and society, with design at the cross-road. The selected papers aim to bridge (engineering) design with social (mechanisms and design), and has provided an opportunity for many contributors to step out of their familiarities to synergise with other disciplines and vocations, in support of well-being and empowerment. These papers range from architecture to fashion, philosophy to entrepreneurship, and menstrual health to eco-tourism, have been diverse in the foreground, but interconnected in terms of well-being and sustainability.

The book has been organized into three chapters, comprising the following topics in design for well-being and empowerment:

1. Perceptions of well-being and empowerment: their influence on design
2. Using normative approaches in design for well-being (Capability Approach and Design)
3. Sustainability and well-being: challenges and opportunities for design
4. Individual versus collective well-being and empowerment –conflict resolution through design
5. Equity, ethics and profit – can they exist together?
6. Role of ethics in design
7. Pedagogical design tools – Normative approaches in design for generation-next
8. Novel design methodologies/frameworks/methods/ pedagogy for well-being and empowerment
9. Adaption and evaluation of design methodologies/ frameworks/ methods for well-being and empowerment
10. Design & innovation for sustainability – a systemic perspective
11. Successful design & innovation: role of stakeholders
12. Extending design: inclusive Social Sciences, Markets, Engineering and Entrepreneurship
13. Grass-root innovations and sustainability: Lessons learnt
14. Invention to successful innovation: role of design

In order to make the information and ideas to be presented at the conference promptly and widely available, participants in the conference were invited to submit written papers and posters for inclusion in this document.

During the review process, submissions were sent to at least two scholars [See Scientific Committee] who were asked to provide a scholarly judgement on the paper's suitability for publication. The review results were fed back to the authors, who resubmitted the papers after addressing the issues raised by the reviewers.



Of the 105 Abstracts originally received, following the review, 43 papers have finally made it as selected papers in the current edited volume.

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The Netherlands

*Bangalore, India, 29<sup>th</sup> April 2015*



The editors would like to acknowledge and thank the following scholars, of international repute, hailing from diverse disciplines in academia, research and practice for their efforts in reviewing the papers:

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Venkatarama Reddy, B.V., Indian Institute of Science, Bangalore, India



Discussions and debates on design and sustainability are crucial in the successful journey to well-being. We wished to provide a firm basis for this debate through the Indo-Dutch International Conference on Design for Sustainable Well-being and Empowerment, and the current edited book. We thank all the contributors and participants for supporting our endeavour to share a platform to step outside our familiarities and synergising in support of well-being and empowerment. In the journey so far, we are indebted to our colleagues, students, families and friends who have patiently supported us all through.

We sincerely acknowledge the working group in the joint collaborative research on 'Technology and Human Development - A Capability Approach' between IISc and TU Delft. But for the unyielding support of Mr. Pramod Khadilkar in all aspects of the conference planning and coordination, and Ms. Annemarie Mink and Ms. Ilse Oosterlaken for online support, this book would have remained undone. Unwavering support from Prof. B. Gurumoorthy (Chairman, Centre for Product Design and Manufacturing) and Prof. B. V. Venkatarama Reddy (Chairman, Centre for Sustainable Technologies) and their offices has been crucial in seeing this through.

A lot of effort in terms of proof-reading, formatting and editing has gone into this book, from the camera-ready proofs to this final version. We thank Mr. Balaji N.C., Mrs. Gayathri Aaditya, Ms. Kumari M.C., Mr. Prashant Aanand, Ms. Shruti Soni and Mrs. Arpita Singh in supporting us in this tedious task. Thanks to Editage (Cactus Communications) for their professional copy-editing support. Thanks to Mr. Kashyap M., for superbly designing the layout and graphics of this book. We thank Aditi Enterprises for their consistent support in formatting the book.

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We also acknowledge the support of NWO and CSIR in facilitating many activities connected with this book.

Thank you, one and all!

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The Netherlands



This book summarises a prelude of key messages and reflections from the following eminent personalities, who have devoted themselves through innovations, critical thinking and practice, in their own disciplines, to the common cause of well-being, particularly amongst the deprived and underprivileged:

Prof. Andy Dong, University of Sydney, Australia.

Prof. Anil Gupta, Indian Institute of Management, Ahmedabad, India.

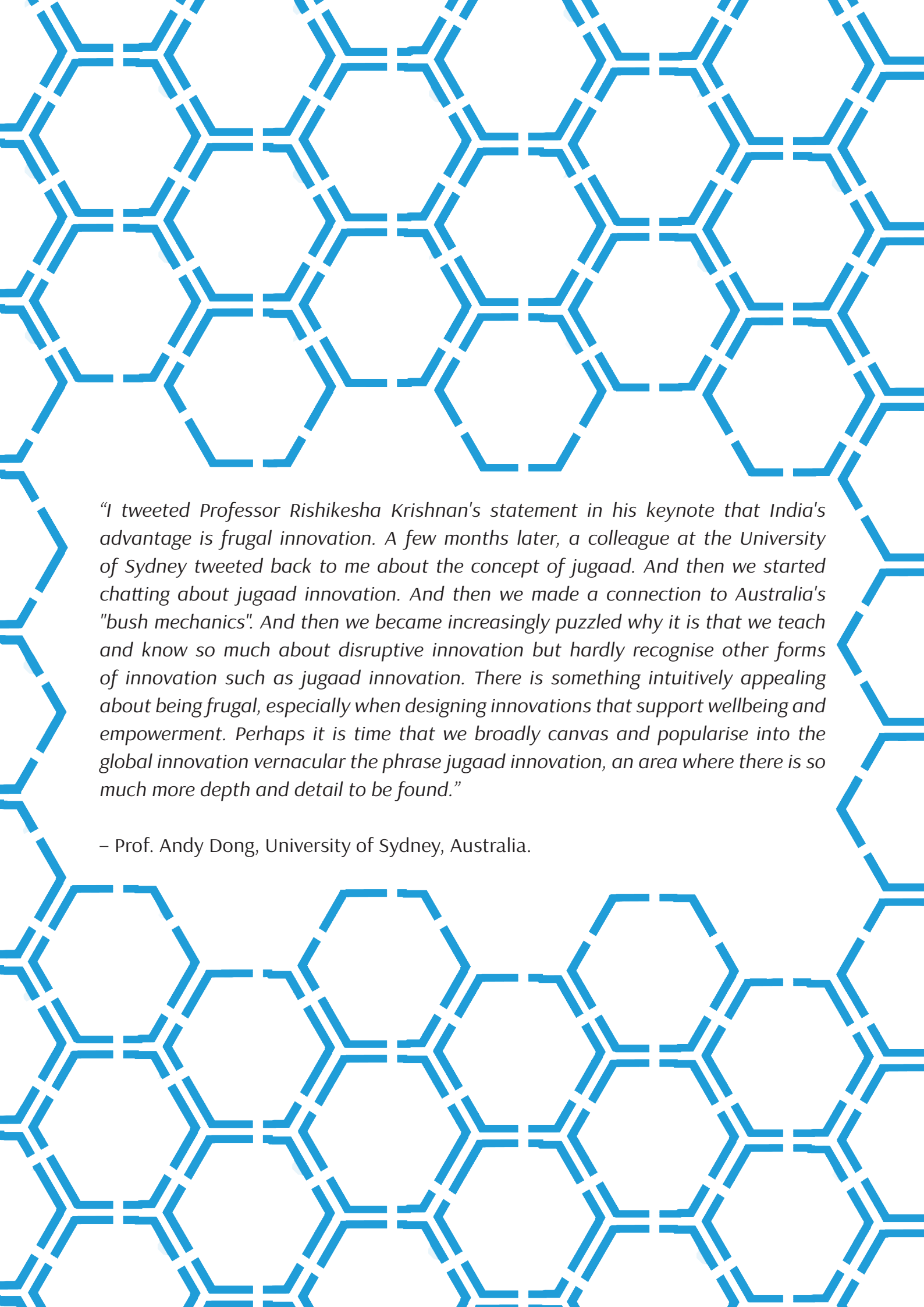
Dr. Balasubramaniam, R., Development activist, Medical doctor, Founder SVYM, Mysore, India

Dr. Devi Shetty, Cardiac Surgeon, Founder, Narayana Health, Bangalore, India.

Prof. Ganesh, L.S., Indian Institute of Technology in Madras, Chennai.

Prof. Ille Gebeshuber, Vienna University of Technology, Austria and The National University of Malaysia.

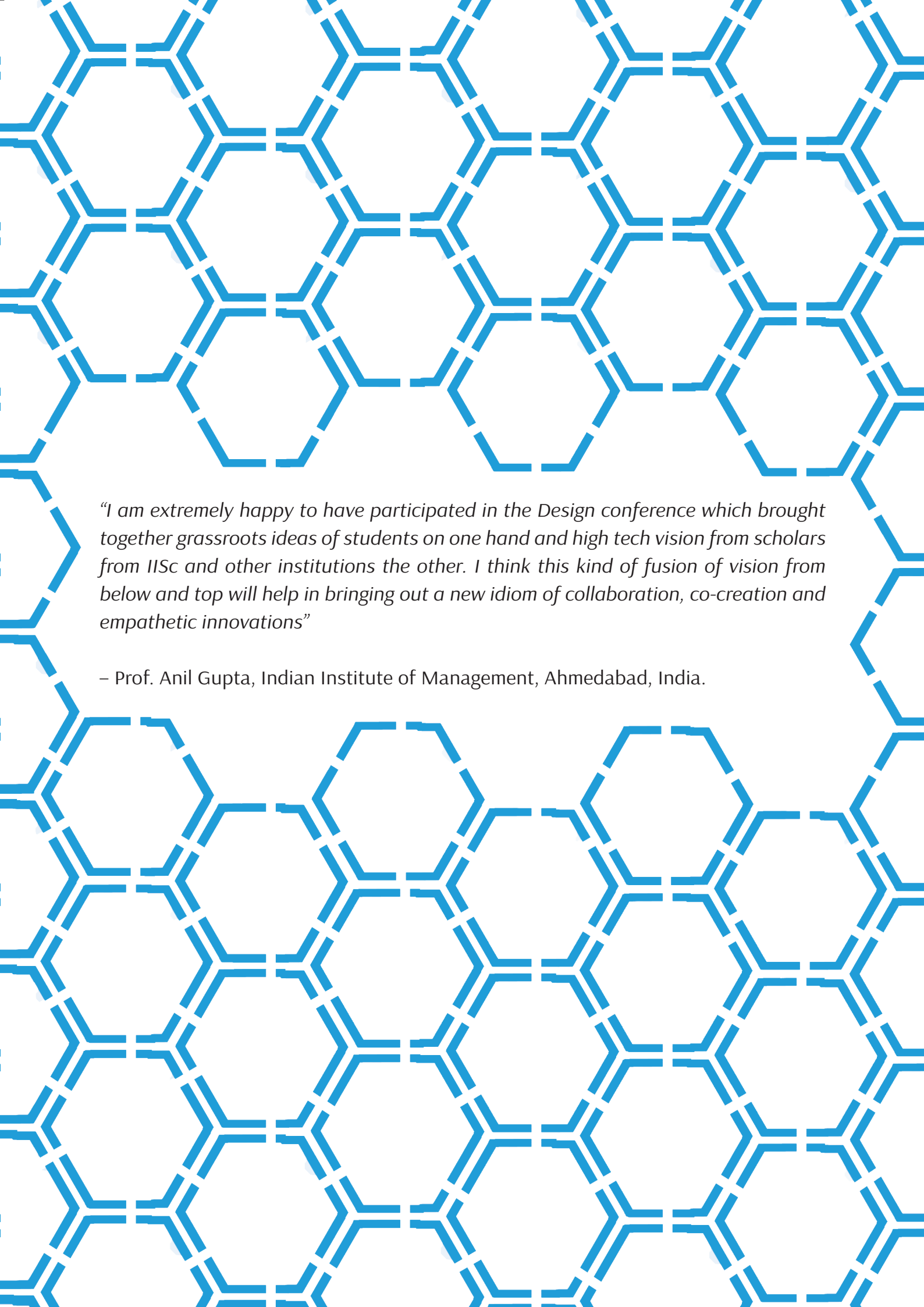
Prof. Rishikesha Krishnan, Indian Institute of Management Indore, India.



*“I tweeted Professor Rishikesh Krishna's statement in his keynote that India's advantage is frugal innovation. A few months later, a colleague at the University of Sydney tweeted back to me about the concept of jugaad. And then we started chatting about jugaad innovation. And then we made a connection to Australia's "bush mechanics". And then we became increasingly puzzled why it is that we teach and know so much about disruptive innovation but hardly recognise other forms of innovation such as jugaad innovation. There is something intuitively appealing about being frugal, especially when designing innovations that support wellbeing and empowerment. Perhaps it is time that we broadly canvas and popularise into the global innovation vernacular the phrase jugaad innovation, an area where there is so much more depth and detail to be found.”*


– Prof. Andy Dong, University of Sydney, Australia.





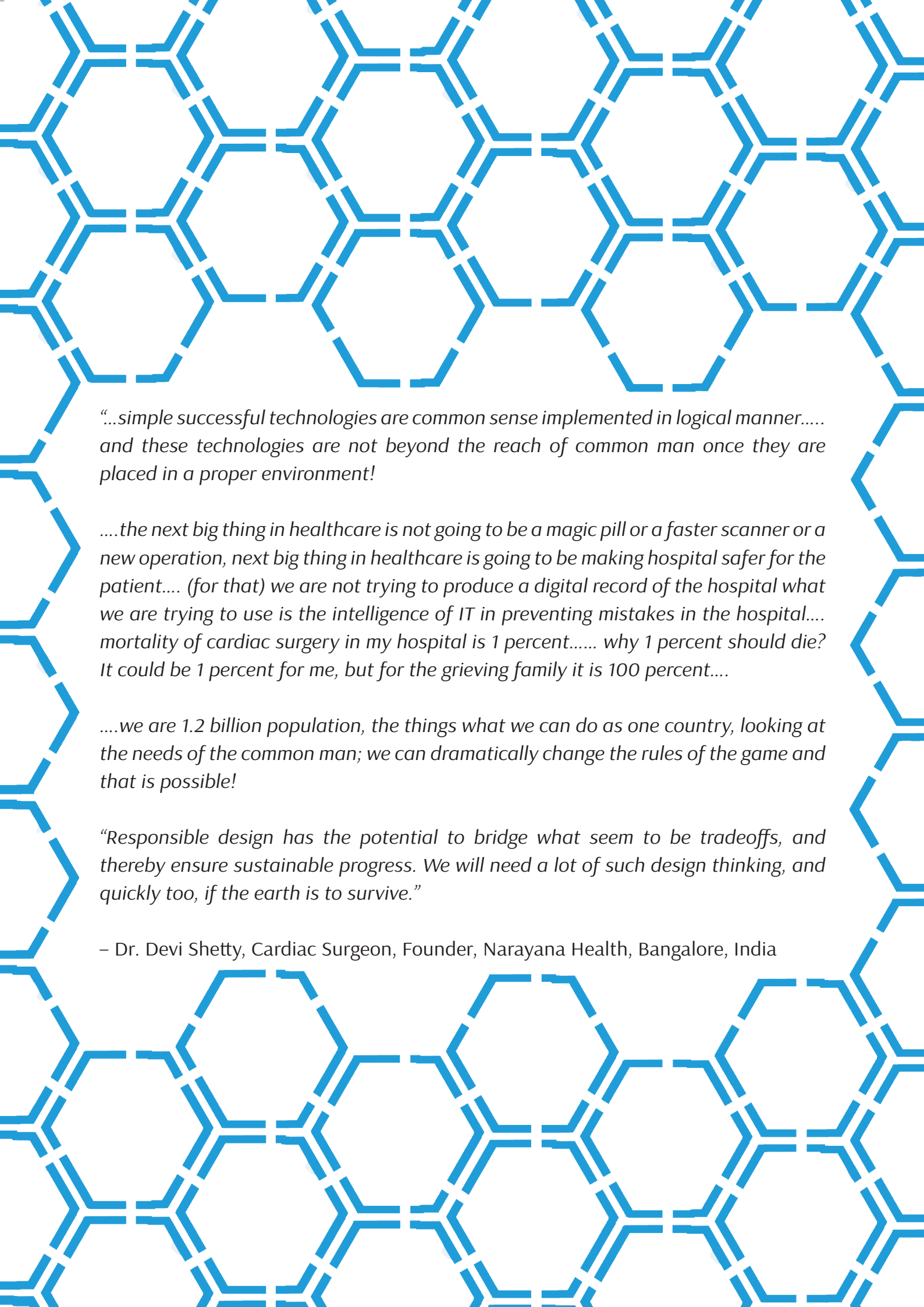
*“I am extremely happy to have participated in the Design conference which brought together grassroots ideas of students on one hand and high tech vision from scholars from IISc and other institutions the other. I think this kind of fusion of vision from below and top will help in bringing out a new idiom of collaboration, co-creation and empathetic innovations”*

– Prof. Anil Gupta, Indian Institute of Management, Ahmedabad, India.



*“We tend to see design and sustainability from the perspective of a provider. And this necessarily means that we tend to filter everything we see through the lens of our own competence. We now need to consider a whole new paradigm – a paradigm that revolves around and driven by the community for whom design, innovation and sustainable change is being conceived. This will need us to become more humble, shed our provider outlook and take on the role of a constructive partner. More than anything, it will mean operating from zones of our incompetence. Then and only then will our designs and innovations become contextually relevant, culturally appropriate and sustainable in a meaningful way.”*

– Dr. Balasubramaniam, R, Development activist, Medical doctor, Founder SVYM, Mysore, India.




*“...simple successful technologies are common sense implemented in logical manner.... and these technologies are not beyond the reach of common man once they are placed in a proper environment!*

*...the next big thing in healthcare is not going to be a magic pill or a faster scanner or a new operation, next big thing in healthcare is going to be making hospital safer for the patient.... (for that) we are not trying to produce a digital record of the hospital what we are trying to use is the intelligence of IT in preventing mistakes in the hospital... mortality of cardiac surgery in my hospital is 1 percent..... why 1 percent should die? It could be 1 percent for me, but for the grieving family it is 100 percent....*

*...we are 1.2 billion population, the things what we can do as one country, looking at the needs of the common man; we can dramatically change the rules of the game and that is possible!*


*“Responsible design has the potential to bridge what seem to be tradeoffs, and thereby ensure sustainable progress. We will need a lot of such design thinking, and quickly too, if the earth is to survive.”*

*– Dr. Devi Shetty, Cardiac Surgeon, Founder, Narayana Health, Bangalore, India*



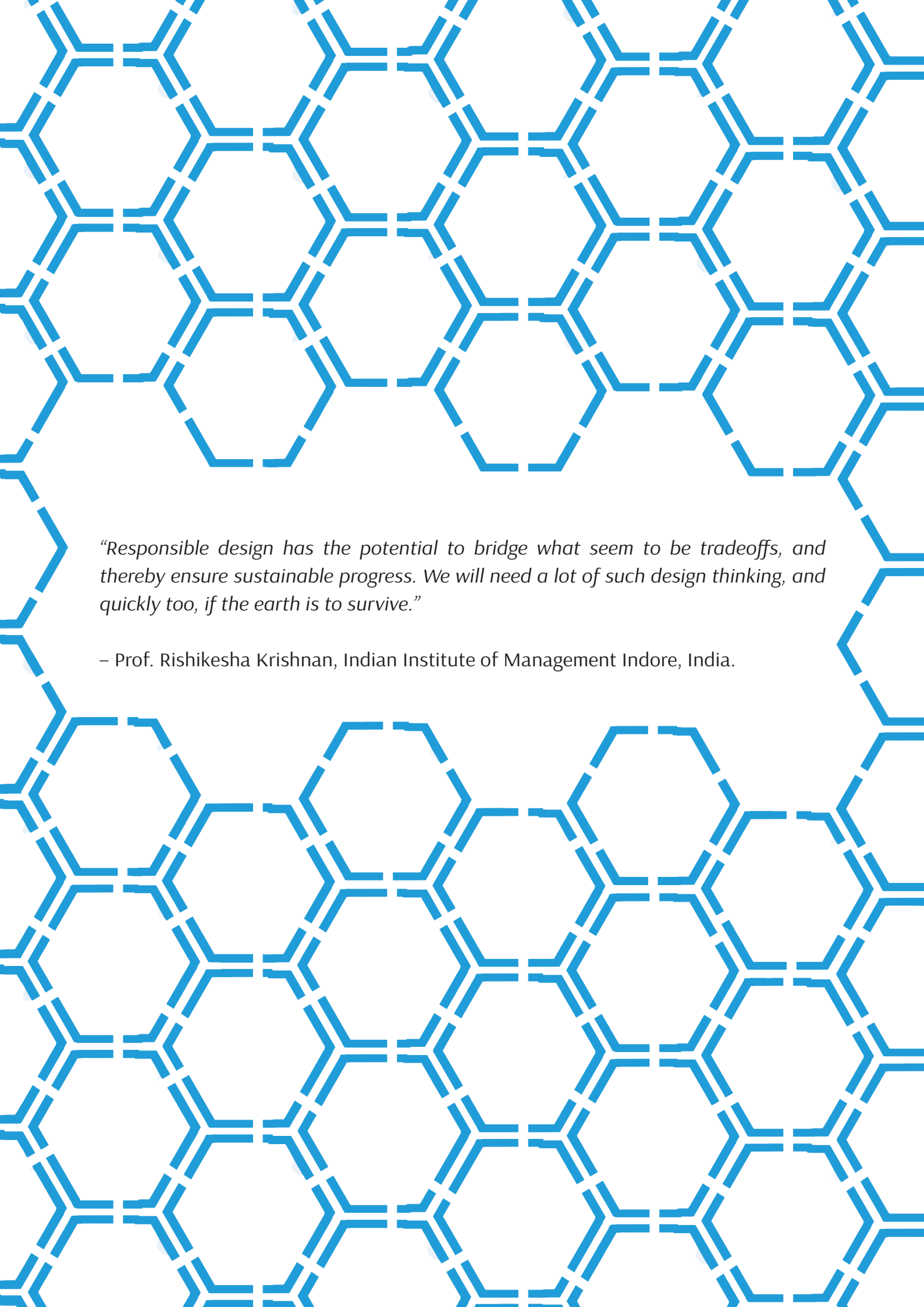
*“According to several observations, analyses, inferences and predictions made by experts worldwide, and independent of the extent of agreement or disagreement prevailing among them, the human species is staring at a bifurcation point reflecting our current state of ‘development’, whatever that may mean to different people. “To what extent are we leading imbalanced lives globally, regionally and locally?” is among the most profound questions facing all of us. The bifurcation, at the extremes, signifies two paths that are before us. One could lead us to a sustainable state of existence, lifestyles and even ‘development’, and the other could plunge us into an irreversible situation that may well mark the end of our species or, most frightfully, the wiping out of most life forms as we know them. The drivers of these two extremes and many other states that fall in between are primarily human-influenced. Clearly, humans hold the key to future states of existence, lifestyles and ‘development’. But, will humans choose wisely despite all the differences they hold? This is precisely the point at which “Design for Wellbeing and Empowerment” offers principles that should help all of us build the necessary responses for a more balanced contemporary civilization, one that is marked by wise choices for our existence, lifestyles and ‘development’. Wise design requires wide systemic perspectives, technical and interdisciplinary expertise, fertile imagination, foresight, and above all restraint and deep concern for our natural environment. It is high time for designers to display a deeper understanding of human behaviour and sensitivity to larger, but not so very apparent, issues facing their very survival in the long-term. Wellbeing and Empowerment are two compelling motives for designers to pay the maximum possible attention to the tricky issues of ‘balanced’ design..”*

– Prof. Ganesh, L.S., Indian Institute of Technology in Madras, Chennai.



*“Understanding materials, structures and processes in living nature and subsequent biomimetic transfer of deep principles to the human sphere allows for responsible design as a major pillar of sustainable well-being and empowerment, for a liveable future for all.”*

– Prof. Ilse Gebeshuber, Vienna University of Technology, Austria and The National University of Malaysia.



*“Responsible design has the potential to bridge what seem to be tradeoffs, and thereby ensure sustainable progress. We will need a lot of such design thinking, and quickly too, if the earth is to survive.”*

– Prof. Rishikesha Krishnan, Indian Institute of Management Indore, India.



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## Chapter 1

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# Design for Well-Being and Sustainability





paper

1

Uncertainty and Capabilities:  
A Note of Caution to Designers

Mahendra Shahare



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# Uncertainty and Capabilities: A Note of Caution to Designers



## Abstract:

A general thesis under discussion in this conference can be summarized as follows: the Capability Approach to development is about increasing the freedoms or effective capabilities that an individual has. In this context, artefacts and technologies are seen as enablers that make it possible to have or enhance certain human capabilities. Furthermore, because technologies are not value-neutral, designing ‘capability sensitive’ artefacts and technologies for developing populations/communities will lead to their well-being, empowerment, and help achieve sustainability. While supporting this line of thought, this paper, however, attempts to outline limitations of using the Capability Approach to design in general. By focusing on the uncertainty aspect through the use of two important concepts in design (i.e. affordances and unintended consequences), it is argued that the Capability Approach is a static analytical tool that cannot fundamentally resolve the problems of technology.

**Keyword:** Capability Approach, uncertainty, design, affordances, unintended consequences

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## 1 Introduction

Longing to create is an inherent characteristic of human beings. The process of creation, aided by *designing*, often results in what are termed artefacts (or technologies). These artefacts are generally seen as a response to the needs (real or perceived) arising out of dissatisfaction with a certain state of affairs. Amartya Sen through his seminal work on development and human well-being has made us aware of the ‘remarkable deprivation, destitution, and oppression’ (Sen, 2000: xi) in a world that we live today. He reminds us that we should be dissatisfied with the ‘persistence of poverty and unfulfilled elementary needs, occurrence of famines and widespread hunger, violation of elementary political freedoms as well as basic liberties, extensive neglect of the interests and agency of women, and worsening threats to our environment and to the

sustainability of our economic and social lives’ (Sen, 2000). How can design and technology respond to this multiplicity of issues faced by the majority of the world population, is a pertinent question.

The underlying theme of this conference is - to intervene through design (technology) as a way of effectively increasing *capabilities* or *freedoms* that people have to overcome persistent deprivation in a *sustainable* manner. Three elements are crucial to this idea: design, *capabilities*, and *sustainability* (or broadly environment). First, we should look at the interrelation between these elements by asking the following. Does the design of artefacts and technologies always result in increased *capabilities*, *freedoms*, and *sustainability*? The history of technology tells us that this is not the case. Risk and *uncertainty* are always associated with technological artefacts. While risk to an extent can be forecasted

or a probable measure can be known beforehand, *uncertainty* cannot be taken care of. This paper focuses on *uncertainty* or the contingency aspect of artefacts and technologies and its impact on *capabilities* and *sustainability*. In particular, using the concept of *(un)intended consequences* and *affordance* in design, this paper attempts to sketch a cautionary note in regard to projected outcomes while operating with the three mentioned elements.

## 2 Development and the Capability Approach (CA)

Amartya Sen conceives ‘development as a process of expanding the real freedoms that people enjoy’ (Sen, 2000: 3). In this perspective, personal income, industrialization, or technological advance are narrower views of looking at development, though they are important means. In Sen’s approach, the expansion of freedom is both a) the *primary end* (constitutive role) and b) the *principle means* (instrumental role) of development. While expansion of freedoms is in relation to individual agency and the individual is thus central to his approach, he simultaneously recognizes the influence of social arrangements on the extent of individual freedom. For example, absence of political freedoms (e.g. freedom of speech), economic facilities (e.g. access to finance), or social opportunities (e.g. access to education) severely constrains the exercise of individual freedom. Hence, Sen takes a normative stance in seeking ‘individual freedom as a social commitment’ (Sen, 2000).

Sen’s theoretical persuasion has crystallized into what is called as the Capability Approach (CA). Robeyns (2005: 94) provides a more lucid definition of CA as ‘a broad normative framework for the evaluation and assessment of individual well-being and social arrangements, the design of policies, and proposals about social change in society’. Here, the evaluative component is in relation to the effective opportunities that people have *to do* or *to be* what they value, termed *capabilities*. Sen (1988: 36) further distinguishes between *functionings* and *capabilities* in his writings: ‘A functioning is an achievement, whereas a capability is the ability to achieve. Functionings are, in a sense, more directly related to living conditions, since they are different aspects of living conditions. Capabilities, in contrast, are notions of freedom, in the positive sense: what real opportunities you have regarding the life you may lead?’ Thus, development requires removal of sources of *unfreedoms*, which will result in an increase in potential *functionings* (i.e. human *capabilities*) that can be effectively achieved. The following section introduces the role of design in realization of *capabilities* through artefacts and technologies.

## 3 Artefacts, Technologies, Capabilities, and Sustainability

Reminding ourselves that *designing* takes place in relation to dissatisfaction with the status quo, designers can then be seen as being engaged in changing the state of affairs through artefacts. Conceptualization of a desired state is often the key

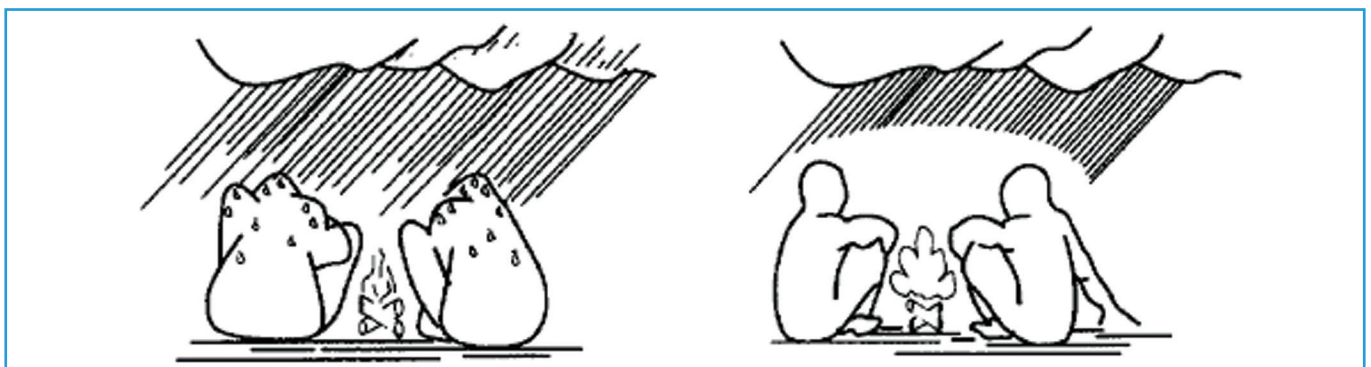


Figure 1 Conceptualization of desired state

Source: Resenman & Gero, 1998



in this process of *designing*. Rosenman and Gero (1998: 164) provide a better visualization of this progression (Fig. 1). For simplicity, we can also view technologies as artefacts providing solutions to everyday life problems, bringing change in the state of affairs. And perhaps it will not be an exaggeration to say that, technologies make it possible to have or contribute to a bundle of *capabilities* which we have reason to value (e.g. access to potable drinking water or mobility). That is to say, a set of *beings* and *doings* have a causal relationship with artefacts and technologies. Oosterlaken (2009: 94) makes this dimension more prominent by claiming ‘After all, what is technology for, if not increasing the capabilities that we have as human beings?’

### 3.1 Artefacts and Capabilities

The basic claim is that artefacts and technologies augment human *capabilities* leading to an increase in freedoms and well-being or development, the central object of the Capability Approach. Artefacts and technologies in this view provide diversity to conceptions of a good life, leading to a plurality aspect of well-being. Human well-being in modern societies is thus tightly knit to the notion and existence of technologies. Van den Hoven (2012: 27) has proposed a capability–technology affinity (CTA) thesis, which views the CA, engineering, and technology as amplifiers of agency and human capabilities. He and Oosterlaken stress the significance of the ‘details of design’. Using the established understanding from the domain of science and technology studies (STS) that technologies are value-laden, Oosterlaken (2009: 95) writes that ‘Values such as privacy, autonomy, sustainability, safety, and justice can be realized in our technologies—or these could rather embed and create the opposite: injustice, insecurity, and so on’.

A notoriously famous example in this regard is the use of ultrasound technology in India and the associated rise in female feticide. Van den Hoven emphasizes that a redesign of ultrasound can eliminate the possibility of misuse and will result in removal of *unfreedoms* produced by the existing design. That is

to say, a better artefact or technology as a solution to the problems created by existing technologies, will lead to enhancement of *capabilities*. CA ‘has drawn attention to the existence of immense human diversity; not only in terms of what we value, but also in terms of personal and social/environmental characteristics that influence the conversion from resources into capabilities and functionings’ (Van den Hoven, 2012). Moreover, because artefacts and technologies are ‘resources whose properties can be moulded’ (Van den Hoven, 2012), consideration of these conversion factors while designing would produce effective freedoms. Hence, there has been a call to designers for ‘value sensitive design’ and ‘capability sensitive design’.

### 3.2 Artefacts and Sustainability

Creation of a diverse *capability* set through artefacts and technologies is typically insufficient if they are not relevant to the majority of the world population (i.e. the developing world). Clearly, a different set of values must inform the design of artefacts and technologies which will help in the removal of unfreedoms for this group of people. The present conference probes such possibilities, and Oosterlaken (2009: 101) makes this need very clear in saying that ‘However, I would especially like to encourage a capability approach towards design for development, since both the need and the potential impact are high’. Appreciably, one value that is being sought in this intervention is sustainability.

As noted on the conference website, the three pillars of the notion of sustainability are planet, people, and profit. The popular notion of sustainability comes from the Brundtland Commission of the United Nations: ‘sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs’ (Brundtland, 1987). In the context of developing nations, achieving financial as well as environment *sustainability* poses a great challenge. Prahalad’s focus on innovative products for the ‘Bottom of the Pyramid’ (BoP) promises a perspective that could lead to development with

financial *sustainability*. *Capability* sensitive design for BoP can thus lead to the well-being of respective groups and individuals. Nonetheless, mere financial *sustainability* will create havoc, because precious resources are abused in the process. For example, Mongolia's copper and gold reserves are found in its driest part, the South Gobi. Thus, there are serious implications as the 'resource-rich country is riding high economically but a battle is brewing for water between people, mining, and agriculture' (Balch, 2014).

Therefore, given the rising demand and burden on natural resources, environmental *sustainability* is more likely to diminish, reducing the human capabilities in the mid- and long-term future. What is important here is that people must learn to be frugal in their resource use, and *things* (artefacts and technologies) they use should allow them to do so. However, designers know that achieving such a feat of creating opportunities for *sustainable* well-being is rare. Although we need not be pessimistic or luddites, we should be aware and conscious about the fact that *technologies are both the solution and cause of the problem*. The following section illustrates the problematic aspect of technology using the concepts from design theory to construct a cautionary note.

## 4 Design, Technology, and Well-Being

*Design for X* is such an over-exploited term that designers often do not pay any heed, and are happy doing what they do best (i.e. *designing*). Designers' creativity is always stretched in search of a configuration that will satisfy a long list of demands, including: *Design for/to* – manufacturability, assembly, cost, logistics, ergonomics, aesthetics, serviceability, maintainability, reliability, testing, safety, quality, minimum risk, modularity, user-friendliness, usability, disassembly, market, participation, human dignity and human rights, universality, global justice, environment, context, society, sustainability, BoP, development, capability sensitive etc. This vortex of requirements cannot always result in an ideal situation, and the resulting

design solution will generally be a compromise or *trade-off*. This trade-off is accepted in real life practice for the obvious practical reasons. Now let us turn to our attention to the *trade-off* that is likely to occur in good number of situations than not, in the context of 'Design for Sustainable Well-being'.

### 4.1 Affordance and Unintended Consequences

Let us first start with design for well-being. The overwhelming idea is that 'capability sensitive design' of artefacts and technologies would provide means for expansion of real freedoms that people have, and thus lead to human well-being. Unfortunately, *things* (artefacts) often *end up doing more than what we tell them to do*. For example, communication towers broadcasting signals for television, radio, and mobile phones cause the deaths of around seven million birds per year in North America alone; or back home in India, archaic toilet design in Indian Railways has kept thousands of humans bonded to the undignified job of manual scavenging. A very obvious solution to these situations, a common sense reply would say, is to revise the design.

Morello (2000: 39) explains this idea of progressive redesign from Gilbert Simondon's thesis: 'passage of time and repeated design processes make technical objects undergo successive modifications that develop them from a more abstract to a more concrete state... gradually more in tune with the context in a process of reciprocal adaptation'. However, there are two explicit assumptions in this statement: a) such design revision will take place in resistance to the entrenched power relations, and b) revised design will not create any new problems. Either or both of these assumptions do not always hold well in practice. For example, the ubiquitous QWERTY keyboard layout, which was originally developed for Morse (telegraph) receivers, has not changed in over a century despite not being ergonomic (Ferguson and Duncan, 1974).; or CFL and LED bulbs reduces energy consumption compared to incandescent bulbs but introduce toxicity because of materials used such as mercury, lead, and nickel. Thus, even though artefacts are

being used for their intended purpose (e.g. typing text or illumination, respectively), the resulting effects, that is, the *unintended consequences* of technologies, actually arise from the *trade-off* made in the process of *designing*.

Such *unintended consequences* do not arise solely from the design; *things can also be put to use by users for a purpose other than one intended by the designer*. Psychologist James Gibson's 'Theory of Affordances' is useful to understand this phenomenon. According to him, *affordance* is 'an action possibility available in the environment to an individual, independent of the individual's ability to perceive this possibility' (Gibson, 1977). The 'action possibilities' are in relation to the agents and dependent on their *capabilities*. Don Norman (n.d.), who used the concept of affordance in the context of human-machine interaction, says, 'To Gibson, affordances are a relationship. They are a part of nature: they do not have to be visible, known, or desirable. Some affordances are yet to be discovered. Some are dangerous. I suspect that none of us know all the affordances of even everyday objects'.

It is from this open space of *object affordances* that a second set of *unintended consequences* arise. First, when artefacts and technologies are intentionally put to use (by users) for doing something for which they were not originally designed. Thus, a kitchen knife intended to cut vegetables works as a tool for murder or an airplane becomes a bomb instead of a transport device, or ultrasound machines, surrogacy, and IVF treatments become tools for feticide or exploitation. While these artefacts were never designed for these purposes as such, the user appropriates *affordances* available in artefact's inherent configuration and intentionally uses it to produce consequences that she wants to achieve. Even if we were to use Van den Hoven's suggestion to redesign the ultrasound machine configuration, there is no guarantee that the new design will not produce any *unintended consequences*. As a matter of fact, the proposed solution that he mentions, of blurring ultrasound image around the genital area, will deprive doctors from diagnosing cases of 'ambiguous genitalia'.

Secondly, things become more complicated when users use technologies for purposes other than those intended by the designer and face consequences that they never desired. The famous DDT, which brought Noble prize to Muller, was used for Malaria vector control because of its insecticidal properties. Farmers then started widespread use of DDT for agriculture (and even today it continues in India). This has created serious health issues for this exposed population. In addition, mosquitoes developed resistance to DDT, causing a resurgence of malaria leading to difficulty in treating it.

#### 4.2 (Un)intended–undesirable Consequences and Uncertainty

Uncertainty is a part and parcel of everyday life. Whether we choose to act or not, changes are inevitable (e.g. aging or environmental changes) and thus the consequences. Some of these consequences arising out of our actions can be anticipated, and they include: intended and desired, not desired but common, not desired and improbable (Healy, n.d.). Similarly, consequences of an action that cannot be anticipated include: desirable, and undesirable. When we are dealing with artefacts and technologies, a designer or a user typically focuses on anticipated consequences that suit his intentions or end goals (i.e. intended consequences). However, due to the unpredictable system, environment, and human relationships certain unanticipated consequences also manifest. That is to say, interactions between these entities produce *unintended consequences* that were not known beforehand to the designer or the user.

To be sure, artefacts and technologies also do produce unintended consequences that are positive or desirable to the larger society. For example, the introduction of bank ATMs in India allowed the lower class/caste population to avoid potentially humiliating interactions with higher class/caste bank tellers (Angeli, Athvankar, Joshi, Coventry, & Johnson, 2004: 38). As a welcome unintended consequence, the ATM queue took away the privileges generally associated with class/caste in Indian society and brought down

the chances of discrimination. Examples described in the previous sections of both design trade-offs and affordances, actually produced negative or undesirable consequences for the larger society, even though the effects might be desirable to a particular designer or user. Now, two things should become clear from the above discussion. First, there is a good amount of uncertainty involved about the negative consequences that an artefact or technology will produce because they cannot be fully determined and controlled beforehand. Let us formally term these effects (un)intended-undesirable consequences, which result from both the artefact design and its use in actual practice. The 'un' in parentheses accounts for differences in the intentions of the designer and user.

Second, these effects are different from (and must not be grouped with) *risk*, which is inherent to the design of complex technologies such as civil structures and expressed in terms of probability of failure of the system. As Murphy and Gardoni (2012: 173) explain in relation to human *capabilities*, 'In the context of engineering design, risk refers more specifically to the probabilities of realizing different levels of performance of the designed behavior and the associated consequences'. In simple terms, *risk* here refers to those situations when an artefact fails to fully or partially perform its intended function, producing certain consequences that are usually *undesirable*. Murphy and Gardoni (2012) focus on this aspect, using CA as a way to account for societal impact of *risk* associated with design.

The point of departure for this paper is not the consequences produced when artefacts fail to work (*risk*) but instead the consequences produced when artefacts or technologies are fully functioning. The *uncertainty* under discussion here is the *uncertainty* of artefact behaviour in known and unknown environments, and thereby the negative consequences produced by it, which cannot be predicted, measured, or known beforehand; it is known only as *after effects*. Once we have this knowledge of *after effects*, it is only then that these effects either become *risks*, *hazards*, or *undesirable*

*consequences*. In general, we can conclude that quite often than not artefacts and technologies will produce *(un)intended-undesirable consequences*, and thus consequently would diminish *capabilities* and human well-being. The following section takes this understanding forward by adding the dimension of *sustainability*.

## 5 Sustainability and Technology

A general rule of thumb in discussions about *sustainability* is – meeting the needs of the present and future generations. An important starting point for us is to focus on actions of the present generation and the likely consequences for future ones. In particular, we should scrutinize the 'technological-fix' approach to environment and development that seeks to maintain progress and profits. Sustainability economics, an allied discipline that focuses on people and profits, has been described by Baumgärtner and Quaas (2010: 2057) as follows: 'Sustainability economics is ethically founded in the idea of efficiency, that is non-wastefulness, in the use of scarce resources for achieving the two normative goals of (i) the satisfaction of individuals' needs and wants, and (ii) justice, including justice between humans of present and future generations, and justice towards Nature, within the setting of human-nature relationships over the long-term and inherently uncertain future'. Two aspects of this description are crucial to the present discussion. First, the idea of efficiency and non-wastefulness, and second, a long-term inherently *uncertain* future.

The previous section highlighted the second aspect of inherent *uncertainty* noted in relation to design and artefacts. The other aspect has two radically different components: a) the idea of efficiency, and b) non-wastefulness. We must appreciate the fact that efficiency does not necessarily mean less waste. The Jevons paradox in economics explains that technological progress and the associated increase in efficiency of resource use tends to increase the rate of consumption of that resource. In regard to energy consumption, economists Khazzoom and Brookes suggest that 'energy efficiency improvements that,



on the broadest considerations, are economically justified at the microlevel, lead to higher levels of energy consumption at the macrolevel' (Herring, 1998). In certain situations, efforts on efficiency might then turn out to be counterproductive, causing wastefulness. More importantly, there are social spaces where efficiency is less of a consequence.

Verbeek and Kockelkoren (1998) describe the approach of Eternally Yours, a group of Dutch industrial designers in their article, developing ideas about 'cultural sustainability' or, better, 'durability'. For them, the life cycle analysis (LCA) approach to eco-design is insufficient: The 'Life Cycle Analysis may make it possible to design products that are friendlier to the environment, but leaves a fundamental problem unaddressed - the short lifetime of our products. We live in a throwaway culture discarding products while they are still in good shape' (Verbeek & Kockelkoren, 1998). Even with its normative stance, CA doesn't question the kind of *beings* and *doings* that a person holds as valuable. American and European users of mobile phones increasingly look forward to new product launches while still carrying perfectly well-functioning phones in their pockets. A reflection of this *throwaway* culture can be gauged by the fact that on average, these users replace their handsets every 18–22 months. It was argued that *technologies are both solution and cause of the problem*, but in relation to *sustainability*, we need to go a step further. As noted by Verbeek and Kockelkoren (1998), the 'environmental crisis is not only a technological problem, but a cultural problem as well'. In general, the present generation has not inculcated the terms of justice for its next generations yet. The next section attempts to articulate the limitations of CA in relation to 'Design for Sustainable Well-being'.

## 6 Limitations of CA and Design for Sustainable Well-being

From the perspective of sustainability and capabilities, this section uses the theoretical description provided above, and applies it to a real-life case study to outline the limitations of

CA. Tube/bore well technology allows farmers and households to draw water from a considerable depth below the earth's surface for irrigation and drinking purposes. Thus, it is a technology that has immensely benefitted the rural agrarian population in India and helped increase the food security of the country. In this perspective, it is an enabler technology that helped people increase their *capabilities* and achieve a basic level of *functioning*. However, the story does not end here – let us try to follow it.

### 6.1 The Case of Tube/Bore Well Technology

The state of Punjab is the breadbasket of India, supplying a total of 20% of wheat and 12% of rice to the country. The 'green revolution' in Punjab was largely made possible by the supply of fertilizers, tube/bore wells, and free electricity. However, over the decades, this has resulted in 'overexploitation' of land resources and yielded consequences that are now difficult to manage. The Columbia Water Centre (CWC, n.d.) notes that 'From 1982-87, the water table in Central Punjab was falling an average of 18 cm per year. That rate of decline accelerated to 42 cm per year from 1997-2002, and to a staggering 75 cm during 2002-06. Water tables are now falling over about 90 percent of the state, with Central Punjab most severely affected'. Effects of this serious ground water table depletion, *(un)intended–undesirable consequence* of technology, would be borne not only by the local state population but also by the majority of the poor population of India; the result being a net reduction in *capabilities*. Mitigating this crisis requires application of strategies apart from technology redesign, such as reduce, reuse, and recycle. The point here is insufficiency of knowledge in the past and present to decide the *sustainable* levels in this case while harm has been done. Furthermore, there is no guarantee that the new design will not pose new problems.

In addition, the tube/bore well technology was also adopted by government agencies in the state of West Bengal and in the Govt. of Bangladesh in the 1960–1970s as a way to supply drinking water to

the rural population. No doubt these efforts were aimed at enhancing *functionings* and the well-being of the rural population. However, in the year 1982, dermatologist Dr. K. C. Saha from Kolkata (West Bengal) came across patients with skin lesions. The disease was caused by naturally occurring Arsenic in the Ganges delta. Water fetched through tube wells made this population vulnerable ‘to several cancers; toxic effects on the liver, skin, kidney, cardiovascular system, and lung; and fatal poisoning’ (Argos et al., 2010: 252). The Geological Survey of India (GSI, n.d.: 2) report notes that ‘The estimated population in these eight districts [of West Bengal] was around 40 million (population survey, 2006), within which people using high arsenic contaminated water (above 50 ppb) was more than one million, while the estimated population using moderate arsenic contaminated water (between 10 and 50 ppb) was around 1.3 million’. Sadly, the case of Bangladesh is even more severe, as this particular hazard was only noticed in the 1990s. According to the team of researchers led by Dr. Habibul Ahsan, ‘An estimated 35–77 million people in Bangladesh have been chronically exposed to increased concentrations of arsenic through drinking water’ (Argos et al., 2010: 252). The World Health Organization described this tragedy as the ‘largest mass poisoning of a population in history’ (Argos et al., 2010: 252).

These failures cannot be entirely attributed to failed state mechanisms or the choices made by people. Technologies are always in relation to humans. As philosopher of technology Don Ihde says ‘Were technologies merely objects totally divorced from human praxis, they would be so much “junk” lying about. Once taken into praxis one can speak not of technologies “in themselves,” but as the active relational pair, human-technology’ (Ihde, 1993). Humans, including both designers and users, enter into a relationship with technologies, and only then it becomes meaningful to talk of a ‘successful’ or ‘failed’ artefact or technology. No artefact or technology exists or can be evaluated in isolation to humans; relation with humans defines technology. The *(un)intended–undesirable consequences* of

the tube/bore well were not known to any entity beforehand and are *after-effects*. At the same time, it was only due to the introduction of this artefact (i.e. the tube well), that these consequences manifested; humans alone could not have brought into existence this state of affairs.

Thus, the posturing of redesigning for ‘capability-sensitive design’, after the original technological design has effectively diminished *capabilities* and *functioning* that perhaps cannot be regained or restored, is no solution to the already exposed population. Neither do we have a solution now to overcome the aspect of uncertainty and *undesirable consequences*, even with artefacts that are capability sensitive designs. We should not necessarily remain inert, but we should also not propel the illusion of ‘*new and improved*’ design to be the magic bullet.

## 6.2 Limitations of CA

In light of the case of the tube well and with concepts of *unintended consequences* and *affordance*, it should become possible for us to appreciate that CA cannot be much of a help to fundamentally resolve the problems of technology. This is largely because CA is a static evaluative analysis of the state of affairs at a given point in time. This evaluation of course is also affected by the availability of resources such as goods and services to a person or a group of people and by the existing conversion factors (personal, social, and environmental) at the time of evaluation. Thus, the picture of a person’s well-being in CA is a function of the static input data fed into the analysis. Because a person chooses *functionings* from his *capability* set (in our specific case, a set enabled by artefacts and technologies) that are valuable to him, we only have a limited way to foresee how different opportunities and constraints presented by chosen *functionings* affect the well-being and sustainability aspect. Rauschmayer and Leßmann (2011: 1835), commenting on the application of CA for sustainability, mentioning that ‘Using a concept that is not able to consider dynamics is not really helpful for sustainability issues’.

CA certainly is a helpful *Design for X* (*value sensitive* or *capability sensitive*) tool for generation and assessment of a different set of design requirements. It is also essentially a rich framework for the evaluation of artefacts and technologies from the perspectives of human *functionings* and *capabilities*. Nonetheless, CA does not take into consideration aspect of *uncertainty* in the sense of *risk* or the *(un)intended–undesirable consequences* described here. To put it simply, CA cannot provide an exhaustive list of *capabilities* that an artefact will create, either during the design phase or after the complete realization of the artefact (i.e. after manufacture), because of the inherent *affordance* various elements of an artefact will generate. More significantly, we cannot expect CA to generate beforehand an exhaustive list of *capabilities* diminished by an artefact which is either being designed, constructed, or already in use. Hence, in a good number of cases, CA will result in a type-II error or a false-negative result (i.e. ascribing an artefact or technology as an enabler of *capabilities*, while in practice it ends up diminishing the well-being of a person or group of people and hampers *sustainability*).

## 7 Discussion and Conclusion

This paper argued that *technologies are both the solution and cause of the problem*. Specifically, by focusing on *(un)intended–undesirable consequences* arising from artefacts and technologies, the role of *uncertainty* in diminishing capabilities was highlighted. This particularity is due to the inherent indeterminate nature and *affordances* offered by the artefacts and technologies. It thus becomes possible for us to say that, CA being a static framework for evaluation cannot address the issue of *uncertainty* on its own. Hence, an artefact or technology that is seen as effectively adding up to the *capabilities* set of a person based on the CA analysis might actually in the future produce *(un)intended–undesirable consequences* that diminish *capabilities* and well-being. It is in this sense that this paper puts forth a word of caution to designers.

Further, if we add another dimension of *sustainability* or environment to design of technologies, the *uncertainty* aspect in this combination becomes pronounced. The usual approach of efficiency and non-wastefulness as a ‘technological fix’ does not always result in a *sustainable* way of life. As philosophers of technology Verbeek and Kokelkaren (1998: 28) point out, ‘environmental crisis is not only a technological problem, but a cultural problem as well’. Thus, uncertainty in regard to *(un)intended–undesirable consequences* of technologies on environment, and our *throwaway* culture diminish mid- and long-term *capabilities* and well-being of people, which cannot be accounted for by CA. As Robeyns (2005: 111) explains, ‘The capability approach is not a panacea for research on development, poverty, justice, and social policies, but it can provide an important framework for such analyses’. In conclusion, CA applied to ‘Design for Sustainable Well-being’ can act as a fundamental analytical tool, but neither it can weed out uncertainties nor accommodate dynamic conceptions of capabilities.

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paper

2

To Have or to Be:  
The Power and Moral Responsibility of the  
Designer to Contribute Towards a Sustainable Future

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# To Have or to Be: The Power and Moral Responsibility of the Designer to Contribute Towards a Sustainable Future



## Abstract:

The title is a reflection on the work of German philosopher Erich Fromm (1900–1980). The paper challenges the ethics of the design profession, from manufacturers to consumers to the products they produce and use. The path to a sustainable future is signposted by the concept of ‘enough’.

A reorientation away from ego-centrism to eco-centrism and from dollar-centric to homocentric design philosophy will shift the emphasis in design education and practice, as well as the global political and socio-economic fabric.

The paper discusses the role of the designer and advocates a course of action which is hoped to awaken a consciousness of joint responsibility to facilitate solutions and secure a sustainable future for all living constituents of the ecosphere. To this end, it is vital that we develop a global sense of solidarity. After all, we are all in this together.

**Keywords:** *cardinal virtues, human potential and knowledge, empathy, compassionate action and care, awareness, mindfulness and respect*

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## 1 Prologue

*‘Man is a singular creature. He has a set of gifts, which make him unique among the animals, so that, unlike them, he is not a figure in the landscape – he is the shaper of the landscape. In body and in mind he is the explorer of nature, the ubiquitous animal, who did not find but has made his home in every continent’.*

*The Ascent of Man by Jacob Bronowski*

To add to this opening observation, a phrase from Genesis paints the canvas for the background of my thinking (Bronowski, 2011). From Genesis 1, New International Version:

*‘God blessed them and said to them, ‘Be fruitful and increase in number; fill the earth and subdue it. Rule over the fish in the sea and the birds in the sky and over every living creature that moves on the ground’.*

Fast-forwarding to 2014, one wonders if God would still give the same instructions, seeing what homo sapiens have done to the creation, the harm we have inflicted on the fish in the sea, the birds in the sky, and every living creature that moves on the ground. Could we have misinterpreted these words? There are examples of people who have different notions of ownership or stewardship or taking responsibility of what has been given into their care. Ruling over could equally mean to be in charge of,

to be responsible for, to look after or make sure it sustains the purpose of life.

Human nature has been called parasitic, egocentric, and proud – an entire species living at the expense of others, exploiting others, sitting comfortably at the top of the food chain, conquering and destroying, and shamelessly drawing resources from other constituents of the natural environment. The environmental footprints of most nations are living proof of this, and they far outweigh the few exemplary testimonies of small communities and kingdoms guided by insightful rulers. In 365 B.C., Sri Lanka and other harmonious communities lived by the seemingly obvious intuition that human beings and nature are one: depending on each other and existing with each other, and not in spite of each other. Sri Lanka's King Devanampiyatissa, in order to control human impact on the environment, established nature reserves during his reign dating back to 307 BC. The reserves were dedicated to promoting sustainability and harmonious living with nature. Two-thousand-year-old wisdom, yet we have failed to learn from it and are still unwilling to see the need for action. It seems we are lemmings, blindly following all the societies which failed to survive, whose demise Jared Diamond describes in his book *Collapse* (Diamond, 2005).

My paper does not delve into the latest statistics, uploaded data, or sophisticated modelling. Humans already have the knowledge and technological prowess to guide our actions towards a sustainable outcome. I do not wish to elaborate on the summits and international protocols, where those who speak have nothing to say, other than advancing their own agenda. Rather, the paper makes an appeal to old values, the cardinal virtues taught in classical antiquity and the need to face facts; rather than carry on in the haze of delusions created by opportunistic politicians, the 'merchants of doubt', the big gamblers in geo-engineering, or the military-industrial complex attempting to control the weather. Perhaps my small but sincere contribution, when multiplied by 7.2 billion, will tip the scales in favour of a sustainable future.

## 2 Introduction

*'The richest man is not the one who has the most, but the one who needs the least.'*

*Proverb of unknown origin*

In 1874, Jules Verne published his beautifully narrated story *The Mysterious Island*. Two episodes are relevant to our present discussion. Early in the story Verne offers a compelling metaphor depicting the end of a daring balloon escape, and later, he anticipates a dramatic paradigm shift from a coal- or carbon-based economy to one that is dependent on hydrogen. As matter and energy are the two governing numerators in sustainability, this is a promising proposition (Verne, 2008).

The balloon episode takes place at the height of the American Civil War, in March 1865, when five prisoners of war hijack a balloon and make their escape one tempestuous night. While the circumstances are exciting enough, they are immaterial to the point I wish to make. The moral is in the final episode, when the balloon starts to fail and the passengers, precariously hovering just above the stormy ocean, can feel the spray of the waves. At this juncture, a commanding voice emerges from amongst the five on board, taking charge over the perilous situation.

Where is this voice today? Does it come from the Intergovernmental Panel on Climate Change (IPCC)? The United Nations? The world's wealthiest nations? The long list of celebrities, philanthropists, authors, and advocates for a sustainable future? These voices barely constitute a whisper against the noise made by the big and overbearing corporations, their merchants of doubt, and the lethargy of the silent majority. The 7.2 billion passengers on spaceship earth are desperately hoping for this voice.

Having relieved the balloon of all its ballast, there was still \$2000 worth of gold left to be thrown overboard. (At the 1865 price of \$18 per ounce, this amounted to about 111 kg, the equivalent of more than \$160,000 dollars in 2014.) There was no

hesitation to throw this valuable cargo overboard. It was a case of 'do or die'. While this action offered some temporary relief, the balloon could not be mended and the next step was to cut loose the car and clamber onto the ropes of the balloon. This desperate action gave the balloon sufficient uplift for the storm to carry it onward and cast its passengers onto the beach of the Mysterious Island. It is worth adding that there was a dog on board and the escapees never even considered abandoning the animal for the sake of their own survival.

Desperate situations require desperate measures. What has to happen to make us desperate? What will tip the scales? Who can convince us of what needs to be done? Where is the leading voice, the guiding spirit to marshal mankind to a concerted action?

Our collective behaviour as a global community reminds me of the way Indian boys catch monkeys by exploiting their inability to make a connection between their greed and the price they pay for it. The monkeys trade their freedom for peanuts. In our case, we are bartering our survival.

### 3 To Have or To Be

*'There is enough for everybody's need; but not everybody's greed!'*

*Mahatma Gandhi*

In searching through the related literature, I happened across many others who were occupied by the idea of 'being' instead of 'having', what it means to rise to our innate potential, and what a shift in awareness could do to bring about a sustainable future. The history is long and encouraging, but the evidence, which stares us daily into the face is disparaging. Observe the perversion of Indian spirituality into an aggressive form of materialism, China's ballooning 'middle class', or the Russian oligarchy's ruthless exploitation and criminal conduct.

In Ivan Illich's collection of essays *Celebration of Awareness: A Call for Institutional Revolution* (1971), Erich Fromm offers an inspiring forward. Here

the Jewish Fromm praises Illich, the Jesuit, for his contribution toward lifting mankind out of its self-inflicted predicament. What a testimony of human good will, tolerance, and understanding. Fromm's forward demonstrates the capability of the human heart to transcend boundaries, overcome obstacles, embrace our mutual destiny, and celebrate awareness and common sense (Illich, 1973).

These two men and their theses are complementary.

I wholeheartedly support Illich's observation that 'institutions create certainties, and taken seriously, institutions deaden the heart and shackle the imagination' (Hoinacki and Mitcham, 2002).

When the Berlin Wall fell on 9 November 1989, the East flooded into the West, hoping for the illusionary paradise, the land of plenty. We can observe Illich's statement firsthand. The 'Promised Land' turned out to be a place where people were challenged to be the masters of their own destiny, to think and plan for themselves. Freedom turned out to be something which had to be acquired, learned, and earned.

One cannot obtain the consciousness and awareness required to lead a life of being rather than having or take the step from ego-centrism to eco-centrism without a sincere desire to maintain conviviality on earth and without a holistic view of the world. This awareness is equally required in following E.F. Schumacher's claim that 'small is beautiful' and his plea for 'doing more with less!' Yet, people will drive a Hummer to take their kids to school, go to work, or collect a pack of cigarettes from down the road. The justification of the Hummer driver: 'I know if I hit something, I'll win'. This is the new suburban survival of the fittest. Only a few decades ago, the world powers conceived the notion of mutually assured destruction, and it is gut-wrenching to contemplate just how many times mankind has come close to triggering that course of action (Schumacher, 1973).

We are not born like this. Our egotistic and materialistic society cultivates this attitude from an early age.

‘Man is gifted with reason; he is life being aware of himself; he has awareness of himself, of his fellow man, of his past, and of the possibilities of his future. This awareness of himself as a separate entity, the awareness of his own short lifespan, of the fact that without his will he is born and against his will he dies...his helplessness before the forces of nature and of society’ (Fromm, 1956).

In ‘The Art of Loving’, Erich Fromm (1956) offers many insights into the complexity of human existence. He argues that contemporary Western culture has lost the capability to learn and engage in the art of love. As a result, ‘modern man is alienated from himself, from his fellow men, and from nature’. Crucial to his thinking is that love – not the commodity of exchanging love, but the awareness of oneness with all – is the only way to build a sustainable existence.

Fromm (1956) again: ‘Beyond the element of giving, the active characteristic of love becomes evident in the fact that it always implies certain basic elements, common to all forms of love. These are care, responsibility, respect, and knowledge’. These are the cornerstones on which humanity needs to build in order to change the course of our fate.

In February 2014, a play called *1507* premiered at the Perth International Arts Festival. The author, playwright, and researcher based the title on diligent research investigating the possessions of hundreds of teenagers. The average number of items found in a teenager’s bedroom was 1507. Some were found with more than 6000, while a few were content with a lot less. I wonder where this cohort would rank on the ‘Happiness Index’, where, not surprisingly, poorer nations generally rank higher than affluent societies.

**‘Omnia mea mecum porto’** (All that’s mine I carry with me) by *Marcus Tullius Cicero*.

What would these teenagers take in case of fire or eviction? Maslow’s hierarchy of needs could help to set priorities. When Cicero originally coined this phrase, he more likely meant: I carry with me all that

I truly am. My inner worth, my place in the scheme of things, my capacity to fulfil my potential and render my contribution with the power of all I know. The modern day consumer has externalized these values and sees them as tangible objects that can be bought in an effort to achieve self-satisfaction. The designer is instrumental in this process as well as culpable in its consequences.

Nelson Mandela, on the occasion of the Fifth Steve Biko lecture in 2004, admonishes us forcefully:

*‘The values of human solidarity that once drove our quest for a humane society seem to have been replaced, or are being threatened, by crass materialism and pursuit of social goals of instant gratification. One of the challenges of our time, without being pietistic or moralistic, is to re-instil in the consciousness of our people that sense of human solidarity, of being in the world for one another and because of and through others.’*

## 4 Sustainability

*Sustainability is to sustain what sustains us!*

*Definition provided by one of my students when given the task to define the meaning of the word.*

Only a few versions ago, Microsoft invited the word ‘sustainability’ into the pantheon of its spell-check. For years, the annoying red wriggle under sustainability was indicative of a general inattentiveness to the subject. The definitions and agendas tossed around at conferences are inadvertently watered down to the smallest common denominator in order to facilitate the widest possible acceptance, so that some success may be achieved. They rarely prescribe a serious course of actions.

Change has to happen from the bottom up! Sustainability implies a volume of growth that can be maintained on the basis of our finite resources. Is growth – not the natural growth of a tree or



an infant, but industrial and economic growth – essential to what sustains life on earth? Or can life continue based on the concept of ‘enough’, the bare essentials that people need to be happy? The definition of sustainable development was carefully, albeit politically, crafted by the Brundtland Commission: ‘Meeting the needs of the present, while not compromising the ability of the future to meet its own needs’.

World Bank economist Herman Daly highlights the arguments for sustainability, whose merit he finds questionable: ‘Sustainable development is development that sustains the highest rate of economic growth without inflation’ and ‘Sustainability considers the expanding needs of a growing world population, anticipating a steady and necessary growth’. This again implies that development will need to be continuously on an upward trajectory: More and more in a finite world!

Formulations like the above are inadequate, so Daly himself proposes three specific rules of sustainability in economic terms:

- i. Harvest renewable resources only at the speed at which they are able to regenerate.
- ii. Limit waste to the assimilative capacity of local ecosystems.
- iii. Require that part of the profit be put aside for investment in a renewable substitute resource.

This last suggestion is not unlike the ‘resource tax’ in Canada and Australia. For Daly, sustainable development does not follow from more free trade between production and consumption in economic systems across global networks. For a nation to create a sustainable economy, it must step back from the global economy and empower the individual and neighbourhood communities. With all the problems Europe is facing, the German industry is doing well, because its economic backbone is built on small, often family-owned enterprises, which continuously reinvent themselves and quickly respond to changing scenarios. There are many outstanding initiatives, such as the now famous ‘clever little bag’ packaging

of Puma sport shoes or the Systainer system of the Festo toolmaking company.

Sustainability requires a smaller scale. It is far more likely to be successful at the grass roots level, as in the Agenda21 project, outside of and even in defiance of political control.

## 5 Paradise Lost

*‘...that is maybe the most important thing: It’s to shake off this erroneous notion that life is there and you’re just gonna live in it, versus embrace it, change it, improve it, make your mark upon it.’*

Steve Jobs

On 15 May 2013, 350.org informed its subscribers that earth’s atmospheric CO<sub>2</sub> concentrations had reached 400 parts per million (ppm). ‘The record 400ppm CO<sub>2</sub> milestone “feels like we’re moving into another era” and scenario’ said Ralph Keeling, the son of renowned climate scientist Charles David Keeling. Judging by the growing numbers of protest marches and grass root activities across the globe, people are increasingly aware that action to counter the adverse impacts of climate change has to be high on the agenda. People sense that this issue is becoming critical and demands a sense of urgency. No place on earth will be left untouched by catastrophes if things do not change. On 16 January 2014, Adelaide, South Australia, had the infamous honour of being named the hottest city on earth by the UN. The elderly, the poorly housed, and the fringe dwellers, along with the flora and fauna, suffered most.

The mediation of atmospheric pollution has been put into the ‘too hard basket’ or left to adaptation. Prevention has been eschewed in favour of cure, even though cure is the more costly and painful option. This wisdom is brushed over by front-page headlines in the Australian Murdoch press such as ‘Coal will dominate the global power sector for decades’. Escalating energy prices impoverish the



ordinary middle class family and chain them more and more to the corporate supply line and their dictatorial pricing regimes.

Saint Augustine, the much quoted medieval bishop, is more renowned for his wisdom, but reveals an earthly sense of humour when he prays: 'O Lord, help me to be pure, but not yet'. This prayer is a true reflection of the attitude of corporations, politicians and individuals, which might see the need to invest in sustainable technologies, renewable energy, mediating climate change, balancing the eco-systems, exercising social justice and equity, but not yet, not while there is easy money in the old, unsustainable way of doing business. Just a little bit longer...until it is too late.

Human history is rich with the contributions of great minds. We have episodes of ancient visionaries advising us what to do and what not to do. Vitruvius, in his *Ten Books on Architecture*, proves to have been a critical observer of the environmental mismanagement of his time. Vitruvius documented the consequences of lead poisoning and argued for the earthenware equivalent for waterlines, storage, and drinking vessels. Modern ice core analysis testifies to these Roman environmental transgressions. Yet, it took us more than half a century to take the lead out of our own petrol and paints. Bisphenol A is still conspicuously present in our ubiquitous water bottles, and a cocktail of toxins can be found in our built environment and the food we eat. Electromagnetic radiation (EMR) and electromagnetic fields (EMF), by-products of the conveniences of modern life, are expected to trigger their own epidemiological nightmare. How can an urban environment assure the health and wellbeing of its inhabitants if there is no place on earth where anybody can escape from pollution, waste, toxins, and disrupted eco-systems? Mercury, arsenic, lead, and many other pollutants are regulated in most countries, but many unregulated chemicals have slipped through the net of the Kyoto Protocol. One such culprit is nitrogen trifluoride.  $\text{NF}_3$  is 17,000 times more powerful a greenhouse gas than  $\text{CO}_2$ . Industrial application of  $\text{NF}_3$  is common in high-tech manufacturing for products from computer chips

and flats-screen LCDs to thin-film solar PV panels; designers are involved with all products, yet most have no idea about  $\text{NF}_3$ . To my utter dismay, the 124 solar panels I installed in good faith will need years to make up for the damage caused by their production, let alone the embedded energy. Are these issues outside of the professional domain of designers? Can we wash our hands in innocence?

In 1962, Rachel Carlson brought the global malaise to popular attention with her seminal book 'The Silent Spring', which exposed the naivety with which DDT had been accepted by the unassuming public and the ruthless marketing push by big business (Carlson, 1962). Why do I stress this point? Because we are inclined to make the same mistake over and over again. Monsanto pushed Glyphosate as the pan-ultimate, super safe herbicide, a substance which we are now learning may have unimaginable consequences for the health and safety of every living organism on earth. Equally,  $\text{NF}_3$  was initially presented as a compound to fight global warming. Michael J. Prather and Juno Hsu, two researchers from the University of California at Irvine noted that  $\text{NF}_3$  is one of the most potent greenhouse gases known to humanity and persists in the atmosphere for 550 years. According to their report (2007),  $\text{NF}_3$  is now present in the atmosphere at four times the expected amount, with atmospheric concentrations rising eleven percent a year.

The Club of Rome in 1973 makes it clear: 'If mankind continues to move on the same post World War II trajectory, we will lemming like walk over the cliff'. Hollywood has exploited the theme of sustainability in several major productions, yet the result is entertainment, something to fill a spare evening, rather than a serious shift in the public mindset or movement toward concerted action (Neurath, 1974).

## 6 Educating the Designer and the Designer as Educator

*'Human history becomes more and more a race between education and catastrophe.'*

*H.G. Wells in The Outline of History (1920)*

Environmental education was more like a nature walk. Heart-warming, feel-good curriculum activities. Education for a sustainable future now places each individual at the centre of this experience and appeals to the awareness, consciousness, and empathy that will be necessary in order to build the foundation for a healthy, dignified, civilized, and harmonious existence in the future.

Education in sustainability is increasingly incorporating the concept of behaviour into curricula, meaning that technological subjects assimilate the social and cultural merits of design: they must consider not only what people want, but also whether a product serves a cultural purpose, if it enriches people's lives, and what people will do with it. The University of South Australia, Adelaide, has a Center for Sustainability & Behavior. Yes, behaviour, conduct, and cooperation are all essential, but without awareness, they are like houses without foundations.

The populist and heavily advertised movement of 'mindfulness', as it is being commercialized by entrepreneurs in the US with a comet tail of franchises in its wake, displays a selfish, ego-centric attitude, a far cry from what Erich Fromm (1956) advocates in his book *The Art of Loving* or its original concept in Buddhist philosophy.

Any students, particularly those who shape our physical environment and create the utensils to extend our dextral and sensory limitations, should be continuously challenged and probed on their attitude regarding their moral and ethical imperative that comes with our professional duties. Not unlike the 'Hippocratic Oath' medical practitioners have to swear, the design professional should equally commit to a professional credo. This should not be a matter of lip service or tokenism, but a sincere commitment on the part of designers to assume stewardship of the earth's resources, advocate the balance and health of its ecology, and minimize the footprint they leave with their creations. The principle of 'Do no harm!' should be the basis of this commitment.

There are many ways in which designers and architects and the beneficiaries of their creative endeavours – namely, consumers – can contribute toward building a productive and viable industry as a prerequisite for a sustainable future. The recent paradigm shift from built-in obsolescence towards quality assurance and from speculative mass production to manufacturing on demand has developed in conjunction with a new philosophy based on the 4 Rs – reduce, reuse, recycle, and repair – which characterize the actions of an ecologically sensitive designer and consumer. The 4 Rs have spawned new sciences, disciplines, and technologies. Germany has developed very sophisticated recycling technologies. Meanwhile, in Adelaide, I observed several contractors collecting garbage from the same bins; one truck bore the words 'Waste Disposal' and the other 'Resource Recovery'.

There are certain characteristics to consider in the design of a product, in order to minimize the need for this process:

- A product's utility and place in society
- Its contribution to the quality of our lives
- The environmental impact on and justification for its production
- Its own life-cycle assessment

There are sophisticated software tools to assist in this task, but it is ultimately the heart and mind of the designer who chooses the input, which in turn governs the outcome. Ethics and morality, awareness, and honesty have to be foundation for such actions. At the end of the design process, there is the task of interpreting the data. Who are the judges? What is their moral make-up? What is their primary concern? Who is their paymaster?

Before the mechanical process of production unfolds, there is the fundamental question as to whether the item they are designing, the roadway they are to lay out, the bridge they are to construct, or the yet higher building somebody wants them to

design is really necessary and whether it warrants the expenditure of materials and energy, or if it just another ego-driven, grandiose dream.

Assuming that the 4 Rs are to have a stronghold in any ecologically oriented industry, with a strong reference to their ethical and philosophical dimensions, design students and their future clients must begin to incorporate them from the outset.

William McDonough (1992) proposes a succinct and spirited course of action in *The Hannover Principles: Design for Sustainability*, which he wrote as a manual for the City of Hannover, Germany, in preparation for the World Expo 2000 (McDonough, 1992). He urges that we:

1. Insist on rights of humanity and nature to co-exist
2. Recognize interdependence
3. Respect relationships between spirit and matter
4. Accept responsibility for the consequences of design
5. Create safe objects of long-term value
6. Eliminate the concept of waste
7. Rely on natural energy flows
8. Understand the limitations of design
9. Seek constant improvement by the sharing of knowledge

Having visited the Expo site in Hannover ten years after the event, I have serious doubts if reality ever measured up to his guidelines. Like so many other big, global events, the over-expenditure of materials and energy for such a singular occasion left a big void with a very visible footprint. I experienced the social dislodgements caused by the Olympic Games in Mexico City. Unlike the huge investments in Olympic facilities, or the 2014 World Cup in Brazil, where the hype of national pride steamrolled social justice and triggered street riots, Hannover still has the potential to adopt McDonough's principles, even though they were not fully executed. McDonough suggested that *'The Hannover Principles* should be seen as a living document committed to the transformation and

growth in the understanding of our interdependence with nature, so that they may adapt as our knowledge of the world evolves'. It is refreshing to see that McDonough is not shy about bringing spiritual aspects into the discussion, which he has demonstrated on other occasions as well, such as the foreword he wrote to the book *Divine Nature*. McDonough and Braungart reconfigure the expression 'from cradle to grave' in their book *Cradle to Cradle*. The concept it promotes, described as 'circular economy', is gaining traction in big business models (McDonough, 1992).

This new concept breaks with the old historical patterns of digging up resources, making something while burning energy and then disposing of it. Focusing on reducing material-intensive output and energy expenditure while increasing qualitative development should allow societies to find their footing on a sustainable ecological scale. This promises better health and wellbeing and greater personal fulfilment in the context of a healthier planet.

The circular economy not only recycles, but also remanufactures and redesigns. The French carmaker Renault has this high on their agenda. The company's new business model, which offers the chance to shift our attitude from 'having' to 'being', is based on leasing goods rather than owning them. Car sharing is in its early stages as one such leasing model, wherein one pays for access on demand, rather than buying a car outright. It is then in the interests of the fleet operators to have their cars working well and lasting as long as they can. Interestingly, the carmaker BMW is already operating such a business concept in house and Mercedes Benz's subsidiary 'car2go' has 3500 electric Smart cars for hire in German cities. A study of the true speed of an Australian car owner reinforces this argument. Considering all the stationary activities required to own a car: earning the money to buy, fuel, insure, register, clean, repair, and house the car, and factoring in the driving average of 15,000 km per annum, the true speed amounts to somewhere between that of a pedestrian and a bicycle – even less if the driver accumulates big fines. Taking a taxi,

or leasing or sharing a car makes much more sense. But how do we break out of the mindset that we have to have one?

We tend to lease computers, because they are outdated quickly, or special tools, because we need them very rarely. White goods could follow. Some people have started to discover the benefits of fully furnished apartments. To move in and on is simple and cheap and gives the sense of choice and freedom. 'Omnia mea mecum porto'.

## 7 A Path to a Sustainable Future: From Carbon to Hydrogen

*'If you want to change the world, be that change!'*

*Mahatma Gandhi*

I would vote for an enlightened world government guided by the four cardinal virtues. Many authors, philosophers, and ordinary people have dreamt of such a Utopia. If these virtues were to govern the actions of Earth's 7.2 billion people, perhaps we would not be living in our present-day dystopia.

In 1972, I attended a memorable lecture by the renowned architect and inventor Buckminster Fuller, who expressed great optimism for the future of mankind. He suggested that homosapiens, like the hydrogen atom, are designed for success. Forty years of human misdemeanours, slash and burn, wars and destruction, consumption, and waste have since passed, and rather than changing our ways, we are edging closer to the precipice. What needs to happen to initiate the necessary change?

This brings me back to the second point I raised in the introduction, regarding the paradigm shift from carbon to hydrogen in *The Mysterious Island* written 150 years ago. Jules Verne envisaged this scenario at the time when the Ruhr Valley in Germany, the British Midlands, and Pittsburgh in the US – not unlike several industrial centres in present-day China – could have been described as 'hell, with the lid blown off!' After the advent of the industrial revolution, mass production and mass consumption

created smog and acid rain, depleted the ozone layer, destroyed eco-systems, drove species vital to the ecology of the planet to extinction, and irreversibly destroyed the metabolism of the bio-sphere; all in the name of satisfying our excessive consumption of materials and energy.

Nature has no regard for political boundaries or human transgressions. The consequences of Soveso, Three Mile Island, Bohpal, Gernobyl, Exxon Valdez, the Gulf Wars, Deepwater Horizon, Fukushima, desertification, GHG, acidification of the oceans, and ozone depletion are not controlled or fenced in by ideologies or political edicts. The earth exists and functions well outside of our control. The great mistake we make is that we think we are in command and like to believe that the consequences of our actions will be rectified by the natural systems which govern the universe. James Lovelock, the author of the Gaia theory, in his critical diagnosis of the health of our planet, makes it clear 'that we are putting lipstick on a corpse' (Lovelock, 2007 & 1991). Further, Stephan Hawkins suggests that 'we lost the plot on earth and should make for an early departure to a new destination'. The question is, where to?

Despite the aggressive campaigns contrived by the 'merchants of doubt' to convince us otherwise, the magnitude of Earth's environmental and social problems is unprecedented. We can refer to successful joint actions like the banning of CFCs to mend the ozone hole over Antarctica. Ecological sustainability and social justice are not only more desirable and more humane than ecological degradation and social disintegration, they are cheaper, just as prevention is cheaper and less painful than cure.

We know how to produce goods efficiently, and meeting basic human needs with the necessary goods, even food, is a challenge we can meet. The Marxist idea that the machine should liberate the human being to engage in higher pursuits has not been realized even in Western economies, where the profit derived from automation and robotic labour is not shared equitably. Quite the contrary: the rich

get richer and the poor remain enslaved in debt and poverty.

Our biggest challenge to implementing effective solutions is shifting the prevailing mindset. Interestingly enough, though, the economic narrative is changing and this has its origin in the reinvented business models of some visionary companies who advocate a system of leasing rather than owning, of sharing rather than having.

This kind of sharing will change the economic landscape with universally accessible software to 3D print what you need on demand. Like always, new technologies are equally accessible for the saints and the sinners. 3D printing gained public attention through the one-shot gun a person can download and print. This technology is in its infancy, but has the potential to reshape society and reconfigure commerce. What will be the role of the designer if we manage to replicate the DNA instructions of a seed, such that the resulting object self-manipulates the materials over time to suit its varying purposes? Research and development on 4D printing is heavily financed by the US Army Research Office.

## 8 Conclusion

*'A nation should not be judged by how it treats its highest citizens, but its lowest ones.'*

*Nelson Mandela in A Long Walk to Freedom (Mandela, 1995)*

Aristotle, the founding father of Western Political Science, put this across another way 2300 years ago: 'One should call a city-state happy, not by looking at a part of it, but at all the citizens'. This principle has to apply to the world community in its widest sense, the ecosphere embracing all elements of life on earth – in short, Lovelock's Gaja community (Lovelock, 2007 & 1991).

This observation is nowhere more true than in the situation of environmental refugees. They have been forced into their predicament through the actions

of industrialized nations, and sometimes their own culpable governments, with their out-of-control consumption and myopic, laissez-faire attitude toward the consequences their actions have for others. The US represents less than 5% of humanity, yet consumes 30% of the earth's resources and generates 30% of the global waste. Most of what they consume is produced in China, so their own backyard has been kept clean. However, even this is changing as exuberance for high-tech fracking has gripped the energy industry of the US, adding yet another 'heinous crime against nature', as Robert F. Kennedy calls it in his scathing account *Crimes Against Nature* (Kennedy, 2005).

The proliferation of extreme weather events and the pollution of soil, air, and groundwater appears to have caught the attention of more and more US citizens, signalling the fork in the road ahead. Citizens know that they have to part ways with big government and big corporations. People worldwide feel betrayed by their political leaders and misled by big business, big oil, and the big conglomerates of faceless corporations, many of whom take immoral scientists into their fold as 'willing merchants of doubt' to advance their agendas. David Suzuki in his book *Wisdom of the Elders* (1992) points out 'that the public will always face the challenge to distinguish between an ordinary elderly scientist and a true scientific 'elder' (Knudsen and Suzuki 1992).

'Let it never be said by future generations, that indifference, cynicism or selfishness made us fail to live up to the ideals of humanism,' cautioned Nelson Mandela in his Nobel Peace Prize acceptance speech in 1993. The focus of his life was on freeing his people, but he, like many others, was equally aware that the human bond to the environment is fundamental for a happy, healthy, and dignified existence. One cannot exist without the other and a society can only be sustainable if there is a harmonious balance.

Yet there does not seem to be a prevailing sense of joint responsibility or a commitment to making



a concerted, global effort. The modern materialistic and individualistic society suffers from a great disconnect. We walk in different directions, following the Pied Piper, the merchants of doubt, into a fateful world where profit-driven, myopic corporations are dictating the agenda.

As I finished this paper, I heard an interview with Daniel Barenboim, a renowned and highly decorated Israeli musician and conductor, who, to the dismay of the Israeli government, accepted an 'Honorary Palestinian Citizenship'. He invited musicians from all over the Middle East to play together. To his surprise the response was so overwhelming, that it turned into a big orchestra. When they all played together, they were not Iraqis, Palestinians, Lebanese, Syrians, Israelis, or Egyptians, they were violinists, cellists, pianists, flautists, and all the musical components of an orchestra.

It is my ardent and sincere wish for humankind to learn to play together in this spirit – for our own sake.

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paper

3

Closing the loop: Sustainability and Well Being

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## Abstract:

It is said that the Gateway to Liberation has four gatekeepers: Enquiry, Tranquillity, Contentment, and the Company of Virtuous people. One has to get hold of at least one of these in order to be liberated. Interestingly, for a sustainable world to exist, it is essential that we lead a contented life. There are two basic types of contentment: physical contentment and mental contentment. Physical contentment requires food, clothing, and shelter. Only if we are able to meet these three requirements can we think with a free mind and reach the other gateways of liberation. Considering the basic requirements of physical contentment, we can clearly see that humans are currently consuming much more than what we require. Sustained wellbeing can only be achieved if we ‘close the loop’, so to speak, with respect to the usage and rate of usage of materials and energy. In an unsustainable, open loop, we consume and discard materials that cannot be replenished, or we consume them at a faster rate than they can be replenished. If such materials are used at all, the cycle has to be closed – the material has to be completely recycled. These concepts will be discussed in more detail in this paper and an example will be given illustrating how an unsustainable system might be made sustainable. The paper concludes with a word on achieving mental contentment out of physical contentment.

**Keywords:** closing the loop, sustainability, wellbeing, liberation

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## 1 Introduction

A sustainable life would mean that we are able to give our children the same quality of life that we enjoy, and that they in turn would be able to do the same. However, It is widely known that humans are not leading sustainable lives. It is often quoted by many that ‘we have not inherited this planet, but have borrowed it from our children’. A closer look at this statement in terms of the usage of materials tells us that this is not how we are living. The planet we leave for our children may be nothing but a wasteland.

A search on Scencedirect.com using the keywords ‘sustainability’ and ‘wellbeing’ throws up several hundred papers. This introduction only refers

to a few of them. For the keyword search using ‘sustainability’, the *Journal of Cleaner Production* is referred to, as this journal had the largest number of papers using sustainability as a keyword. The title of this journal also seems apt. It is possible that I have missed some very interesting papers on ‘sustainability’ and must say that this was not intentional. For the other keyword, ‘wellbeing’, many interesting papers were found as well, and I have incorporated some of them into the introduction. If a few important papers have been missed, again, this was not intentional.

What is sustainability? The answer to this could be very simple: does it refer to the quality of something that can go on forever, or at least as long as the sun keeps terrestrial temperatures within the range

that makes life as we know it possible? There are many publications on sustainability and wellbeing. John Ehrenfeld (1997) describes 'industrial ecology' as a 'new system for describing and designing sustainable economies. Arising out of an ecological metaphor, it offers guidelines to designers of products and the institutional structures in which production and consumption occur, as well as frameworks for the analysis of complex material and energy flows across economies'. His paper ends with a short discussion on 'the differences between industrial ecology, cleaner production, and pollution prevention'. The first two [industrial ecology and cleaner production] are generally taken to extend beyond the traditional regulatory bounds of single-media, end-of-pipe systems of environmental management. With respect to pollution, systems 'should produce zero emissions from every process. If it were practically possible to do this on a broad scale, pollution prevention might be a satisfactory framework, but, given practical limits, the broader loop-closing aspect of industrial ecology would seem to lead to more efficient use of resources within the larger system'. Oldenburg and Geiser's (1997) article 'Pollution prevention and... or industrial ecology?' discusses the differences and similarities between pollution prevention and industrial ecology, concluding that 'pollution prevention programs that serve to "correct" and tailor production systems could be seen as a powerful tool in an industrial ecologist's instrument bag and industrial ecology could become a source of vision for the detailed operations of pollution prevention programs at the firm level'. A paper by Nes and Cramer (2006) discusses 'Product lifetime optimization: a challenging strategy towards more sustainable consumption patterns', considering concepts such as lifetime extension and the 'ecological payback period'. The article concludes with these two interesting statements: 'Design for longevity requires conscious thought during product development in regard to what will happen during the life of the product. The challenge in design for longevity lies in achieving an enduring satisfaction with the product rather than only meeting the

momentary desires of today'. There are several other papers on how to make life sustainable. Despite all the relevant literature, one can see that steps toward sustainability are simply not being taken, particularly in countries with high GDP growth. It is these high-growth countries that provide the world with manufactured products, thus controlling the level of sustainability of product development and output. One can see that implementation is one of the biggest impediments in making life on Earth sustainable.

On wellbeing and contentment, too, there are several papers, including some interesting articles by Poage, Ketzenberger and Olson (2004) linking spirituality and contentment. 'Employee contentment in an organization' by Rahmana, et al., (2012) relates contentment to pay, promotion, supervision, benefit, contingent reward, operating conditions, co-workers, nature of work, and communication. In their projection, job contentment will lead to better loyalty, confidence, and work quality. 'The influence of holiday-taking on affect and contentment' by Kroesen and Handy (2014) concludes that 'holiday trips...are unable to enduringly raise happiness'. A paper by Pennock and Ura (2011) on 'Gross National Happiness as a framework for health impact assessment' proposes the Gross National Happiness framework as an inclusive conceptualization of wellbeing that 'incorporates current determinants-based models of health impact assessment within a broader framework which better supports intersectoral collaboration and whole-of government approaches to public policy than current models of health impact assessment'. Dolan and Metcalfe (2012) relate innovation to subjective wellbeing, showing the connexion between creativity and wellbeing. Riordan's 'Sustainability for wellbeing' by O'Riordan (2013) discusses the link between wellbeing and mental sustainability.

Though one could delve into the issues of 'sustainability and wellbeing' in much greater detail, it is important to realise that material sustainability is a prerequisite for mental sustainability. In this paper,

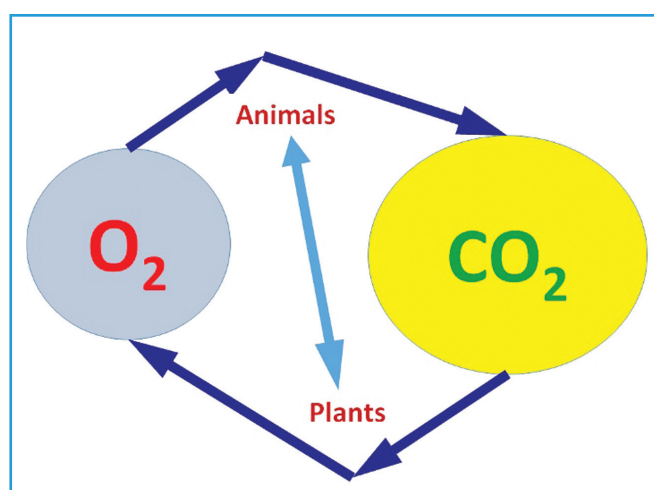
therefore, I discuss wellbeing with respect to material sustainability and 'closing the loop'. In the end, I address what brings about 'mental sustainability'.

## 2 Primary Goal

The primary goal of every human on Earth, and possibly all living beings, is to live a contented life. Only if one is contented can one achieve liberation. 'Liberation' means unconventional, open-minded, free thinking, modern, and enlightened, among other things. In the book 'Essence of Vogavaashishta' (Bharati and Samvid, 2013), written at least several centuries Before Christ, in the section titled 'Guardians of the Entrance to Liberation', the first 'sloka' or verse reads:

In the gateway to liberation, it is declared, there are four doorkeepers. They are tranquillity, enquiry, contentment and the fourth, association with virtuous people.

The interesting thing to note is that contentment is one of the four doorkeepers and contentment is the key to achieving sustainability. Thus the question of how to make life sustainable becomes the key to becoming liberated.



**Figure 1** Everything in this world is cyclical and interlinked

Can a society become completely sustainable and completely contented?

## 3 Closing the Loop

In this world, everything is cyclical, and all cycles are interlinked<sup>1</sup>. In other words, we are not, and can never be, independent entities in this universe. This is possibly the 'eternal truth' humans are always seeking. We are intrinsically a part of this universe, and always have been, even before our birth and long after we die. The universe is essentially composed of matter and energy. Matter and energy co-exist such that one cannot survive without the other. Figure 1 shows the basic cycle that sustains life on Earth.

From this simple but critical cycle of oxygen and carbon dioxide conversion, in which plants and animals (including humans) are interlinked, several other such cycles derive, connecting humans to their environment. The cycles that link us to the external world are supported by multitude of other cycles that go on both inside and outside the body. The universe is made up of cycles that can be as short as a femtosecond, as in the changing of pigment in the eye, or as long as several billion years, such as the cycle lasting from the big bang to the final 'big collapse', a theory in which the presently expanding universe will begin to collapse, possibly leading to a new big bang. This cycle is estimated to last around  $10^{18}$  seconds – over thirty billion years. Roughly,  $10^{14}$  seconds have gone by since the big bang.

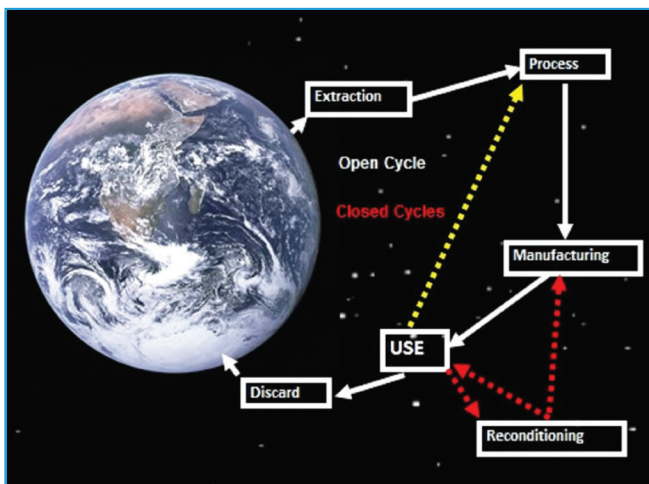
## 4 Contentment

Contentment means satisfaction, happiness, pleasure, gratification. We are content when we are successful and happy. We are content when we are able to lead a 'comfortable life'. There are two kinds of comfort: physical comfort and mental comfort. Physical and mental comfort is what leads to physical and mental contentment.

<sup>1</sup> This and the other two points have been addressed in the book written by the author 'Liberation Through Education' by Kailas, (2014) , on which this paper was essentially based.

## 5 Physical Contentment

For physical contentment, we need three things: food, clothing, and shelter. Of course, many other things can provide physical comfort, but without these three basic comforts, the other comforts never enter into the picture. For achieving physical comfort, we need to consume materials. Yet if we look at these basic requirements, it is clear that we are using far more materials than we actually need to. We eat more than we need, we buy and wear more clothes than we need, and we build houses of gigantic, unreasonable proportions. All of this waste could be avoided if we were to accept it as unnecessary. It is vital to control our use of resources because we are consuming materials at a much faster rate than nature can replenish them, and many of the materials that we use cannot be replenished at all. Cycles in the usage of materials are shown in Figure 2.



**Figure 2** The concept of 'open' and 'closed' cycles.

When does material usage become a problem and when does it not? We extract materials from the Earth, process them, manufacture systems, use the materials, and discard them. Sometimes we reprocess them after use and follow the cycle shown by the longer dashed arrow, or sometimes we recondition them and use them again, as shown by the shorter dashed arrows. The cycle that ends up with the part in use being discarded is what is generally referred to as an 'open cycle' and the cycles depicted by the dashed arrows are 'closed cycles'. The question is, when do we adopt an open

cycle or a closed cycle? It is here that the time scale of material usage becomes important. If a cycle is open, it is essential that the extraction–disposal time should equal the time taken to replenish the materials being extracted. All other cycles have to be closed. This means that if the material being extracted cannot be replenished, it has to be recycled at a rate of 100%. Otherwise, the cycle is not sustainable. For example, if we mine iron or aluminium and use it, all of the iron or aluminium has to be recycled for the cycle to be closed. Of course, this recycling needs to account not only for the metal itself but also the oxides of iron and aluminium that are collected, refined, and extracted. If 100% recycling does not happen, the earth will run out of iron and aluminium and, eventually, all other non-renewable materials. We will also run out of the energy that is used to produce these materials, as most of the energy being generated today is from increasingly depleted resources. At the rate at which we are currently using non-renewable materials, we will run out of them within the next 100 years. 'Non-renewable' resources such as oil and gas will also run out simply because we are using them faster than nature can produce them. These non-renewable resources were produced by nature over a period of a few million years but are being used by the 'educated' and 'industrious' human in a matter of mere centuries. If crude or natural gas were to be used at the rate at which it is produced by nature, it would be considered a renewable resource. This outlook for material and energy usage certainly makes most of the products being used today – including the very laptop used to type this article and the laptop or paper you are using to read this book – unsustainable. The concept of an 'open cycle' or 'closed cycle' is dependent on the time scale. The question to be asked is what time scale should we aim for to become sustainable. The answer is simple: as far as we can see. Imagine such an approach to living. It calls for a complete change in the present-day lifestyle and in the process of design and development.

Most of the products and processes we use to make them are simply not sustainable. One of the



arguments is that people are sensible enough to come up with solutions to problems when they are confronted by them. But, at what cost? The cost is perhaps too terrible to imagine. Consider the hazardous way in which non-renewable materials are discarded. Mercury, lead, chromium, cadmium, nickel, gallium, indium, tungsten, and many other materials, including rare earth elements, are used in tiny quantities in some of our advanced devices and discarded without being reprocessed. The effects of mercury, lead, chromium, and many other elements on human health are well documented. One can expect other elements to have similar, yet-unknown effects.

Unless we change our lifestyle and begin using materials and energy in a completely closed cycle, life on Earth will not become sustainable. Energy, transportation, communication, and food production must be made sustainable; currently, none of them even comes close. Sustainable energy production clearly rules out fossil fuels, nuclear fission, and the still-to-be-used nuclear fusion. Might this also be the case with solar energy and wind energy, the so-called renewable energy resources? Perhaps, because the production of solar and wind energy requires materials that cannot be replenished, and these materials are not being recycled 100%. Further, no one has really questioned the impact solar and wind energy might have on global weather patterns. Beyond a certain limit of extraction, use of these energy sources might lead to irreparable damage, just as fossil fuels have done, despite the fact that they were touted as an inexhaustible source of energy at the start of the industrial revolution. The removal of solar energy beyond an unknown limit, which should have heated up the earth dictating the wind and weather pattern, and the removal of wind energy, which could alter wind patterns and thereby weather patterns, have the potential to be disastrous.

Light production is an example of how a completely sustainable activity became unsustainable. One of the earliest forms of lighting was the oil lamp, which used vegetable oils or animal fats and a

cotton wick. The lamps themselves were made from clay or other non-flammable materials and burnt using wood. The rate at which the clay and wood were extracted did not exceed nature's ability to replenish them. This source of lighting offered very low power and efficiency, but it was sustainable. Even if mineral oil had been used, the rate of usage was so low that it could have been a sustainable arrangement. These low-efficiency devices were replaced with the much more powerful and efficient incandescent lamps, which were subsequently replaced with the fluorescent lamps and then with the highly efficient and powerful Light Emitting Diodes (LED). The incandescent lamps required much higher energy to be manufactured and materials to be used such as copper, tungsten, and glass, none of which were recycled. Fluorescent lamps followed, which required much more energy to manufacture and used mercury, which is essentially a poison. In many countries these fluorescent lamps were discarded without proper care and the resulting pollution is hazardous to humans and the environment. These fluorescent lamps are now being replaced by LEDs, which require much less power in the manufacturing process and are efficient to use. However, they use many rare earth elements which are not being recycled. Furthermore, there are no serious studies on the effect of these rare earths entering the ecosystem when the LEDs are discarded carelessly. What one needs to create is a system of lighting that uses very little energy to manufacture and operate, and can be completely recycled. Unless someone comes up with a system similar to the low-power, low-efficiency, completely sustainable, oil wick lamp, no lighting system is sustainable.

Needless to say, the present way products are developed, used, and discarded is completely unsustainable. It is also important to note that making a certain product more sustainable does not make sense as long as the whole system is still unsustainable. Having more efficient transportation vehicles is a good example of this: the use of cars is still ultimately unsustainable, so the net result has a limited impact. Sustainability, one might add,



is binary: a system is either sustainable or it is unsustainable. Talking of methodologies to make an unsustainable system more sustainable system is not the right way to go about it. Product design must create products that are essentially sustainable and if one moves away from this sustainability, the product should not be introduced into the market. At present, it is crucial to reduce materials to their minimum usage.

## 6 Mental Contentment

What is it that gives mental contentment? This is a difficult question to answer. However, looking at the life of Mohandas Karamchand Gandhi, who was called Mahatma Gandhi, one can learn that truth and humility are more powerful than empires. If one leads a truthful and humble life, one attains mental contentment.

Only with physical contentment and mental contentment can we achieve contentment, which is one of the doorkeepers of liberation [Essence of Vogavaashishta (Bharati and Samvid, 2013)]. To be liberated, in the true sense, should be the primary goal in life. Here one should not confuse 'freedom to do what one pleases' with 'liberation'. One can conclude that *science without sustainability and sustainability without science are both meaningless.*

## Conclusions

1. Science without sustainability and sustainability without science are both meaningless.
2. Close the loop. This should be the cornerstone of development.
3. Sustainability is binary. A system is either sustainable or unsustainable.
4. Contentment has two components: physical and mental. For physical contentment, sustainable product usage is essential. For mental contentment, truth and humility are essential.

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paper

4

## The Role of Sustainability in Aesthetic Order

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## Abstract:

This study explores the role of sustainability in making a product more beautiful. A product's aesthetic appeal is not confined to its physical aspects alone. Emotional aspects and mental aspects are also involved in the aesthetic order of a product's design. According to Desmet and Hekkert (2007), product experience involves aesthetic experience (physical), emotional experience, and the experience of meaning (mental). Among these, the experience of meaning takes account of sustainability in product design. In the framework of aesthetic order in products, a sense of appropriateness is responsible for the experience of meaning in product design. Therefore, it is possible to say that sustainability is partly responsible for enhancing the overall aesthetic order in product design. A more sustainable product is perceived by users to be more beautiful, when all other conditions or attributes remain the same. In order to validate this claim, this study examined products that are vastly different in terms of sustainability but similar in all other aspects. Conclusive results about the impact of sustainability on the aesthetic appreciation of these products are discussed in the paper.

**Keywords:** *aesthetic order, product experience, mental aspects, meaningfulness, sustainability*

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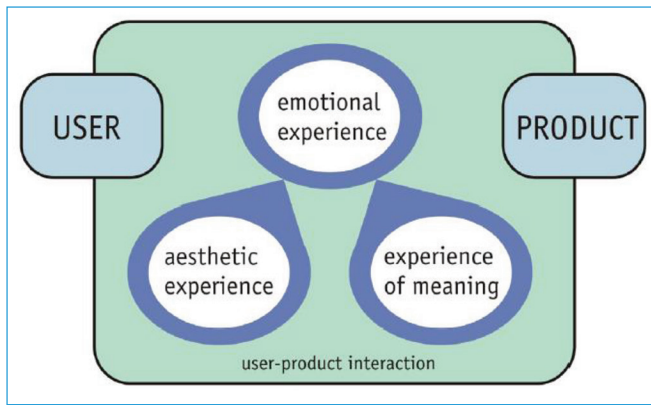
## 1 Introduction and Overview

The aesthetics of a product is not confined to its physical aspects alone. Emotional aspects and mental aspects are also involved in the aesthetic order of a product's design. Sustainability is one of the mental aspects involved in the aesthetic appreciation of a product. This paper examines where sustainability is situated in the overall structure of aesthetic order, and what role it plays in the aesthetic appreciation of a product. Arguments about the role of sustainability in the aesthetic order are validated through the results of a comparative study of products with different levels of sustainability.

## 2 Product Experience

Desmet and Hekkert (2007) have identified different aspects of product experience, which they explained

through the framework of product experience presented in Figure 1. According to their description, product experience encompasses three parts: aesthetic experience, emotional experience, and the experience of meaning. Aesthetic experience relates to the physical aspects of a product, as it involves all the physical senses, including vision, hearing, smell, taste, and touch. Emotional experience is based on different emotions elicited while using a product, such as happiness, sadness, anger, or surprise. This part of the experience happens instantly and subconsciously. The experience of meaning, however, is related to the mental aspects involved in encountering or using a product. This experience occurs only after engaging in some amount of conscious thinking. Any perceived meaning of the product is based on the knowledge, awareness, personal likes and dislikes, and the culture that the user/viewer is part of. All sustainability-related



**Figure 1** Framework of product experience

**Source:** Desmet and Hekkert, 2007

aspects of a product's design affect the experience of meaning, within the overall product experience. This is because the user will have to exercise some conscious thinking about the product's sustainability. Whether the material(s) used to make a product are recyclable, whether the energy it uses is renewable, and whether the methods employed in its manufacturing process are efficient and less toxic to the environment are all aspects concerned with the sustainability of a product's design. These aspects must all be considered when someone forms an opinion/perception about the sustainability of the product. Hence, there are physical, emotional, and mental aspects of product experience, and sustainability constitutes part of the mental aspect of product experience.

### 3 Product Entity

If there are physical, emotional, and mental aspects involved in product experience, these aspects must be first present in some form as a product entity. Only then may someone experience them later. Therefore, a product entity is something in which all the physical, emotional, and mental aspects of a product's design are embodied and present. During the course of product experience, the user/viewer perceives these physical, emotional, and mental aspects, but in his/her own personal way. It may be easier to understand that product entity and product experience are two aspects of product design, like two sides of the same coin. This may be further explained with an analogy. If a biscuit is examined as a product, the constituents of the

biscuit – namely, the flour, sugar, nuts, etc. which are nothing but chemical compounds like proteins, carbohydrates, fats, vitamins, and minerals – make up the product entity. Different tastes like sweet and salty do not exist within the product entity. They are part of the product experience. They are realized only when someone takes the biscuit into his/her mouth and experiences the different tastes. Much in the same manner, the physical, emotional, and mental aspects of a product's design are embodied in a product entity. As noted above, sustainability is a mental aspect. Therefore, we could say that sustainability is embodied in some form in the product entity.

### 4 Aesthetic Order

Although the term 'aesthetic order' has been used only since the 1980s, its synonyms such as beauty, truth, goodness, order, and visual order have long been used.

Beauty, truth, and goodness are subjects that have been studied by philosophers, aestheticians, poets, and thinkers for centuries. Plato (400BC) discussed beauty in his works on Theory of Forms and Composition in Art. Aristotle (330BC) explored the complex nature of the physical, emotional, and mental aspects that contribute to beauty in his works *Metaphysica* and *Poetics*.

Baumgarten introduced the term 'aesthetics' in 1735 (Hammermeister, 2002), in his graduate dissertation, which he defined as 'a science of how things are to be known by means of the senses'. Four years later, in his work *Metaphysica* during 1739 (Hammermeister, 2002), Baumgarten expanded this definition to include the 'logic of the lower cognitive faculty, the philosophy of the graces and the muses, lower gnoseology, the art of thinking beautifully, the art of the analog of reason'. A decade later, in his monumental *Aesthetica* during 1750 (Hammermeister, 2002), he refined the definition further: 'Aesthetics (the theory of the liberal arts, lower gnoseology, the art of thinking beautifully, the art of the analog of reason) is the science of sensitive cognition'.

Kant made great contributions to the aesthetic appreciation of arts through his works *Critique of Pure Reason* (1781) and *Critique of Judgment* (1790). He explained how sensory input, intuition, and intellectual aspects combined to create artistic imagination and aesthetic response. William Hogarth's book, *Analysis of Beauty* (1810), offered simpler guidelines on beauty to painters, artisans, and performing artists. In his book, a chapter on 'Fitness' addresses the role of appropriateness in aesthetic appreciation. In *Grammar of Ornament* (1856), Jones similarly prescribed 37 propositions for art students. His fourth proposition reads as follows: 'True beauty results from that which the mind feels when the eye, the intellect, and the affections are satisfied from the absence of any want'. This is both a clear indication of his approach, which encompasses the physical, mental, and emotional aspects of design, and a reflection of his holistic view on the subject. Santayana (1896), in *The Sense of Beauty*, offers the following definition: 'beauty is a pleasure regarded as the quality of a thing'. He further elaborates that the pleasure is a *value* that we perceive out of the *quality* of a thing. From this statement, it is evident that beauty exists in perception as a value, and in things as a quality. Around the start of the twentieth century, many textbooks on art education were published in the US. All of them prescribed easy steps to follow in the creation of art, especially drawings and paintings. Dow (1899) authored a book titled *Composition*, which listed line, notan (value), and colour as the basic elements of design, and opposition, transition, subordination, repetition, and symmetry as the basic principles of design. Dow suggested that harmony is the highest attainable quality resulting from art creation. Ross (1907), in *A Theory of Pure Design*, suggested that the elements of design are line, outline, tone, and colour, and that the principles of design are proportion, balance, and rhythm. According to Ross (1907), when the elements of design are arranged as per the guiding principles, a composition has order. In 1908, Prang and Co published a textbook, *Art Education*, which prescribed outline, value, and colour as the elements of design, and proportion, balance, and rhythm as the governing principles of design.

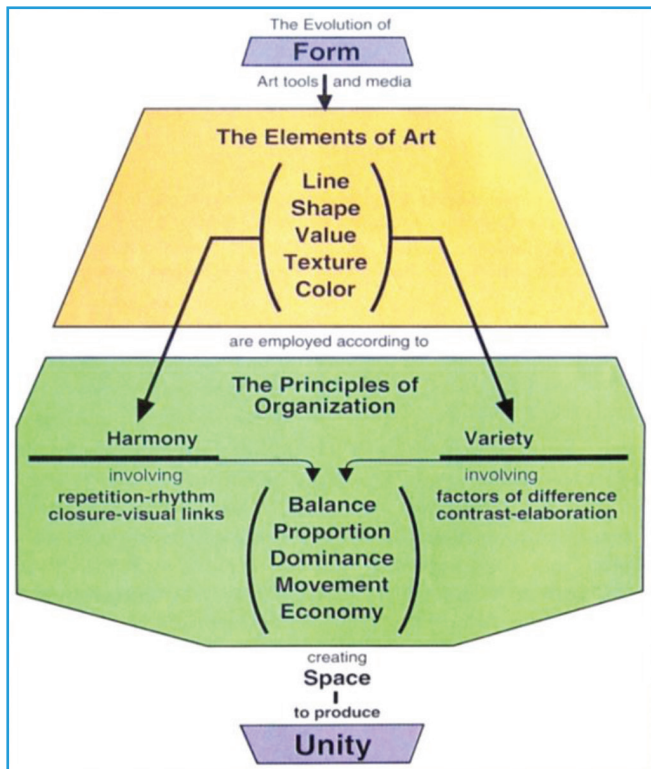
Harmony was seen as the highest possible quality in the composition. This design method, also known as the elements and principles approach, has been followed by designers, in America, Europe, and the rest of the world (Young, 1985).

In product design, when design elements are arranged in a particular order, they should be aesthetically pleasing to the users/viewers of the design. Since time immemorial, artists and designers have been attempting to please the senses of users/viewers through the composition of design elements, in accordance with the established design principles. According to Ocvirk (Ocvirk, Stinson, Wigg, Bone, & Cayton, 2002), unity is the highest aesthetic order that is attainable in the creation of art, crafts, or design (see Figure 2).

It may be noted that the entire framework covers only the physical aspects of product design. Hence, the other dimensions of product experience – emotional experience and the experience of meaning – are not accounted for in this framework. The aesthetic experience, as described by Desmet and Hekkert (2007), is all about what one may perceive through any of the sensory modalities. In other words, aesthetic experience of products is all about the physical aspects only. Thus, the emotional experience and experience of meaning will have to be accounted for in the framework of aesthetic order.

Papanek (1984) authored a book titled *Design for the Real World*. In the last three decades, this book has remained the most widely read book on design. It has already been translated into more than 20 languages. This book is mostly concerned with the *fitness* aspects of design, like cultural values, sustainability, ecology, and social change. Papanek argued that some furniture, such as a dining table with legs, constructed of stainless steel and a marble top, evoke the response to lie down and wait for the doctor to come and extract one's appendix. Nothing about the table says, 'dine off me'. This connotation or communication between the product and the user is related to the mental aspect of the aesthetic order.





**Figure 2** Framework of unity  
 Source: Ocvirk et al., 2002

#### 4.1 Appeal and meaningfulness

Emotional experience and the experience of meaning are both psychological in nature. One concerns the emotional aspect and the other relates to the mental aspect. While the emotional aspect is a sub-conscious experience, the mental aspect is a conscious experience. Together, both form the psychological experience of a product. As noted above, unity is the highest attainable quality in the physical aspect of the aesthetic order.

Ross (1907), Prang (1908), and Malcolm (1972) called the highest attainable visual *quality as harmony*. Later, Lauer (1979), Young (1985), and Bevin (1994) propounded *unity* as the highest attainable visual quality and explained how *harmony*, along with *variety*, resulted in *unity* in an artwork or design. However, it is important to note that with all these different terminologies, what are being referred to are all about the physical aspects of the aesthetic quality of a product. Appeal and meaningfulness are the psychological aspects of the product experience. These aspects compliment the physiological aspects of product experience, namely unity (attractiveness). While appeal is responsible for why we love or hate a

product, meaningfulness is responsible for the purpose for which the product has been created. Both appeal and meaningfulness, together, account for what is known as appropriateness in a product design.

#### 4.2 Sustainability is meaningful

Many factors are responsible for making a product meaningful. Sustainability is one of them. It is not a coincidence, but something that is deliberately built into a product during its design, through features that give it a meaning. When a product is made in a form that is relevant to the user, it is meaningful. For example, a dustbin for a children's room, when shaped like a kangaroo, becomes very meaningful. When a product is made in a colour that is relevant to the user, it is meaningful. For example, a light green handbag looks cool on a young woman, but is generally less suited to a male army officer. When a product is made with a simple and efficient mechanism for operation, it is meaningful. When a product is made from more eco-friendly material than products used before, it is meaningful. When a product is made with a technology that leaves fewer toxins than before, it is meaningful. When a product is made with renewable energy, it is meaningful. In short, a product that is more efficient, eco-friendly, leaves a smaller carbon foot print, and is made with renewable sources of energy is more sustainable. Thus, sustainability is meaningful, and it may be said that the role of sustainability in aesthetic order is to construct meaningfulness.

### 5 Validation

In order to validate this claim that the role of sustainability in aesthetic order is to construct meaningfulness, following procedure was used:

1. Selection of products: A set of products with known sustainability values were chosen.
2. Survey on meaningfulness: A survey on meaningfulness was conducted for the same set of products.
3. Results of the survey: Responses to the survey were analysed and the materials



were tabulated according to the rankings of meaningfulness.

4. Analysis of correlations: Rankings of meaningfulness of all the materials were checked against the sustainability values for correlations.

The following sections describe in detail the validation.

**Table 1** List of materials with SimaPro Single Score point values

Material	Amount	Single Score
Stainless steel	1kg	1.12
ABS plastic	1kg	0.303
Melamine	1kg	0.217
Silicone product	1kg	0.211
Glass	1kg	0.105
Natural rubber	1kg	0.0604
Wood	1kg	0.00231
Cork	1kg	0.00625
Polycarbonate	1kg	0.456
Straw	1kg	0.002*

**Source:** SimaPro 7, a type of LCA Software

*\*This is an assumed value as the Single Score point value for Straw is not available*

### 5.1 Selection of products

After much consideration, a simple product of common usage – a tea coaster – was selected. Ten different coasters bearing a simple round form were chosen from the market.

Efforts were made to select coasters made from materials bearing different carbon footprints. The different materials used in the coasters are silicone, rubber, glass, ABS plastic, wood, stainless steel, melamine, cork, polycarbonate, and straw. SimaPro, a type of Life-Cycle Assessment (LCA) software, was used to study the environmental impacts of the selected materials. The Single Score point values of the selected materials (for the amount of 1 kg each) identified using SimaPro 7 are given in Table 1.

### 5.2 Survey on meaningfulness

A survey was conducted using Google Drive. Photographs of all 10 different coasters were placed

in a survey form on Google Drive. The material each coaster was made of was mentioned along with each photograph. All participants were asked to rank the coasters according to meaningfulness/purposefulness. At the end of the survey, all were asked to give their remarks, at least concerning the first-ranked and last-ranked coasters. A link to the survey form was emailed to volunteers, with a request to spend a few minutes completing the survey. Demographic information (such as gender, age, nationality, religion, and educational level of the participants) was also collected. The survey form was accessible for two days, and then the results were collated and analysed.

In total, there were 48 participants in the survey, with the following demographic details: 30 male and 18 female; mean age = 41.2 years, with a standard deviation = 16.67 (youngest 22 years old and oldest 74 years old); 33 Indians and 15 other nationalities; 32 Hindus, 10 Christians, 3 Muslims, and 3 Buddhists; all participants had an education level of graduate and above.

### 5.3 Results of survey on meaningfulness

Ranking details of the survey on meaningfulness are given in Table 2. The percentage of participants who ranked each material in a particular rank is also given in the table.

**Table 2** Ranking details of the survey on meaningfulness

Rank	Material	Respondents
1	Straw	45%
2	Wood	40%
3	Cork	33%
4	Rubber	36%
5	Silicone	25%
6	Glass	26%
7	ABS plastic	24%
8	Melamine	33%
9	Polycarbonate	31%
10	Stainless steel	36%

**Source:** Survey results obtained through Google Drive

### 5.4 Analysis of correlations

As presented in Table 1, wood has the lowest Single

Score point value, and cork has the next best value. It may be noted that there is no Single Score point value available for straw in SimaPro software. The reason for this lack of information could be that straw is not yet recognized as a material for industrial manufacturing, and hence is not listed. However, for this analysis, straw can be taken as the material with lowest Single Score point value, as it is natural and more sustainable material than wood or cork. Thus, for the purpose of this analysis, a Single Score point value of 0.002 has been assumed for straw.

Table 2 reveals that coasters made of straw, wood, cork, and rubber are the top four highest-ranked coasters according to meaningfulness. These four coaster types match very closely with the rankings of the Single Score point values for the same materials. Polycarbonate and stainless steel were the two lowest-ranked materials in the Single Score point values, as well as in the meaningfulness of these materials for coasters. These rankings again correlate very well.

However, slightly less correlations were present among the materials in the middle rankings. Glass and silicone are the fifth- and sixth-ranked materials according to the Single Score point values, whereas in the meaningfulness ranking, they are sixth and fifth, respectively. Similar interchangeability of the rankings was present in the seventh- and eighth-ranked materials, ABS plastic and melamine.

## 6 Discussion

The participants of the survey used adjectives like natural, eco-friendly, attractive, good texture, valuable, sustainable, environment-friendly, durable, soft, and classy to describe their first-ranked coaster material. These descriptive terms alternate between those that describe the visual appeal of the product and those that describe its perceived sustainability. The same participants used adjectives like cheap-looking, bad, hard, heavy, and eco-unfriendly for their last-ranked coaster material.

Straw, wood, and cork were the coaster materials that received the top three rankings. Melamine,

polycarbonate, and stainless steel were ranked in the last three positions. There is a clear indication of preference for natural materials among the participants. Although the individual responses from the participants remained anonymous, their collective demographic details are known from the survey. All the participants were graduates and above in education level, and their mean age of 41.2 years indicates that they were mature and somewhat knowledgeable on issues of materials, sustainability, and product design. Other demographic details like gender, nationality, and religion do not indicate equal distribution, but it was not a lopsided representation, either. Thus, the results of the survey can be assumed an indicator of what people generally feel or perceive.

As noted in Section 4.2, sustainability is not a coincidence, but it is deliberately built into product design to construct meaningfulness through product features. For example, in the case of the coasters, using a material that is more sustainable is one of the product features. Provision of lugs in a coaster, made of glass, will improve its handling and usage. This product feature indirectly increases the expected life cycle of the product and thereby adds to its sustainability score.

As noted in Section 2, all sustainability-related aspects of a product's design are parts of the experience of meaning within the overall product experience. However, some product features that are deliberately incorporated through some sustainability-related aspects may not necessarily be perceived by the user of the product. Here it depends on chance and on the user's individual sensibilities more so than his/her demographic profile. By means of deliberately increasing the sustainability aspects in the product entity, the designer increases the chances of its perception in the product experience.

## 7 Conclusion

This study has shown that natural materials like wood, cork, straw, and glass have higher

meaningfulness for users of coasters. Stainless steel and synthetic materials like silicone, melamine, ABS plastic, and polycarbonate are less meaningful as coaster materials. This trend correlates well with the sustainability values (Single Score point) of these materials. Most respondents preferred to receive wooden or straw coasters as a gift. This indicates that when most conditions (cost, availability, size, shape, etc.) remain the same, people valued natural materials much higher.

In nature, most creations are beautiful, and sustainability is always built-in. The study presented in this paper shows that in human-made objects, sustainability must be consciously built-in so that they are meaningful and thereby beautiful.

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paper

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A Card Game based on the Participatory Learning and  
Action (PLA) Approach for Health Education

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# A Card Game based on the Participatory Learning and Action (PLA) Approach for Health Education



## Abstract:

Education on aspects of health, hygiene, and sanitation has been a primary concern in many developing countries. A study on the present mode of delivering healthcare education in school curriculums shows that it is, for the most part, sterile and impersonal. There is an urgent need to improve the overall quality of health, hygiene, and sanitation at an early stage through our primary education system. These topics are understood even more poorly in rural schools. Inputs at an early stage of learning on the subject of primary health and hygiene can significantly contribute to a child's understanding of its overall impact on the well-being of the community. This paper outlines the participatory learning and action (PLA) methodology followed in using a series of games that are culturally appropriate in a rural setting to help schoolchildren gain awareness about aspects of nutrition, common diseases and their symptoms, and causes and prevention. It presents the outcomes of a series of experiments conducted with schoolchildren in a village school in Guwahati, India and summarizes the results. The paper further outlines the way forward in the development of the design of more health-related educational activities through designing experiments for the classroom.

**Keywords:** *health education, participatory learning approach, game design, rural schools*

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## 1 Introduction

There are some disturbing facts regarding the current education system in India. In the 2011 annual survey conducted by the Pratham Education Foundation, which covered 550 rural districts in India, it was found that although the enrolment of children in school has jumped from 93% to 97%, the quality of education actually declined (Sharma, 2014). The survey found that a higher percentage of students in class V today are unable to read a textbook assigned to Standard II. Similarly, more students in Class VIII were unable to do simple division. The '11<sup>th</sup> Education for All Global Monitoring Report' published by UNESCO has also found that one third of all primary age school children do not learn the basics even if they go to school. This is

seen to have negative repercussions resulting in an increase in the school dropout rate of children. The reasons for higher dropout rates are attributed to factors such as the poor quality of education, teachers' absenteeism from school, and economic factors. There is a greater impact on female children than male children, which points to a gender bias in the community.

With the aim of understanding some of these issues and identifying a suitable design for a school education project, the statistical data on the Kamrup (Rural) district of Assam (Census report-2012) regarding the status of education was examined. It revealed the following facts: there are a total of 574 upper primary schools and 130 upper primary schools with high schools across the district in



which there are a total of 86,603 students, 43,868 of which are girls. There are 3,445 teachers employed amongst these schools; 1,632 are employed by government-run schools and the remaining 1,813 are teaching at government-recognised schools. The boy to girl ratio is a healthy 1:1. Considering these facts, it is evident that any significant interventions in reformulating content and creative modes of delivery can have a significant impact on the quality of education amongst the rural schools.

This is further corroborated through studies (Tooley, 2009) on communities of the poorest of the poor in different parts of the world and how they are educating themselves. The author examined the role private schools play in contributing to the education of the poor and came to the conclusion that the aspirations of the poorest of the poor for quality education are high since it is the belief amongst this class that education is the only means for their children to attain a good job and a career, which will allow them to create a future for themselves. In his research on school education in India, Tooley presents an interesting argument; drawing from statistical facts, he finds that during the pre-colonial days of the British Raj in India, the numbers of students who were undergoing education was much higher. He questions the school education model the British introduced, which emphasised making school the centre for learning in comparison to the pre-colonial model where the emphasis was more on education that was independent of a school building and conducted in a more informal setting such as community open spaces and temple premises that were convenient for the community. He opines that the British model resulted in shifting the focus to the investment in infrastructure and the management of running schools rather than on educating the child. To date, this model continues to be followed and he believes it could be the source of problems affecting school education.

## 2 Identification and selection of the problem space

Different subjects were examined and analysed, beginning with the syllabus and curriculum outlined

by the National Council of Educational Research and Training (NCERT, 2009). The revisions to the school syllabus, based on the NCERT guidelines, emphasises training through activity-based learning.

An ethnographic study collected first-hand information from four to five government-run, rural schools located in the Bazera block of the Kamrup (Rural) district of Assam to understand the ground reality prevalent amongst the local rural-based government schools. These were chosen because they were in the proximity of IIT Guwahati campus and the study team could have continued interaction with the students and teachers at the school during the different stages of the project. Preliminary research on the schoolchildren revealed a high degree of enthusiasm for learning during the early years. However, a direct correlation between hunger and the school dropout rate was revealed. The government mid-day meal scheme run by the NGO, Akshayapatra, Guwahati branch, has made significant contributions to student retention; however health and hygiene were poor in the schools. Thus, health and sanitation were the subjects chosen for intervention in this project.

### 2.1 Importance of health education in schools

Published literature on aspects of health and hygiene has focused on two dimensions: prevention and cure. A study undertaken by the US Department of Health and Human Services (2007) states that promoting healthy practices is more effective in instilling healthy behaviours among the young than it is to change unhealthy practices already established among adults. A report published by Everydaychoices (2007), pointed out that health education provided young people with the knowledge and skills they needed to become successful learners and healthy and productive adults.

It became evident that the schools are a very effective arena for the introduction of health education and establishing healthy behaviour patterns among children and young persons on a large scale. This would evidently carry over into adulthood, which

results in the overall well-being of the community. Inclusion of activities related to health and sanitation would draw positive outcomes if adapted to suit the local realities and socioeconomic context. The schools could become a hub for children to learn aspects of their health status, identification of health problems, and timely interventions like taking appropriate, remedial measures. Regular monitoring of the school health education programs could help overcome problems of tobacco use, poor nutrition, lack of physical activity, and drug and alcohol use. A larger impact would be that it would help children to know and accept individual and collective responsibility for healthy living at home, school, and in the community. School health education could incorporate inputs to create appropriate awareness among children about rules of safety in hazardous situations to avoid accidents and injuries. It also could acquaint them with first-aid measures for common sicknesses and injuries (NCERT, 2009).

Based on these considerations, preventive healthcare was also chosen as the focus of intervention for this project.

## **2.2 Research approach: Participatory Learning and Action (PLA) in school education**

Field visits to the government-run, rural schools located in the Bazera block of Kamrup (Rural) district of Assam revealed the limited infrastructure, financial resources, and facilities available within these schools. Furniture in the classrooms was barely adequate, and toilets provided for boys and girls were found to be in very poor condition. Whatever existed was poorly maintained due to a paucity of funds. Chalk and chalkboards were used with traditional classroom learning but activity-based learning was not used. However, as a positive, the children were highly enthusiastic.

Considering these conditions, it seemed ideal to encourage peer learning amongst the students through interactive learning approaches. PLA focused on creating learning through participation in activities was successful in rural communities

as there was greater engagement by all members of the community in this approach. As seen in PLA case examples initiated in rural communities (EI, WHO and EDC, 2001), it was extremely effective in tapping into the unique perspectives of the rural poor and spreading awareness about HIV/AIDS and other STDs in Africa. The results show that to ensure engaging, effective, and relevant learning, the approach needs to take into considerations the social dimensions of the community and help propagate the learning within the classroom to the home and society.

Two interactive participatory sessions were initiated, inviting a mixed group comprising one senior schoolteacher, two social activists, IIT student volunteers engaged in a program called ZIZ program (Zero Illiteracy Zone), and a group of five students from the local government school. Two sessions were held on the IIT campus in the Department of Design. Pen and paper interviews, followed by informal discussions, revealed that the local schools were being encouraged to shift their emphasis towards activity-based learning that would help students learn concepts. It was evident that the students were generally weak in their fundamental understanding of science and language concepts. The Assamese language was the preferred method of communication. There was, in general, good collective enthusiasm and a keen ear for popular music and local games amongst the students. The students identified the local games they played and a list of these were made. The format of games embodies the PLA approach and provides a high degree of engagement, thus, these were chosen as the format for planning and designing the exercises for health education using the PLA approach.

## **2.3 Planning the Participatory Learning and Action (PLA) activities using games**

The syllabus on health education outlined by the NCERT formed the basis for identifying the age and grade level of the target group. The teachers of Auniati Kamaldev High School (AKHS) and North Guwahati Girls Higher Education School,

Category	Local Names
Kinaesthetic games	Teesti, Pansti, Kabaddi, Kho-kho
Team games	Antakshari, Dumb charades
Indoor games	Cards, Chess, Ludo, Cross and noughts
Video games	Video games

Dhologobinda, were approached requesting the participation of students from their school. The students between 12–14 years in the 6<sup>th</sup> grade were selected as the participants for the experiments. The medical doctor, Ms. Mayurakshi, of the Out Patient Day Unit, Community Health Centre, North Guwahati, was consulted to cross-verify that the contents of the health related inputs were appropriate for the age group for whom the games were intended. This interaction with the doctor helped to identify common diseases, important health concerns, and the issues of sanitation and hygiene responsible for diseases in the area.

### 2.3.1 Identification of games

A study of popular, traditional, Indian games and those identified as popular in the local community formed the inspiration of the format for the games. Using this information, a participatory session

(Figure 1) was held with teachers and students, during which, they were asked to outline their schedule and common games they played in the evening. Following the activity, there were discussions about other games they liked to play and how they liked to spend their spare time. This helped to confirm the following four categories of games and their local names:

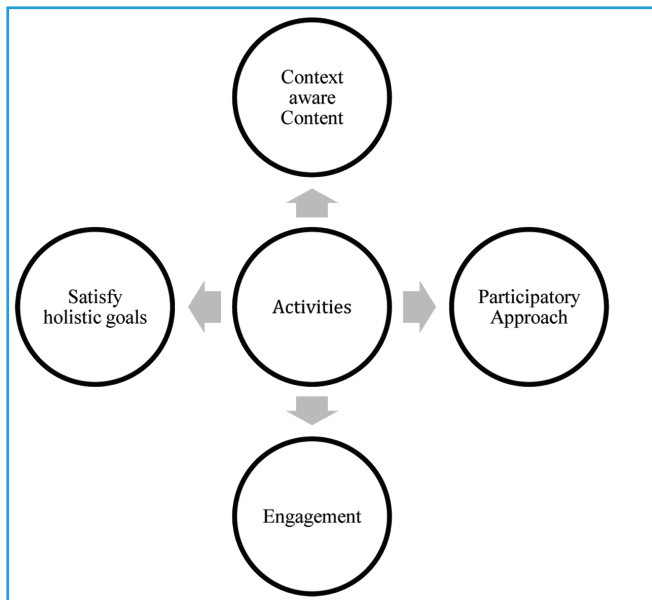
From these interactions, the following games in particular, were analysed to understand the characteristics that make them interesting:

- a) Dumb charades: Dumb charades is a very popular game and is known by different names in different places. This game is characterised by the importance of teamwork in winning, and the spirit of competition makes it really interesting and popular. Skill is important; strategies and skills in gestures and body language have to be used.
- b) Card games: Card games are competitive in nature and require a mix of strategy, memory, chance, and skill to win. All age groups can play them collectively.



**Figure 1** Confirmatory interactive session for learning students likes and dislikes in games





**Figure 2** Tenets to be considered in the design of the activity

c) *Teesti/Pansti* (Kinaesthetic life-size board games): Also popularly known as hop-scotch, these are one of the most popular games amongst school girls. A 3 ´ 3 (Teesti) or 5 ´ 5 (Pansti) board is drawn on the ground and their motive is to hop and carry a small flat stone across blocks with their leg.

### 3 Design of the games

The schematic diagram (Figure 2) summarizes the following four key features that need to be

incorporated when designing and developing instructional games and activities:

1. The content on health care used in the design of the games should be appropriate in the local context.
2. Content should satisfy one or more of the holistic goals of health education in the school curriculum for the 12–14 years age group.
3. The games should incorporate the PLA approach.
4. The games should be engaging.

The framework (Figure 3) was developed to design participatory learning activities in the healthcare domain to help instil behaviour change and improve health awareness.

Using the framework, health-related activities were designed in the form of games; following that, they were field-tested. The experiments were conducted separately with girls and boys in the 6<sup>th</sup> grade classes of these two schools.

Due to the limited time available, a qualitative analysis was conducted based on direct observations, diary notes, still photographs, and video recordings made during field trials at the two schools. A team of three members, who spoke the local Assamese language, accompanied and assisted the design team during

	Content	Strategy	ACTIVITY DESIGN	Goals	
Components	Health Issues Healthy Habits Hygiene Preventions Symptoms	<b>Participatory Strategies</b> Examples: Kinesthetic      Art      Drama Reading          Hands on      Writing  <b>Engaging Strategies</b> Gamification      What children love Examples:              Examples: - Competitive      - Emulating Adults - Goal Oriented      - Creativity - Chance              - Express		A C T I V I T Y  D E S I G N	Awareness Behavior Change Influence Community
Methods	Curriculum Expert Interviews	Literature: PLA activities Literature: Game Elements Field Research: Local Games			

**Figure 3** Proposed framework for designing PLA-based learning activities

the documentation of the field trials conducted at the two schools.

The school authorities gave permission to conduct pilot tests using the newly designed games for a two-hour period during the latter half of the school session. These trials were conducted over the course of one week.

The card games were made using colour printouts pasted on card paper and a graphic outlay was used for the posters. The sessions were conducted in the local Assamese language.

### 3.1 Field Trials

Field trials of the following games took place at the two schools.

#### 3.1.1 'Aarogya' Card Game (Duration: 60 minutes)

This card game (Kishore & Gupta, 2013) draws elements from the popular game, dumb charades, in that it promotes teamwork and uses skill to win. The game aims to help children of ages 12–14 years gain awareness about various diseases, their symptoms, and prevention, in addition to nutritious food items and their benefit to the human body.

The game is played between two teams of four members each. The card game comprises a deck of 24 colour-coded cards of which 11 are green, five are yellow, and seven are red. The green cards contain names of nutritious food item(s) and their benefits towards our health. Each of these cards has a score of +1 on them. The player who draws the card from the stack reads aloud the content of the card to his/her team members.

Each red card, on the other hand, holds the name of a disease, the symptoms of it, and the preventive measure to be taken to avoid getting it. These cards have a score of -5, which can be converted to +5, subject to the use of skill while the game is played.

The player who draws a red card has to enact the symptom and the prevention to their teammates (the name of the disease can be communicated verbally). If the members are able to guess correctly the pieces of information, the team earns a score of +5. Otherwise, the team gets a -5 score.

Each yellow card holds a funny graphic and a point value. These cards help to introduce randomness and surprise in the game.

The game begins with the deck at the centre and two teams sitting facing each other. The players draw a card each, one from each team, until all the players have each drawn a card. Three rounds are played in a typical game. Cards which add to the score and the cards with -5 are stacked in two different decks for each team. In the end, the points gained by each team are tallied and points lost are subtracted to give the final score. The team with the highest score wins.

This card game is characterised by non-verbal modes of communication involving body gestures and sign language, which lead to a high degree of group participation, teamwork, and a single-minded focus on decoding content to score points. There is a sense of drama. In the process of guessing the name of the disease through gestures indicating its symptoms, students learn as much about what the disease is as what it is not. Cards become only a means to bring randomness, fair play, and competitiveness between the two participating teams. Hence, there is increased retention of knowledge.

#### 3.1.2 'Flee the Fly' (Duration: 45 minutes)

This kinaesthetic game (Kishore & Gupta, 2013) draws elements from the traditional game, *Teesti/Pansti*, popular amongst the local children. It can be played by a group of up to nine players in a large room. Circles are marked with chalk across the floor as shown in the illustration.

Players draw a chit from a given set, two of which have 'fly' written on them; the rest have names of



**Figure 4** Cards for the game *Aarogya* and the game in progress

random food items. Consequently, two players are assigned 'fly', while the remaining players get the names of different 'food' items.

In this game, each 'fly' aims to prevent the 'food' from reaching its destination (which is the two opposite walls of the room). The game begins in the central circle of the room with all 'food' players moving in one of the two directions; their objective is to reach the walls, while avoiding the flies. They can transverse the distance by pausing at the intermediate circles.

The marked circles are 'hotspots' where the flies cannot reach the food. The flies can only touch them when they are outside the circles. A player is 'out' if the fly succeeds in touching the player (the 'food'), when he/she is outside the circle. A player wins if he succeeds in reaching the wall.

This game is designed to complement classroom learning and reinforces concepts in nutrition, good eating, and hygiene habits. It encourages group-based participation and collective learning.



**Figure 5** Layout for the game *Flee the Fly* and the game in progress



### 3.1.3 'Intruder, intruder, pass the cucumber' (Duration: 45 minutes)

This is a kinaesthetic game, which tries to facilitate learning about the immune system of the body and the importance of eating healthy food in order to stay strong.

The game is an extension of 'flee the fly' and can be played with seven players at a time. Three 'immunity' players form a human chain to guard an area marked with chalk from two 'germ intruders'. Two additional 'nutrient' players are placed at suitable distances and can join the 'immunity' chain when the chain touches him/her. Each addition strengthens the chain and makes it harder for the intruders to reach the designated area. If any player in the chain touches any of the 'germ intruders', he/she is out of the game. On the other hand, if a 'germ intruder' succeeds in reaching the area, he/she is victorious in causing disease. This game is also designed to complement class learning and reinforce concepts about the body's immune system. It encourages group-based participation and collective learning.

### 3.1.4 Poster-making: Food is good – identify why! (Duration: 20 minutes)

This is a creative activity, which includes identification of food items and strives to elicit knowledge about nutritious food items and the benefit they have for the human body.

In this activity, a chart with images of nutritious food items grouped according to their benefit to the human body is distributed to the children. The benefits are initially presented in the form of a set of dots in an ambiguous pattern. The dots are meant to be joined with a pen/pencil in a specified order to form the recognizable benefit/body part helped by that group of food items. After the picture is completed, there is an interaction with the facilitators, which should enable them to gain the motive behind the activity. In the end, the chart is meant to be taken back home and displayed on the wall for the family to see and be reminded of the importance of giving children a balanced diet. The parents accepting this is an essential part of the activity, and it is for this reason, the food items are grouped by benefits, rather than nutrients present.

The exercise encourages engagement of students within the classroom and subsequently extends to the home to include participation of family members.

### 3.1.5 'Poster making: Do's and don'ts' (Duration: 45 minutes)

This is another creative activity in poster-making that focuses on general awareness related to health care and community well-being. In this activity, the children colour and complete a set of posters, which are then stuck outside the school for the community to see. The content on the posters pertains to healthy practices that should be followed by any



Figure 6 Layout for the game and the game in progress



**Figure 7** The game chart and participants engrossed in it

member of the community. The graphic outline and caption text is already written and the colouring is done by the children.

Coming from the children, the posters have a greater chance of being noticed by passers-by. The activity aims to spread awareness about healthcare beyond the school walls to neighbouring communities.

### 3.1.6 Role playing: Scenario building and response (Duration: 45 minutes)

This is a role-playing exercise, which allows the children to act out the roles of characters in a given scenario. It is important to note that the scenarios given are suggestive and incomplete. Participants are encouraged to use their creativity to decide on their response to the events in the scenario.

Scenario 1: 'Hygiene at Home': This scenario uses the setting of a typical home, where the characters are

a child attending school, his/her younger brother, their parents, and other people involved in the typical morning routine (e.g. milkman, vegetable seller). The emphasis is on the daily routine of the child's hygiene habits. These include food being cooked at home and its nutritional value; morning ablution activities, body care, and hygiene; the children's road safety practices while crossing the road; etc. The characters' sketches are explained to the children along with the plot of the scenario. The action, dialogues, and parts of the play are left to the children to decide and enact.

Scenario 2: 'First aid first': The second scenario is at a recess break in school. A group of friends are playing in the field when one of them accidentally sprains her leg. The participating children are encouraged to enact and respond to such a scenario. Discussions follow about their observations on the following: How do her friends react? How do they check the injury? What actions do they take? Do they call



**Figure 8** Completed poster along with the group of participants



the teacher or the elders? How do they help? What immediate first aid needs to be given? Children are encouraged to air their views and critically analyse what may have been the appropriate action.

Scenario 3: 'Responding to emergency': The third scenario is that of a group of friends playing in the evening; suddenly, a friend calls one of the girls from across the road. The girl runs across the road without looking, and has an accident resulting in a leg fracture.

What do her friends do? What is the immediate first aid they apply? What is the subsequent follow up action they take? How do they get help? How do they reach the doctor? What is the role of the doctor? These are some questions the participating students have to decide on and enact.

### 3.1.7 *Afraid no more: Visit to a doctor* (Duration: 60 minutes)

The workshop can be summarized ideally with a field trip to a nearby doctor's clinic or health centre. The participation of the doctor adds an important dimension to the workshop and helps the children overcome their inhibition of visiting him/her.

This activity can be seen as an extension to the previous activity and the final role-play, which involved responding to an emergency and included the role of a doctor. The act is performed again at the health centre with a doctor watching. After the play is over, the doctor can give suggestions and comment on what they did correctly, and what the best practices are. This is followed by an interactive session, where the children can express their doubts and concerns, and the doctor can respond and clarify the reasons behind suggested practices.

## 4 Concluding remarks and further work

This study was quite exploratory and qualitative in nature, and even when the results for engagement and retention were highly encouraging, it would be interesting to extend the study to evaluate quantitative indicators and compare them against traditional methods of assessment. It would also be interesting to test the same framework for a field other than health, but some overall observations and concluding remarks are in order.

This project commenced with the idea of designing card games as teaching aids for education. As the project progressed, however, the scope turned out to



Figure 9 Role-playing in progress



**Figure 10** Visit to the doctor and interaction in progress

be one including the design of a series of participatory learning activities on health care and hygiene, of which card games emerged as one of the solutions.

Field trials and experiments introducing general health and hygiene inputs through participatory learning activities have addressed the creative and generative phases of design. There have been follow-up actions in generating a series of board games for other domains such as language, mathematics, and history. This initiative, through the use of games in the educational routine, shows promise for scalability and use in the education system considering the overall enthusiasm shown by the children in these schools during the pilot test.

The ages of 12–14 years are crucial in the life of girls due to the bodily changes as they enter puberty. Understanding and knowing that this is a natural phenomenon and group activities amongst the girls seemed to have sharpened their curiosity in a positive way. During the group activities, it was evident that they helped them to overcome shyness and awkwardness in their interactions with the teachers and the female doctor, in particular, as seen from video recordings.

The students in group activities had higher levels of interest and participation. This resulted in more openness and an exchange of information amongst

the students. The teacher/instructor was happy to be in a situation of being a ‘guide on the side’, helping the students to learn from each other.

Participatory learning activities in the classroom, when complimented with traditional text book learning, resulted in improvement in children’s recall. Some children could use participatory learning and be encouraged to use their creativity to develop their own games appropriate to the context of the learning in the classroom.

It was evident from the field experiment and the direct observation of responses that much could be achieved in classroom learning when the role of the teacher was one of a facilitator rather than a regulator.

In the process of engaging with schoolteachers, students, and the doctor at the local health centre, the designers participating in the project were exposed to the rural education scene and what it means to the aspirations of the local community. There was immediate bonding evident between the students, the teacher, and the facilitators. One of the outcomes of the project has been follow-up visits between the schoolchildren and their teachers at the institute. Following this project, there have been other projects related to education that have been conducted in the design program with the

continued participation of the local schools. A series of nearly eight board games, ready for field testing, have been designed.

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4. Appropriate consent has been obtained with regard to the included photographs and the children featured therein, solely for the purposes of illustrating the card-game. The authors will be responsible for responding to any objections raised, related to the individuals featured in the photographs.

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Design and wellbeing: Bridging the empathy gap between neurotypical designers and autistic adults

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# Design and wellbeing: Bridging the empathy gap between neurotypical designers and autistic adults



## Abstract:

This paper is focused on the wellbeing of people with autism spectrum disorders, who are often excluded from design research. Drawing upon on-going design research collaboration between The Helen Hamlyn Centre for Design and the autism charity The Kingwood Trust, this paper reflects upon a neurotypical (i.e. not on the autism spectrum) designer's experience of working with adults with autism who have limited verbal speech and additional learning disabilities. The hypothesis under investigation is that, by interacting with and observing a person in conjunction with his or her physical environment, the designer can unravel clues and insights to develop empathy and better understanding of a person with autism's everyday experiences, which can thereby inform empathic designs that enhance and sustain a state of wellbeing. The conclusion explores how the inclusion of autistic people within the design process creates a shared experience, which helps to develop trust and empathy between the designer and the person with autism, enabling the designer to understand and appreciate different ways of being in the world.

**Keywords:** *autism, wellbeing, design, empathy, sensory environment*

- \* In compliance with research ethics, the real names of the participants have not been used within this paper.
- \* The term 'autistic' person is the preferred language of many people with autism (see Sinclair, 1999). In this paper, we use this term as well as person-first language (such as 'children with autism') to respect the wishes of all individuals on the spectrum.
- \* Throughout the paper, the term 'neurotypical' is used to describe people who are not autistic; it is a word that is widely used in the autism community. This research does not condone the use of this word (what is typical), nor does it attempt to provide a definition of any words that label or separate people from one another, but due to the subject of this paper, it was deemed necessary to use the word 'neurotypical'.

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## 1 Introduction

Wellbeing is subjective and can mean different things to different people; its meaning is determined by a number of factors, including their culture, values, preferences, and relationship with the world in which they live. This paper is concerned with the wellbeing of people with autism. With an estimated

prevalence rate of 1 in 100 people, autism is not rare (Baird et al., 2006; Brugha et al., 2009). These are not only people whose perceptions, experiences, and interactions with their surroundings are unique, but are also people who may not be able to verbally communicate their experience to the remaining 99% of the population. Therefore, an autistic person's sense of wellbeing may neither be

heard nor understood. Either way, their experiences remain largely unexplored.

The World Health Organization (WHO, 2013) defines mental health as ‘a state of well-being in which every individual realises his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community.’ However, in the case of autistic people, how much of this definition relates to their way of being in the world? Living within a world that is largely designed by and for neurotypical people, even the stresses of life considered ‘normal’ can be a challenge for a person with autism, such as sitting on a bus or walking on wet, shiny floors. People with autism may also experience difficulties relating to other people, leading to social isolation. Further, with only 15% of people with autism in full-time employment (Howlin, Moss, Savage & Rutter, 2013), the concept of getting a job is not all that ‘fruitful’. As Milton and Bracher describe, ‘it is crucial that researchers explore the subjective significance of AS (autistic spectrum) related experiences in relation to wellbeing, as this may not be immediately apparent to non-AS observers’ (Milton & Bracher, 2013, 64).

This sentiment is precisely what this paper is about. The research investigates how the non-human material infrastructure of the environment and what it affords are critical to a person with autism’s understanding of themselves, other people, and the world around them. It may also be vital for designers to create better understanding of what happiness, comfort, and satisfaction might mean for autistic people, that can be translated into what design for the wellbeing of a person with autism (in this study) might mean. To explore this issue, the paper draws upon a four-year research collaboration between the Helen Hamlyn Centre for Design and the autism charity, the Kingwood Trust, which provides support and accommodation for adults with autism.

In this collaboration, participatory design approaches were selected and developed that were sensitive to the cognitive processing styles and

perceptual experience of the autistic participants. In addition, the development of empathy (a translation of the word *Einfühlung*, which means ‘in-feeling’ or ‘feeling into,’ coined in 1909 by Edward B Titchener) was simultaneously explored, to enable the designer to try and perceive the environment from the perspective of an autistic adult. This, however, presented many challenges, as Milton hypothesised in his Double Empathy Theory:

The ‘double empathy problem’: a disjuncture in reciprocity between two differently disposed social actors which becomes more marked the wider the disjuncture in dispositional perceptions of the lifeworld – perceived as a breach in the ‘natural attitude’ of what constitutes ‘social reality’ for ‘non-autistic spectrum’ people and yet an everyday and often traumatic experience for ‘autistic people’ (Milton, 2012).

There is a body of autism research that proposes that people with autism experience delay in developing Theory of Mind (TOM) (Baron-Cohen, 1995; Baron-Cohen, Leslie & Frith, 1985), which is the ability to imagine another person’s thoughts and feelings, leading to empathic difficulties (Baron-Cohen, 2012). However, what if we flipped this around? How much empathy do neurotypical people have for people with autism? In support of Milton’s Double Empathy Theory, this study investigates how empathy can be learned and incorporated into the design process with the following underlying question: How can a neurotypical designer begin to understand and empathise with an autistic person whose lifeworld and lived experience are so different to their own, and who may not be able to verbally communicate this to them? For example, could the producers of the UK television program *Eastenders* have ever thought that changing the pitch of the theme tune would have made Sarah at the Kingwood Trust, a regular watcher of the show who has autism, feel so anxious? It would be surprising to learn that the designers of the Henry vacuum cleaner and the illustrators of *Thomas the Tank Engine* anticipated that their designs would cause so much enjoyment

for Philip and David. Further, how could the designers at Dyson have anticipated that the sound of the new air hand-dryers would have been so frightening for Andrew?

This study explores how working with autistic people can inspire designers to be more aware of the sensory qualities of the environment and experience things from different perspectives, opening up the design toolbox to include methods that move beyond written and spoken language to modes of non-verbal communication that can be extrapolated into general design practice. With reference to Dr Lorna Wing's description, 'once you've met one person with autism, you've met one person with autism', it is important to emphasize that the descriptions in this paper cannot be generalised. Nevertheless, this paper seeks to share design ideas and experiences with designers, autistic adults, family members, support staff, and service professionals, to encourage them to work together to make the environments and everyday experiences of autistic people more meaningful and enjoyable.

### 1.1 The beginning...

This paper begins with the designer's first experience at the Kingwood Trust. With little understanding of autism, the designer visited the home of a man called Tom. Tom was not present, but with notebook and camera in hand the designer documented the 'destruction' he had caused to his home environment: a ruined sofa where all the leather had been picked off and a damaged wall, where all the paint had been peeled and wood eroded. Leaving Tom's home, the designer's first question was, how could we prevent this from happening?

Several weeks later, the designer made a second visit to Tom's home, and this time met and interacted with him, by mirroring his favourite activities like ripping pages in magazines. In time, the designer could see that Tom looked content and relaxed sitting quietly picking at the leather on his sofa, resting his ear against a wall, rubbing it while

listening and feeling the vibrations of the music above. Unable to ask Tom directly, 'What do you like about doing that?' the designer then mirrored Tom's actions and experienced it for herself, which enabled her to externalise her thoughts and begin to understand and empathise with Tom: picking the leather off the sofa was surprisingly satisfying and could be equated to the satisfaction one gets from popping bubble wrap.

So instead of a ruined sofa, the researcher now perceived Tom's sofa as an object wrapped in fabric that is fun to pick. Pressing her ear against the wall and feeling the vibrations of the music above, the researcher felt a slight tickle in her ear while rubbing the smooth and beautiful indentation, which Tom had sculpted into the wall. So instead of a damaged wall, the researcher perceived it as a pleasant and relaxing audio-tactile experience. On reflection, this experience illustrates how upon the first visit to Tom's home, the designer instantaneously internalised and conceptualised her observations of the environment with negative connotations, 'destruction'. However, upon the second visit where the designer met and interacted with Tom, the designer began to empathise with Tom – the sofa, wall, and music revealed vital clues and helped the designer to form some understanding of the sorts of things Tom likes to do.

## 2 Autism Spectrum Disorder

Autism spectrum disorder (ASD) is a lifelong complex neurodevelopmental disorder. It is a spectrum condition, so it affects people in different ways. Someone with autism might be very sociable or find social relations difficult; some have learning disabilities while others possess high levels of intellectual ability. In the latest revision of the diagnostic criteria (Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition; DSM-5, 2013, American psychiatric Association), sensory sensitivities are for the first time recognised as a core characteristic of autism. This can affect a person's ability to interpret, filter, and regulate sensory information from the environment, leading to person

becoming hypersensitive (over-stimulated) and/or hyposensitive (under-stimulated) by what they sense, influencing how they perceive and experience the environment in which they live. Taking examples from the Kingwood Trust, Matt is hypersensitive to sound and feels anxious when he hears the lawn mower, Sarah feels relaxed by the sound of her washing machine, and Steven feels calm when he flicks through the pages of a retail catalogue.

Currently, research on autism is largely focused upon the underlying biology and causes of autism (Pellicano, Dinsmore & Carman, 2013), including an emergence (since the 1970s) of cognitive theories to explain the core features of autism, such as difficulties with theory of mind (Baron-Cohen, 1995; Baron-Cohen et al., 1985), executive function (Pennington & Ozonoff, 1996; Ozonoff, Pennington & Rogers, 1991), and weak central coherence (Frith, 1989, 2003). These theories, however, largely focus on the internal characteristics of the autistic individual. Although the 'environment' does feature somewhat highly within autism research, in this context the environment equates to things that are considered by some as possible causes for autism, such as exposure to mercury and pesticides (Roberts et al., 2007).

Research has shown how sensory sensitivities may affect a person's experience with both everyday objects and the physical environment in which the activity is to be performed (Bagby, Dickie, & Baranek, 2012; Gaudion, 2013). Some studies have explored a person's interest within the unintended affordance of objects (Baron-Cohen, 1987; Charlop-Christy & Haymes, 1998; Gaudion, 2013; Loveland, 1991, 1994; Ungerer & Sigman, 1981; Williams, Costall, & Reddy, 1999; Williams, Kendell-Scott, & Costall, 2005; Williams & Kendell-Scott, 2006). Despite this research, the relationship between autistic people and the physical environment has been a relatively under-researched area. However, we do have accounts of the first cohort of people diagnosed with autism (Bemporad, 1979; Donvan & Zucker, 2010; Grandin, 1984; Williams, 1992, 1999) and the continuous flow of autobiographies and parent

accounts subsequently (Blackman, 2001; Dickie, Baranek, Schultz, Watson, & McComish, 2009; Woodgate, Ateah, & Secco, 2008) that describe and reveal a person's unique way of perceiving and processing the sensory information of their surroundings. The composition of the 'physical' environment has begun to be considered causation, not for autism per se, but for how a person with autism might feel and behave. As described by Donna Williams (1992, p. 11), 'I had always known that the world was fragmented. My mother was a smell and a texture, my father was a tone, and my older brother was something, which was moving about'.

The revised DSM-5 is an important milestone that puts the sensory environment back onto the roadmap within autism research, creating a natural avenue for designers to explore how their deep understanding of the sensory quality of materials, skills in making, and spatial/visual thinking can develop new modes of non-verbal communication, dialog, and understanding around the everyday experiences of people with autism.

## 2.1 Autism and the Environment

Dr Leo Kanner (1943) and Dr Hans Asperger (1944) formed the basis for our understanding of autism and the springboard from which research in autism has grown and evolved. This paper rewinds 70 years to Dr Kanner's seminal article, 'Autistic Disturbances of Affective Contact', which is a 33-page detailed account and discussion of observations on the patterns of behaviours and personalities of eleven children with limited verbal speech (eight boys and three girls) by both Kanner and the children's parents. Interestingly, Kanner's observations of the children are filtered through their preoccupation and direct engagement with the unintended affordance of the physical environment and things within it, rather than the persons present, for example, spinning objects, ripping paper, and placing books into the toilet. While the things in Kanner's office were a source of interest and entertainment for the children, parents also reported on how some things

within the environment can also cause distress, for example, tricycles, dogs barking, and planes. In contrast to Heidegger's (1993), description that 'Man would not be man if it were denied him to speak,' meaning and understanding was harnessed not through knowledge and language, but via the children's tangible interactions of doing, sensing, and interacting with the things in his office space. Kanner's article illustrates a different way of being-in-the-world, in which the children's reciprocal relationship with the office environment took precedence over the people present. As described by Kanner (1943, p. 246):

The children's relation to people is altogether different. Every one of the children, upon entering the office, immediately went after blocks, toys, or other objects, without paying the least attention to the persons present. It would be wrong to say that they were not aware of the presence of persons. But the people, so long as they left the child alone, figured in about the same manner as did the desk, the bookshelf, or the filing cabinet.

Kanner's observations of the children relates to James Gibson's concept of affordances, a term introduced in the article 'The Theory of Affordances' (1977) and further explored in 'The Ecological Approach to Visual Perception' (1979), which explains that, 'The affordances of the environment are what it offers the animal, what it provides or furnishes, either good or ill' (Gibson, 1979, p. 127). Gibson's key concept is 'Ask what's not inside your head but what your head's inside of' (Mace, 1977), meaning our 'head' is in the world (and receiving inputs for action and understanding via affordances), rather than that the world is in our heads (we have an inbuilt knowledge of how to interact with the outside world). According to Gibson, the physical environment generates action opportunities and an affordance is the 'fit' between a person and the environment, which then creates opportunities for actions, whether good or bad. It is therefore the 'fit' that determines these opportunities for actions and if the affordance is not compatible with a person's capabilities, they may find it hard to 'fit in' with their environment. This is a key concept for designers,

where exploring the 'fit' between the capabilities of a person with the environment that they inhabit is an important part of design activity; for example, the OXO good grip can opener was developed through the designers' understanding of the capabilities of a person with limited hand strength.

In addition to physical acts, the affordances of our environment are also often designed to create social acts by and for neurotypical people; the quality and meaning of these affordances are not always compatible with the capabilities of people with autism, creating a confusing, uncomfortable, and frightening world for them to live in. For example, playing football, cooking, and reading are all things that we might do, that create shared dialogs, meanings, and understanding in which to exchange and connect with other people, but Jack at Kingwood avoids social interaction and perceives these things very differently: a football as an object to bite and a book as an object to flick and tear. Like Jack, if a person does not engage with the intended affordance of things, there's a danger people may perceive him as odd or strange, leading to further social isolation and a sense of not fitting in. As Loveland (1991, p. 104) describes:

It is the perception of a human environment with its layers of specifically human affordances that allows us to behave in human ways. It is also this complex set of transactions with the environment that looks to us like human behaviour. A person who fails to perceive the specifically human affordances of the environment will therefore exhibit behaviour that will seem strange, disturbing or even inhuman to us.

Whether autistic or not, individuals all share and live in the same multi-sensorial embodied world. The environment is furnished with designed objects whose sensory properties and affordances influence what we do and how we feel and behave. Design does not only result in form and function, it also results in feelings, affecting our state of wellbeing. Feelings are connected to our senses, which enable us to experience and respond to our environment, which can be very different from one person to the next. To create a better fit and enhance our levels of wellbeing we continually control, modify,



and adjust ourselves to the environment, by designing, adapting, repurposing, and signifying new affordances. For example, to feel happy and energised we may turn the music up and dance and to feel more comfortable we may choose to sit in a no-mobile-phone ‘quiet’ carriage on a train.

But imagine if you had no or little control. Imagine if a sound became intolerably loud but you were unable to turn it down, or the light too bright but you were unable to switch it off. This situation can be the case for many people with autism, whose experiences and perceptions of the physical environment are individual and unique. For example, the majority of neurotypical people would recognise a paper clip as a tool to hold papers together, but for Zac at the Kingwood Trust, it offers comfort and support; fans are used to help us cool down when we are hot, but for Sarah the purpose of a fan is generating a pleasing sound: C minor pitch on speed dial 2. We might walk through shadows on the ground, but for Jack they are black rectangular holes that he could easily fall into and hence a source of much anxiety.

Affordances are the key mechanism that designers use to trigger understanding and action in others. As studies show that autistic people appear to have a different use/understanding for affordances, this means it is important to develop different design methods and empathic understandings. Like visiting another country whose culture, values, and language are very different to our own, the process of listening, observing, and adapting ourselves accordingly to connect, learn, and understand was of particular importance to this research. The paper briefly describes three perceptual theories the designer used to help understand or imagine the sensory perceptual differences between herself and the autistic participants to exercise a more flexible way of perceiving the affordances of the physical environment. The unique perceptual experiences of people with autism was first explored by Uta Frith’s (1989) notion of weak central coherence, a theory that describes how a person tends to focus on the small details of the environment rather than perceive it as a whole.

Therefore, in contrast to gestalt psychology, which describes how people first see an object as a whole before seeing it in parts (a whole is greater than the sum of its parts), an autistic person’s strengths might be processing local or detailed information within their environment, in which the sum of its parts is greater than the whole. The following description by an autistic person illustrates this perfectly:

When I step into a room for the first time I often feel a kind of dizziness with all the bits of information my brain perceives swimming inside my head. Details precede their objects; I see scratches on a table’s surface before seeing the entire table, the reflection of light on a window before I perceive the whole window, the patterns on a carpet before the whole carpet comes into view. (Tammet, 2009)

Frith’s weak central coherence theory was followed by Mottron & Burack’s (2001) theory of enhanced perceptual functioning, whereby an autistic person may have not only excellent focus on details but also superior abilities in various aspects of perception – recognizing, remembering, and detecting objects and patterns. This relates to some of the autistic participants who have a heightened sense of details and aspects of the environment, which a neurotypical person may have overlooked. For example, Pete will not walk on shiny wet floors, Tim does not like it when the extractor fans in the staff room are turned off, and Sarah struggles with the sound of things that are not in C minor pitch.

Lastly, Pellicano & Burr (2012) describe how the perceptual experience of autistic people is one that is less influenced by prior knowledge about the sensory world. As a result, autistic people have a tendency to perceive the world more accurately rather than imbued by prior experiences. Therefore, in the context of an autistic person’s interaction with the environment, could a person’s difficulty with building up or using prior knowledge about the environment lead to an idiosyncratic set of affordances? For example, the idea of weakened prior knowledge might mean that a person does not

have a robust template of what a washing machine is (within a neurotypical context), in terms of what it looks like (the perception of the washing machine) or what it is used for (the concept of the washing machine). This might explain why Tim at Kingwood is interested in the unintended affordance of his washing machine, so instead of perceiving it as an object to wash clothes, he has it on all day (with or without clothes) as he enjoys the sound and spinning effect that it makes.

### 3 Design Studies

There is growing realisation of the influence our physical environments have on our sense of wellbeing within environmental psychology (Parr, 1966; Lang, 1987) architecture (Pallasmaa, 2005), and experimental psychology in which Dr Charles Spence expressed ‘...our need for a balanced sensory diet and the essential part that this has to play in our wellbeing’ (Spence, 2002). In response to this, a succession of methods of measuring and assessing the sensorial qualities of our environments is being explored. For example, Malner and Vodvarka (2004) developed the sensory slider as a method of comparing the sensorial qualities of buildings. Environmental adjustments are also being made to compensate for our sensorial intolerances; for example, quiet carriages on trains, no mobile phone zones in public spaces, and massage chairs in busy airports. However, the needs of people with autism, whose sensory tolerances are more extreme, have rarely been considered. While there are a growing number of design researchers who are considering the physical environment as an important point of intervention for people with autism, by improving the design of schools (Beaver, 2003, 2011; Gumtau, Newland, Creed & Kunath, 2005; McAllister, 2012; Mostafa, 2008; Scott, 2009; Tufvesson & Tufvesson, 2009; Vogel, 2008) and supported living accommodation (Ahrentzen & Steele, 2009; Brand, 2010; Burlison, Newman, & Brotsman, 2012; Linehan, 2008; Lopez & Gaines, 2012; Whitehurst, 2006, together with outdoor spaces (Gaudion & McGinley, 2012; Herbert, 2003; Hussein, 2010; Menear, Smith, & Lanier, 2006; Sachs & Vincenta,

2011; Yuill et al., 2007), it is doubtful as to how much of this research starts with the autistic person and involves them as active participants within the design process.

To create a holistic picture of how autistic people engage within the environment, the designer examined their different interactions and reactions to three environmental contexts of the home, namely the garden, the interior, and everyday objects. All three vary in scale, action opportunity, and sensory elements, presenting different levels of control, the garden being the least controllable environment due to the unpredictable nature of the outdoors. The design research started with the person and instead of focusing on a person’s often-cited triad of impairments (Wing & Gould, 1979) in which difficulties in social communication, social interaction, and social imagination are often used to describe autistic people, the research took on board a strengths-based approach by exploring a person’s triad of strengths, in which a person’s sensory preferences, special interests, and different action capabilities (not deficits) were an important part of the design process, which helped the designer to connect, communicate, and understand a person’s interaction with their home.

A person’s triad of strengths enabled the designer to adapt the affordances of each environment in three different ways, where positive behavioural responses could be anticipated and wellbeing extended. This involved (1) creating an entirely new affordance (garden), (2) adding affordances into the home (artworks), and (3) adapting the affordance of an existing object (a bubble blowing vacuum cleaner). Although each design project resulted in real-world applications of the findings, the most important part of the journey was the selection, adaptation, and development of appropriate participatory design methods that involved people with autism in the design process (see Fig. 1). These are people who are often excluded from traditional qualitative design methods, which are largely designed by and for neurotypical people and dependent on written and spoken feedback, such as questionnaires,

**Table 1:** Design methods used within the three stages of each design study.

	Study One GARDEN	Study Two OBJECTS	Study Three INTERIOR
<b>Stage One</b>	<p><b>ASD:</b> <i>Connecting, communicating, building trust and empathy.</i></p> <p>Sensory activities Mirroring interests Making &amp; doing activities Participatory observation Shadowing Garden activities</p>	<p><b>ASD:</b> <i>Connecting, communicating, building trust and empathy.</i></p> <p>Sensory activities Mirroring interests Making &amp; doing activities Participatory observation Shadowing</p>	<p><b>ASD:</b> <i>Connecting, communicating, building trust and empathy.</i></p> <p>Sensory activities Mirroring interests Making &amp; doing activities Participatory observation Shadowing</p>
<b>Stage Two</b>	<p><b>AS:</b> <i>Gathering and documenting context specific insights</i></p> <p>Mapping interests Mapping sensory preference cards Garden diary evaluation</p>	<p><b>AS:</b> <i>Gathering and documenting context specific insights</i></p> <p>Mapping interests Mapping sensory preferences Objects of Everyday Use Doing things with things Hubble Bubble vacuum cleaner trial</p>	<p><b>AS:</b> <i>Gathering and documenting context specific insights</i></p> <p>Mapping interests Mapping sensory preferences Artworks I like booklets Online survey Artwork selection activity Artwork evaluation</p>
<b>Stage Three</b>	<p><b>SD:</b> <i>Generating design ideas</i></p> <p>Storyboarding Co-creation workshops Ready Steady Make Interviews</p>	<p><b>SD:</b> <i>Generating design ideas</i></p> <p>Storyboarding Co-creation workshops Ready Steady Make Interviews</p>	<p><b>SD:</b> <i>Generating design ideas</i></p> <p>Storyboarding Co-creation workshops Ready Steady Make Interviews</p>

interviews, and co-design workshops. In support of this, the research built upon existing design research that involved autistic people within the design process (Benton, Johnson, Brosnan, Ashwin & Grawemeyer, 2011; Benton & Johnson, 2014; Brand, 2010; Brand & Gaudion, 2012; Frauenberger, Good, & Keay-Bright, 2010, 2011; Frauenberger et al., (2012); Gaudion & McGinley, 2012; Gaudion, 2013; Guha et al., 2004; Keay-Bright 2007, 2009; Millen, Cobb, & Patel, 2011; Van Rijn, 2012).

Although neurotypical and autistic people might perceive and experience the world differently, the common ground they share is the physical environment. In stage one of the design process, the design methods were themed around a person's triad of strengths, but disseminated and mediated through the environment. For example, during the sensory activities, non-verbal conversations were mediated through the exchange of an assortment of props that were chosen for their visceral and sensory properties in terms of touch, sound, sight,

smell, and movement. To create an equal platform for interaction between the designer and participant, the props were abstract in shape, stripped of social context, with no intended affordance. The purposeful purposelessness of the props helped the designer observe a person's interactions with them without being distracted by their own subjective prior knowledge of the intended affordance of the prop. Equally, the design method of mirroring the interests and interactions of the autistic participants enabled the designer to break away from how they conventionally interact with and perceive the environment, and instead, be flexible and open to other ways.

One of the most important environmental variables to consider during the research (particularly for people with autism who can be uncomfortable with social interaction) was the presence or absence of persons; and should there be persons present, what combination they were in: be it one-one, in a group situation, or online. Each study involved

three separate configurations of people at different stages within the design process: people with autism (A), their support staff (S), and the designer (D). Each person brought with them their own unique lifeworld and lived experiences; yet, as the lifeworld of an autistic person can be very different from that of the neurotypical designer and support worker, each configuration presented a different set of challenges, which influenced the selection, development, and facilitation of the design methods.

Figure 1 illustrates that the first stage (A-S-D) involved all parties: a person with autism, their support staff, and the designer. In this stage, in which the design brief unfolds, the design methods are primarily used to help connect, communicate, and build trust and empathy between each person. The second stage (A-S) involves people with autism and their support staff, where design methods are used to uncover and gather insights, knowledge, and understanding about their everyday experiences, to validate the designer’s initial observations and interpretations from stage one. This stage is also largely involved in the evaluation process of the design prototypes. The third stage (S-D) involves the designer and the support staff, where slightly more directive design methods are used to generate design ideas. The diagram below illustrates that the support staff are consistently present throughout the research; this is because the majority of the participants in this study

have limited verbal speech and learning difficulties. The support staff act as informants throughout the research, whose expertise in observing, interpreting, and communicating with the person they support helped to develop understanding between the autistic person and designer. Therefore, much of the data gathered during the project did not derive first-hand from the autistic participants, but was largely interpreted by the support staff through direct observation.

#### 4 Developing Empathy

Figure 1 illustrates how the autistic participants, their support staff, and family members were invited to participate in a range of design methods that included workshops, storyboarding, and sensory profiling, however overshadowed by the question of ‘How can a neurotypical designer subjectively form an understanding of a situation, when their observations are being processed neurotypically far removed from the cognitive processing style of the autistic participants within the research?’ In light of this, it was the designer’s empathic ability to listen, observe, and interpret the information derived from these design methods that proved to be the most important and challenging design method of all.

The design process revealed that through their thousands of hours of collective observances,

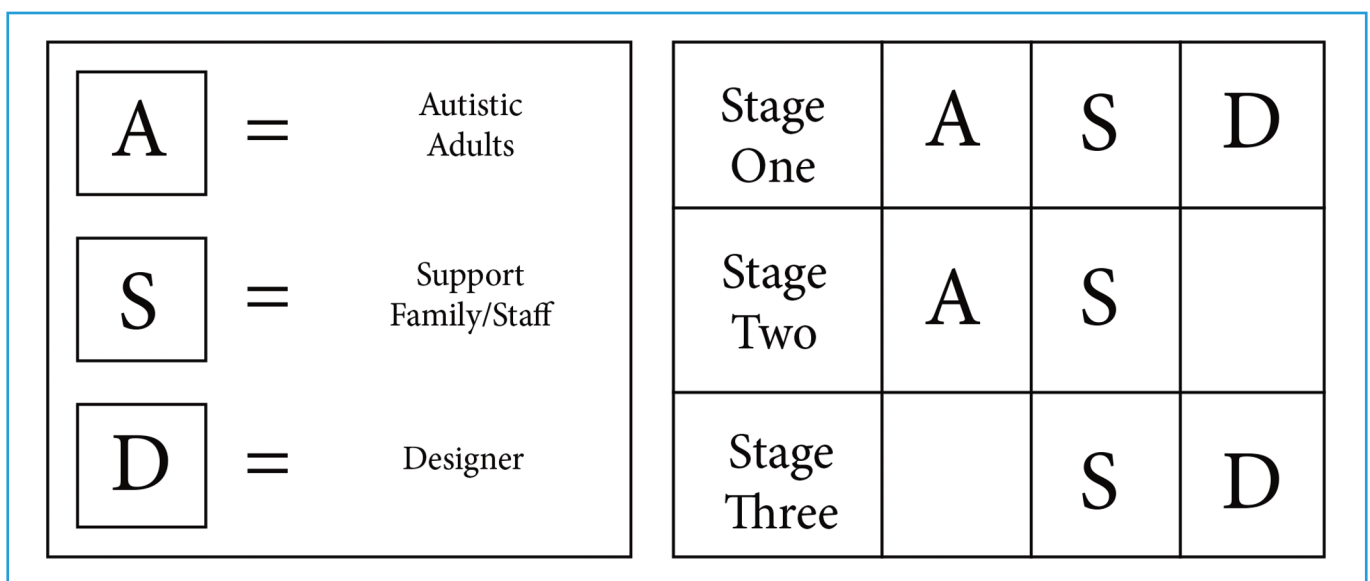


Figure 1 Persons present during the research

family members and support staff hold the key to understanding the person they support and every day engage in empathic acts to help them feel happy and their environment comfortable and enjoyable to live in. For example, the designer would not have asked the taxi driver to stop on the opposite street to where Sarah lives if the support worker had not informed her that Sarah does not like the sound of a car engine running. The support worker would not have connected Tim's anxiety one evening to the washing machine that had been switched off, if she had not first connected Tim's feeling of enjoyment to the sound of his washing machine. The support staff are now mindful not to arrange an outing with Pete on a rainy day, since they had connected his anxiety on previous outings to wet and shiny floors.

These empathetic acts are the result of developing deep and sustained relationships with the people they support and avoiding fundamental attribution errors, by which they objectively connect the person's behaviours to the surrounding environment. The designer's visit to Tom at the beginning of this paper is an example of how effective it can be. From the onset, the designer committed a fundamental attribution error, whereby on her first visit to Tom's home she internalised her thoughts and applied her subjective biases to the situation. However, on the second visit to Tom, the designer externalised her thoughts and objectively connected Tom's actions with the environment. It was this slight change of perspective that created a little understanding and empathy between the designer and Tom where different ways of seeing, doing, and behaving are embraced, accepted, and celebrated.

It is difficult to know how reciprocal this empathic connection was with the autistic participants in this research but what was genuine was the connection the designer felt while joining in with the things the participants enjoyed, for example, blowing bubbles with Tom, ripping magazines with Sam, and spinning objects and listening to the sound of the last spin of the washing machine with Sarah. These simple acts should not be underestimated, as they are the

important things that describe what wellbeing might mean for an autistic person, which as described by Milton may not be immediately apparent to a neurotypical person.

## 5 Conclusion

This research paper set out to expand our understanding of what wellbeing might mean for a person with autism, as well as how neurotypical designer's might empathise with autistic people, whose perceptions and experience of the world might be different to their own. By reflecting upon three design studies the paper concludes that while small adaptations had to be made to existing participatory design methods (e.g. swapping words for pictures), the majority of the methods were appropriate and complementary to the capabilities of the autistic participants. Consequently, exploring new ways to develop autism-friendly design methods was of little concern to this research. Instead, priority was placed upon the designer and her skills of interacting, listening, observing, and accurately interpreting information derived from the design methods. The priority of this direction was triggered and exposed by the designer's first visit to Tom's home (described at the beginning of this paper), where the designer's poor observation and misinterpretation led to an incorrect interpretation of 'destruction' with regard to his door and sofa.

The paper concludes that it was not the design methods but the perceptual shift of the designer that needed to change; this helped to create understanding and empathy between herself and the autistic participants. The perceptual theories (described in this paper) in combination with the expertise of the support staff aided this shift that encouraged the designer to step outside herself and exercise more flexible ways of perceiving the affordances of the environment. This is illustrated in the second visit to Tom's home, where the designer externalised her thoughts and tried to engage with how Tom experienced and perceived the affordances of his home by experiencing it for herself. Consequently, it was only when the designer knew how she felt about things and what her emotional responses to



things were, that she was able to start empathizing and understanding what another person's emotional response to those things might be.

The research proposes that Gibson's concept of affordance best supports a framework for designing with autistic people, as it describes how it is the relationship between the environment and a person's capabilities and not the infrastructure of our environment alone that creates action opportunities. 'Affordance is the mutual relationship between environment and animal. This relationship only exists relative to a particular animal, which can perceive it and use it' (Gibson, 1979, p. 29). Gibson's theory is therefore a useful framework to encourage more flexible design that invites different types of action opportunities and encompasses a subjective way of experiencing the world. It foresees making the environment compatible with all human actions rather than trying to direct and control human actions solely from a neurotypical perspective. By creating flexible environments that relate to the perceptual world of everyone, designers can help progress our conventional attitudes to the point where different ways of seeing, doing, and behaving are embraced, accepted, and celebrated and wellbeing extended.

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paper

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## Aalto LAB Mexico: Co-Designing to Maintain Ecosystem Services

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## Abstract:

As a strategy to achieve a sustainable way of living, the project Aalto LAB Mexico (ALM) aims to collaborate and empower a community called '20 de Noviembre' (located in Calakmul, Campeche, Mexico), who are currently vulnerable to climate change. Using co-design and ecosystem services valuation methods, we identified the existence of provision, support, and cultural ecosystem services within and around 20 de Noviembre. Climate change is modifying the provision of these services for which the well-being of these people depend. ALM aims to inspire community social innovation by collectively encouraging engagement across community members, experts, and students using co-design and valuation methodologies. The 'Water System' project was one such collaborative effort, designed as an attempt to empower the community to confront their own problematic, whilst maintaining their own livelihood and reducing risks related to climate change. This type of systemic approach may be able to ensure a sustainable future.

**Keywords:** *co-design, co-create, ecosystem service, sustainability*

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## 1 Introduction

Aalto LAB Mexico (ALM) is a project that works with the community '20 de Noviembre' (located in Calakmul, in the Mexican State of Campeche), using various knowledge fields. A first diagnosis at the community's site has established that this community is especially vulnerable to climate change; thus, the main objective for ALM is to empower the community as a strategy to achieve a sustainable way of living.

This paper describes how ALM used co-design methodologies and tools in order to preserve ecosystem services at the 20 de Noviembre community. Specifically, the co-design approach was employed to gather knowledge from experts and students from various nationalities, institutions (such as Aalto University, TEC de Monterrey and

UNAM), and disciplines. These methodologies relied on community participation during the various investigative processes, and the approach led to ideating feasible projects that could, at the very least, prepare the community to face or prevent disastrous effects from external factors.

Ecosystem services are elements the environment provides through its natural processes, including soil, water, and biogeochemical cycles, as well as the goods and services upon which humans depend for their livelihoods. Thus, the preservation of ecosystems is crucial for a balanced existence.

The ethnographic research methods and design tools revealed that provision, support, and cultural ecosystem services exist in 20 de Noviembre. The community obtain both water and food from their environment (they harvest rainwater and practice

subsistence agriculture and hunting); they also extract some raw materials (like honey and wood), which are used in some economic activities, including tourism. Additionally, an interview with officials from the National Commission on Protected Areas informed us that climate change has had a measurable impact on the study area. One aspect affected is rainfall patterns, and our measurements showed that the months of rainfall are reduced. This development certainly has not only environmental but also social impacts because many of the economic activities of the local people depend on water resources. Moreover, as the head of the government agency testified, the dry season may increase the risk that some species living in the jungle will enter the 20 de Noviembre community to find water.

In short, the vulnerability of the community's livelihood became evident. The level of vulnerability was increased also because the community were not focused or simply had ignored these climatic conditions (i.e. people did not report this type of information).

During visits to 20 de Noviembre, ALM formed the purpose of increasing the level of engagement among all involved stakeholders over time by employing co-design methodologies (Mattelmäki & Visser, 2011). ALM envisioned a two-stage process: the first stage aimed to sensitise experts that were exposed to and confronted with this specific ecosystem in context, and the second stage aimed to raise the awareness of the people about their vulnerability to climate change, should they choose to do nothing at all.

## 2 Climate change, ecosystem services, and co-design tools

### 2.1 Climate change and its impact on key ecosystem services

Previous discussion by Tompkins and Adger (2004) suggests that the climate is shifting and that projected changes will have significant impacts on ecosystems. Staudinger comments that 'climate

change is expected to increasingly impact, both positively and negatively, the provision and value of welfare-enhancing services around the world' (Staudinger cited in Nelson et al., 2013). These impacts are most commonly felt by natural resource-dependent communities, like the one examined in this paper.

Mexico has a long history of legal inconsistencies that have resulted in failure to protect the habitat and natural ecosystems. Such lapses during the second half of the twentieth century have included permits and concessions that have been legally granted for the exploitation of natural resources, the absence of integration of policies for the protection of the environment, and government weakness in terms of enforcing environmental justice. These failures have resulted in a deep deterioration of the ecosystem services of this country, especially in rural areas (Carabias, 2012) because such policies favour the commercial exploitation of natural resources in order to generate revenues.

The most significant environmental issues in this country are soil erosion, deforestation, watershed pollution, desertification, loss of biodiversity, and coastal and marine habitat destruction (Tello, 1991; INEGI, 1995; Plan Nacional de Desarrollo, 1995; Gomez-Pompa and Kaus, 1999 as cited in Cruz-Torres, 2000). Eighty percent of the land is eroded, and 31 of the nation's most important aquifers are contaminated (as cited in Cruz-Torres, 2000). In addition, Gomez-Pompa and Kaus (1998) state that there is deforestation rate of 500 to 800 hectares of rain forest per year (Cruz-Torres, 2000).

For many years, such natural resources as crops in agriculture, bees in apiculture, and fish in fisheries have sustained rural communities. In some rural settlements in Mexico, up to 65% of headed households depend on agriculture, and about 23% of the households are engaged in subsistence farming (Cruz-Torres, 2000). For this reason, it is said that any decrease in the availability of natural resources contributes to further marginalisation and impoverishment of an already poor rural

population. In Mexico, for example, eight in every 10 rural families are poor, and four in every 10 rural families live in extreme poverty (Carabias, 2012 as cited in Cruz-Torres, 2000).

This paper discusses specifically the Mexican *ejidos* (this refers to a rural property for public use) to which the 20 de Noviembre community belongs and which is the site of the ALM project. In this type of social organisation, land distribution restores the property rights of the indigenous communities (Boege, 2009). Some opinions and stated positions concerning the *ejidos* suggest that the ownership of the land and the consequent benefits from its use must ensure care for and maintenance of the original ecosystem (Carabias, 2012). The inhabitants of the 20 de Noviembre *ejido* use the natural resources of their environment for their survival and development; hence, the ravages of climate change pose a serious risk in terms of maintaining a balanced ecosystem.

During the ALM process, the experts, students, and inhabitants of 20 de Noviembre, identified some of the factors that have increased climate change risk. Notably, these included lack of knowledge about the impact of current relationships with the ecosystems, as well as the direction they are headed and the long-term impact, as follows:

- little integrated action among the people for solving problems,
- little power for solving environmental problems (among others) owing to an expectation of government involvement, and
- lack of systemic strategies for the medium and long term in response to evident conflict at this time, as predicted within the community by ALM experts in sustainable development.

From the previously cited risk factors, one of ALM's key objectives was to develop ways to ensure the empowerment of the 20 de Noviembre people for protecting and maintaining the health of the ecosystem services upon which their livelihoods depend. By using co-design tools, in addition to offering discourse-based ecosystem services

valuation methods (to empower the people to handle their own problems), ALM sought to ensure sustainable livelihoods by integrating different kinds of knowledge (empirical and academic). Thus, with the cooperation of the community and its residents, solutions could be generated that were relevant to their aspirations and lifestyles whilst focusing on ecosystem protection (Nousala & Garduno, 2013; Nussbaum, 2010).

## 2.2 Ecosystem services: a common good

As one component of ecosystems, humans depend on ecosystem properties and interactions for sustenance, just like all other species. In this way, ecosystem services are those benefits that people obtain from nature (United Nations Environmental Programme (UNEP), n.d.). They have been classified into four main categories according to the Millennium Ecosystem Assessment (MA), as shown in Table 1.

Ecosystem goods and services are inherently public in nature, containing all 'the conditions and processes through which natural ecosystems and the species that make them up, sustain and fulfil human life' (Daily as cited in Howard & Wilson, 2002). Thence, goods and services provided by an ecosystem benefit the society as a whole, not merely individuals.

The first step is to define the ecosystem services in order to consider their characteristics, those of the systems from which they derive, and which are most important for purposes of understanding their link with human welfare. However, it is also important to know the value of ecosystem services for a particular community in order to achieve social recognition and acceptance of ecosystem management (Villa et al., 2002). To quantify this value, different methods based on economic approaches have been developed. The most common are contingent valuation, hedonic pricing, and the travel cost method (Organization for Economic Co-operation and Development (OECD), 2002). Nonetheless, because ecosystem good services are common goods,

these ‘traditional’ methods must be merged with methodologies that employ open group deliberation (Coote & Lenagha; Jacobs, Blamey & James as cited in Howard & Wilson, 2002). One example of this is the ‘discourse-based method, in which community members collaborate to determine which ecosystem services are primordial and the value they may have. Therefore, the value of ecosystem services is meant to result from group consensus rather than the sum of individual preferences (Howard & Wilson, 2002). It was fundamental for the inhabitants of 20 de Noviembre to understand the services they get from natural resources and are required to maintain, mainly because of the complex relationships between them. For example, their ability to use different plant species for food depends partly on good soil conservation, which is also related to nutrients, water retention, and infiltration; its natural ability to resist disease; and its relationship with the living organisms which are, in turn, part of other food chains.

Specifically in the case of 20 de Noviembre, the collaborative work of different stakeholders with various perspectives has highlighted the need to strengthen several of the items listed in the MA classification. Based on their relative importance for the livelihood of the people, ALM currently focuses its efforts on three issues in particular, the ‘Water System’ (the provisioning service) being one of them.

### 2.3 Methodology: Co-design for maintaining ecosystem services

Even though the valuation of ecosystem services involves community participation, the final results and proposals tend to stay in reports without offering a practical, tangible solution. For this reason, the valuation methods of ecosystem services must be merged with additional methods in order to achieve visible solutions for the final users. In this fashion, ALM used the co-design approach as its methodology to tackle this issue and accomplish its objective. Co-design ethics focuses on ‘designing to enable people to live as they like’ by participating in the social process of community ideas development (Manzini, 2006).

Co-design involves the collaboration of users as well as a design team and other important stakeholders, and it empowers participants by letting them offer their expertise and knowledge in the designing process (Mattelmäki & Sleeswijk, 2011). In this matter, participants interact to create solutions in which everyone is interested, which is known as ‘co-creation’.

Specifically in the case of ALM, the initial stages of the project (2012) were dedicated to conducting workshops with students led by experts, which aimed to start mapping an overview of stakeholders in relation to the quality of life of the inhabitants of 20 de Noviembre. This first overview served as

**Table 1** Classification of ecosystem services according to the MA

<b>Provisioning services</b> <i>Products obtained from ecosystems</i>	<b>Regulating services</b> <i>Benefits obtained from regulation of ecosystem processes</i>	<b>Cultural services</b> <i>Nonmaterial benefits obtained from ecosystems</i>	<b>Supporting services</b> <i>Services necessary for the production of all other ecosystem services</i>
<ul style="list-style-type: none"> <li>• Food</li> <li>• Freshwater</li> <li>• Fibre</li> <li>• Fuel wood</li> <li>• Genetic resources</li> </ul>	<ul style="list-style-type: none"> <li>• Climate regulation</li> <li>• Water regulation</li> <li>• Disease regulation</li> <li>• Water purification</li> <li>• Pollination</li> </ul>	<ul style="list-style-type: none"> <li>• Cultural heritage</li> <li>• Recreation / ecotourism</li> <li>• Educational</li> <li>• Sense of place</li> <li>• Inspirational</li> <li>• Religious and spiritual aspects</li> </ul>	<ul style="list-style-type: none"> <li>• Soil formation</li> <li>• Nutrient cycling</li> <li>• Primary production</li> </ul>

Source: Millennium Ecosystem Assessment (UNEP, 2003)

background for students and experts when they were in the community conducting interviews and workshops with local people. In subsequent stages of the project (2013), work focused on more specific issues which were defined after reflecting on what was learned in the field. New workshops and charts were designed by the students and experts for closer engagement with the inhabitants to identify stakeholders and key actions, and to outline priorities for the subsistence of the community (Figure 1).

The role of design throughout the collaborative process, from problem contextualisation (where the mapping of stakeholders and involvement starts) to finding and implementing solutions, is to generate interfaces. In the early stages of the collaborative process, the design works to help explore problems, reveal questions that make sense to everyone involved, and through creativity exercises, advance beyond the most obvious questions to the ‘meta challenge’ to be solved (Fuad-Luke, 2012). Having identified the

problem, design methodologies help to extract the knowledge and skills inherent to each stakeholder – for example, through brainstorming. Later in the process, design works as a facilitator in communicating ideas – for example, in using visualisation tools that help the stakeholders understand the proposals. Before the solutions created in conjunction with various stakeholders are finally implemented, the design generates experimental interfaces so that the ideas can be tested and improved in an iterative process with quick prototyping.

In this sense, co-design can function to trigger ‘creative communities’, helping to develop interaction among stakeholders that enables social innovation, in this case towards more sustainable livelihoods in a rural community. A creative community can be understood as a group of people who share different knowledge and experiences that, through discourses and performances, create something new and valuable, such as wellbeing (Steinsson, 2013).

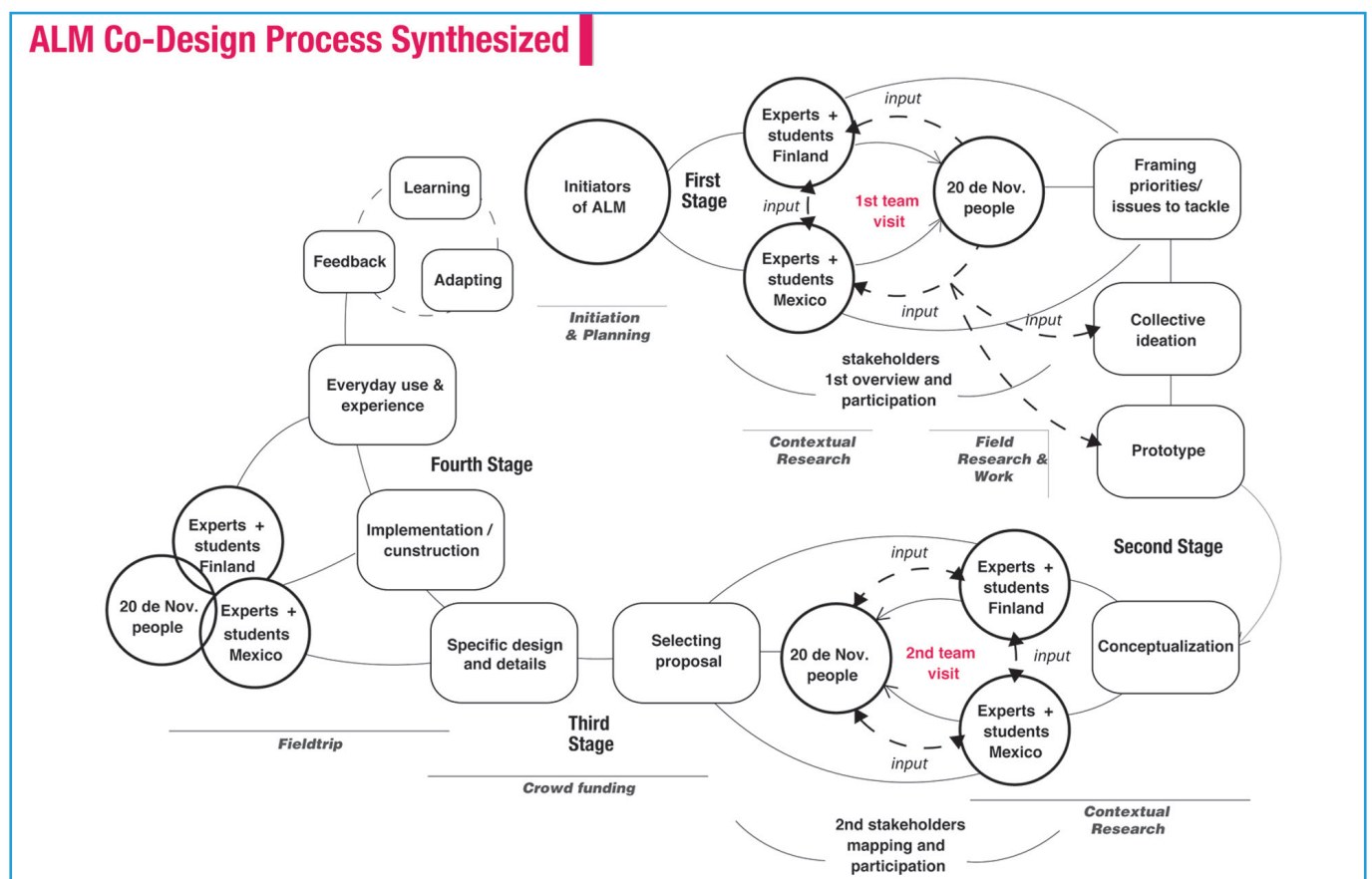


Figure 1 ALM Co-Design Process synthesised. Based on the scheme ‘An idealized schematic for the co-design process’ (Fuad-Luke, 2012).

Source: drawn by Xaviera Sánchez de la Barquera



## Design Probes



**Interviews were done in 17 households, which account for 15% of the community population, to ascertain the different uses of water in each house.**

**Figure 2** Design probes (Mattelmäki, 2006) were developed as a tool to facilitate research.

**Source:** Slide made by the LABBERS for the ALM 2013 presentation.

ALM have set these processes in motion, for example, on issues related to water ecosystem services. This is a form of interaction in which problem solving is elicited from the inhabitants with the support of experts. Thus, a network of both local and outside people emerges, which may serve to empower the people of 20 de Noviembre to create solutions that previously could not be considered.

The next section of this paper explains how co-design tools and methods have been combined with participatory ecosystem services valuation methods in the ALM sub-project 'Water System'. The aim was to achieve a desired solution for one specific problem, previously defined by the collaborating team (i.e. with and for the final users) by sharing a collective creation and innovation process.

### 3 'Water System': Using the co-design approach to make intangible climate change risks tangible

As a result of the combination of the methods mentioned above, the Aalto LAB Mexico multidisciplinary team realised that 20 de Noviembre community members strongly rely on the environment's natural services

for their sustenance, especially on rainwater.

This finding emerged partly from ethnographic techniques for design, but mainly from coexistence over some weeks in which the most significant visits to the community occurred. For two different periods during autumn 2012 and autumn 2013, students from different fields in Mexico and Finland, as well as experts in energy, sustainable development, systems thinking, and design lived in the houses of the community people, exchanging ideas with them and learning from one other.

During the first visit, the experts who led workshops gave a general perspective of the 20 de Noviembre livelihood situation. Then, after a year of research on the findings and prior to the second official fieldtrip (the experts conducted a few memorable extracurricular fieldtrips), students from both countries worked with consultants to develop workshops designed specifically to work with the community to develop the projects further (concerning water issues and two other large themes). The goal was to create a rich background of necessary information so that the water problem could be addressed once work had been established within the community.

From community involvement with the co-discover workshops, interviews, and observations during the second visit (Figure 2), we concluded that 20 de Noviembre residents use water as a resource to satisfy their basic needs, which are as follows:

- drinking
- cooking
- cleaning
- personal hygiene
- washing clothes and dishes
- farming
- irrigation

To address the need for a steady water supply, rainwater collection systems have been installed all around the community with the collaboration of two Mexican governmental institutions – CDI (National Commission for the Development of Indigenous Peoples) and SEDESOL (Social Development Secretary) – and that of the Non-Governmental Organisations working in the region.

Nonetheless, we revealed several issues relating to this topic. For instance, the water quality was found not to be the best for human consumption: biological agents and other hazardous components were present in ALM’s water samples (Figure 3). Some of the people, being aware of these issues, have preventive sanitary practices (like boiling water or buying bottled water), but most of them

<b>Prior to the fieldtrip</b>			
<b>Water quality</b>			
<b>Results of samples vs. regulation (NOM-127-SSA1-1994)</b>			
Compound	Result	Condition	Permissible
Coliform organisms	Present	x	Absent
Cl	250	within limit	250
Fe	0.3	within limit	0.3
Na	200	within limit	200
hardness	560	x	500

**Figure 3** Results of water samples taken by Omar Rojas from two households in 20 Nov, analysed by Fernando Méndez and interpreted by Pablo Monterrubio.

**Source:** Slide made by the LABBERS for the ALM 2013 presentation.

do not. Even more, the water resource is being compromised owing to current changes in the region’s climate conditions, as an official from the National Commission on Protected Areas told us in an interview. Karl et al., (as cited in Nelson et al., 2013) affirm that climate change is expected to create variability in the water supply, as well as to change the evaporation and evapotranspiration rates, making water scarcity and water-quality issues more evident.

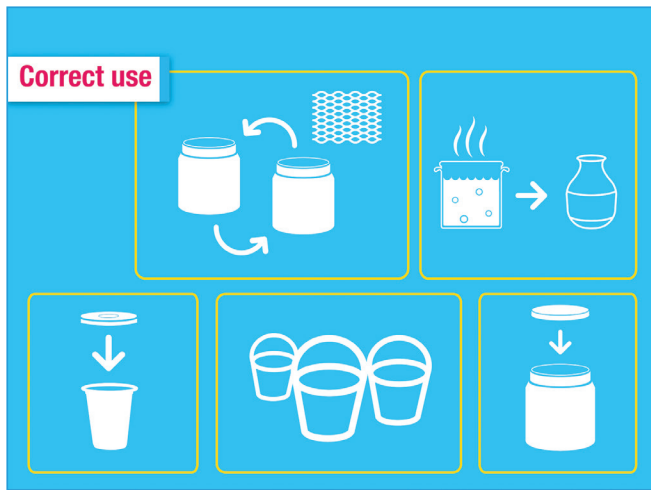
We found that the 20 de Noviembre community was lacking a basic human right, as defined by the UN: ‘On 28 July 2010, through Resolution 64/292, the United Nations General Assembly explicitly recognised the human right to water and sanitation and acknowledged that clean drinking water and sanitation are essential to the realisation of all human rights’ (UN, 2010).

To cope with this problem, the ALM team finalised a proposal named ‘Water Project’. The main objective of the project is to ensure water safety for the wellbeing of all community members. To achieve this, three main proposals were defined:

- Water purification techniques (filtration, use of chemicals, boiling)
- Amelioration of rainwater harvesting systems (enlargement for more water storage)
- Construction of a *jagüey* (human manufactured lake)

The water purification techniques are used to achieve better water quality, as well as the safe and complete use of rainwater and a substantial reduction in people’s expenses for bottled water. Expanding the rainwater harvesting systems ensures enough water supplies for a long period (even in dry seasons) for the community members. Constructing a *jagüey* prevents jungle animals that are looking for water from entering residential areas.

The three above-mentioned proposals require further research, development, and funding. However, by making use of co-design tools, ALM was able to



**Figure 4** When the students shared their learning with the community members, the latter were able to identify best practices for water use in their situation.

**Source:** Slide made by the LABBERS for ALM 2013 presentation

identify immediate actions that will reduce the risk of consuming bad quality water. Once students and experts shared their information about the hazardous situation, the community members became engaged in identifying best practices to achieve positive changes in order to face their own problematic – in this case, water quality and supply owing to shifts in climatic conditions.

## 4 Discussion

Nousala and Garduno (2013) write that ‘The contribution of the ALM research aimed at enhancing recognition of the potential for design thinking to translate the learning process, through a communicative platform in a poly-disciplinary context. The ALM project also addressed the importance of an empathic approach and awareness of intercultural problems. Both of these aspects were required from all fields to address sustainability issues, which impacted social complex adaptive systems, on multiple scales...’

Because the project was aimed at empowering those engaged in the process, it was necessary to involve layers of thinking and tools to match that would create awareness and would emphasise humans and the impact of everything within the ecosystem. We also needed to engage peoples’ interest regardless

of their levels of experience or expertise (Garduno & Nousala, 2014).

Nousala and Garduno (2013) also note that The ALM project continues as an educational exercise that aims (among other layers)... to nudge the students’ interest towards matters traditionally exclusive to the humanities field through design thinking...’. The project was thus meant to ‘go beyond’ so as to ‘... include those topics that are non-human based issues and concepts...’.

Through all of the instances of learning and doing, it was possible to demonstrate how the process and approach of ALM gave all participants, regardless of their life experiences and background, a way forward to share what they know as well as to find out what they need to know, how to learn it, and how to do it. These combinations of methods, tools, and approaches made it possible for participants to extend beyond the individual to include in their daily activities what needs to be done, whilst simultaneously creating the possibility to build on what could be done collectively (Garduno & Nousala, 2014). In this sense, we also need to consider monitoring changes in the ecosystem that result from socio-environmental processes, such as urban growth, exploitation of aquifers, and habitat fragmentation, so that we can adopt emergency measures for adapting to changes that may arise from climate change.

Highlighting these commonalities between theory and application through a holistic approach was something that the design discipline and relevant tools could offer, and they did so to great effect.

## 5 Conclusion

As an initial experiment, the Aalto LAB attempted to create and apply a co-design approach for maintaining ecosystem services that are vulnerable to shifts in climatic conditions. The skill sets that are now becoming critical for delivering a new way of both highlighting and maintaining key processes for humans and environments will need further development. Models like these are necessary

for encouraging project-based learning solutions and experiences that support approaches for empowerment. Co-design and design education has a significant role to play in this work, as it has the ability to provoke understanding and interest that can extend the constructs of knowledge through exchanges between design thinking and other disciplines and approaches (Nussbaum, 2010). The Water System project of ALM provides an excellent example of this method. Ultimately, ALM offers an experience that is becoming a critical factor for all communities that wish to learn the best way to engage with their environments as well as what knowledge that is relevant to themselves should be constructed and how to construct it (Nousala & Garduno, 2013).

The students, the experts, and the members of the community have engaged in learning how to design projects that have the potential to enlarge their capabilities. Previous projects in the region had elicited community participation but had not included its members in the implementation process, causing them to cease work on the projects. While the Water System project is still in the exploratory phase, the other two projects are in the implementation phase. Some members of the community have indicated that they value the opportunity of walking through the process with ALM, from (1) the identification of areas of opportunity to (2) the generation of projects and (3) the implementation.

## Acknowledgements

We would like to thank the inhabitants of 20 de Noviembre for trusting us and letting us work with them. Very special thanks to all the experts and facilitators who assessed this work, particularly the water project (Pablo Monterrubio, Renata Fentón, Fernando Méndez González, Jussi Alaputto). The fieldtrip was made possible through the financial contributions made by Aalto University, Tec de Monterrey, and UNAM. Finally, very many thanks to all the LABBERS, the spirit of ALM.

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paper

8

Engineering Perception: Approaching the  
Urban BoP for Provision of Financial Services

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## Abstract:

The paper under scrutiny aims to provide a perspective on the tricky Bottom of Pyramid (BoP) urban demographic panorama, to understand, ascertain, and distil the brand semiotics deeply rooted in its psyche. The main purpose of the research is to connect—for social enterprises willing to work towards financial inclusion—consumer requirements and the planning and execution of a sound and holistic brand strategy. Interviews with members of the BoP in India revealed four key concerns regarding financial entities: (1) Familiarity with the service provider; (2) Convenient entry and access points; (3) Flexible payment schemes; (4) Cordial and amicable approach. Results from an empirical study of the interviews and learning from a Teach-Back point towards the need to provide “Personalized Privileged Banking” for the urban poor. For improved brand penetration and recall, brand architecture and language should be developed on the basis of these research findings. The paper applies its findings to the development of an empirical, all-inclusive matrix useful for future sustainable financial inclusion system design, especially its branding design elements.

**Keyword:** *financial inclusion, brand strategy, bottom of pyramid, urban poor, brand design*

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## 1 Introduction

The promise of a rising India has bedazzled many, but the paradox of its forgotten poor has generated interest in new approaches to social inclusion that resolve extreme economic disparity. This paper stems from the quintessential need to disseminate financial education and imbibe practical financial literacy amongst the Bottom of the Pyramid (BoP) masses, both activities being required to create the basic foundation for any financial activity.

Although BoP masses possess small and inexpensive assets, mostly in day-to-day sustenance amounts that may not seem big on a transactionary scale, these amounts, coupled with the volume of people transacting them regularly over a period of time, form

an economy worthy of being included and regulated for the greater good of the masses. Currently, as the members of this segment have little or no fixed assets, they are at risk of being taken advantage of, owing to their lack of awareness and to the lack of security their meagre liquid incomes provide. Their inability to prove social identity reduces their chances of accessing mainstream financial saving instruments, creating an innate scepticism that thwarts their chances of securing a safe financial future. Social initiatives in the BoP segment are difficult to implement as a lack of awareness compounded by rumour mongering and a sceptical attitude towards the customers in the segment demands higher inputs for establishing trust. This is where the researcher’s hypothesis of engineering (or re-wiring) perceptions and aligning pre-conceived

notions through a holistic brand strategy is required to build the trust mileage required for the success of the venture.

Further, since the segments of customers are differentiated by interests, priorities, and attitudes, (Dhumal, Tayade & Khandkar, 2008), a very important part of the study is perception and financial profile mapping of target customers. This study aspires to unearth their needs in the context of their existing surroundings. The researcher needs to interpret the chaotic and often cluttered information characterized by varied profiles, sporadic income sources, difficult living conditions, lack of education and information, and generic follower tendencies. The virtually untapped BOP mass market consumer needs to be studied to arrive at a comprehensive yet pragmatic and relevant brand structuring for rolling out a social venture aimed at financial inclusion.

## 2 Methodology

The research employs a qualitative approach since it deals with subjective assessments of attitude, opinion, and behaviour. It also needs to culminate in a decision-oriented, definitive brand positioning strategy. According to Berg (2007), qualitative research seeks to answer questions by examining various social settings and the individuals who inhabit these settings. Qualitative researchers are interested in human arrangements and their settings and in how inhabitants of these settings make sense of their surroundings.

In the first phase, existing studies are reviewed to gain understanding of the context of concern. Also, as a benchmark, qualitative analysis of web content, media presence, and brand messaging is carried out for current companies in the domain.

The second phase is recording of the respondents' perceptions by means of open-ended questions. These represent the primary data of the study. The data derived from the interviews is analysed through text data analysis, a form of content analysis described by Berg (2007).

The responses on all questions are systematically organized, processed, analysed, and presented in the respondent's own words. Since questions are open-ended, the responses are sorted into categories established through a reading of the data itself. This makes the method unique. Field notes are made verbatim, as the style of questioning is conversational. The insights hence drawn by the researcher, however, are translated into English for global understanding. The researcher has tried her best to not lose the emotional impact of the consumers' responses.

The research then goes further using Design Thinking Approach—a discipline that makes use of the sensibility of a designer and the methods to match people's needs with technologically feasible and viable business strategies that create customer value and market opportunity (Brown, 2008)—to use interview data to create a Voice of the Customer, markers for brand positioning, and interpretative insights useful for drawing up a definitive brand positioning and identity strategy.

Kotler & Keller (2006) provide at least a partial rationale for an in-depth user when they say, "The buying actions of consumers are known to be greatly affected by their thought process and the feelings experienced. They are also influenced by factors like opinion of others, and self-concept deriving from that opinion." Researchers were dealing with a unique, nearly invisible target consumer segment until its immense business value was recently brought into the limelight by proponents of Bottom of the Pyramid (BoP) volume economies like C K Prahalad and Muhammad Yunus, who promote "re-engineering of the supply chain to deliver products and services to the population that is currently un-served". There exists no segmented and logical demographic matrix to understand their mind space owing to the varied chaotic lifestyles and profiles in the segment. Hence, to understand Bottom of the Pyramid consumers who are the target consumers for this study, it is imperative to –

- Gain access to the way people attribute meaning to what goes on around them,
- Find out how they react to action or lack of action (Pralhad, 2009)

However, the researcher understands, it is very rare for qualitative data to be collected all in one go, then processed and analysed. If that happens, we might criticize the project for not being true to the context in which it was generalized, which would make it a weak piece of work. To avoid this and to produce believable, credible, and trustworthy work, the researcher aims to use triangulation by adding other dimensions, like an Expert Teach-back. Triangulation is a term borrowed from geography. In qualitative analysis it means more than one perspective on a situation. This element augments the current study, offering expert perspective on the topic being studied and clearing away any of the researcher's misconceptions or biases.

## 2.1 Sampling

In order to achieve the research objectives, non-probability purposive random sampling was employed. Considerations of convenience, time, and cost along with the desire to perform this study in an optimum way without diluting the essence of the research led to the following sampling criteria:

### **Type of Universe:**

Finite: Bottom of the Pyramid (BoP) population in Pune.

### **Sampling Unit:**

Chawls, wadas, and slum dwellers in the urban city of Pune.

The description of inexpensive rental accommodations available for BoP population in Pune is as follows:

1. Chawls; Patra chawls (consisting mainly of semi-permanent structures, which can be both authorised and unauthorised)
2. Zopadpattis (squatter housing) and pavement dwellings

3. Wadas: crumbling very old settlements refurbished from time to time

### **Size of the Sample:**

Twelve semi-structured interviews of potential consumers and current users of various financial services.

### **Parameters of Interest:**

Nil or basic involvement (any form of savings, chit fund account) in Banking Activity, Economic status of BoP

## 2.2 Questionnaires

The questionnaire was unstructured, containing mostly open-ended discussion-cues to help the interviewer attain desired information without breaking conversation flow. All interviews were video and voice recorded, as per the comfort level of the respondents. The questionnaire was pre-tested to determine if relevant perceptions would be gathered and whether the questions would be interpreted correctly.

Since the pre-tested questionnaire produced meaningful data, the researcher decided to use interviews as the principal research instrument.

The questionnaire was divided into four main parts, each designed to gain specific insights:

- 1) Demographics: This was formulated to create a consumer profile in the mind of the researcher and to derive important information for further use anywhere quantifiable user statistics were required.
- 2) Aspirations: Consumer aspirations were mapped; thereby, clarifying the need for brand diversification and positioning.
- 3) Financial Activity: An understanding of the current level of customer involvement in financial activities was important to judge the practical, tangible needs of the segment.
- 4) Brand Perception: As Kotler and Keller (2006) explain, an individual selects, organises,

and interprets information by the process of perception, which also depends on other internal factors like belief, experiences, needs, moods, and expectations. Insights from this segment helped the researcher form brand personality guidelines, through qualitative data analysis of keywords derived from consumer inputs.

### 2.3 Data Analysis

The text data analysis method of Berg (2007) requires that perceptions be recorded in the exact words of the respondents, with verbatim field notes and recordings used as the main data for analysis. However, since the respondents' language is a mix of Marathi and Hindi, the researcher has translated these notes into English, while striving to preserve the emotional impact of each response.

First, all perceptions collected through the questionnaire are recorded on an Excel spreadsheet in the translated words of the respondents, and the frequently mentioned needs are placed in a framework as illustrated in Table 3.

Table 1 explains the steps followed in text data analysis.

## 3 Discussion

### 3.1 Understanding Paradigm Shifts in Marketing and Branding

The researcher acknowledges the need to build upon previous academic and applied work in the domain of brand building, more specifically the work on lower economic strata markets.

Hence, Table 2 presents major marketing and branding paradigm shifts that have accompanied the

shift from an industrial economy to an information economy, according to the researcher's thorough review of literature.

While this model of branding for information economies is current, it needs further tweaks and customizations in order to be applied successfully to BoP consumers. For one, organizing by customer segment is not possible owing to the varied BoP consumer base and its sporadic income attributes—neither of which can be quantified neatly to compile a comprehensive demographic profile. Further, absence of any qualitative analytical matrix for these consumers makes it more difficult for the researcher to gain insights on the user patterns and behavioural preferences required to create a Brand Architecture. Also, navigating the communication planning and dissemination approaches that are effective with BOP consumers is like finding one's way through the catacombs: the researcher would end up dwelling more on these aspects of the field research that are necessary to validate widely-held notions about region-specific marketing and less on the electronic marketing necessary to be efficient in creating brand awareness with these consumers.

A survey by the National Council for Applied Economic Research (NCAER), India's premier economic research entity, recently confirmed that the rise in rural incomes is keeping pace with the rate of increase in urban incomes<sup>1</sup>. To tap that market, every marketer needs to understand the rural market and rural customers by creating awareness or increasing visibility of his brand in an environment where the perceptions and values a consumer imparts to the brand are major governing factors.

Some of the reports reviewed here have hinted that the basis of any financial service is trust. This trust

**Table 1** Text Data Analysis

Step 1	Recording of consumer responses
Step 2	Identifying frequently mentioned needs
Step 3	Grouping the most frequently mentioned needs in a primary needs framework

<sup>1</sup> CRISIL, a global analytical company, providing research, ratings and advisory services, (2012) mentions the survey in a press release.

**Table 2** Differentiation between industrial economy & information economy marketing (Fort 2005).

Marketing in an industrial economy	Marketing in an information economy
Customer-as-target	Customer-as-relationship
Organize by product units	Organize by customer segments
Focus on profitable transactions	Focus on customer lifetime value
Focus on satisfying shareholders	Focus on satisfying several stakeholder groups
Build brands through advertising	Build brands through company behavior
Measure customer satisfaction	Measure customer value and loyalty
Over-promise to get an order	Under-promise, over-deliver
Make the firm the unit of analysis	Make the value chain the unit of analysis

can be communicated to consumers by an effective brand building exercise customized to the selected group. In subsequent sections, the researcher will validate some of the points partially hinted at by the literature review and apply new domain understanding gained through ethnographic user interviews to meet the stated goals of this study.

### 3.2 Industry Benchmarking

The researcher believes a brand’s unique positioning is the most important factor which allows it to stand differentiated from its various competitors. Although considering competition as a benchmark is acceptable, building a model replicating them does not bring the brand to a favourable position. Creating a niche while being a late entrant, is possible provided there is aggressive disruptive marketing and creation of a differentiated profile in the same segment—close to the competition though not at the same spot.

It is instructive to consider a few examples of existing financial service providers to the BoP, to study their branding strategies, and to develop further understanding into the brand positioning

opportunities that exist for other providers. The few companies discussed here are noteworthy placeholders in the domain of financial service provision to bottom of the pyramid consumers.

*Oxigen Services Pvt. Ltd.*, has demarcated its various verticals with a “house of brand” strategy, having the advantage of approaching its customers with its varied offerings in a 360-degree branding sphere suited to their customized needs. Even while providing a range of services, Oxigen does not confuse consumers, mainly due to its clear and neat branding.

*Sanchayan* and *Zero Mass foundation* have a single minded focus on the services they provide and the consumer segment they serve. ZMF offers services at the grassroots level and it concentrates on the rural sector.

*Sanchayan* has successfully demarcated its services around its core business of providing financial literacy to youth to enable them to manage their personal finances.

Taking into consideration the core business propositions made by these and other players in the



**Table 3** High Frequency category of need

Category	Need	Respondents											
		R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12
C1	Familiarity	1	1	1	1	1	1	1	1	1	1	0	1
C2	Trust	1	1	1	1	1	0	0	0	1	1	1	1
C3	Daily Savings	1	1	1	0	1	1	0	0	0	0	0	0
C4	Awareness	1	1	1	0	1	0	0	0	0	0	0	0
C5	Affordable	0	0	0	0	0	0	1	1	0	1	1	0
C6	Convenient Access	1	1	1	1	1	1	1	1	1	1	1	1
C7	Convenient Entry	1	1	1	1	1	1	1	0	0	1	0	1
C8	Aspirational Saving	1	1	1	1	0	0	0	1	1	1	1	0
C9	Flexi-options	1	0	1	1	0	1	1	1	1	0	1	0
C10	Cordial Executives	0	1	0	1	1	1	0	0	1	1	0	0
C11	Local	0	0	0	1	1	1	1	0	0	0	0	0
C12	Emergency Schemes	0	1	1	1	0	1	1	0	1	0	0	1
C13	Document Assistance	1	1	1	0	1	0	1	1	1	0	1	1

industry, they clearly are working towards provision and distribution of services to the poor. However, they have yet to tap into their customers’ aspirational goals or to customize their offerings so that their customers have a choice. A differentiation of the consumer as underprivileged and poor does form the core of his identity as a target consumer, yet the researcher feels that the key to identity may lie not in the consumer’s needs but in his aspirations. Financial inclusion is the need recognized by most financial entities around the world as a definite opportunity for growth and sustainability but mere sympathizing with the consumer may not be a successful strategy any more. The need that emerges calls for providing the Urban Poor with “Holistic Finance management” instead of just being facilitators.

### 3.3 Analysis of Consumer Needs

#### 3.3.1 Need Identification

It is important to build constructs and identify patterns in the data. Responses were translated from the field notes and interviews for universal understanding. It is important to note that some needs were mentioned more than once by a single respondent but were counted as one response by the researcher.

After a complete tabulation, it became clear which responses were mentioned most frequently.

Frequently occurring responses were grouped together with the aim of keeping the data transparent and tractable.

The frequently mentioned categories of need were translated into keywords and copied into another workbook as shown in the Table 3 above. The individual respondent’s responses were then plotted in the columns represented by R1 to R12. Each of the respondent’s responses are plotted against the 13 most frequently mentioned needs, with a “1” indicating that the respondent mentioned the need and a “0” otherwise.

The rows C1 to C13 present the category of needs as formulated after the analysis of recorded responses.

For example, the responses indicated in Table 3 by respondents (R2) and (R3) summarize the following translation of their stated needs:

R2-“Prefers an agent collecting the amount over having a small micro branch opened in his vicinity as he does not have the time to go. He might end up not saving anything if someone doesn’t reinforce the need to put some amount aside.”

R3-“Her son wants to set a computer shop. She wants all her children to study and get some jobs for regular income. If they get a loan without much hassle, it’ll help them expand business.

She needs to save for her daughter's and son's marriage.”

For (R2), these sentences indicate a clear need for convenient access to services and a requirement for daily savings. In Table 3, these were marked with a “1”. Similarly, “Aspirational saving” and “Convenient access” have also been marked “Similarly , “for (R3)”, “aspirational saving””.

### 3.3.2 Grouping of the 4 Primary needs

The third step consists of grouping the initial 13 high frequency needs in a four-category primary perception framework. The needs are grouped according to similarity in direction, as indicated by similar colours in Table 4 and Table 5 respectively.

In summary, the four primary need categories are as follows:

- # Local Premium Banking – relates to the local flavour and amicable approach the target consumer expects from a financial service. It includes affordability of schemes, personal relationships they build with executives, and

**Table 4** High frequency category of need

Category	Need	Primary Need
C5	Affordable	P1
C10	Cordial Executives	
C11	Local	
C13	Document Assistance	
C6	Convenient Access	P2
C7	Convenient Entry	
C9	Flexi-options	
C12	Emergency Schemes	
C8	Aspirational saving	P3
C3	Daily Savings	
C4	Awareness	
C1	Familiarity	P4
C2	Trust	

**Table 5** Framework for the 4 primary needs

Category	Primary Needs
P1	Local Premium Banking
P2	Personalized Convenience
P3	Encouraging Savings
P4	Familiarity

assistance they receive to understand and utilize their policies.

- # Personalized Convenience – consumers expecting door step services, convenient entry into the system, schemes to suit their needs, and emergency/easy loans.
- # Encouragement towards savings – relates to unrealized need of aspirational savings and the importance of financial awareness; creating financial discipline.
- # Familiarity – captures the basic need of creating familiar approaches that consumers look for in financial entities before trusting them with money.

### 3.4 Brand Perception

Respondents were questioned about their perceptions of brands. It was observed that most respondents reacted to the inquiry in an indirect, metaphorical manner. For analysis of that data, semantic analysis was used. Semantic analysis is the process of relating syntactic structures–phrases, clauses, sentences, and paragraphs–to their language-independent meanings.

The exact words of the respondents are recorded as field notes in Hindi; however, to make the understanding of the research global, the researcher has translated those words, phrases, and sentences to draw recordable and workable insights.

These responses are further analysed for keywords. For instance, translation analysis of a response like, “The bank that looks & sounds Indian is more reliable. Think that ICICI bank is a foreign bank as it feels HI-FI. Word of mouth publicity is the most reliable form of information”, is analysed to form keywords like, “Good, national banks, down to earth, affordable, gets more”.

The keywords analysed above and the consumer needs assessed previously are used as the key essence of the responses and further plotted in the brand personality worksheet adapted from Keller (2003) in Table 6. The worksheet enables the researcher to identify important intangible elements

**Table 6** Brand Personality worksheet

Sincerity (Honest, down-to-earth, wholesome, cheerful)	Excitement (Daring, spirited, imaginative, up-to-date)	Competence (Reliable, Intelligent, successful)	Sophistication (Upper class, charming)	Ruggedness (Outdoorsy)
Stability		Facility is good	Foreign bank feels Hi-Fi	
Name says Maharashtra, feels own		reliable returns, trust	HI-FI bank is good but costly.	
our kind of people, vicinity		Trustworthy	Privileged	
down to earth,		old is reliable	Personalized	
affordable		Services provided are important	Convenience	
present everywhere		gets more		
easily available		good schemes		
Local		Familiarity		
Encouragement				

of brand essence. These can then be used to develop guidelines for an effective brand strategy.

#### 4 Summary Expert Teach-Back

An expert Teach-Back is a knowledge elicitation technique where the researcher attempts to teach the information back to the domain expert, who then provides corrections and fills the gaps, (Geiwitz, et al, 1990, as cited in Burge, 2013). A Teach-Back was conducted with the Vice President – IL&FS, Social Inclusion Group, who has considerable experience with developing livelihood and infrastructural strategies for the Bottom of the Pyramid.

The researcher presented the perceptions formed from the field interviews to the expert, who then confirmed and corrected as he deemed appropriate. The expert, having considerable subject matter expertise, explained that a lot of unorganized sectors do not have a link to formal banking, a disconnect which could be related to a stigma related to the urban preoccupation of “looking nice”. He quoted an example of a bank official who requested that he not bring BoP customers to the branch as its regular customers might be inconvenienced. The stigma is felt on both sides as the poor feel reluctant to enter a bank environment whose formality and orderliness contrasts with the chaotic and haphazard surroundings with which they are more familiar.

It is essential to go beyond preserving and parking money in a trusted location, towards making money beneficial in the long run. Also, according to the expert, it is important to make available other services like insurance, identity protection, and credit to create a holistic growth ecosystem.

On the ways to reach beyond the apprehensions and inhibitions of the target consumer, the expert felt that the word of mouth marketing strategy is a definitely an option, because when someone has tried and tested a service, others are likely to try it as well.

Another important aspect of brand language is simplicity, so that people who are street-smart but illiterate can understand without much effort. For instance, services can be listed with the premium, the amount covered, and any additional benefits clearly demarcated.

Also, the expert confirmed that it is important to tap the whole aspirational aspect of these people, which is mostly ignored by other studies. As an example, he suggested that getting a PAN card is aspirational because a PAN card is the passport to the formal banking system.

It is also essential to go beyond trying to create the perception of dependability, towards providing actual dependability.

The expert also strongly believes that in this sector no single model will suffice, user insights are the best foundation for any model of brand positioning, and every sector may respond differently in this market. Herein, is an opportunity for the service facilitators who customize their business strategies around the most important stakeholder—the consumer—while others follow a single linear model.

## 5 Results

The findings are henceforth classified by guidelines for three key brand elements: brand personality, brand positioning, and brand promise. The researcher recommends these be followed for greater impact on BoP consumers and for success in building trust and loyalty.

### 5.1 Brand Personality Guidelines

Consumers are known to make purchasing decisions based on a number of associations they have with individual brands, and companies spend millions on advertising and marketing activities so that they can influence what those associations might be (Bughin, Doogan and Vetvik, 2010)

The Brand Personality describes the human characteristics people experience during an interaction with a brand (Aaker and Fournier, 1995). A company's brand personality is known to match the customer's self-perception of their own personality or a personality they aspire to become. The brand personality analysed on the worksheet, strongly presents three main personality dimensions (Keller, 2003), described in detail below:

- # Sincerity - Consumers perceive sincere brands as being honest, not-exaggerating, truthful, and cheerful. This aspect of brand personality speaks clearly of brand values as honesty, integrity, and mutual respect.
- # Competence - Consumers perceive competence from service reliability, deliver-ability, and the success symbols of a brand. Customer commitment and “being a good corporate

citizen” as brand values are considered under this dimension.

- # Sophistication - A brand that is perceived to be sophisticated is stereotypically viewed as being charming and associated with a higher snob value and thus fit for the upper society, or to fulfil higher-order needs on Maslow's hierarchy of needs.

### 5.2 Brand Positioning Guidelines

Taking into consideration the core business propositions made by most players in the industry, it is noticed that they are working towards provision and distribution of services to the poor. Among the positive aspects of these business models which can be adopted and adapted are the following:

- Provision of one stop solutions
- Multiple channels of service delivery
- Focus on a well-defined product category
- Direct door-step marketing for maximum conversion

After considerable research on the financial ecosystem in India, a service with all the features discussed above is present in the market, but it caters to a completely different segment. Known as Privileged Banking, these are carefully individualized services provided to the most valued customers of commercial banks. While a differentiation of the consumer as underprivileged and poor does form the core of his identity as a target consumer, the researcher feels that the key may lie not in the consumer's needs but in his aspirations.

However, aspirations have the potential to become the differentiating factor for any company focusing on the BoP. To provide “Privileged Banking at the Bottom of Pyramid” is to provide a sophistication that will make the brand stand out in the financial market.

### 5.3 Brand Promise Guidelines

The brand identity strategy requires the inclusion of an emotional appeal, highlighting the extrinsic factors of the brand and therefore its values and

personality. This also becomes the motivation behind consumer loyalty.

The Brand Promise is a commitment a brand makes to prospects and customers. It is mostly believed to be the primary intangible benefit of the service. It has been established that companies with the clearest brand promises have the strongest brands (Whitson, 2006)

Building on the need of familiarity and convenience for the BOP mass consumer, brands also need to create a promise which has these key elements:

- # Familiarity;
- # Down-to-earth (Sincerity);
- # Complete support system for the consumer (Competence)

## 6 Conclusion

In conclusion, the results indicate that a brand identity strategy can influence the perceptions consumers form of the brand. Given that BoP is a sensitive segment with its own apprehensions and a unique set of aspirational needs, brand identity becomes crucial.

Proposals are made to guide the important business remodelling that will have to be done. However, the researcher has focused the discussion on core branding activities that require little or no business restructuring. They include the following:

- # Personal Attention and individualized services
- # Building Relationships by assigning relationship managers
- # Financial advice
- # Money multiplier

A simple model of understanding the branding exercise is formulated by the researcher and is explained below.

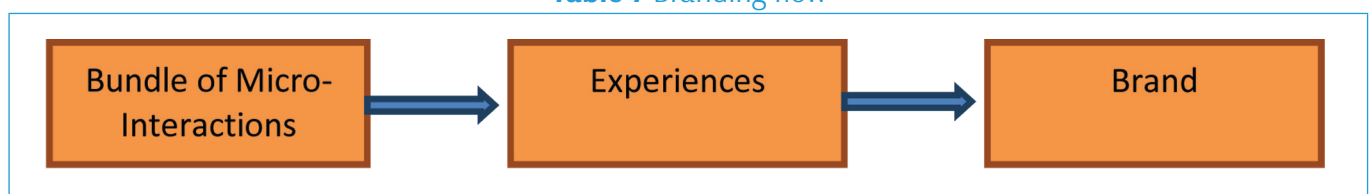
Thus, from the above discussions, we arrive at the following three stages which must be built to create permanency in the minds of BoP consumers:

- # Bundle of Micro Interactions: These are all the touch points of a service with the consumer. The following are formulated as improved micro interactions for a brand's consumers, for example,
  - Service executives in uniform
  - Technology savvy transactions
  - SMS alerts for transactions
  - Individual case files with a copy each for executive and consumer
  - On ground financial literacy, etc.
- # Experience: These micro-interactions gradually convert into the experience of a brand which the proposed positioning confirms:
  - Holistic Finance Management through Privileged Banking.
- # Brand: These interactions personify a brand. As suggested, the experiences should ideally place the Brand as "Down-to-earth, competent, reliable, and yet charming".

Financial inclusion is the need recognized by most financial entities around the world as a definite opportunity for growth and sustainability but mere sympathizing with the consumer may not be a successful strategy anymore

Financial entities should position themselves instead as brands which provide "Privileged banking" to the Bottom of Pyramid through these proposed brand activities in the domain of service provision.

Table 7 Branding flow



## 7 Scope for further work

Areas for further research on brands and brand identity strategies for Bottom of Pyramid are virtually unlimited. Based on this research, the potential for further research in the following domains has been identified:

- Quantified results can be obtained by building upon the determination of consumer perceptions in this paper.
- The research can be conducted in other parts of the country to determine if there are any geographical differences in perceptions of need.
- Conducting other research with a similar methodology for any brand catering to the Bottom of Pyramid.
- Validation of these findings by piloting a brand built on these guidelines.

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Technical Interventions for the Empowerment of  
Rural Women: A Case Study of the Manufacturing  
of Beads from Holy Basil (Tulasi)

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# Technical Interventions for the Empowerment of Rural Women: A Case Study of the Manufacturing of Beads from Holy Basil (Tulasi)



## Abstract:

In this paper, we demonstrate how interventions using basic technology empowered women in the villages of the Brij area (Mathura, Brindavan, and nearby districts) in the state of Rajasthan, India. Some of these women are engaged in making beads from the stems/twigs of the Holy Basil (*Tulasi*) plant. They earn their livelihood making garlands. Previously, they made the beads using a wooden structure with a tailstock supported by a randomly selected DC motor connected to a 12-volt DC battery. The motor was held in hand to produce forward movement, while turning and cutting beads from the stems. A user was required to sit on the ground and bend her body towards the device while holding the DC motor. There were several complaints of hand and back pains from the users, in addition to low levels of productivity. A local NGO (Lupin Human Welfare and Research Foundation) raised the problem to the Rural Technology Action Group (RuTAG) at IIT Delhi, who took up the responsibility of modifying the device. This improvement has generated a 3-4 fold increase in the productivity and earnings of the women, thereby empowering women in the region.

**Keywords:** *Holy Basil (Tulasi), DC motor, Computer-Aided Design*

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## 1 Introduction

Technical interventions are generally referred to as the use of technical knowhow to improve processes, machines, devices, etc., in order to achieve increased productivity and profit with little time, effort, or labour. While international research focuses on the products manufactured in organized sectors (e.g. automobile, pharmaceutical companies, and others), the production activities conducted in unorganized sectors (e.g. the improvement of processes and devices in the handicrafts and similar sectors) are generally ignored. Because of the significant investment (mainly by private companies) and glamour attached to the former type of research and development, young researchers or engineers are easily attracted to research on this type of manufacturing. Hence, the knowledge domain is

enriched year after year. On the other hand, attention to the other types of manufacturing activity is minimal. Even though several organizations and researchers from universities worldwide take up such research activities, either out of their passion or as a part of CSR (Corporate Social Responsibility), they are handicapped with a very different set of criteria for the improved designs. For example, as pointed out in Fischer (2007), a designer is tempted to design devices for the poor that will save them time and labour. Unfortunately, the poor have both time and labour in abundance. Unless they have a way to make money, they are unlikely to invest in such designs, irrespective of all the benefits that are typically promoted in the new design of, say, a car. This aspect was addressed during this study's attempts to improve the device to manufacture beads from the Holy Basil (*Tulasi*) plant.

Before we explain this intervention, we turn to the concept of ‘women’s empowerment’. According to the Oxford Dictionary, to ‘empower’ means to ‘give strength and confidence’. Hence, that which gives strength and confidence to women is ‘women’s empowerment’. Many research articles – e.g. Duflo (2012), Nagaraja (2013), and others – address various aspects of this issue, including gender equality and how women’s empowerment leads to better economic development of a society. In this paper, we do not perform any analysis of these issues. However, we base our study on the premise that simple technical interventions can enhance the earnings of the women who are making beads from Holy Basil (*Tulasi*). This certainly supports the general philosophy of women’s empowerment based on enhancing women’s access to employment and education opportunities, which generally reduces the likelihood of household poverty. Moreover, increasing the resources controlled by women engenders a range of positive outcomes for human capital and capabilities within the household.

This paper is organized as follows: Section 2 explores the present status of the processes employed for manufacturing beads from the Holy Basil or *Tulasi*. Section 3 explains the philosophy of alternative

designs, along with the new design concepts. Section 4 presents the modified device, and Section 5 explains the feedback and empowerment outcomes. Finally, conclusions are drawn in Section 6.

## 2 Present Status

Traditionally, beads made from the Holy Basil (*Tulasi*) plant are produced manually (see “How to make Tulasi beads” (2012) for an instructional video about how to make garlands). These garlands are either offered to the deity or used by the devotees, in large numbers. In the villages in the Brij area (Mathura, Brindavan, and nearby villages) of Rajasthan, India, however, these beads are made in a semi-mechanized way, as shown in Figure 1. This is mainly due to the high demand from patrons of the temples of Mathura and Brindavan. Many women (400-500) are engaged in making these beads from the stems/twigs of *Tulasi* to earn their livelihood. A Bharatpur-based NGO (Lupin Human - Welfare and Research Foundation), whose activities are listed by “Rural Industries” (n.d.), organized these women bead makers living in 18 villages of the Bharatpur district into several Self-Help Groups (SHGs). To make the beads, these women use a wooden structure to support one end of the stem, as shown in Figure 1, while holding the other

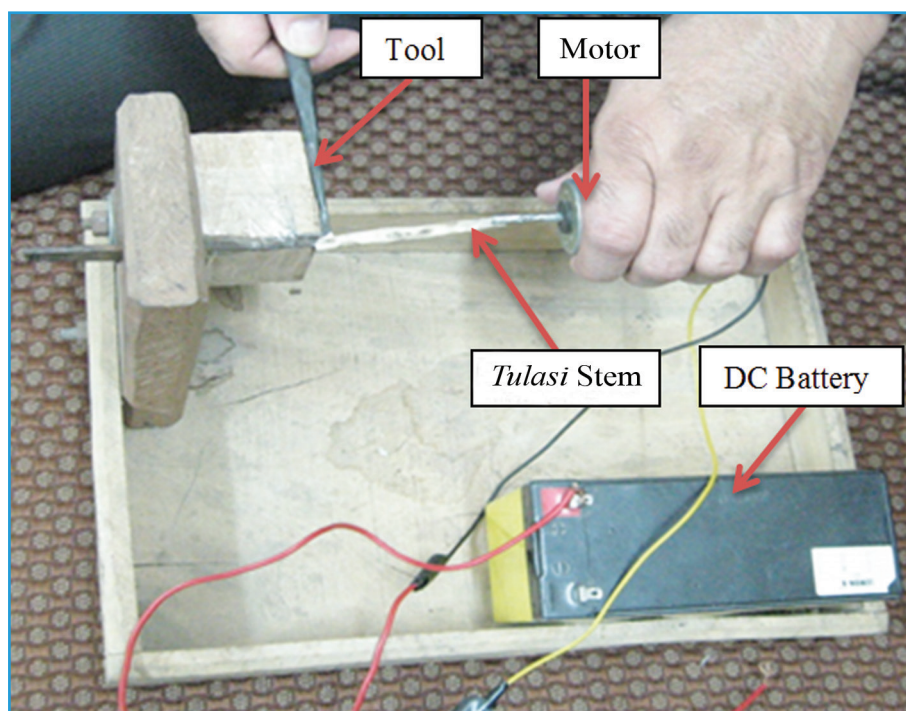


Figure 1 Existing device for making beads

end in a hollow-shaped bent sheet connected to a DC motor running at about 1500-1800 rpm. The motor connects to a 12-volt DC battery. The motor is carried by the operator, as depicted in Figure 1. While a tool is used to peel off the shell of the stem and make a round shape by turning the tool-carrying hand in an arc, the hole is automatically made in the bead, as it is supported on a sharp needle-like tailstock. However, this method is not very productive. The people working this job somehow survive, but they face several other problems. For example:

1. The shaft of the DC motor is stopped by the user's fingers after one bead is completed, in order to separate the bead from the stem. This causes irritation and pain in the arm.
2. In this semi-mechanized production process, a user sits on the ground, bending her body towards the device while working. This causes neck and back pain due to the continuous bending of the body.

The Rural Technology Action Group (RuTAG) at IIT Delhi studied the problem and identified the key issues that directly affect productivity. Based on the ergonomic study, the following areas have been identified as requiring immediate attention:

- An arrangement or provision must be provided so that the motor need not be carried by hand.
- A mechanism is needed to stop the motor without the use of one's fingers.
- Additional modification in the user's sitting arrangement is also important.

Several alternatives were proposed concerning the modification of the device described above. These alternatives are shared in this paper, before we present the acceptable prototype that was fabricated and demonstrated to the user SHGs.

### 3 Philosophy of Alternate Designs

Once the problems faced by the women (pain, etc.) were explained to the team at RuTAG, the first task pursued was to study the operations carefully, as

explained in the Introduction. Possible solutions were identified, keeping in mind the following necessary attributes:

- a. No cost or minimum additional cost for the modifications;
- b. Minimal change to the devices so that no change in habits is required (this is important from a psychological acceptance point of view); and
- c. Local manufacturability of the device.

The proposed solutions were based on the answers to following questions:

Q1. How can the women avoid using their hands to stop the motors?

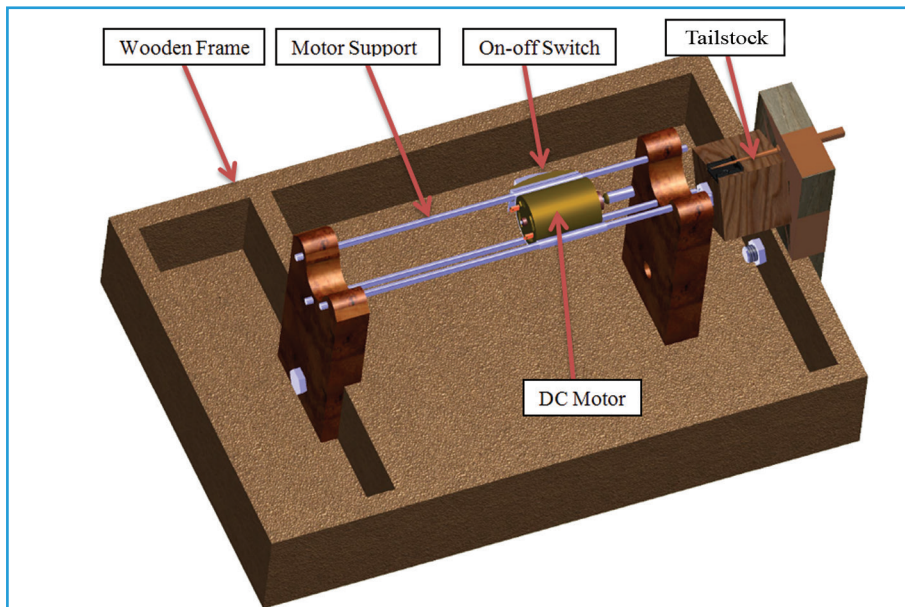
Q2. How can the operators avoid carrying the motors?

Q3. How can the axis of the motor shaft carrying the stem be suitably aligned with the sharp tailstock support so that users' eyes are not strained in monitoring the alignment closely?

To answer the above questions, while keeping in mind the constraints outlined above (a-c), several ideas were generated. In order to visualize them, Computer-Aided Design (CAD) models were created using Autodesk Inventor (Autodesk, 2014). The thought processes that led to potential solutions are summarized below.

A1. One solution was based on using an electrical switch to turn the motor on and off. The next question was what kind of switch to use. There are many varieties available on the market. Keeping the constraints in mind, as mentioned in (a-c), a domestic electrical switch was considered. Initially, 5-amp light switches were chosen. However, after the first-phase of testing it was found that they needed to be replaced every 1-2 days because of the damage to the switches. It is important to note here that after every bead is made, the motor needs to be switched off and on again before the start of the next operation.





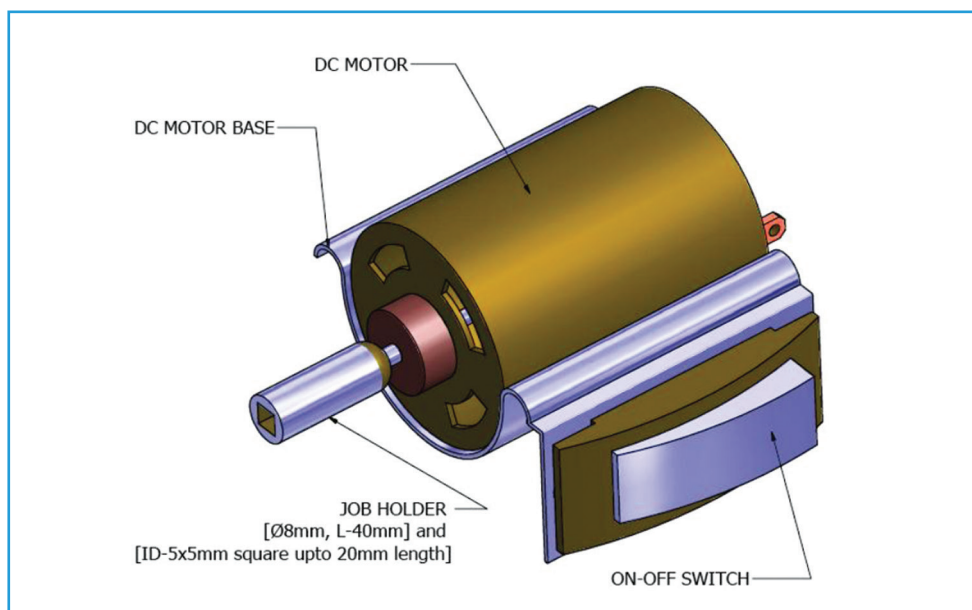
**Figure 2** CAD model of the device for making *Tulasi* beads

A2. In order to relieve one of the hands from carrying the motor (approximately 150 g), a support similar to a lathe bed was considered. However, it was still to be determined whether the support would be solid, or the material should be wood, metal, or plastic. The first prototype was made of a wooden support, similar to the one shown in Figure 2. It had wider horizontal support instead of the three rods depicted in Figure 2. Due to high friction, it was not smooth enough to enable the user to push the motor towards the tailstock. Hence, there was difficulty in performing the machining operations. The final solution is shown in Figure 2.

A3. The alignment was determined by making the appropriate support height so that once the motor is simply pushed by the left hand, the stem directly hits the tailstock. Moreover, two additional alternations were made, based on the observations of the operations.

A4. We replaced the 12-volt DC battery running the motor with 220-volt AC with a 12-volt DC adaptor, as the villages using the device have access to a 220 V, 50 Hz, AC power supply.

A5. We changed the stem holder from the rounded sheet to a machined hollow square tube.



**Figure 3** CAD model of the DC motor with the switch and stem holder

A6. Since sitting on the floor while operating the device is not ergonomic, a table and bench arrangement was also proposed, which is not presently adopted.

#### 4 Modified Device

To model the device for making the beads from the stems, its components (i.e. wooden frame with tailstock support, tool guide platform, motor platform support, motor platform rod, DC motor, motor base, on-off switch, etc.) were modelled in Autodesk Inventor 2012. The assembly of devices for making *Tulasi* beads was also modelled in Autodesk Inventor 2012, as shown in Figure 2.

The existing 1-amp DC motor was randomly selected without any technical consideration. When it was tested, it was observed that it could machine only the thin stems to make smaller beads, but it was not fit for making bigger beads from the thicker stems. Hence, the motor was replaced by a 2-amp DC motor. Through testing, we observed that it worked well for making medium-sized beads, but it was not fit for bigger beads. We then tested a 3-amp DC motor for making beads of bigger sizes. It worked smoothly without any trouble. Hence, this motor was recommended, since it can machine beads of any sizes. An isometric view of the DC motor with the stem holder is shown in Figure 3. The final prototype is shown in Figure 4.

#### 5 Feedback and Empowerment

The improved device, which was sent to the SHGs, is shown in Figure 4. Feedback was collected from at least 10 users through the NGO. The users were very happy with the modified device. They told us that they operate this improved device for up to 12 hours in a day without becoming tired. Thus, a worker can earn about Rs. 800-900 per day (at least a two-fold increase over previous earnings) after working 8 hours in a day, while others can earn Rs. 1200-1400 per day (3-4 fold increase) after working about 12 hours in a day. Using the existing device, they could not work for long hours, because of fatigue and the pains in their hands. Using the previous device, they were able to earn an income of only Rs. 300-400 per day. A village carpenter in Nadbai Village of Bharatpur is now manufacturing the improved device and selling it for approximately Rs. 2,500 per piece. In order to popularize the device, a demonstration was made at the Vatsalya Mela organised at Dilli Haat in New Delhi on 15 November 2012 by the Ministry of Women and Child Welfare. It was also demonstrated at the National Fair India Innovation Initiative (i3) 2012, held at IIT Delhi on 3 December 2012. At both demonstrations, the device was widely appreciated. A news report on the device also appeared in the daily newspaper *The Hindu* on 7 September 2013 (Iqbal, 2013). A paper cutting of the newspaper story is shown in Figure 5.

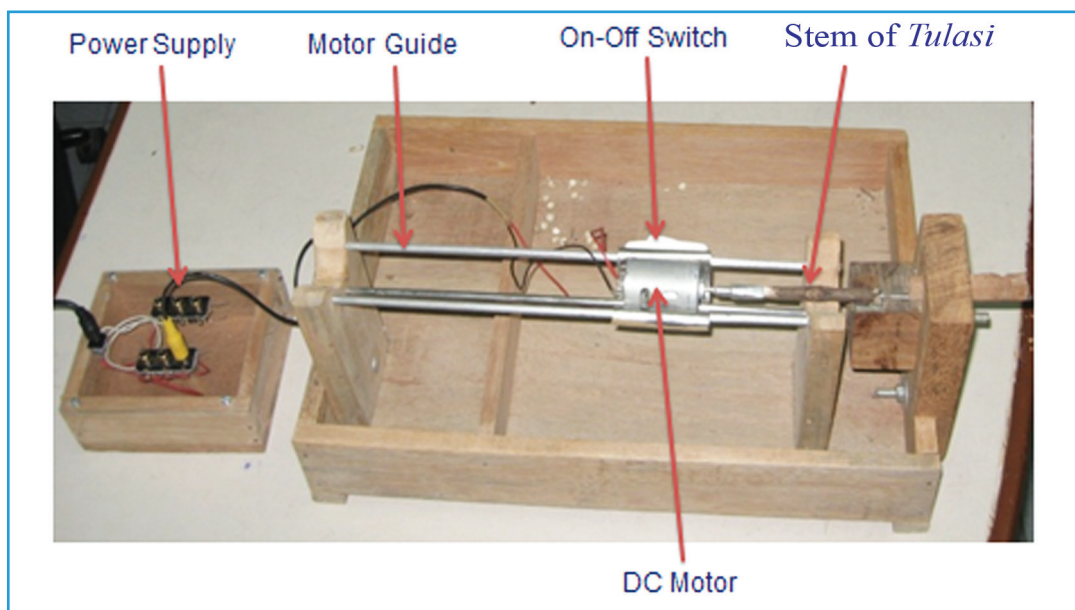


Figure 4 Improved device for making beads



Figure 5 Newspaper coverage of the improved device in The Hindu, 7 September 2013

## 6 Conclusions

In this paper, a case study is presented where an ad hoc device to make beads from the stems/twigs of *Tulasi* was modified to enhance the comfort of the women operators, while increasing their productivity. The improved device has been successfully adopted by a local manufacturer to ensure its supply to users. Even though the improvements have been encouraging, challenges remain for the appropriate usage of the device. In a recent event involving the breakage of the holding device, it was found that the local people again used the earlier rounded sheet, which degraded the device's performance and thereby caused dissatisfaction to the users even though they are paying more to buy it. Such adoption is dangerous from the point of view of technology intervention, as the confidence of the user community will diminish. Appropriate training should be considered before such intervention takes place. Moreover, to avoid the regular replacement of the switches (required once every four to five weeks), an electronic non-contact switch is under consideration to avoid these frequent replacements, thus enhancing the reliability of the device.

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Eri culture: Exploring the concept of 'Ahimsa silk' as a strong device for female empowerment in Assam

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## Abstract:

Most silk on the market is reeled or made by unwinding the caterpillar's chrysalis (cocoon). To keep a caterpillar from developing into a moth, producers boil, steam or apply dry heat, killing the caterpillar inside. It takes almost 15 silk moths to produce one gram of woven silk. The massive wiping out of these tiny insects adversely affects ecological balance.

Today, many companies/organisations are moving toward the concept of cruelty-free, eco-friendly Ahimsa silk and doing good business in the global market. However, there is always some question of how authentic their processes are in terms of not killing the silk worms, labour and production costs involved and so forth. As such, my study explores eri culture as a sustainable practice for Ahimsa silk. Using my own work as a case study, in addition to examples from the fashion milieu and the wider design world, I discuss possible design interventions to improve the knowledge and skills of women weavers in Assam for better employability as well as market position.

**Keyword:** *Eri culture, Ahimsa silk, female empowerment, design interventions, employability*

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## 1 Introduction

India is colourful and vibrant, a land as diverse as its people, a mosaic of faiths, cultures, customs, and languages in a harmonious blend. India's diverse cultures and traditions have influenced the world since time immemorial. Our sense of eating, ways of dressing etc. have always aroused Western attention; in particular, the richness and the reality of Indian fabrics and handicrafts have garnered tremendous appeal and demand in the West.

Eri silk is among the oldest forms of silk. It has remained a favourite of silk lovers in India and around the world. Eri silk is considered the father of all forms of cultured and textured silks. Because

of its eternally elegant and beautiful textures eri silk continues to be popular among silk lovers across the globe.

### 1.1 Historical background of eri culture

The Brahmaputra valley of Assam and its adjoining foothills are believed to be the original home of the eri silkworm (*Samia ricini*) (Donovan). The history of silk in the Brahmaputra valley of Assam can be traced back to the Vedic texts (around 1600 BC). Silk from the Brahmaputra River Valley was marketed to Mugadh and Mithilla (ancient Indian cities), as well as Brahmadesh (Myanmar), in 1340 BC. The silk trade from Assam to North India was at its peak during the period of the great king Bhaskar Barman



(AD 600-650) of Kamrup. The Buddhist visitor Hieun Tsang (AD 629) mentioned in his writings that Suvarnkusi (present-day Sualkuchi) of Assam was an important silk-producing centre; now, this place is called the Manchester of the East. Later, in AD 1492–1520, the great 'Ahom' king Sarna Narayan patronised the silk industry of Assam. Based on this history, it is apparent that eri culture in Assam has been in practice since time immemorial and has had a close link with the traditions and socio-economic life of the people.

Before the opening of the railway lines (under British colonial rule in 1884), eri culture had remained confined to rural areas. However, the cocoons slowly found their way to important trading and weaving centres. The woolly white silk is often described as the fabric of peace since the process does not involve killing the silkworm. The moths leave the cocoon as soon as it is ready to be spun. Eri silk fabric is a boon for those who practice non-violence and, believe in the consumption of products obtained from nature without killing any animal or harming the environment. Therefore, over the years eri silk became popular all over the world. Vegans and Buddhist monks in India, Bhutan, Nepal, China, and Japan prefer this silk because of its non-violent production.

Eri culture involves various activities such as food-plant cultivation, silkworm rearing, spinning of yarn, and weaving. To capitalise on this vast potential and widen the horizons of eri culture, the Central Silk Board has been promoting eri production in not only the traditional north-eastern states but also in non-traditional states like Andhra Pradesh, Tamil Nadu, Orissa, Uttaranchal, Punjab, Bihar, and Jharkhand. As a result, in India production increased from 100 metric tons per year in 1950 to over 2460 metric tons in 2009-10, which is remarkable.

### 1.2 Eri culture and women's employability in Assam

The north-eastern region of India produces more than 90% of the total cut cocoons and spun silk

in the country. Eri culture generates employment opportunities for many unemployed people in Assam, especially women who are, partially or fully involved in various activities (Kumar De, and Das, 2007). For rural women in Assam (especially tribal members), rearing of eri cocoons and spinning, as well as the weaving of *endi* clothes, have been integral parts of their daily activities. In addition to their daily household activities, these women use their leisure time to produce useful but comparatively cheaper eri fabrics with the help of their traditionally inherited skills and knowledge. These activities increase household income and help many women emerge from acute poverty. As such, these women become more economically and socially empowered. In other words, eri culture acts as an instrument to empower rural women (Kumar De, and Das, 2007).

The agro- and plantation- based rural economy of Assam has been suffering from slow growth, high unemployment, grim industrialisation and increased poverty. In 2004-2005, Assam ranked seventeenth in terms of the incidence of poverty among all 35 states and union territories of India. While the Planning Commission Report (2007) shows a drastic overall decrease in poverty (55.77 lakh or 19.7%) a significant portion of the rural population of Assam lives in poverty (22.3%) and the rate is undoubtedly higher among females (Kumar De, and Das, 2007). The situation for these people becomes particularly sensitive during the time of flooding that frequently occurs in several areas. In the absence of capital or other resources, eri culture provides ample opportunities for employment and income generation. As a labour-intensive activity, eri culture has long served as an antidote to unemployment and poverty; without it rural poverty in Assam would surely be more severe. Benchemin and Jolly (1987) also identified eri culture as 'low investment and high output' source of employment and income.

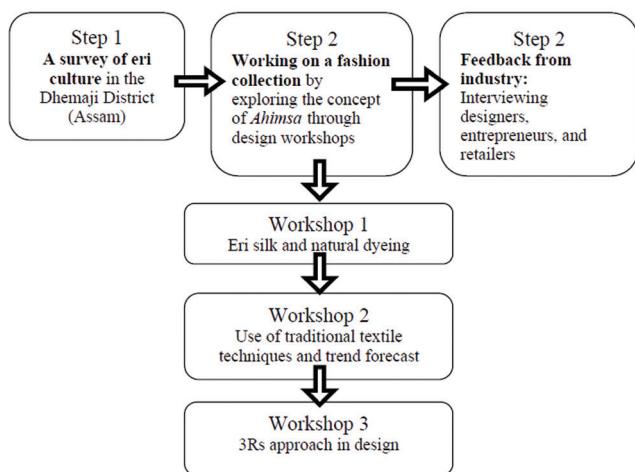
Though eri culture has been endured for a long time, it is not growing at a very fast rate due to eri weavers' lack of capital. Common weavers in the state are not receiving adequate support for technological

invention or innovative and contemporary design approaches to enhance their traditional skills.

## 2. The rationale for the research and the methodology

This study was undertaken on the basis of my personal interest in reflecting on eri culture as a sustainable practice for 'Ahimsa silk'. From the literature review, it was observed that while eri silk has almost all of the good properties of fabric, it is used most extensively for home furnishing products. The use of eri silk for apparels is very limited to traditional garments. In this project, therefore, the concept of *Ahimsa* was further explored by practically working on a fashion collection. The findings of this research can suggest possible design interventions to improve the knowledge and skills of women weavers for improved employability and market position.

The research methodology involved the following three activities at different stages:



### 2.1 Survey of eri culture in the Dhemaji district

The survey was conducted by preparing a questionnaire in the local language and distributing it to 50 female weavers (aged 25 and above) in the Dhemaji district of Assam. This survey aimed to get an overview of the current status of eri culture in the region; the findings could then be used as a

basis for the fashion collection work in the next step.

### 2.1.1 Findings from the survey

1. All the respondents identified eri culture and agriculture as the main sources of family income; 57% of weavers agreed that 50% of their monthly income came from eri culture.
2. Seventy-one per cent of weavers were involved in eri culture and engaged with various activities as traditional practices; 29% had newly acquired these skills to contribute to their family's income.
3. Although most weavers indicated that they sell their eri fabrics to local markets, several mentioned other market opportunities.
4. All respondents were aware of eri silk having a special demand in the international market but did not understand why.
5. Their understanding of the end use of eri silk fabrics, product diversity, etc., was limited to traditional shawls, saris and local dresses for men and women. Many were unaware of how elaborately this fabric is used for home furnishing products.
6. Although 50% of respondents indicated that they receive help from the state government, the support was limited to free seeds and some basic weaving equipment. About 85% were seeking financial support from the government, and 14% asked for education and training on eri culture, modern technology, and design to enhance their traditional skills.
7. Opinions on the current growth of eri culture were mixed. Fifty-seven per cent mentioned increases while 43% mentioned decreases. Another important observation pertained to average earnings from selling traditional handwoven eri shawls, which were remarkably lower than actual market prices.

### 2.1.2 Reflection on findings

It was apparent from the survey that the Dhemaji district plays an important role in the

production of three different kinds of silks; *pat*, *muga*, and *eri*. However, due to a lack of proper infrastructure and appropriate marketing, this industry has not been exploited to its fullest potential. In this region, a huge portion of the 'other backward classes' (OBC) population comprised of Ahoms, Chutiyas, Konches, etc., and scheduled tribes like Mishings, Sonowal Kacharis, Bodos, Deoris, Lalungs, Hazongs, etc. are actively involved in eri culture. It is associated with their socio-economic and cultural life, especially for women. While the problems facing eri culture and the grass-root people in the district are diverse, the lack of marketing linkages, contemporary design approaches, and skills for product standardisation were very prominent in this survey.

## 2.2 Working on a fashion collection

The basic aim of working on a fashion collection was to explore various properties of eri silk by nurturing its purity, values, and vast potential. Therefore, the concept of Ahimsa as a possible design practice was explored by conducting three design workshops with BA (Hons) students in fashion design and textile design. This step helped me generate a range of fresh design ideas by following a theme.

The initial research was built on the idea of 'Ahimsa as an ethical practice'. By examining this as a possible design theory, the design development focused on various surface techniques and silhouettes development. The idea was to spread environmentally friendly messages to people. The word *Ahimsa* derives from the Sanskrit root *hiXs*, which means to strike. *HiXsā* means injury or harm while *a-hiXsā* means the opposite i.e. *non-harming* or *non-violence*.

The principles of Ahimsa underpin the direction and development of this project, and some significant terms/phrases associated with the concept were selected for reflection in the design process:

- Not merely harmlessness, but a positive state of love
- Largest love, greatest charity
- Bearing and nurturing
- Creating but not owning
- Giving without demanding
- Utmost selflessness

Ethical awareness asks us to behave responsibility towards all forms of life on earth, and this has become of paramount importance for contemporary designers when creating new artefacts (Fletcher, 2008). While the concept of Ahimsa exists naturally within eri culture, our design development process adopted further sustainable design practices such as the following:

- Natural dyeing
- Re-use or recycling
- Minimum wastage
- Green fashion
- Eco-friendliness
- Local production processes

### 2.2.1 Workshop 1: 'Colours from Kitchen'

The second-year BA (Hons.) students in textile design were involved in the workshop to explore the theme for surface embellishment. A PowerPoint presentation was used to orient the students regarding the theme and the concept of Ahimsa silk. The presentation was followed by a live demonstration of natural dyeing, clearly identifying the steps to follow, which mordant to use, and how to document the process. The presentation also highlighted the various properties of eri silk, and as a protein fibre how students can relate this with woollen fibres to explore various natural dyeing techniques. About 30 students in the class were able to produce a good amount of samples exploring vegetable dyes (using ingredients from their kitchens) on eri silk. Figures 1-6 show some of the outcomes:

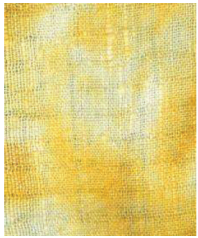


Figure 1  
Turmeric



Figure 2  
Tea

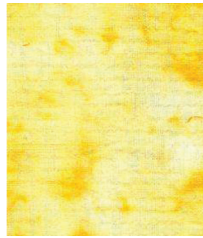


Figure 3  
Saffron



Figure 4  
Onion peel



Figure 5  
Radish leaves



Figure 6  
Coffee

## 2.0.2 Workshop 2: 'Modern meets traditional'

The second workshop with the same group of students aimed to explore traditional textile techniques on eri silk by following trend forecasts. The students were encouraged to explore tie-dye and *shibori* techniques using various natural dyes available in Assam. The students were introduced to trend forecasts (A/W 2014-15) to find direction in selecting colours and textures. Eri shawls and natural dyes were sourced from Assam. The students produced a range of innovative samples (Figures 7-14) using natural dyes.



Figure 7 Lac and weld

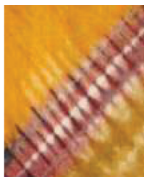


Figure 8 Lac

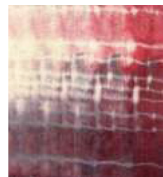


Figure 9 Indigo

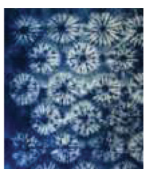


Figure 10 Cochineal



Figure 11 Shibori using  
indigo and weld

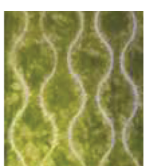


Figure 12 Madder and  
weld

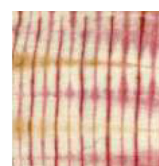


Figure 13 Elder

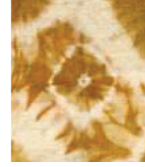


Figure 14 Patchwork  
and indigo dye



The following steps were commonly followed in both workshops for dyeing process:

### (a) Mordant recipes

**Ingredients:** 10% alum, 8% cream of tartar of yarn/fabric (dry weight)

- For all explorations, the mordant used was alum (potassium aluminium sulphate).
- All yarns/fabric were fully scoured and wetted out prior to mordanting process.
- Since eri silk is highly textured, it requires special care in de-starching. Boiled water with white vinegar was used to wash the eri silk to remove starch.

### The method:

Step1: Dissolve the alum and cream of tartar in warm water in a mordanting vessel.

Step 2: Add cold water, then add the skein/fabric, making sure it can move freely in the vessel to ensure even uptake of the mordant.

Step 3: Slowly bring to a boil over a period of not less than one hour. Simmer for 30 to 45 minutes. Let the bath cool. Remove the skein/fabric and either dye immediately or store in a plastic bag. Before dyeing, rinse well in hot water to ensure the removal of surplus/unfixed alum for a good result.

### (b) Dye recipes (madder as example)

**Ingredients:** For 100 gm of yarn/fabric (dry weight), 100% madder (or as per requirement), and use 3-4 litres of water, ensuring there is enough water to cover the material being used.



### The method:

Step 1: Place the chopped roots in cold water in the dye-pot and soak overnight. If using powder, paste with warm water and leave overnight.

Step 2: On the next day, add more water to the roots or the powder. Add the yarn/fabric and slowly bring the water to a low simmer at 60° C (140° F).

Step 3: Simmer at the same temperature for one to two hours. Leave it in the dye –bath overnight.

Step 4: Wash in mild soapy water and rinse until the water runs clear.

### 2.2.3 Workshop 3: '3Rs approach in design'

The third workshop was conducted with BA (hons.) fashion design students to address sustainability issues closely connected with textile and fashion. A group of six final-year students took this work further to incorporate it in their ongoing projects.

The fashion and textile industries involve complex sets of factors. The process of growing, manufacturing, distributing, marketing and selling textile-based products is often driven by money with insufficient consideration of social and environmental consequences (Clark, 2008; Fletcher, 2007). As Kate Fletcher (2008) notes in her book *Sustainable Fashion and Textile*:

'The total amount of clothing and textile waste arising per year in the UK is approximately 2.35 million tonnes. This is equivalent to nearly 40 kg per person per year, a figure that includes waste from industry and domestic sources. Only around a quarter of all waste textiles in UK are reclaimed, with 13 percent going to material recovery and 13 percent to incineration. The remainder (30 kg per person per year) goes to landfill, producing methane emissions to air and polluting ground water through toxic leach-ate.'

As a manufacturing country, if we calculate the same for India, particularly the metropolitan

cities, then the estimate will become more vigilant. What happens, then, to the concept of Ahimsa? In searching for an answer, the students were introduced to the '3Rs approach in design' meaning 'reduce, reuse, and recycle'. This is a popular strategy for managing waste that arises from the textile and fashion life cycle. Adopting this approach, the students developed a range of design ideas.

### (a) Appliqué techniques for recycling 'left out fabrics, after pattern making'

(PGFD students, final year)

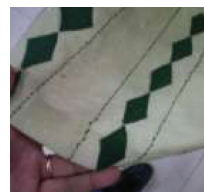


Figure 15



Figure 16

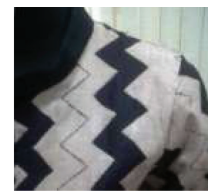


Figure 17



Figure 18

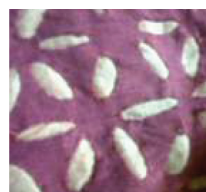


Figure 19



Figure 20  
Appliqué and  
kantha

### (b) Recycling eri silk fibres/yarns for surface treatment

(Samples developed by Ashna Garg, BA (Hons.) fashion design, final year)

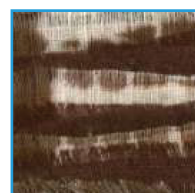


Figure 21  
Fringes with  
tie-dye

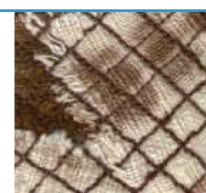


Figure 22  
Cross-stitch  
techniques

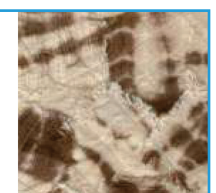


Figure 23  
Irregular  
surface



Figure 24  
Re-weaving  
techniques

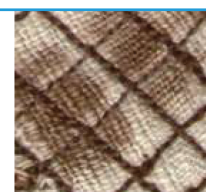


Figure 25  
Quilting and  
dyeing

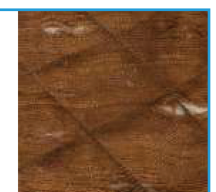
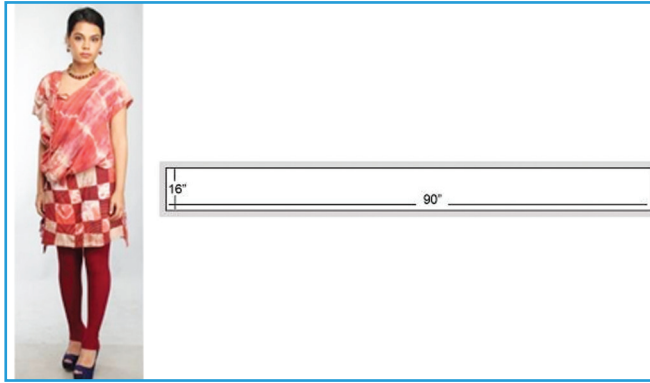
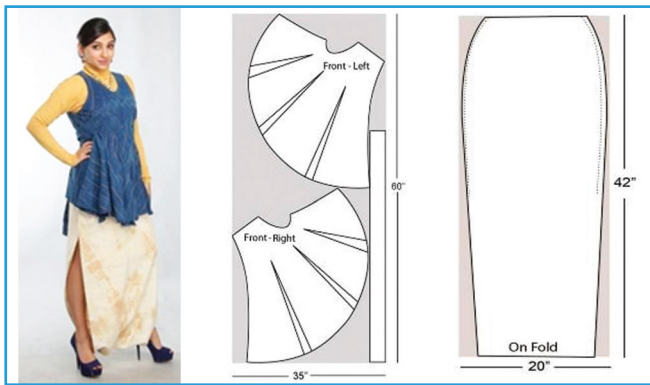


Figure 26  
Re-use of  
damaged power  
loom eri fabrics

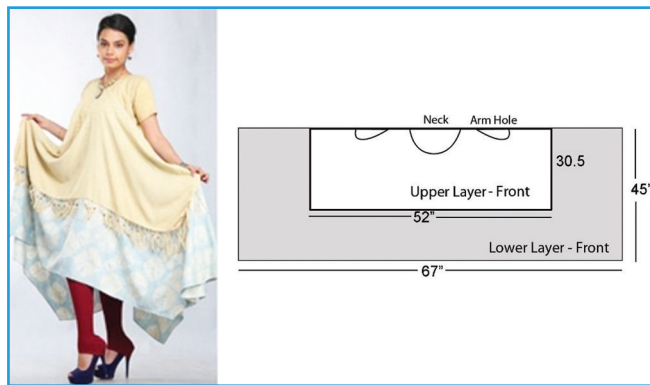
**(C) Minimum wastage through pattern making**



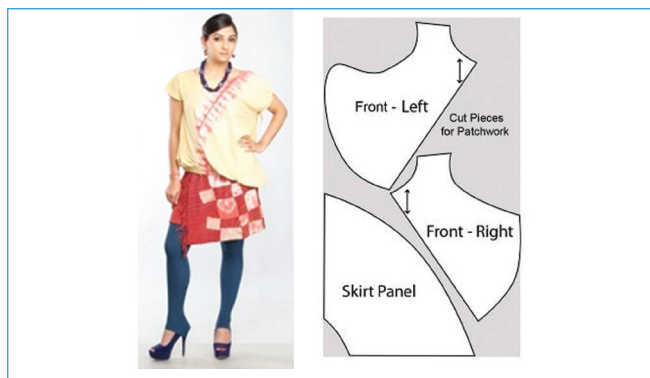
**Figure 27** Draped garment (A 15-year old eri shawl was draped for the upper garment.)



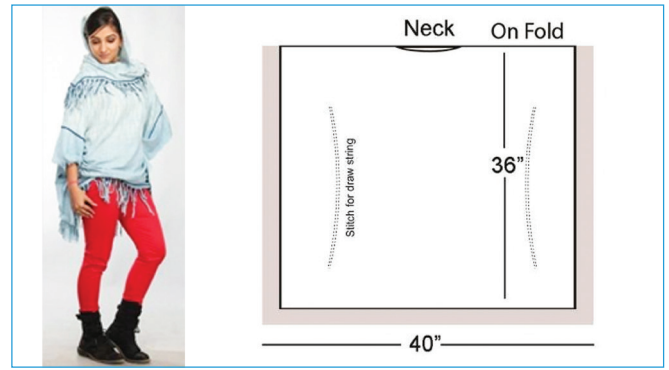
**Figure 28** Woven half-circular top and long skirt with side slits



**Figure 29** Layered dress



**Figure 30** Top and skirt



**Figure 31** Poncho with fringes

**2.2.4 Reflection on final outcome:**

The designers working within the framework of sustainability generated various strategies that responded to the socio-cultural requirements. There has been substantial research on ethical approaches, eco-friendly and recycled materials, renewable sources, and less harmful, local production processes that more efficiently sustain the planet. Nevertheless, consumers continue to purchase disposable products and discard commodities that could have longer life cycles. This is not because they lack choices for environmentally friendly products but because there remains a lack of awareness.

Fashion is also about excitement and change, and designers can play a significant role in challenging people to change. Stella McCartney's collection of bags produced in collaboration with Le-Sportsac is a good example of a high profile, ethical design response. All fabrics, swing tags and packaging for her 2007 collection of bags were created from 100% recycled materials using eco-polyester body fabric and eco-mesh (nitro licious, 2007). Since 2007, the Canadian home furnishings company Looolo Textiles has designed its products to be fully biodegradable within one year after the end of their life cycles (Fletcher, 2008).

Eri culture needs the attention and creativity of designers to nurture its purity, values and vast potential. From the outcomes of the workshops it was observed that the fabric can easily transform into many colours, like a kind of super chameleon. However, the tradition of natural dyeing is fading



among the eri weavers in Assam because of the availability of cheap chemical dyes and limited understanding of traditional values.

The physical appearance of eri silk and its availability in the market do not inspire many designers to visualise a fashion collection. The fabric requires a lots of pre-treatments especially degumming before it can be used for apparels. It was observed, however, that the traditional method of degumming cocoons in eri culture is also an eco-friendly process. The cocoons loosely tied in cloths, are boiled in a 10% sodium solution for 45 minutes to one hour. The weavers use ash obtained from banana leaves, wheat stalk, paddy straw, pieces of green papaya, etc., as alternatives for degumming chemicals. Thus, sustaining these ethical practices and creating awareness among people will be important factors in providing a bigger market for eri silk weavers.

In Assam the tradition of natural dyeing is an ancient art closely connected with handloom weaving. With its vast hills and forests, the state is home to a variety of herbs and plants that are commercially valuable. For the vegetable dyeing of silk yarn, the dyes are obtained from various parts of plants and herbs, such as steam, wood, roots, bark, leaves, flowers, fruits, and seeds. Prominent among them are indigo (*Indigofera Tinctoria, L.*), turmeric (*Curcuma Longa*), morinda (*Morinda Citrifolia L.*), mudar (*Rubia Tinctorum L.*), and elephant apple (*Dilhenia Indica*). Together designers and various NGOs can play a vital role in reviving this craft.

According to the literature, eri silk fibre can be blended very easily with other fibres, but exploration in this area is still very limited. For a long time, eri culture has survived in the remote corners of the north-east region with insufficient exposure to modern technology.

### 2.3 Feedback from industry

After completing the fashion workshop, a questionnaire was prepared to interview up-and-coming fashion designers, fashion entrepreneurs

in Delhi, and retailers (mainly fabricators) who are already in the business of retailing and exporting Assamese eri silk. The aim of the survey was to collect feedback from industry and evaluate the potential market for the collection. Ten designers, five entrepreneurs and five retailers were targeted for feedback by sending the questionnaire along with a synopsis and photographs of the collection highlighting its special design features. Some important findings/remarks from the industry include the following:

- All respondents were aware of eri culture and the related concept of Ahimsa silk. They responded positively to the design approach and the direction in terms of fashion sustainability, minimum wastage, etc. They agreed that this approach could add value to eri products and create new market opportunities for the weavers.
- One designer, Astha Sethi (fashion designer, Delhi) mentioned that ‘the products with sustainable features can only be acknowledged if the consumer understands and appreciates what has gone behind the making of it, so it is very important for us as designers to educate the consumer’.
- Kirti Sinha (designer with Neeru Kumar, New Delhi) said there is a potential market for the collection since there is strong awareness of reusability both in the textile market and among consumers.
- ‘People are always looking forward to a contemporary approach in fashion. The various design features, values and concerns of the collection will attract consumers for a complete experience with one purchase only’ comment by Ruchika Sachdeva (designer label – ‘Bodice’, New Delhi).
- Some designers also mentioned that the unique fabric properties of eri make it well-suited for apparel; it is a matter of setting a trend, and the rest will follow. However, easy accessibility and availability in the market will attract more designers.
- Some respondents mentioned blending eri fibre with other natural fibres like cotton, wool and

- *pashmina* for innovation in eri silk blending.
- 'We are exporting a maximum of eri silk for the American market. Our buyers mainly deal with home furnishing products, but we have some buyers using it for apparel' - Khitish Pandya (CEO, Eco-Tussar, Delhi, a silk exporting company).

### 3 Conclusion

The entire project was a great learning experience, from studying post-cocoon activities to understanding the current status of the people involved in eri culture. As an academic researcher, involving students in different design tasks through various workshops was for me a sustainable activity in itself since they are the future of fashion and textiles. The project also created many opportunities for the researcher and the students by providing industry connections, sponsorship opportunities, and participation in national and international design competitions.

Due to time constraints and the distance from Delhi to Assam, it was not possible to work closely with eri silk weavers for design development. However, I am committed to pursuing this work further in future research.

With the excellent farming, weaving and spinning skills of its local weavers, Assam has a great scope for excelling in both post- and pre-cocoon activities. In January 1946, when Mahatma Gandhi came to Assam, he specifically mentioned that 'Assamese women weave dreams on their looms'. These skills still exist, but they require proper nurturing under the guidance of experts and designers to produce quality eri silk products. The Central Silk Board (under the Ministry of

Textiles) needs to play a major role in the overall development of this sector.

### Acknowledgements

This research was conducted as part of my MA final design project. Sincere gratitude goes to my academic mentor for guidance throughout the process; the fashion and textile design students for participating in the design workshops; and the eri silk weavers of Assam, the designers, and other participants for taking part in the survey.

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paper

11

It is time to take the bull by the horns:  
Menstrual product debris can be reduced  
by using Uger fabric washable pads

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# It is time to take the bull by the horns: Menstrual product debris can be reduced by using Uger fabric washable pads



## Abstract:

Menstruation is a bodily expulsion that requires management. Traditionally, women have made their own pads, harvesting cloth from old garments, washing, and reusing it until the end of the fabric's life. In Southern Rajasthan, India, a commercially available, reusable fleece material called the *Time Piece* (TP) and commercially branded, disposable sanitary napkins are quickly replacing traditional, sustainable methods. This has given rise to large volumes of menstrual debris. This debris is detrimental at many levels: social, environmental, and health. The use of *Uger* Sanitary Pads is a simple solution, designed in an effort to lower the levels of debris and provide a convenient, healthy option. The pads of cotton fabric are washable. Our research has shown that each pad can be washed and reused at least 60 times. We have demonstrated that dignity can be returned while using reusable products and that the migration toward unsustainable options can be potentially slowed down.

**Keyword:** *menstruation, debris, reusable, napkin, cloth*

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## 1 Introduction

We are in a world inundated with single-use, disposable, commercially available products. Tissue paper has replaced handkerchiefs, paper cups are used instead of stainless steel coffee tumblers, and children's diapers have edged out the traditional cloth nappy. In the same way, menstruation is now commonly managed by the use of disposable sanitary napkins and other, cheaper substitutes. The waste that is generated by disposable sanitary napkins and other menstrual products has an impact on the environment, on individual health, and on a community's well being. This is proving to no longer be sustainable.

Can a reusable menstrual management product lower this impact? If so, what should the design of this system be? Many aspects of menstruation were

considered. Literature review, field work, visits to the homes of adolescent girls and women, observations, interviews, and focused group discussions have guided this ongoing study. We followed our research by developing a product that was tested by users. This product could potentially address some of the unsustainable menstruation management systems that are commonly in use.

## 2 Background

### 2.1 Menstruation: A bodily expulsion

The earth renews itself. Leaves fall off a tree to let new ones come in their place. Nature has always had its own methods of rejuvenation and regeneration; this process of rejuvenation begins with an expulsion, a removal, or a release. Menstruation is no different – it is a natural phenomenon – an expulsion much like

the falling of a leaf. Once the cycle of blood release is completed, the body begins to prepare itself once again for a potential pregnancy. The process of the new replacing the old continues.

Communities take care of bodily expulsions, such as faeces, urine, sweat, phlegm, saliva, dandruff, or ear wax, in different ways. However, menstruation is the only woman-specific expulsion; it is physiologically different from other expulsions.

One egg is released every month and reaches the uterus after passing through the fallopian tubes. As the egg proceeds through the tubes, a layer of blood coats the walls of the uterus. Gradually, this layer begins to thicken. If fertilization does not take place, the inner layer starts breaking. This causes bleeding. This process is called menstruation. (Murthy, 2000)

Menstruation comes with discomfort, cramps, headaches, and mood swings. During the adolescent years, between 9 and 19, hormonal changes trigger the onset of menstruation, or periods. A woman will experience periods for an average of 40 years in her reproductive life time. Periods stop altogether after menopause (NHS, n.d.).

## 2.2 Menstruation and society

The physiological phenomenon is not very simple in itself; it has many social, economic, and environmental dimensions. Menstrual blood was not scientifically understood historically; rather, it was feared. Taboos, misconceptions, blind beliefs, and negative attitudes surround menstruation in most cultures. This 'time' has always been regarded as dirty. This attitude takes on many strong, negative forms that eventually affect a woman's position within society. In some parts of Nepal, women separate themselves from the rest of the household during menstruation, a system called *chaupadi* (Gaestel, 2013). Women are banned from worship during their periods. An extreme form of this practice occurs at the *Shabarimalai* Temple in Kerala, where women of reproductive age are forbidden from entering the shrine (Krishnan, 2006).

Excluding men from conversations about menstruation is a phenomenon existent in many cultures. Typically, boys first learn about periods from their friends, their peer group, magazines, and advertisements. Females within the family, sisters and mothers, are never vocal about it (Allen, Kaestle, & Goldberg, 2011).

Isolating men has led to insensitivity. Writer C. S. Lakshmi (2005) talks about how male insensitivity results in infrastructure that is poorly design for women in her article, 'Planning Public Spaces'. This insensitivity is evident in the government schools in India. 'The unavailability of sanitary pads, inadequate sanitation and absence of separate toilet for girls in schools, compounds the problem and has a huge impact on girls school attendance and is a major reason for dropouts of girls from schools' (Roy, 2011).

If one were to examine the ways women managed menstruation over time, one would find a variety of innovative and imaginative ways that were used to suit cultural and geographical contexts. The absorbent materials in the past have included sphagnum (moss), cloth, coconut coir, banana fibre, water hyacinth, corn, grass, newspapers, leaves, and cotton plugs. The creator of the website, 'Museum of Menstruation', has been documenting many of these products (Finley, n.d). Currently, there are a variety of menstrual products, such as tampons, cups, sponges, sanitary napkins, and others.

## 2.3 Environmental impact of menstruation

Modern mass-production methods to create menstruation-management products, such as tampons, tampon applicators, and sanitary napkins, generate large amounts of debris. Regarding some global garbage figures, the United Kingdom alone generates 1,000,000 tons of children's nappies, adult incontinence products, and sanitary napkins every year that go into landfills (Knowaste, 2013). According to a recent survey commissioned by the Pune Municipal Corporation, India, 250,000 used sanitary napkins are being flushed down toilets or

end up littering pavements each day (Sabnis, 2013). Solid waste disposal is indeed a major challenge for many municipal corporations, as landfills are choked. In a landfill, pads remain in the same state for a very long time (Cadmen, n.d). The impact of disposable products on the environment can no longer be ignored.

## 2.4 Objective of this study

A number of aspects to menstruation have been previously contemplated by many researchers. Products to manage menstruation have also been under focus. However, understanding the product, its use, and its impact from the point of sustainability is a vast area that still has potential to be explored, particularly in the context of a developing country where sanitary napkins are used by an estimated 12% of the 355 million women residing there who menstruate (Sukumaran, 2013). The corresponding disposable menstrual products would potentially be a staggering amount. The objective of this study was to examine and understand the residue from menstrual products and its impact at three levels, on the human body, on the environment and on a community. Further, there was an attempt to determine if a reusable product can lower the debris, thereby creating a more sustainable menstrual management system.

## 3 Method

The areas selected for the study were the districts of Rajsamand and Udaipur in Southern Rajasthan. The researcher collaborated with a Non Government Organisation (NGO) in the area.

### 3.1 Study 1

The method used for information gathering:

- a. Home Visits (HV) to five Scheduled Caste homes
- b. Conducting group discussions (GD)
  - GD 1–9: Women, aged 25 to 50, below the poverty line, at a Mahatma Gandhi

National Rural Employment Guarantee Act (MGNREGA) work site (Government of India's job guarantee welfare scheme)

- GD 2–16: Women, aged 16 to 33, Scheduled Caste, part time workers employed by their own community through an NGO
  - GD 3–18: Men, aged 21 to 36, Other Backward Class, workers employed by their own community through an NGO
  - GD 4–43: Women, aged 13 to 21, Scheduled Caste, at a reproductive health training programme at the NGO
- c. Interviews with nine women, aged 17 to 32, women having problems with branded sanitary napkins identified through word of mouth
  - d. Interviews with three doctors (IWD)
  - e. Self Administered Questionnaire (SAQ) answered by 197 female undergraduate students, age group 17 to 21, government girls college, peri-urban location
  - f. Studying menstrual products

We discuss the findings of Study 1 in Section 4.

### 3.2 Product design

After analyzing the findings from Study 1, a reusable menstrual product was developed to determine if menstrual debris could be reduced. The details of the design of this product are discussed in Section 5.

### 3.3 Study 2

Once the product was developed, it was tested.

- a. 45 users in the age group of 16 to 45 years old used the product over 12–13 menstrual cycles. Selection was random, given to those willing to try the new product. The group was mixed: rural, urban, high, and low income.
- b. No timeframe was allotted, and no record keeping was requested, as the product was new and we were exploring the many aspects of this. We only requested feedback and for all the used products to be returned.

- c. We took back used items at different times to cover at least 12 cycles, that is, one year.
- d. As they returned, or as we took back products, we spoke to individuals
- e. The returned, used products were examined closely.
- f. Insights from this exploratory user testing pointed to ways a menstrual product can reduce the negative impact on health, the environment, and communities.

These findings are discussed in Section 6.

## 4. Findings from Study 1

### 4.1 Isolation and silence

We found that isolation at this time of the month continues to exist. The kitchen is out of bounds. The area or alter where the gods' idols rest cannot be touched. 'Baarney hu' (I am outside) used in *Mewadi*, the local language of South Rajasthan, to mean menstruation, aptly describes the isolation (GD 4).

'I light the lamps and say prayers when my mother has her period';

'I was told not to touch my mother during certain times in month';

'My father would be the one cooking, with my mother instructing him from the side';

'The pickle jar is not touched at this time, as the pickle will spoil' (GD 3).

We found that silence about menstruation is prevalent everywhere. 'When I asked my mother questions about periods, the subject was always changed; I only understood later' and 'The school teacher always skipped the reproductive health chapter, telling us to read it at home' (GD 3).

Silence is not just restricted to conversation; it translates into insensitivity in the infrastructure.

Most homes do not have latrines; consequently, women have no privacy. Many houses demarcate a small area in the corner where water is stored in drums and cement tanks. A sheet draped on a string is tied across this area to temporarily cordon it off when women need to bathe or wash their menstrual cloth (HV).



**Figure 1** The space in the corner of a house for bathing and washing menstrual cloths, taken during a home visit

### 4.2 Products to manage menstruation

Three types of products are commonly used: cloth harvested from used garments, a Time Piece (TP) or *falanil*, and more recent commercially available sanitary napkins (CSN) (GD 1, 2, 4; SAQ).

#### 4.2.1 Cloth harvested from old garments

Cloth is harvested and recycled from old garments and old bed linen. This cloth is referred to as 'gaba'



or 'ghar ka kapda'. Women save cloths for use during this time of the month; these come from petticoats, turbans, veils, towels, bed sheets, pants, saris, loin cloths, and pyjamas. Many superstitions are associated with the menstrual cloth.

'It will shorten my husband's life if I let him see my cloth'; 'Men will go blind when they see or step on the cloth' (GD 1, 2, 4).



**Figure 2** Used cloth from an old garment given to a researcher

The consequence of these beliefs – the menstrual cloth is hung in the darkest corners, hidden amongst roof tiles or under other clothes on a clothes line. Women select dark coloured cloth to camouflage blood stains. The coloured fabric poses a health risk, as abnormal discharges are difficult to identify on dark backgrounds (IWD).

#### 4.2.2 Time Piece (TP)

Costing around Rs 15–20 and also easily available at the local market, the TP is very popular. Also known as a *falanil*, it is available in cherry red, navy blue, black, olive green, or chocolate. Washing requirements are similar to that of a cloth. Girls and women have this to say:

'Easy to wash, it can be dried anywhere. I do not feel embarrassed at all when I hang out the cloth';

'It does not show stains';

'I gave up petticoat cloth; it is old fashioned';

'It is affordable and lasts for 4 to 6 months' (GD 1, 2, 4).

TP is not just restricted to the state of Rajasthan; it is available in the neighbouring state of Gujarat and has been noted by other researchers as well (Shah et al., 2013).



**Figure 3** Time Piece, dimension 20" × 15", purchased by a researcher from the local market



Two TP samples were tested at the textile laboratory at Banasthali University, Tonk Rajasthan. The tests used were for the identification of the fibre, as per ASTM D276 standards, and identification of the dyes, as per AATCC 161-2012 standards. The report showed it was made of a poly acrylic fibre – non-woven, fleece material – using dispersed dye.

#### 4.2.3 Commercial Sanitary Napkin

Disposable CSNs – one time use and throw – available in the study area are Whisper, Kotex, Stayfree, and Don't Worry. Most users cannot recall brand names, as the text on the packaging is in English, an unfamiliar language. All branded napkins are called medical *wallah* napkins and bought at a pharmacy or a grocery store. Since money is spent on this product, it is used sparingly. Changing is done only twice a day to allow the same pad to last as long as possible. Ultra thin gel-based pads allow for longer periods of wear, giving stain protection (GD 1, 2, 4; SAQ).



**Figure 4.** Napkins (marker pen to show scale).  
**Source:** author generated.

We opened up sanitary napkins from five brands to see what was inside: Whisper (Proctor and Gamble), Sofy (Unicharm), Stayfree, Carefree (Johnson and Johnson), and Don't Worry (Mankindpharma). They are composed of derivatives of plastics and polymers and are less than 1 mm in thickness (YouTube, 2013a; Textile learner, n.d.). Interview responses revealed that the layers in a pad differed depending on the brand, but the materials in the pad tend to make the vaginal area very warm.

We examined the outer packaging of these five brands, none of which had any information on raw materials. We also realized that consumers themselves are poorly informed. Only 29.9% of respondents in the survey knew that the pads were made of non-degradable material (SAQ).

#### 4.3 Changing attitudes: Aspiration and migration toward disposable

Increasingly, recycled cloth is being perceived as old fashioned, not contemporary:

'A reusable cloth pad? That will be disgusting, who is going to wash it?'

'One can get cheap disposable pads now so why not use disposable?'

'Cloth shifts, but the pad is fixed nicely to the underwear';



**Figure 5** Layers in a pad

‘Where is the time to wash it?’ (GD 1, 2, 4; SAQ)

A clear migration from lower-end menstrual products to higher-end ones can be observed. Women have made the move from cloth to TP, then others from TP to CSNs. TP is inexpensive, looks modern, is socially acceptable, is pre-cut, takes half the time to wash and dry, and does not show any blood stains. This migration is perceived as an upward social move, and this change has been rapid.

There is also a clear shift toward CSN. Many studies indicate that girls are opting for disposal options (Shitole, Patnaik, Pandey & Patil, 2012; Juyal, Kandpal, Semwal & Negi, 2012). There is more willingness to buy products requiring less effort to manage, so disposable menstrual products are an attractive option. However, along with disposable comes a range of debris – this is difficult to wish away.

#### 4.4 Menstrual product debris: The residue, remains, and scars

Dictionaries define ‘debris’ as the scattered remains of something, or the fragmented remains of dead or damaged cells or tissue (Debris, n.d). Menstrual debris, in medical terms, is understood to be tissue shed from the uterine wall (Menstrual Disorders, n.d). We defined menstrual product debris to mean residue, remains, or scars caused by the use of a menstrual product. We categorized this in three ways:

- Debris in the body: health problems of the user caused as a result of using menstrual products

- Debris in the environment and surroundings: caused by volumes of menstrual product waste that does not biodegrade placed in the earth
- Debris in society: scars caused by the erosion of values

##### 4.4.1 Debris in the body

We examined how products affect the human body. TP users said:

‘It is a very warm product, but it’s okay for me – it has to be used for only four days’;

‘I have very severe itching followed by burning with this item’;

‘I don’t mind the discomfort; I use this with a ‘tube’ if I have any problems. This is far better than the old cloth method’ (GD 1, 2, 4; SAQ).

‘Tube’ refers to an over the counter anti-fungal cream which is used when there is itching and swelling. Clearly, the product suits the family budget, even though it is of inferior quality. There is social acceptance of the cloth (it does not show stains), and this overrides health, as using the product along with medication appears to be acceptable.

We asked CSN users about their experiences. Some users are very happy while others are not:

‘I get a reddish rash from the CSN – it hurts me. There is irritation and a severe scratching sensation.



Figure 6. Migration from cloth to *Time Piece* (TP) to Commercial Sanitary Napkins (CSN).

Source: author generated.

I suffered for many months, and after that I started using cloth’;

‘I get boils in the vaginal region and between my buttocks. It starts as a red kind of rash, and then it becomes like a pimple and turns into a boil. I once had an abscess. I feel helpless; I have no other product options’;

‘I have got habitual rashes and boils. When I am in the flow, I accept that I will suffer. I use CSNs and cannot bear the thought of using reusable’;

‘I use CSNs with a cream that my gynaecologist prescribed’ (from interviews; IWD).

‘Yes, we get many patients with problems due to their menstrual products’ (IWD).

The cost to women’s bodies due to menstrual product debris cannot be taken lightly.

#### 4.4.2 Debris in the environment and surroundings

The preference for and use of disposable sanitary napkins has given rise to huge volumes of waste. This includes packing material, plastic wrappers, covers, boxes, release papers, and used pads. We found pads disposed of into dry river beds, empty plots, a river, on the roadside, in a latrine, and in a drain.



**Figure 7** Sanitary napkin packet thrown by the wayside and a napkin choking a water outlet

We found stray animals, cows, dogs, and pigs, foraging through the menstrual debris, looking for food.



**Figure 8** Cows ingesting garbage, including menstrual waste; close-up of garbage

We spoke to the coordinator of *Suchi Abhiyan*, a garbage campaign in Udaipur City that started in 1998. At that time, 30% of total garbage was plastic material. Now, 16 years later, 80% of garbage is empty snack food packing, used adult and children’s diapers, used toilet paper, and sanitary napkins.

We tried to find out what happens to a disposed pad. We came to understand that it breaks down eventually; it photodegrades into small polymer pellets. This process is estimated to take 10–20 years. The pelletized material goes back into the earth and into the ground water (Cadmen, n.d). However, if a pad is burned or incinerated, the toxic fumes are harmful (Ibnlive, n.d.).

The volume and burden of menstrual waste on the environment is enormous and removing it is complex.

#### 4.4.3 Debris in society

While health and environmental factors are easy to quantify, what remains unaccounted is the debris in society. There has been a steady erosion of older sustainable systems. Not wasting anything used to be a value; it was a form of respect toward resources. This practice was no longer visible during our observations. This came to the forefront in a group discussion response: ‘Madam, I use homemade cloth as CSNs don’t suit me. But, I tell my friends I use CSNs. I don’t want



people to think I am old fashioned or cannot afford it'. There is so much anxiety about belonging and conforming to what everyone else is doing that the truth is hidden at any cost. Buying a throw-away is perceived as a signal that 'we can afford this'; recycling and reusing is only for the poor. There is no dignity in reuse.

Multinational companies, through their advertisements, seem to compound the erosion by making the viewer believe that disposables are hygienic and best. An example is the 'Whisper Ultra Clean: New Rule vs. Old Rule' commercial (YouTube, 2013b). It tells you to bring in the new and not stick to old methods. Nowhere is the advertisement openly saying that cloth is out; it only subtly suggests it. The convincingly attractive packaging triggers a migration toward the product.

In the study area, loans get routinely taken out by families for the purchase of a motor bike. However, no loans get taken for building bathrooms. Kesibai's story (name changed) illustrates this further. Her husband built a four-room house. He did not construct a bathroom, citing that there was an empty plot next to the house which would suffice for their bathroom needs.

Society's well being gets compromised by notions of what is better or fashionable. Communities become value blind and do not see the larger picture.

#### 4.4.4 Summary of costs and felt needs

We compared the health, environmental, and economical impact of the three products.

**Table 1** Impact of products on community

Product	Health costs	Environmental costs	Social Costs	Economic costs
Cloth from home	Cotton: cool to skin, provides aeration. Fungal infections when they occur are not from the cloth itself but more from lack of personal hygiene or the cloth not being washed properly.	None: used cotton cloth will biodegrade in 4 to 5 months  The cloth will have lead two lives – first as a garment and next as a menstrual cloth.	No erosion of values, no waste, respect toward resources.  Superstition results in improper care of cloth.  Silence, no facilities for women.	No Cost
TP	Warm fibres create raised temperature in vaginal area, causing health problems.  Dark coloured fabric: blood not washed out completely.  Fibres trap trace detergent and may also become the cause of skin allergies, such as contact dermatitis.	Materials go through photo-degradation – getting pelletized, entering water ways.  Materials remain intact in land fill for an estimated many hundred years.  If burned, harmful gases are released into the atmosphere.	Erosion of values, market products preferred over home made.  Silence perpetuated, use of inferior dark coloured material.	Rs 160 per year  Approximately 320 to 400 TPs in a life time
CSN	Polymer based material makes the product very warm. Health problems result, as above.  Gel technology: infrequent changing causes itching and infections.	As above.	Convenience placed over values or concerns for the larger environment.	Rs 700–800 per year  Approximately 3000 to 6000 pads in a life time.

From all of our research, what emerged is that there is a need for a product that can reduce the three types of debris, a product that would be sustainable. Other researchers point to this, as well (Connett, n.d.). Ideally, the product would have to be reusable cotton fabric and use a design that comprises elements from both the *TP* and the *CSN*, to include the best of both systems. We found more than 20 options for reusable cloth pads already on the internet. Some of these companies are Gladrags, Party in my Pants, Luna pads, and Pink Robin. We studied their designs, after which we closely consulted with *Ecofemme* at Auroville, Tamil Nadu, the pioneers of cloth pad making in India (Ecofemme, n.d). We took our inspiration from their product, both the design and the philosophy of reuse. Table 1 above, guided the brief for the design.

The product was to:

- not create waste after final disposal – hence, cotton fabric was selected.
- have dignity, and not look like any piece of cloth – therefore, stylish.
- be a comfortable shape and size, be affixed well, and not shift when moving.
- not cause discomfort, like itching or scratching – therefore, select raw material that is cool to the skin.
- manage different volumes of discharge throughout the cycle – hence, provide adequate layers.
- be socially acceptable and easy to maintain – compromise had to be made here – the colour of fabric that would touch the skin had to be white so the user could identify abnormal discharges.

## 5 Product design

### 5.1 Findings from Study 1, which guided the design brief for the product

### 5.2 The product

Two pads were developed – the *Uger* Insert pad and the *Uger* light pad. The word *Uger* means a new



Figure 9 A light pad for light flow; the fabric close to skin is always kept white



Figure 10 Folded pads in a stack





**Figure 11** Insert pad with towel for heavy flow; fabric close to skin is always kept white

beginning in *Mewadi* – the language of Southern Rajasthan. The pad was mass-produced by a women’s Self Help Group associated with the NGO supporting our work.

## 6 Findings from Study 2: Product testing

The *Uger* pads were tested for design, comfort, and acceptability.

### 6.1 Feedback from users

**Table 2** The previous menstrual products of those women trying *Uger* pads

Number of Users	Their previous menstrual product
18	<i>Time Piece</i> (TP)
13	Commercial Sanitary Napkins (CSN)
9	Old Cloth
3	Old Cloth + TP
1	Menstrual Cup
1	Other (reusable stitched cloth pad)
<b>Total = 45:</b> We had initially approached 25 CSN users to try <i>Uger</i> pads; of these only 13 had agreed. This respondent number is reflected above.	

- It takes half a bucket to one bucket of water to wash out the pads, depending on discharge.
- All 18 TP users found the *Uger* pads ‘*bahuth badiya*’ (far superior) to their existing product: ‘It is cool and very comfortable’. One user returned her *Uger* pads after 60 washes and estimates that they will last five washes more.
- Of the respondents, 13 were using reusable pads for the first time. In this group, two users

reluctantly tried *Uger*, but abandoned it almost immediately, saying, ‘It is too much trouble to wash’. Eight users claimed that they have given up CSNs for good and are now using *Uger* pads. Three claimed that they are now using *Uger* in combination with CSNs. ‘What a godsend this has been. What choice did I have until now? I am finally free from all the torture of itching and boils’. ‘I want a white pad each time. There will always be a light brown stain on *Uger* pads. I know I have washed it well, but it still makes me uncomfortable’.

- Of the nine respondents using cloth, all felt that the design was better than just placing a cloth in their underwear.
- The cup user said, ‘I’ll use the pads mainly for light flow and additionally as a precaution with my cup’.

### 6.2 Learning from the user trial

The pads work for what they were intended, absorbing menstrual flow. There were other insights. Twelve users who did not even make the attempt to participate in the trial were disposable product users. They had the following to say: ‘I cannot touch blood’; ‘Cloth is not hygienic’; ‘I cannot take this to work. How can I bring home a bloodied cloth in my handbag?’

CSNs are white in colour, so users who have only used CSN in the past expected *Uger* pads to remain white after washing. This is an unrealistic expectation, as there will be dull residual stains from proteins in the blood after washing. Users who have experience with



**Figure 12** Pad new; pad after two washes

cloth have no such expectation. Residual stains on a well-washed fabric have previously not been known to cause any general or specific infection (IWD).



**Figure 13** Pad after 60 washes, still fit for use

## 7 Discussion and conclusion

In terms of convenience for the user, there is no doubt that a low-maintenance disposable pad ranks above a high-maintenance reusable product like *Uger* pads. It has been observed that disposable pad consumers may not easily make the switch to reusable.

*Uger* pads are made of cotton. Cotton crop cultivation is highly water intensive; processing fibre into fabric is also water intensive and maintaining an *Uger* Pad requires water. Significantly lower amounts of water are required for manufacturing a disposable sanitary napkin. Additionally, for disposing a CSN, the end user requires no water for the action. Thus, more research would be required to accurately

assess the actual environmental impact of all three products: TPs, CSNs, and *Uger* pads.

It has been indicated in the user testing that cool cotton fabric next to skin feels more comfortable than artificial materials such as those used in TP and CSN. However, there are many other factors that will determine what a user will finally select for their menstruation needs.

If we are to reduce menstrual debris, we have to actively advocate at many levels:

- Break the silence on shame, taboos, and superstitions to create conducive environments for women to manage menstruation openly and healthily and to express their problems.
- Include men in menstruation conversations. This will help advocate for women's needs and will influence decision making in the home – for example, by encouraging the building of a bathroom.
- Through dialogue with communities, re-examine values like reuse and recycling.
- Help future 'menstruators' make informed choices about available products.
- Work along teachers and trainers who teach reproductive health.

Finally, as another strategy we can also use guilt, making users feel guilty about what they are not doing for the environment. It is well documented that guilt can also motivate people to change (Mallett,

2012). Potentially, we now have a menstrual product that can reduce menstrual debris; however, more assessment is required.

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paper

12

Organic Cotton Farming and  
Sustainable Development for Rural India

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## Abstract:

Cotton fabric enjoys the highest global consumption amongst textiles, and its cultivation contributes about 65% of the pesticides found in the soil where it is grown. Organic cotton cultivation involves the use of organic fertilizers and pesticides, easily available from bovine excreta in farms. BT cotton is popular among farmers due to its higher yield per hectare. The rate of conversion from BT to organic cotton in India is still slow. Concerted efforts by both the industry and the government are required to educate the farmers about the benefits of organic farming and organic certifications, like GOTS, Fair trade Policy, etc. A case study of Project VASUDHA in Madhya Pradesh was undertaken to study farmlands cultivating organic cotton, with direct, on-field interaction surveys with the farmers. They are satisfied with the support, but have certain problems, which were identified and solutions suggested.

**Keywords:** *BT cotton, organic fertilizers, organic insecticides, organic certification, sustainable clothing*

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## 1 Introduction

### 1.1 Moving Towards a Sustainable Future

As we are moving towards an eco-friendly and sustainable environment, the use of eco-friendly products is the demand of the day. Due to global warming, people are more sensitized towards environmental issues and adopting organic products. People are making an effort to save the planet by taking 'Green Action'. The organic market is wide ranging, from food to garments for children, to home textiles. Organic cotton provides a solution to all of our needs. Without doubt, the fashion industry supports the growth of organic cotton production. Today, fashion apparel outlets are selling clothes and accessories made from organic cotton. Many people thought that organic cotton clothes were unstylish and not up-to-date. However, clothing companies have produced organic clothes that focus on environmental issues and fashion

trends as well. Knowingly or unknowingly, we are contributing to the environment while we are buying these clothes.

Similar to the demand of organic foods, the organic cotton market is growing unexpectedly quickly. 'During the 2007–2008 crop years, organic cotton production was enhanced by 152%. As a result, organic cotton production reached 145,872 mt, equalling 668,581 bales, grown on 161,000 hectares, in 22 countries' (Organic Cotton, (2010).

Today, India is the largest producer of organic cotton, followed by Turkey in second place. There are also several countries that have started to produce organic cotton in large quantities, such as Syria, China, Tanzania, the United States of America, Uganda, Peru, Egypt, and Burkina Faso (Organic Cotton, 2010). They were participating against BT cotton production, which was recognized as being risky to the environment and for the workers.

## 1.2 Objectives

- To perform a case study of organic cotton farming to find solutions to the problems faced during conversion from BT cotton farming to organic cotton farming.
- To understand the problems faced by farmers and the challenges in organic cotton farming.
- To study various projects of organic cotton cultivation being undertaken in various parts of India.

## 2. Literature Review

### 2.1 About Cotton

Cotton is an essential component of our daily lives and the most important fiber crop of India. The production of organic cotton is becoming increasingly important for the planet's ecological balance. It is the backbone of our textile industry, accounting for 70% of the total fibre consumption, and 38% of the country's export. Area under cotton cultivation in India (8.9 million hectares) is the highest in the world.

However Cotton productivity in India is low as compared to world standards. Modern cotton production technology relies heavily on the use of fertilizers and chemicals.

Organic cotton is grown without pesticides and spun without chemicals. These Farmers rely on natural fertilizers, manual crop rotation, and integrated pest management. Weeds are removed with equipments, as well as manually (Organic Cottons, 2008).

#### 2.1.1 Scope for Organic Cotton Cultivation

Cotton, though cultivated on 5% of cultivable land consumes 54% of the total pesticides used in Indian. Organic farming aims to conserve natural resources, while being profitable for the farmer. In order to keep a certain threshold of profit for the

farms, all farming practices have to be redesigned to undo the ill effects that have crept into the current agricultural scenario, while attempting to increase cotton production in the prevalent cropping systems.

Originally, the cotton grown in the country was 'eco-friendly'. Many pockets in India where it was produced include, Y-1 *desi* cotton from the Khandesh (Maharashtra), Maljari (Madhya Pradesh), areas growing Jayadhar and Suyodhar in Karnataka, Nandicum in Andhra Pradesh, and parts of the North-Eastern hilly regions. Cultivation of cotton with organic methods has helped farmers to improve sustainable productivity (Rajendran et. al., n.d.).

## 3. Environmental Impacts of Cotton Production

Modern agricultural practices demands use of substantial fertilizers and pesticides. Globally, cotton accounts for 11% of all pesticides and 25% of insecticides annually despite occupying 2.4% of arable land. In developing countries this estimate is nearing 50%. Five of the 46 insecticides and acaroids used these are classified as extremely hazardous, and eight as highly hazardous. Endosulphan is a pesticide that is classified as highly toxic. The use of pesticides poses health risks to workers; to the soil; to migratory species and to freshwater ecosystems. Organic agriculture protects the health of people, and the planet (Blessed Earth, 2013).

### 3.1 Organic Farming Gives Indian Farmers Greater Financial Securit

Organic cotton farming is more profitable than using them Genetically Engineered (GE) variety that puts farmers in high debts. In 2009–10, farmers cultivating organic cotton earned 200% more net income than those growing BT Cottons (Erroneous, 2010). A comparative analysis in Andhra Pradesh reveals that GE cotton results in greater crop loss to pests, despite extensive use of pesticides BT cotton farmers not only spend on 26 different but also lose financially due to their high input costs (Euronears, 2010).

### 3.2 Global Market - Organic Cotton Products

Consumers are no longer simply eating organically grown food only—they are also wearing clothes, using personal care products, and outfitting their kitchens, bathrooms, and bedrooms with products made from organic cotton. By using organic cotton, companies can bring added value to their customers and position themselves for long-term growth. (GreenBiz, 2006). 100% organic cotton programs, are also developing programs to blend small percentages of organic cotton with modern cotton products.

Use of organically grown cotton by well-established retailers, fashion designers, and small and medium size companies resulted in 35% increased sales globally, and 55% annual increase in the US. (GreenBiz, 2006).

The brands adopting organic cotton globally are Nike (Oregon), Coop (Switzerland), Patagonia (California), Wal-Mart (Arkansas), Coop Sweden (Sweden), Earth Creations (Alabama), H&M (Sweden), Howies (UK), IKEA (Sweden), Indigenous Designs (California), LoomState (New York), Maggie's Organics (Michigan), Marks & Spencer (UK), Organic Essentials (Texas), People Tree (UK), and The Timberland Company (New Hampshire). More than 1,200 small- and medium-sized brands and retailers offer organic cotton products in North American, European, and Asian markets (Green Biz, 2006).

MORALFIBRE is an emerging textile brand that uses almost no electricity and no harmful chemicals. The

fabric is suitable for all seasons and are made from cotton, silk, wool, blends, and organic cotton, using natural dyes and printed patterns. (Moral Fibre, 2011).

### 4. Advantages of Organic Cotton

Organic cotton, natural, for delicate skin. Pesticide and chemically-treated clothing, diapers, and bedding, by trap heat and preventing it from 'breathing' resulting in eczema.

Organic farms enrich their soil and water. Organic cotton is more durable when compared to BT cotton that are weakened by chemicals used in cultivation, processing, and dyeing. (Organic Cotton, 2013).

#### 4.1 Organic Certification

Certified Organic, brings in credibility, and means that the cotton has been grown according to strict consistent standards that are verified by independent state or private organizations. Certification includes inspection of fields, and periodic testing of soil and water. It also fetches the farmers a good price for their produce (Organic Cotton, 2013). The Global Organic Textile Standards (GOTS) have been set on the Global Organic Textile Standard, and each certifying organization follows the same standards and control. (GOTS, 2012).

Fair trade Standards in cotton ensure: Minimum Prices for cotton, depending on the region of production, and are set 20% higher than conventional minimum.



Figure 1 Various Certification Standards for Organic Cotton

Source: Compiled from internet

Fair trade in cotton in 2004 has demonstrated that it can substantially improve the lives of communities, also allowing them to invest in community development projects. (FLO, 2011).

On similar lines, the Southern India Mills Association (SIMA), in South India has demanded a Fair Cotton Trade Policy to revive of the ailing textile industry (Fashionunited, 2011).

## 5. Methodology

### 5.1 Case Study and Documentation-Project VASUDHA

For documenting organic farming, we visited the VASUDHA project in Barwah and Karhi in Madhya Pradesh. Farmers were interviewed and the process of preparation of organic fertilizers and pesticides was studied and documented.

The methodology adopted was primary research, with direct interaction with the farmers at the farms.

### 5.2 Developing a Questionnaire to Assess the Challenges Faced by the Farmers

In order to assess the challenges and problems faced by farmers in organic farming, a questionnaire

was developed, and discussions with the farmers were carried out to understand the nature of their problems in the areas of Barwah and Karhi.

A questionnaire was developed with multiple choice and close ended questions to obtain information.

## 6. About Project VASUDHA

VASUDHA produces 9,000 tons of organic and Fair trade cotton. These are spread over 125,000 acres of contract farming, including short, medium, and long staples.

VASUDHA covers organic and transitional cultivation, with 28,000 farmers across 250 villages in four states of India, certified under the control union USDA NOP standards, as well as the FLO trade standard.

VASUDHA employs a staff of 120 administrators to support and educate farmers in organic farming practices. Every step of production is documented and recorded, from raw fibre to finished garment, to ensure product integrity and substantiate claims.

VASUDHA cotton spans across the Indian states of Madhya Pradesh, Maharashtra, Orissa, and Rajasthan.

**Table 1: VASUDHA-Moving Towards Sustainability**

Name of Organization	Pratibha Syntex Ltd.
Address	Plot No.4, Industrial growth Centre, Kheda-454774 Pitampura, Dist. Dhar, Madhya Pradesh Email:www.pratibhasyntex.com
Managing Director	Mr. Shreysakar Choudhary
GM-VASUDHA	Mr. D.P. Arya
States under VASUDHA	Madhya Pradesh, Maharashtra, Orissa, Rajasthan
VASUDHA foundation	1999
Area under organic cotton farming	125,000 Acres of farmland
No. of farmers	28,000
No. of administrators/ staff	120
Cotton fibre quality	Short staple, Medium Staple, Extra Long Staple
Certification	Fair trade, GOTS, FLO, USDA, NPOP, Control Union, GSV
Production of Organic Cotton	7000 tons
Fair Trade Cotton	2000 tons



**Table 2: VASUDHA in Madhya Pradesh**

No. of villages	168
No. of farmers	5329
Acreage of organic farmland	28,463 acres
Production of cotton	3928 mt ton/year
Variety of organic seed	Maruti 9632, Ankur Akka 651, JK Durga, Banni 145
Rate of organic cotton in 2010	Rs. 5000-7500/quintal
Rate of Organic cotton in 2011	Rs. 4000-5000/quintal
No. of staff /administrators	54

**Table 3: Varieties of Organic Cotton and their Fibre Length**

Quality of organic cotton	Length of fibre (MM)	Tresh %	Max moisture %	Maturity value (Micronaire)
Mech -1	29-31	3 - 3.5	8%	3.8-4.2
H4	27-28.5	3.5 – 4	8%	3.3-3.6
J34	28-29.5	4 - 4.5	8%	4.2-5
S-6	29	2.5 – 3.5	8%	3.8-4.2
DCH 32	34-35	3.5 – 4.5	8%	3-3.3

### 6.1. Growing Process of Organic Cotton



**Figure 2** Farmland of Organic Cotton under VASUDHA

The process of growing organic cotton is as follows:

- Before sowing, the soil is treated with rock phosphate and gypsum in urine, and the soil of the adjoining area is allowed to ferment for three days.
- Sow the seeds in May.
- After 2 weeks of sowing, the seed soil is treated with cow urine+ Karan Patta+ Neem Patta+ Latina+ Sitaphal+ Dhatura, which is decayed for 15 days and then used as an insecticide.
- 15 days after sprouting Neem oil, Karanj oil (insecticide) is sprayed. Vermi-compost is added to the soil, as it gives length and shine to the fibre.

- Regular spraying with a solution of 10kgs of Urine+ Cow dung+ 2kgs of sugar and gram powder every fifteen days.
- For every acre of land, 2ltrs of Vermicompost solution+ 80 ltrs of water is sprayed 2 to 3 times in a full cycle, to give shine and prevent flower fall.
- Spraying of insecticide (Neem oil and Karanj oil) is done as per requirements.
- Biogas slurry is put around the plant once every crop cycle.
- Crop harvest occurs between Dec-Feb.

### 6.2 Process of Organic Fertilizer and Insecticide Production

- a) Making of vermicompost: In a mixture of cow dung in channels mixed with worms, the dung is allowed to culture the worms for around 15 days, with continuous sprinkling of water at regular intervals.
- b) Development of vermicompost: The worms added to the soil increase its fertility, porosity, and absorption of water. They also give shine to the fibre.



**Figure 3** Making of Vermicompost



**Figure 4** Development of Worms

c) Fermentation of dry leaves in urine: Cow urine, Neem Patta, Latina, Sitaphal, and Dhatura are decayed, filtered, and sprayed



**Figure 5** Fermentation of Urine and Leaves

d) Water from vermicompost: Water from the worm-drained soil is collected in the pit and used as a spray. This increases the length and shine of the fibre



**Figure 6** Water from Vermicompost Collected in the Pit

e) Friendly worms: Some of the insects and flies that are generated during crop rotation, are helpful in protecting the crops from harmful insects.



**Figure 7** List of Friendly Worms and Diseases

f) Pest control: Many organic sprays are developed to protect the plants from pests such as a urine spray, buttermilk spray, chilli paste spray, Karanj oil spray, and Neem oil spray.









**Figure 13** Female Plucking the Bloomed Cotton Pods

- l) Cotton collected in clean cotton bags provided by VASUDHA. Farmers are provided with these bags to reduce trash and dirt content in the cotton.



**Figure 14** Cotton Collected in Clean Cotton Bags

- m) VASUDHA cotton seed development project, where seeds of the best quality are cultivated to supply to the farmers.
- n) The Karanj plant, from which oil is extracted to spray on plants for pest control.
- o) Administrative team of VASUDHA at Karhi, which provides guidance and support on the field to farmers.



**Figure 15** Field for seed cultivation



**Figure 16** Karanj plant



**Figure 17** Administrative Team of VASUDHA

- p) Different types of organic insecticides: The insecticides are prepared on the field using

material available, and are either fermented/decayed in a copper vessel or in mud pots kept in sunlight.

The various methods to make the insecticides are as follows:

- Neem oil + Karanj oil, which is sprayed.
- Cow urine, Neem Patta, Latina, Sitaphal, and Dhatura are decayed, filtered, and sprayed.
- Buttermilk-15ltrs of butter + 5kgs of Latina + copper plate, dipped for 15-20 days, allowed to ferment and then sprayed.
- Cow urine-10ltrs of urine + 2kgs green chilli paste +2kgs Lahsun, allowed to ferment for 30 days and then sprayed.

## 7. Results & Discussion

### 7.1 Challenges in Organic Cotton Farming

- Firstly, yield per acre and subsequently, the savings per acre are higher in BT cotton than organic cotton. But the actual benefits and security in growing organic cotton is higher

because the risk of crop failure is nil. In the long run, there are no health hazards and soil decay, which farmers are not able to foresee.

- Secondly, the lack of know-how about development of organic fertilizers and the benefits under the Fair trade certification for organic farming.

A study is given below to assess the comparative benefits.

- Comparative study of the costs of production of organic and BT cottons per acre.

From the study, it is clear that not only the *expected yield in BT cotton is higher per acre by Rs. 1200 per quintal*, but *also the cost of production of BT cotton is higher by Rs. 5450 per acre*. The rate of risk of crop damage and the health of the farmers is also at stake. The seeds have to be procured from a government agency, which may not be of good quality, and the price is higher. Also, gradually, the fertility of the soil is reduced as the soil hardens and the air holes decrease, which greatly affects the production of BT cotton in the absence of a regular supply of water.

**Table 4: Comparative Study of Cost of Production**

Process involved from sowing of seed to plucking the cotton	Organic cotton (Cost in Rs.)	BT Cotton (Cost in Rs.)
Summer ploughing	1200	1200
Neem cake + Gypsum + Castor Doc + Rock phosphate	2250	3000
Transportation + labour	700	700
1 <sup>st</sup> Matka culture	200	0
Seed	1000	1600
Seed sowing labour charges	200	200
2 <sup>nd</sup> Matka Culture	200	0
Drip system	0	0
Vermicompost	1000	1000
3 <sup>rd</sup> Matka Culture	200	0
Neem oil spray+ chilli paste	500	5000
Labour charges for spray	200	200
Pheromone trap	700	0
4 <sup>th</sup> Matka khad	200	0
Irrigation + Water + Electricity	2500	2500
Cotton picking labour	2000	3000
Extra labour Charge	500	500
Extra expense	1000	1000
Total (in Rs.)	16550/-	22100/-
Yield expected 6qtl/8qtl @6000/-	36000qntl	48000qntl
Savings per acre	Rs.19450/-	Rs.25900/-



**Table 5:** Study on the Impact on Soil by Chemical and Organic Fertilizers

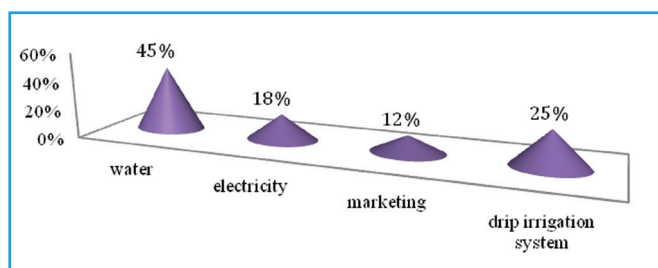
Impact on soil and other factors	Chemical fertilizers	Organic fertilizers
Soil quality	Soil fertility decreases	Fertility increases
Porosity of soil	Slowly decays and reduces in pores	Increases the porosity and thereby fertility
Quality of product	Products are less hygienic due to the presence of harmful chemical in the product	Product is hygienic as all fertilizers are made from nature, such as cow dung, cow urine, and fermented leaves
Cost	High	Less, as manure is prepared on the farmland using indigenous techniques and farm waste
Availability	Sometimes not readily available	Readily available and prepared under the control of the farmer
Biodegradable	No, hence a major health and environmental concern	Yes, hence eco-friendly
Impact on health	Infectious	No major concerns

ii) Comparative study of the impact of chemical and organic fertilizers.

The impact of chemical fertilizers is harmful in the long run. Usage of organic fertilizers adds to the fertility of the soil and improves the health of the farmers. Organic fertilizers are less costly and readily available.

**7.2 Results from the Questionnaire to Assess the Problems Faced by the Farmers**

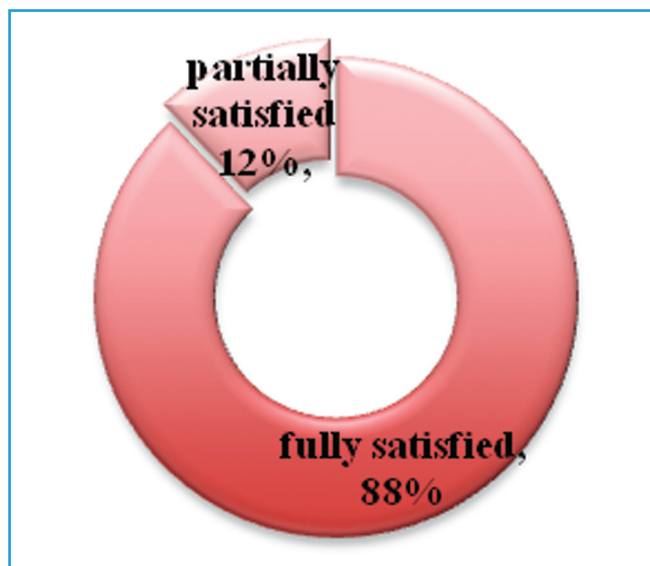
i) Problems faced by farmers: No regular water supply, electricity shortage, marketing of organic rotation crops such as wheat, soybeans, etc. and the non-availability of drip irrigation systems at subsidized prices.



**Figure 18** Various Problems Faced by Farmers

ii) Seed quality: In order to find a solution for the quality of seeds for organic cotton, under project VASUDHA, good quality seeds are made available to the farmers at subsidized rates and in a timely manner.

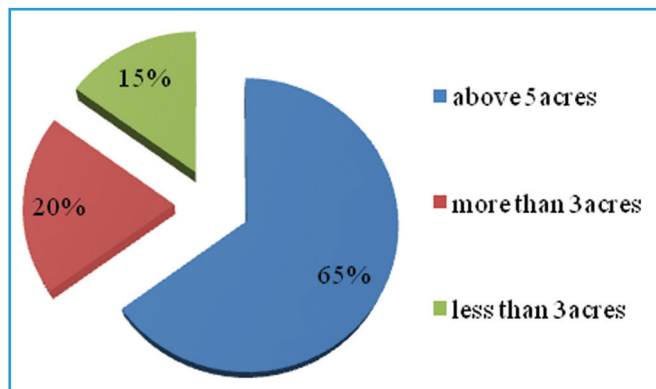
We interviewed a sample of 45-50 farmers involved in organic farming. The results indicated that 88% are fully satisfied with the quality of seeds provided under VASUDHA, with only 12% being partially satisfied.



**Figure 19** Satisfaction of Farmers Concerning Seed Quality, in Percentages

iii) Drip irrigation facilities: With regard to the drip irrigation facilities under project VASUDHA, farmers having a plot size bigger than 3 acres are provided with a drip irrigation system at subsidized rates and payment can be made in instalments. This has proved to be a great boon to the farmers. The survey also reflected that 65% of the farmers had more than 5 acres of land, 25% had more than 3 acres of land, while

20% had less than 3 acres of land. The farmers having a plot size bigger than 3 acres have drip irrigation facilities and have an excellent yield of 6-8 quintals of cotton per acre.



**Figure 20** Farmers & Plot Sizes, in Percentages

### 7.3 Projects of Organic Cotton Farming in India

i) Maikaal project: The Maikaal project in Central India has been one of the most successful initiatives in organic cotton cultivation. There is increasing interest in the socially, economically, and ecologically sustainable production of cotton.



**Figure 21** Stacks of Cotton

ii) Chetna: Chetna Organic from India has grown from 234 farmers in 2004 to a membership base of 8,138 farmers in 2010, in Andhra Pradesh, Maharashtra, and Gujarat. From a small project, it developed into a large-scale, independent organization. Several European fashion labels procure organic cotton from India.

## 8. Conclusion & Future Work

The problems faced by farmers in organic farming are mainly related to seed quality, water, drip irrigation systems, electricity, and better markets for the crop rotation products.

- The government has to take a major initiative to educate the farmers with regard to advantages of organic farming, which gives good quality yield and better security to their soil and their families.
- The benefits of Fair trade Certification need to be propagated through organized machinery.
- The electricity supply should be regular to increase crop yields in villages.
- Development of mandis to pay a premium price to the farmers for crop rotation cereals like wheat, soybean, and jowar, which are organically grown. As the urban consumer is ready to pay more for organic products, the government should develop a better marketing strategy for the village mandis to purchase the organic variety categorically.
- The VASUDHA Project, in its own small way, has made an attempt to bring farmers under the umbrella of organic cotton farming.
  - i) Availability of seeds at subsidized rates of Rs. 350/pkt in comparison to Rs. 700/pkt available in the market, in a timely manner.
  - ii) The training of farmers in developing organic fertilizers, by using cow dung and urine. Monetary support is also provided to construct the pits for fermentation. Well-trained manpower is always on the fields to assist the farmers in their problems.
  - iii) The entire process of crop collection is taken care of. After the government declared the price for cotton to be Rs. 4000/quintal, the company paid Rs. 4100/quintal of organic cotton in 2012.
  - iv) Due to organic fertilizers being used, the fertility of the soil is retained and crop loss due to pest attacks is low.
  - v) The farmers get monetary support for fertilizers and seed procurement, development

of drip irrigation systems, and social welfare activities for families, in terms of schools, medical facilities, and training centres for women to learn stitching and embroidery.

- vi) Skin and lung diseases have been reduced, and the farmers are happy with regard to their health and hygiene while following organic farming.
  - vii) Attacks by pests are taken care of by trained personnel in a timely manner, avoiding losses to crops and providing solutions to the various situations.
  - viii) To reduce contamination levels in cotton while plucking, they are provided with large cotton bags to hold the cotton safely.
  - ix) Under the organic certification of Fair trade, the farmers following organic farming benefit socially and economically.
  - x) Farmers having good water supply obtain a yield of 6-8 quintals/acre of land with organic cotton, especially as drip irrigation facilities are made available to them at a subsidized cost.
- Projects of organic cotton are being undertaken in various parts of India, which reflects the increasing awareness towards an eco-friendly, sustainable future. India is a major supplier of cotton to the world and if a concerted effort is made by the government, then there will be a revolution in organic cotton production.
  - Similar efforts of sustainable farming can be practiced in other agricultural farming practices, so that we may advance towards an eco-friendly, green world.

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Materials in Sustainable Wellbeing:  
A Case Study of Melamine

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# Materials in Sustainable Wellbeing: A Case Study of Melamine



## Abstract:

The sustainability of a product's design with respect to wellbeing can be assessed using different methods and techniques. Among these, a morphology-based approach permits a comprehensive articulation of a product's structure to determine its interaction with the external system. Discerning the morphology provides a sound footing to understand product behavior at various levels and permits an indicator-based sustainability assessment.

This paper presents a need to benchmark an indicator-based approach in a given condition by incorporating various social and health issues. These indicators can in turn provide long-term sustainability by directing the design process. This approach is illustrated through a case study of melamine resin. The case study demonstrates how to identify relevant variables and indicators and assess the level of a product's sustainability with the help of identified indicators and trends achieved through a simulation. This information can be used to make product designs more sustainable.

**Keywords:** *sustainability, wellbeing, morphology, indicators, and simulation*

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## 1 Introduction

“Humans are the central concern of sustainable development” is Principle 1 from the Rio conference on Sustainable development (United Nations Sustainable Development, 1992). Integrating human wellbeing with sustainability is a key concern in today's world. Deci and Ryan (2000) defined “Wellbeing by two separate philosophies -the Hedonic approach- wellbeing is conceptualized as involving the pursuit of pleasure and the avoidance of pain and the Eudaimonic approach-the focus is on self-realization and self-development, whereby wellbeing is conceptualized as the extent to which an individual is fully functioning.” However,

Deci and Ryan (2000) suggested that ideally there should be a balance between these two approaches. This means that greater wellbeing will be experienced when human preferences are more fully satisfied. On the other hand, sustainability is defined as development that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (World commission on Environment and Development, 1987).

Presently, the integration of wellbeing with sustainable development is the biggest challenge of the century, in which technology plays an important role. On one hand, technology offers the

certification of an improved world through material upgrades to fulfill everyday comforts. However, over-misuse of this technological development has created discharges of hazardous materials and contamination of air, water, and soil, which are responsible for remarkable ecological destruction. Although technology claims to advance society and its wellbeing, many technology designers have neglected its societal impacts, as evident through consequent impacts of air conditioners, mobile phones, Internet access, etc. (e.g., health disorders, crimes, etc.). Collectively, all of these issues call for a deeper investigation and understanding of the way technology is improving and its impacts on the environment, society, and society's wellbeing. Therefore, the best way to describe a product's sustainability is better performance with less impact on the economy, environment, and society. As a result, the areas of the technology designer's responsibilities become more extensive than before when considering these societal matters in design.

The materials and manufacturing of a product are important when evaluating its sustainability, but they are not the only determining factors. A society's acceptance and intended usages of product overtime also have important social consequences. For example, hand sanitizer can lead to addiction and compromised physiological immunity, which in turn affects society.

## 2 Methodology

Continuous technological changes have drastically changed our lifestyle over the past decade, and some have been controversial in terms of the net benefit they bring to society. The bigger challenge is to know upfront how sustainable new technologies will be. Awareness of the need to assess the expected impacts of new technologies is slowly taking form. Thus, the need for a methodology that assesses the sustainability of these new technologies is becoming increasingly essential. A methodology that incorporates the study of a product's evolution, the reason behind its acceptance or rejection, and its improvement/deterioration over time has to be examined. The environmental and societal challenges that result from developing, discarding,

and using products also need to be determined.

The sustainability of a technology/product can be assessed using different methods and techniques; among these a morphology-based approach permits a comprehensive articulation of a product's structure (comprising components), which can then be used to determine its interaction with the external system (the user and environment). These interactions provide a holistic approach for identifying variables and indicators to assess the level of sustainability. The complete methodology will act as a footing to support designers in designing or redesigning new and existing products, services, and technologies in addition to conducting traditional as well as future evaluations. This methodology measures the integrated impacts on the critical aspects of sustainability: the natural environment, social wellbeing, human health, and societal prosperity to provide a cohesive perspective for sustainability. This assessment is illustrated through a case study of melamine as a technology.

### 2.1 A Case Study of Melamine

A German scientist discovered melamine, a thermoset plastic material, in 1830. The company American Cyanamid became the leading manufacturer and distributor of melamine powder to plastics molders, which they referred to as "melmac" (Wikipedia, 2013). The cheap price, lightweight, and durability of this product made American industrialists eager to produce melamine as a functional product for both commercial and residential use despite its known impacts on society (health) and the environment. Literature on the attractiveness, accidents, health issues, and social change pertaining to melamine has been reviewed to assess its sustainability.

#### *Understanding the Sustainability of Melamine*

The fast acceptance of melamine in infinite applications over the years stems from its overall benefits in comparison to other materials; in particular, its reliability, ease of manufacturing, lighter weight, aesthetics, and affordability. Thus, melamine is still being used by society despite heightened awareness of its social and environmental impacts.

Environment:

- The disposal of melamine contributes to environmental hazards, including the contamination of water and soils.
- Its manufacture also adds to air and water pollution.

Economy:

- Employment associated with workers in the industry.
- The raw material costs also play a fundamental role in defining its sustainability.

Society:

- The ingestion of melamine through food causes serious renal disease that affects the sustainability of human wellbeing.
- Societal status plays a major role in deciding upon the selection of melamine products for dinnerware.

## 2.2 Morphological Analysis

Morphological analysis deals with the study of “structure” and “form.” In the case of products/technology, it is the study of its components or parts. This study will shed light on the interaction between these parts or components with the overall environment in addition to providing a path for the improvement or discovery of new technologies.

This study of melamine resins offers a detailed view of the relationship between the three pillars of sustainability. This provides a holistic understanding of the different components of melamine, which in turn permits the identification of the various impacts associated with melamine products and its components, such as the disintegration of melamine when exposed to heat and migration into food when in contact with acidic foods for long periods. A detailed study of each component of melamine found that it migrated to food very easily because it is a less scratch resistant product. Melamine is also hazardous to workers involved in recycling its by-products and to the environment when it comes into direct contact. Table1 illustrates a broad morphological analysis of melamine.

**Table 1** Morphological analysis

Morphology of a Melamine Product			
	Dinner ware	Fabric	Furniture
Usage	Food	Fire retardant fabric	MDF boards
Size	All Sizes	All Sizes	All Sizes
weight	Light weight	Light weight	Light weight
Shape	Any Shape	Fabric	Sheet like only
Color	All Colours	Ivory white	All Colours
life span	7-10 yrs	10-15 yrs	7-10 yrs
Flexural Strength	9-13 Kg/mm <sup>2</sup>	nil	11-13 kg/mm <sup>2</sup>
Bending Strength	2-3 Kg-cm/cm <sup>2</sup>	nil	2.5-3.5 kg.cm/cm <sup>2</sup>
Hardness	Yes	No	Yes
Durability	Yes (after 150 degree celcius)	Yes (after 200 degree celcius)	Yes (After 200 degree celcius)
Shine and Lustre	Yes	No	Yes
toxicity	Yes	Yes	Yes
Impact Resistance	Yes	Yes	yes
Heat Resistance	Negligible	Negligible	Negligible
Acid Resistance	Negligible	Negligible	Negligible
Absorption	Negligible	Negligible	Negligible
Shrinkage	Negligible	Negligible	Negligible
Cleaning type	Temperature of water	Temperature of water	Temperature of water
	Dishwasher cleaning	nil	nil
	Cleaning agents used	washing agents used	Cleaning agents used
Disposal	Possible only by (melting in industry)	Possible by burning	Possible only by (melting in industry)
Age group Usage	10-30 yrs	All age groups	All age groups

**Source:** Author generated data from (Lund and Petersen, 2006)

This kind of analysis builds up the background for a system analysis, as the information collected can be further deciphered by identifying the system variables and interactions to evaluate a product's sustainability.

### 2.3 System Analysis

In this paper, a technology/product is considered to be a system. A system consists of components identified in the morphological study that are interdependent in nature within a boundary, or the society where the given product has been used (i.e., the economy and environment of the defined system). This enables all aspects of a product to be scrutinized, which can be further achieved by defining the interactions between each component of the technology/product. A matrix is used to help determine the current and future needs of a product and its societal, environmental, and economic consequences.

### Melamine System Analysis

The product of melamine has been divided into three

components: manufacturing, user/society, and disposal. The interactions between these different system components are analyzed in Figure 1 in order to find the variables to be used in a simulation of cross impact analysis. Figure 1 displays the system's behavior and interventions.

### 2.4 Melamine –AIEA (Activity Impact Entity Attribute) Matrix

In this section, the various activities of melamine products/technologies that influence the system are identified. The usage of products is one activity performed by society, and these activities lead to changes in society, which can be termed as the "impact." For example, the usage of melamine products will affect users' health and therefore, impacts society. These impacts are caused by entities that can be quantified with the identified attributes. For example, the number of renal patients per year is an attribute of the melamine chemical entity. The AIEA matrix (Table 1) provides a clearer perspective of the identified variables, which are mutually exclusive and collectively exhaustive.

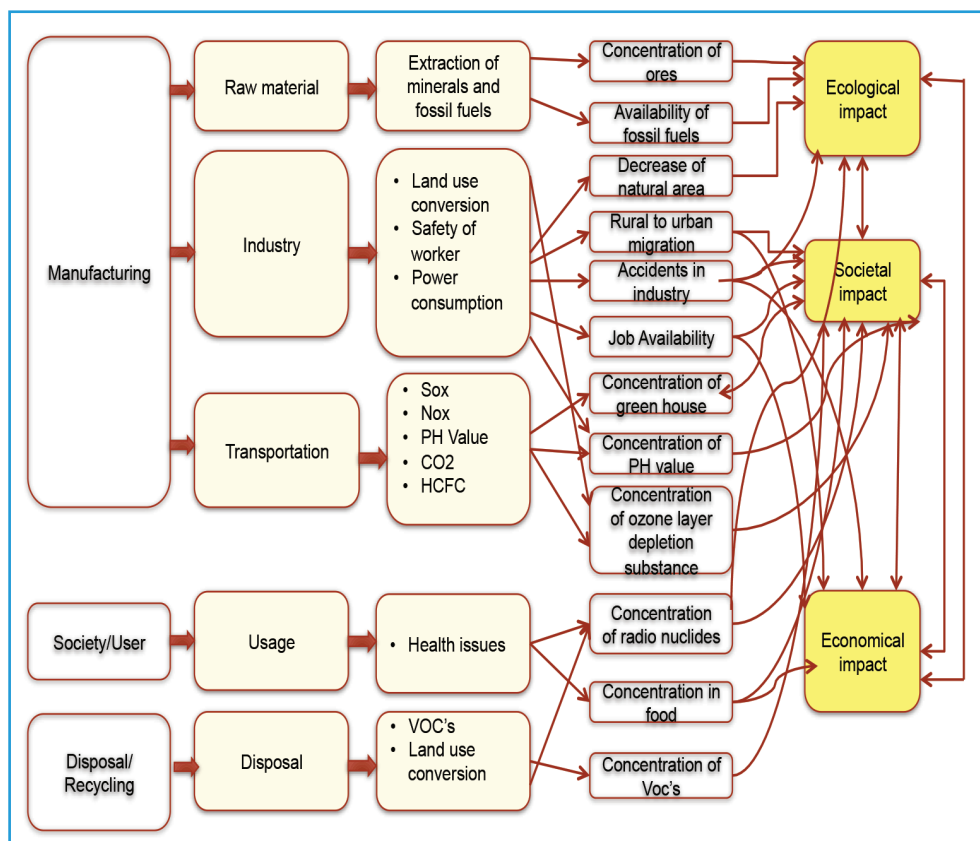


Figure 1 Entity Interaction Diagram

**Table 2** AIEA matrix of melamine

Activities	Impacts	Entities	Attributes
Furniture	<ul style="list-style-type: none"> <li>•Indoor air quality decreases</li> <li>•Increase in Carcinogens in body.</li> </ul>	Melamine, Formaldehyde, Environment and User	<ul style="list-style-type: none"> <li>• Hardness of product</li> <li>• Detergent reaction on melamine</li> <li>• Life of wood</li> <li>• Reusability of wood</li> <li>• Indoor air quality in fire</li> </ul>
Cutlery at Home and restaurant	<ul style="list-style-type: none"> <li>•Increase in Bpa level</li> <li>•Food quality decreases.</li> <li>•Light weight</li> </ul>	Melamine, Formaldehyde, And User	<ul style="list-style-type: none"> <li>• Dissolution of melamine</li> <li>• melamine content in ground water</li> <li>• Migration of melamine in microwave</li> <li>• Migration of melamine in dishwasher</li> <li>• Hardness of product</li> <li>• Detergent reaction</li> <li>• Indoor air quality in fire</li> </ul>
Manufacturing	<ul style="list-style-type: none"> <li>•Environmental degradation</li> <li>•Pollution</li> <li>•Land use land cover change</li> </ul>	Labour, Transport, Machines, Economy, Forest, Environment, product, Technical experts, Marketer, Manufacturer	<ul style="list-style-type: none"> <li>• life of Machine and its parts</li> <li>• Machines disposal</li> <li>• Power consumption</li> <li>• Competition in the market</li> <li>• waste generated in manufacturing</li> <li>• Growth of industry</li> </ul>
Disposal and Recycling	<ul style="list-style-type: none"> <li>•Waste accumulation</li> <li>•Landfills</li> <li>•Water pollution</li> <li>•Heavy metals increase in food</li> </ul>	User, product, Rag pickers, Landfills, Plastic, Smell, water table, Birds, Animals, recycling industry	<ul style="list-style-type: none"> <li>• Waste landfills</li> <li>• Recycling</li> <li>• Effect on food chain</li> <li>• Land Degradation</li> <li>• Underground Water quality</li> </ul>

### 2.5 Cross Impact Analysis

In 1972, Julius Kane developed a simulation method known as Kane’s Simulation (KSIM). KSIM replaces events with time-series variables, and event-probabilities with variable-values. Instead of conditional event probabilities, interactions between time-series variables form the basis of this simulation technique (Gordon, 1994). The implementation of system thinking principles provides a path for the abovementioned simulation, which captures the behavior of non-linear systems that could be modeled without mathematical sophistication (Kane, 1972). The cross impact matrix displays the interaction between identified variables. This mathematical model was designed to run a simulation period of 25 years.

The adopted methodology to create across impact matrix is as follows:

- Identified variables are listed in rows and columns of the matrix.
- The interaction coefficients are the impacts of the column variable on the row variable and are articulated between a scale of -1 to 1 through 0.
- The net result of all positive and negative impacts of one variable over others is calculated and further projected to determine the trends and graphs from the generated matrix.

#### Product Analysis: Melamine

This complete methodology prevents the duplication of variables in the matrix. The measurement and allotment of values as the interaction coefficients were taken from the literature study because a real time measurement of the cases proved to be a time-consuming task, but it is validated by the WHO report projection in Figure 6. This simulation technique attempt to imitate the interactions



between variables in a realistic manner and provides a real image of a product, its benefits, and impacts.

On interpreting the analysis for a product's sustainability, we witnessed many interesting trends among the various variables identified in the graphs (see Figures 2-6). As awareness of a product increases, the usage of that product declines after approximately ten years, and the amount of migration also shows a steep decrease. A technology designer can use these graphs and trends to design and modify a product/technology with all aspects of sustainability in mind.

### 3 Validation

The acceptance of such a simulation framework might require information for cross-validation. Cross-validation is primarily a way of measuring the predictive performance of a statistical model. As specified previously, the patterns of a few basic variables have been found to be in consonance with other comparable (WHO report) projections.

In this case, an increase in the use of melamine products is correlated to an increase in the

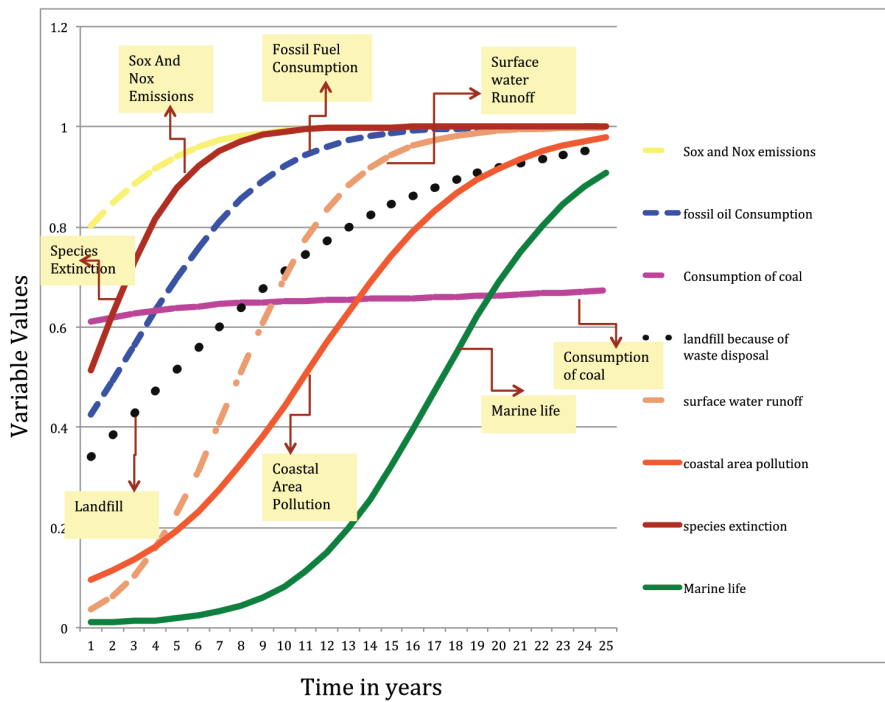


Figure 2 Trends in Environmental Variables

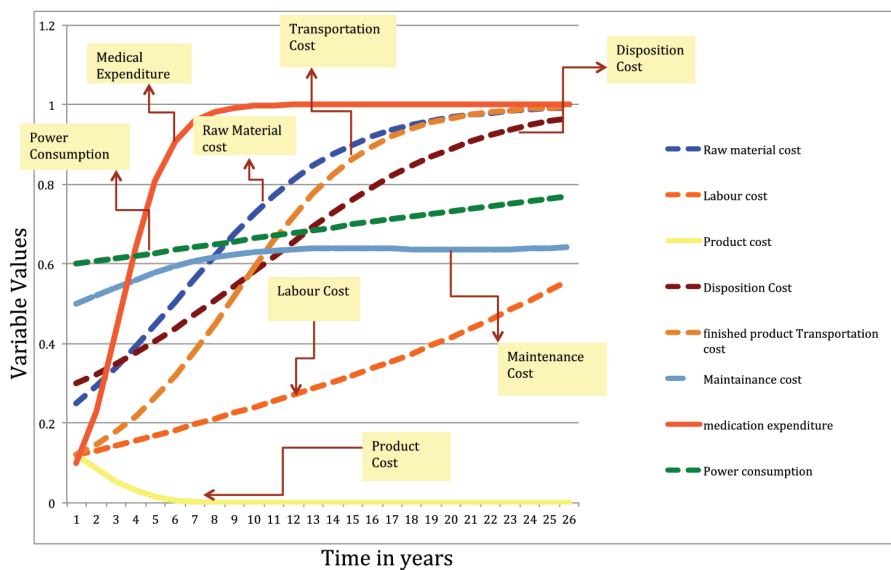


Figure 3 Trends in Economic Variables

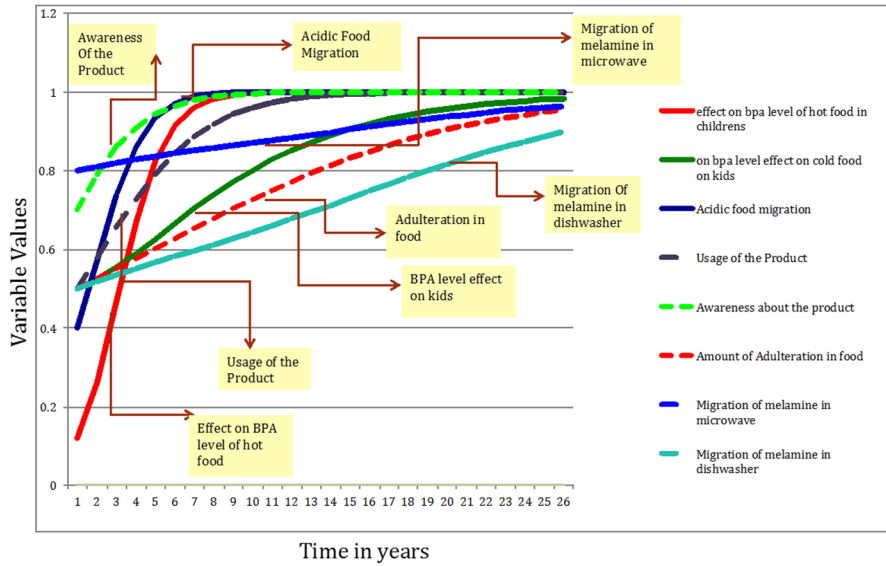


Figure 4 Trends in Societal Variables

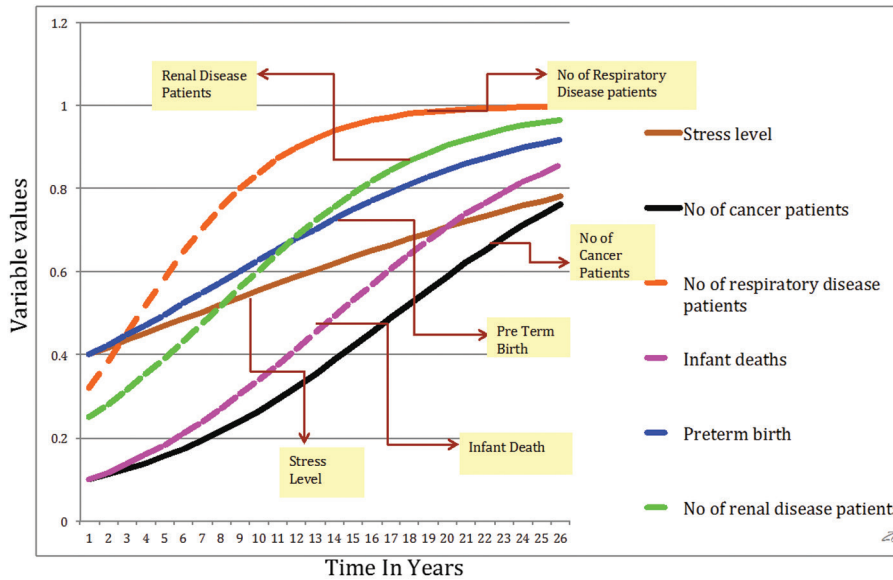


Figure 5 Trends in Health Variables  
Source: Author generated data from (EFSA, 2010)

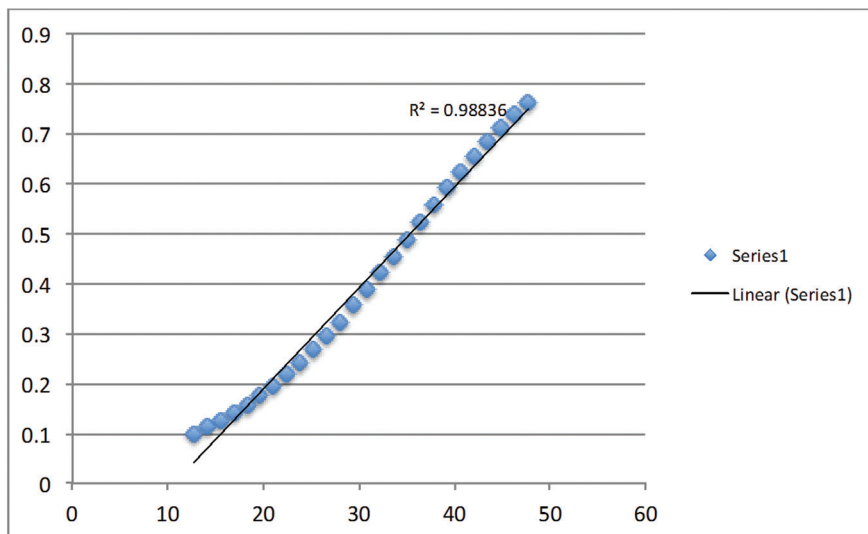


Figure 7 Validation of Predicted Data with the WHO Report  
Source: Author generated-data from (The Guardian, 2014 and World commission on Environment and Development, 1987)

number of patients per year. These diagrams are in accord with the outcomes found by a comparable report (it is anticipated that the worldwide growth in cases will sail by 70% over the next 20 years, The Guardian, 2014). This correlation positively validates the trends found through the R square model in Microsoft Excel, as shown in Figure 6.

#### 4 Recommendations and conclusions

Numerous areas of potential research for improving the sustainability of melamine products have been identified from the literature study, such as:

- Increase public awareness of products in terms of their usage and disposal. For example, the use of melamine in microwaves should be restricted.
- Composite materials can be incorporated into melamine products. For example, a steel coating can be added to the serving side of dinnerware.
- Implement safety conditions for industry workers.

This paper attempts to describe a methodology for assessing the sustainability of a technology/product through a case study of melamine. Morphological analysis provides a sound footing to discern product behavior at various levels, which can then be used to perform an indicator-based cross impact evaluation of the product. This paper also presents a matrix and various trends and graphs that can be further deciphered by technology designers to define design strategies and evaluate their impact with respect to sustainability.

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paper

14

Design of a sustainable urban household  
organic waste handling system

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# Design of a sustainable urban household organic waste handling system



## Abstract:

The management of household waste faces issues across aspects of segregation, transport, disposal, storage, and treatment. In the urban scenario where water supply can seasonally get scarce and intermittent, household waste management solutions that are dependent on continuous supply of sufficient water fail to deliver. It is also observed that subsidised potable water supply is being used indiscriminately as a vehicle for transporting waste. Though systems for recycling wastewater for reuse exist, these do not aim to decrease the quantity of water required for transporting waste. Categorising toilet and kitchen waste as household organic waste, this paper discusses the design aspects of collecting, handling, transporting, and partially digesting household organic waste onsite, using less water. Further, systemic aspects for managing the products of digestion and handling the partially digested waste are suggested. Aiming at closing the loop or what is called the cradle-to-cradle cycle for household waste, the present paper describes design aspects of sustainably managing urban household organic waste that require necessary intervention from various stakeholders involved.

**Keywords:** *urban organic household waste management, sustainable urban sanitation*

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## 1 Introduction

Water is a vital connecting link between many nutrient and ecological cycles. The availability of water for these cycles has been declining due to increasing quantities being utilised by human beings. The problem gets compounded as water supplies get scarce and people stick to using existing water-intensive solutions of waste disposal that also pollute water indiscriminately. The latter scenario is further exacerbated by the fact that rural population migrating to urban cities resort to urban ways of using water sooner or later and intensify the demand for water. Currently, close to 60% of the world's population is urban. The urban population accumulated so far is expected to double in the coming decades and 96% of this urban

growth is expected to occur in the developing and underdeveloped countries (Planning Sustainable Cities: Global Report on Human settlements, 2009). Catering to this increasing population puts enormous pressure on urban infrastructural systems such as those concerning water supply, sanitation, and sewerage and requires these systems to change rapidly (IBM/BWSSB, 2014). In cities such as Bangalore where the state subsidises a significant (close to 50%) proportion of the cost for supplying potable water to the public, the use of water for flushing waste is inappropriate and needs to be curtailed. Though solutions for providing recycled water exist, they only solve the problem partially. It has hence become necessary to reduce the per capita utilisation to ensure availability of water to the rest and to redesign the system for handling waste

end to end, taking culturally sensitive requirements into account. This is also supported by the fact that developing and underdeveloped nations need to pursue different growth trajectories, which are unlike that of the developed world, to ensure that their growth is sustainable.

The urban management of waste in India is problem-ridden from collection to disposal. Problems of segregating organic and inorganic waste arise during collection. Problems concerning acceptability by the locals arise during land-filling and other forms of treatment (Sindhuja, 2012). Management of household organic waste comprising black water (faecal and urinal matter), grey water, and kitchen refuse is replete with problems, too. At present, the management of black and grey water is separated from that of kitchen refuse. Wherever an underground drainage system is in place, black water is directly led to empty into these covered sewers. However, due to the seasonal availability of water in cities such as Bangalore and Chennai, sewers do not get sufficiently drained, resulting in their drying up and clogging (Nadella, 2013). The 150 litres or so of water required per individual to properly flush the waste down the gravity-based central sewers puts tremendous pressure on the Bangalore Water Supply and Sewerage Board's (BWSSB) resourcefulness (resource availability and service capability). This is because of three reasons: one, the water is potable and can be put to better use than for flushing toilets; two, the state significantly subsidises the cost of making water available from far-off rivers (FAQ); and three, 45% of water being supplied is lost in transmission (IBM/BWSSB, 2014). Consequently, the necessity for drawing an increasing amount of groundwater has become unavoidable in many localities and very frequently agricultural bore wells fill this gap, supplying water to residential areas. This has resulted in an appreciable loss from the groundwater table and the situation gets aggravated at multiple localities in the summer. Averting these situations requires redesigning the system of managing waste right from the collection stage.

Supplying an estimated 150 litres per head, close to 800 sq. km of Bangalore has piped water (IBM/BWSSB, 2014) though close to 475 sq. km has no sewerage system (Verhagen, et al., 2012). Hence, households resort to constructing storage or septic tanks inside or outside their plots. These tanks store black water and are emptied periodically by private mobile sanitation tanks that suck the waste and dispose it onto farmlands of consenting farmers without any treatment. The practice of honey-suckers operating outside of law and legislation in Bangalore is exemplary in this regard (Verhagen, et al., 2012). The disposal of untreated toilet waste is harmful to agricultural labourers coming in direct contact with it or consumers of the agricultural produce soiled by untreated waste. The World Health Organization (WHO) recommends a standing time of at least a year for separated faecal sludge before being used in farms by which time the pathogen proportion is reduced to tolerable limits for humans and agricultural uptake (WHO, 2006). Human excreta is a rich source of required nutrients for plants. A study estimates that annually the amount of food grain necessary per individual can be grown out of a crop fertilised by the nutrient in that individual's waste (Vinnerås, 2001). Areas assigned by the Bruhat Bangalore Mahanagara Palike (BBMP) and BWSSB for such safe disposal do not attract private players, as they levee a fee and they are better off disposing waste in the lands of consenting farmers nearby. Before the sewerage system is laid and irrespective of whether the locality has potable water supply, there is a need to solve the problem of disposing toilet waste irresponsibly. Ensuring that minimum water is used in the process and least harm done to natural resources is necessary in this process. This article presents the design of a sustainable system of handling household organic waste, considering the stakeholders involved.

Section 2 describes the methods used for research and design. Section 3 identifies requirements based on the results of a customer survey and market survey to formulate problem statements aligned to proposing a solution. Section 4 details aspects of the selected solution. For developing an end-to-end

holistic solution, Section 5 discusses the inclusion of stakeholders, giving due consideration to their requirements. Section 6 concludes with findings and recommendations, and lays out directions for further work.

## 2 Method

A survey was conducted amongst typical houses in Bangalore and Chennai to understand the composition of urban household organic waste generated daily. This includes kitchen and human waste. As the existing solutions for sewerage and sanitation handling are long established, another survey to understand public perception of aspects of a new system of handling household organic waste was carried out amongst 60 respondents spread over Bangalore, Chennai, and Trichy. These surveys provide information on systemic requirements for the design of a new system. An extensive market survey of existing products in the domain of improved sanitation was conducted online to understand aspects of their solutions and amenability to urban Indian requirements. Based on these surveys, the whole system of managing organic waste has been functionally decomposed and candidate solutions conceptualised against all sub-functions. These candidates have been critically evaluated using the weighted objective method for criteria of evaluation drawn from the requirements that surfaced from the surveys. On having solutions across the sub-functions arranged in decreasing order of preference, a design that meets most of the urban requirements gauged from the surveys is selected.

## 3 Identifying stakeholders' requirements

In the rural scenario, as in the villages surveyed around Trichy, Ecological Sanitation or EcoSan is a widespread concept and its acceptability here is primarily driven by the dignity (freedoms) it ensures women. The products of EcoSan are also accepted locally. Practices of open defecation have decreased, as EcoSan has provided a secure alternative for women who were otherwise vulnerable to animals

and antisocial elements late in the evenings. The practice of dry sanitation as part of EcoSan and the local agricultural demand for the composted waste as a source of fertiliser on the farms has made it prevalent. The practice of 'honey-suckers' comes close to adapting EcoSan in the urban situation, albeit in an unsafe way. The prevalent use of water for flushing in the commodes of urban toilets and the Indian practice of ablution makes the option of having dry toilets culturally incompatible. Also, the real estate required for a dry toilet and its unavailability on an average plot in Bangalore (and urban India) makes the option less feasible and unattractive. However, to sensitise people of the necessity to manage toilet waste better and understand their perception of aspects of EcoSan that could be emulated in the urban situation, a survey was conducted among households. The survey was particularly targeted to assess water usage, gauge customer requirements and expectations of such a new product/system as waterless toilets, and gain quantitative understanding of issues such as space, time, and investment. The households surveyed belonged to middle and upper middle classes in Bangalore, Chennai, and Trichy. The results are as follows:

- Ninety per cent of the respondents wish to use the new toilet and its end product.
- Forty per cent of men do not prefer to sit (like in a Western commode) to urinate.
- People living in apartments preferred the treatment system to be underground or in the basement while individual householders preferred underground or their backyard.
- Even if the muck (faecal matter) is safely treated, few respondents showed willingness for in-house treatment/storage.
- Respondents were willing to spend up to INR 10,000 on an average for the new toilet from a minimum of INR 3,000.
- Respondents emphasised that the system should operate without electricity or consume as little as possible.
- Agricultural labourers spend 80% of their monthly income (INR 1,250) towards building an EcoSan toilet.

**Table 3.1** Market survey of products for improved sanitation

Aspect Brand	Urine diversion	Mode of water saving	Composting and Tech	Technology for urine handling	Innovation	Remarks
Sensor flow	Urinal only	Senses and solenoid regulates dispensed water	--	--	Infrared sensor, adjustable time for water flow	Requires 12 V and a thermostat
Eloo	Source separation	No flush; Dry toilet Toilet water evaporated	Aerobic Composting, self-contained Bacterial and biological technology	Diversion and vented evaporation	Ventilation, use of radiant heat to aid composting	Tank large enough to hold a year's waste and emptied then
Envirolet	--	No flush; Dry toilet Toilet water evaporated	Aerobic Composting, Self-contained Fans and chimney aid odour escape Automatic six-way aeration process. Dual fans, C acceleration by microbe addition. Occasional garden peat moss added Aerator bar (with mulcherator blades) aids composting)	Diversion and vented evaporation Thermostatically controlled heat element evaporates	Automatic six-way aeration process	Cleaned once in a year (since 90% of toilet waste is water that can be evaporated); Three variants 120 V AC type; (\$1,750) 12 V DC type; (\$1,725) Non-electric (\$1,550)
Kiwibog	Source separation	Almost no water use (claim)	Aerobic Composting	--	--	12 V & 230 V models
Separett	Source separation	No flush; Dry toilet	Aerobic Composting, self-contained Fans and chimney aid odour escape	--	--	110 V or 12 V models
Sun-mar	--	No flush; Dry toilet Toilet water evaporated	Aerobic Composting, self-contained Fans and chimney aid odour escape, three chamber design. Evaporation chamber Bio-drum for better composting	Filtering and seeping of excess grey-water and vented evaporation. Thermostatically controlled heat element evaporates	Three chamber design; Evaporation chamber; Bio-drum for better composting	110 V Self-contained and centrally located modules available
Roovac	--	Vac. i.e. flush with air	--	--	Central and decentralised vac pumps	Vac systems
Falcon-free	Urinal only		Cartridge with sealant prevents odour and saves water per flush	Bio-degradable liquid sealant	Bio-degradable liquid sealant	Possible smell
Uridan	Urinal only		Cartridge with sealant prevents odour and saves water per flush	Bio-degradable liquid sealant URILOCK	Bio-degradable liquid sealant URILOCK	Possible smell
Urimat	Urinal only	Float seals odours	--	Sensor activated float seals off odours	Float design Recyclable PC pan	Possible smell
Cotuit	Source separation	No flush; Dry toilet	Aerobic; self-contained Humus (5-10 days), oxygen limiting (for hot weather) and dehydrator modes	3:1 dilution and direct application as fertiliser	Two modes & absence of moving parts; anti-splash back filter pad	Hardwood planer shavings to aid composting
Naturum	Source separation	No flush; Dry toilet	Aerobic, rotating drum aids self-contained composting	No treatment, drained out	Rota-drum	Drum can hold 30 litres of compost mass

**Table 3.1 (contd...)** Market survey of products for improved sanitation

Aspect Brand	Urine diversion	Mode of water saving	Composting and Tech	Technology for urine handling	Innovation	Remarks
Rota-loo	Source separation	No flush; Dry toilet	Aerobic Requires basement installation, rotating drum aids composting	Rotaloo: Evaporation Aided by SOLTRAN module Ekoleet: Biological pre-cleansing liquid mixed with compost	Rotating sectors of containers SOLTRAN module for providing composting environment	Turntable No raking Forced ventilation possible
Nature-loo	--	No flush; Dry toilet	Aerobic, self-contained			Possible smell and vectors
Bio-sun		No flush; Dry toilet	Aerobic, basement tank Humus (2 – 5 yrs) Batch-type	Evaporation	Mixing with kitchen garbage	Excel-aerator™ forced ventilation system; Suction through ventilating pipes
Ecolet	--	No flush; Dry toilet	Aerobic; self-contained; Humus in 2–3 months or a year depending on use. >18°C maintained by thermostats etc.	Heated thermostats Evaporates excess liquid; fans forced draught aids evaporation	Composting acceleration	25 W fan; 225–310 W heater Electric and non-electric model available
Clivus Multrum	--	No flush; Dry toilet	Aerobic Composting, self-contained under the basement	Drained out	Uses starter bacteria	Heavy duty 12 V fan NO extra heater Wood shavings mix
Phoenix	Separated later with baffles	No flush; Dry toilet	Aerobic Composting; (2, 4, or 8 toilets can feed a composting tank). Liquid spray to keep moist. 1 or 3 shafts with tines for aeration	Liquid spray to keep moist Excess is leached, evaporated, or stored in holding tank	Improvements over Clivus Multrum	5 W fan for circulation consuming 45 kWh per yr
Equaris	--	Vacuum flush One pint per flush	--	--	BMRC technology	Draws 4–6 amps in use
Ekologen	Source separation	One-pint flush	--	--	Vacuum flush	--
Biolet	--	No flush; Dry toilet	Aerobic Composting (> 2 yrs regulation), self-contained	Thermostat evaporates, forced ventilation	Motor driver turner puts waste out of sight	--
Watermatrix	Urinal only	Liquid sealant Eco-trap	~	Liquid sealant Eco-trap	Liquid sealant Eco-trap	Possibility of smell



- The elderly preferred a portable toilet.
- Treated compost should be absolutely safe to handle.
- Product should be hygienic to use. It should not smell at all.
- Solid waste should not be visible after flushing (by whatever means the new system achieves it).
- Cleaning should preferably be carried out every six months.
- Fifty-five per cent of the respondents showed considerable unwillingness to sit while urinating.
- Product should be easy to operate, requiring minimum maintenance. The system should automatically handle and discharge waste.

Customer requirements translated to system/technical requirements

- Complete (or to an extent that is harmless to humans) killing of pathogens.
- Pungent odours from H<sub>2</sub>S, Indoles, Mercaptans should be trapped/treated well.
- Generated waste has to be transported: first, out of sight without a trace, and; second, to the treatment centres with minimum user involvement.
- Moving parts need to be avoided as far as possible to reduce the maintenance required.
- Toilet needs to be accessible to people unable/unwilling to sit for urinating.

- Menstrual waste has to be handled by the same toilet pan.

A market survey was also conducted online to understand how different products/systems in the domain of sanitation deal with the problem of managing toilet waste and to enable classification of the problem/system into broad sub-problems/sub-systems.

On surveying the market extensively for products in this domain, we found that no single product existing in the market meets all of the customers' requirements. Further, the following functions (Table 3.2) are identified as essential to a waste handling system in this domain. Against these, in the adjacent column, are functional descriptions. The identification of functions and describing them allows a systematic consideration of the different stakeholders involved beyond the users. Possible stakeholders are listed in the last column of Table 3.2. Understanding the varied nature of requirements of these stakeholders in the broad Indian and local context provides the basis for holistic solutions that function inclusively and systemically.

**Table 3.2 Stakeholder identification across problem functions**

Function	Functional description	Possible Stakeholders
Collection	Collect all types of muck effectively at point A	Manufacturer; users of different genders, abilities and capabilities; cleaner/maintainer/servicing personnel; civic sewerage, water supply, pollution control, and town planning bodies
Conveyance	Transfer collected muck completely to point B	Manufacturer; private players; householder; apartment association office bearers; civic sewerage, water supply, pollution control, public health, and town planning bodies
Sanitisation	Render muck harmless to humans henceforth	Manufacturer; private players; householder; apartment association office bearers; civic sewerage, water supply, pollution control, public health, and town planning bodies; local residents
Treatment	Convert safe muck into a form acceptable to earth (i.e. that which could be taken up by agriculture and which does not despoil aquifers, water bodies etc.)	Manufacturer; private players; householder; apartment association office bearers; civic sewerage, water supply, pollution control, public health, and town planning bodies; local residents
Despatch	Conversion into a saleable/carry-able form and delivery	Agriculturists; horticulturists; farmers; private players; nurseries; householders; public health and safety bodies; pollution control bodies

The following are the perceived requirements of the stakeholders. These are partially raised by the customers being surveyed out of concern for an appropriate system while the others are perceived personally from the experience of the authors.

Manufacturers, as stakeholders here, include those manufacturing all aspects of the system end-to-end. For example, within the existing system, they include manufacturers of pans, commodes, and flushing tanks such as Parryware and Roca at the collection stage and manufacturers of plumbing, storage, and holding tanks at the conveyance and storage/treatment stage. Apart from timely surface cleansing, the ceramic ware of existing commodes do not generally require service within their lifetime though the plumbing may need maintenance twice or thrice in the lifetime of the commode. As the plumbing work is separated from the 'pans' and 'western commodes', this maintenance is performed by plumbers (in absentia, masons) available locally. Currently practitioners follow masonry procedures similar to that related to the construction of water retention tanks. Consequently, problems of seepage to the water-table cannot be ruled out. Apart from this, installation of the pans/commodes is done by the masons whose availability and skill levels are reportedly fast depleting.

Users of different genders expressed their interest as stakeholders in requiring the system to handle menstrual waste at the collection stage just as the existing system does. Men were reluctant to sit while urinating. Unless using an Indian commode or what is called the Orissa Pan, children below three feet height cannot use the western commode, resulting in them urinating in the bathwater sewers or open drains sometimes. Combining the requirement of men and the children requires the urinal to reach the users as a possible feature in the system. As this reduces the amount of contact with the system, it scores well on the hygiene front. Also, this feature aids the elderly and women at the collection stage and can potentially reduce the amount of water required to flush. There remains a significant amount of stigma related to changing the existing system of collection and storage irrespective of

the respondents accepting that these are water intensive and need replacement.

The private players include entrepreneurs who make the concrete rings necessary for building septic tanks or storage tanks, the architects/civil contractors who design and build tanks onsite or on public space adjacent to the householder's plot, those who make the PVC plumbing and holding tanks privately, particularly for holding toilet waste, and those who periodically collect the faecal sludge from such tanks and transport it onto farmlands or composting sites. People who transfer the products of treating faecal sludge and the farm produce fertilised with it to prospective markets of users also fall within this category. Agriculturists producing edibles using products of treating faecal sludge and horticulturists and nurseries producing non-edibles are some other stakeholders whose interests vary widely.

Mahatma Gandhi considered improving sanitation more important than independence for India. The public benefits of improved sanitation are enormous. In Bangalore, existing sewage treatment plants (STPs) operate below their maximum limit while new STPs are slated to be installed by 2016 by which time all sewage would be completely treated. Thereafter it will be let out into natural water bodies or storm water drains wherefrom it can be re-used. Insufficiently treated water let into water bodies is a major cause of infant mortality resulting from water-borne diseases. Pollution of water bodies is a significant public health issue and the Karnataka State Pollution Control Board (KSPCB) has many times pulled up the BWSSB, BBMP, and the Bangalore Development Authority (BDA) together for aspects related to inappropriate disposal of sewage, lack of monitoring of dumping yards, and insufficient standards in granting no objection certificates to plots that do not construct toilets (Deccan Herald, 2013). The lack of sewerage coverage at many places in Bangalore has resulted in individuals and commercial establishments letting out their sewage into storm water drains (DNA, 2011). Consequently, the re-use of water that otherwise did not require treatment poses serious public health risks.

The survey conducted in Trichy revealed that most of the small-scale farmers were users of the produce of the composting toilets and had a mixed response to questions of acceptance. However, due to the widespread work of NGOs such as SCOPE, the concept of EcoSan is widely prevalent and has come to be accepted well at the household level. The demonstration of these dry toilets and the nature of the result of composting, coupled with appropriate education in using diverting toilets were said to be reasons for their acceptance (as stated by SCOPE personnel). People who have built an EcoSan toilet on their plot spent close to a third of their monthly income on it while the state of Tamil Nadu sponsors the rest.

#### 4 Selection and aspects of a solution proposal

Table 4.1 shows the various solutions that have been evaluated against each sub-function laid from the most desirable (right) to the least desired (left). The zigzag line shows the solutions chosen under each of these sub-problems. The proposed system of managing urban household organic waste end-to-end comprises all these solutions.

As the main nutrient resides in urine, a pan that separately collects urine is chosen. Though some field experts of SKG sangha have found this not necessary, it is chosen as the separation affords the freedom of using just urine. Further, the pan has a facility wherein its urine collection portion can be dislodged so as to aid men, the infirm, differently abled, and women. The mode of collecting faecal matter is the same as any vacuum toilet. As the stigma for handling waste in any different way persists, it is suggested that the odour be neutralised before being masked by masking sprays or de-odourisers. A two-stage digester that occupies space that was otherwise meant for holding tanks or septic tanks onsite is proposed here. The volumes of the digester have been designed around the generated volumes of toilet and kitchen waste in an average household of five on a 1200 sq. ft. plot and the prescribed retention times for the

sludge by the WHO. On partially treating the faecal sludge onsite, it is proposed to be collected by the municipal authorities or licensed private players who convey it to treatment centres for complete treatment before using it on farms. Figure 4.1 is a schematic of the proposed system. Waste from the kitchen is mixed with toilet waste and gravity flushed into a macerator where it is macerated and pumped into the primary phase of anaerobic co-digestion. The primary phase occupies less space and is situated above the ground level and over the secondary phase of partial co-digestion lying below. The mixture of faeces and kitchen garbage requires an equal amount of water for the bacteria to digest properly, which would be provided by the ablution water and urinals during defecation. The primary digester has a feature centrally to facilitate addition of neutralisers and bacterial potions to eradicate stench and improve co-digestion. Addition of a neutraliser (generally cow dung) 10% by weight is necessary to neutralise the shock to which the bacteria may be subjected to had the composition of feed material varied drastically. The addition of new waste can continuously take place over the period of 30 days. The difference in the densities of old and new sludge ensures that the latter floats up. So a tank is positioned beside the digester to collect the overflow of 5-6 litres a day for N days (depending on the space available onsite) as necessary. The primary digester, secondary digester, and the annular volume in between these two volumes ensures sufficient retention time for the generated waste to be partially safe by the time it comes out and collects in the appropriately constructed holding tank. This partially treated faecal sludge can be sucked out by licensed private players or the BBMP personnel, wherefrom it should be rendered completely safe. Similar to the subsidised provision of EcoSan in rural areas by some state governments, the cost of this system requires fillips for adoption (AECOM International Development, 2010). The responsibility and subsequently the costs of treatment are in this way divided between the major stakeholders, that is, waste generators (householders) and the government interested in preventing disease outbreaks at large.

**Table 4.1** Functional decomposition of the problem of managing urban household organic waste end-to-end

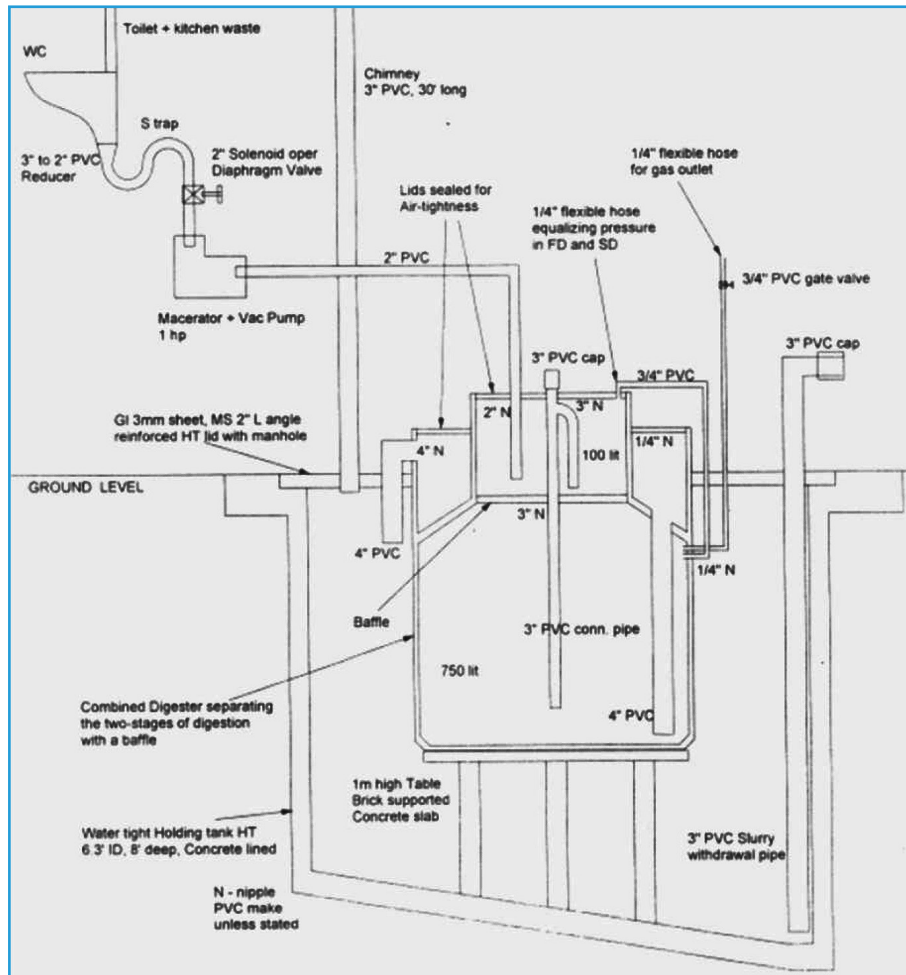
Functional decomposition		Ways of achieving sub-tasks in order of priority (left to right)				
<b>Collection</b>	Package	Urine diverting pan	Separate ablation	Drop hole	Separate pans	Reaching toilet pan
Putting it out of sight	Package	Rotating cone	Rotating cylinder	Paddle wheel	Rotating table	Moving hole
Rendering it odourless	Odour neutralisers	Odour masking				
<b>Conveyance to sanitisation centre</b>	Vacuum pump	Bio-bags Manual transfer	Screw conveyor	Rotating cone	Rotating cylinder	Dung beetle
<b>Killing pathogens (temperature)</b>	Microwave	IR blowers	Solar UV	Incineration	Insulation (gen heat retention)	X-rays
ph	Urea Competing microbes	Ash	Lime	(SDS) Sodium Dodecyl Sulphate	Glutaraldehyde (disinfectant)	
Humidity	Natural / Forced draught	Microwave	X rays	IR blowers	Solar UV	Incineration
<b>Conveyance to composting centre</b>	Vacuum pump	Bio-bags Manual Transfer	Screw conveyor	Dung Beetle		
<b>Composting (Aerobic)</b>	Inclined drum	8 concept				
<b>Composting (Anaerobic)</b>	Multi-stage continuous	Single stage continuous	Single-stage batch wise	Multi-stage batch wise		
<b>Despatch or Delivery</b>	Manual pack, wheeled drums	Screw conveyor	Packaging	Municipal service trucks		

The total organic waste per day from a family of five is approximately 8.5 kg comprising: Kitchen waste generated everyday = 300 g (from surveyed households in Chennai and Bangalore); faecal matter per individual per day = 300 g (\*5 = 1500 g); ablation water per individual 1000 mL or 1000 g (\*5 = 5000 g); and urine per toilet use = 300 mL (\*1 use (considering toilet use at work, school, etc.)\* 5 = 1500 mL). Further, 8.5 kg or litres of such waste would give 1 m<sup>3</sup> of bio-gas. This comprises 600 litres of combustible methane approximately, the calorific value of which is 23 MJ. With a thermal efficiency of 65% for the stoves in general, 0.5 m<sup>3</sup> of biogas is enough for an hour's cooking on a single burner stove (tapped energy) providing approximately 12 MJ. This is sufficient for cooking for three people a day for a month. Based on the space available onsite, the digester volumes co-digest waste generating methane gas over a cycle time of approximately 30 days, beyond which the partially digested sludge is

emptied into the holding tank where it is retained for more days before collection by the authorities. The fully digested waste would be a rich soil conditioner having N, P, and K and is proven to produce a good harvest of harmless banana crop (Sunitha, 2009).

## 5 Conclusion

The proposed system divides the problem of managing toilet waste in particular amongst the major stakeholders, that is, generators and the civic bodies interested in public health. The importance of handling household organic waste at the source more inclusively is the motivation behind the project. It may be noted that the co-digestion of kitchen and toilet waste is suggested along with urine and water during and after defecation respectively. The latter cannot be culturally done away with and the former is a source of the required nitrogen to keep up the C:N ratio within desirable limits. However, a urine-



**Figure 4.1** Recommended layout for partially digesting urban household-organic waste

diverting pan is still provided as a feature only to aid the profile of users at the collection stage. There is perceived requirement for a pan which further reduces the water usage that goes into cleaning the pan itself after every usage. Also, the products of digestion need to be piped or packaged separately, as the stigma around it remains prevalent even in rural areas. The associated stench while burning biogas requires the stove to be in the open, which in turn, drastically brings down the thermal efficiency of the stove. Hence, solutions for on-site storage and utilisation/sale of the gas generated are future requirements.

## Acknowledgements

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basic details of co-digestion feasibility, and helping survey EcoSan users, respectively.

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paper

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Design of soil compaction press for the decentralized  
production of stabilised soil blocks

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# Design of soil compaction press for the decentralized production of stabilised soil blocks



## Abstract:

The paper is focused on the design, development, and evaluation of a manually operated soil compaction machine for the production of stabilised soil blocks. The paper touches upon the machine design philosophy, compaction characteristics of soils, employment generation potential of small-scale stabilised soil block production systems, and embodied energy.

Static compaction of partially saturated soils was performed to generate force-displacement curves in a confined compaction process. Based on the soil compaction data, engineering design aspects of a toggle press are illustrated. The results of the time and motion study of block production using manual machines are discussed. Critical path network diagrams were used for small-scale SSB production systems. Such production systems generate employment at a very low capital cost. A case study of manufacturing more than three million blocks in a housing project using 8–10 sets of manually operated machines is illustrated.

**Keywords:** *soil compaction, soil block, compressed earth block, toggle press*

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## 1 Introduction

Soil is an easily available material and has been exploited for the construction of earthen walls and other building components. Cob walls, adobe block masonry, wattle and daub, rammed earth, etc. represent some of the pure earth wall construction techniques. The major drawbacks of pure earth based constructions are loss of strength on saturation and erosion due to rain impact. Hence, stabilised soils are used to alleviate these problems. Portland cement and lime represent the commonly used inorganic binders for stabilised earth products. Stabilised soil blocks or bricks are produced by compaction of a suitable mixture of soil and stabiliser at optimum moisture content using a machine. Stabilised soil blocks

have several advantages, such as low embodied carbon, decentralised production, recyclability, eco-friendliness, etc. The technology of SSB is five to six decades old. There are several studies dealing with various aspects of SSB technology, such as optimum soil grading, strength-density relationships, characteristics of SSB in dry and saturated state, behaviour of SSB masonry walls, mortars for SSB, etc. Information on stabilised soil block technology can be found in the investigations of Olivier and Ali (1987), Venkatarama Reddy and Jagadish (1995), Houben and Guillaud (2003), Heathcote (1991), Walker and Stace (1997), Walker (2004), Venkatarama Reddy and Walker (2005), Venkatarama Reddy and Gupta (2005), Venkatarama Reddy et al. (2007), and many other publications. The earliest attempt to manufacture



the SSB using a manual machine was in the mid-1950s (Venkatarama Reddy and Gupta, 2005).

Even though there are studies on various aspects of SSB technology and manual machines for SSB production are available in the market, there are hardly any investigations on the machine design aspects for manual production of SSB in a decentralised manner. Design and development of a manually operated machine for SSB production involves understanding the compaction characteristics of wide variety of soils, analysing a suitable machine mechanism to match the force-compaction relationships for soils, machine design, and analysing the manual production process for maximising the block production. Therefore, the current study aims to examine the machine design process and monitor the block production system in an actual SSB production centre employing manually operated machines.

## 2 Machines for stabilised soil blocks and the compaction process

The simplest way to produce a stabilised soil block (SSB) is by tamping the processed soil into a mould using a tamping rod. However, the degree of compaction cannot be easily controlled in this process and the productivity will be low. Machines are employed for the production of SSBs. These machines can be broadly grouped under two categories: (1) manual machines and (2) mechanised machines. The mechanised machines are ideally suited for an industrial production type system, whereas the manual machine/press is well suited for

decentralised production system. The mechanised machines generally use a hydraulic power pack to generate a large amount of compaction force. The manual machines generate the necessary force of compaction using animate energy. In the manual machines, the processed soil is compacted using the static compaction process. The static compaction process involves confined compaction. Wetted mixture of soil, stabiliser, and water is compacted into a dense block in a mould using a piston from either one side or both sides. The energy supplied in the compaction process is not a unique value. It depends upon the soil composition, moisture content, and the targeted block density. Three stages of static compaction process employed in the production of SSB using manual machines are illustrated in Figure 1.

The design of a manual press for the production of SSB requires the following information.

- Force-piston displacement (stroke) relationships for compaction of soil mass and the peak force, that is, the compaction characteristics of soils.
- Machine mechanism to match the force-stroke relationship of the soil mass
- Block or brick dimension (soil mass) to match the available human energy supply during compaction

## 3 Compaction characteristics of soils

Soil compaction is generally studied with reference to a standard test, such as the 'Standard Proctor compaction test'. In this test, a definite amount of

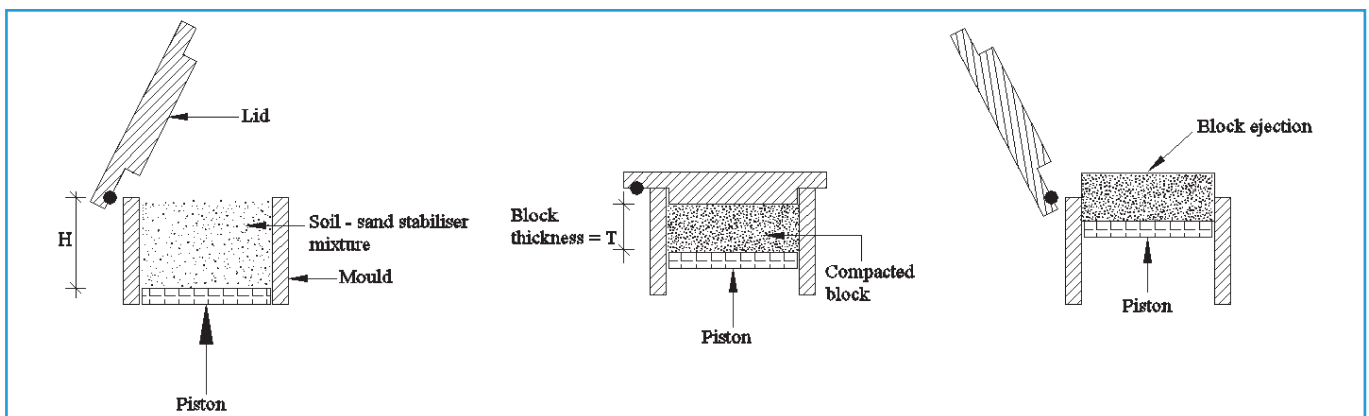


Figure 1 Static compaction process

energy is provided to the soil while compacting it. Such a test reveals the optimum moisture content and the corresponding maximum dry density for the standard energy input, but it does not yield any information on the force needed in a static compaction operation used in the SSB production. In a static compaction operation, the force needed to achieve a particular density will depend on the size of soil mass under compaction. A direct test to evaluate the force on a soil mass during compaction is hence desirable. The task of the soil compaction machine is then to produce the desired force variation. Thus, the force-deflection (stroke) relationship of the soil mass is a basic prerequisite in designing the soil compaction machine.

The force-deflection (stroke) relationship of a soil mass depends on the following:

1. The final density of the compacted soil mass to be achieved
2. Moisture content of the soil mixture during compaction
3. Soil composition (quantity of sand, silt, and clay fraction in the soil)

Two soils were selected to generate force-deflection relationship of the soil mass. The soils are designated as Soil A and Soil B. Figure 2 shows the grain size distribution curves for these two soils. The characteristics of these soils are given in Table 1. It is clear from the table that Soil A has 10% clay and 55% sand, whereas Soil B has more sand (75%) and less clay (3%).

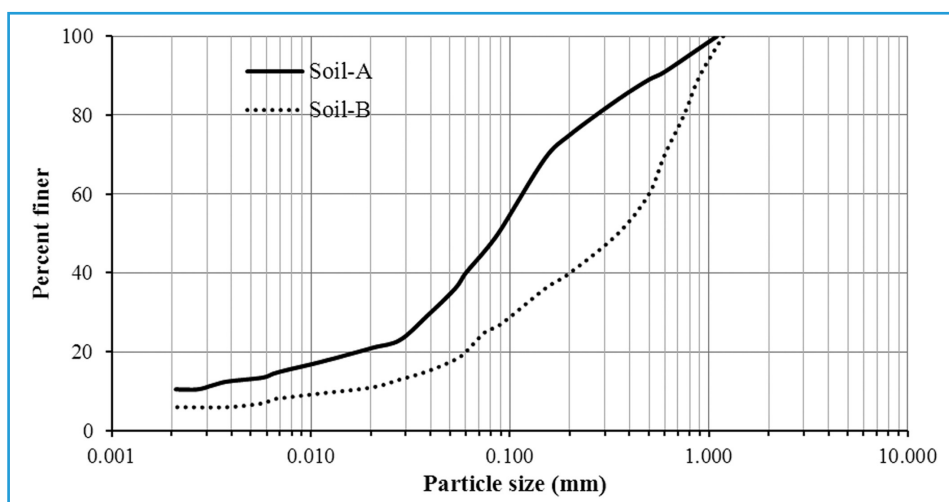


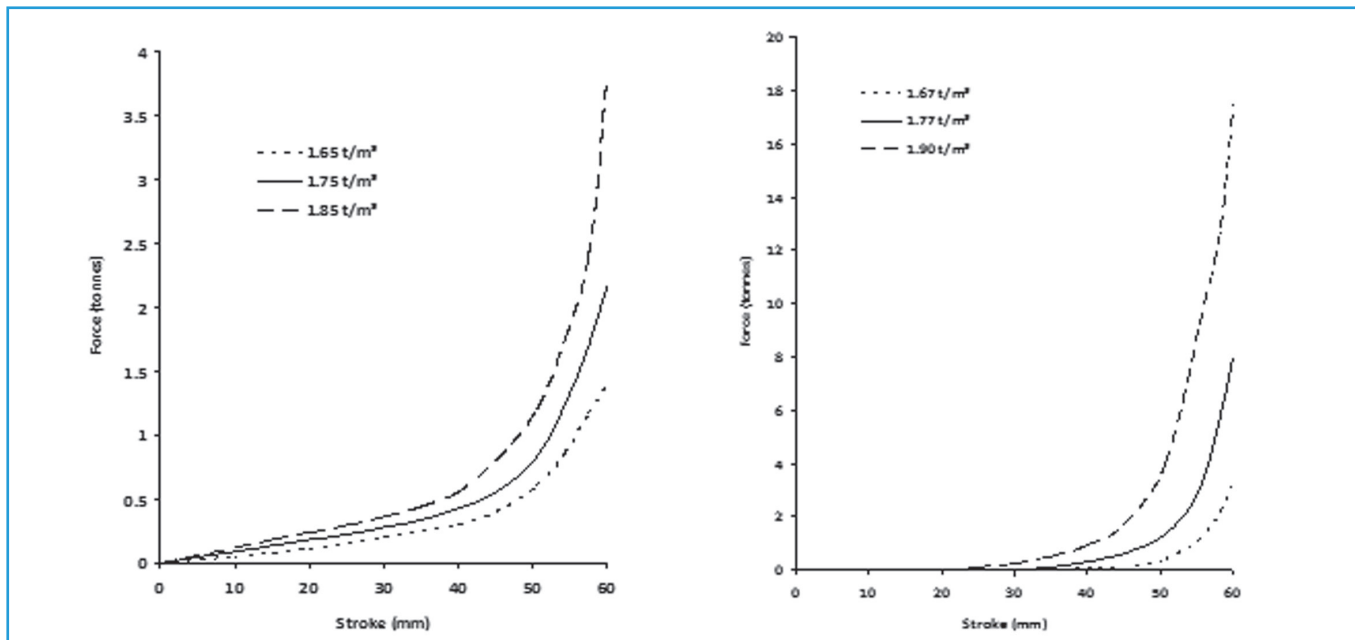
Figure 2 Grain size distribution curves for soils

Force-stroke relationships were obtained for these two soils. The test procedure adopted to generate force-stroke relationships is as follows.

1. Soils were mixed with the respective standard Proctor optimum moisture contents.
2. A metal mould of size 305 x 144 x 160 mm (length x width x height) was loosely filled with processed soil.
3. The soil filled mould was positioned under the piston/plunger of the Universal Testing Machine.
4. The loosely filled soil was compacted by allowing the plunger to move downwards. The force and the corresponding stroke/deflection of the plunger were measured. The plunger was stopped when it moved by 60 mm. Thus the stroke length is 60 mm.
5. The test was carried out for different values of the initial soil mass, to ascertain the relationship between density and the magnitude of the compaction force.

Figure 3 shows the force-stroke relationships for different initial soil masses for Soil A and Soil B respectively. These figures reveal several features of static compaction of soils.

1. A stroke length of about 60 mm is essential to produce 100 mm thick soil block.
2. The compaction force increases slowly in the beginning but attains very large value at the completion of the stroke.
3. The force required for compaction increases with increase in soil mass density.



**Figure 3** Force-stroke relationships (L: for Soil A; R: for Soil B)

4. The sandy soil (Soil B) used in the test needs nearly 3 to 4 times the maximum compaction force needed for less sandy soil such as soil-A.
5. For the two cases using different soils, the maximum compaction force varies between 1.4 tonnes (Soil A with dry density of 1.65 t/m<sup>3</sup>) to 17.0 tonnes (sandy soil, Soil B with dry density of 1.9 t/m<sup>3</sup>).

These tests clearly reveal that the forces needed for different soils will vary over a wide range. It may be difficult to compact sandy soils (such as Soil B) to higher densities in the manual machines, as the force needed will be very large. The compaction force needed for less sandy soils (such as Soil A) is much smaller.

#### 4 Toggle mechanisms for manually operated soil block machines

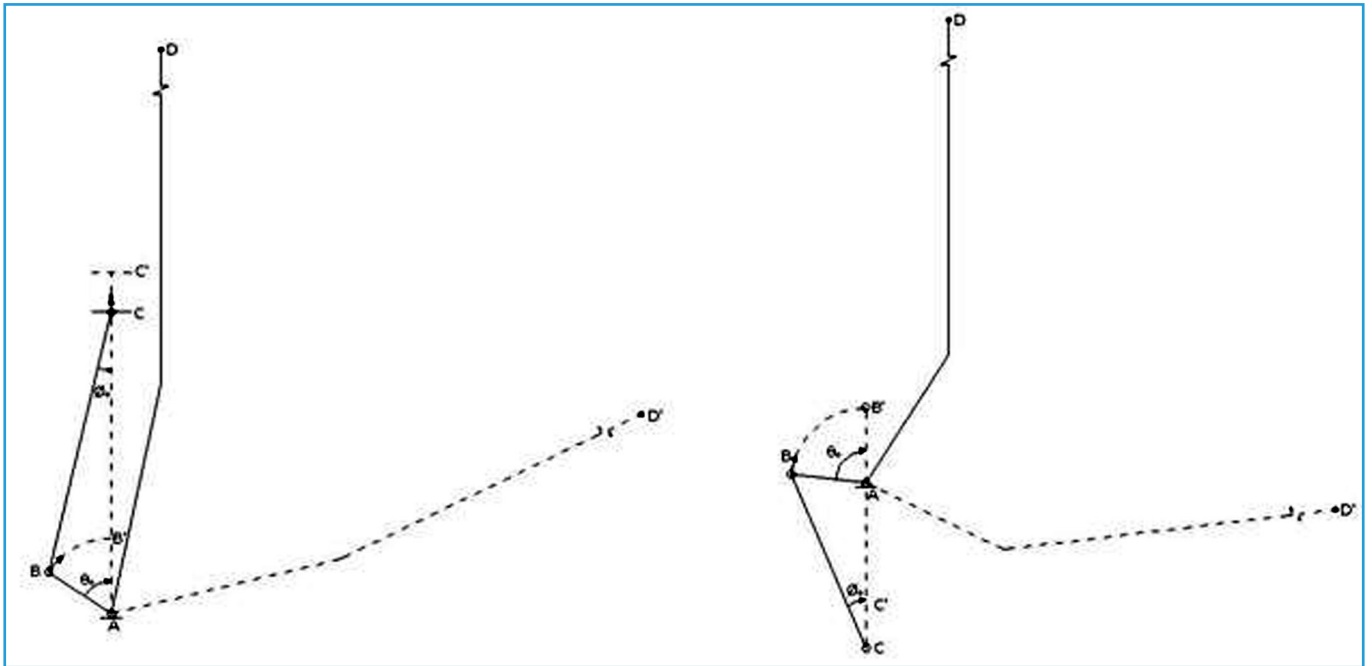
The force-stroke curves for soils shown in Figure 3 indicate that large forces are necessary towards the end of the compaction stroke. This means that

the mechanism for a manually operated machine for the soil block production should be capable of providing gradually increasing force amplification as the compaction proceeds. The toggle mechanism is ideally suited for this purpose, as it has large mechanical advantage that produces a large output force at the end of the stroke. This force increases and approaches infinity as the angle between the links reduces. Toggle mechanisms are used extensively for manually operated tools and clamps where a large force is required (Tuttle, 1967).

There are two types of toggle mechanisms: (a) the toggle mechanism and (b) the reverse toggle mechanism. Figure 4 shows the toggle mechanism and reverse toggle mechanism. The links AB and BC are two main links of the mechanism, and AD is the lever through which the force is applied manually to generate large forces at C. When the lever AD occupies the position AD', the point C moves to C', thereby AB and BC will be in one straight line. The point C is hinged to the bottom of the mould in the machine. As the lever AD is pulled down, the

**Table 1** Characteristics of the soils (OMC: Optimum Moisture Content)

Soil designation	Soil composition (%)			Standard Proctor OMC (%)
	Sand fraction	Silt fraction	Clay fraction	
Soil A	55.0	35.0	10.0	14.3
Soil B	75.0	22.0	3.0	12.9



**Figure 4** Toggle mechanisms of soil block machines (L: Toggle link; R: Reverse toggle link)  
(AB = r; BC = l; CC' = Xm; AD = L)

point C moves upwards, and the stroke length CC' is responsible for compaction of soil in the mould. The mechanical advantage of the toggle mechanism is the ratio of the angular velocities of point C and point B.

#### 4.1 Mechanical advantage of the toggle mechanism

Let  $\Phi_0$  and  $\theta_0$  be the initial angles (Fig. 4). The maximum value of the stroke length CC' depends on the initial value of angle  $\theta$ . As  $\theta$  approaches zero, the point C moves to C'.

Let  $CC' = X_m =$  maximum stroke length

$$A_T = \left| \frac{L\dot{\theta}}{\dot{X}} \right|$$

The expression for mechanical advantage is

$$A_T = \left| \frac{L\dot{\theta}}{\dot{X}} \right| \quad \dots(1)$$

Then

$$A_T = \frac{L}{r \sin \theta \left[ 1 + \frac{\left(\frac{r}{l}\right) \cos \theta}{\left\{ 1 - \left(\frac{r}{l}\right)^2 \sin^2 \theta \right\}^{1/2}} \right]} \quad \dots(2)$$

Asymptotic behaviour of  $A_T$

As  $\theta \rightarrow 0$ ,  $\sin \theta \rightarrow \theta$ ,  $\cos \theta \rightarrow 1.0$

$$\lim_{\theta \rightarrow 0} A_T = \frac{L}{r\theta \left( \frac{r}{l} + 1.0 \right)} \quad \dots(3)$$

Again as,  $\theta \rightarrow 90^\circ$ ,  $\sin \theta \rightarrow 1.0$ ,  $\cos \theta \rightarrow 0$

and  $A_T \rightarrow \frac{L}{r}$  ... (4)

The value of  $\theta$  varies between initial angle  $\theta_0$  and zero. It is clear from equation (3) that, to achieve maximum amplification towards the end of the stroke (i.e. when  $\theta \rightarrow 0$ ), the  $r/l$  ratio should be close to zero. Hence, to keep  $A_T$  large for a given value of  $\theta$ ,  $L/r$  should be large and  $r/l$  should be close to zero. In practice, it is difficult to have exceedingly small  $r/l$  ratios.

#### 4.2 Mechanical advantage of the reverse toggle mechanism

The mechanical advantage of reverse toggle link is

$$A_{RT} = \left| \frac{L\dot{\theta}}{\dot{X}} \right|$$

Then

$$A_r = \frac{L}{r \sin \theta \left[ 1 + \frac{\left(\frac{r}{l}\right) \cos \theta}{\left\{ 1 - \left(\frac{r}{l}\right)^2 \sin^2 \theta \right\}^{1/2}} \right]} \quad \dots (5)$$

Asymptotic behaviour of  $A_{RT}$

As  $\theta \rightarrow 0$ ,  $\sin \theta \rightarrow \theta$ ,  $\cos \theta \rightarrow 1.0$ ,  $\sin^2 \theta \rightarrow 0$

$$\lim_{\theta \rightarrow 0} A_{RT} = \frac{L}{r \theta \left( \frac{r}{l} - 1.0 \right)} \quad \dots (6)$$

Again as  $\theta \rightarrow 90^\circ$ ,  $\sin \theta \rightarrow 1.0$ ,  $\cos \theta \rightarrow 0$

and  $A_{RT} \rightarrow \frac{L}{r}$  ... (7)

The value of  $\theta$  varies between initial angle  $\theta_0$  and zero in this case also. Equation (6) describes the behaviour of  $A_{RT}$  as  $\theta$  tends to zero. For a particular value of  $\theta$ ,  $A_{RT}$  will be large if  $L/r$  is large and if  $r/l$  is close to 1.0.

Equations (3) and (6) clearly indicate that, for particular values of  $\theta$ ,  $L$ , and  $r/l$ , the reversed toggle

will always have a better amplification than the toggle mechanism.

## 5. Machines for soil block production

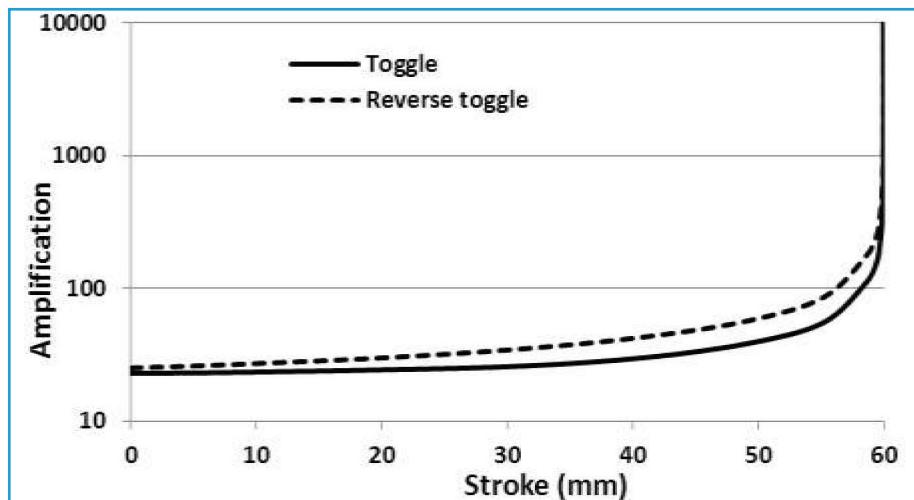
Force amplification versus the stroke length for the two types of toggle mechanisms was computed and plotted in Figure 5. The figure shows the relationships for both toggle and reverse toggle links with the assumed values given in Table 2.

Considering the details of the mechanisms given in Table 2, two machines were designed, which are designated as toggle press and reverse toggle press. Both the presses were designed to produce a SSB of size 305 x 144 x 100 mm with a constant stroke length of 60 mm. Figure 6 shows these soil block machines. Both the machines produce blocks of constant thickness because they have a constant stroke length of the piston.

The magnitude of force to be applied at the end of the lever to produce a soil block of dry density 1.85 and 1.90 t/m<sup>3</sup> using toggle and reverse toggle machines is shown in Figure 7. The maximum effort needed for block compaction using Soil A and Soil

**Table 2** Details of mechanisms

Type of mechanism	Maximum stroke length $X_m$ (mm)	Initial angle $\theta_0$	$(r/l)$ ratio	Amplification at		
				50% stroke	75% stroke	95% stroke
Toggle	60	75.52	0.25	26	33	70
Reverse toggle	60	75.52	0.25	34	48	110



**Figure 5** Force amplification versus stroke length in a manual soil block making machine





**Figure 6** The toggle press (L) and the reverse toggle press (R)

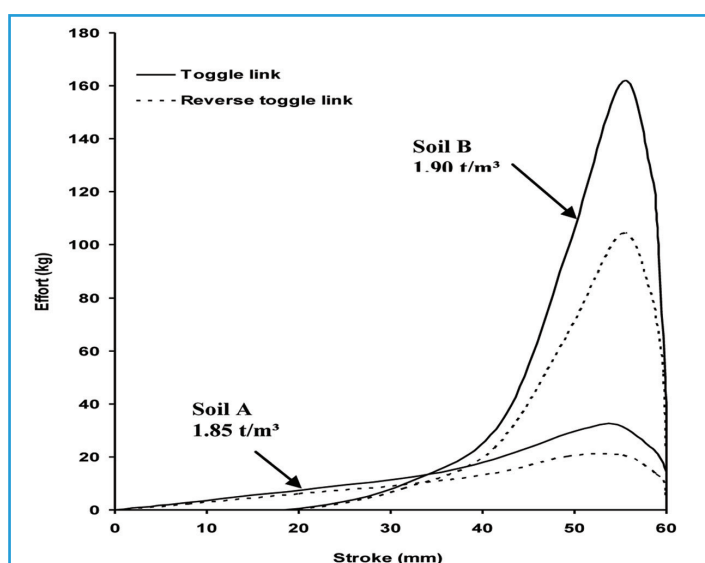
Soil B (sandy soil) is displayed in the figure. The force/energy required to compact the block has to be supplied by human effort during block production process. It is clear from the figure that to achieve a block density of  $1.9 \text{ t/m}^3$  with sandy soil (Soil B), the human effort required is about 160 kg and 105 kg using toggle and reverse toggle links, respectively. Whereas for Soil A, to achieve a density of about  $1.85 \text{ t/m}^3$  for the block, the peak effort required is much lower at about 30 kg and 20 kg using toggle

and reverse toggle links, respectively.

## 6 Soil block making using the manual machines

The block-making activity using a manually operated machine involves a sequence of activities as follows.

1. Preparing/mixing the soil
2. Loading the scoop



**Figure 7** Variation in human effort during pressing of a soil block

3. Filling the machine mould
4. Lid opening and ejection
5. Stacking the block

The block making process using a manually operated machine was monitored at a construction site where the SSBs were produced on site. Figure 8 shows the block-making operation in progress at a site. The time needed for each activity of block making is given in Table 3.

The block manufacturing is generally done in batches, where each batch operation consists of (i) mixing/preparing an amount of soil for ‘n’ blocks

and (ii) making the blocks in the machine. These can be parallel operations. The batch operation is needed for the following reasons.

1. If the soil contains Portland cement as stabiliser, the batch of mixed soil should be compacted within the initial setting time of cement.
2. In a manual mixing process, it is difficult to achieve a good intimate mix with large quantities of soil.

The total production of blocks per day depends on the number of persons working at the machine and the number of persons preparing the soil. Figures

**Table 3** Time duration for various block making activities  
Block size: 305 x 144 x 100 mm; Standard Deviation values in parenthesis

Sl. No.	Activity	Average time required
1.	Mixing and preparing soil (for one batch of 25 blocks) (a) One person (b) Two persons (c) Three persons	31 minutes 26 minutes 22 minutes
2.	Block making (a) Loading the scoop (b) Filling the machine mould (c) Lid closing and compaction (d) Lid opening and ejection (e) Stacking the block	7.6 seconds (3.34) 14.7 seconds (4.71) 8.1 seconds (3.41) 7.3 seconds (3.57) 14.0 seconds (3.33)



**Figure 8** Block making in progress at a construction site

9 to 11 show the activity networks and labour utilisation diagrams for various combinations of persons working at the machine. Figures 9 and 10 show the activity network and labour utilisation diagrams for making one block with two and three persons respectively. When two persons are making blocks, there are no parallel activities and the total time needed for making one block is more (51.7 seconds). When three persons are involved, some of the activities are carried out in parallel and time taken per block comes down to 30.1 seconds. Figure 11 shows the activity network and labour utilisation diagram for making one block when four persons are working at the machine. There are some parallel activities here, but even then the total time needed for making one block is 30.1 seconds. The labour utilisation with four persons at the machine is not as efficient as with three persons.

Figure 12 shows the activity networks for making one batch (25) of blocks for various combinations of persons working at the machine and preparing the soil. The activity networks clearly indicate that, in general, the time needed for making one batch

of blocks (25) is less than the time required for preparing the soil for that batch. The total time needed for completion of the batch operation is hence controlled by the soil preparation activity.

Making use of the above-mentioned networks, the total production of blocks per day and block production per day per person was calculated and shown in Figure 13. The figure clearly shows influence of number of persons working at the machine on productivity. The number of blocks per person is maximum (125) when three persons are working. It must be noted that even here, the machine is idling most of the time, because the soil preparation activity determines the rate of block production. On examining Figures 9 to 12, it can be seen that the machine is capable of producing about 960 blocks per eight-hour working day (30.1 seconds per block) when three persons are working at the machine. The productivity capacity of the machine is high, and it needs to be provided with prepared soil at the same rate for better capacity utilisation. In the event of more efficient soil preparation, the productivity of the manual machine could be more than doubled.

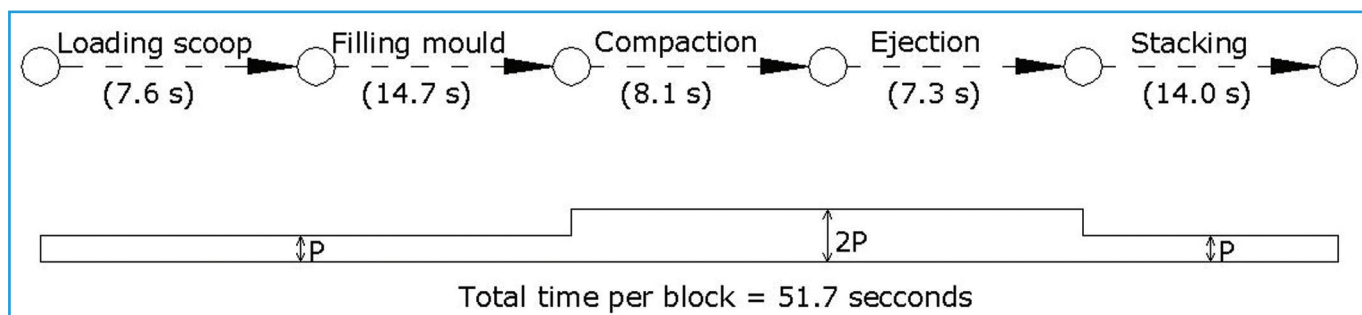


Figure 9 Activity network and labour utilisation diagrams for making one block with two persons (P: person)

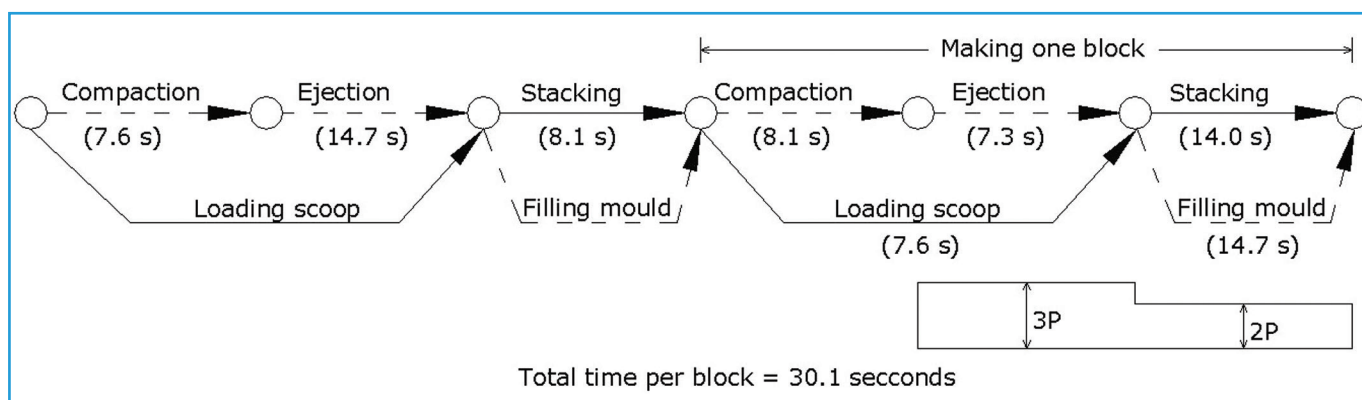


Figure 10 Activity network and labour utilisation diagrams for making one block with three persons (P: person)



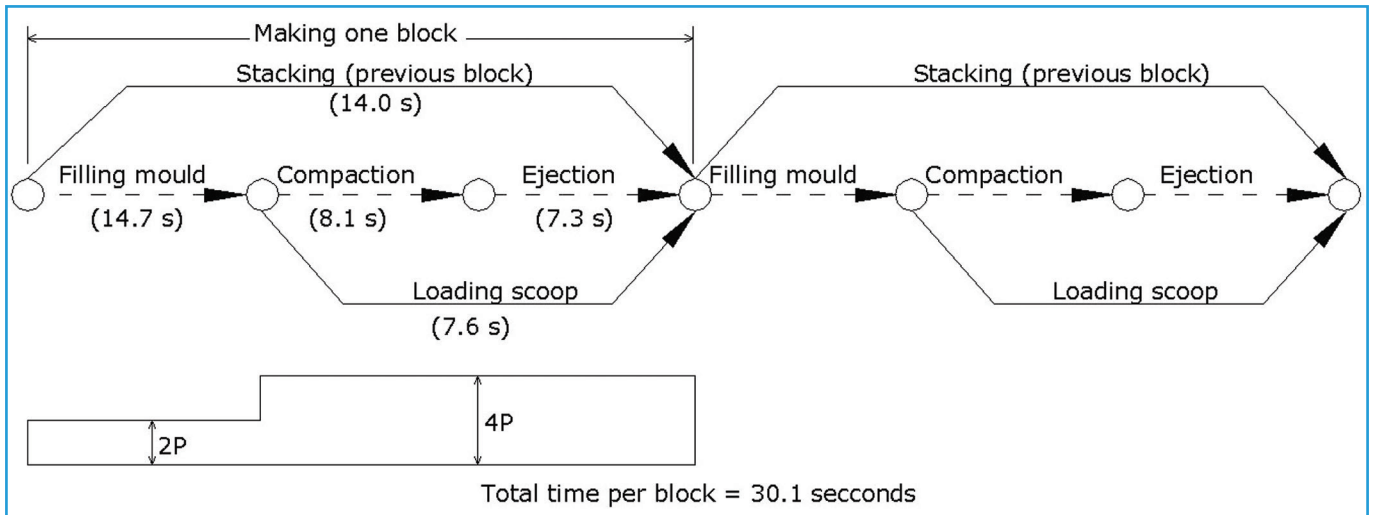


Figure 11 Activity network and labour utilisation diagrams for making one block with four persons (P: person)

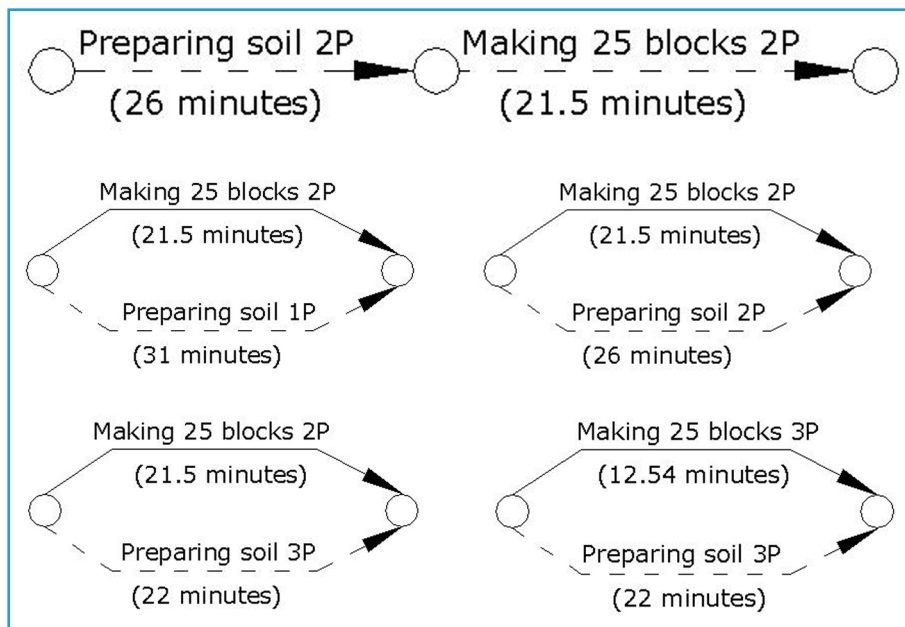


Figure 12 Activity networks with different number of persons with the machine and soil preparation (P: person)

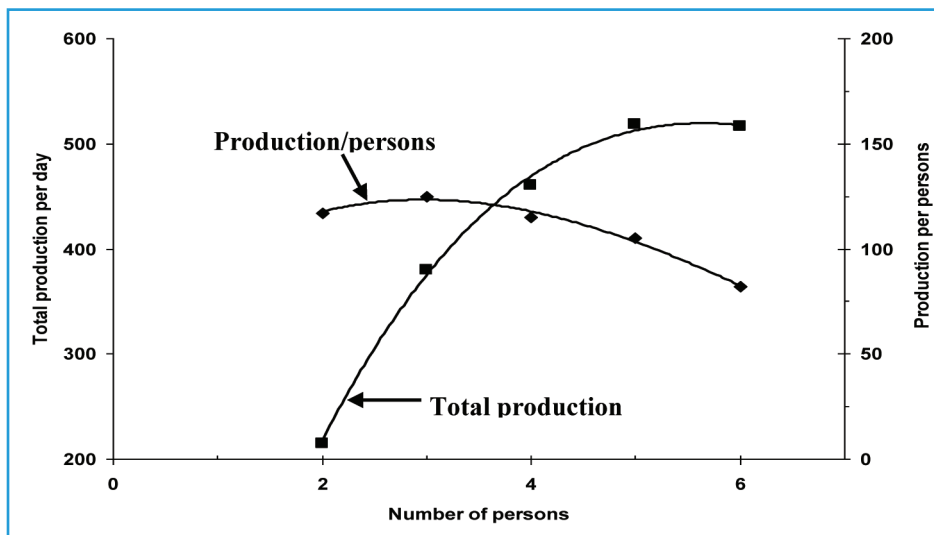


Figure 13 Block production per day and production per person

## 7 A case study of three million blocks produced at one construction site

SSB technology has been used for the construction of buildings, and there are a number of structures in India. The technology has been conveniently exploited for the construction of buildings in rehabilitation programmes after natural disasters in India and elsewhere (Walker, 2004; Venkatarama Reddy, 2009). In such rehabilitation programmes, SSBs were produced using manually operated machines. Currently, a large project involving production of over three million SSBs is under construction. This project is a commercial venture meant for middle- and high-income group families. Details of this case study have been provided below.

Figure 14 shows a cluster of houses in the housing project where 500 dwellings are being constructed using SSB masonry. These are load bearing masonry buildings. Load bearing structures of about 200 houses have been completed. The SSBs were produced using ten manually operated machines. Figure 15 shows block production and stacked blocks in one of the block making units at the construction site. The manual machines were carted to different places in the construction site where the blocks are required. The SSBs were consumed at the place of production without much transportation. These operations are clear examples of decentralised block production systems.

In each block production team, eight persons work on one machine. Soil preparation and block production are parallel activities. All the activities are manual. The distribution of persons for various activities is as follows.

1. Soil preparation (including sieving) – 3 persons
2. Block making activities at the machine – 4 persons
3. Curing the stack of blocks – 1 person

Prepared soil is made available continuously such that the block production takes place without idling

the machine. Here, the block production per day per team is in the range of 700–800 blocks. In a span of about two years, the ten block making teams have produced over three million SSBs.

SSB masonry is a low embodied carbon material. The embodied energy of cement stabilised SSB (7–8% cement) and its masonry is in the range of 1 to 1.25 MJ/kg and 500 to 600 MJ/m<sup>3</sup>, respectively (Venkatarama Reddy and Jagadish, 2003; Venkatarama Reddy, 2008).

## 8 Concluding remarks

This paper discussed static compaction of soils, analysis of toggle mechanisms, design of manually operated soil compaction machines, decentralised stabilised soil block production systems, time and motion study of manually operated block production systems, critical network analysis using CPM technique, and a case study involving large-scale production of blocks using decentralised production systems. The investigations demonstrate the following.

1. The force required to compact highly sandy soils is an order of magnitude higher when compared with force requirement for clayey soils having less sand content. The effort needed for compaction reaches a maximum when 90% of the stroke has been completed.
2. Toggle mechanism is ideally suited for the manually operated soil compaction machines to produce soil blocks of dry density in excess of 1.8 t/m<sup>3</sup>. A reverse toggle link is more efficient than the toggle link in reducing the effort needed for compaction of soil block.
3. Manually operated machines are capable of producing two blocks per minute provided the processed soil is supplied continuously. The study reveals that soil processing is a controlling factor in block production.
4. The block (size 305 x 144 x 100 mm) production using manual presses can be as high as 800–



900 blocks per day with a per capita production of 125 blocks per day.

5. The manual machines are very effective in generating employment at lower capital cost.
6. Manual machines can be successfully employed to produce large requirement of blocks in a construction site by carrying out block production in batches at different places simultaneously.

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**Figure 14** Cluster of SSB masonry houses in the case study project (Bangalore, India)



**Figure 15** SSB block production teams and stack of SSBs

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paper

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Reassessment of Sustainable Well-being Indices:  
A Case Study of Bekasi Municipality, Indonesia

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# Reassessment of Sustainable Well-being Indices: A Case Study of Bekasi Municipality, Indonesia



## Abstract:

Economic growth in urban areas can lead to the urbanisation of the hinterland, which may trigger problems related to the provision of housing and employment. Urbanisation is also placing pressure on limited land resources, which in turn may be negatively affecting sustainable well-being. According to the Sustainable Development Goals, the core of sustainable development is well-being for the next generation, with the fundamental concern for quality of life. This study combines the Human Development Index and Environmental Performance Index to examine sustainable well-being. These sustainability indices play an important role in comprehensively assessing whether a regional development plan has achieved sustainable well-being. The presented review focuses on the reassessment of sustainability factors that influence sustainable well-being levels. The main factor in this index is the provision of decent housing. This study was conducted in the dynamic suburban area of Bekasi Municipality, West Java, Indonesia. We combine the sampling techniques of stratified and cluster treatments and use quantitative research methods to obtain the measurement model of sustainable well-being. Several tools such as descriptive and inferential statistics, Powersim Constructor 2.5, and ArcGIS 10.2 software are also employed to support the findings.

**Keywords:** *sustainability indices, well-being, measurement, spatial indices, sustainable development goals*

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## 1 Introduction

Efforts to save the lives of future generations have come to the world's attention. For example, the 1992 United Nations Conference on Environment and Development in Rio de Janeiro discussed the importance of indicators to help countries improve their awareness of sustainable development. In 1995, the UN Commission on Sustainable Development formulated 46 themes with 96 indicators of sustainable development, which have since been continuously refined (simplified to 14 themes by 2007).

In the same vein, United Nations Department of Economic and Social Affairs analyses the relationships of all indicators to guide and monitor the

implementation of sustainable development in each country. Likewise, a variety of indicators including the Sustainable Development Indicator formulated by the UN Commission on Sustainable Development in 2007, the Sustainability Performance Index, and the Environmental Performance Index (EPI which is a refinement of the Environmental Sustainability Index), are all a refinement of the Environmental Sustainability Index and the Human Development Index (HDI). These have been evolved and adopted both nationally and locally in each UN member state.

Through the lessons learnt from the problems faced by each member state in implementing sustainability indicators, UN members agreed on

several indicators to be achieved by 2015 in the form of the Millennium Development Goals (MDGs). The MDGs were formulated to monitor the achievement of sustainable development in each country. Furthermore, based on the evaluation of the MDGs and proposals from Columbia and Guatemala, the UN Conference on Sustainable Development in 2012 in Rio de Janeiro introduced the Sustainable Development Goals (SDGs) to enhance the theme of the MDGs, especially for sustainable aspects. The core of the SDGs is the achievement of public welfare through a holistic process (UN, 2012). The achievement of public welfare is identical to the improvement in human resources, which has a critical impact on the development of human capital for the next generation.

Stiglitz, Sen and Fitouss (2010) believe that sustainability may be a problem in its own right. The underlying idea is that the well-being of future generations compared with ours will depend on what resources we pass onto them. Meanwhile, Sachs (2008) argues that the challenge of sustainable development is protecting the environment, stabilising the world's population, reducing the gap between rich and poor, and ending extreme poverty. Thus, the planning and control of natural resources use is at the core of sustainable development. The main resources needed to meet the well-being of the next generation are land, water, and air. All types of areas (i.e. urban, rural, and peripheral areas) have their own problems regarding the availability of primary resources and natural conditions.

Decent housing might be a benchmark for successful sustainable development. A decent house can be affected by the quality of housing and the quality of housing can be affected by the quality of the community, which influences well-being through the healthy living of residents. However, this objective faces the issue of land and carrying capacity. Population growth requires additional land to support housing needs and quality of life for the next generation. Similarly, economic growth also requires sufficient land. Hence, because meeting the needs of decent housing demands economic capabilities, there

is conflict between economic and housing interests.

The perception of well-being can be influenced by the level of income, both household income and the aggregate income of a region (GDP). Nevertheless, some experts argue that the level of GDP alone is not enough to assess the level of well-being in an area. Sen (1984, cited in Jackson, 2011) has a different view about the welfare of three characteristics, namely prosperity, benefits, and the ability to move forward. In principle, Stiglitz et al. (2010) agree that prosperity is one of the characteristics of well-being, but not only in terms of quantity.

Jackson (2011) finds that prosperity is often discussed in relation to overcoming hunger, ending poverty and injustice, and creating a secure and peaceful world. This vision suggests that life is meaningful. It brings a sense of comfort that things will improve for the current generation as well as for future generations, such as a better society for children and a fairer world. Although the belief in such a possibility is important, it requires realistic action, without which prosperity remains an illusion. Jackson (2011) further argues that although the Malthusian theory of population has been much debated, population growth is faster than the growth in the insistence on managing natural resources for food and housing. Jackson (2011) considers that eventually, the population will grow beyond its ability to find jobs, meaning that it is unavoidable that many people will become poorer.

The HDI has been employed to measure well-being, while the EPI, which is a refinement of the Environmental Sustainability Index and the Environmental Quality Index, have been used to measure the environment's quality. The achievement of the HDI is affected by several environmental indicators. Samimi, Alireza, Parvaneh and Maryam (2011) find that the HDI has a positive and significant impact on the EPI in the United States, but recommend that to improve the EPI in developing countries, HDI improvement is first necessary. Meanwhile, Jaffeer (2011) states that environmental performance indicators aim to

support the achievement of social objectives such as increased welfare and environmental/ecological sustainability. Jackson (2011) states that any action starts with defining the true meaning of prosperity, because human beings live in a limited world. Therefore, real wealth growth depends on two critical factors, namely limited natural resources and global population growth.

This study combines these social and environment indices to understand sustainable well-being. Sustainable indices play an important role for comprehensively assessing whether a regional development plan has achieved sustainable well-being. The reassessment focuses on having decent housing as the central sustainable factor that influences sustainable well-being.

## 2 Introduction to Bekasi Municipality

The discussion of sustainability cannot be separated from the circumstances in Bekasi Municipality

(West Java, Indonesia), a dynamic suburban area in terms of its social and economic dimensions. Bekasi Municipality has closely interlinked rural/urban livelihoods as well as communication, transport, and economic systems. As a hinterland region of the Jakarta metropolitan area, it has fairly high and dynamic population and economic growth. The population growth in suburban areas is not solely due to the economic growth in the area; it can be largely influenced by migrants that work in urban areas seeking housing in suburban areas. According to the population census, Bekasi Municipality grew in size by 58% from 2000 to 2010, accompanied by GDP growth of 7% and GDP per capita growth of 3%.

The growth and development of Jakarta can influence economic growth in Bekasi Municipality, as the people who work in Jakarta cannot easily afford residence in this city with limited space, and hence, choose to live in nearby Bekasi. This presents challenges related to the provision of settlements and construction of good infrastructure in anticipation of

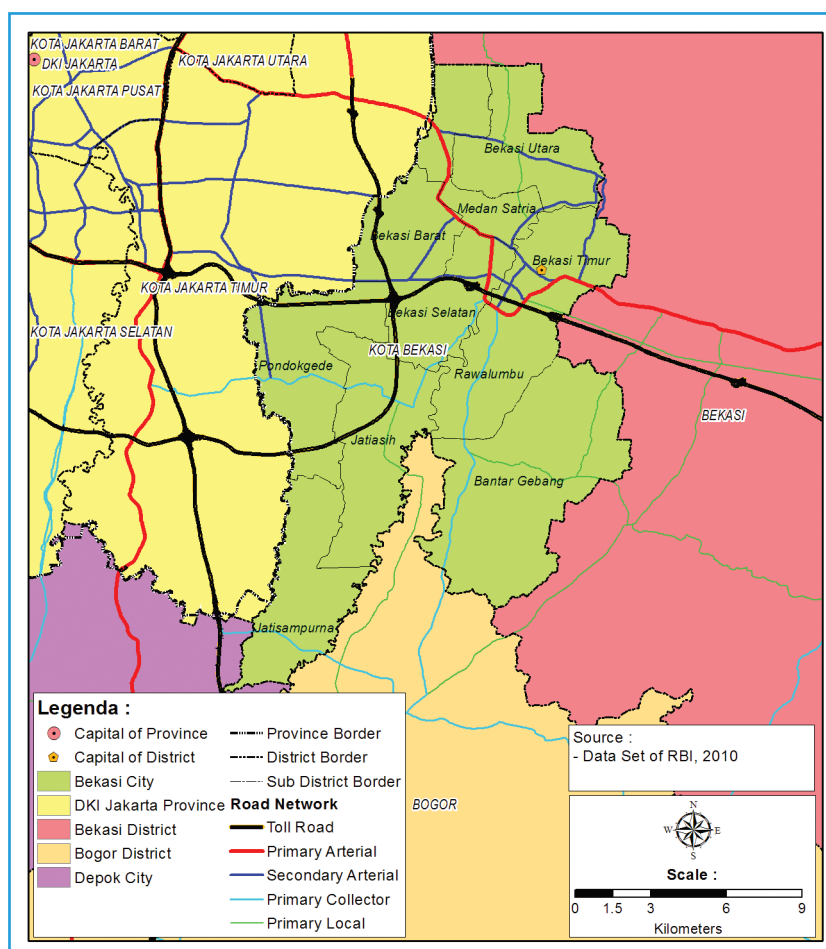
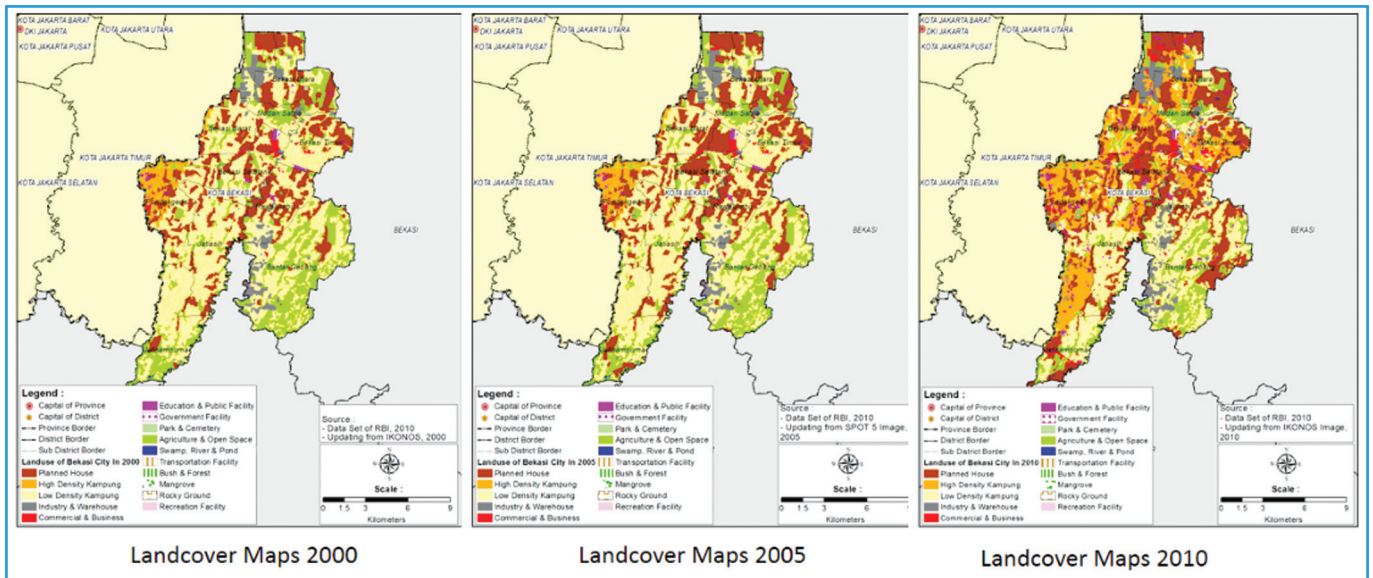


Figure 1 Bekasi Municipality Map



**Figure 2** Bekasi Municipality Land Cover Changes, 2000–2005  
 Source: Indonesia Mapping Agency

population growth due to migration flows. The major challenge is the provision of residential mobility in suburban areas given the high traffic density during rush hour. As shown in Figure 1, Bekasi Municipality has a bypass that connects Jakarta to West Java, an outer ring road that joins Jakarta and Tangerang, as well as a primary road from Jakarta to West Java.

Compared with Jakarta’s other hinterland areas, namely Bogor Municipality, Bogor Regency, Depok Municipality, Tangerang Municipality, South Tangerang, Tangerang Regency, and Bekasi Regency, data in 2010 showed that the settlement area of Bekasi Municipality had the highest population density (111 people/ha). Even if viewed from the perspective of net population density, Bekasi Municipality was ranked third (Hayati, 2013). This high degree of population density suggests that the settlements in Bekasi Municipality still require further restructuring to lead to sustainable well-being. Figure 2 shows that Bekasi Municipality has the highest residential density, with both formal housing (planned housing) and informal housing (*kampoeng*) growing rapidly between 2000 and 2010.

In addition, the number of daily commuters from Bekasi Municipality to Jakarta is the highest (359,550 people), while the number of commuters from the other hinterland areas of Jakarta only range from 63,458 to 196,080 people per day (Hayati, 2013).

This fact indicates that the preference to reside in Bekasi Municipality is high because land and house prices are still affordable. This phenomenon shows that Bekasi Municipality, as a peripheral area of Jakarta, is placing pressures are evic. Environmental pressures are evident from many emerging types of infectious diseases that occur in Bekasi Municipality, notably tuberculosis and ISPA/URTI. The body’s resistance to such diseases is influenced by nutrition. Parasite infection was involved in 26% of the 14 types of diseases that resulted in fatalities. Tuberculosis, infections, and parasites are associated with the air quality both indoors and outdoors.

### 3 Design of Sustainable Well-Being Indices

#### 3.1 Sustainable Well-Being Indices

Sustainable well-being indices are a measurement tool to find balanced conditions among social, environmental, and economic factors. The present evaluation research examines the current phenomenon by comparing the standards, policies, and programmes that have been set. Meanwhile, this study proposes a modified model.

A combination of both quantitative and qualitative approaches is employed in this study. The



quantitative approach is used to analyse the correlation among the variables that affect well-being and to find the influence of these variables. Structural equation modelling using LISREL and inferential statistics is used to find the best model. Based on that analysis, we find the weight of each indicator by using a pairwise comparison. To examine the dynamic relationships between the variables, a system dynamics approach using the Powersim Constructor is also employed. Some variables such as housing area, business area, and land use are analysed by using GIS tools (ArcGIS 10.2).

Figure 3 shows the selected sample area, identifying both formal housing and informal housing. The sample aims to represent three criteria, namely density, morphology, and the buffering of the polluted area.

### 3.2 Variables Used to Construct the Model

In previous research, some indices have been developed separately to assess social, economic, and environmental factors. Social aspects have tended to be analysed by using the HDI, although many indices such as the Quality of Life Index and the Happiness Index have been reviewed to refine the measurement of social aspects. Stiglitz et al. (2010) define the well-being dimension, based on academic research and a number of concrete initiatives developed around the world, as material, health, education, occupation, governance, social connections, the environment, and personal insecurity. In this vein, the present study uses four dimensions, namely human capital, productivity, environmental capital, and social capital. Each

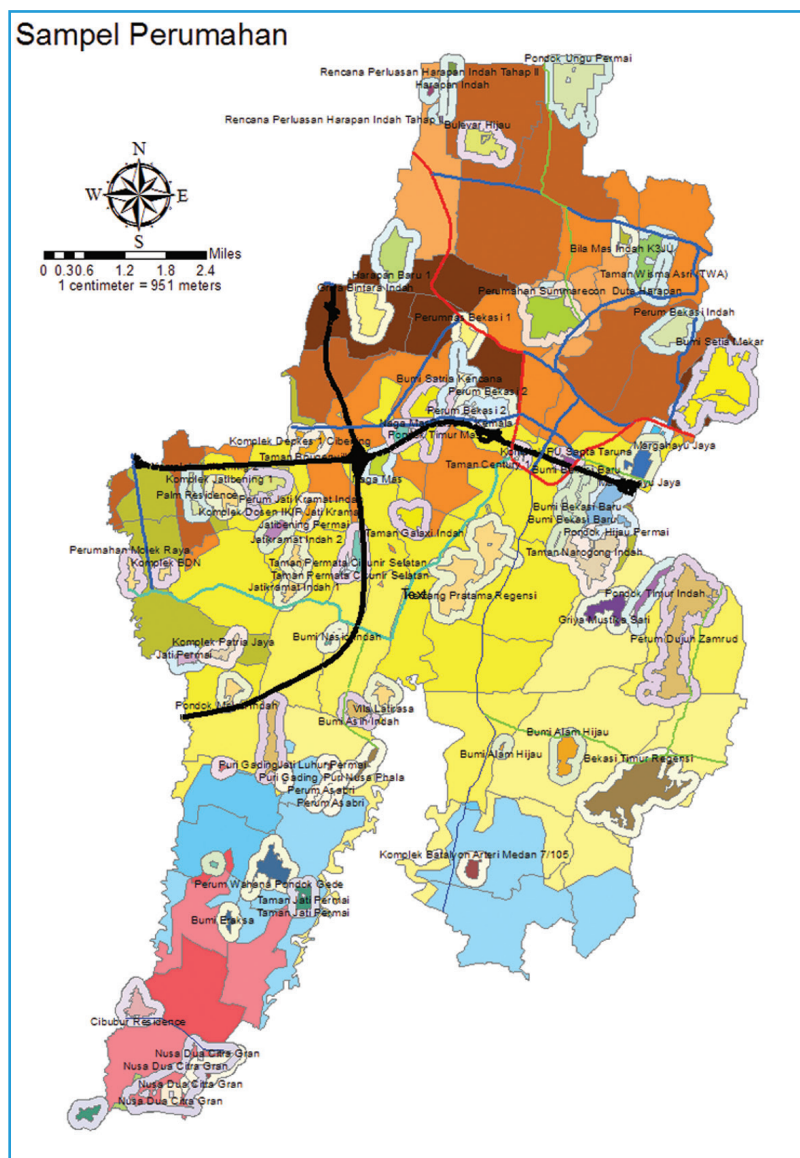
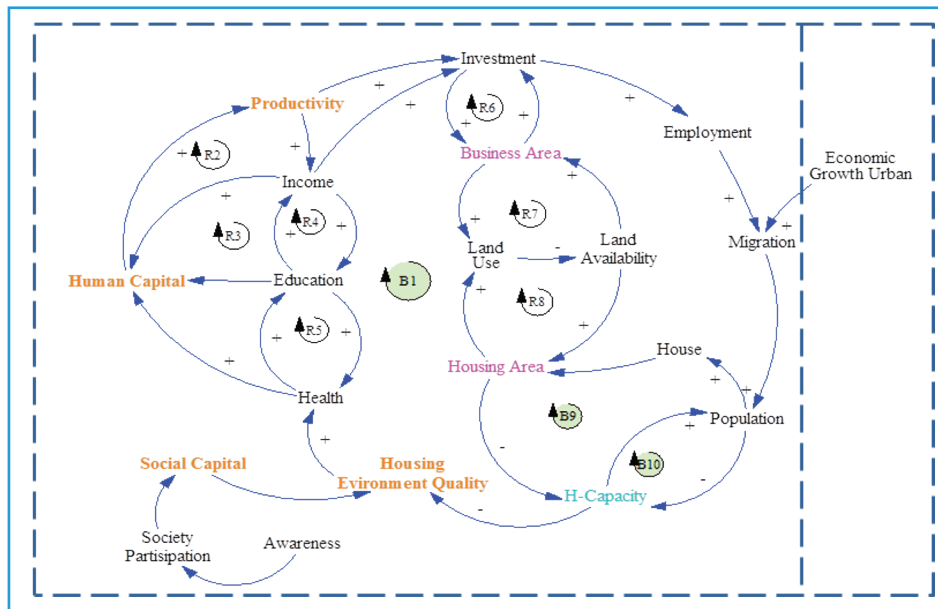


Figure 3 Selected Sample Area







**Figure 5** Causal Loop Diagram of Sustainable Well-Being

capital, the region cannot take advantage of other resources such as natural resources. Therefore, if health increases, human capital would increase and vice versa. Furthermore, an increase in human capital would increase productivity and thereby affect profitability. Profit growth would lead companies to make new investments. Another impact of a productivity rise is increased income for individuals, triggering them to purchase capital goods and make investments. Furthermore, the growth in investments would create new employment, which can then lead to rapid population growth through migration. The migrant population is mostly composed of childbearing or productive age individuals who need housing immediately. Thus, Loop B1 is formed by Population – House – Housing Area – Housing Capacity – Housing Environment Quality – Health – Human Capital – Productivity – Investment – Employment – Population Migration and thus it leads to environmental problems.

### Loop R2

The variables in Loop B1 form another sub-loop. Loop R2 illustrates that human capital affects the productivity of both individuals and companies, which are economic actors. Then, high productivity would affect income. Thus, this loop is formed by Human Capital – Productivity – Income.

### Loop R3

This loop develops from Loop R2, as the increase in revenue would allow individuals to pursue and improve their education. Education is an important factor that shapes human capital. Basically, improving the quality of human capital begins with the individual. Thus, this loop is formed by Income – Education – Human Capital – Productivity.

### Loop R4

This loop describes the mutual influence of income and education. Higher income offers the opportunity to reach higher education levels as well. If this opportunity were utilised, it would usually lead to a higher income. Thus, this loop is formed by Income – Education.

### Loop R5

This loop explains the reciprocal influences of health and education. An increase in education level improves health level. In addition, if a person has good health, he or she would be able to maintain a better education. Thus, if education increases, health would also increase. This loop is thus formed by Health – Education – Health.

### Loop R6

This loop describes the influence of investments and business areas. Investment growth would increase

demand for land for businesses or economic activities and vice versa. This loop is formed by Investment – Business Area.

### **Loop R7**

This loop describes the impact of land use for business on land availability. Demand for Business area would increase land use, which would reduce the availability of land. This loop is thus formed by Business Area – Land Use – Land Availability.

### **Loop R8**

This loop describes the impact of land use for housing on land availability. HDemand for Housing area would increase land use. This loop is formed by Housing Area – Land Use – Land Availability.

### **Loop B9**

This loop, part of B1, explains the impact among population growth, housing demand, housing area, and housing capacity. Population growth would increase demand for housing. In this case, if the land requirements were not met by Loop R7, this would reduce the housing area and thus the capacity of residential areas would be exceeded. This will cause discomfort, and individuals who have more money will move to a more comfortable area.

### **Loop B10**

This loop explains the impact of population on housing capacity. The higher the population, the greater is the degree to which housing capacity will be exceeded. If carrying capacity is no longer available, then the population would seek other areas and housing may be left.

This scenario comprises another factor that must be considered in parallel with the conceptual design, namely economic growth in neighbouring regions. In this case, the neighbouring regions that contribute to the migration rate in Bekasi Municipality include Jakarta. Economic growth in Jakarta would open up employment opportunities. Considering the cost of living in the Jakarta metropolitan area, people will

prefer to live in peripheral areas such as Bekasi Municipality.

## **5 Discussion and Conclusion**

Given that the main purpose of the SDGs is to improve human well-being, paying attention to the quality of the housing environment in dynamic suburbs is another important factor besides food sufficiency. Food sufficiency can be fulfilled through the supply chain between producers and consumers. However, decent housing or settlement sufficiency is directly affected by the prevailing environmental circumstances. The inability to provide decent housing has a significant impact on health and in turn human well-being.

Environmental quality issues, especially air quality, are also affected by geographical constraints, in this case altitude and morphology. On highlands, because the wind flow is not impaired and humidity is lower, bacteria and parasites cannot reproduce quickly. Meanwhile, on lowlands, the velocity of the wind may cause higher humidity, which is exacerbated by residential density, industrial air pollution, and fuel emissions from vehicle use.

Although sustainable well-being indices can be formulated by combining the four dimensions of human capital, productivity, environmental capital, and social capital, it is still important to compare regional characteristics. Therefore, further research is needed with empirical data to build sustainable welfare indices based on a conceptual design that considers regional differences.

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paper

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Well-being and sustainable design:  
A case study of building typology transition  
in a rural settlement in India

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# Well-being and sustainable design: A case study of building typology transition in a rural settlement in India



## Abstract:

Rural settlements in the state of Karnataka in India predominantly use locally available resources to build their dwelling units. The houses are constructed either by the villagers themselves or by local masons skilled in vernacular architecture. However, the vernacular way of construction and materials are slowly giving way to modern concrete dwellings and lifestyles. To analyse this trend of transition to modern dwellings in rural settlements, a case study was conducted on three villages near the city of Bangalore in Karnataka. Many people from these villages migrate to Bangalore for jobs and education. The increased affordability of modern construction materials and the proximity of Bangalore have led to a new wave of aspirations for the people of these villages, in terms of their style of construction of houses. This paper will situate this transition in the context of sustainability and well-being.

**Keywords:** *well-being, sustainable design, rural planning, rural-urban transition*

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## 1 Introduction

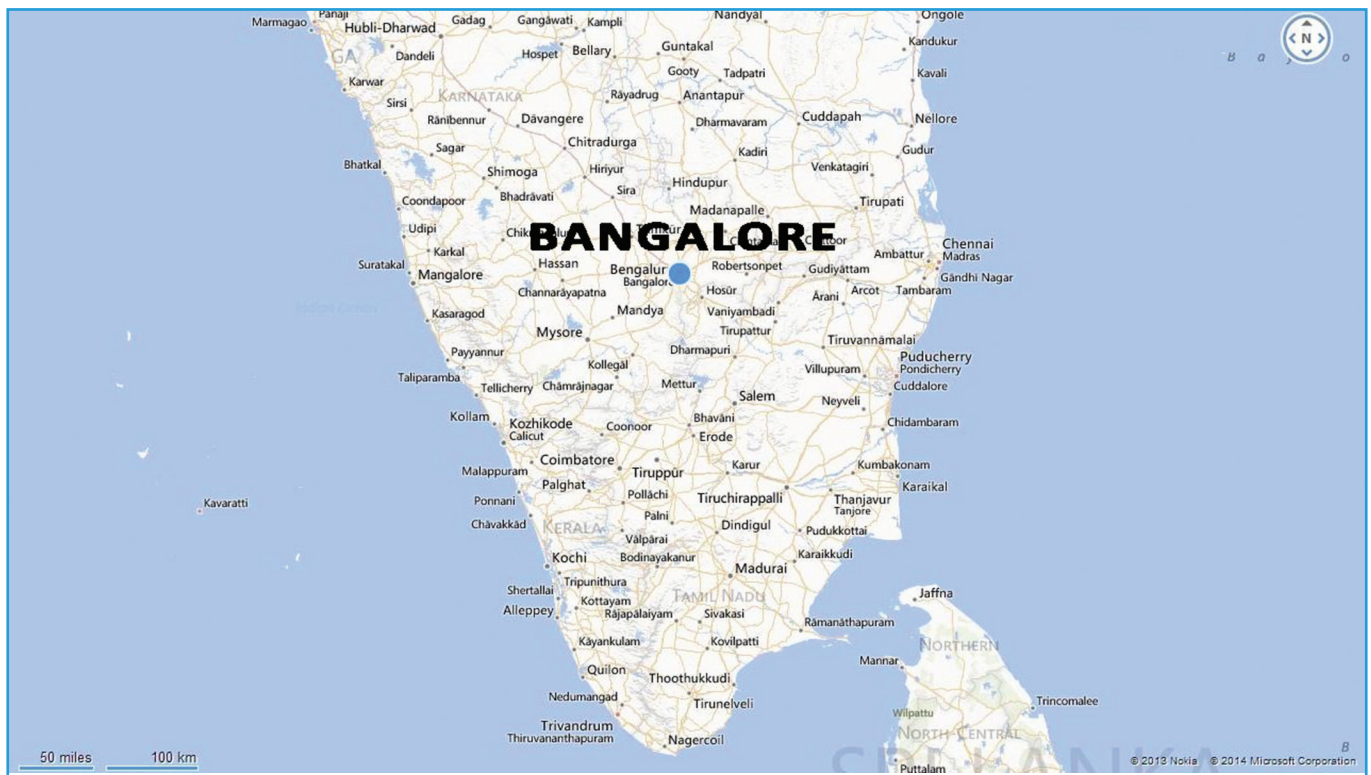
Rural settlements near the city of Bangalore are undergoing a transition towards an urban style of living. Bangalore (Figure 1) with a population of 11 million people in 2011 (Census of India, 2011), provides new employment opportunities leading to migration from rural to urban areas. Tumkur District adjacent to Bangalore, has 10 Taluks (Taluks are administrative units) and a population of 4 million (Census of India, 2011). The study area of this work is Ungra Panchayat of the Kunigal Taluk in Tumkur District, which has a population of 0.2 million (Census of India, 2011). The presence of a metropolitan city, Bangalore, which is 100 km to the east of Ungra, has influenced this village (Figure 2). The population of this Taluk has declined in the past decade by 4.4%, suggesting migration to the city. However, the percentage of population in the rural area within

Kunigal decreased by 2.27% and that of the urban area within Kunigal increased by 2.27%, which hints at intra-taluk rural-to-urban transposition of the population (See Table 1). While the total population decreased by 10335 and the rural population by 14144, the urban population increased by 3809. This statistic merits attention, as the change in lifestyle of the urbanising rural population, and the shrinking rural population will reflect in the design and use of the built-environment of this area.

The study is centred on three villages, Bommanahalli, Bommanahalli 1 (two different settlements with the same name, Bommanahalli), and Pallerayanahalli (see Figure 3), based on data collected onsite in April 2013. This study is part of ongoing fieldwork in this area to study the rural-to-urban transition of building typologies observed in these villages (see Figure 4). The families of Bommanahalli and Bommanahalli 1

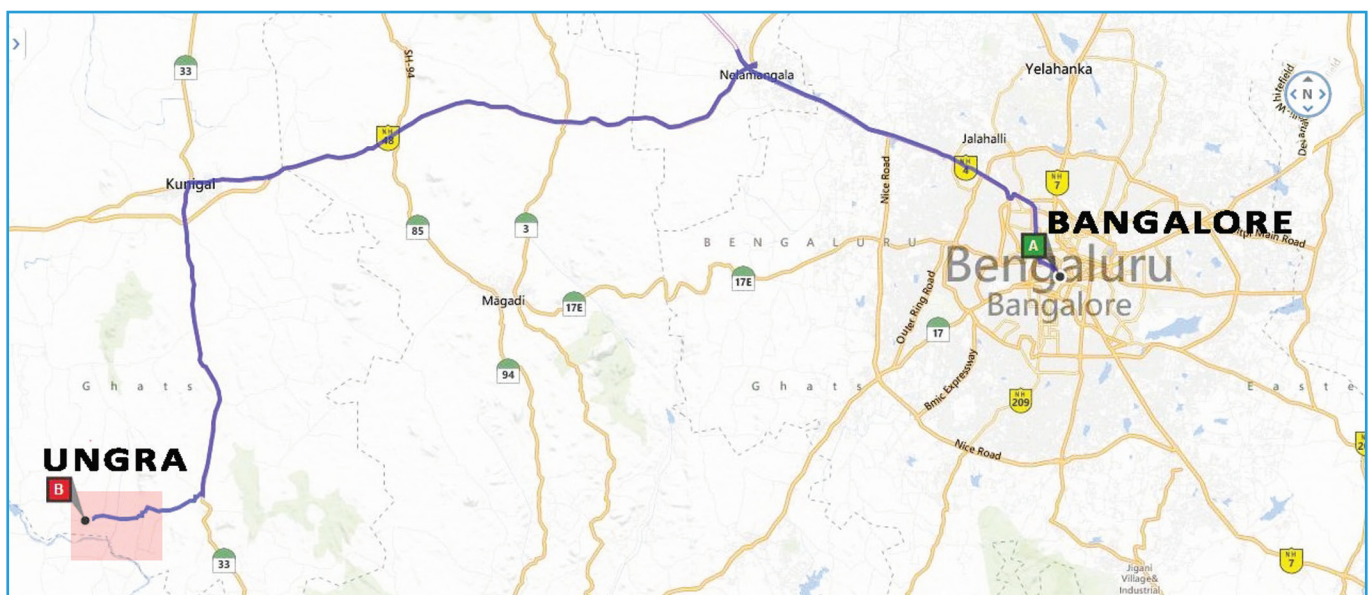
residents had been living in these villages near their agricultural lands since the time of their ancestors. Pallerayanahalli is a decade-old settlement laid out by the Government of Karnataka for tribes who had migrated from the forest or distant places. Every household (HH) in these villages has at least one person living in the city of Bangalore for either work or education. This paper concentrates on the changes in architecture and building typologies due

to rural-to-urban transition. This paper concentrates on the changes in architecture and building typologies due to rural-to-urban transition, and on how a shift in lifestyle is inducing this change and vice versa. Documentation of the building typologies and interviews with the villagers were carried out to find answers to the research questions of why people choose modern materials and how this associates with their well-being.



**Figure 1** Location of Bangalore City in Southern India.

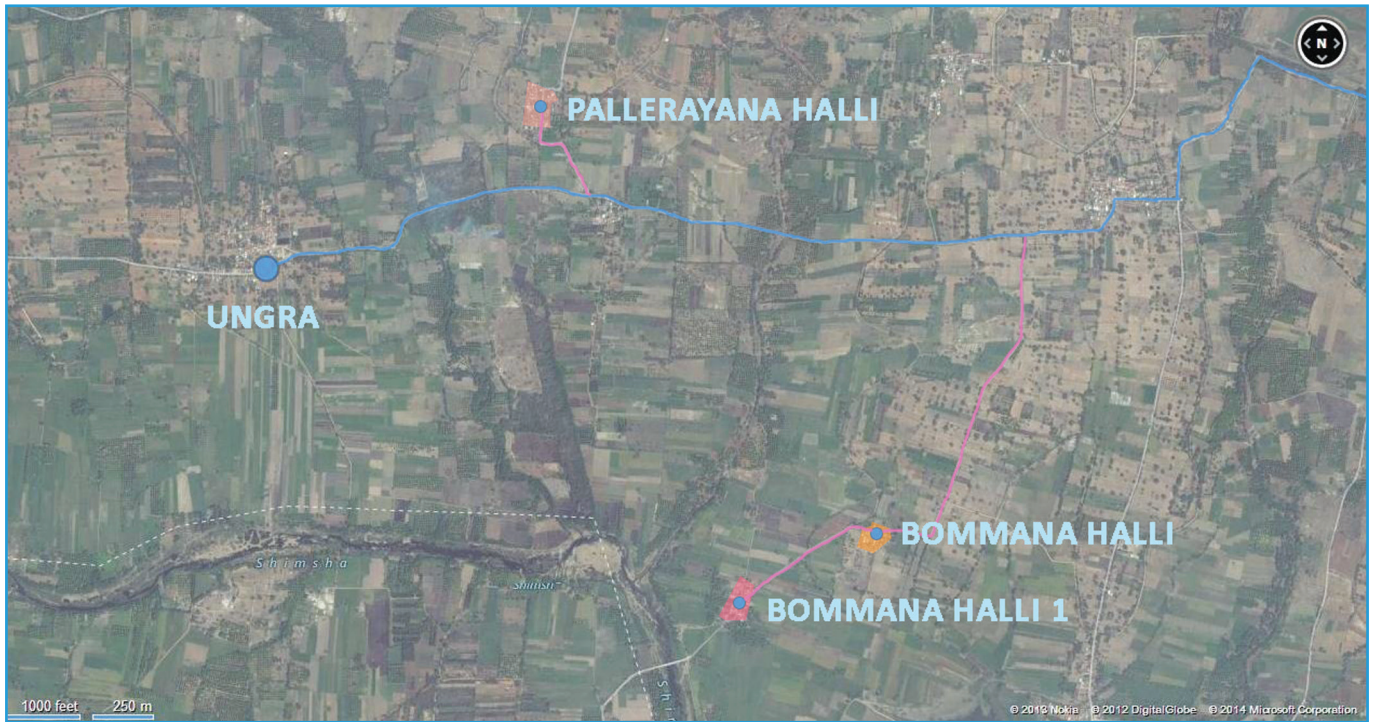
**Source:** Base map from Microsoft. “Bangalore”. Bing Maps (Map). Cartography by Nokia. Retrieved 7 March 2014



**Figure 2** Ungra village in Kunigal Taluk.

**Source:** Base map from Microsoft. “Ungra”. Bing Maps (Map). Cartography by Nokia. Retrieved 7 March 2014





**Figure 3** The case study villages

**Source:** Base map from Microsoft. “Ungra”. Bing Maps (Map). Cartography by Nokia. Retrieved 7 March 2014



**Figure 4** A sample of building types in Ungra village: gabled roof adobe house (left), gabled roof brick plastered house with verandah (centre), and flat roof concrete dwelling with compound wall and parking space (right)

**Table 1** Kunigal Taluk Rural-Urban Demographics. Source: Based on data from Census of India (2001, 2011)

Kunigal Taluk	Total Population	Rural	Urban	Density per sq km	Percentage Rural Area	Percentage Urban Area
2001	236030	205687	30343	241	87.14443	12.85557
2011	225695	191543	34152	230	84.86807	15.13193

## 2 Building Typology and Transition

The traditional building typology of these villages is characterized by a single-room space with a gabled thatched roof, walls constructed from adobe or sundried bricks or straw bamboo reinforced adobe, and floors plastered with cow dung or mud. Random rubble (RR) masonry and stone flooring with clay-

tiled roofing are also in practice. A comparison of aerial maps of these villages obtained from Google Earth for the years 2002 and 2013 reflect the increase in built-spaces of the villages as well as the transition of the roof materials (see Figures 5-7). While the number of households has dwindled (see Figure 8) from 1998 to 2013 for Bommanahalli 1 and Pallerayanahalli, the site coverage of the villages





**Figure 5** Aerial view of Bommanahalli in 2002 and 2013.

**Source:** Google Earth. (April 2, 2013-left and March 3, 2002-right). Bommanahalli.  $12^{\circ} 48' 13.31''N$ ,  $76^{\circ} 58' 55.35''E$ , Eye alt 2921 ft. Borders and labels; places layers. NOAA, DigitalGlobe 2013. <<http://www.google.com/earth/index.html>> (Accessed March 12, 2014)



**Figure 6** Aerial view of Bommanahalli 1 in 2002 and 2013.

**Source:** Google Earth. (April 2, 2013-left and March 3, 2002-right). Bommanahalli 1.  $12^{\circ} 48' 05.37''N$ ,  $76^{\circ} 58' 40.99''E$ , Eye alt 3214 ft. Borders and labels; places layers. NOAA, DigitalGlobe 2013. <<http://www.google.com/earth/index.html>> (Accessed March 12, 2014)

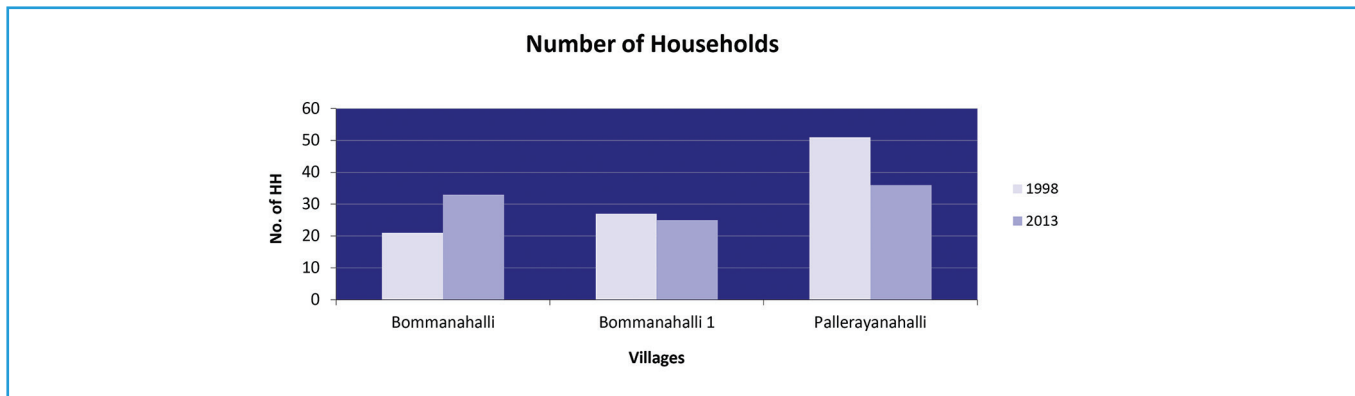


**Figure 7** Aerial view of Palarayanahalli in 2002 and 2013.

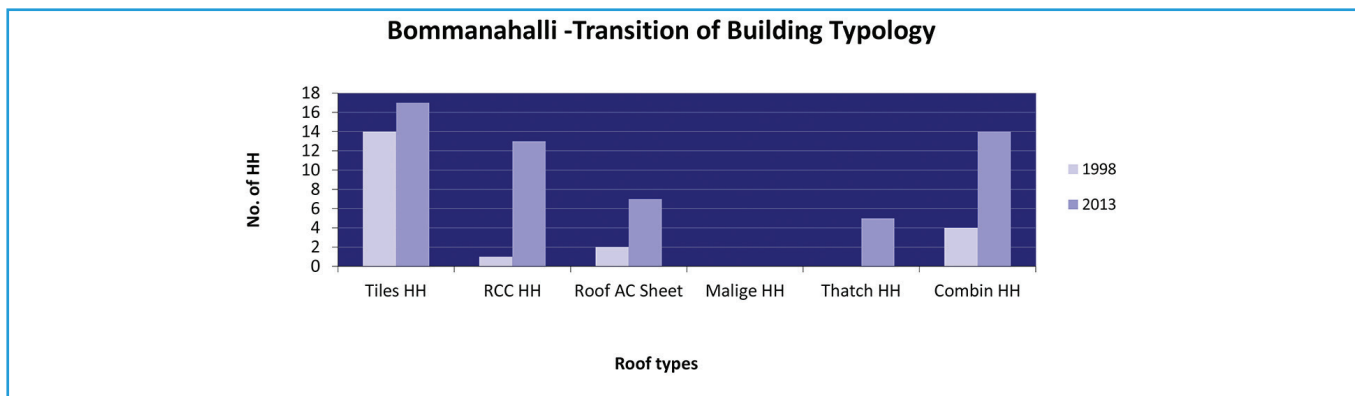
**Source:** Google Earth. (April 2, 2013-left and March 3, 2002-right). Palarayanahalli<sup>1</sup>.  $12^{\circ} 49' 09.66''N$ ,  $76^{\circ} 58' 11.99''E$ , Eye alt 3225 ft. Borders and labels; places layers. NOAA, DigitalGlobe 2013. <<http://www.google.com/earth/index.html>> (Accessed March 12, 2014)

<sup>1</sup> Palarayanahalli is used as an alternate spelling for Pallerayanahalli.

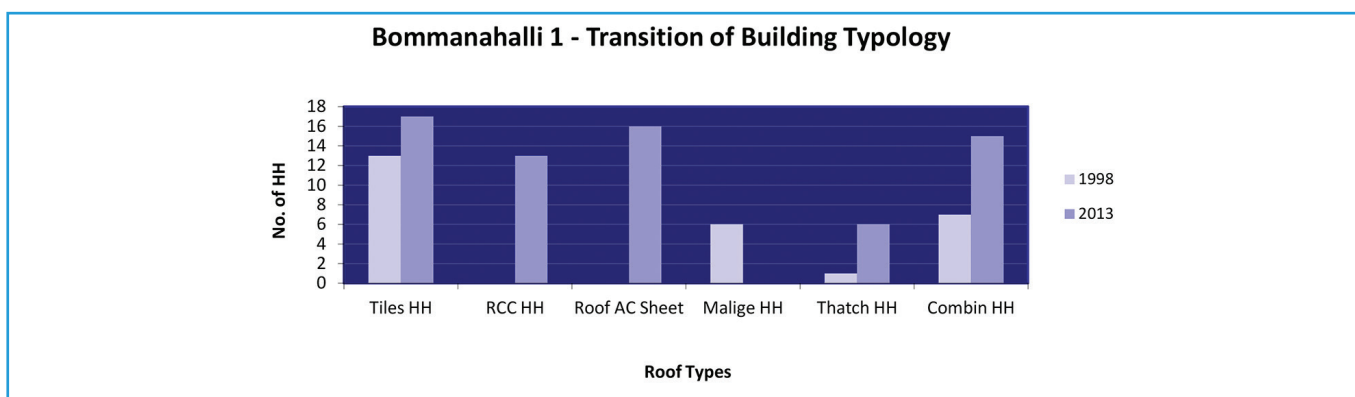




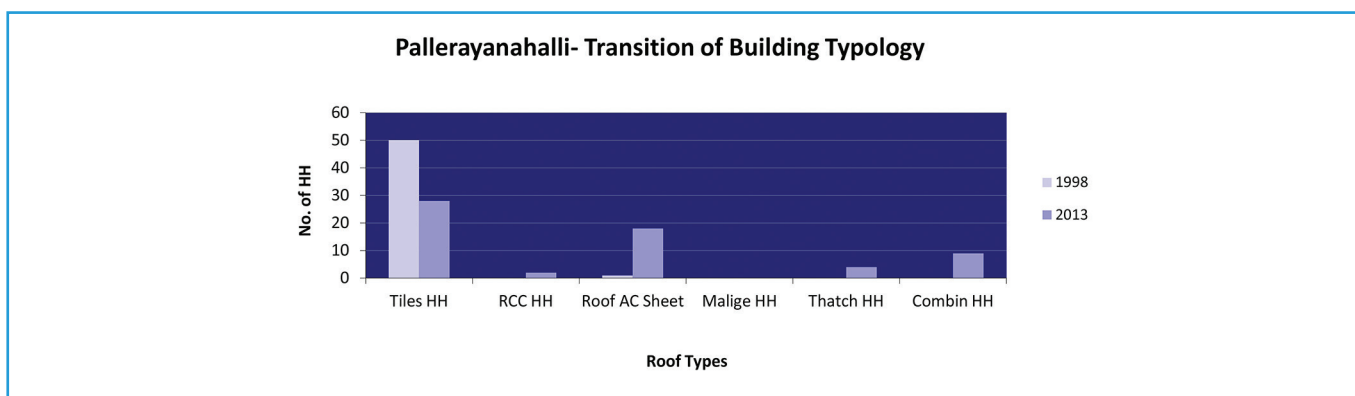
**Figure 8** Total number of households (HH) in Bommanahalli, Bommanahalli 1, and Pallerayanahalli in 1998 and 2013



**Figure 9** Roof types in Bommanahalli in 1998 and 2013<sup>2</sup>



**Figure 10** Roof types in Bommanahalli 1 in 1998 and 2013



**Figure 11** Roof types in Pallerayanahalli in 1998 and 2013

<sup>2</sup> Malige HH refers to “malige mane” in Kannada, which means house with upper story. Combin HH refers to households with combination of different roof types.

has increased. This shows an increase in the area occupied per person.

A comparison between our survey on the building typologies conducted in April 2013 and data of this area from 1998 (ASTRA, 1998) shows us that the use of Reinforced Cement Concrete (RCC) roofs is on the rise, along with Asbestos Corrugated (AC) sheets or Galvanised Iron (GI) corrugated sheets, as well as houses with a combination of old and new roof types and

materials (see Figures 9-11). In Pallerayanahalli, Mangalore clay tile (or simply 'tiled') roofs have been giving way to AC sheets.

The current composition of building materials used for roof, wall, and flooring for all the three villages together is shown in Figures 12-14. Considering further the trend of transition of roof types alone, it can be seen from Figures 9, 10, 11 and 12 that in the last 15 years, RCC and AC sheet together constitute 49% of roof types of all the households in the three

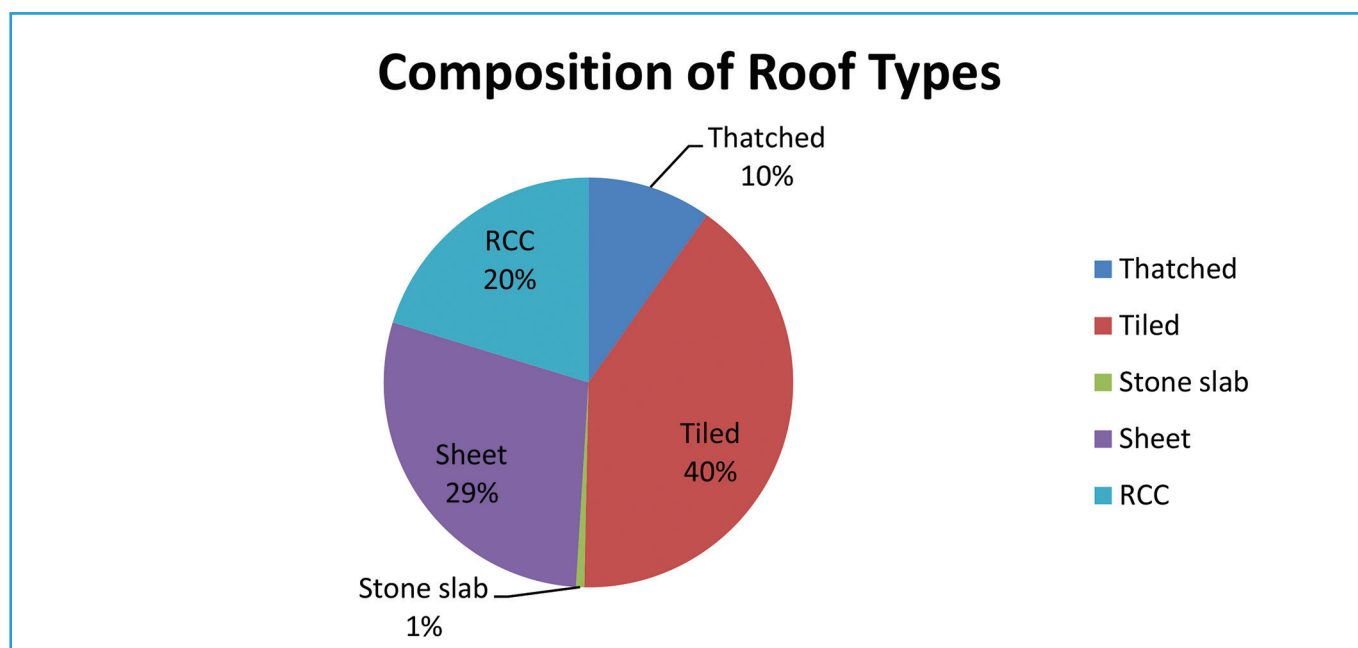


Figure 12 Composition of roof types in the villages, as of April, 2013

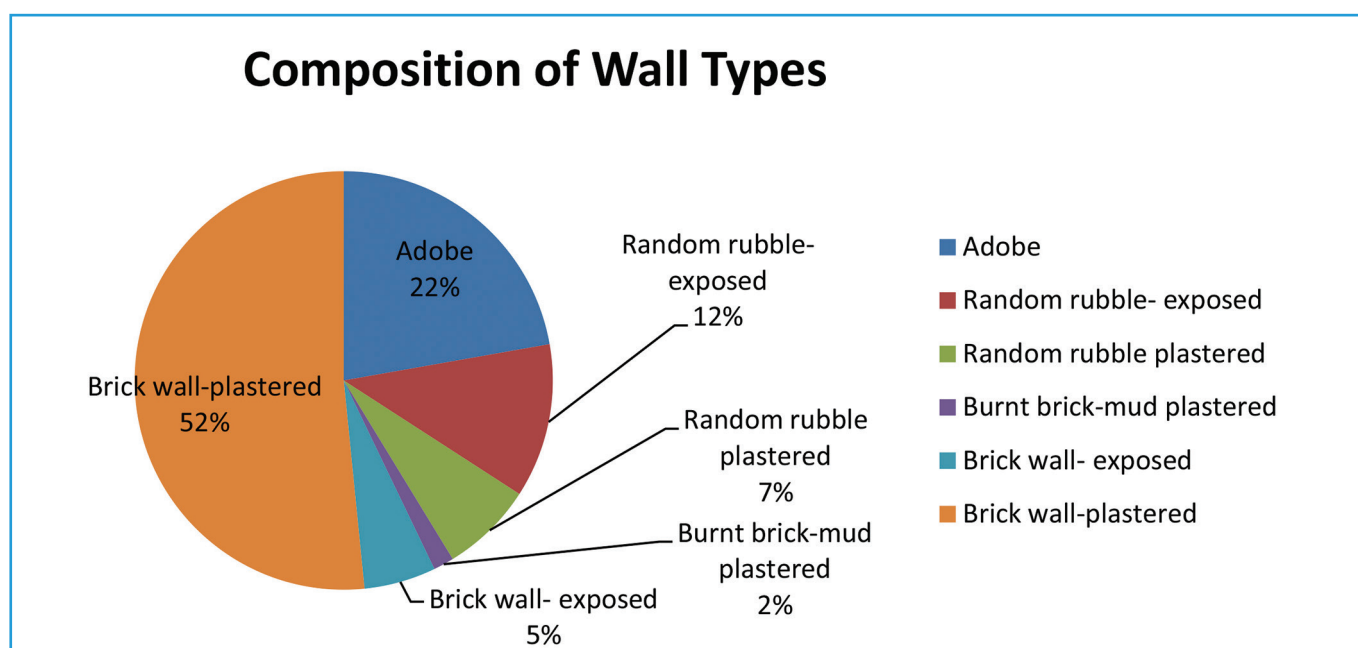
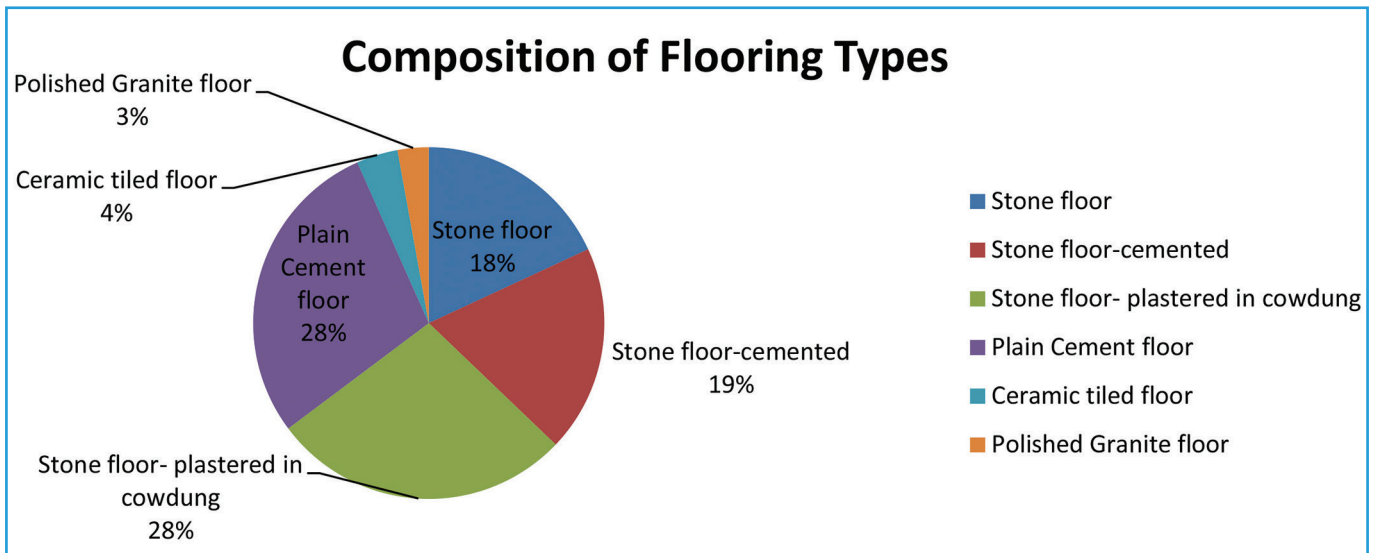
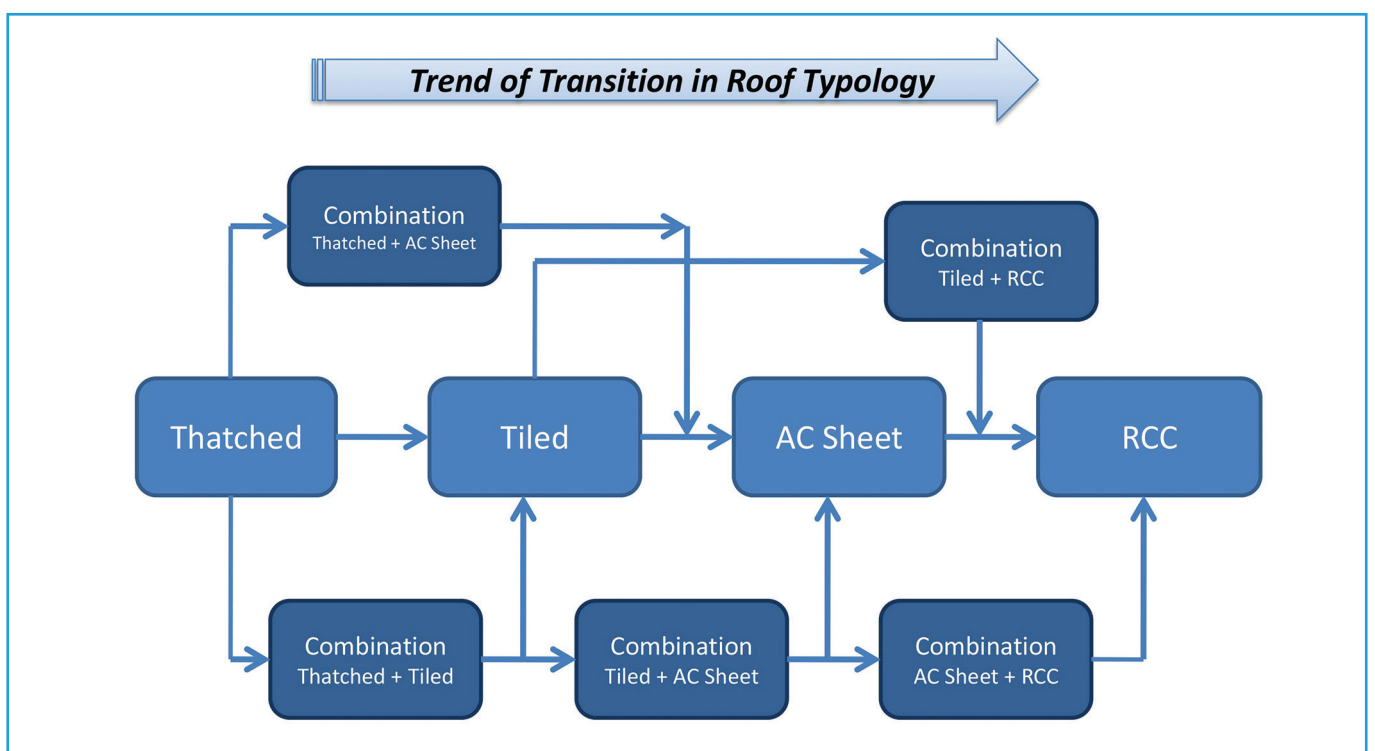


Figure 13 Composition of wall types in the villages, as of April, 2013



**Figure 14** Composition of flooring types in the villages, as of April, 2013



**Figure 15** Morphology of the observed trend of transition in roof typology in the villages

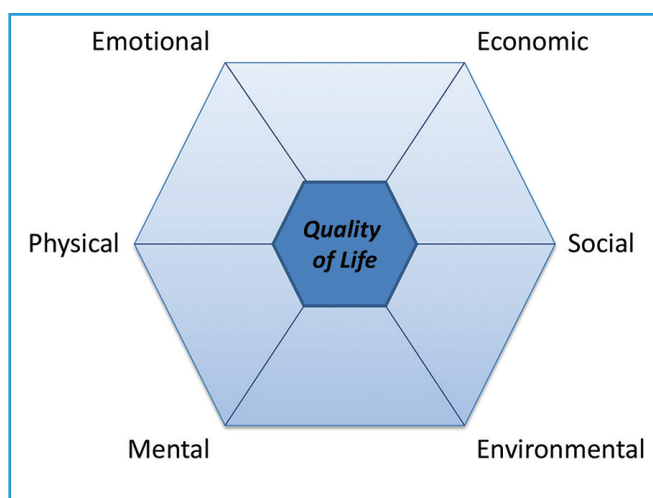
villages together. The traditional thatched roof is used in only 10% of the houses, while the population and the number of households have decreased in the last decade. This means that among the existing population, there is demand for refurbishment and preference for new building materials over traditional materials. The morphology of this transition with respect to roof types is summarised in the Figure 15. The trend in roof type preferences reflects a transition towards RCC roofs and departure from the traditional thatched roofs, with the preferences for tiled roofs

and AC sheet roofs in between. A combination of two different roof types can be seen where buildings have been partially refurbished, such as addition or modification of porches, sheds, verandahs, etc.

### 3 Well-Being, Sustainability, and Design

As the paper being on settlements, the authors refer to well-being as a concept which incorporates both individual well-being and the community's (here, community is referred to as a collection of individuals)

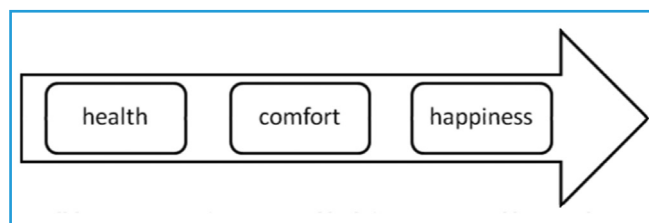
well-being, than individual well-being alone. Well-being is referred to here as one's quality of life. Quality of life is defined here as an interdependent network of individual aspects – *physical, mental and emotional*, and collective aspects of a community – *social, economic and environmental*. These six aspects can be represented as part of a hexagon, with the interconnections between the vertices together representing the quality of life (see Figure 16). Sustainable well-being will then be that quality of life which can continue to survive and remain in the long term for the future generations by the resources available on our planet.



**Figure 16** Well-being as quality of life

In relation to sustainable design and building, Steemers (2009, p.174), defines well-being of people in terms of “health, comfort and happiness as lying on a well-being spectrum from the directly measurable (e.g., symptoms, body temperature, blood chemistry etc.) to the unmeasurable (quality, delight etc.)” (see Figure 17). It can be said that these are the individual aspects – *physical, mental and emotional*, of well-being. BOOM-Duijvestein, (2009) situates quality of life as one part of sustainability. Duijvestein (2009) explains that quality of life focuses on the here and now, while sustainability is also about the later (see Figure 18). Duijvestein (2009), emphasizes the necessity to broaden the sustainable building and adds design to the sustainability triangle of *People* (society), *Planet* (environment) and *Prosperity* (economy). The fourth design-centred dimension, *Project*, forms the tetrahedron of sustainable building, as shown

in Figure 17 (BOOM-Duijvestein, 2009; Steemers, 2009). With respect to our well-being model (Figure 17), Duijvestein brings in the collective aspects of well-being – *social, economic, and environmental*. Both Steemers and Duijvestein link the role of design to well-being and sustainability with respect to architectural design.



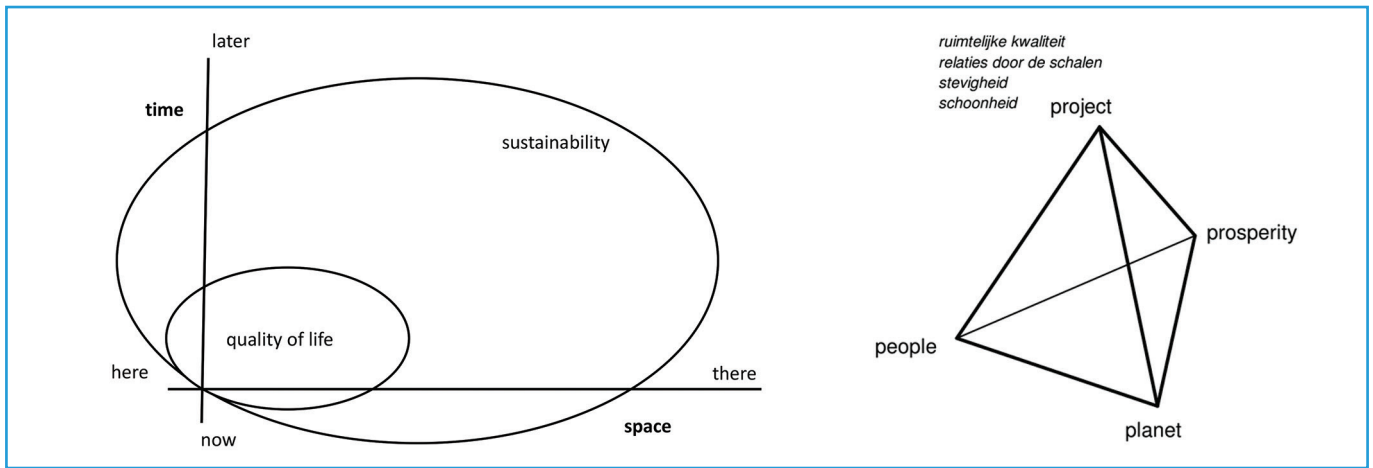
**Figure 17** Well-being spectrum from measurable (left) to unmeasurable or qualitative (right)

**Source:** Steemers (2009)

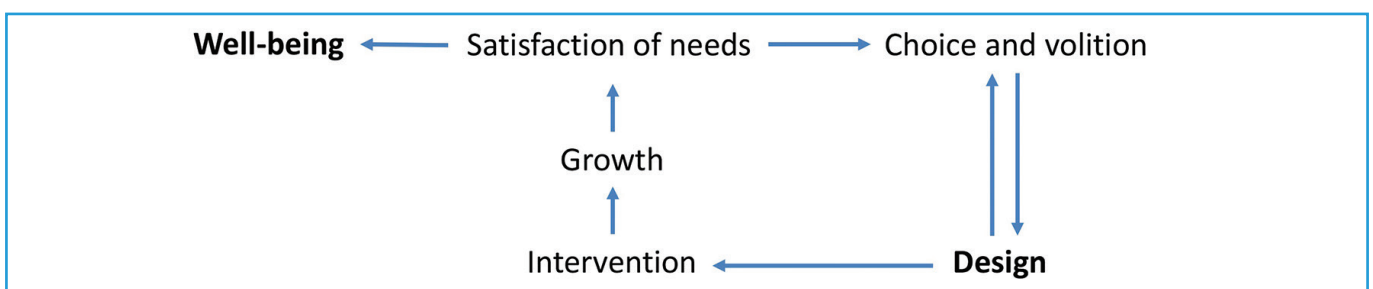
Raibley (2012, p.1122) explains that well-being as agential flourishing, is closely related to a postulate of Ryan and Deci's self-determination theory, viz.,

“well-being is an outcome characteristically promoted by the **satisfaction of needs for competence** (the propensity to have an effect on the environment and attain valued outcomes within it), **autonomy** (the propensity to self-organize experience and behaviour and to have activity be concordant with one's integrated sense of self), and **relatedness** (the propensity to feel connected to others in loving and caring relationships) (Deci and Ryan 2000, p. 231; cf. also Ryan et al. 2008, Sheldon 2004). Ryan and Deci further hypothesize that individuals are naturally oriented towards the satisfaction of these needs, as well as toward “**growth**” and the “integration of their psychic elements into a unified sense of self and **integration of themselves into larger social structures**” (p. 229). These are among the values that are universal because “**built into human nature**” (2008, p. 148). When individuals pursue goals that intrinsically involve the **satisfaction of such** needs (“intrinsic goals”), their behaviour will be characterized **by choice** and volition and the





**Figure 18** Quality of life as part of sustainability (left). The tetrahedron of sustainable building (right)  
**Source:** BOOM-Duijvestein (2009). (Figure at left translated and redrawn by author)



**Figure 19** Design leading to well-being

result will be high levels of life satisfaction, psychological health, self-actualization, self-esteem, ego development, and other indicators of well-being (2000, p. 241)”

From the above literature, it can be seen that ‘satisfaction of needs’ is a driving force for growth. Growth requires an ‘intervention’ to ‘change the current situation’. An intervention, in the form of human-made (or altered) objects, or services, leads to growth which leads to satisfaction of needs. The authors call this human-intervention as design, and it is thus a design intervention which leads to growth, satisfaction of needs, and hence well-being (see Figure 19). The universality of the human nature’s need for integration into larger social structures is to be noted here as one of importance with this case study being on a rural settlement. From the data presented in this case study, it was observed that people are choosing more durable materials, which require less maintenance. Is durable design an indicator of sustainable design? Duijvestein (2009)

gives an example: “Preserving wood makes the wood by impregnation with copper arsenic compounds especially durable but definitely not sustainable”. Wood waste treated with copper-arsenic compounds (CCA) has been classified as hazardous waste in the United Kingdom, by the Department for the Environment, Food and Rural Affairs (DEFRA 2012, WRAP 2012). Hence, sustainable design should aim at the sustainable well-being of the people. And, the authors define here *design for sustainable well-being* as that design which can provide *sustainable well-being*, which is *quality of life* in the long term for the future generations by the resources available on our planet.

#### 4 Choice of Building Materials

The data presented in Section 2 reveals that the preferences of people have been changing from traditional practices to new practices. However, it will be interesting to determine answers to the following questions:

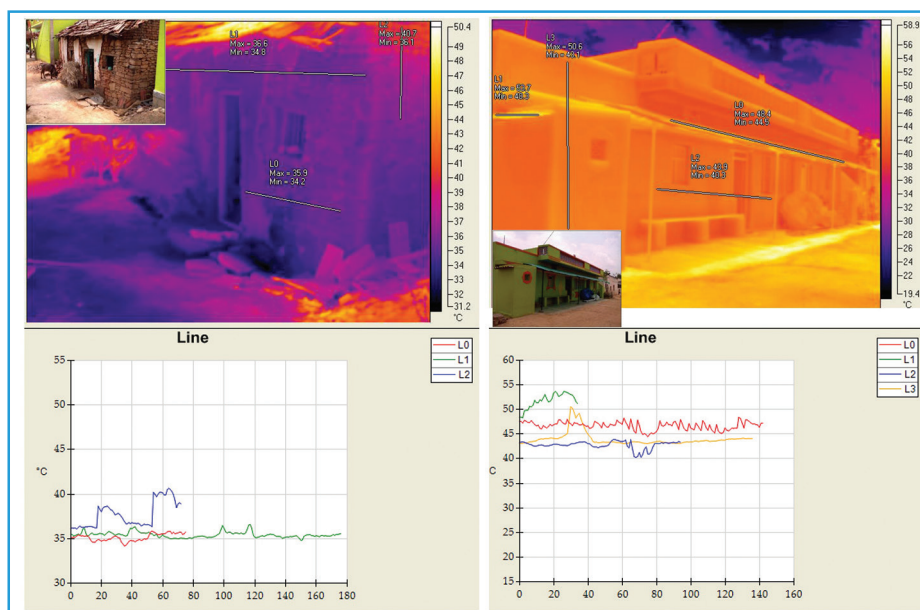
- Is this change a preferred one or an induced one?
- If a preferred one, is it giving comfort, satisfaction, and hence improved well-being?
- If it is an induced one, is it improving their well-being?
- Is this change environmentally sustainable?

The above points and the transitions observed in the case study villages will be discussed and analysed in this section from the perspective of well-being and sustainability.

The district of Tumkur has an average maximum temperature of 34°C and an average minimum temperature of 12°C (MSME, 2012). To see if the preferences for new materials are adding to thermal comfort, the infrared (IR) thermography imaging technique was adopted to evaluate the surface temperatures of the building envelope. The IR system used was FLUKE TiR 32 IR Fusion Technology. Here, two houses – one traditional construction (RR masonry walls and tiled roof) and one new construction (brick masonry, plastered and painted walls, and RCC roof) – were compared (see Figure 20). The results show that the traditional construction's wall temperatures had a maximum and minimum of 35.9 and 34.2°C, respectively, and the newer construction had

maximum and minimum temperatures of 43.9 and 40.3°C. The difference in external wall surface temperature is around 8°C. A similar study conducted in the village of Sugganahalli, located in the same Taluk of Kunigal, found that the indoor temperatures increase by 7 to 10°C in the summer months in modern constructions (Shastry et al., 2012). The choice of surface paint colours in the newer constructions is found to vary the surface temperatures by 2 to 3°C (see Figure 21).

If the newer constructions provide less occupant comfort and hence less satisfaction and well-being, it would be interesting to know if this choice was a preferred or an induced one and what other factors contributed to this choice. Interviews with local people were undertaken to understand this. Five local people from each of the three villages were interviewed. The interviewees work in agricultural fields and are more than 50 years in age. The choice of new type of construction was based on resources available in the nearby town of Hulyadurga (10 km away from the villages), the availability and affordability of 3-wheeler and 4-wheeler small-sized goods and passenger vehicles for transportation of construction workers and material, and less effort required in construction by use of ready-to-use materials, e.g., asbestos and GI corrugated roofing sheets, steel channels and pipes.



**Figure 20** Infrared thermography images of a traditional and a newer construction. Image on right: ~north facing, 11 April 2013, 12.04PM. Image on left: ~east facing, 11 April 2013, 01.32PM

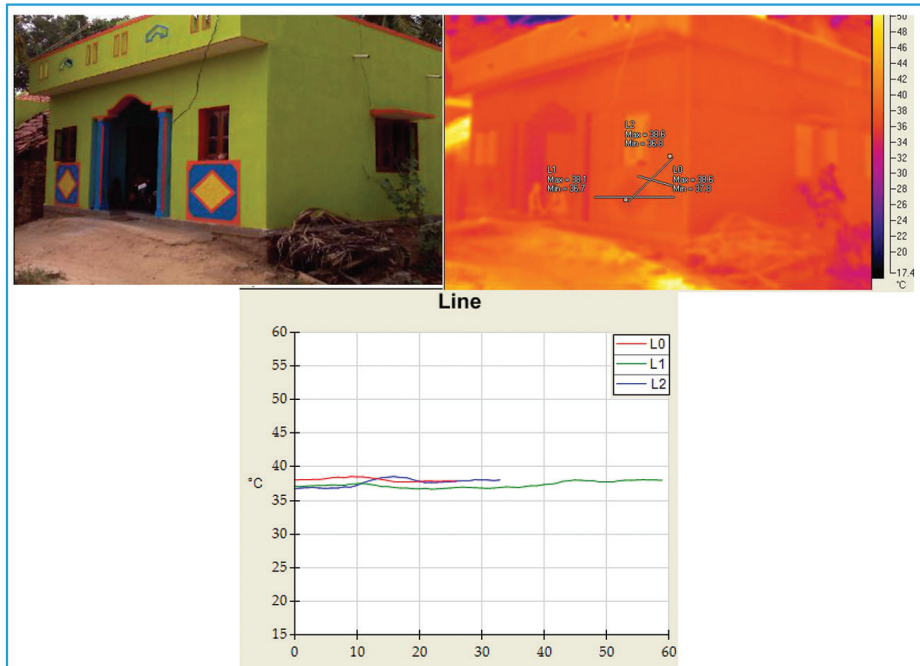


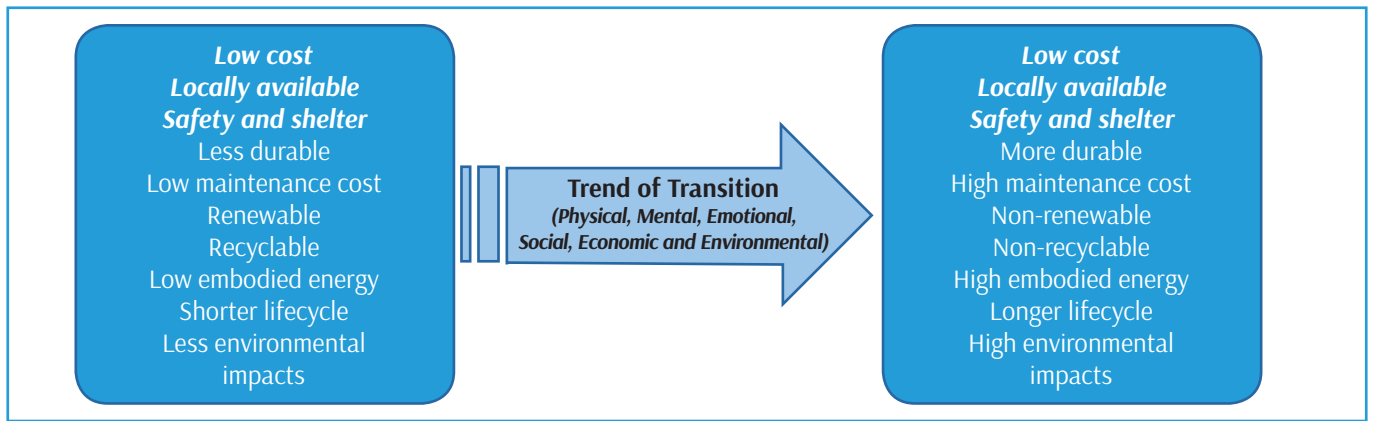
Figure 21 Variation of surface temperature by wall colour.

Most of the people aspire to build new houses, especially houses with RCC roofs. The aspiration and motivation for having a modern-style house comes from seeing neighbours' new houses or new constructions in and around the villages. Those who cannot afford a new house opt for partial refurbishment of their existing houses. When adobe/RR masonry walls deteriorate, the homeowners often replace them with brick masonry walls. Old walls are plastered with cement mortar to avoid erosion. People also wish to have similar kinds of exterior paints as their neighbours' homes, in vibrant shades of yellow, green, blue etc. When roof tiles break, maintenance-free AC/GI sheet roofing will be used to replace existing tile roofs. Local vendors offer several-day payment period for materials purchased, which makes this construction easier to manage financially. People do not consider spatial configurations, the orientation of houses, or plot coverage. They wish to live without any worries, in safe and maintenance-free houses. A small percentage of people (mostly the influential persons in society) wish to show off their wealth and richness with their buildings.

The skilled masons who carry out the traditional RR masonry and adobe constructions are available in and around the villages. Most of them do not prefer

practicing their traditional skills in construction. Instead, they work as masons in modern construction sites, where they earn daily wages of ~250 to 500 INR.

Hence, it can be seen that people choose modern materials for social, economic, and emotional reasons. How these choices affect the buildings' thermal comfort or environment is not a consideration for them when planning new construction or refurbishment. If one considers only the environmental aspects of roofs, aluminium and concrete have higher embodied energy values as opposed to straw/bamboo (aluminium = 227 MJ/m<sup>3</sup>, concrete = 1.30 MJ/m<sup>3</sup>, straw bale = 0.24 MJ/m<sup>3</sup>) (DPTI 2012). Based on the interviews and data, the aspects leading to people's choices and the induced aspects due to those choices can be summarised in the trend of transition diagram presented in Figure 22. It can be seen that the common factors here are *low cost*, *locally available* (materials and labour), and *safety and shelter*. Is this trend leading to sustainable well-being of the individual and the villages? Looking back at Figure 19, the choices people make reflect in the design and in the satisfaction of needs, leading to well-being. Here, the choices, hence design, is leading to growth and satisfaction of needs, and hence some dimension



**Figure 22** Trend of transition in roof typology from thatched roof (left) to RCC/AC sheet roof (right)

of well-being (emotional, social, economic) will be achieved. However, not all the dimensions of well-being will be achieved. Is well-being then important to the people who are making the choices?

Scanlon (as cited in Rodogno, 2008, p.198) claims “well-being is important in the thinking of a benefactor and in moral argument because of its importance for the individual whose well-being it is”. Scanlon’s (as cited in Rodogno, 2008, p.199) claims on whether well-being is important to the individual whose well-being it is, are:

“(a) It sounds absurd to say that individuals have no reason to be concerned with their own well-being, [(b)] because this seems to imply that they have no reason to be concerned with those things that make their lives go better. [(c)] Clearly they do have reason to be concerned with these things. [(d)] But in regard to their own lives they have little need to use the concept of well-being itself, either in giving justifications or in drawing distinctions... The concept of one’s overall well-being does not play as important a role as it is generally thought to do in the practical thinking of a rational individual.”

It can be argued that incompleteness in achieving overall well-being aspects is due to the unidentified needs of people that should be satisfied, and which must be reflected in their choices, and hence in design interventions. Here, people are not completely aware of their needs, and do not identify what those needs

are which can satisfy them, which when met by design interventions, can satisfy them and continue to satisfy them, not only those needs, but all the needs which leads to well-being. Hence, a design should take into consideration not just the immediate requirement for satisfaction, but a holistic understanding of what the person’s needs are and his other needs are, so that it does not conflict with each other.

Rodogno (2008, p. 198) supports Scanlon’s claim that “concern for well-being is important in moral argument because well-being is indeed important to the person whose well-being it is as the basis for those rational decisions in which she alone is concerned.” From the case study presented, it can be concluded that well-being is important to the person. However, not only do people have unidentified needs, but they are also unaware of what leads to their overall well-being and to the collective well-being of the community. Hence, designers have an important role to play in society, as they have an understanding of the holistic needs of both the individual and the community. Designers therefore need to think in two scales, one at an individual level (people), and two at a collective community level (people-people interaction). The next section will discuss how the community design aspects can play a role in individual as well as collective well-being.

## 5 Shift in Lifestyle

Section 3 showed how changes in lifestyle, affordance, and aspirations are inducing changes in architecture and building typologies. This section



will discuss how the changes in architecture are inducing a shift in lifestyle. Examples of some design elements are taken from the vernacular and the modern houses to demonstrate this.

*Transition Spaces Vs Compound Walls:* The villages studied are very close communities – everyone knows everyone else. Interactions happen at houses, common spaces for work and recreation, religious places, and farmlands. Transition spaces (semi-private spaces) outside houses act as places to carry out work, play, and sit and chat with neighbours (see Figure 23). The transition space is usually a verandah, or a knee-high platform shaded by the eaves of the roof. It acts as a shaded space for people in the house, as a resting place for people going in the street, and also as a shed for cattle. It also functions as a place for spreading and drying crops. In the evenings, women sit and chat, and children sit and play. At night it acts as open sleeping spaces during summer months. The houses constructed in the new architectural style adopted from cities are barricaded with 1.5 m high plastered and painted brick walls. Compound walls in cities have multiple functions, including providing security against theft, marking plot boundaries, providing barriers to noise

from traffic and visual barriers from strangers in the streets. In a village settlement like the one in Ungra, no one is a stranger to anyone.

*Cattle Sheds Vs Parking Spaces:* Cattle and livestock were traditionally more integrated with humans and treated equally. In the traditional houses, sheds for cattle are integrated with the houses, where they are fed. In the new houses with RCC roofs, these sheds have been replaced by parking spaces (see Figure 23d and 24). Some of them have been turned into RCC-roofed verandahs (inside the compound walls), which are not used in the same ways as the ones in traditional houses, but are more private. Even though no one owns a car, most new constructions have parking space for cars and motorbikes. Cattle are treated more like agricultural equipment and are left outside the compound, even though the modern verandah space is empty most of the time.

*Passive Design Vs Active Design:* Traditional houses have lower indoor temperatures than modern houses (Shastry et al., 2012). Occupants require no active ventilation, even in summer, although houses have ceiling fans. In the RCC houses, the lack of continuous power supply causes discomfort due to



Figure 23 Semi-private spaces





**Figure 24** Modern-style houses

the building design demanding power to function well indoors. The use of electrical appliances like fans, air coolers, and refrigerators is on the rise, even though the villages have access to only six hours of electricity per day.

## 6 Need for a Sustainable Rural Design

This case study of the villages has shown how buildings can shape the way people live and interact with their environment. The role played by people's aspirations to match an urban lifestyle is important here. It is important to satisfy people's needs, and at the same time, it is also important to provide a sustainable way of living for their well-being. Understanding current lifestyle is important, rather than imposing a new alien lifestyle. For example, in Figure 24c, a woman is washing kitchen utensils in a newly constructed house's verandah, in the manner this is usually done in the transition spaces of traditional houses. Reduced social interaction will also lead to people finding other modes of entertainment, such as watching television, as most of the houses own a DTH (Direct-To-Home) connection. Design should

enhance people's standard of living by providing long lasting comfortable buildings, and allied infrastructures and spaces as what their lifestyle and work demand. Not only is that attention to building design important, but also to consider design at street level and village level. A design solution which can work at both people-scale and village-scale is required. The concept of urban design (the process of designing and shaping cities) as a domain has been existing for quite a while for shaping cityscapes. However, there has not been an equivalent for rural settlements. Even though the term urban design can be lent for rural settlements, the word 'urban' in the term could mislead people to think that our final objective is to urbanise. Replacing 'urban' with 'rural' will give a new term, 'rural design', to help explain better what the authors are proposing. Rural design would hence be designing of rural streetscapes, common spaces, open spaces, public spaces and its spatial configuration and massing of the settlement as a whole. The term 'rural design' has been used by Thorbeck (2010) as a new research discipline dealing with rural issues, with their work focussing on rural areas in North America.



**Figure 25** Interaction spaces and activities

The need for a sustainable rural design is important in the context of villages undergoing transition in India. The spending capacity of rural households in India has been increasing, as more than 70% of the total income of migrants from villages working in cities is remitted to their homes (NSSO, 2012). With respect to the area investigated in this case study, an industrial estate is proposed in Tumkur District (MSME, 2012), and further urbanization trends in rural lifestyles can be expected. The rural power consumption has doubled between 2008 and 2011 in the areas around Bangalore, and farmers started running irrigation pump sets even during the night hours when the power supply increased (Bescom, 2011). With respect to ground water, 16% of the area of Kunigal Taluk and 55% of the area of Tumkur District are over exploited (MWR, 2008). Sustainable solutions are needed to meet the demands of the rural areas. The following design considerations can be taken into account for sustainable rural design.

*Public spaces and market squares:* The common spaces in villages where people interact are places where people perform their activities like washing clothes and kitchen utensils near water-sources,

and feeding cattle. Places near local stores where people meet and chat, and open spaces near trees at temples where children play, act as public spaces (see Figure 25). While these are unplanned public spaces, designed public spaces (like playgrounds for children) can make these places rich in character, improve people's outdoor experiences, and encourage interaction in the community. Designing small market squares allows businesses to prosper, considering their increasing purchasing power. It can drive the local economy with small cafes, eateries, and shops. Sustainable rural design should be design for rural public spaces and activities, understanding the rural lifestyle typical in each village.

*Movement:* With increased rural income and with the prevalence of new houses in villages with parking spaces, the entry of cars and other personal vehicles into the rural settlements can be anticipated. Care needs to be taken to avoid mistakes made by planners in cities. Cycling-friendly streets should be designed to promote cycling within villages and to nearby villages. Providing resting places on streets (like street-side benches) will encourage walking as





**Figure 26** Waste in gutters and streets

a means of transport. Improving public transport to nearby towns will improve accessibility and reduce the need to own personal vehicles.

*Trees and landscapes:* While temple trees act as meeting places with the platform they provide for sitting, more trees could be planted to provide adequate shade and sun-protection for people and cattle. Designing open spaces, with trees as a meeting and resting place, will improve social interaction among people in the village.

*Waste management:* The traditional practice of handling waste was to feed kitchen waste to cattle, and to use agricultural waste like straw for roofing and fencing. Now, with the entry of plastics through packaged consumables available in local stores, waste is thrown into empty plots along with other organic bio-degradable waste like fallen palm leaves. It is eventually burnt in the open, leading to pollution (see Figure 26). Excreta of animals were traditionally used as manure, but are now thrown into open drains. Sewage in open drains breeds mosquitos and leads to the spread of other infectious diseases. Waste segregation and disposal practices at the household level should be promoted. Policies and infrastructure needed for the treatment of sewage and other waste should be built.

*Educating design practitioners on environmental design:* Modern concrete dwellings are designed by engineers who are not trained in environmental design or architectural design. Traditional masons are not formally educated in architectural design, but practice based on knowledge passed on through

generations. Educating the traditional masons about modern building design constructions will help them use modern materials innovatively using their traditional knowledge. Engineers who practice must have knowledge in vernacular architecture and understand environmental design considerations. Current construction practices emphasise for standardised design with little concern for the local climate and environment. Local administration could register the masons with them and provide a forum for learning from and meeting with engineers, and vice versa. Local administration can empower the masons by providing them with other work when there is no construction activity in the village, or help city architects use the masons' knowledge, providing work for them in the city during the off-season. Co-ordinating masons and engineers will help produce designs that can be constructed using traditional materials in a modern way so that vernacular buildings can be made more durable to satisfy the needs of the people.

*Promoting the use of renewable resources:* Policy decisions are needed to promote the use of renewable resources by design practitioners. Efficient use of local materials and technology can be achieved by newly trained practitioners who are a team of masons and engineers. The concrete dwellings might be more affordable, as resources are available to purchase locally. However, moving away from vernacular construction to concrete dwellings completely will make building houses less affordable to the villagers in the future. The construction industry has already started facing a shortage of skilled workers by a figure of 40%, and

the prices of cement, steel rods, bricks, and other input material have steadily increased by over 30% since 2009 (Assocham, 2011). It is important to preserve and document the knowledge of traditional masons and to encourage them to practice in the new rural environment. Ironically, the ministry of steel is lacking long-term vision and is promoting the use of steel in rural areas. Their plan involves – “Promoting, developing and propagating the proper and effective use of steel and increasing the intensity of steel usage, particularly in the construction sector in rural and semi urban areas” (MoS, 2009, p.20).

*Community awareness and participation in rural design:* Awareness on sustainable living and the environmental impacts of modern construction materials could be imparted to the villagers. It is important to interact with them and understand their needs in order to create sustainable design.

## 7 Conclusions

Well-being is often not understood by people as to what is good for them. This reflects in their choices and eventually in the designs they adapt. With respect to building architecture and rural design, planners have an opportunity to design for rural settlements from a clear slate. It is an opportunity to undo the mistakes made by planners in cities. The well-being of people should be considered in design through educated analysis, rather than well-being as perceived by people themselves. Design practitioners should educate the people by showing them the problems associated with their choices, by involving them in the design process, and by discussing their needs and understanding their lifestyles. The government should intervene by making policies to promote sustainable development and growth in rural areas, and not just economic growth and income. Change is constant, and changes in building design styles and practices have been happening over centuries. Modern architecture takes no inspiration from vernacular; an approach where both vernacular and modern architecture take inspirations from

each other is what is required for design in transition. This will require creative designers, to break the mould of classifications and typologies, and design buildings for the climate that draw on the strengths of both the vernacular and the modern. Community participation, responsible designing, knowledge and awareness of people, designers, local administrators and policy makers on sustainable growth and development, are all key for the sustainable well-being of a community.

## Acknowledgements

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paper

18

Designing for People's Well-being:  
The Case of an Office Building in Australia

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## Abstract:

Modern offices are traditionally associated with air-conditioning systems; however, concerns about improving environmental performance in buildings have recently led to the integration of natural ventilation and the creation of hybrid systems, called mixed-mode systems. While air conditioning conforms to the concept of 'steady state' conditions of thermal comfort, mixed-mode systems allow for variations associated with external thermal conditions, in order to improve indoor air quality and people's thermal comfort. This study aimed to understand people's behaviours and perceptions in a multifunctional office space designed with ecological principles. The National Australia Bank (NAB) building in Melbourne Docklands was conceived with a mixed-mode north façade that allows occupants to exercise adaptive strategies, including choosing between air conditioning and natural ventilation. This paper explores how design can improve the well-being of people and, in particular, how office design can reflect people's needs, especially concerning natural ventilation.

**Keywords:** *sustainability, mixed-mode systems, adaptive thermal comfort, environmental psychology.*

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## 1 Introduction

Buildings play an important role in shaping the physical space in which office activities take place and people's well-being can be enhanced. Moreover, society is evolving towards new models of living, in which comfort assumes both physical and psychological meanings. Space efficiency and people's comfort and well-being are very important points of reference in modern offices.

Interdisciplinary studies support the importance of people's perceptions about their physical environments and the role that buildings play in affecting people's behaviour and well-being. These parameters act synergistically for both the office space and its climatic conditions. Well-being is a 'combination of feeling good and functioning effectively' (Huppert, 2009). It has both physical

and psychological dimensions that involve the development of one's potential, having some control over one's life, and experiencing positive relationships (Huppert, 2009). According to the World Health Organization (WHO), health is related to physical, mental, and social well-being (World Health Organization, 1948). More recently, this definition was deepened to define health as a state of well-being in which people can realize their own abilities, cope with the stresses of life, work productively, and contribute to the social life of their communities (World Health Organization, 2001). Therefore, well-being is more than just the absence of ill-being, but includes people's perceptions, thoughts and behaviours (Huppert, 2009).

Space efficiency and thermal efficiency are both aspects of efficiency that contribute to people's thermal comfort and well-being. Understanding

the simple physical aspect alone is not enough to understand the relationship between people and space. The term 'alliesthesia' refers to a neurophysiological approach to thermal comfort which suggests that the phenomena of pleasantness and unpleasantness (each induced by a stimulus) depend not only on physiological responses but also on the subject's internal state highlighting the difference between thermal sensation and thermal perception (de Dear, 2009). Given a specific climatic condition in a space, people react both physically, experiencing certain sensations, and psychologically as a result of their perceptions and their behaviour. Comfortable conditions are created when both parameters are addressed. As Leaman & Bordass (2000) and (more generally) World Health Organization (1948) have previously suggested, de Dear (2009) argues that people need to control their environments. They need to create their own 'comfort state', possibly in spaces that specifically allow this to happen. Therefore, designing buildings with people's needs in mind results in environments that enable adaptive strategies and people's well-being.

The present standards for people's thermal comfort in offices are based on laboratory experiments conducted by the engineer Fanger in the 1960s. These experiments led to the creation of Standard 55 by the American Society of Heating Refrigerating, and Air-Conditioning (ASHRAE) and Standard ISO 7730 by the International Organization for Standardization (ISO 7730) (2005). The resulting mathematical model derived from what is called the heat balance theory, which considers six major environmental parameters of air: radiant temperature, humidity, air velocity, radiation, and the two personal parameters of clothing insulation and activity. The comfort equation used includes a combination of all these parameters, and it is translated into the Predicted Mean Vote (PMV), which predicts the heat balance and the sensations experienced by people in a controlled thermal environment. While this model mostly worked for air-conditioned office spaces, it is not effective when natural ventilation is integrated into the system, as in mixed-mode environments

where people can exercise control and determine their own comfort.

The 'mixed-mode' environment allows for variations associated with external thermal conditions, in order to improve indoor air quality and people's thermal comfort and well-being. In these office buildings, the roles and experiences of occupants have become central; this also relates to the new modern office design principles of interaction, collaboration, and communication. From this perspective, people's adaptive thermal behaviour is central, and it affects the thermal environment. This constitutes the core idea of the adaptive thermal comfort theory, which has been developed by researchers like Humphreys and Nicol (1998), Auliciems and Szokolay (1997), de Dear (2004), de Dear and Brager (1998), Brager (2006) and Baker (1996). Central to this notion is the idea that people are influenced by the environments they find themselves in and that they interact and modify these environments, creating satisfactory thermal spaces through these interventions. While people were previously considered passive recipients of thermal conditions, with the development of the adaptive thermal comfort theory, they became seen as active participants that effect their thermal environments. Based on this theory, researchers conduct their investigations not in laboratories but in field studies, observing people in real situations and everyday life.

This study has been conducted within the framework of adaptive thermal comfort theory and its application in modern offices, through fieldwork at the National Australia Bank (NAB) building located in Melbourne Docklands. The entire north façade of the NAB building has been designed with a mixed-mode space, so that occupants entering those areas would be able to choose to switch the system from air conditioning to natural ventilation, open the windows, and exercise their adaptive strategies to enhance their sense of well-being. This research considered not only the thermal conditions of the occupants in the mixed-mode space, but also the behavioural adjustments people performed within it, demonstrating the importance of mixed-mode

space within an air-conditioned office. At present, this is the only study conducted in a mixed-mode environment within an air-conditioned office that focuses on understanding people's perceptions and behaviour relating to their comfort and well-being. It demonstrates that a well-designed mixed-mode environment satisfies its occupants and enhances their sense of well-being.

## 2 Background

The thermal comfort standard has changed very little since 1966, when ASHRAE's Standard 55 was released. Amendments to the standard were proposed by de Dear and accepted in 2004. He believed in the importance of thermal perception, in which 'factors beyond fundamental physics and physiology play an important role in building occupants' expectations and thermal preferences' (de Dear and Brager, 2002). While the engineering 'heat balance' approach can account for people's behavioural adaptations (like changing clothing) to some extent, it does not consider the psychological aspects of adaptation that are especially important when people can interact with the environment, as occurs in a mixed-mode building where the air-conditioning system co-exists with natural ventilation. In this case, the thermal experience is altered by people's expectations, their thermal sensations, and their sense of satisfaction (de Dear and Brager, 2002).

Due to the application of standard 55 for office environments in every climatic situation, people still expect constant thermal conditions. However, because of mixed-mode systems, they are able to exercise more control over their environments. Furthermore, user control is enhanced by modern offices conceived as 'Clubs' in which interaction, collaboration, and communication occur. Offices have become places where knowledge workers are a dynamic component of their environment, influencing it and co-creating its response to their thermal needs (Duffy, 1999). This less-controlled office environment requires less-controlled systems: it is not based on the use of air conditioning to

assure constant climatic conditions, but rather, for example, on the introduction of a mixed-mode system that enables occupants to interact with their environment, choosing between air conditioning and natural ventilation, or the possibility of opening a window. Modern collaborative offices where users' control has become of primary importance follow the adaptive thermal comfort theory, which is based on occupants exercising their 'perceptual relativity', that is, the cognitive and emotional context of person-environment interaction (de Dear, 2004).

The current definition of thermal comfort accepted by ASHRAE and ISO refers to comfort as the condition of the mind that expresses satisfaction with the thermal environment (American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), 2004; ISO, 2005). This definition embraces many concepts such as the mind, the thermal environment, and the idea of satisfaction. It refers to a person's physiological reaction to their physical environment, but also to the psychological impact of that same environment. The idea that the mind is the intermediary between the environment and the person implies different layers of perceptions that are not only physical. Furthermore, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) (2009) Handbook refers to people's behaviour as the ways in which people find comfort through their own actions and interactions with the environment in order to reduce discomfort. Physiological reactions constitute the basis of the deterministic definition of the standard, while the psychological behavioural responses are merely implied in the same standard. The ways people react to their surroundings in order to find comfortable situations, called 'behavioural thermoregulation', also form part of the essence of people's well-being.

Previous research has examined mixed-mode environments by either comparing naturally ventilated with air-conditioned environments, or analysing mixed-mode buildings in a concurrent manner. These studies found that mixed-mode environments were preferred over both air-



conditioned and naturally ventilated spaces. To date, no research has focused specifically on attempting to understand occupants' thermoregulatory behaviours in a changeover multifunctional mixed-mode environment within an air-conditioned office, as this study has done at the National Australia Bank (NAB) building in Melbourne Docklands. At present, this is the only research that has been undertaken in these particular conditions.

### 3 Methodology

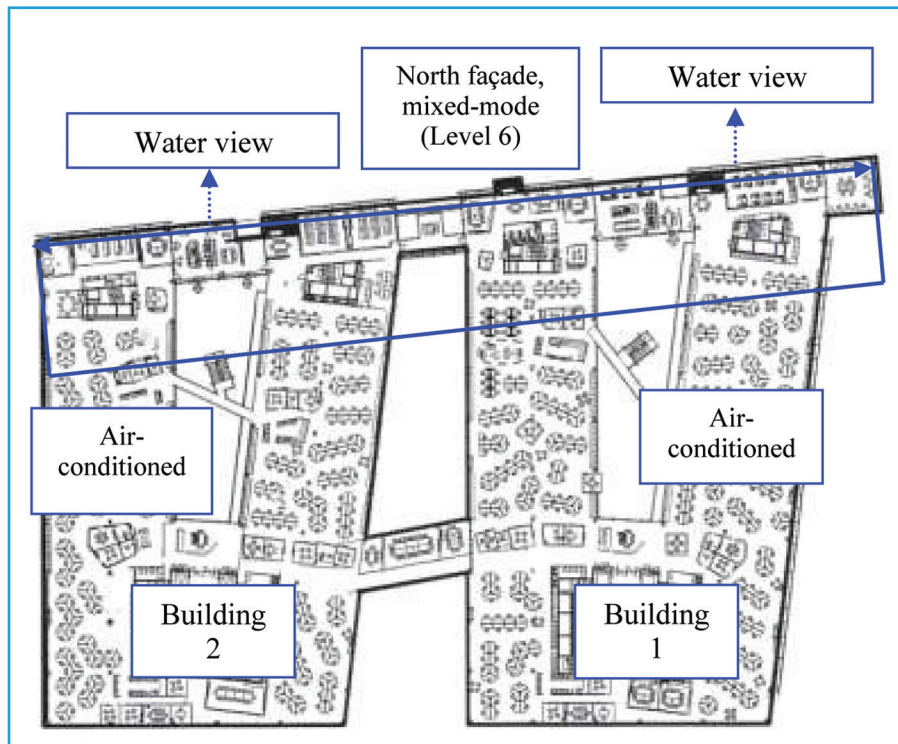
This research investigated how people felt and behaved in the NAB mixed-mode space, where natural ventilation could be chosen as an alternative to air conditioning. The changeover mixed-mode space studied was the kitchen-lounge on Level 6 of NAB Building 2 in Melbourne Docklands (Figure 1), an open space with operable windows where occupants could go to take a break from their work and the air-conditioned office. The study aimed to understand the level of comfort that people felt in this mixed-mode kitchen space and how they behaved in it. Analysing the way occupants behaved

in the NAB changeover mixed-mode kitchen-lounge and the control they exercised on their environment revealed the characteristics of the mixed-mode space, its importance, and the users' levels of acceptance of the space, and their sense of satisfaction and well-being.

NAB buildings have two conditioning systems in place: the air conditioning installed in the office spaces and the changeover mixed-mode system in the kitchen-lounges on the north façade, which feature the two options of air conditioning and natural ventilation (Figure 2). The changeover mixed-mode areas of the kitchen-lounges are characterized by operable windows as part of the natural ventilation control strategy. Each kitchen-lounge has three independent window pairs that are controlled by switches located at the tea bench area of the lounge. The system is locked if weather conditions are not conducive to operating the windows. Windows can only be opened when wind speed is lower than 12 m/s, no rain is detected, no fire alarm is present, and the outside temperature is between 19.0 °C and 27.0 °C.



**Figure 1** National Australia Bank (NAB) building, Melbourne Docklands: the north façade  
(Photo: Angela Alessi, Oct 2009)



**Figure 2** NAB Office Plan, Buildings 1 and 2, Level 6: the mixed-mode north façade (Drawing courtesy of Mr John Hurren, NAB Facility Manager)

In this study, thermal, perceptual, and behavioural approaches were used simultaneously. As in traditional thermal comfort studies, direct measurements were taken in the changeover mixed-mode kitchen-lounge on Level 6 of the NAB Building 2, in order to monitor traditional parameters of thermal comfort such as temperature, humidity, and air velocity. Indoor climatic data was collected through instruments positioned in the kitchen-lounge (Figures 3-8), while outdoor climatic conditions were derived from the Australian Government's Bureau of Meteorology (BOM).

The instruments positioned in the NAB kitchen lounge were as follows:

1. Omega linear thermistor (OLT1) to measure temperature and mean radiant temperature (Figure 3);
2. Second Omega linear thermistor (OLT2) to measure mean radiant temperature (Figure 4);
3. Hygrometer-hycal solid device (HSD) to measure relative humidity (Figure 5);
4. Pyranometer (P) to measure radiation (Figure 6);
5. TSI heated sphere anemometer (TSI-HAS) to

measure air velocity (Figure 7);

6. People counter at the two doors of the NAB mixed-mode space (Figure 8).

Two surveys were conducted to understand people's preferences for the mixed-mode kitchen-lounge. The surveys were conducted in autumn and spring, the two seasons when outdoor and indoor climatic conditions were thought to be more conducive to behavioural adaptations such as switching from air conditioning to natural ventilation. The surveys were conducted in the middle of each of the two seasons; the days for the investigations were chosen after analysing the average temperature in those seasons in Melbourne for the previous three years. The autumn survey took place on 29 April 2009 and the spring survey occurred on 10 November 2009. The survey questions were designed with the aim of understanding occupants' acceptance and control of the indoor climatic conditions in the mixed-mode space when the environment was naturally ventilated. The survey was developed in accordance with de Dear and Brager's ASHRAE system RP-884 database (1998). Questions were based on the seven-point ASHRAE





Figure 3

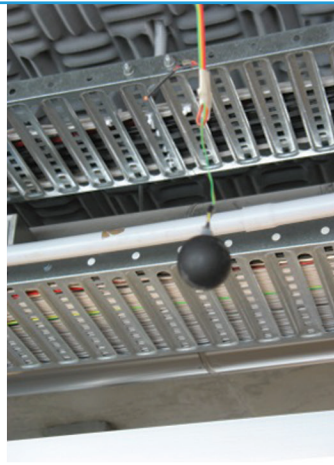


Figure 4

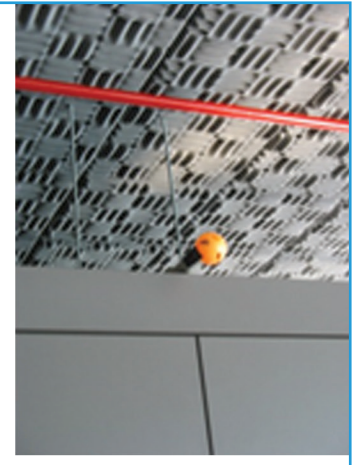


Figure 5



Figure 4



Figure 5



Figure 8

**Figure 3-8** Instrumentation positioned in the kitchen lounge

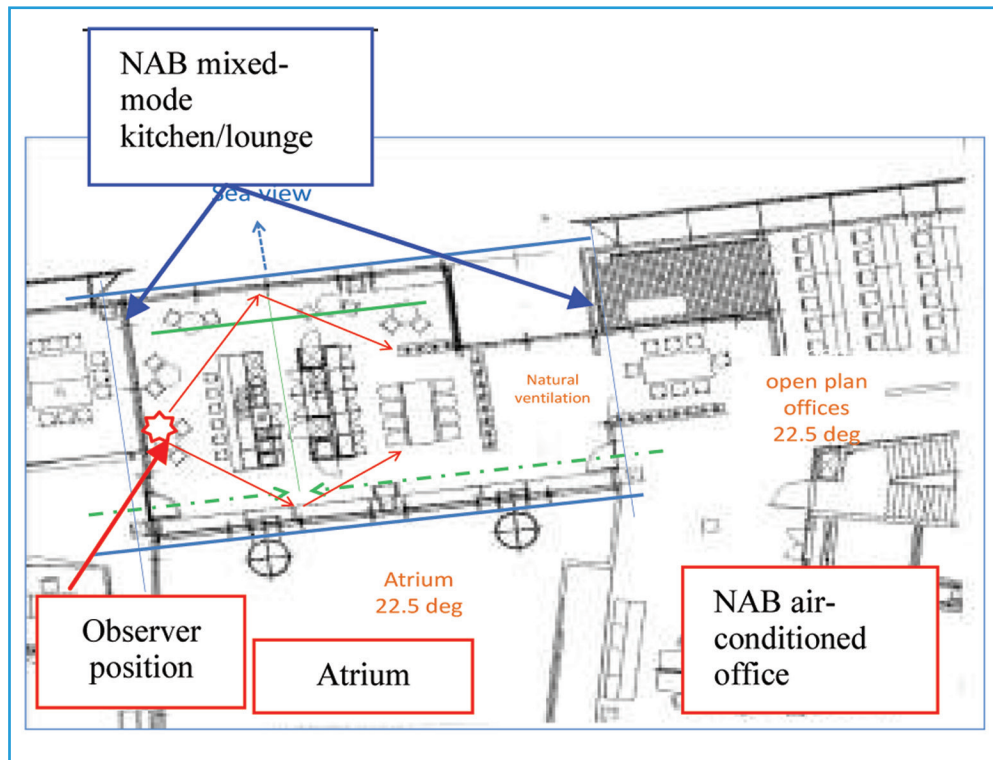
scale (cold, cool, slightly cool, neutral, slightly warm, warm, and hot) and aimed to establish the acceptance, the preferences, and the desires of the occupants relating to their thermal environment, together with their clothing levels and the use of windows and air conditioning. Adjectives and descriptors commonly used in architecture, design, and thermal comfort were used on a unipolar rating scale to guide the selection of a set of descriptions that would best reflect the notions associated with mixed-mode space and the possibility of choosing natural ventilation over air-conditioning systems. The surveys also addressed issues related to the use of the space, investigating what occupants thought about the mixed-mode room and what they liked most for their well-being.

Behavioural data was obtained through repetitive observations over one week in each season of the year of investigation (from March 2009 to March 2010), during the months of April 2009, July 2009, October 2009, and February 2010. During those weeks, observations were conducted in the

NAB mixed-mode kitchen-lounge (Figure 9) from Monday to Friday, during office working hours from 8 am to 6 pm. This amounted to 10 hours of observation per day, and a total of 50 hours per week and 200 hours of observations throughout the year of observation.

## 4 Results

The climatic data results, surveys, and observations all highlighted the importance of peoples' perceptions of the mixed-mode space in its entirety for their overall well-being. The climatic data showed that winter was the season in which the system was run in Heating Ventilation and Air Conditioning (HVAC) mode most of the time, because of the outdoor climatic conditions being below 19°C. However, the outdoor climatic conditions in the summer unexpectedly showed that the mixed-mode environment could have been utilized in its natural ventilation mode for 63% of the days during the entire season. In both spring and autumn, the outdoor climatic conditions allowed NAB occupants



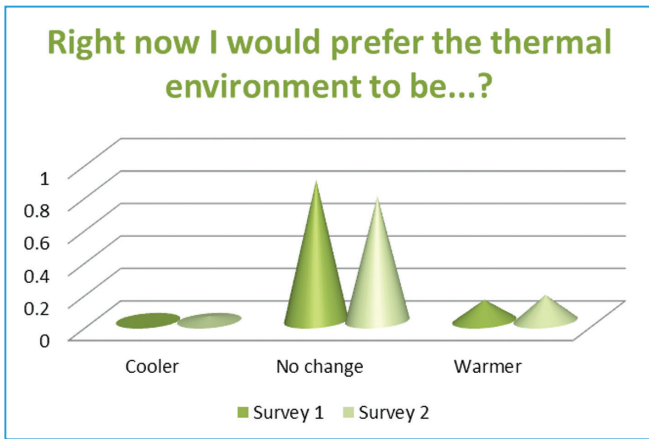
**Figure 9** The NAB mixed-mode kitchen-lounge, the point of observation and people's pathways within the space

to operate the mixed-mode system in a natural ventilation mode with the possibility of opening the windows for 12.5% of autumn and 32.3% of the spring season. Overall, NAB occupants could have been in control of their environment and exercising their adaptive strategies for one third of the 256 working days during the year of investigation.

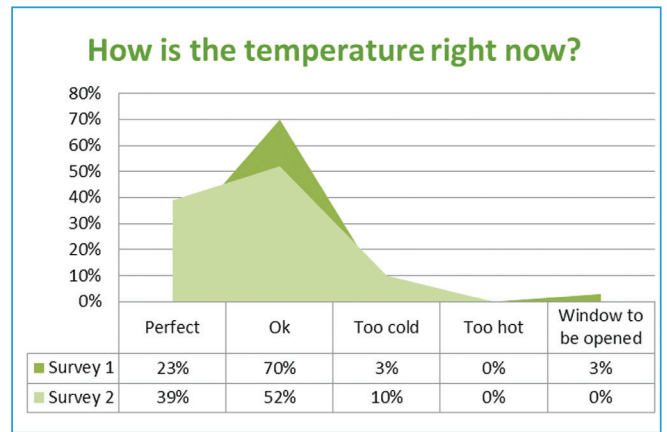
Perceptual data obtained through the surveys showed a high level of acceptance of the thermal environment (Figures 10 and 11), despite the fact that on both survey days the mixed-mode system was switched automatically to HVAC mode because of the outdoor climatic conditions (too cold in autumn and too hot in spring). In this situation, people could not have had the possibility to switch the system to natural ventilation or to open the windows. However, in both surveys, despite reporting feeling a bit cool (Figure 12), participants affirmed the thermal environment to be acceptable, if not perfect (Figure 13). While this situation of discomfort could be related to the thermal sensation of the air temperature cooling while the ground is still warm in autumn (and vice versa in spring), it could also mean that the HVAC system

was inducing unnecessarily cooling. However, in both surveys people reported the importance of the mixed-mode space for their comfort because of its characteristics such as the view, the light, it being a place of relaxation, and it offering an environment with fresh air (Figures 14 and 15). This last result leads to very important considerations. In fact, the perceived opportunity of breathing fresh air was found to be as important as having the actual possibility of doing so, highlighting the psychological aspect of people's thermal comfort and their overall well-being. While saying that NAB residents entered the mixed-mode kitchen-lounge to breathe fresh air is not possible, breathing fresh air together with the view, light, and sense of relaxation represented very important aspects of the space that people appreciated and that contributed to their sense of comfort and well-being in the mixed-mode space.

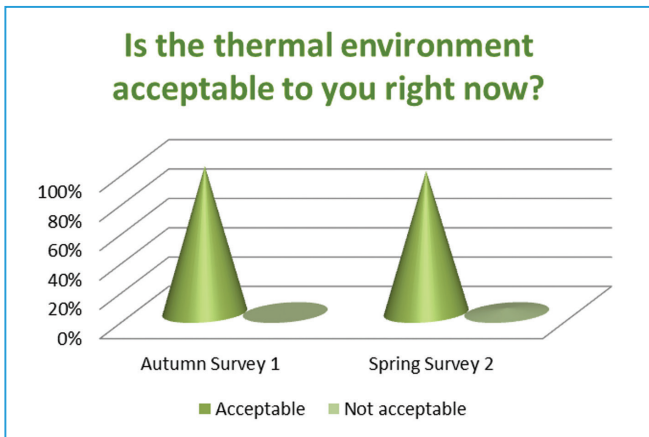
Data showed that although NAB occupants entered the mixed-mode space mostly in spring and autumn (Figure 16), they behaved almost the same throughout the year. People chose to enter the mixed-mode kitchen-lounge for activities related to the function of the space (i.e. to eat and



**Figure 10** People's preferences in the NAB mixed-mode space



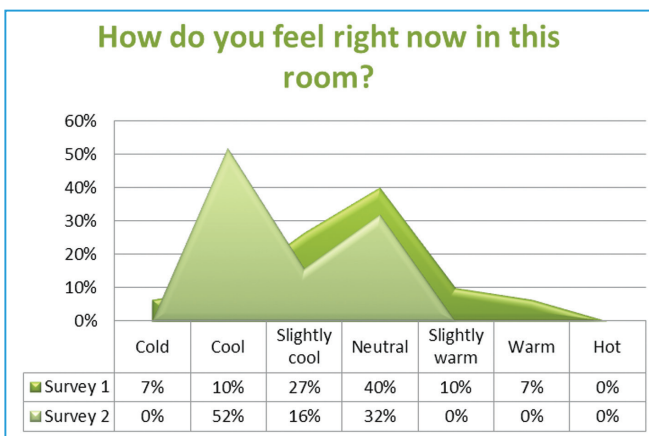
**Figure 13** People's perceptions of temperature in the NAB mixed-mode space



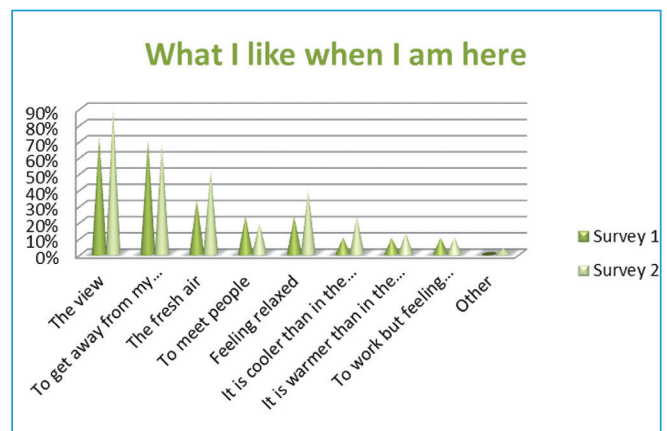
**Figure 11** People's acceptance of the thermal environment in the NAB mixed-mode space



**Figure 14** People's perceptions of the NAB mixed-mode space

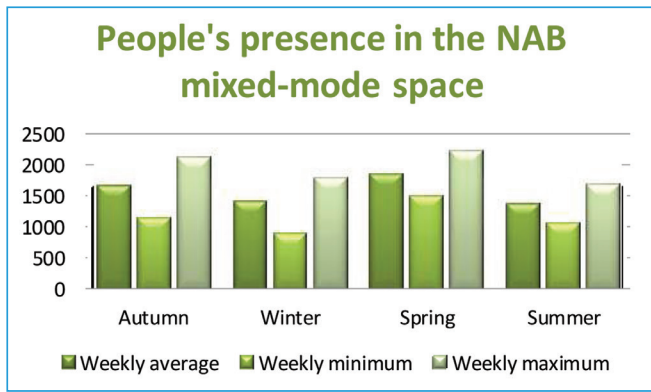


**Figure 12** People's thermal sensations in the NAB mixed-mode space



**Figure 15** People's preferences concerning the NAB mixed-mode space





**Figure 16** People's presence in the NAB mixed-mode space

drink). However, it was observed that there was an apparent desire for relaxation that was indicated in both surveys as one of the most important reasons why people entered the mixed-mode space, which led the occupants to indulge in various activities. For example, they would fill a glass of water without drinking it, prepare food while looking outside the window at the view, or take an overly long time to wash their dishes and glasses. Furthermore, people would enter the mixed-mode space for no apparent reason, as if it was for a stroll. They would enter without a specific objective, reach the kitchen bench, look out of the windows, and then exit again in what was called a 'zum-zum walk'. This behaviour highlighted how the mixed-mode space was a destination where people could achieve physical and emotional comfort. Unsolicited conversations with NAB occupants confirmed the importance of the mixed-mode space, with its characteristics of light, a nice view, and fresh air (even if only perceived), for their well-being.

## 5 Implications

One of the most important implications of this research relates to peoples' perceptions of the mixed-mode space, as well as how the characteristics of such space determine people's comfort and enhance their sense of well-being. The surveys showed that despite occupants' thermal sensations being characterized by a slight sense of discomfort, their acceptance of the thermal environment was very high. People's satisfaction with the environment was also related

to other aspects of the mixed-mode space, such as the view, the light, and the fresh air (even if it was only perceived), as well as the overall sense of relaxation that people enjoyed in the space. People chose to enter the mixed-mode space for activities related to the function of the space, but also for no apparent reason, as in the case of occupants taking a relaxing 'zum-zum walk'. The space became a destination of choice that could satisfy people's sense of comfort and well-being. Therefore, the design of offices today should include spaces such as the NAB mixed-mode kitchen-lounge where people can enhance their sense of well-being.

## 6 Conclusion

In conclusion, this study has highlighted the important role people play within an office environment in enhancing their comfort through adaptive thermal strategies and other means of interaction with the environment. Furthermore, this research also revealed the importance of the space and its characteristics such as the view, the light, the sense of relaxation, and the fresh air. People chose to enter the mixed-mode space for various reasons, some of them related to the function of the space but others simply connected to the perceived possibility of enhancing their sense of comfort. The 'zum-zum walk' can be considered part of people's thermoregulatory behaviour but it can also be interpreted as part of people's adaptive strategies to enhance their sense of well-being. The NAB mixed-mode space has become a very important point of reference for its occupants for both their thermal and overall environmental comfort and well-being. Therefore, the design of such spaces with the possibility to access fresh air is of paramount importance in modern office buildings.

## Acknowledgements

This research has been made possible thanks to an Australian Research Council (ARC) Discovery Grant obtained by A/Prof. Scott Drake (The University of Melbourne, Australia) and Prof. Richard de Dear (University of Sydney, Australia). My gratitude

also goes to Dr Chris Heywood for his assistance in the elaboration of the results. Not least, I wish to extend my thanks to Mr John Hurren, National Australia Bank (NAB) Facility Manager, for studying the building, and to the NAB occupants for their contributions to this research project.

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paper

19

Appropriate Design of Top Floors of Low-rise  
Modern Residential Buildings in Kolkata for  
Thermal Comfort and Sustainability

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## Abstract:

Kolkata is one of the leading metro cities in India, ranked seventh in population for cities in India. Because of the unprecedented rate in urban development, many single or double storey buildings are being replaced with buildings consisting of three to five storeys. These buildings suffer from a lack of attention towards climate and the myopic focus on cutting construction costs. Lack of proper ventilation, space planning, and wall/roof insulation make top floors tremendously hot during the summer; further, these factors contribute to roof damage during summer months. Quick solutions of air conditioning or repeated roof repairs add cost burdens to housing infrastructures and contribute to an urban heat island effect. To minimise energy consumption and provide comfortable indoor environments for inhabitants of top floors in low-rise residential buildings, this article aims to formulate an appropriate architectural solution to mitigate the stated problems and promote sustainability. Methodology for the study included a literature review, as well as field and analytical surveys.

**Keywords:** *low-rise residence, Kolkata, design of top floor, thermal comfort, sustainability*

**Citation:** Sarkar, S., and Bose, S. (2015). Appropriate Design of Top Floors of Low-rise Modern Residential Buildings in Kolkata for Thermal Comfort and Sustainability. In Mani, M., and Kandachar, P., *Design for Sustainable Well-being and Empowerment*, IISc Press and TU Delft, 239-249.

## 1 Introduction

Kolkata is one of the leading metro cities in India. Per the provisional report of the Census of India (2011), the population of Kolkata—reported as 4,486,679—ranked seventh for cities in this country. In the last two decades, an unprecedented rate of urban development (i.e. residential, commercial, and other architectural and infrastructure development) has been observed in Kolkata. From April 2005 to March 2013, the total number of residential buildings sanctioned by the Kolkata Municipal Corporation (henceforth, KMC) area was recorded as 29,394 (Banerjee, 2013); about 90% of those buildings are five storeys or less in height. Kolkata's climate is tropical hot and humid, and the maximum temperature in summer (March–May) is approximately 39°C (Bose, n.d.); further, the relative

humidity may rise as high as 90%. It has been observed that most of the inhabitants of top floors in low-rise modern residential buildings experience tremendous discomfort in indoor environments from the intense heat in summer months, and roof damage, including leakage from rainwater in monsoon season, is another phenomenon. Although the aim of architecture is to provide comfortable shelter for people, the inhabitants of top floors in modern buildings truly suffer during the summer. To experience relief from this situation, inhabitants who can afford it are utilising mechanical air cooling and air conditioning systems that consume high levels of energy; subsequently, the demand for energy in the city during summer is affecting the environment negatively. Modern architectural practices, techniques, and building construction materials are different from traditional ones in



Kolkata, which reflect respect for the environment and climate-responsive design (Pellegrino, 2012). Air conditioners, though providing comfort, consume huge amounts of energy. With a view towards minimising energy consumption, offering comfortable indoor environments to inhabitants of top floors in low-rise residential buildings as well as saving roofs from damage by rainwater penetration and promoting sustainability, this study was undertaken to find appropriate design solutions and suitable materials and techniques for building construction through field surveys and a literature analysis and formulate an appropriate architectural solution to mitigate this problem.

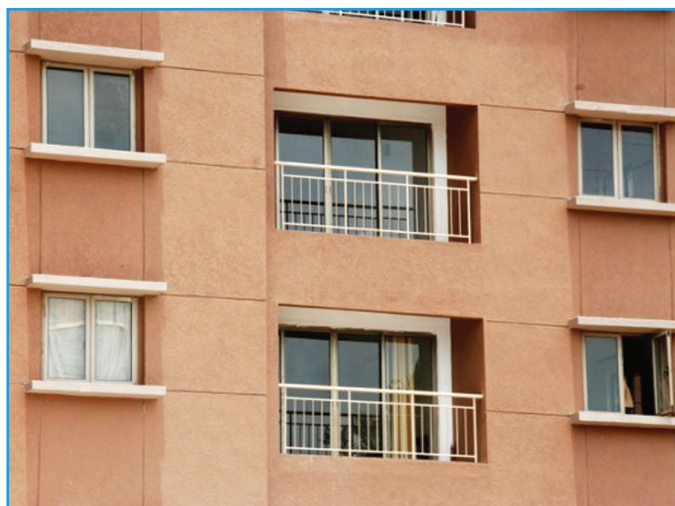
## 2 Climate and architectural practices in Kolkata

The climate of Kolkata is tropical hot and humid, with average annual rainfall being 1,651 mm (Bose, n.d.). Until the first half of the 20<sup>th</sup> century, architects of urban houses in Kolkata never neglected the lessons learned from tradition (Taylor, 2006). Houses were built with thick brick walls (about 500–550 mm) and lime-sand-surki (brick dust) mortar; later, they were built with cement-sand mortar. In addition, a house contained a courtyard in the centre with a running veranda along its periphery; shading systems such as verandas; porches and cornices; louvered timber windows; ventilators; roof treatments with lime terracing; higher room height, etc. These features made them climate-responsive architecture

(Pellegrino, 2012). Floors consisted of two layers of burnt clay tiles separated by lime concrete and a structural system of timber beams and rafters; later, iron beams (rolled steel joists) and iron T-rafters were used. A layer of lime terracing (100–150 mm thick) was placed on a roof as insulating material. The indoor environmental quality of the top floors of these buildings was acceptable. In some cases, inverted earthen pots were used over a basic roof with a layer of lime terracing all over to promote thermal cooling and comfort on the top floor.

However, architectural design, materials, and construction methods have changed since the latter half of the 20<sup>th</sup> century; further, they are becoming standardised with new materials such as plywood, PVC, various tiles, glass, steel, aluminium, and composite panels. Accommodations for low- and middle-income groups in apartment buildings have become a compromise for space versus price, or affordability irrespective of indoor comfort.

Modern technology associated with construction of common residential buildings in Kolkata includes framed structures with reinforced cement concrete (RCC), thin external brick walls, steel or aluminium-framed windows with sheet glass panes (Fig. 1), no ventilation, and flat RCC roofs without layers of lime terracing or thermal insulation on top. Roofs of most buildings developed by middle- and low-income groups and profit-seeking promoters do not have insulation on top, as these buildings are



**Figure 1** Glass window in a modern building with narrow sunshade



**Figure 2** A two storey building with AC on top floor and GI-shed over roof



Figure 3 Floor plan of a typical apartment building complex

Source: Magicbricks, 2013

constructed for bare minimum statutory compliance and moderate financial investment. The comfort aspect for occupants is unheard of in this market. Especially, the top floors of low-rise residential buildings produce unbearable indoor environmental conditions during summer months (March to mid-June), characterised by tremendous heat and humidity. The afternoon high temperature reaches approximately 39°C in Kolkata during summer months, and the surface temperature of a concrete rooftop rises to about 67°C. The heat gain occurs from conduction and radiation, no exhaust because of the absence of a ventilator, hot air blasted from the overheated ceiling by a ceiling fan, and the closing or curtaining of windows for privacy; altogether, these factors create an intolerable indoor environment in a top-floor room. Many inhabitants install air conditioners in their rooms to ease discomfort during the summer, which leads to a huge demand for energy in the city. In Kolkata, persistent and heavy monsoon rains damage roofs because of leakage. Because present technical solutions of applying waterproofing products directly over roofs are ineffective and costly, people often erect sheds of colour-coated galvanised iron sheets over roofs

for thermal comfort and for protection against rainwater penetration (Fig. 2).

As dwellings are built mostly for multiple owners and users, and since there is no such mandate for thermal comfort in India, traditional insulating materials and labour-intensive construction methods that facilitate natural ventilation throughout the building are avoided to keep construction time and costs as low as possible. Sizes of apartments are small. Internal floor-to-floor building height is about 2950 mm (9' 8"), and the internal clear height of a room is about 2800 mm (9' 2"); yet, in traditional buildings, internal height was about 3600 mm (12' 0"). An apartment with two beds, one hall, and a kitchen (known as a 2BHK flat) typically has a covered floor area of 650–800 sq. ft.; a 3BHK apartment is 900–1200 sq. ft., with very small rooms and without an adequate scope of cross ventilation. The average bedroom size is 3000 mm × 3000 mm (10' × 10'), though some bedrooms measure 3000 mm × 3600 mm (10' × 12'). Cross ventilation is compromised in plans, especially where units are placed in a finger like pattern to minimise mandatory open space in a housing complex; furthermore, external walls of two

dwelling units are hardly 2 m apart (Fig. 3). Here, hot exhaust from one air conditioner is sucked back into the next unit (i.e. short circuiting), leading to a vicious circle of an ever-increasing cooling load.

Modern windows are no longer made up of timber with Venetian louveres as in the ‘old days’ when ventilators below roofs on all four sides of a room were used; additionally, room heights have become shorter and walls are only 200–250 mm thick, compared to 550 mm used previously. Composite floors made of lime-concrete sandwiched between two layers of burnt clay (terracotta) tiles over a

network of timber beams and rafters to bring thermal comfort indoors is no longer possible, and the central courtyard-overlooking architectural layout of palaces are no longer found in small buildings.

### 3 Indoor environmental quality issues of top floors

Indoor environmental quality (IEQ) is the result of influences of air, thermal conditions, light, sound, odours, and vibrations on the physiological sensory systems of the human body (Healthy Heating, 2013). However, in Kolkata, where people are used

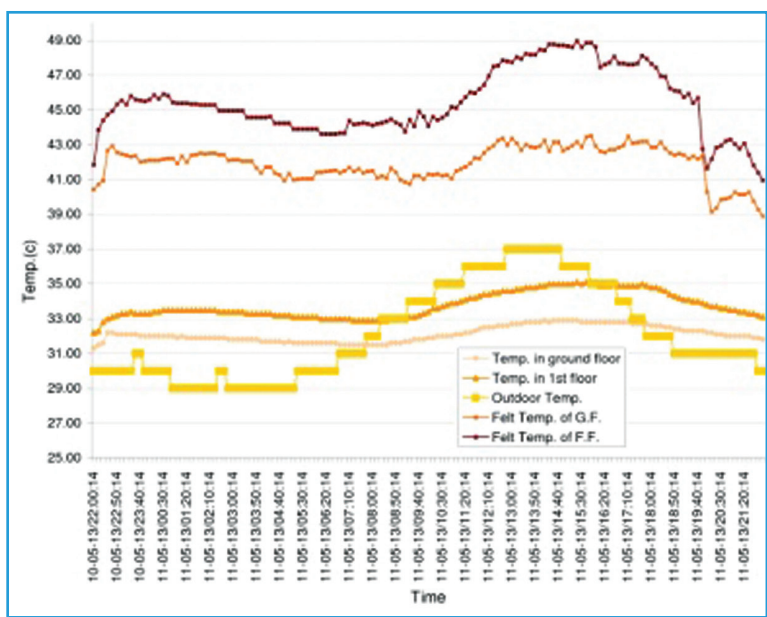


Figure 4 Temperature graph of top and bottom floors of a two storey house (May 2013)

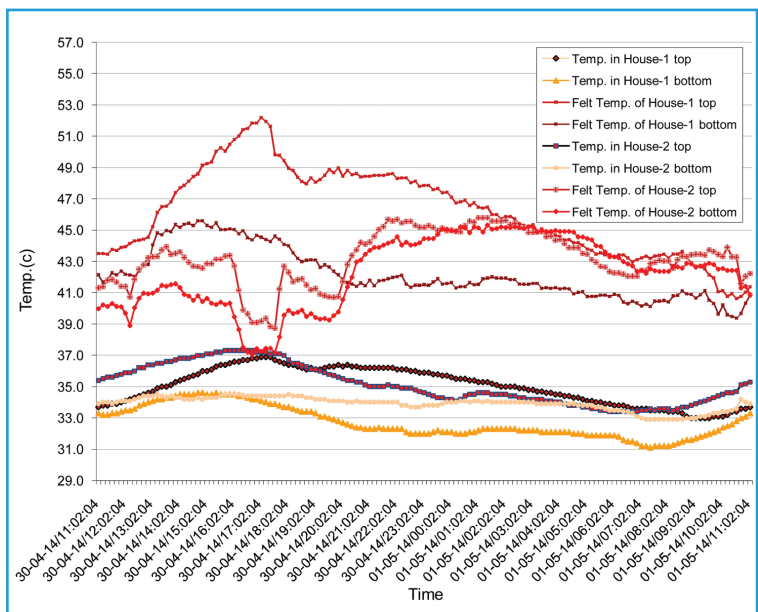
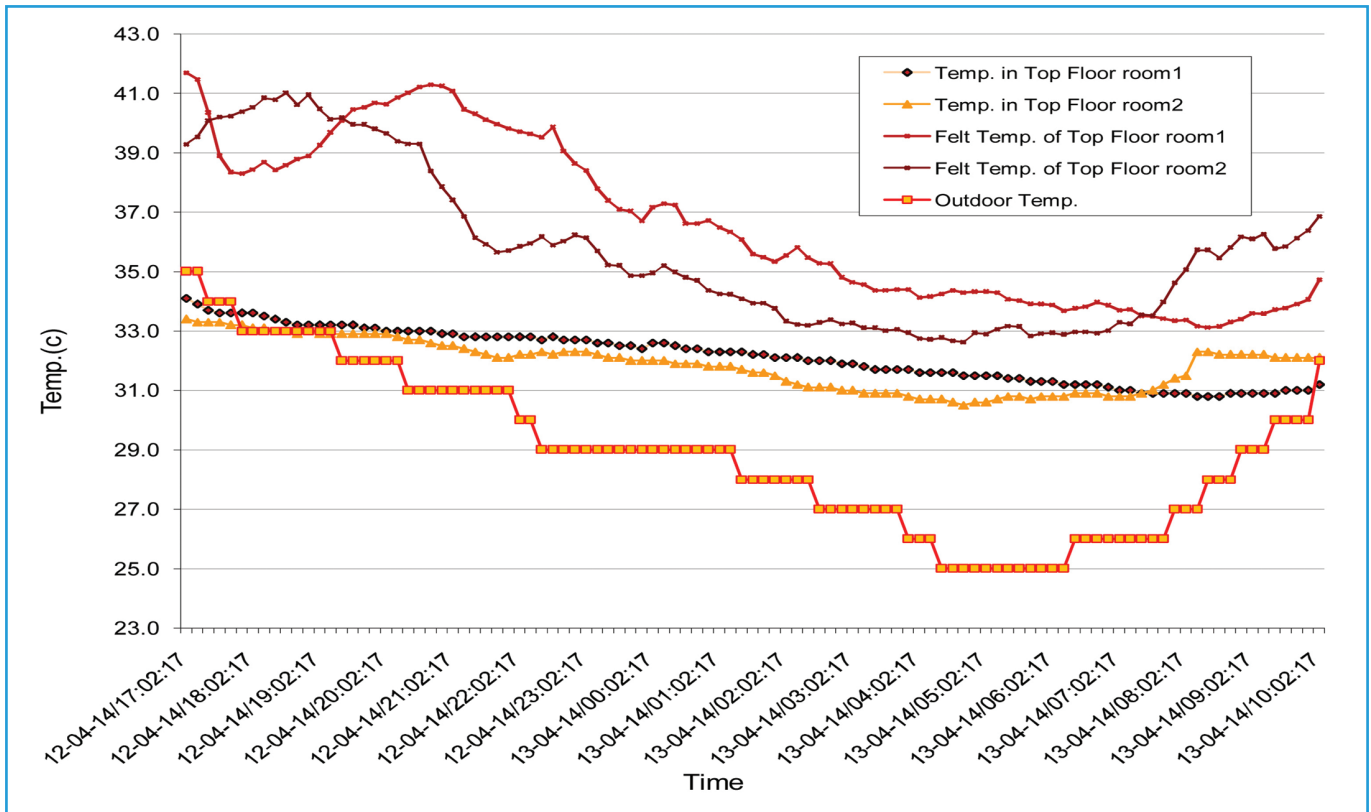
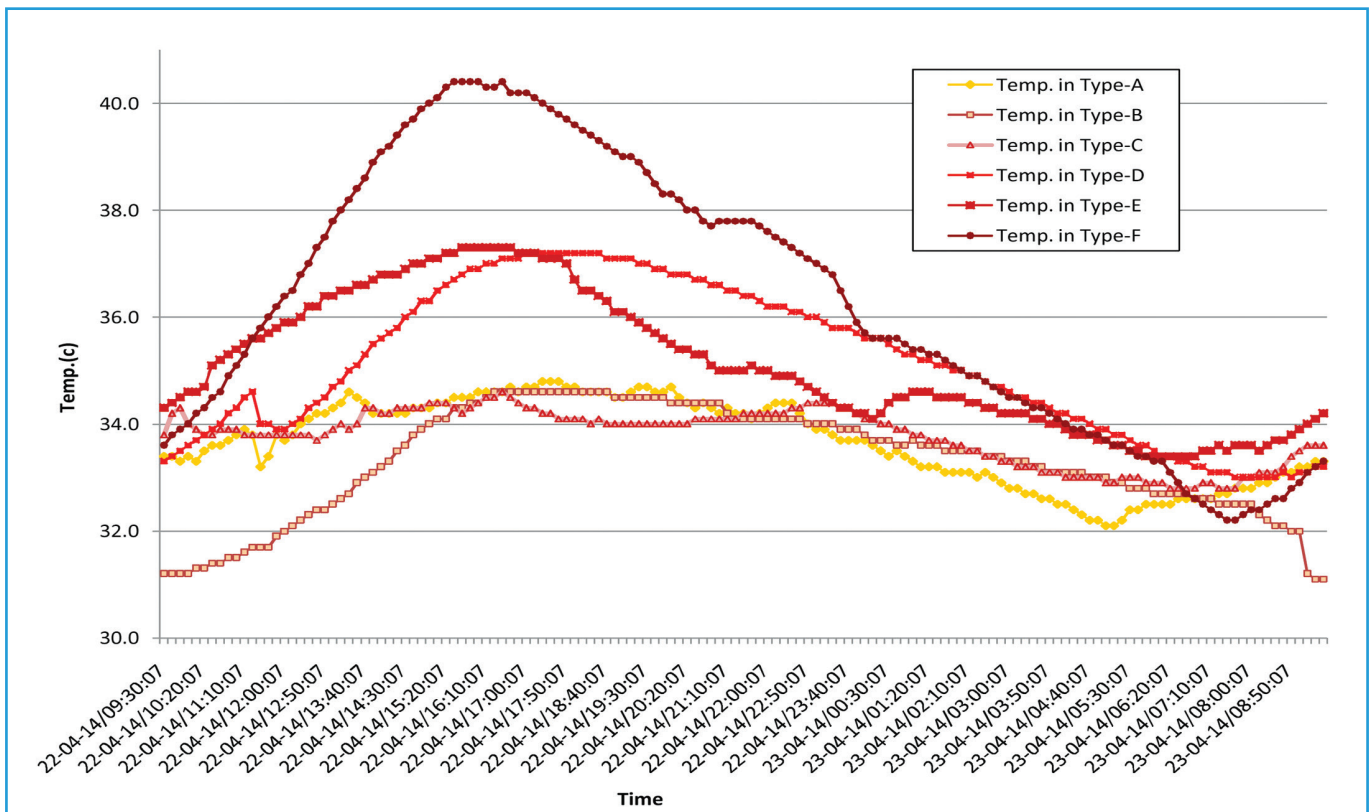


Figure 5 Temperature graph of top and bottom floors of two houses (April–May 2014)





**Figure 6** Night-time temperature graph of two rooms on the top floor of a building with 62 mm screed concrete over an RCC roof slab (April 2014); the room with better ventilation shows lower temperatures



**Figure 7** Temperature graph of top floors of six buildings with different roof treatments (April 2014)

to loud noises from various sources on streets and in neighbourhoods, along with high levels of air pollution, the IEQ is accepted commonly as thermal quality, humidity, and airflow in the interior. A data logger has been used for recording air temperature and humidity, and an anemometer has been used to assess quality of airflow in the rooms of top floors as well as in the floors below in many low-rise residential buildings from 2011 to 2014. It has been observed that the IEQ of these buildings becomes uncomfortable in summer months, and the top floor is mostly unbearable compared to lower floors (Figs. 4 and 5). At night, indoor temperature on top floors is higher than the outdoor temperature, and better cross ventilation in a room keeps it cooler than a room with less ventilation (Fig. 6). The average outdoor high temperature in 2012 during summer months was about 34.7°C, and the average relative humidity was about 93.67% (Weatherspark, 2013).

During the summer of 2012, the characteristics of indoor thermal conditions on the top floor of a two-storey building with terrazzo mosaic tiles over an RCC roof slab and that of a building with only an RCC roof slab virtually did not differ. Thermal conditions on the top floor of a three-storey building with lime terracing insulation on the roof and considerable natural cross ventilation in the interior rooms were more comfortable than those of the top floor of a two storey building with an RCC roof, based on data taken during the same time for both buildings in the same neighbourhood (Bose, 2012a). Figure 7 demonstrates the temperature graph (for April 2014) of top floors of six buildings with different roof treatments. Type A represents a house that is 120 years old with lime concrete between the top and bottom layers of terracotta tiles constituting the traditional roof over timber beams and rafters and lime terracing insulation; Type B, a 40-year-old house with lime terracing insulation on top of an RCC roof slab; Type C, a new house with inverted terracotta pots and a PCC top finish over the RCC roof slab; Type D, a new house with a cement mosaic finish over an RCC roof slab; Type E, a 30-year-old house with screed concrete finish over an RCC roof

slab; and Type F, a new house without any treatment over its RCC roof slab (Fig. 7). It shows that a lime terracing treatment over a roof is quite effective for heat insulation, while cement mosaic and a screed concrete finish are more effective for rainwater proofing than heat insulation.

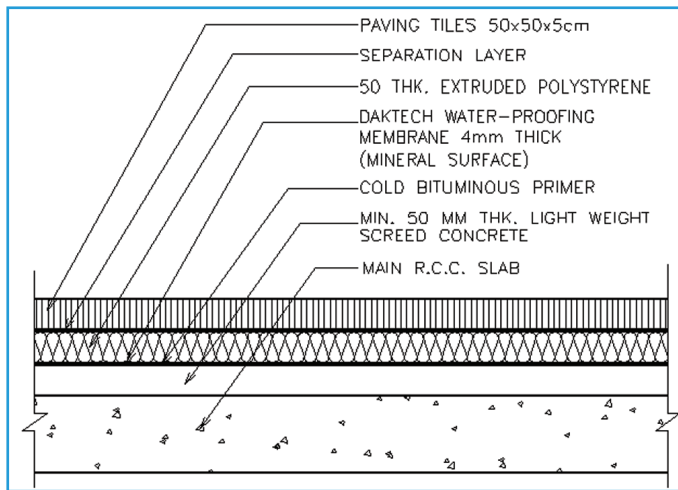
Recently constructed buildings have casement or sliding glass windows in steel or aluminium frames. For maintaining audio-visual privacy in a closely clustered neighbourhood and for preventing invasion of mosquitoes and burglars, windows are kept closed; thus, there are no provisions for natural ventilation. Many small flats owned by working couples remain vacant and closed during the daytime, and their internal temperatures rise significantly from heat gain through glass windows and blocked ventilation. External walls of smaller thicknesses of only 200–250 mm are characterised by low thermal mass, which add to the problem.

As a result, many inhabitants of top floors install coolers and air conditioners for comfort and relief during hot summer months, producing a huge demand in the city for energy and contributing to environmental unsustainability. The Calcutta Electric Supply Corporation (CESC) has confirmed that maximum demand rose from 774 MW in 1990–1991 to 1238 MW in 2000–2001 (i.e. a 60% increase). An increase in demand to 1359 MW in 2006–2007 resulted in another 10% increase (Samajpati, 2007; Bose, 2012b). Additionally, it is quite common that hot air expelled by the air conditioner from one apartment is sucked into the adjacent apartment, creating an abnormally large cooling load.

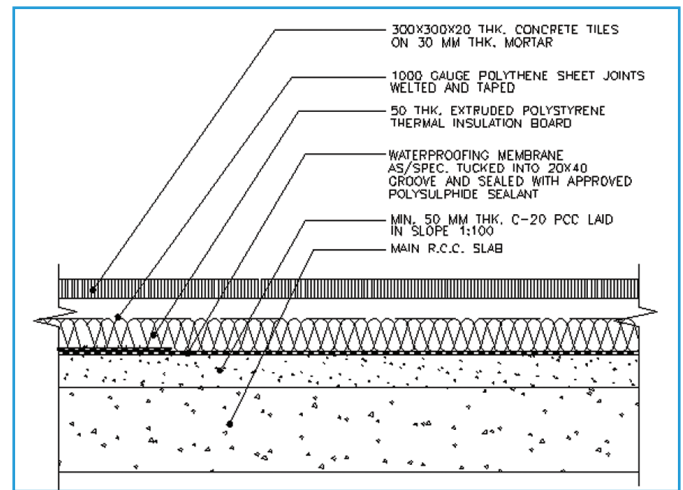
#### 4 Recent roof insulation techniques

A survey regarding materials and roofing insulation techniques was conducted recently by some consulting architects in Kolkata. Additionally, it was found that no notable measures were taken to insulate walls. Results of the survey revealed that polystyrene and screed concrete combined with waterproofing compounds and bituminous layers have been used in buildings constructed by reputed





**Figure 8** Section of a modern roof showing insulation option 1



**Figure 9** Section of a modern roof showing insulation option 2

developers. Common methods of treating roofs of modern residential buildings are noted as follows.

- Two coats of liquid applied as a membrane (waterproof polymer substance) are placed initially as coats of paint over the RCC roof slab. Then, an application of screed concrete with a thickness of 50 mm is followed by an application of a cold bituminous primer. Next, a layer of Daktech waterproofing membrane (4 mm thick) is applied and topped with extruded polystyrene (50 mm thick). Hot bitumen @ 1.2 kg/sq m is sprayed on top of the polystyrene, and concrete paving tiles (500 mm × 500mm × 50 mm) are placed over it (Fig. 8). In the overall process, desirable slopes towards roof drainage gutters are maintained.
- Some architects use a waterproofing membrane with a polysulphide sealant over the screed concrete (50 mm thick) on top of the RCC roof slab. Extruded polystyrene (50 mm thick) is placed over it, followed by placement of thick polythene sheets that are torch-welded and taped at joints on the top. Mortar with a thickness of 30 mm is applied, followed by a top layer of concrete tiles measuring 300 mm × 300 mm × 20 mm to finish the surface (Fig. 9). However, results from use of these insulating applications on the top floors of indoor environments, as well as longevity of the insulation through various weather conditions, has not been measured yet.
- Commonly, for a small residential building, a

roof is treated with a layer of screed concrete (thickness of 50 mm) mixed with a waterproofing compound, which slopes over the roof slab. The top of that layer is finished with a neat cement polish, resembling a layer of Indian Patent Stone (IPS). In some cases, this layer of screed concrete is used as a base for terrazzo tiles (300 mm × 300 mm × 20 mm) for insulation purposes.

- In certain buildings, bitumen sheets are placed over a base layer of screed concrete covering the roof slab. Generally, such treatments remain effective in preventing rainwater penetration for up to six years; after that time, deterioration occurs, creating greater complexities.
- Recently, structures consisting of tubular steel posts and truss beams covered by polycarbonate, fibre, or GI sheets have been erected to encompass entire roof areas for protection from direct rainfall and sunlight. This shading device has been very effective, though it spoils the aesthetics of the building and adds to the urban heat island effect.
- Although seldom used, brick laid flat or on edge in desired slopes over the RCC roof has proven to be effective in keeping the indoor environment of a top floor noticeably cool.

## 5 Proposal for promoting comfortable conditions

Results of this research thus far indicate that interior heat comes mostly from the roof's heat, and good interior ventilation minimises a rise in indoor

temperature, thereby promoting comfortable conditions. Heat transmitted through walls with southern and western exposure to adjoining rooms is also another factor. Hence, the first scientific attempt to promote comfort on the top floor of a residential building should be to insulate the roof. The traditional roof with lime terracing insulation, out of all existing typologies of roofs (except for that with polystyrene insulation in posh modern buildings), appears to be the best choice for maintaining a comfortable indoor environment.

Colour-coated GI roofing sheets on iron posts and a beam network over the roof is the best and most popular solution for providing shade, and it minimises the possibility of roof damage from rainwater penetration. However, this solution mars the beauty of the architecture; therefore, it is the least acceptable choice of architects. The limitation of this research funded by the University Grants Commission (UGC) is that researchers have not been able to explore or create new materials and technology for insulating roofs; further, they have not monitored the results of applications for appropriateness and cost effectiveness for widespread adoption. Porritt, Cropper, Shao & Goodier (2012) commented that the comfortable condition of a top floor depends greatly on the performance of other contributing factors such as cross ventilation, internal and external wall insulation, etc. The basic philosophies regarding tools for cooling indoor top floors include i) good amounts of cross ventilation through doors, windows, and ventilators in strategic room positions; ii) use of louvres consisting of semi-transparent, translucent, tinted, or reflective glass of appropriate thickness on aluminium frames in window fenestrations; iii) insulation in external walls providing cavities that are at least 25 mm thick or which are composed of lightweight materials such as extruded polystyrene (EPS) or polyurethane (PUR) of appropriate thickness; iv) secondary external walls at projections of 500 mm from basic building lines on southern and western side elevations for cooling (they also add value for beautification);

v) insulation through reflective coating on roofs and outer walls based on the application of light-coloured paint with higher solar reflectance levels (Bretz & Akbari, 1997); vi) application of creepers on walls for thermal insulation; vii) placement of pergolas (in north-south inclination) over roofs; and above all, viii) roof insulation using suitable materials and methods of construction or application to cover existing roofs (i.e. should be uncomplicated and economically acceptable to common people).

## 6 Conclusion

The demand for housing in low- and middle-income groups is the highest in Kolkata. On the one hand, local small-scale developers are constructing buildings on small plots for lower middle-income groups by keeping the areas of flats smaller; on the other hand, established and large developers are building housing complexes on large plots or on single plots that are greater than 400 sq. m.; these buildings are not affordable for lower middle-income groups. These flats are actually for higher middle-income groups or high-income groups. With prices for every commodity skyrocketing in the country, the price of housing continues to climb; therefore, a cost-effective but technically sound solution for bringing comfortable conditions to the top floors of low-rise residences is needed. This would in turn eliminate the need for the installation of air conditioning units, thereby minimising the demand for energy and emissions of chlorofluorocarbons and greenhouse gases in summer months. Reintroduction of and inspiration from certain elements of traditional methods into modern techniques for designing and constructing top floors of buildings is necessary. Providing comfortable conditions in the top floors of low-rise residences should not be perceived as an extra element of design and construction; currently, it appears to be an issue that modern architects have been avoiding. This research sets the background for future research on the relative performance of possible solutions with an aim to augment energy efficiency and sustainability of the housing sector.

## Acknowledgements

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paper

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Build-Use-Shape Habitat

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## Abstract:

The ‘Build-Use-Shape’ (BUS) house began as a prototype of a mobile home-cum-office and has evolved into a potential affordable housing solution. At 250-450 square feet, it contains spaces for sleeping, cooking, storage, and sanitation, including a skylit covered courtyard—a much-desired and versatile hub within a home. The idea of portability gave rise to using the structure as a skeleton that accommodates several ‘skins’, making the envelope dynamic and user-centric.

The BUS house has a predetermined wet and dry core component of ferroconcrete panels that are connected by means of a courtyard, the size and treatment of which are determined by the available site area and budget.

The house building process involves the owner, whose individuality is reflected in his or her choices and personal expressions. This produces a sense of dignity and pride, endowing the home with a necessary human element.

**Keywords:** *precast elements, ferroconcrete, affordable house, prototype construction, assembly*

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## 1 Concept

The ‘Build-Use-Shift’ (BUS) house, as it was initially conceived, was designed as a 250 sq ft house with multifunctional living spaces linked to a kitchenette, bath area, and toilet, as well as a central courtyard with many potential uses. It included provisions for lofts and sleeping spaces in the upper levels.

This project had a twofold objective:

- To provide a living, cooking, sleeping, and working space for our volunteers and social workers who visit the remote villages where our organisation has ongoing projects; the housing

unit should be reusable and capable of being moved to our next rural project.

- To serve as a testing ground and forerunner to our GRIHA project—our quest for a sensitive and affordable rural core housing solution within the budget stipulated by the Indian government.

### 1.1 The Design Challenge

- In its capacity as a guesthouse, the prototype needed to offer flexibility in terms of assembly, dismantling, and transport, in addition to providing a robust housing solution. As a forerunner of our GRIHA project, the approaches we used were necessarily low tech and low cost,

and the materials had to be locally available. The project initially aimed toward a budget of Rs. 1,00,000 or USD 1700. We posed several questions related to the idea of the BUS leading to a 'home' concept:

- How can there be a modular solution that does not compromise the anonymity of design which modularity entails?
- How can the solution lead to scalability yet be suited to individual tastes and needs?
- How can the homeowner be involved in the design and construction process such that the responsibility for decision making and construction is owned by him or her, thereby creating joy and pride in the process, its execution, and the final product?
- How can we incorporate flexibility and future growth into the solutions?
- How can local culture and ethnic flavour be successfully reflected in the design?
- How can the cost be controlled while respecting and adhering to the above conditions?

### 1.1.1 The Approach to Design

The starting point for our design was the 'Tiny-house movement (n.d.)' in the United States. The idea of portability led to two approaches: a house on wheels versus one that can be either flat-packed or fully assembled and transported on a flatbed trailer or a truck. A review of transport costs made it obvious that a fully assembled house on wheels was not a workable solution. A caravan was also ruled out due to cost and local cultural connotations.

### 1.1.2 Design Innovation

The approach, therefore, was to think of the house as a kit containing parts: sleek structural columns that allow for walls as infill panels. The walls are considered a skin—a protective, safe, secure armour that allows for additional layers to be incorporated by the user over time, depending on thermal comfort needs, internal storage requirements, and budget. The superstructure would have to be removable, portable, and reusable.

Our analyses of space allocations in tiny homes (Tumbleweed Tiny Homes Company, n.d.) led us to separate the house design into two distinct zones: wet and dry cores, each eight feet wide. The wet core is comprised of the kitchen, toilet, bath, and utility area. The dry core is the multipurpose area. We introduced the courtyard element to creatively tie up these two modular cores. The size and treatment of the courtyard would be determined by the shape, size, and orientation of the plot; the owner's budget; distinctive local characteristics; and available building materials. The sleeping/storage areas would be introduced in stages over the kitchen and living areas according to the budget.

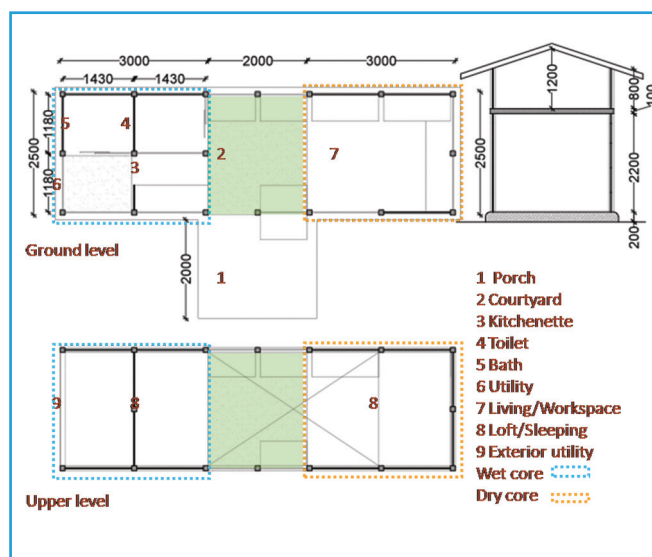


Figure 1 BUS concept

### 1.1.3 Design Principles

The BUS house is based on three design principles:

- Architectural design: a wet core connected to a dry core by means of a flexible courtyard that will bring individuality to the modular concept.
- Structural design: the BUS house is designed for stability as the primary criterion and is later checked for strength.
- Construction logistics: the house is dismantlable and transportable, and it uses unskilled labour for the entire construction.

## 1.2 The Next Step

Next, we focused our research on developing a flexible structural system that would allow for many alternative materials to be used as the skin. Based on interaction with the structural engineer, we decided on ferroconcrete as a viable option for both the vertical supports and horizontal panels in BUS version 1.0. We made this decision for the following reasons:

- Ferroconcrete is less labour-intensive than ferro-cement.
- It has become popular with many villagers. There are plenty of local entrepreneurs making cement rings, *jaalis* (decorative ventilators), etc. Therefore, as a material, it would easily find acceptance among local villagers.
- By popularising this idea, it would be easier to train local entrepreneurs in casting columns and panels, thus ensuring local acceptance and mass dissemination.
- There are already several large-scale entrepreneurs in ferroconcrete building systems who have invested in machinery and factories manufacturing columns and panels for compound walls. They are likely to find merit in our system and extend their production to BUS panels.
- These materials are sturdy and relatively easy to stack and transport.
- They can be handled manually and do not depend on bulky machinery for installation.
- As the 'skin', the wall serves a crucial function: it ensures the safety and security of the inhabitant.

### 1.2.1 Some Concerns about Ferroconcrete

The walls are thin, which necessarily means less thermal comfort. The amount of cement consumption was also a concern. Social acceptability and safety superseded these concerns for the first prototype.

### 1.2.2 From Shift to Shape

The work at the original village, which prompted

the initial BUS concept, proceeded in a mercurial manner. Hence, investing in a BUS there was an unwarranted indulgence.

We found a supporter for our idea who wanted to build a BUS that might serve as either a farmhouse or a caretaker's house. The location was a one-acre plot in the village of Tharalu, about 40 km southwest of Bangalore on Kanakapura road. Since the structure was intended to be used as a house, we decided to revisit the size of the BUS and 'optimise' it for village use. The focus shifted from making it an Rs 1 lakh structure to making it an 'ideal' house at a minimal cost. Our research found that people in villages consider 10' x 10' the optimal size for a room. These dimensions also work very well anthropometrically. A sense of spaciousness is important for mental well-being. Thus, 'Shift' changed to 'Shape' in the first BUS prototype. How, we asked ourselves, can the structure of the BUS be designed/modified for future growth? We began to give more thought to *Vastu*. So, based on an 8' x 10' grid, we used three grids of 10' x 10' to get 300 sq ft of built-up area, along with the provision of two lofts, totalling 150 sq ft of space.

Upon visiting the site, we realised that a BUS taking up 30 ft of space lengthwise, though climatologically appropriate with the long side facing north, would eat too much into the site. Designed as wet and dry core components, the BUS concept naturally lends itself to an L-shaped configuration. The L shape formed an inviting external courtyard that looked inward, satisfying both requirements. If the owner wanted to use the space as a farmhouse, it would act as a private inner courtyard. If used by the caretaker, it would ensure that the family's activities would be curtailed off from the rest of the farm area.

The kitchen now faced east – a basic *Vastu* requirement.

## 2 Design Development of the BUS

### 2.1 Genesis of the Design

**LEGEND:**

1. Veranda
2. Living Room/Bedroom
3. Kitchenette
4. Bathroom
5. Bedroom
6. Storage
7. Table Counter

**Figure 2** Understanding spaces via the ‘tiny-house’ concept. We found no references to similar projects in India or abroad for either the design or the use of ferroconcrete; as such, we are unable to provide comparative cases.

Wet Core  
Veranda

Courtyard

Dry Core

**Figure 3**

- Adapting the ‘tiny house’ to the Indian context
- Dividing spaces into wet and dry cores of equal size (modularity)
- Introducing a skylit courtyard and veranda—they can be adapted according to available space and budget

Wet Core

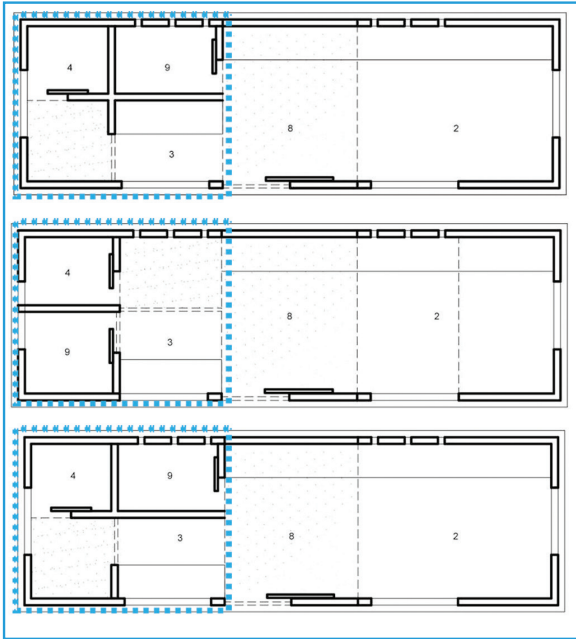
Courtyard

Dry Core

**Figure 4**

- Re-orienting the veranda with a courtyard/ entrance enhances the feeling of space
- Entry through the skylit courtyard now becomes a multifunctional, transitional space as well as a binding element between the two cores
- Courtyard as an element of local flavour and growth

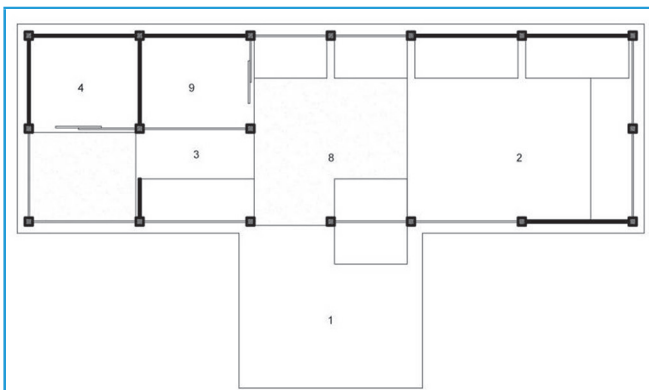




**Figure 5** Various configuration possibilities for the wet core components (bath, toilet, utility area, and kitchen)

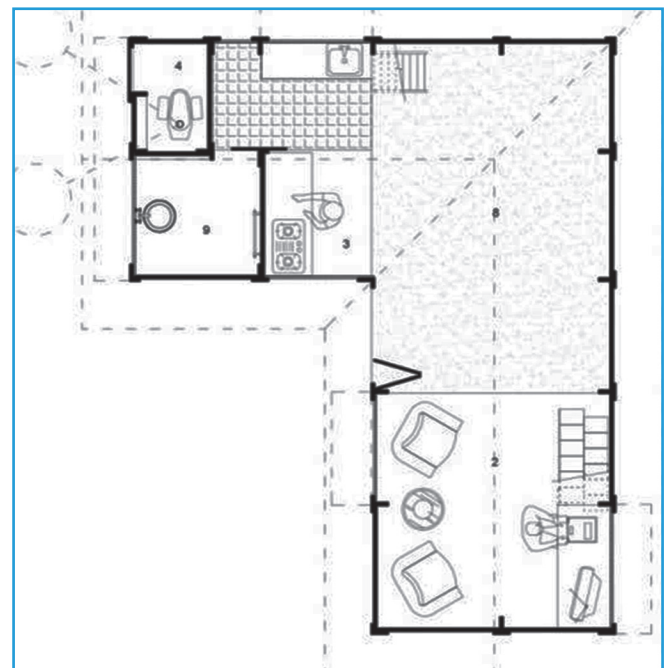


**Figure 6** Views



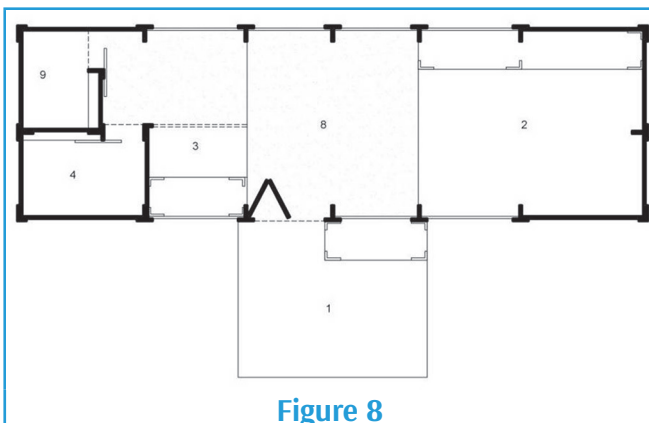
- Plan with segregated toilet and bath spaces
- Adapting the structural system to various materials

**Figure 7**



- Developing the plan/form for a rectangular unit
- T-Structure design with bolted panels

**Figure 9** The plan adapted to an L shape, per site requirements



**Figure 8**

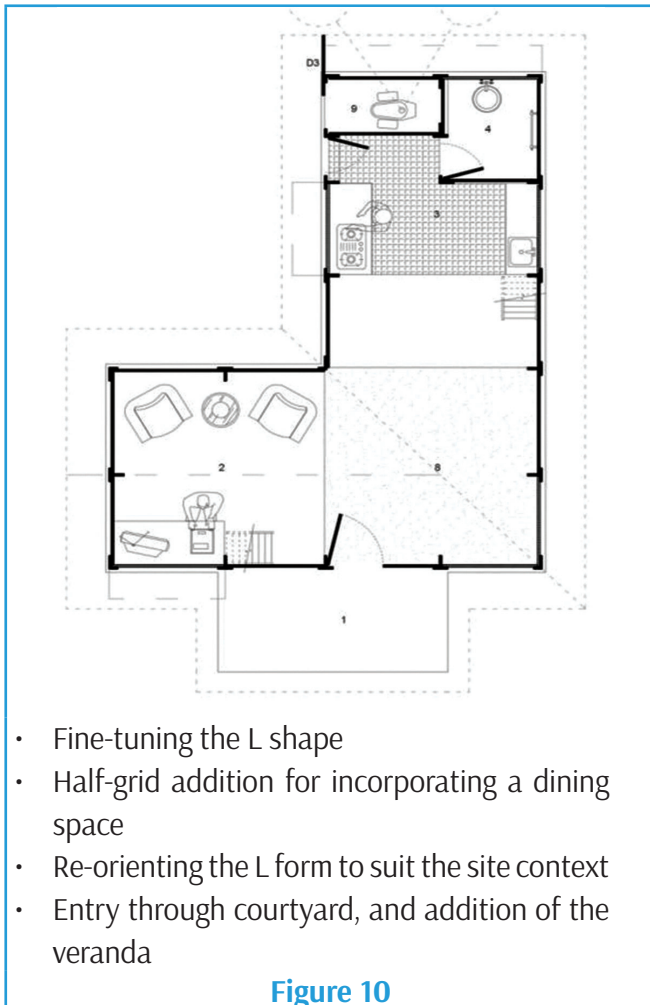


Figure 10

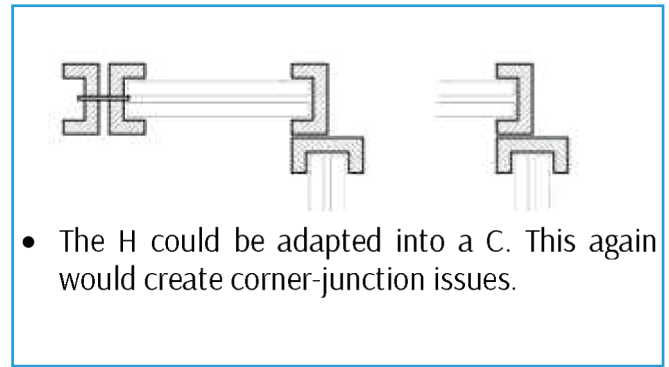


Figure 13

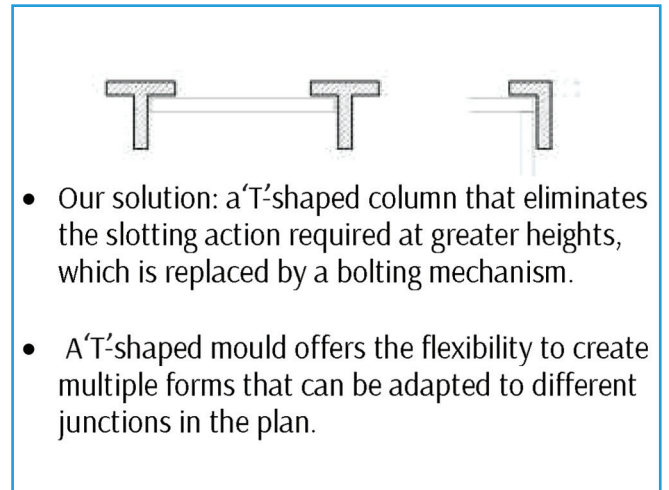


Figure 14

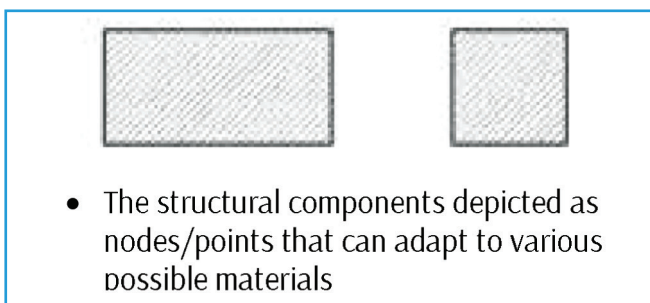


Figure 11

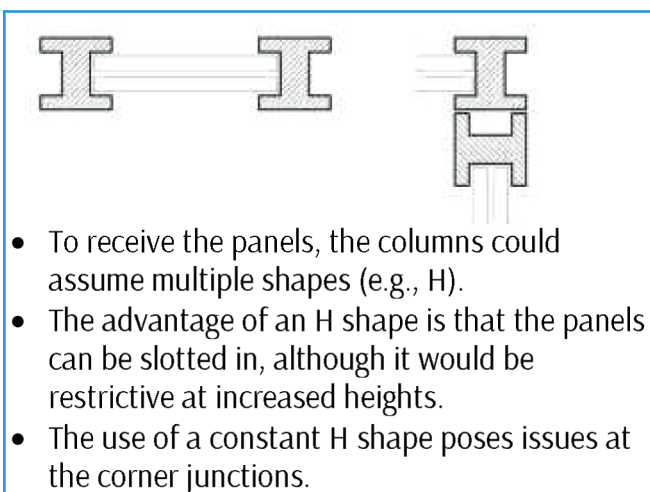


Figure 12

## 2.2 Genesis of the Structure

- The structure can handle the load of one RCC slab.
- Initially, a varying grid size was used due to the spatial divisions created in the wet core, with a 1.4 m depth for the toilet and a 1.6 m width for the bath. As the design progressed and explorations were performed, practical issues concerning material size, space efficiency, and asymmetrical roof installation became looming concerns. To smooth out the production and installation processes, we shifted to a uniform grid of 1500 mm. This resolved the panel sizing issues to a uniform width of 600 mm and a depth of 300 mm throughout.
- The lofts would be separate entities that could be integrated later.

### 3 BUS Structure

#### 3.1 Structural Configuration

**Table 1** Design parameters

Sl. no.	Component	Structural design parameters
1	Vertical load-bearing element	Self-weight Weight of panel Weight of roof Compressive, flexure, bearing strength Withstanding stress during lifting and transportation Ease of casting Height
2	Panels	Self-weight Flexural strength, bearing strength Ease of casting
3	Pedestal and foundation	Providing stability during erection Soil condition, plinth height
4	Roof	Span Weight Connectivity with vertical elements

The structural system of the BUS house is a framed system. The design parameters for the structural system are shown in Table 1.

#### 3.2 Choice of Material

Various materials can be adapted for the ex-situ type of cast/prefabricated component (Table 2). While structural steel was not considered during the design of the prototype, the other three types were considered. The preferred material appeared to be either ferro-cement or ferroconcrete. Figure 15 shows ferro-cement being used in the mass production of community toilets. Ferro-cement is labour-intensive and cumbersome since the product has to be made

by ‘plastering’ rich cement mortar on either side of the reinforcement mesh. The compressive strength of mortar is generally less than that of concrete for a given amount of cement. This is because of the absence of coarse aggregates. In addition, the presence of wire mesh in ferro-cement does not permit the use of coarse aggregates. Ferroconcrete, however, does permit coarse aggregates sized 3 mm to 10 mm since the wire mesh is eliminated. This makes it possible to create elements by ‘pouring’ as opposed to ‘plastering’. The introduction of coarse aggregates reduces the quantity of cement without altering the compressive strength.

**Table 2** Choice of materials

Sl. no.	Material	Relative merits/demerits
1	Conventional concrete	Low strength/weight ratio Cannot be cast in thin sections Can be done with relatively low workmanship Widely accepted
2	Ferro-cement	High strength/weight ratio Can be made into very thin sections High cement content per unit volume Needs skilled workmanship Requires skill in the preparation of skeletal reinforcement with mesh
3	Ferroconcrete	High strength/weight ratio Can be made into thin sections Relative low cement content per unit volume Quality depends on the mould and the flow ability of the concrete Elimination of mesh
4	Structural steel	Very high strength/weight ratio Connection between elements needs detailing Needs maintenance with regard to corrosion



**Figure 15** Casting and erection of ferro-cement for a community toilet (Sholingur, Tamil Nadu)



Making thin ferroconcrete elements is tricky as well. The availability of viscosity-modifying agents (plasticisers) and various fine materials (sand, quarry dust, fly ash, granulated blast-furnace slag) makes it possible to easily pour concrete into moulds capable of making thin sections. In many ways, ferroconcrete is identical to conventional concrete except for the thinness of the sections.

### 3.3 Choice of Cross-section

Various sections—such as rectangular, double flanged sections (I, H, and channel sections), angled sections (L sections), and even hollow sections—can be considered for the vertical load-bearing elements. The H section appears to be the ideal choice with regard to the ease of ‘inserting’ the precast panels. There are many examples of compound walls being made of such sections. However, the casting of an H section has to be carried out either in two phases (the bottom flange followed by the web and the top flange) or by an extrusion process. Another possible way to cast an H section is through a ‘gang-casting’ process, as is done in a casting yard, where pre-stressing has to be done. A disadvantage arises when the panel has to be inserted in between the flange

#### 3.4.1 Casting Process for Vertical Elements, Ferroconcrete Panels, and Pedestal

The casting process has nine stages:

- (i) Preparation of reinforcement
- (ii) Preparation of mould

of an H section; the panels have to be lifted to roof height and then inserted right below. We decided, therefore, to try casting T sections as the vertical elements. This alternative meant that the panels had to be bolted. The sequence of dimensioning the geometry of the T section becomes a function of the weight of the panel to be transferred and the minimum edge distance for bolting.

### 3.4 Structural Design

The introduction of High Yield Strength Deformed (HYSD) reinforcing bars necessitates the provision of nominal cover concrete, and the ferroconcrete thickness cannot be less than 30 mm. Figure 16 shows the cross-section of the vertical load-bearing elements (T section). The vertical load capacity and the flexural capacity were computed as per the provisions of IS 456-2000 (2007). As a compression member, the load-carrying capacity is 100 kN (IS 456-2000, 2007). As a flexural member, the sections are capable of withstanding a design moment of 2.99 kNm. The wall panels were also designed using ferroconcrete elements. Two types of reinforcement arrangements could be adopted (Figure 17). The specifications of the structural elements are presented in Table 3.

- (iii) Pre-placement of holes using cut PVC pipes
- (iv) Mix proportioning of concrete
- (v) Mixing
- (vi) Placement of concrete into the mould
- (vii) Surface finishing
- (viii) De-moulding
- (ix) Curing



Preparation of reinforcement

Ingredients for concrete

Casting

**Figure 16** Typical casting process carried out in the laboratory trials

**Table 3** Specifications of structural elements

Sl. no.	Details	
1	Self-weight of T section	0.89 kN (~90 kg) 0.28 kN/m
2	Grade of concrete	M20 with 6.0 mm and down-sized coarse aggregates Proportion Cement: filler (quarry dust or fly ash) : sand : coarse aggregate : water) 1 : 0.6 : 2.7 : 1.8 : 0.45 Plasticiser: 1% to 2% by weight of cement
3	Grade of steel	Fe415 or Fe500 (HYSD or TMT rebars)
4	Stirrups	4 mm GI @ 150.0 c/c
5	Clear cover	15.0 mm
6	Ultimate moment capacity	2.99 kNm
7	Moment due to self-weight (assuming columns are lifted at the ends)	0.341 kNm x 1.5 (load factor) = 0.51 kNm
8	Weight of 600 mm panels	0.72 kN (~72 kg)
9	Weight of 300 mm panels	0.36 kN (~36 kg)
10	Weight of wall panels transferred to each column at a spacing of 1.6 m	5 panels x 0.72 = 3.6 kN Weight of T section = 0.89 kN Total weight = 4.5 kN
11	Weight of roof truss plus light roof cover (assumed to be 1.0 kN/sq m) transferred per column	1.0 (kN/sq m) x 3.2 (maximum span) x 1.6 (column spacing) x 1/2 = 2.56 kN
12	Design factored load on column	4.5 + 2.56 = 7.06 kN x (1.5) load factor = 10.6 kN
13	Load capacity of column	100 kN
14	Weight of pedestal	0.48 kN (~48 kg)
15	Design factored load on each footing (say SSM)	10.6 kN + 0.48 x 1.5 = 11.32 kN
16	Steel roof truss elements	40 mm hollow tubular sections (1.5 mm thickness minimum), 2 rafters + 1 knee (tie member) and 2 purlins
17	Roof cover	Corrugated sheets with J bolts



### **Embodied Energy Calculation**

Vertical member (T-section) volume	= [(0.2 × 0.03) + (0.17 × 0.03)] × 3.2 = 0.03552 m <sup>3</sup>
Volume of panels for height of 3.0 m	= [0.03 × 1.6 × 3.0] = 0.144 m <sup>3</sup>
Total volume of concrete	= 0.03552 + 0.144 = 0.179 m <sup>3</sup>
Cement: filler : sand : coarse aggregate	= (1 : 0.6 : 2.7 : 1.8)
Assuming that filler + sand + CA constitutes crushed stone, the ratio can be represented as (1 : 5.1)	
Thus, cement content	= 0.1795 × (1/1 + 5.1) = 0.0294 m <sup>3</sup>
Crushed stone content	= 0.1795 × (5.1/1 + 5.1) = 0.15 m <sup>3</sup>
Cement required in kg	= 48.5 kg (density of cement assumed as 1650 kg/m <sup>3</sup> )
Crushed stone content	= 0.15 m <sup>3</sup>
Embodied energy of cement	= 48.5 × 4.2 MJ/kg = 203.7 MJ
Embodied energy of crushed stone	= 0.15 m <sup>3</sup> × 780 MJ/m <sup>3</sup> = 117.0 MJ

### **STEEL QUANTITY**

For T columns	= 4 rods × 3.2 m length × 8 mm $\phi$ × density
	= 4 × 3.2 × area of 8 mm $\phi$ × 7850
	= 4 × 3.2 × ( $\pi$ × 0.0082/4) × 7850
	= 5.05 kg
For GI stirrups	
Each stirrup $\approx$ (0.5 m × 22) number over a span of 3.2 m	= 11 m × ( $\pi$ × 0.0042/4) × 7850 = 1.085 kg
For mesh	
0.83 kg/m <sup>2</sup> × 1.6 × 3.0 = 3.984 kg	
Total steel	= 5.05 + 1.085 + 3.984 = 10.119 kg
Embodied energy of steel	= 10.119 × 42.0 MJ/kg = 425 MJ
Total embodied energy (per 1.6 × 3 m)	= 117 + 425 + 203.7 = 745.7 MJ
<b>Embodied energy/sq m</b>	= 745.7/(3 × 1.6) = <b>155.35 MJ/m<sup>2</sup></b>

The embodied energy is as per the quoted reference (AVIE energy source). It is 30% lower than that of equivalent ferro-cement or conventional concrete.

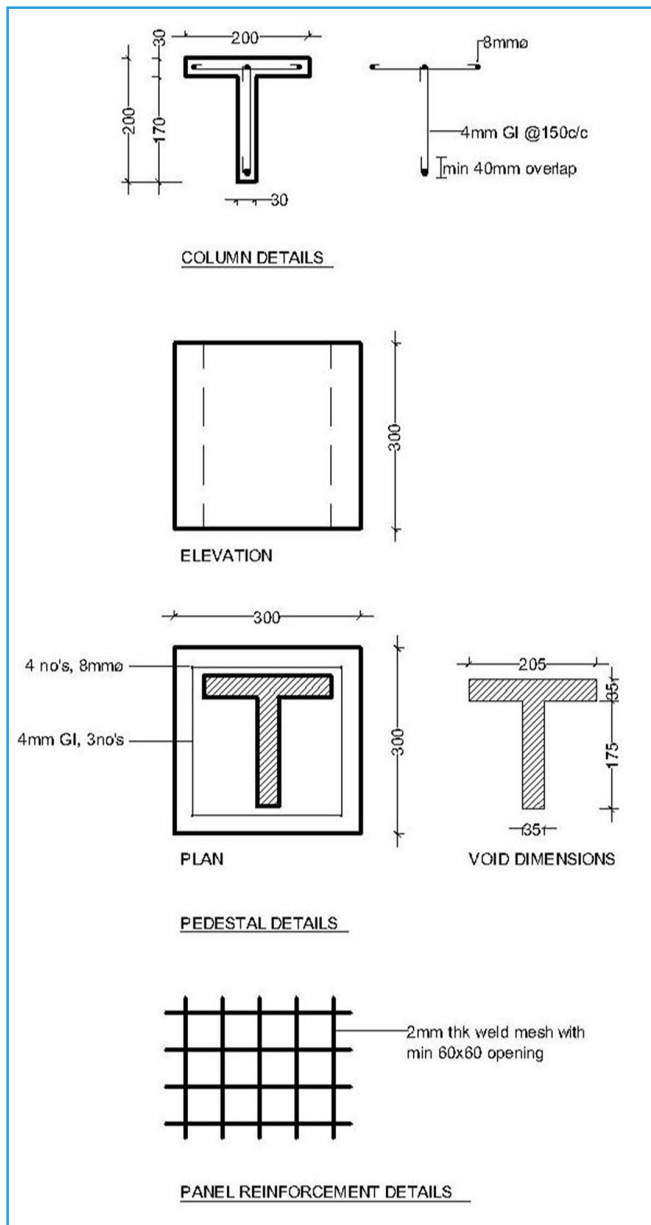
## **4 Walking the Talk**

Moving from the safe environment of the college lab, where the column and panel prototypes were created, to a site 40 km from the city reveals that the true challenge lies in 'walking the talk'. Apart from the logistical issues of material transport, labour sourcing, construction planning, and cost control, one faces continuous decision making that could instantly change the course of events.

We retained a contractor from the village and trained him in our methodology. His quote for the

BUS would have made it an Rs 6 lakh structure! The local ferroconcrete entrepreneurs—to our surprise, chagrin, and concern—were not enthusiastic about the free training or the fact that we would be buying the panels or columns from them. The quantum of work did not spur them to proactive action.

As the young local labourers were disinclined to work, we eventually enlisted a few senior (aged 60 and over) unskilled labourers to work on this project. Construction began in November 2013 and was heavily interrupted by festivals and family and farming commitments.



**Figure 17** Structural good for construction drawings

Having only one T-mould (as we did not want to invest in more) delayed the process.

Using a frame to cast the panels was a faster process—once the concrete set in (about two hours), the frame could be de-bolted and used to cast another panel. This ensured we had a supply of at least four panels/mould/day.

## 5 Timelines

We initially made a schedule that clearly demarcated the stages of construction into

Fabrication and procurement:

- (i) Work on site
- (ii) Assembly

This amounted to a total of one month of work, as per our planned schedule.

The actual timelines for the prototype worked out as follows:

**Table 4: Project Timelines**

Month, Year	Days Worked	No. of Labourers	Work Done
November 2013	5	10	Pit excavation Foundation for columns Bar bending
December 2013	15	31	SSM completed Plinth backfilling All pedestals cast (23) All T columns cast (14) 24 Panels cast Twin pit excavated
January 2014	24	85	All L columns cast (9) 56 + 22 panels cast (solid) 6 + 13 panels cast ( <i>jaali</i> ) Installation of all columns Fixing of panels up to height of 7'
February 2014	20	31	Carpentry Roof fabrication Plumbing Roof sheet fixing
March 2014	16	46	Carpentry Veranda work Electrical Fixing of remaining panels
Total	80	203	

Completion of the project took 80 working days spread over four months.

## 6 Costs

- The costs do not include travel, administrative, or consultation expenses.
- The cost per sq ft was about Rs 610 for 500 sq ft of space, or USD 10 per sq ft (for 350 sq ft of

**Table 5 Costing**

Sl. no.	ITEM	Description	MATERIAL	LABOUR	TOTAL
			in INR	in INR	in INR
1	Foundation	Pedestals, packing flooring with RR	9500	10800	20300
2	Columns	-	18000	14500	32500
3	Panels	-	25600	14500	40100
4	Roofing	Recycled plastic roof	33200	43000	76200
5	Flooring	Cement flooring	17660	6600	24260
6	Toilet and Bath	Indian WC, IPS flooring	23000	4000	27000
7	Electrical	Seven light points, 5nos 5Amp point	6500	5000	11500
8	Carpentry	Windows, doors, lofts, louvres, and roof gable end	42000	31100	73100
<b>GRAND TOTAL</b>					<b>304960</b>
					<b>(about USD 5085)</b>

floor area plus 150 sq ft of loft area).

- The cost of the foundation was about 7% of the total cost compared to conventional foundation costs of 15%-20%.
- The wall component was 24% of the total cost,

compared to a conventional wall cost of 40%.

- Unskilled labour accounted for 14% of the total cost.
- This is the amount the homeowner can save if all unskilled labour is provided by the household.



**Figure 18** Construction photos



**Figure 19** Construction photos





Figure 20 Completed prototype

## 7 Reflection

### 7.1 Construction Components

#### 7.1.1 Pedestals

The casting of pedestals was a smooth process, but we later realised the T inside the pedestals was not uniform, leading to the columns not sitting plumb. There were multiple elements to align, which made the process cumbersome. The pedestal can be avoided if a rigid, neat platform can be prepared on Sized Stone Masonry. This avoids the need to check the tube level at the top and helps to easily mark the centre line. The T flange of 200 mm is self-stable, which has to be taken advantage of.

#### 7.1.2 Foundation

The regular excavation, SSM, footings, etc., were labour-intensive, time-consuming, and non-reusable.

#### 7.1.3 T-Shape

Though the T was developed with the intention of being an easy-to-cast column, using it necessitated

the use of a nut-and-bolt panel system; this added labour and cost in drilling holes and purchasing bolts. Creating these punctures produced a secondary issue regarding precision. Aligning these heavy columns was a mammoth task. Further, in case of relocation, realigning the pre-made holes would certainly be an issue of concern. The third issue involved chipping; there were unavoidable chippings on one side of the panel/T once the hole was drilled. This was a quality concern with no implications for strength. Finally, we also realised that the bolts projected into the interior space, causing a safety issue; rounded caps needed to be placed over them to provide a safe finish, which again added to cost. The nut/bolt system also posed several restrictions on the kind of material that could be bolted on. The material needed to be drillable and easy to lift; though materials like ferro-cement/concrete and GI sheets fit into the pallet, there were restrictions on the use of widely available local types of stone.

#### 7.1.4 Panels

We did not want the panels to look like compound wall panels, so we made them wider. This worked well aesthetically. Handling them, however, was a more cumbersome affair than envisioned; carrying and fixing them at higher levels was challenging as well. Initially, we did not use plasticiser, which led to a few visible craters on the surface. We managed to get a decent finish on only one side of the panels. Painting them with cement and sand slurry, applying putty to cover the undulations, and applying mud mortar mixed with an adhesive did not work, most likely because of the thinness of the panel.

### 7.2 Quality Issues

The BUS house invites the homeowner to be part of the building process. This helps reduce costs and establish pride. However, this means the columns and panels will be produced by unskilled labour, and the finished product might not possess the beauty one would like to see in something new. This can be overcome by the following measures: a pan mixer, plasticiser, experienced and qualified supervision, a controlled environment, and constant curing.

### 7.2.1 Other Issues

Pre-preparing the holes is essential to avoid drilling at a later stage.

Drilling through reinforcement is not easy in ferroconcrete.

We could not use other locally available materials like *jaalis*, which could not be fixed to the T column. *Chajjas* could be fixed from the outside, but stability in wind-prone areas, without the option to grout inside the wall, may be a point of concern.

## 7.3 Reflection: What Worked Well

### 7.3.1 The Design Approach

The wet core/dry core design was tactfully adapted to the specific prototype. The transformation of the initial rectangular plan to an L shape with the addition of a dining grid demonstrated the versatility of the concept. The theoretical concept of adaptability and flexibility in spatial formation is now a reality. The flexibility for horizontal growth in the house structure is also a certainty. If the caretaker had been appointed, we would have involved him in choosing the materials used for the courtyard and the kitchen *otta*, the placement of doors and windows, and the creation of the panels. The courtyard design and treatment with deal wood convey the unique identity of this house, which may change depending on the next user's input. Since the village of Tharalu does not have a strong ethnic influence or flavour, we did not adapt the courtyard design to reflect local characteristics. The size and internal space worked out very well.

### 7.3.2 Component Sizing

The panel heights of 1' and 2' worked well both on paper and on-site. They provided ample flexibility to create various sill and lintel heights, as well as appropriate opening sizes at various levels.

### 7.3.3 The Hipped Roof

It was possible to make all concrete columns the same height. A single mould was sufficient to cast

all the columns. We provided openings at the upper loft levels for thermal comfort. With this roof, the upper-level openings are protected from rain on both sides.

### 7.3.4 Compatibility with Other Disciplines

The fixing of doors, windows, carpentry work, electrical (exposed) work, and plumbing did not create unsolvable interface issues. Fixing picture frames or shelves using a 4 mm drill was possible without chipping.

### 7.3.5 Design Changes and Reusability

We installed panels in some areas and later decided to replace them with windows. We could unscrew those panels and reuse them. All elements above floor level are reusable, including the roof. We envision that the structure could be dismantled for reassembly in four to five days with three unskilled labourers at a cost of INR 5000-6000 (USD 85-100). We expect to salvage 70% of the civil costs. The foundation costs cannot be recovered in this version.

### 7.3.6 Criteria for User Perception

The structure was erected by unskilled farmers with no prior construction experience, which is not possible in any other type of construction. With proper supervision, quality can be improved. People who worked on this project felt they could do it again in the future if they were to build for themselves; there was an element of pride. The 'Shape' aspect of the BUS has been well received by visitors. Since it is a prototype, it is too early for us to develop criteria for user perception.

### 7.3.7 Forerunner to the GRIHA Project

The 10' x 10' grid worked well in terms of structural spacing, material sizing, and spatial efficiency for various functions. We are fine-tuning the sizes and using the wet core/dry core concept to incorporate into our first GRIHA project at Kundapur, Udipi District. The BUS form has been easily adapted to suit their local culture and vernacular practices. It is likely we will use ferroconcrete as a skin in a core house, for both the wet and dry areas, with other



layers added according to the inhabitant's financial capacity.

## 8 Path Forward

The BUS idea is bold and exciting with numerous possible applications. The market is severely constrained by the range of options available to homeowners in the affordable housing sector. BUS version 1 achieved its stated objectives, except in terms of quality. The production process requires quality control and good supervision. We are working on the possibility of outsourcing the production of columns and panels to large-scale entrepreneurs in ferroconcrete building systems. The challenge lies in trying to work with the available sections, and/or convincing them to make sections of our choice, while ensuring costs do not increase. This would leave only the assembly work of the wet and dry cores to unskilled labour.

We are also looking to analyse materials such as Sadarahalli, deal wood, bamboo, and *Casuarina*. We intend to research materials that are equivalent to ferroconcrete in terms of security, are environmentally friendly, and are easy to transport and reuse.

The BUS model has tremendous potential and versatility. It can function as a caretaker's quarters, a farmhouse, a BPL villager's abode, or a mobile home-cum-office. It is a scalable solution that can be dismantled, transported, and reused. We excitedly seek to combine the convenience of fast-to-put-up living spaces with the emotional value of homeliness!

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Tumbleweed Tiny House Company (n.d) <<http://thetinylife.com/what-is-the-tiny-house-movement>>



## **Chapter 2**

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# **Design for Well-being: Approaches and Methods**





paper

21

Technology-led human development:  
From ability to capability

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# Technology-led human development: From ability to capability



## Abstract:

The capability approach seeks to serve as an alternative that is better than human rights for approaching the issue of sustaining human development (sustainability) as a human capability. The expansion of capabilities valued by people in the context of their development is said to usher appropriate human development. Concerns over unsustainability are often attributed to the consequences of anthropogenic use of technology since the industrial revolution. If technology is seen to expand human capabilities, the fact that the consequences of its use result in unsustainability requires clarification. In an attempt to clarify, this article argues for distinguishing ability from capability and understanding tools as means for extending abilities to capabilities. Design specifies the process of extension, and technology is defined as the context of extension, generally. From the perspective of design, this paper discusses the expansion of capabilities as the extension of human abilities to capabilities for human development.

**Keywords:** *ability, capability, tool, extension, technology, sustainability, design*

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## 1 Introduction

Prior to the World Commission on Environment and Development (WCED) definition, sustainability was conceptually founded on the core principles of human rights and dignity. Synonymous with the goals of human development, Articles 22, 26, and 29 of the UN Declaration of Human Rights provide for the free and full development of the human personality. The intellectual issues that human rights discourse needs to overcome are not new, and they affect interpretations of human development since sustainability is based in rights. As it seeks to address these intellectual issues, the capability approach is positioned to be a better alternative for understanding human development.

*The process of development is not separable from the expansion of human capabilities for its intrinsic as well as instrumental value (Sen, 1996). The WCED report pitches sustainability as the ability, not of the individual but of all humans (Brundtland, 1987), to sustain human development. It remains to be understood whether such ability exists innately (nature) or is learned (nurture), akin to Sen's observation of Smith's remark on education being peculiar (Sen, 1996). That anthropogenic change has affected the habitability of the earth helps us infer two possibilities: (1) PosA, that we had been oblivious to this fact while pursuing development and (2) PosB, that we had knowledge of the consequences of our<sup>1</sup> actions but did not sufficiently heed the warnings. PosB provides a case for developing and*

<sup>1</sup> This question can be divided across generations unless humanity as a whole is not bound by it.

underdeveloped nations to question developed nations for shirking their responsibility regarding a planet-wide humanitarian concern. More recently, a similar behaviour has led the European Commission to try the UK for breaching an obligation to improve its air quality (McGrath, 2014). When technology-led, developed nations falter, reasons to believe in PosA are strengthened, though we can no longer claim ignorance (Dechert, 2014). This also leads us to infer that sustainability can be a belief in our ability to conduct ourselves with full awareness of the consequences of our actions. Though the belief may have arisen from our technical capability to intervene in systems of the scale of the earth's systems (climate engineering, geo-engineering, etc.), the degree of control we can have following an intervention of such global magnitude is a matter on which intellectual circles are very uncertain. Proposals to counter global warming by intervening in the ocean system are exemplary cases. This causes us to ask whether sustain'ability', in the context of being led by technology, is a capability we should be wary of or an ability that resides more equitably within all members of humanity.

The prevention and remediation of select consequences of technology is the subject matter for sustainability, whose proponents admit that the ontology of sustainability is strange (Ehrenfeld, 2009). Pursuant to the ontological status of artefacts espoused in philosophy (Hilpinen, 1992; Thomasson, 2007; Hilpinen, 1993), and drawing on cognitive ideas treating even language as an artefact (Clark, 2004) (Wheeler, 2004) enabling the extension of the mind (Clark & Chalmers, 1998) (Clark, 2010), this article argues for conceiving all artefacts, authors, and authorship as tools, tool users, and tool making, respectively. This conceptualisation of tools is extended in retrograde to understand the ontological statuses of being and activity as 'tool' and 'tool-use', respectively, with the objective of disclosing the entangled, co-constitutive relationship between humans and technology. This conceptualisation also enables an understanding of the role of design in the context of technology-led transitions to sustain human development.

Section 3 elaborates on ability as pertaining to agents in general and to human constitution or being. Further, it provides broad definitions of 'capability', technology, and design. Section 4 describes tools generically as 'artefacts' defined in philosophy and attempts to broadly situate them in human history. Section 5 explores the potential of the concept of extension and ontological parallels between being and tools through phenomenological explanations of authorship (i.e. making artefacts and poverty). In light of the preceding sections, Section 6 conceptually explores what sustainability can be at the individual level, though defined as a collective one, and situates the prescription for sustainability as a human capability to communicate effectively. Section 7 discusses the implications of the ontology of tools and the concept of ability extending to capability. Summarising the main messages, Section 8 concludes this research article.

## 2 Method

This research article is a conceptual exploration of the ontological status of all artefact types as tools. The wider anthropological and archaeological sense of the word 'artefact' and the concept of 'extension' are leveraged to connect phenomenological approaches discussing tools and development approaches discussing human capabilities. In the context of design, this leveraging is central to the inferences derived in this article.

## 3 Ability and Capability

The Merriam-Webster online dictionary defines ability as follows (Idictionary, 2014a):

Ability (noun) – 1 a: the quality or state of being able; b: competence in doing. Date: 14<sup>th</sup> century

Etymology: Middle English *abilite*, from Anglo-French. From Latin *habilitat-*, *habilitas*, from *habilis* apt, skilful

Ability is the agent's potentiality for capability (explained further in this section). It refers to

mere existence or being(ness), separate from any processes of consciousness, due to which the event of the agent realising its capability is plausible. An agent's substantiality affords this potentiality. An agent's reflexive responses, like knee-jerk responses to certain stimuli, are also by definition abilities since these are primarily required for securing that very substantiality of the agent from other prying agents. The process of realising abilities complementarily requires the agent to expend energy in volition. Ingesting resources converts them into forms fit for assimilation, partly due to which the involuntary needs of the agent are automatically met. However, the event of the reserves, or the results of assimilation, being available for volition and subsequent action is not completely excluded temporally from that of their serving involuntary needs. The ways in which the reserves can be spent are informed by experiences of perceived value in return for their expenditure. A list of our abilities comprises those that are inaccessible for volition (i.e. conscious [voluntary] control that nevertheless lets us *be*). Some examples are breathing, hearing, smelling, and tasting, which one can choose not to initiate but cannot control perceiving once the senses receive the signals.

Merriam-Webster's online dictionary defines capability as follows (Idictionary, 2014b):

Capability (noun) – 1: the quality or state of being capable; *also*: Ability 2: a feature or faculty capable of development: Potentiality 3: the facility or potential for an indicated use or deployment. Date: 1587

Capability (with its shared etymology with 'capacity') presumes an organ extending in space (length, area, volume, etc.) providing opportunity. Capability is extended ability. Tools, as means of extension, can be substantial, like a crowbar, car, or stone, and can also be insubstantial, like language, knowledge, and institutions. Capability is realised in the agent's acts of volition, which afford the fathoming of tools (naturefacts) (Hilpinen, 2011 quoting Oswalt 1973), tool use (e.g. a Bonobo using a piece of wood as a

club to break nuts) (Attenborough, 2002), and tool making (e.g. the Caledonian crow using a piece of wire to create a hook) (Weir, Chappell, & Kacelnik, 2001).

Capability is generally attributed to active entities, like animals and individuals, equipped with tools. However, within anthropomorphic teleological explanations, capability is also attributed to non-living entities, for example, the capability of a metal to be fused (Idictionary, 2014b). Anthropomorphic and teleological accounts of tools suggest that their ontological status is comparable to that of agents. Observing further examples of the use of ability (Oxford Learners Dictionaries, 2014a) and capability (Oxford Learners Dictionaries, 2014b), it can be proposed that agents (active embodiments) are constitutionally just able, and when externally equipped with tools (passive embodiments), they assume capabilities (i.e. they become capable). Technology is a context of extension and not a thing in itself. The process of specifying this context is design. Being capable of doing more than one could ably do increases opportunities for achieving a life one values and can also accelerate this very process of achievement. Consequently, realising one's full potential seems more plausible.

## 4 Tools and Human History

Humans are unique among life forms in being capable of communicating using language (Corbalis, 2003). Language as a tool has enabled people to think (Wheeler, 2004), extend their cognition (Clark & Chalmers, 1998), gather as groups, organise efforts, be enterprising, and effect changes in resources to better produce tools, which in turn have equipped them to combat threats to survival better. Consequently, tools have been extending humans' rather frail abilities to unlimited capabilities, but this has not been uniform across the world wherever people thrived into civilisations. Each progressed at its own rate determined by locally available resources and the personal limitations of the populace in effecting change for their advantage. This resulted in the great diversity of human beings,

inculcating and thriving with worldviews that fit their local environment, determine their disposition, and situate them in ‘the<sup>2</sup> world (Diamond, 1997). The availability and spatial distribution of necessary resources that the environment provides for the sustenance of life is unequal and dependent on various factors. Wherever people had access to more resources, they grew to be more dependent on them. Further, within the governance structures of the world and its limited resources, this has unfortunately meant that increasing numbers of coexisting peoples have decreasing access to resources.

## 5 Potential of the Concept of Extension

Conceiving any intervention as a tool that extends human ability to capability can potentially explain (Section 5.1) the ontology of being. Section 5.2 situates the acquisition of tools and their use as the process of realising and expanding human capabilities, which is termed ‘human development’ within the capability approach.

### 5.1 Tools and being

An agent becomes capable by being able to fathom tools and tool use—realised either in existing objects (naturefacts) or by synthesising them out of available resources to meet a realised end (artefact)—for effecting change. Tools extend abilities to capabilities. Tools, as means, can be tangibles, like a stone, crowbar, or sling, and can also be intangibles, like language, knowledge, or institutions.<sup>3</sup> For human agency, tools extend limited human abilities to capabilities that can be limitless. Consider a craftsperson making an artefact. The craftsperson handles a tool to mend the artefact (in the making) until it meets his or her representation of the desired specification. Without the tool, the craftsperson may be incapable of

achieving the specification and hence making the artefact. However, not all work needs a tool. There are vocations where the craftsperson uses his or her hands to make the artefact as desired (e.g. modelling clay). In such a situation, backcasting the concept of the tool-making-the-agent-capable, we can say the craftsperson uses his or her hands (embodiment) as the tool. Such statement, though normal in language, would have been incomprehensible had we (or our language) not presumed that the craftsperson’s identity is split into the substantial embodiment E and an insubstantial capability to intend C. With this knowledge, it can now be stated that in the phenomenon of craftsmanship, C engages E as a tool in effecting the artefact. C, as a representation of specification X, assumes substance (to be) from being insubstantial (to not be [i.e. *artefact of the mind*]) (Thomasson, 2007) and becomes capable by definition, as substance also affords being a tool.<sup>4</sup> The structure of C (as a capable artefact in the making), as an effect that has resulted as a Gestalt negative (in 3-Dimension, as sculpting clay is the phenomenon of interest) of the positive activity (impression) of E based on natural law/principle, indirectly provides a representation as knowledge (as that which will be part of C eventually and hence needs to be retained), say K. When E impresses without encroaching into K, it affords access to K and serves as a tool (*ready-to-hand, Heidegger*) until the capability C is fully realised (i.e. the artefact is made as intended). When the impression of E is insufficient or encroaches into K, then it cannot serve as a tool (*present-at-hand, Heidegger*) that is involved in creating the artefact (i.e. realising capability C).<sup>5</sup> This, while the being (craftsperson), as a whole, assumes ability (i.e. *to be in deed*). The ability C that gets extended is its representational-indefinite-ontological status to a material-definite-ontological existence in the form of the artefact that is effectuated through E. Hence, being can be phenomenologically considered to comprise three

<sup>2</sup> ‘The’ world does not exist for us; we can only access ‘our’ world, which is the world as it is disclosed *by us*, (Verbeek & Kockelkoren, 1998) quoting Don Ihde.

<sup>3</sup> While tangibles can possibly engage or disengage users (Borgmann, 1984), it seems that intangibles, as things, cannot but engage users unless they subvert the user, taking decisions and scripting (Akrich, 1992) themselves.

<sup>4</sup> The notion of designers inscribing (Akrich, 1992) their value systems into the artefacts they design may be occurring in this manner.

<sup>5</sup> The same notions of C, E, and K are applicable to the tool itself, as an artefact, as it also keeps wearing out under the artefact in the making (i.e. as a tool).



actions: activity that fits K, activity that encroaches into K, and inaction. The first two involve the being as a tool engaged by C (i.e. the representation). Inaction that also avoids reflexive reactions is synonymous with vegetation as a condition of (the) being just able. Hence, the being and being can be conceived as tool and tool use, respectively.

## 5.2 Resources, volition, and poverty

An agent's energy reserves afford its voluntary expenditure, and such expenditure is often directed to gather reserves further. At times when the agent does not source and consume resources (tools) in accordance with its periodic energy requirements, its dwindling energy reserves may not be sufficient for maintaining itself while also leaving nothing for volition. In such situations, the agent's ability to maintain itself is stressed, and such a deprived agent needs to be primed (externally) with resources. In being temporarily made capable, the agent can then choose to knowledgeably (tool) expend these reserves voluntarily towards regaining the state of maintaining necessary reserves by sourcing resources for continual consumption. If it fails to act thusly even after being primed with means (tools), the reserves dwindle bringing the agent back to a state where it needs to be primed again. To know how to gather and thereof, gathering resources required for priming oneself is a recurring problem for some due to either their unavailability or incapability. Such people are categorised as the poor, and consequently they need State's help. Poverty can be defined as an individual's recurring incapability to gather sufficient reserves for performing productive work. This incapability makes them vulnerable to external disturbances that can sooner or later threaten their very survival. This incapability can be attributed to various reasons that can be broadly classified under those within their control (lack of motivation, infirmity, and unwillingness to work) and those outside their control (lack of work, physical/mental disability at birth, affordability [low incomes coupled with high commodity prices],

and employability). Consequently, they depend on the economy rather than contribute to it. This is a deplorable state if they are able-bodied (i.e. able to be capable) but continue to be unproductive. The recent National Rural Employment Guarantee Scheme (NREGS) of the government of India is exemplary in this regard.

## 6 Sustainability as a Human Capability to Communicate

Sustainability is the ability to meet our needs without compromising the ability of future generations to meet their own (Brundtland, 1987). Though mentioned as a collective ability, it is primarily an individual ability to act in a way that does not consume opportunities that afford others, coexisting and to come, to act similarly. Action, as a response to requirements, can be voluntary or involuntary. When voluntary, it can be attributed to the being's volition, and when involuntary it can be attributed to instinct and self-organising processes in response to changing environments.<sup>6</sup> Such adaptation affects populations through to the individual's constitution. In comparison with the evolution of complex features like the eye, volition is more recent and an ability that is characteristic of the extremely high interconnectedness of our constitution that the course of self-organization is unfolding into. In this sense, volition might be privy to humans. Self-organisation is considered to be the character of all life and, thermodynamically, of all open systems. Entropy is the exhaust of the evolution engine, and consequently even involuntary activities of life increase the disorderliness of the universe that provides for our larger cosmic being. The universe, taken as an isolated system comprising open systems, is progressing towards increasing its disorderliness, through both voluntary and involuntary actions that are possible for its constituents. In such a scenario where both avoidable and unavoidable activities increase the rate at which opportunities will be consumed, the prescription for sustainability

<sup>6</sup> In connection with the evolution of artefacts and contexts, this can be compared with the propositions of Petroski (1992) and Schlossberg (1977), respectively.

as a human ability is to avoid as much voluntary activity as possible so that more opportunity is afforded to the coexisting and those to come. As this should be the agenda for all human conduct, in a situation where such a prescription may not be fathomable to all, our constructive discontent should be directed towards ensuring the successful communication of this prescription to all. Beyond whatever is necessary for self-maintenance and self-replication, this alone should determine the direction for all voluntary action. This is purposive action and hence meaningful. In a situation where everyone understands this and behaves accordingly, contented acceptance replaces constructive discontent. When the nature, variability, and spontaneity of the processes of the earth shift the balance of opportunities, it is our responsibility to adjust between such constructive discontent and contented acceptance and restore the balance of opportunity. With this basis of argument, it is appropriate to refer to our interventions as 'tackling unsustainability', in a Sisyphean sense, which involves more time and effort rather than a vainglorious phrase of 'achieving sustainability', which is only momentary. Hence, sustainability as a human ability requires us to be able to mutually inform ourselves successfully of purposive action, the particular purpose being the affordance of purposive action in others. The more such a purpose is afforded in people, the more such people afford similar affordances in others (Withagen, de Poel, Araújo, & Pepping, 2012), thereby sustaining habitable and enlivening conditions on the planet for a longer period.

Living effectively is living with information (Wiener, 1989). The prescription of sustainability is to be able to mutually support successfully informing others of purposive action in the hope that people balance constructive discontent with contented acceptance. Given that knowledge in this regard exists, it is a problem of design to communicate this knowledge successfully to as many people as possible as soon as possible. It is a problem of design in particular because of the amount of resistance we naturally face in conveying information—given the various

elements at work that aim to distort information—across the power- and decision-making structures that should be made to allow access to such knowledge for people. Effectively, it is a problem of communication and institutional design that ensures the dissemination of this knowledge to all. In addition, in the context of our dependence on current institutional structures, the transition should be informed by an understanding of the process of expanding human capabilities (i.e. knowing what abilities are appropriate and understanding how they should be extended to capabilities).

## 7 Discussion

Developmental literature does not specifically differentiate capability from ability. Differentiating ability from capability provides for the consideration of the process of expansion that is central to the capability approach. This differentiation affords the idea of extension by means of tools, making explicit the notion of technology as a context of extension and design as a process of specifying the tool. Design is the process of arriving at the representation of tools required for the extension of human abilities to capabilities. This representation may be for tool use (i.e. a process specification) or for tool making (i.e. a product and process specification). Tool use by design involves matching specific attributes of already existing objects for the required purpose. Design in tool making involves coming up with a representation for an object that will be the tool, abiding by and implementing the means by which the tool can be made to be used for realising the purpose. The design process involved affords an examination of interventions in finer detail necessary for better evaluation of the effectiveness of alternative interventions. The idea of extension encompasses the design process in the context of institutionalisation (i.e. formalising rules, procedures, norms, etc.). The idea of extension applied to the concept of sustainability as a human ability—with knowledge and language as tools for content and communication, respectively—re-emphasises the human-centricity of the interventions. This emphasis can be positioned to counter criticisms

of capability approach (CA) being individualistic, insensitive to social needs, and so on (Robeyns, 2005). Further, rather than having to list down capabilities (Nussbaum, 2000) which goes against the participative people-friendliness of CA (Sen, 2005), the distinction of abilities from capabilities and the concept of the tool provide for identifying 'capabilities' negatively. To start with, those given by Universal Declaration of Human Rights (UDHR) of the UN, and the various covenants that ensued, can be identified as requisite capabilities to which corresponding human abilities should be extended. As abilities are not value based, a list of human abilities as defined in this article may not divide opinion as does the idea of listing capabilities or the question of what should or should not be listed.

In the philosophy of artefacts, the unintended consequences of the process of authorship (i.e. making artefacts, either in the short term or long term) comprise what is called residue or debitage (Hilpinen, 1992). Problems of unsustainability, like that of global warming, can be considered to be the consequence of the accumulated debitage of the industrial revolution being unattended to. As we can neither claim ignorance of the effects of anthropogenic climate change nor suddenly halt the industrial engines of growth, the prescription entails a requirement to simultaneously make artefacts and attend to the debitage. Such simultaneous emphasis is humanly impossible. In addition, since the consequences of accumulated debitage requiring remediation before ushering further debitage have assumed urgency, the process of making artefacts needs to emphasise the debitage positively more than the artefact in the making. Regardless of the urgency, this is an ontologically strange problem. Well before proceeding to making artefacts, this ontological problem affects their design itself as follows.

Design is the intentional process of arriving at specifications/representations (Galle, 1999), which, if implemented, transform situations of discontent into those of content(ment). In the context of products, implementation is production. In the form of intention, a nascent specification exists as

an *artefact of the mind* (Thomasson, 2007). This is the design intent which can then be realised with or without externalising a representation of it. As design and production were not treated differently, craft largely resulted in fewer externalised representations since these were largely passed down as *artefacts of the mind* through generations of apprenticeship and practise (Wischnitzer, 1965). Contrarily, mass production was primarily made possible by the representable nature of the mechanical forms that industrial machinery alone could produce. The processes of craft and industrial production both leave the consequences to be attended to as an afterthought, however with starkly different intensities. The ontology of the consequences (i.e. *debitage*) is dependent on authorship. Synonymous with design intent, a 'debitage of the mind' as remedial intent does not exist independently (i.e. its existence is not active but reactive). This will remain so unless we can install *debitage* so positively that design for the remediation of consequences that spawn from it automatically result in authorship as the unintended consequence. This seems impossible as well.

Whether intended or unintended, it is noteworthy that archaeology and anthropology treat both outcomes of human endeavour as artefacts (Schick & Toth, 1993). From such a wider embrace of the word 'artefact', consequences assume equal emphasis, though their ontological status is dependent on the artefact. Nevertheless, such emphasis can be closely approximated by gradually reducing the cycle time of the make-reflect-modify cycles as theorised in some models of learning and design (Schon, 1996). This results in tests/evaluations being done more frequently, providing hope within three possible situations: (1) designers, made so aware of reflection, will be better at foreseeing possible consequences for humans (in an ongoing process of engagement or otherwise), society, and the environment; (2) the deleterious consequences of the process of coming about with technology will be identified early in the design stage and can hence be averted; and (3) the amount of impact that technologies designed so have will not be so grossly underestimated so as to

later make us reflect on how ignorant we were in not accounting for it before accumulating so many untoward consequences.

## 8 Conclusion

This article argued for treating abilities as separate from capabilities. A definition of technology—essentially as a context in which abilities are extended to capabilities by a tool—was proposed. Prevailing arguments regarding degree (i.e. basic, focal, and normal capabilities) were likened to a division of kind (i.e. of abilities and capabilities). A broad definition of design was proposed as the process of specifying the tool and hence the context in which capabilities (and hence human development) are realised. Defining technology not as a thing but a context resulting from design makes it appropriate to conceive of development as being led by design rather than (misled) by technology. The concept of extension was back-casted to understand human agency as (human) being able to be capable. This was shown to be synonymous with human development as defined by the capability approach as the expansion of human capabilities for realising full potential. It was proposed that the problems of listing capabilities that undermine the participative nature of public self-determining capabilities can be resolved by identifying abilities since these do not involve judgments (as capabilities do). The problem of unsustainability was pitched as a human capability to communicate. From the perspective of averting the consequences of the use of technology being a major concern for unsustainability, the phenomenon of designing artefacts was observed identifying ontological problems. A suggestion, based on the iterative nature of design, was given to approximate the simultaneous emphasis that artefacts and their de-bitage require.

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paper

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## Using the Capability Approach to Detect Design Opportunities

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## Abstract:

When developing products and services to improve the well-being of the multidimensional poor, designers need deep contextual insight. However, literature does not specify which topics to discuss or which questions to ask. We used Sen's capability approach to develop question categories and specific questions, and we selected tools to support them. This resulted in an *Opportunity Detection Kit*, which has been tested to evaluate the impact of the Philips Chulha in rural South-India. The kit stimulated the participants to think deeply about the impact of the Chulha and encouraged them to share their stories. In this way, new areas for improvement were detected. Thereby, a holistic and comprehensive picture could be drawn about participants' lives, which indicated opportunities for new product development. The integration of the capability approach and design for development therefore seems promising for the evaluation of product impact and opening up new design perspectives.

**Keywords:** *product design, design for development, capability Approach, well-being*

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## 1 Introduction: Design for Development and the Capability Approach

Design for Development (DfD), described by Donaldson as 'product design aimed at disadvantaged or marginalized populations' to advance social, human, and economic development (2002, p.97), is considered to be truly relevant for poverty alleviation (Thomas, 2006; Kandachar & Halme, 2008). Thereby, developing countries represent a large consumer market, and insights based on designing products for these markets might be an important source of innovation that can be beneficial for all markets (Prahalad & Lieberthal,

2003; Viswanathan, Yassine, & Clarke, 2011).

The field of DfD has been growing rapidly in the last few years, although in 'haphazard ways' (Donaldson, 2009, p. 97). Literature offers 'little theoretical or practical guidelines for innovative product development' for underserved markets (Viswanathan & Sridharan, 2012, p.52).

We describe product design as 'the successful creation of tangible products or services that induce change to a new context' (Mink et al., 2014), and the targeted population as the multidimensional poor (UNDP, 2010; UNDP, 2012)<sup>1</sup>. When innovating

<sup>1</sup> Authors use several different names to refer to the 'poor': emerging markets, Base/Bottom of the Pyramid (BoP, defined by Prahalad (2005) as people living on less than \$1,500 a year), newly industrialized economies, developing countries, the Third World, and subsistence marketplaces, among others. In this paper, we use the term 'multidimensional poor', which relates to the Multidimensional Poverty Index (MPI) as measured by the Oxford Poverty and Human Development Initiative (OPHI). This index is grounded in the capability approach and is used by the United Nations Development Program (UNDP). According to this index, an estimated population of 1.75 billion people worldwide experience multidimensional poverty (UNDP, 2010). The MPI 'complements money-based measures by considering multiple deprivations and their overlap' (UNDP, 2012).

for this target population, designers encounter several challenges. These challenges include more complicated information gathering than in mature markets (Castillo, Diehl, & Brezet, 2012) and difficulty in identifying people's true needs (Shahnavaz, 1989; Donaldson, 2006; Chavan & Gorney, 2008; Viswanathan & Sridharan, 2012).

Castillo et al., (2012) state that qualitative methods

are effective tools to use when gathering data about the user context. IDEO (2008, p.22) also indicates that 'Qualitative methods can help unveil people's social, political, economic, and cultural opportunities and barriers in their own words'. IDEO (2008) specifies that individual interviews are critical to obtain deep insight. Several valuable design approaches and toolkits have been developed for NGOs, social enterprises, or community workers<sup>2</sup>, most of which

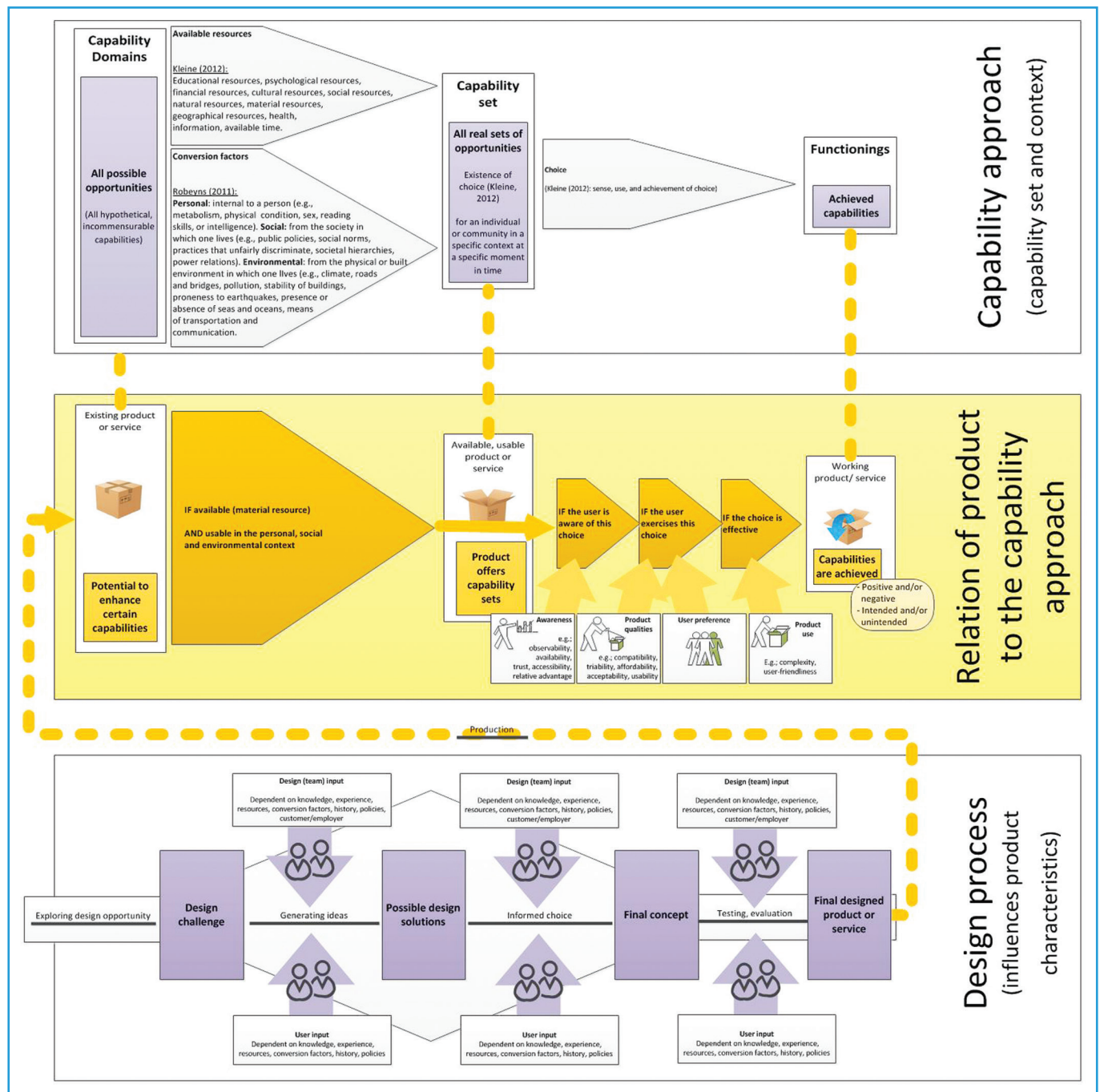


Figure 1 Relation between the product design process and the capability approach.

<sup>2</sup> E.g. Chamber's Participatory Rural Appraisal, Simanis and Hart's BoP Protocol (2nd edition), IDEO's 'Human Centered Design' Toolkit, the 'Market Creation Toolbox' of the Danish International Business Development Department and the BoP Learning Lab, the Bootcamp Bootleg of Stanford's d.School. Frog's Collective Action Toolkit is more recently developed and not yet considered for the work presented in this paper.



mention individual and group interviews. They provide guidelines on how to develop an interview approach (IDEO, 2008b, p. 26, 40; Larsen and Flensburg, 2011, p. 58), establish appropriate questions (D.School, 2010, p.9; IDEO, 2008a, p.9-10; 2008b, p.41; Larsen & Flensburg, 2011, p.58), and question people effectively (D.School, 2010, p.10; Freudemberger, 1999, p.74-76; IDEO, 2008a, p.8-10; 2008b, p.45-49; Larsen & Flensburg, 2011, p.58). They do not, however, specify explicitly which topics to discuss or which questions to ask. These decisions are left to the designer or the design team.

In this study, we attempt to address this issue by using Sen's Capability Approach (CA). According to Robeyns (2005), this approach takes into account all dimensions of human well-being and offers a 'broad normative framework'. The CA makes a clear distinction between what people are free to do to improve their well-being (their capabilities) and the achieved components of a person's life (their functionings). Technology and design are directly or indirectly linked to people's real opportunities (see Figure 1), as products and services have the ability to shape opportunities for the people using them. Johnstone (2007), Oosterlaken (2009), and Kleine et al., (2012) have already discussed the connection between technology, design, and the CA. However, the field of practical applications of the CA remains underdeveloped (Wagle, 2009). While attempts to practically apply the CA have been undertaken, Kleine (2010) noted that scholars have difficulty finding 'a balance between [the CA's] conceptual richness and its potential to be operationalized for development research and practice' (p.676).

In this paper, we describe our attempt to integrate the CA in the field of DfD. We identified capability categories and established related questions. Next, we complemented these categories and questions with design tools, and developed them into an *Opportunity Detection Kit* (ODK). This kit is intended to generate insight into the lives of the multidimensional poor and seek opportunities for product innovation. To validate the effectiveness of this kit, we applied it to the Philips Chulha, a cooking

stove specifically designed for rural India, which has been implemented in South India. By questioning people about all aspects of their lives, instead of only focusing on the product, we tried to obtain a broader picture of the impact of the Chulha. We will not describe this case study in detail in this paper, nor will we prove the ODK works better than other tools. Our focus is on generating feedback on the developed kit and on the usefulness of the perspective that the CA offers in the field of DfD.

## 2 Method: Establishing a Capability-Inspired Design Kit

To obtain deep insight 'into the behaviors, reasoning and lives of people', IDEO (2008, p.28) recommends an individual in-context interview. Larsen and Flensburg (2011) argue for a semi-structured interview. Therefore, we decided to set up a semi-structured, individual, interview in context. The CA was used to establish question categories and specific questions, and DfD toolboxes were employed to identify tools to support the interview. Because both the CA and the field of DfD have concern for human diversity, consider the individual as well as communities, advocate participatory methods, and focus on personal choice (Mink et al., 2014), we also considered human-centred design toolboxes.

### 2.1 Generating questions and question categories

We used the CA to develop question categories and specific questions. Practically applying the CA, however, is not an easy task. To begin with, the CA is a 'broad normative framework' that is radically underspecified, and in some cases needs to be supplemented with explanatory social theories (Robeyns, 2006, p.352). According to Gasper, the meaning of *capability* in Sen's approach 'diverges from everyday language' (2007, p.350). The approach includes a broad variety of dimensions that differ depending on the situation (Robeyns, 2006; Wagle, 2009; Frediani, 2010). Moreover, *capability* itself is a hypothetical concept (Gasper, 2007), which is difficult to capture (Zimmermann, 2006; Gasper, 2007; Kleine, 2011). Capabilities are limited by 'the

degree in which a person can transform a resource into a functioning' (Robeyns, 2011, p.13). Finally, they have an interdependent nature (Krishnakumar & Ballon, 2008), are incommensurable (Robeyns, 2011), change over time (Zimmermann, 2006; Wagle, 2009), and differ between people and regions (Robeyns, 2006; Wagle, 2009). We kept these characteristics in mind when developing questions and question categories.

Within the CA community, much ongoing debate has focused on the establishment of lists of capabilities. Sen deliberately refrained from the use of a standard list of capabilities (Frediani, 2010). However, Nussbaum (2000) formulated an abstract list of ten central human functional capabilities. Our focus is not on developing a list of capabilities, but rather a list of categories that can be used to detect the capabilities, functionings, and desires of target users. To develop such a list, we used what Alkire

(2007) calls 'public consensus' and 'empirical evidence': we used established lists, generated by consensus or formed through empirical analyses. For developing question categories, we used Nussbaum's list, and the lists established or mentioned by Hulme and McKay (2005), Alkire (2007), Burchardt and Vizard (2007), Martinetti and Roche (2009), and Walker, Mclean, Dison, & Peppin-Vaughan (2009).

We began by 'exploring the commonalities, differences, and relationships between the information' (IDEO, 2008, p.67). We then deleted all doubles, and started to categorize all unique items. After grouping and re-grouping, all items fitted into thirteen categories. Each category consisted of several capabilities. We tried to establish categories of related capabilities, which are 'philosophically and theoretically meaningful in relation to a life of full human dignity', and not 'over specified or derived from a particular metaphysical

**Table 1** Capability categories extracted from literature

Category	Related capabilities
Health	Feeling of sufficiently long life expectation, of not being obstructed by health limitations, of the ability to reproduce; not feeling worried, stressed, or strained; feeling of being able to visit doctor/dentist and obtain medicine, and medical care
Nutrition	Feeling of having sufficient food to feed yourself and your family; feeling of being able to enjoy a meal whenever needed; feeling of being able to eat sufficient meat, chicken, fish, and vegetables
Safety	Feeling of safety inside the house and in your living area; feeling of being discriminated or bullied
Education	Feeling of proper education possibilities; feeling of having sufficient knowledge; feeling of having sufficient access to knowledge
Meaningful work	In day-to-day activities: feeling of being able to enjoy activities; feeling of being able to use imagination and reasoning, skills and talents; feeling of being useful and appreciated
Leisure	Feeling of having sufficient spare time in which you can decide yourself what to do; feeling of being able to enjoy recreational activities
Mobility	Feeling of being able to go out of the house whenever you want to, and wherever you want to; feeling of being able to use and operate any kind of transportation which you would like
Partnership/family	Feeling of sufficient affection from and happiness with partner; feeling of being able to leave partner; feeling of involvement in family decision making; feeling of being appreciated by family members
Friends	Feeling of acceptance and appreciation within your community; feeling of being able to establish friendships and express feelings of love, grief, longing, gratitude, and anger
Self-determination	Feeling of being able to evaluate the way you lead your life and where you are going; feeling of living your life satisfactorily; feeling of being able to make decisions about reproduction
Cultural and spiritual life	Feeling of freedom to practice your religion; feeling of freedom to express political views and participate in political activities; feeling to be able to live according to cultural habits
Products, plants, animals	Feeling of being able to have ownership of and attachment to products, plants, animals
Accommodation	Feeling of a sense of ownership of the house; feeling of involvement in the choice of house; feeling free to move to another house; feeling a sense of adequateness of the house for current needs

worldview' (Nussbaum as cited in Walker et al., 2009, p.569). We also considered Gasper's warning not to operationalize the approach to 'familiar, conservative forms that are not consistent with the approach's rationale' (2007, p.350), and IDEO's (2008) recommendation of making the interview general enough to allow for a conversation that can lead to unexpected insights, but focused enough to obtain the required information.

For each capability category, we developed a set of questions by using the sets of capability questions developed by Anand & other authors (Anand & Dolan, 2005; Anand & van Hees, 2006; Anand et al., 2008; Anand et al., 2009; Anand et al., 2011), and by brainstorming with our team. The questions were divided into *ideal* questions, representing what we are actually looking for, and *sensitizing* questions, which are the more pragmatic questions that can be used to start the conversation. The categories and their descriptions can be found in Table 1. The questions for each category can be found in Appendix A.

## 2.2 The Opportunity Detection Kit

To stimulate discussion and encourage reflection, we selected design tools to support our interview. We considered the tools described in Participatory Rural Appraisal (Chambers, 1994a; Freudenberger, 1999), the Human-Centered Design Toolkit and Field Guide (IDEO, 2008a; 2008b), the BoP Protocol 2nd Edition (Simanis & Hart, 2008), the Bootcamp Bootleg (d.School, 2010), and the Market Creation Toolbox (Larsen & Flensburg, 2011). We also included context-mapping tools, as described by (Sleeswijk Visser, Stappers, Van Der Lugt, & Sanders, 2005), as

these techniques specifically aim to reveal people's dreams for the future. We selected three tools to support the semi-structured interview without consuming a lot of time: life mapping, visualizing/drawing, and ranking.

After four pilot studies – two in the Netherlands and two in India – we established what we call the Opportunity Detection Kit (ODK). The ODK consists of:

- 1) an interview set-up, which describes the interview flow and provides instructions for the interviewer on how to use the ODK, how to instruct the interpreter, and how to select participants, as well as tips for conducting the interview effectively<sup>3</sup>;
- 2) a timeline to map a day in the participant's life<sup>4</sup>;
- 3) pictures of the interviewer that give insight into his/her life<sup>5</sup>;
- 4) a set of question cards, featuring icons that symbolize each capability category, along with the related questions (both ideal and sensitizing);
- 5) sensitizing cards, drawing cards, drawing sheets, and a set of markers to stimulate the participants to share their dreams and hopes for the future – and thus reveal their capabilities<sup>6</sup>;
- 6) an importance sheet, consisting of four categories (very important, important, a little bit important, and not important) indicated with exclamation marks, on which the participants can prioritize the different categories<sup>7</sup>;
- 7) a gift for the participant<sup>8</sup>; and
- 8) a camera and voice recorder with which to document the interview.

<sup>3</sup> Tips and tricks on instructing the interpreter, approaching the participants and their context, and conducting the interview were taken from the selected toolkits and included in the interview set-up.

<sup>4</sup> According to Chambers (1994a), d.School (2010), and Larsen and Flensburg (2011), mapping life aspects is a good way to start understanding the lives of the participants.

<sup>5</sup> Larsen and Flensburg (2011) advise the interviewer to share his/her own experiences.

<sup>6</sup> Sleeswijk Visser et al. (2005) argue the importance of letting people create something – e.g. drawings or models – in order to 'access and express their experiences'. Visualizations and drawings are also recommended by IDEO (2008) and Larsen and Flensburg (2011), as they stimulate answering and aid in collecting rich stories. Children can be asked to draw, or the participant can draw. If participants do not want to draw, the interview leader can make the drawings (IDEO, 2008).

<sup>7</sup> A ranking exercise asks people to prioritize, and therefore helps us to understand what people value, and how they assign this value (Larsen and Flensburg, 2011).

<sup>8</sup> Larsen and Flensburg (2011) advise interviewers to bring a gift as a token of appreciation.



**Figure 2** The contents of the Opportunity Detection Kit

The contents of the kit are shown in Figure 2.

Before starting, the interviewer needs to identify and instruct an interpreter, and select participants. Larsen and Flensburg (2011) advise interviewers to first conduct a pilot in order to test the interview content. The interview is conducted according to a structured process. The interview starts with an introduction to the interview and the interviewer, and with obtaining consent, following Larsen and Flensburg (2011). To ‘break the ice’ and initiate the conversation, pictures of the interviewer’s life and surroundings are shown. The actual interview starts with presenting the timeline and asking about people’s daily routine, after which the questions are posed and the answers are visualized through the sensitizing and drawing cards. The interview is concluded with the ranking exercise. The participant is thanked for taking part in the interview, and receives a small gift.

The aim of the ODK is to offer designers an aid in gaining a better insight by uncovering people’s capabilities, functionings, and desires. All categories should be covered at the same moment in time, and the interviewer should pay special attention

in order to detect people’s internal and external resources (Kleine, 2011), the personal, social, and environmental factors that influence the conversion of resource characteristics into functionings (Robeyns, 2011), and the existence, sense, use, and achievement of people’s choices (Kleine, 2011).

### 3 Case Study: Detecting Product Impact and Design Opportunities

Sen (1999) specifically emphasized that both poorer economies and very rich countries have disadvantaged people who lack basic opportunities. However, the Multidimensional Poverty Index indicates that most multidimensional poor, with the greatest intensity of poverty, live in South Asia and sub-Saharan Africa (Alkire, 2011). Given this fact and the authors’ experience in India, we decided to deploy the Opportunity Detection Kit (ODK) in India. We selected the Philips Chulha, an award-winning clay cooking stove, as a case. We specifically looked for a product that was designed for development and has already been implemented in the market. Right now, more than a hundred Chulhas are currently in use in South India. We used the ODK to detect the



real opportunities (capabilities) and functionings of the Chulha users, both before having the Chulha and after they started using the Chulha. We tried to validate the usefulness of the ODK by comparing the outcomes of our interviews with existing evaluations of the Chulha. We identified any change in perception of the participant towards the product during the interview, by starting the interview with product-related questions and then discussing all capability categories, before concluding by returning to product-related questions. We also used this case to identify areas for further improvement of the ODK.

From February to April 2012, the second author – at that time a master’s student at TU Delft – interviewed

the developers, manufacturers, and users of the Philips Chulha. In this way, he gained insight into the reasons behind the product’s development and a view of the impact of the stove. After selecting an interpreter<sup>9</sup>, the interview was discussed with him and with one of the stove installers<sup>10</sup>. Questions regarding affection, the possibility of choosing a partner, happiness, procreation, and life expectation were considered to be offensive or too strong a taboo to bring up. Next, a pilot was executed with five participants. As a result, some questions that were difficult to understand were simplified, and three capability categories were divided, as they turned out to be too broad. The ‘health’ category was divided into health and healthcare, the ‘cultural life’ category was divided into religion and politics,

**Table 2** Participant characteristics (number of participants in parentheses)

Village	Profession	Chulha user(s)	Present during interview
A (10)	Hired farm labourer (6)	Woman (5)	Individual user (2)
			User, family members in background (1)
			User and husband (1)
			User and family members (1)
		Husband and wife (1)	Both users and child (1)
	Housewife (1)	Woman (1)	User and family members (1)
	Landowner (2)	Woman (2)	User and family members (2)
	Livestock caretaker (1)	Woman (1)	User, husband and friend (1)
B (3)	Hired farm labourer (1)	Husband and wife (1)	Both users and family members (1)
	Housewife (1)	Woman (1)	User, friends/family in background (1)
	Livestock caretaker (1)	Woman (1)	User and family members (1)
C (14)	Hired farm labourer (5)	Woman (5)	User and children (2)
			User, family members in background (2)
			User, friend in background (1)
	Housewife (4)	Woman (3)	User, family members in background (1)
			User and family members (1)
			User and multiple women (1)
		Sister and brother (1)	Female user and multiple women (1)
	Landowner (3)	Woman (2)	User and children (2)
		Husband and wife (1)	Male user and friend (1)
	Student (1)	Man (1)	User and friend (1)
School cook (1)	Woman (1)	User and family members (1)	
D (4)	Hired farm labourer (2)	Woman (1)	User, family members in background (1)
		Man (1)	User and wife (1)
	Landowner (2)	Woman (2)	User and family members (1)
			User and husband (1)

<sup>9</sup> The interpreter was an Indian PhD student from a very poor family, who executed an impact study on the same stove one year before. He was therefore familiar with the surroundings and the people.

<sup>10</sup> The installer lives in one of the villages, is the son of the local priest, and is highly trusted by the villagers. Most people installed the stove because he advised them to.



and the 'plants, animals, and products' category was divided into three separate categories. Moreover, sensitivities in the area were pointed out, such as an ongoing conflict with the government, and hence questions about politics and accommodation could not be posed. Moreover, a local prophecy made some people unwilling to participate<sup>11</sup>.

After the pilot, 31 interviews were conducted with Chulha users from four different villages. Present at the interview were the interviewer, the interpreter, and the participant. In each village, one of the installers first had to give an introduction to encourage people to participate, as the conflict with the government and the recent local prophecy made people suspicious and unwilling. Table 2 shows some characteristics of the participants.

## 4 Results

### 4.1 Interviewing experiences

Some knowledge about the context is useful to save explanation time and to keep the conversation going (e.g. about the education and healthcare systems, and some knowledge about local language and habits). In this study, the pilot interviews took almost twice as long as the final interviews, because of the local issues that were raised. Because of the pilot, the interviewer became familiar with the area and the people, which led to adapting the ODK to the local circumstances. The pilot was also useful in getting the interviewer and interpreter acquainted with the interview flow and with their roles. The pilot led to additional instruction of the interpreter. The interviews lasted between 16 and 54 minutes, with an average of 33 minutes. This was shorter than the anticipated hour, which can partly be explained by the expunged and shortened capability categories. However, the interpreter also indicated at several interviews that the participants became impatient or felt uncomfortable. The conflict with the government and the prophecy played important roles, but sometimes people also had work pending

or personal issues (such as illness or deceased family member). In those cases, the interview was shortened.

This study revealed that it is difficult for a designer to conduct interviews in a developmental context when not being experienced in doing so. The interviewer encountered all sorts of prevalent interviewing challenges (e.g. uncomfortable or silent participants, very talkative participants, difficulty of controlling the interview due to working with an interpreter, limitations of relying on an interpreter who made up responses, rushed the interviews, and translated loosely). Thereby, the interviewer also encountered local issues (e.g. the current conflict with the government, a prophecy discouraging people from participating, cultural taboos, class differences, and the influence of the presence of curious villagers or family members during 18 of the interviews), and faced some limitations (e.g. he could only conduct the interview at different times of the day, and there was a gender difference between interviewer, interpreter, and participants). A designer is not specialized in dealing with such difficulties, and the interview outcomes are thus influenced by the skills of the interviewer. The ODK assists in conducting a semi-structured interview, but is not able to prepare a designer or design team for everything they will encounter.

The study also pointed out that not all required information is revealed by using the ODK. The environmental impact of the stove, political and social power structures, and health statistics did not come forth by using the ODK, but by talking to other stakeholders. Using additional methods (such as group interviews, focus groups, and observation) might aid in detecting this missing information.

Using a voice recorder turned out to be essential, as the combined effort of note taking and guiding the interview would have been too much for the interviewer. A second interviewer might have been useful to discuss and interpret the outcomes

<sup>11</sup> Recently, a prophecy circulated, predicting that a close relative would suddenly die when a stranger passed your door step.

with, to pull the audience away, to assist in mapping and drawing, and to better keep track of the questions.

## 4.2 Experiences with the Opportunity Development Kit

### 4.2.1 Capability categories and questions

The capability categories concern general, incommensurable aspects, which can be applied to get to know different people in different contexts. This case did not indicate the need to merge capability categories, but rather the need to divide some categories. The ‘cultural and spiritual life’ category did not actually reveal many cultural specificities, and deserves further attention. Sensitive topics were expunged during this study, so no experience is generated in posing questions about procreation, affection, or choice of partner.

It turned out that some questions needed simplification. Particularly, the questions in the ‘self-determination’ category were sometimes difficult to understand for participants. The large number of questions and the time pressure on the interviews made the interviewer hurry, which resulted in posing less supplementary questions.

### 4.2.2 Design tools

The box containing pictures and questions generated interest and curiosity, and showing the interviewer’s pictures did ‘break the ice’. The timeline worked well to start the conversation and to obtain understanding about the daily lives of the participants. It also helped to identify other potential stakeholders. The mapping of the situation before and after installation of the stove was effective, but because the participants needed much help with placing the cards, it turned out to be easier if the interviewer placed them. The amount of cards appeared to be overwhelming and confusing, and the icons used were often not understood. Still the mapping exercise generated discussion and encouraged participants to tell stories. It also functioned as a validating moment, as the participant was able to see what the interviewer understood to be the answer, and aided the interviewer to keep track of the topics discussed. This turned out to be helpful, as the capability categories are connected, and therefore, when discussing one category, aspects of other categories also came up. Finally, the ranking exercise sometimes caused confusion, but after a thorough explanation of the exercise and the categories, participants were able to perform this task. Figures 3 and 4 show the design tools in use during the interviews.



Figure 3 and 4 ODK tools in use during interviews

### 4.3 Interview outcomes

The interview made it possible to learn a lot about the lives of the participants in a short time span. When applying the ODK, we did not only try to capture real opportunities (capabilities) – we also tried to capture achieved capabilities ('functionings') and valued capabilities for the future ('desires'). It turned out that functionings were easiest to identify. We encouraged people to share capabilities and desires by letting them map and draw representations of their lives, but participants had difficulty doing so. Still, participants did share stories about issues they encountered and desires for the future.

#### 4.3.1 Detecting Chulha impact and possible improvements

When starting to question the villagers about change induced by the Chulha, most of the time the answer was 'nothing'. However, when consequently posing the capability questions, changes were revealed. The Opportunity Detection Kit (ODK) provided the interviewer a way to let the participants think deeply about their lives before and after installation of the Chulha, and encouraged them to communicate their experiences. The participants often started sharing stories, which also revealed underlying reasons for their choices and behaviour. However, in this case, not much has changed for the Chulha users. We discovered that some participants are now able to spend more time with family or friends because of less time spent on cooking and firewood collection, and that some are preparing different types of food on this new stove. For one installer, power relations in his life changed, as he became a respected entrepreneur.

When questioning the villagers about changes they want to make to the Chulha, most villagers indicated that they did not want to change anything. However, during the interview, it turned out that they do experience some problems. For instance, when discussing nutrition, we discovered that the size of the potholes is too big to fit their

old vessels, and that rain sometimes enters the house via the chimney. When discussing safety and leisure, it became clear that the fuel compartment is bigger than required, causing some people to use more firewood than before. When discussing health, it was revealed that some people do not use the second pothole of the Chulha, and do not cover this hole when using the stove. This allows smoke to enter the house. It turned out that the stoves were sometimes implemented without proper consultation of the intended users. When examining the four dimensions of choice, people's sense of choice and use of choice have been passed by, giving the users no time to think about wanting the Chulha or not. This might influence how they use the Chulha. However, the above mentioned problems still indicate areas for product improvement.

#### 4.3.2 Detecting design opportunities

Besides evaluating the impact of the Chulha, we also tried to gain insight into the lives of the (target) user to reveal desired capabilities. While most participants had difficulty drawing and mapping their lives, they did share stories about issues they encountered (e.g. not possessing farmland, lack of electricity), and their desires for the future (e.g. a new rooftop, a television). Asking the questions, 'why', 'what for', and 'what else' turned out to be important. For example, when participants indicated a lack of money (financial resources), the interviewer questioned them about what they wanted to use this money for. In this way, additional insight into their desired capabilities was generated. One participant indicated a desire for a power connection to be able to water the trees and watch television. The underlying reasons for unfulfilled desires were not always sufficiently revealed. In the former example, the reason for not having electricity was not revealed. While there are several reasons this information was not revealed (the interviews had to be kept short, participants were not always willing to answer, and the interpreter did not translate everything properly), the detection of missing resources and conversion factors does deserve extra attention in the ODK.

During the interviews, many resources and conversion factors were revealed. However, some were better identified through discussions with other stakeholders or by consulting secondary sources; a local doctor provided health statistics, power relations were identified during conversations with the installer, and environmental conversion factors such as climate conditions and pollution could be obtained from secondary sources.

### 4.3.3 Limitations of the outcomes

We have to keep in mind that this application of the CA is a qualitative one; thus, it offers a deep understanding, but the outcomes are not generalizable to other situations. Moreover, this exercise of detecting people's functionings, capabilities, and desires is always a snapshot in time.

## 5 Conclusion and Further Work

This study indicates that by questioning people broadly about capability categories, a holistic and comprehensive picture about their lives can be drawn. The questions of the deployed Opportunity Development Kit (ODK) not only broadened the insights of the interviewer, but also made the participants more aware of their own functionings, opportunities, and aspirations. The study also indicates that the deployed kit encourages people to share stories, which aids in generating valuable user feedback and opening up new design perspectives. In this sense, merging the Capability Approach (CA) and Design for Development (DfD) toolkits to

construct a semi-structured interview approach has proven to be effective in generating deep insight in people's lives.

However, it turns out that the ODK should pay more attention to resources and conversion factors. Thereby, this study pointed out that even an extensively prepared interviewer cannot anticipate all interviewing difficulties. We also have to keep in mind that the ODK is not a magic kit making all other methods and tools redundant. The designer still has to look further and apply different tools and methods in order to obtain a full picture, and, according to Chambers (1994b), to crosscheck qualitative data.


The established list of categories and questions will change as a result of this case study, and remains open to critique and modification, as it should be, according to Alkire (2007). The ODK needs continuous development and adaptation, based on experiences of using it (Larsen & Flensburg, 2011). Based on this case study, we preliminarily conclude that using the CA to detect design opportunities appears to be promising and holds the potential to add value to the field of DfD.

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## APPENDIX A – Question cards

	<p>Do you feel you were involved enough in choosing your home?            Do you feel your home is your own property?            Do you feel prevented from moving to another home for any reason?            Do you feel your current accommodation is adequate for your current needs?</p> <p>What type of house do you have?            With whom? Rooms? Roof? Light, electricity, gas?            When did you move here?            Did you build this house yourself or make any changes to this home?            How did you pay for this home?            Are there other houses/places that you would really like to live?            Do you think you will live here the rest of your life?            Do you want to change something in your house?</p> <p style="text-align: right;">1</p>
	<p>Do you experience sufficient affection from your partner?            Do you feel happy with your partner?            Do you feel you are sufficiently involved in the family decision making?            Do you feel prohibited from leaving your partner if you would want to?            Do you feel appreciated by your family?</p> <p>Do you have a partner/children?            How did you and your partner get together?            When do you and your partner/children spend time together?            What do you like most about your partner?            Do you feel happy with your partner?            When do you see your parents?            When do you see your brothers and sisters?            And other family?            Who can you count on most?            From whom do you receive love/care/support?            Who do you go to first if you feel lonely/sad?</p> <p style="text-align: right;">3</p>
	<p>Do you feel accepted within your community?            Do you feel appreciated within your community?            Do you find it difficult to make friendships?            Do you find it difficult to express feelings of love, grief, longing, gratitude, and anger?</p> <p>Do you know a lot of people in your community?            When do you see the people in your community?            Do you have friends?            When do you see your friends?            What kind of things do you talk about with your friends?            Do you feel like you can tell your friends everything?            &gt;&gt; Social status &lt;&lt;</p> <p style="text-align: right;">5</p>





**Do you feel sufficiently attached to plants?**

Are there any plants/trees in or near your house?  
 Do you like them? Do you care for them?  
 Do you need more plants?  
 Do you grow plants yourself or do you want to?

**Do you feel sufficiently attached to animals?**

Do you own domestic animals?  
 What is your favourite animal?  
 Do you want (more) animals?  
 Do you like animals? Do you respect animals?

**Do you feel sufficiently attached to products?**

Which objects do you love to use?  
 Are there certain objects you need to have?  
 Are there certain objects you want to have?  
 Do you like plants? Do you respect plants?

2



**Do you feel you have sufficient food to feed yourself?**

**Do you feel you have sufficient food to feed your family?**  
**Do you feel you can enjoy a meal whenever you need one?**  
**Do you feel you can eat sufficient meat, chicken or fish?**  
**Do you feel you can eat sufficient vegetables?**

What is your diet? When do you eat?  
 What do you drink? Where do you get potable water?  
 Do you have a stock of food in your house?  
 Do you feel you have sufficient food to feed yourself?  
 Do you feel you have sufficient food to feed your family?  
 Do you feel you can enjoy a meal whenever you need one?  
 Are you a vegetarian?  
 Do you like to eat fresh meat, chicken or fish?  
 Do you feel you can eat sufficient meat, chicken or fish?  
 Do you like to eat fresh vegetables?  
 Do you feel you can eat sufficient vegetables?

4



**Do you feel you can go out of the house whenever you want to?**

**Do you feel you can go wherever you want to go?**  
**Do you feel prohibited from using any kinds of transportation (which you would like to use)?**  
**Do you feel prohibited from personally operating any kinds of transportation (which you would like to operate)?**

Which places do you visit in your village?  
 Do you ever go out of the village?  
 Which types of transportation do you use?  
 What is your favourite type of transportation?  
 Do you have a bike/motor/car?  
 Which other places do you want to visit?  
 Do you want to have a bike/motor/car?

6



**Do you feel you are properly educated?**  
**Do you feel you have sufficient knowledge?**  
**Do you feel you have sufficient access to information?**

Have you ever been to school, how many years?  
Would you have wanted to go longer back then? Do you still want this?  
Where did you learn to do your work?  
Did you follow any courses?  
Do you have any other diplomas?  
Can you read and write? Can you count? Do you have a signature?  
Do you want or need any of these?  
In your day-to-day life, do you often face problems you cannot solve by yourself?  
What kind of problems? Then what do you do?  
Do you always find an answer?

7



**Do you feel you can evaluate how you lead your life and where you are going in life?**  
**Do you feel you live your life satisfactorily?**  
**Do you feel prohibited from using contraception, abortion or infertility treatment?**

Are you happy?  
Do you have a dream of a different life?  
If you could change anything in your life, what would you want to change?  
Do you have a plan of what you want to do or be in life?  
What do you want to achieve in your life?  
Do you make your own decisions?  
Do you ever consider using contraception?/Do you think people here want to use contraception?  
Do you ever consider abortion?/Do you think people here want an abortion?

9



**Do you feel you have sufficient spare time, in which you can decide what to do?**  
**Do you feel you can enjoy your recreational activities?**

Do you have free time, when you don't have to do anything?  
What do you do in your free time?  
What do you do when you don't work?  
Do you enjoy this?  
Do you need more free time?  
Are there other activities you would like to do?

11



**Do you feel you can enjoy your normal day-to-day activities?**  
**Do you feel you can use your imagination and or reasoning in your day-to-day activities?**  
**Do you feel you are playing a useful part in your normal day-to-day activities?**  
**Do you feel you make enough use of your skills and talents in your day-to-day activities?**  
**Do you feel you are appreciated in your normal day-to-day activities?**

What kind of work do you do during the day?  
When do you work (time/day)?  
Do you work together with other people?  
What kind of activities do you have to do?  
What are the things you are good at in your work?  
Why do you do this?  
Do you like what you do?

8



**Do you feel free to practice your religion as you want to?**  
**Do you feel free to express your political views and participate in political activities?**  
**Do you feel prohibited from performing your cultural habits?**

What is your religion?  
Has this always been your religion?  
What about your parents?  
How do you practice it?  
Do you vote in government elections?  
Which party do you support?  
Do you fit in your community?  
What are your daily rituals? Product specific,  
- f.i. what is your eating ritual (where, when, how, with what)?  
- f.i. what is your cooking ritual (where, when, how, with what)?  
- f.i. what is your sleeping ritual (where, when, how, with what)?

10



**Do you feel safe inside your home?**  
**Do you feel safe walking alone in the area near your home?**  
**Do you feel discriminated or bullied?**

Are there quarrels/arguments/fights/shouting either inside your home or outside on the street?  
Do you feel secure in the area you live in?  
Do you dare to go out during the day?  
Do you dare to go out at night?  
Do you think people are discriminated in the area you live in?

12



Do you feel your life expectation is sufficiently long?  
Are you or other family members able to visit the doctor whenever necessary?  
Do you feel your health limitations obstruct you in your day to day activities?  
Do you feel you are able to fulfil your wish for children?  
Do you worry much or feel under strain?  
Do you feel lonely?

Do you have a toilet? Where do you go when nature calls?  
Are all your brothers and sisters still alive?  
How old are your parents and are they still alive?  
How old do you think you will become? Do you want to live longer?  
Are you ever sick?  
Can you and your family visit the doctor when you are ill?  
Is your doctor far away?  
Do you have any health limitations?  
Do you want more children?  
Do you worry much or feel stressed? Do you sleep well?  
Do you feel lonely?



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paper

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Design and a 'capability approach-based' evaluation  
of an innovative mould for rapid dissemination of the  
'Astra ole': a firewood based cook-stove'

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# Design and a 'capability approach-based' evaluation of an innovative mould for rapid dissemination of the 'Astra ole': a firewood based cook-stove'



## Abstract:

What should be the scope of design? What responsibilities should design own? To answer these questions, an normative approach that can guide the outcomes of design is essential. This study attempts to answer these questions by constructing a capability approach (CA)-based definition of design. Implications of the theoretical constructs of CA on design are explained through a practical case study of Astra ole: a firewood-based cook stove. CA based product evaluation has empowered the authors to reanalyse the field experience of over three decades with a new perspective. The second case study is the design of a mould for rapid dissemination of Astra ole. According to a CA-based design, the mould should be included in the scope of the original design of the stove, as it is linked with the important product life cycle phase of manufacturing. The second case study highlights the importance of extending the scope of design to the product's entire life cycle.

**Keywords:** design life cycle, design evaluation, capability approach, improved cook stoves

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## 1 Introduction

Conceptions of well-being are complex, multi-dimensional, and individual. There are two evident approaches to well-being, which are not exclusive but have substantial overlap. The first approach distinguishes between objective and subjective well-being (Des, 2007). Objective well-being considers externally assessed and approved measures including non-feeling-based features like access to mobility or low morbidity. Subjective well-being is an individual's personal judgment; thus, it is predominantly feeling based. The second approach differentiates between hedonic and eudaimonic well-being (Deci & Ryan, 2006). Hedonic well-being is similar to subjective well-being. The concept of eudaimonic well-being criticises subjective well-being. Happiness, the basis of subjective well-being, does not ensure psychological well-being,

which is more important according to eudaimonic conceptualisation. Eudaimonic well-being is concerned with living a life to actualise one's full potential. Thus, it is also complex to trace a product's effects on well-being, which is the ultimate success of any product.

Cook stoves are important for well-being, as they are linked to energy security. Thus, they constitute an important topic of research and an interesting market that attracts global attention and large financial expenditure (Global Alliance for Clean Cookstoves, 2012). Traditional cook stoves, commonly referred to as three-stone fires, are inefficient, although positive characteristics include being able to operate on multiple fuels such as firewood, farm produce, cow dung, sawdust, and coal. The rural area population (70% of the total population in India) has access to farm produce and

cow dung, these commonly referred to as biomass. Annually, 2.2 million deaths are caused by the smoke generated by traditional cook stoves' incomplete combustion (Martin, William, Roger, John, & Francis, 2011). The impact on indoor environments is twofold: one is linked with smoke and inhalation; the other is the blackening of houses. Exposure to smoke, which causes long-term health problems, is a lower priority than having a beautiful house, which is the more subjective or hedonic aspect of well-being. Women and young girls spend considerable time collecting firewood. This time can be spent on other purposes, which can be linked to opportunities to actualise one's full potential. This is characterised as part of eudaimonic well-being.

Improved cook stoves (ICS) have features such as a naturally induced or forced draft to clear smoke through a duct pipe, improved burning efficiency, and improved utilisation of generated heat. ICS frees the user from the drudgery and ill-effects linked to traditional stoves, thus improving well-being. Stoves using Liquefied Petroleum Gas (LPG) as fuel are replacing traditional stoves in households that can easily afford them. LPG is a clean energy source; however, its price and availability questions its viability as a long-term energy source (Wene, 2000). Distributional challenges, prevalent in rural markets associated with the poor (Prahalad, 2005; Kandachar & Halme, 2008), further limit LPG availability. Fuel supply and distribution channels for biomass are well established.

Ironically, improved cook stoves are not well accepted by users in populations where they can make maximum positive impact on well-being (Hanna, Duflo, & Greenstone, 2012). Conceptions of well-being compete. LPG, which has a better status value but uncertain availability, competes with these stoves. Ease of availability, low initial costs, and perceived ease of cooking on traditional stoves pose tough opposition to the transition to improved cook stoves (personal communication with Ms Swati Bhogle of Technology Informatics Design Endeavour (TIDE), Bangalore).

The current study forms part of answering the research question, 'How do we design successful products targeted at the base of the pyramid (BoP) population?' The BoP population earns less than \$ 2 a day (Prahalad, 2005). The value of \$ 2 a day is constantly updated based on changing economic conditions and inflation rates. Going beyond specific monetary boundaries, BoP connotes population with monetary and material constraints underlying the influence of poverty.

Evaluation criteria measure the success of a product/service/technology. The designer must fulfil these evaluation criteria to be successful, and based on these criteria, decide on the design scope and effort. It is important to understand and question the adequacy of the current basis of evaluation of success. As such, this investigation is important, because narrow evaluation criteria may not achieve the aim of positively influencing the well-being of involved stakeholders. This study raises and tries to answer a few questions in the context discussed above. In addition to technical performance, how can a product be evaluated? Can this evaluation be approached in a structured manner? Does an existing normative approach support this? The authors use field data to address these questions and demonstrate the inadequacy of existing evaluation criteria.

As a case study, this research evaluates the success of improved cook stoves, or Astra ole. The Astra ole is originated in 1985. The authors of this study are instrumental in sustaining the product's three-decade long existence in the market. Their holistic understanding of the product's ecosystem is the primary reason it has been selected as a case in this study. The analysis of Astra ole is based on interactions, focus groups, and individual interviews by the authors during product design and dissemination. During these field interactions, the inadequacy of existing methods of product evaluation and the necessity for an alternative normative framework was evident to the authors.

The capability approach (CA) is an influential normative framework to evaluate well-being. CA, which emphasises freedom as a measure of development rather than income (or commodity), provides an important alternative development paradigm. Similar parallels can be drawn between product and design evaluation. CA has been used to discuss technology and design, but mostly from a philosophical perspective. In the literature, CA-based evaluations of products/technologies are not located within a prevalent design perspective. This study attempts to connect the constructs of CA with design as practiced, and as such, presents a design-oriented holistic evaluation of a product from a CA perspective. The study not only applies a CA-based evaluative framework to technical artefacts, but also extrapolates backwards to suggest a probable design methodology. This, while retaining compatibility with design practice, can drastically widen the designer's window of perception. In this discourse, perceived differences between traditional and CA-based design perspectives are introduced. Section 2 briefly introduces the product, while Section 3 introduces CA and elaborates its use in evaluating technical products. Here, definitions of design and design evaluation from a CA perspective provide the bases for evaluation of the Astra ole. Section 4 describes the CA-based product evaluation. In Section 5, a design intervention to revive identified shortcomings is introduced

based on field experience. Critical discussions and conclusions are elaborated in Section 6.

## 2 Introduction to Astra ole

Astra ole is a scientifically designed firewood-based stove developed by the Centre for Sustainable Technologies (CST), formerly Application of Science and Technology for Rural Areas (ASTRA). The CST was established as ASTRA in 1974 at the Indian Institute of Science (IISc), Bangalore. Ole means 'stove' in Kannada, a local dialect of Karnataka state in India. The technology has been used since 1984–85. Astra ole has the highest efficiency (45–50%) as calculated on a standard water boiling test, and is one of the best stoves available in the field (Ministry of Non-Conventional Energy Sources, 1993). Based on field tests, the advantages are: 1) Reduced fuel consumption (more than 50%), 2) Reduced cooking time, and 3) No smoke indoors because of a natural air draft.

From a traditional product evaluation perspective, the Astra ole is a successful product for many reasons: 1) Approximately 1.5 million stoves were disseminated from 1984 to 2003, and this number is growing (Jagadish, 2004). 2) The technology acceptance rate is approximately 60% (Jagadish, 2004). 3) The product consistently meets the technical performance of increased efficiency,

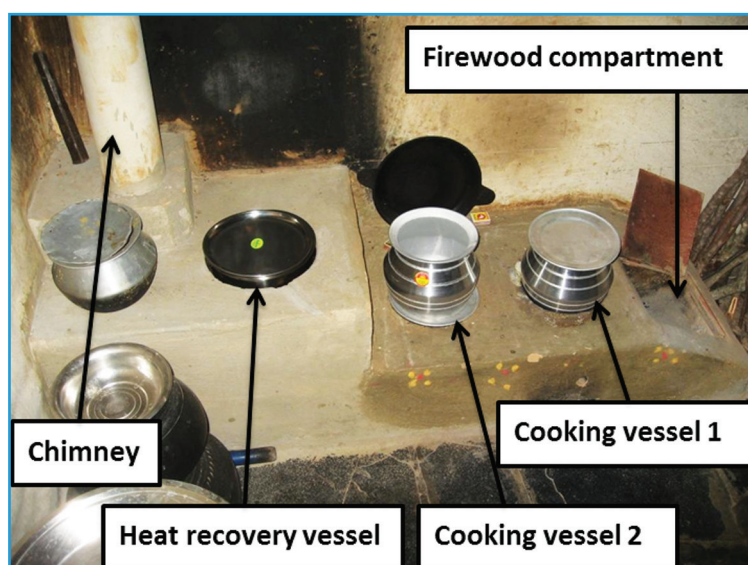


Figure 1 Description of Astra ole

reduced cooking time, and removal of indoor smoke. Though these aspects are impressive with regard to judging product success, technology has not reached the majority of the target population and is, in most cases, pushed by government schemes. Literature reveals that only two of the six reasons behind the low demand for non-traditional stoves are product related, and only one is technology related (Mobarak, Dwivedi, Bailis, Hildemann, & Miller, 2012). While the factors behind low demand are known, a normative basis to generically identify and structure them is missing. If evaluated based on product performance and cost benefits, then ICS as a product should have been accepted in large volumes. This is a complex evaluation, and existing normative approaches fail to holistically evaluate the reality.

### 3 Design: a capability approach-based perspective

#### 3.1 The capability approach: constructs and design

The capability approach (CA) is a broad normative framework to evaluate well-being and justice (Robeyns, 2005). Normative frameworks help determine the **'value judgments'** with which to perceive a given situation or conception of the future. In CA, capabilities refer to effective options for individuals to be and to do, to live lives they value (Sen, 1999), and serve as a measure of well-being. In the literature, CA has been applied to technology to establish links between technology and capabilities (Oosterlaken, 2009), explore design as capability (Dong, 2007), for a capabilities-based evaluation of technology (Kleine, 2010, Gigler, 2004), and to comment on ethical aspects (Hoven van den, 2012). These attempts to measure well-being are not from the design perspective; thus, they present difficulties in guiding design. This section attempts to present the constructs of CA from a design perspective and elaborate capabilities as the basis for design evaluation.

Every product needs a purposeful, goal-oriented 'thoughtful action' to make it tangible and must be

available to end users. The underlying process and thinking can be referred to as 'design'. In its most generic sense, Simon (1996) defined design as a process of changing the existing situation into a desired situation. An operational definition of the existing situation and a desired situation is crucial. For this, one must know what problematic aspects of the existing situation must change to what desired aspects. This definition requires a normative judgment, which also determines the scope of the existing and desired situation. Conceptualising the existing and desired state in terms of capabilities rather than need fulfilment shifts the evaluative paradigm. CA constructs are mainly discussed from the perspectives of social sciences and developmental economics. The authors interpret CA constructs from the design perspective as follows:

1. Importance to ethical individualism (Robeyns, 2005): The basis of ethical individualism is that *'Individuals, and only individuals, are the ultimate units of moral concern'* (Robeyns, 2005). It is important to identify target users, as their well-being is affected by design. As capabilities are linked to individuals, distinct individuals must be identified. Including or excluding certain sets of users affects design. CA insists that positive effects should be evaluated in terms of effect on individuals, not groups. In the absence of sufficient measures, benefits for the poor will always be 'hijacked' by the non-poor (Yunus, 2007). In the case of cook stoves, the reduced volume of firewood may causally improve a family's livelihood; for example, saved firewood -> less time spent collecting firewood -> additional wages earned by women. When family is a unit of analysis, additional income positively affects the unit. When a woman is a unit of analysis, she ends up working harder, this affecting her health. Her jam-packed daily schedule negatively affects her psychological well-being. Therefore, as a unit of analysis, the woman may be disadvantaged. Ethical individualism in 'design for capabilities' compels the identification of the most disadvantaged individual or group, and tries to understand the effects on their well-being.



2. Importance to freedom: In CA, freedom manifests on two levels

- a. Freedom to choose what one wants to be and do based on one's conception of life (Robeyns, 2005): This relates to the eudaimonic dimension of well-being. The constructs of *being* and *doing* something are more abstract than having access to objects of utility such as a car, television, or mobile phone. Understanding the explicit links of *being's* and *doing's* with the conception of life explicates user's conceptions of well-being. For design, this abstractness ensures a deeper holistic understanding of need, which may not be directly aimed at the product. Designing for capabilities ensures in-depth, fair usage of participatory methods, which are often used as tools to confirm the designer's bias (Frediani, n.d.). Most cook stove users are poor. This construct shifts them from being inert recipients of aid to thinking rational individuals (Sen, 1999), forcing the designer to understand users' multi-dimensional conceptions of well-being and a good life.
- b. Freedom to choose from available options (Robeyns, 2005): Individuals and their resources/needs differ. CA values this plurality (Alkire, 2002). A single option or a small set of options cannot match the total population's conceptions of life. High dependency on few products increases the vulnerability of disadvantaged people (Narayan-Parker & Petesch, 2002). This phenomenon is known as the poverty penalty (Prahalad, 2005). In such situations, capabilities as the freedom to choose from feasible options serve as better evaluation space for products (Khadilkar & Mani, 2013). While more options have implications for environmental sustainability, ignoring them affects the sustainability of the population. This aspect needs careful scenario-based attention. LPG is the best technical solution

for most problems including smoke and decreasing the efforts of women. Field experience shows that a weak distribution network and price decreases the complete dependency of the poor population on LPG as main source of energy. Most households have both an LPG stove and traditional cook stove, thus expanding their options. A firewood and traditional cook stove's viability expands the capability space and disadvantages such as smoke and inefficiency diminishes the capability space.

3. Distinction between means and ends (Robeyns, 2005): 'Ends' are the ultimate goals to engage in a certain activity, while 'means' are the methods/routes/tools deployed. While the ultimate ends of well-being for physiological needs are straightforward, they become 'fuzzy', conflicting, and 'messy' as we ascend Maslow's hierarchy (1954). CA emphasises the distinction between means and ends. Each capability, which serves as a mean, should be traced to its end. Ends, as ultimate goals, fuel lower-level beings and doings. Improved cook stoves are not primarily required for saving firewood and reducing smoke; however, they are ultimately required for an increased livelihood and good health. A cook stove that does not save firewood is as unnecessary as one that saves firewood but does not increase livelihood. In regions with abundant firewood, saving firewood does not save cost or generate profit for the user. Here, if an increased livelihood is the only reason for being interested in a stove, then users will never want an improved stove. Factors leading to an increased livelihood may not fit in the technical sphere of design, but may fall under overall design if the scope is defined as the capability to increase livelihood. In this case, scope of design may need an allied business development activity to generate livelihood from saved firewood or provide perks for each kilogram of saved firewood.
4. Distinction between means and capabilities (Robeyns, 2005): Means do not ensure



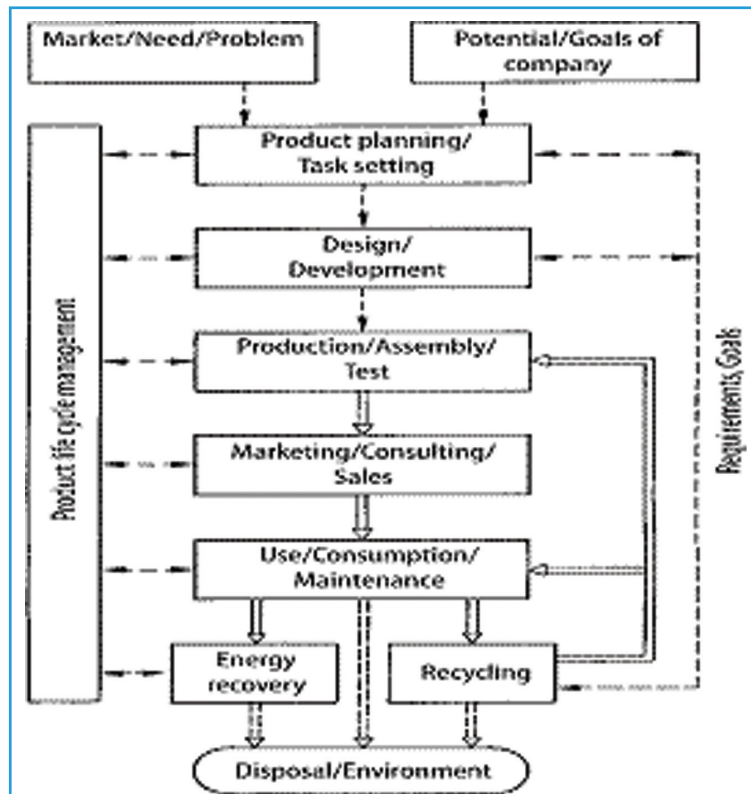
capabilities. Owning an improved cook stove cannot ensure the capability to use it if the user does not have the appropriate technical knowledge, access to the specific fuel needed, or the inclination to use it. There are many geographical, psychological, societal, and material barriers between a mean and capability. Existing normative approaches equate means to benefits. For example, the absence of a service network and social stigmas influence the successful use of available telecentres in many rural areas in India (Best & Kumar, 2008). Capabilities are beyond means.

These constructs are the basis of an alternative perspective for traditional design.

### **3.2 Redefining design from a capabilities perspective**

Predominantly, design is a process of conceptualising a product (Pahl, Wallace, & Blessing, 2007, Ulrich & Eppinger, 2004). This type of definition is rooted in the history of design as making artefacts for personal use and then for industrialisation (Jones, 1992). Design is always linked to product as a tangible artefact (Beltagui, 2011). The relative time span of activities—generating a new concept, detailing, and prototyping—is quite short compared to the entire product life cycle, which includes product testing. During the product conceptualisation and testing phase, standardised prototype stakeholders are searched and assumed to be available in the absence of specific stakeholders such as the manufacturer, distributor, and recycler. In industrialised economies, stakeholders (other than users) are characterised by predictable behaviour because of the market structure. The predictability of prototype stakeholder behaviour is linked to the capabilities they wish to fulfil, which are ‘to maximise profit, legitimise the industry, and follow accepted organisational culture’. In contrast, the capabilities of stakeholders linked to products produced in informal economies are not as uniform. An informal market means that industry and society are closely knit. Furthermore, societal issues and

cultural aspects considerably influence stakeholder behaviour in informal economies. Thus, each phase of the product life cycle must be simulated considering the potential stakeholders in each product life phase. Essentially, this requires ownership of the entire product life cycle. Currently, the approach to design is product-centric, not capability-centric. Rooted in both practice and education (Dorst & Dorst, 1997), product-centeredness is acknowledged in the literature (Courage & Baxter 2005; Trevelyan 2010) as a feature of market-oriented products against the social model of design (Papanek, 1972; Margolin & Margolin, 2002). In design thinking, product centeredness: 1) Limits a needs analysis to directly perceivable/superficial needs linked to product functionality; and 2) Considers design a small part of the product life cycle, focusing on the remaining life cycle through a simplistic assessment of stakeholder availability/unavailability (see Figure 2). Stakeholders such as users, manufacturers, distributors, servicers, and recyclers are involved in product life phases to fulfil their own life conceptions. In addition, each stakeholder has certain expectations for the product related to functional, aesthetic, and ergonomic specifications. To address the superficial needs analysis characteristic of product-centeredness, human-centred design (HCD) methods are employed. HCD methods, for example ethnographic studies or participatory design, cannot achieve desired goals because of designers’ bias towards their own conceptions of design outcomes (Steen, 2008). Design for manufacturing and assembly/disassembly are employed; however, this is mostly targeted at fulfilling technical aspects for standardised manufacturing and assembly setups, which are unavailable in most informal markets. The technical success of design is crucial but not sufficient unless and until the product positively affects stakeholders’ lives. Only referring to technical aspects as design is more harmful in underdeveloped markets such as BoP. Designing for capabilities normatively avoids the unjustifiable importance attributed to product, treating it instead as merely a means to fulfil the capabilities for which stakeholders are involved in the product life cycle.

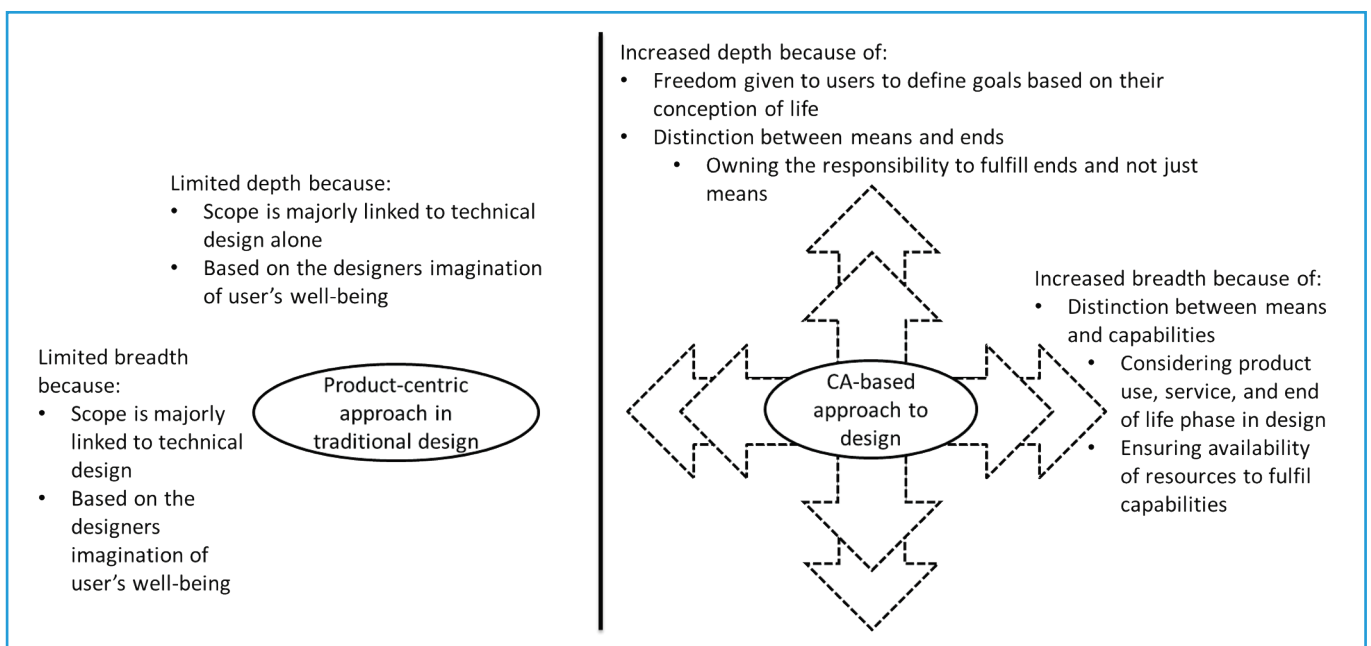


**Figure 2** Positioning design in the traditional design cycle  
 Source: Pahl, Wallace, & Blessing (2007)

### 3.2.1 Applying CA to design

Designing for capabilities widens the scope and responsibility of design. CA-based design discards the current stereotype of designer. From a CA perspective, 'designer' refers to a group of design thinkers with varied skills and responsibilities, who work toward making stakeholders realise a

product's capabilities. In this new perspective the current stereotypical designer will be just another member in the design process. Furthermore, others will share his current intellectual burden. For any shared responsibility, an unambiguous vision of the final goal is essential. Capabilities can provide a unified view of the final goal that design should achieve. Capability constructs related to freedom



**Figure 3** A traditional design approach versus a CA-based design approach

and ethical individualism (see section 3.1) help identify the correct design focus. The construct 'distinction between means and ends' (see section 3.1) adds depth to design by compelling the designer to think in terms of fulfilling ends, which are beyond means; in other words, the product. It ensures that the designer approaches design holistically from a systemic perspective. A designer cannot disown unfulfilled ends for which he devised a means in the form of a product.

The construct, distinction between means and capabilities (see section 3.1) leads to the design's ownership for the full product life cycle. If the product is not made available (manufacturing and dissemination), not supported during usage (training, manuals, service), and not disposed of safely (end of life), then the user's capability to use the product is not fulfilled. Design for capabilities evaluates whether stakeholders for each product life cycle stage are available or made available. The need for involvement of stakeholders from marketing, distribution, and finance (Prahlad, 2005, Kandachar & Halme, 2008) in the design process requires a normative basis to provide them with a unified goal. Existing normative bases are income and product-centric, resulting in a narrow vision of well-being. Most products designed with this narrow vision fail in resource-tight and challenging markets of BoP (Paton, 2007; Ramani, SadreGhazi, & Duysters, 2012). While the importance of a deeper understanding of needs, distributional challenges, stakeholder involvement, and so on are well known, they are still not incorporated in design because of a lack of methodological support (Ramani, SadreGhazi, & Duysters, 2012). CA-based methodology can potentially systemically provide this support.

The generic CA-based evaluation presented here is not based on a specific region or population. The first step of a CA-based evaluation is to determine the unit of analysis, be that an individual or groups of individuals. According to ethical individualism, the most disadvantaged people should be selected. In this case, disadvantage can be linked to: 1) Access

to firewood (land ownership, cattle ownership—cow dung as a source of fuel— distance from forest, economic ability to buy firewood), 2) Access to space (size and aspect ratio of kitchen), 3) Access to information (television with multiple channels, newspapers, a computer, Internet, electricity, and so on.), 4) Gender (patriarchy, role of women in decision making, occupations of women, and so on.), 5) Social structure (cast, reservations, subsidies, government schemes, and so on.), and 6) Economic status (e.g. below the poverty line, land ownership, and so on). The success of the evaluation should be based on the capabilities of the most disadvantaged user or user group from each category. Astra ole works with all available fuels and is compatible with traditional stoves. Additional operational information is not needed. However, its cost can be a barrier as traditional stoves are free; thus, the design process should ensure the capability to buy the stove through the financing schemes or subsidies. Patriarchy plays role in collecting data, as women are not expected to interact with male interviewers. The advantage to women and not to the family alone should be the measure of success in the CA based evaluation.

For the CA evaluation, advantages of Astra ole to save firewood and limit smoke emission in the test environment are not enough. Criteria for success should only be based on the user's capabilities. Technical characteristics are merely enablers for the user's capability. The distinction between means and ends should be ascertained without assuming that users are only interested in technical performance. Means can be upward extrapolated towards ends by asking 'why' questions (see Figure 4). Some answers obtained during the field experience are (without any order of importance) to avoid eye/lung problems, save firewood, stop the house from blackening, gain prestige in the community as users of an improved stove, save time, and save firewood. Each higher-level mean must be treated as another capability—for example, being able to avoid eye/lung problems—and upward extrapolation must be repeated. Asking 'why' questions for each capability traces the ends of each mean. Furthermore, an

established method to more deeply understand needs is to ask questions pertaining to ‘why’ (Cross, 2000). Thus, it is interesting to understand whether CA adds to this in any way, an issue that is revisited later. Following is an example of a response to questions pertaining to the higher-level capability ‘to save time’. Women were interested in the capability of saving time to spend time with children/friends, rest, pursue hobbies, and so on. (field experience and personal communication with Ms Mamta Chandar, Kulu, Himachal Pradesh), which provides insight into desires regarding their lives.

Distinguishing the mean of having an Astra ole and the capability of being able to use it expands the scope of the entire product life cycle. In design for capabilities, the designer must answer questions pertaining to: 1) access to the product, 2) training for proper usage, 3) support for breakage and malfunction, 4) maintaining the stove to lengthen product life span, and 5) salvaging reusable components after the life span ends. Addressing these aspects extends ownership to the whole life of the product. During the technical design phase, the designer is forced to think of each life cycle phase. While this aspect is acknowledged in design methods, it is generally left to the marketing team to handle. Decisions regarding dissemination and service are taken after the technical design of the

product is concluded. Traditionally, because the scope of design is limited until the technical design phase, intervention of design for later product phases is uncommon. Manufacturing or assembly design is practiced; however, this is as an enabler to an already finalised product concept. Design for capabilities addresses these aspects during the product conceptualisation phase, which is a more flexible time for change. The product life cycle for capabilities is crucial for the BoP market, because most stakeholders belong to the informal market. The informal market has non-standard methods/tools/processes for manufacturing/distribution that change alongside geography, this further highlighting the importance of flexibility in design. The Astra ole was designed considering technical aspects. However, ease of dissemination/manufacturing was not a key area of focus during the design phase, which bottlenecked its possible dissemination (see section 5).

Distinguishing means from capabilities adds depth to the design and evaluation by forcing the designer to list and check the resources required to translate each mean into a capability. Kleine’s (2010) CA-based choice framework is useful in this aspect (see Figure 5). Identifying resources for a given capability is referred to as ‘downward’ extrapolation in this analysis. It is now appropriate to discuss how asking

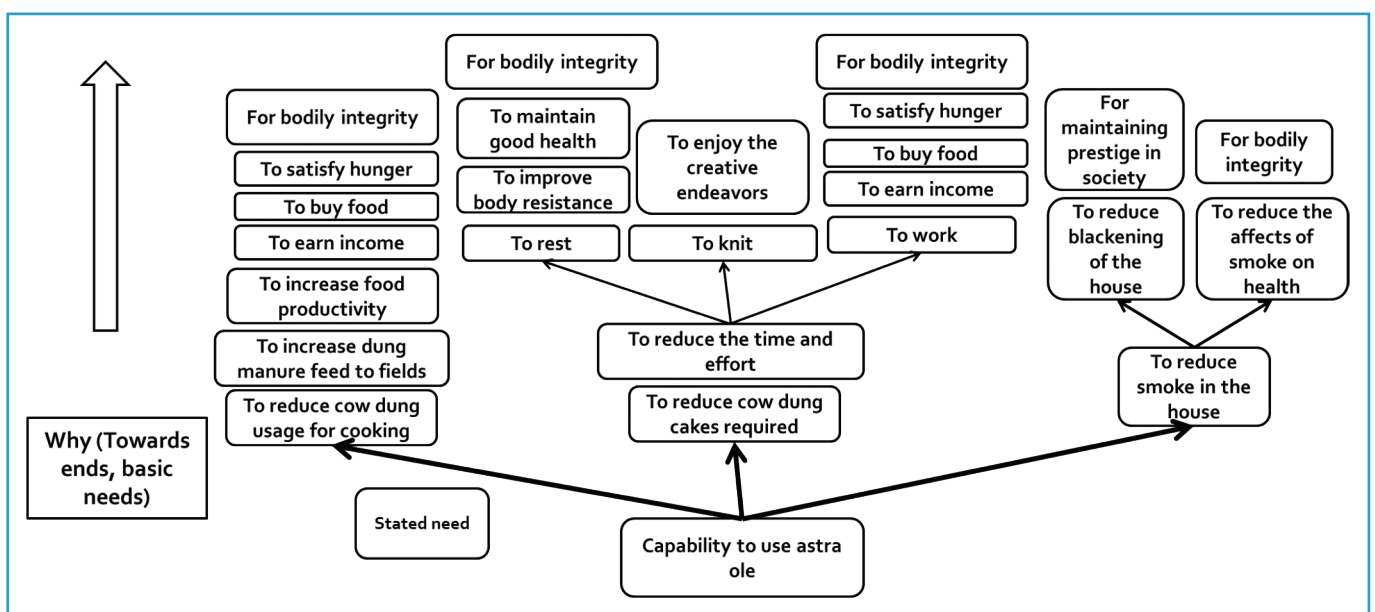
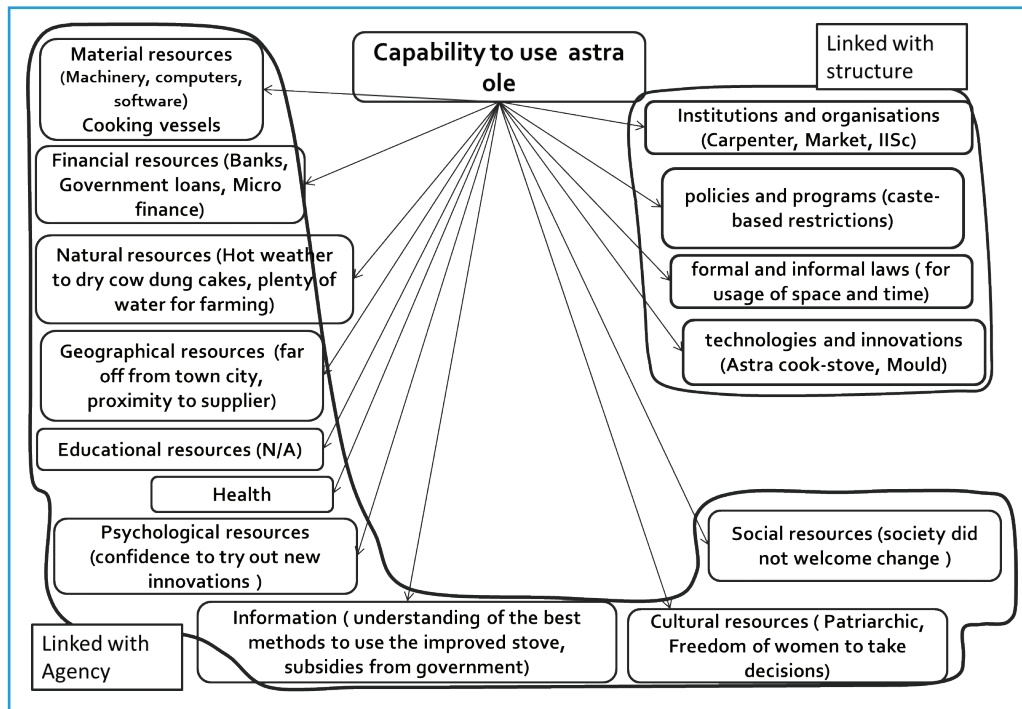


Figure 4 The construct ‘distinction between means and ends’ as a capability to use the Astra ole



**Figure 5** The construct 'distinction between means and ends'

**Source:** Adapted from choice framework (Kleine, 2010)

'why' differs in the capability approach. In a regular design method outcome of each 'why' is treated as information. In design as capability, each answer is a possible capability, and the designer must check its feasibility. Each answer to a 'why' question must be upward and downward extrapolated. This processing converts the information into rich capability perspectives.

An important challenge/shortcoming in the design of the Astra ole as capabilities was in the manufacturing phase. From inception of stove, brick and mortar was used as construction material. Stove efficiency depends on dimensional and geometric accuracy of stove. To construct the stove a skilled mason is a necessity. In rural India—the primary stove market—skilled masons are always in demand due to transitions from traditional houses to Reinforced Cement Concrete (RCC) houses. Masons are not interested in building stoves as it pays less than constructing houses. Semi-skilled or unskilled labour cannot achieve the desired dimensional and geometrical accuracy, this resulting in substandard performance. Training and retaining unskilled labour is a big challenge. Thus, lack of capability to construct the Astra ole using unskilled labour hampers the capability of using the

Astra ole as follows: 1) unavailability of the stove, 2) no fuel saving, 3) substandard appearance, and 4) inefficient smoke removal. These shortcomings are attributed to the unavailability of one important stakeholder.

#### 4 Design of mould for rapid dissemination of the Astra ole through the capability approach

The main shortcoming in the original manufacturing method was the necessity of skills needed for the desired dimensional stability and structural strength. One such method is rammed earth technology, in which a mixture of soil, sand, and cement in the correct proportions are moulded into a specific shape. Using this method, freely available soil from nearby areas constitutes the major volume of the structure. The cost is further reduced by the low cement requirement.

Rammed earth technology uses a mould for construction, which is simple for constructing straight walls. However, building complex, contoured shapes with dimensional accuracy is more of a challenge. CA is used in designing the new mould (see Figure 6). The mould is made from wood



for numerous reasons including its lighter weight, low initial investment, availability, workability, and desired strength. These features enable the capability to own the mould with a low investment. The structure of the mould is intentionally kept simple to reduce the mental effort required in assembly and disassembly. As such, the capability to use it is enhanced. The mould comprises three tiers translated from similar features of the stove. This helps trainees to intuitively determine relative placement. Division into three tiers allows easy manoeuvrability in cramped stove construction sites and facilitates transportation between sites. It also provides the freedom to choose the position of the chimney to suit various rafter positions and *vastu* considerations in the mud houses of rural India. The mould assembly includes templates for accurate dimensioning. Special consideration was given to on-site working conditions such as lack of sufficient light, sand or dust, and a cramped working area. Most important, the need for masonry skills has been completely removed, which means independence from scarce skilled labour without compromising the crucial dimensions. In addition, readily available mould construction material in local markets is consciously used. Specialised parts are avoided so that material needed for servicing can be sourced from nearby towns. These features were

identified based on the construct of distinguishing between means and capabilities. Design of the mould was extended to manufacturing and servicing departments. Manufacturing was kept as simple as possible by avoiding intricate joints. Servicing was simplified by avoiding the use of specialised parts. All small and loose parts of the mould (other than fasteners, as they are available in local hardware shops) were attached to bigger parts to avoid being misplaced or left behind at the work site. Users of the mould were identified by giving special attention. Their expectations and aspirations from the small business of constructing stoves using the mould were used in their selection and to develop a business model. Special efforts were taken to promote the mould based on manufacturing the Astra ole as a business. Development of a full training program is in progress to promote the mould as a business opportunity to fulfil the capabilities users of the mould expect to fulfil with this product.

## 5 Discussion and conclusion

Normative approaches to answering the question ‘What aim should design fulfil?’ are necessary, but not explicit in current design methods and methodologies. This study compares the predominant normative framework for examining



Figure 6 Using the mould to construct Astra ole

design and the new normative framework of the capability approach. This study focused on ‘how’ to design for well-being, rather than questions pertaining to the ‘what’ of design. The capability approach widens the scope of design and compels design that is more responsible. Design for capabilities assumes responsibility for meeting the ‘ends’ users wish to fulfil through the product and does not restrict design to the functional aspects of the product. Design for capabilities also extends ownership of the design to the full product life cycle. As such, CA-based evaluation must also incorporate these considerations. Ownership of meeting ends requires development of the whole ecosystem, which is referred as product-service systems in the current literature. Currently, many phases of the product life cycle such as manufacturing, marketing, distribution, and end of life are considered as the responsibilities of other specialists to be achieved post design. Though acknowledged in the literature, the absence of theory to understand each stakeholder’s motives behind involvement in the product led to unsuccessful implementation of these aspects in practice. Concepts of capabilities applied to each stakeholder can provide these insights. Design for capabilities brings much more under the umbrella of design than traditional design now considers. Traditional designers may be overwhelmed by this increased burden, but design should take on this additional responsibility to do justice to its ultimate aim of improving the well-being of users.

Notions of design as capability are difficult to understand without a working example; the Astra ole serves that purpose. Steps like identifying the unit of analysis using ethical individualism, tracing means to ends, and differentiating between means and capabilities help in understanding how the scope of design is expanded and deepened. The additional example of design of the mould shows how neglected life cycle phases like manufacturing and how stakeholders such as masons can affect the user’s capability to use the Astra ole. This study briefly introduced readers to the practical methodology of designing and evaluating for capabilities.

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paper

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Design to Meet the Challenge of Sustainability in the  
Twenty-First Century: Reflections on the  
Foundation Course in Design

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# Design to Meet the Challenge of Sustainability in the Twenty-First Century: Reflections on the Foundation Course in Design



## Abstract:

*'Admittedly this complex world cannot exist without arduous detail work of the specialist. But the education of the specialist should not start with the training of a single ability before a harmoniously related all round education has been completed ... The new specialist will have to integrate his special subject with the social whole. This integration must be based upon a carefully fostered intuitive and reasoning power, the result of emotional and intellectual development in balance ... In fact, this is his historic struggle, to arrive at an integrated life in which he would function to the fullest of his capacities through a synthesis of the intellectual and the emotional, through the coordination of penetrative thinking and profound feeling.'* (Moholy-Nagy, 1947)

Written in 1947, Moholy-Nagy's thoughts still seem pertinent today. The social, cultural, economic, technological, and ecological challenges facing us as part of the transition from an industrial to a knowledge-based society require a new discourse on how to define design. It is critical that this discourse include a transdisciplinary approach to design. This can ensure a harmonious integration of values and concerns existing at all levels – society, economy, business, government, technology, the environment with society, economy, business, the government, technology, and the environment within the current context. As designers continually extend and negotiate the scope of the design discipline, adding new dimensions to design education seems necessary in order to keep pace with changing circumstances.

This paper presents a historical background of design education in India and highlights current challenges, which call for a re-examination of the constitution of the foundation course in design education in India today. The foundation course of most design curricula has evolved from a need that was originally perceived at the Bauhaus as an initiation to 'Elements and Principles of Design' and 'Design Thinking and Action'. The Ulm School of Design (Hochschule für Gestaltung at Ulm) continued the Basic Design Courses at the Bauhaus as the 'Grundlehre', and focused on non-object-oriented design and training of the hand and eye. This took the Ulm experimentation beyond the areas of exploration at the Bauhaus, where such exploration was restricted to applications on small objects of low complexity.

For design to be relevant to contemporary society, contemporary designers must address complex issues that are multidisciplinary and considerably wider in scope. Twenty-first-century design education should not merely observe 'good form' but also be able to apply design and develop strategies that resolve actual issues.

The problems of the people in India are unique. Within the mesh of cultural, geographical, and technological diversity, along with both national and local economic disparities, opportunities exist for designers to find solutions to the broad range of problem areas in India. Perhaps when design education engages in social, political, economic, scientific, ecological, and environmental discourses in a collaborative and transduces plenary manner, design can then effectively contribute to managing these issues. For instance, designers must understand the complexities of issues such as healthcare, safe water provision, agricultural support, transportation, housing, education and innumerable others as well as be aware of 'intangibles' such as values, empathy, social responsibilities, local/global relevance.

However, grave challenges such as sustainable development are currently restricted to a few theory classes in most design schools.

**Keyword:** *design education, Foundation course, sustainable development, transdisciplinary approach*

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## 1 Introduction

The United Nations forecasts that the global population will reach 10 billion by 2050, necessitating 50% more food, 30% more water, and 45% more energy in the next 15 to 20 years. A dearth of resources may well be the basis for social, political, and economic instability, geopolitical discord, and permanent environmental damage. The constantly growing population, along with urbanisation and industrialisation, creates a constant strain on energy, water, and food supplies. Unsustainable development and the impact of climate change exacerbate these pressures, and underscore the need for a new low-carbon economy. Strategies focusing on one of the three problems without considering interconnections with the other two may lead to serious inadvertent consequences.

One key challenge of our time is in advocating sustainable development. The concept of sustainable development is complex, and no instructions are available on how to proceed. However, given its urgency, sustainable development should be undertaken through exploration and experimentation in collaboration with partners from across disciplines. UNESCO believes education to be the driving force of a sustainable future, and is dedicated to maximising its efforts and including more partners for the development of peace, harmony, and human betterment (UNESCO, 1997) .

## 2 Sustainable Development

Any development that meets current needs without jeopardising the ability of future generations to meet their needs can be considered sustainable development. In other words, a sustainable society is one which gratifies its needs without diminishing the prospects of future generations. Sustainable actions would balance the resources used with regenerated resources, and ensure that resources are just as clean, if not cleaner, both at the beginning and at the end of use. They also restore and maintain the integrity, viability, and diversity of natural systems, enhancing local and regional self-reliance. These activities would aid in creating and maintaining a community and culture of places.

In a broad sense, what need to be sustained are nature (earth, biodiversity, and ecosystems), life support (ecosystem services, resources, and the environment) and the community (culture, groups, and places). Moreover, what must be developed are people (child survival, life expectancy, education, equity, and equal opportunities), the economy (wealth, productive sectors, and consumption) and society (institutions, states, and regions) (U.S. National Research Council, 1999) .

By contrast, the consequences of practices in social, economic, and political affairs have placed the world on the path of 'unsustainability'. The constantly increasing strain on the environment caused by the pervasive industry drives us further down this path.

The exponential growth of the global population, widespread poverty, the constant violations of human rights along with a rise in ethnic and religious conflicts and violence, gender inequity, and so on work as deterrents to sustainable development. Moreover, lack of forethought is leading to more natural catastrophes such as droughts and desertification, and an increase in floods and heavy storms.

These factors could easily be considered symptoms rather than causes, because they are the consequence of thinking, values, and practices. As mentioned, education – one which must stress on a sustainable future – and working collaboratively towards fundamental changes in human attitudes and behavior is the way forward

### **3 Sustainable Development is the Challenge of the Twenty-First Century**

Environmental concerns have existed from the time of the earliest settlements to the present day. History has always been dominated more by war and politics, rather than environment, culture, and development. However, around the mid-twentieth century, the emergence of the ecology movement generated an awareness of ‘the limits of growth’ within political and economic policy circles. Industrial over-exploitation and the brazen overuse of resources have placed the natural foundations of life in jeopardy. Safeguarding these natural foundations currently necessitates interdependent reforms in society, the economy, political systems, and the environment.

The consumption of a disproportionately high share of natural resources of the highly industrialised societies of the Global North is resulting in an excessive environmental burden on our biosphere. The Global North does not possess more rights to use the earth’s resources than the Global South. Reducing the use of resources and energy to a fraction of the current level requires an international mechanism for sharing the ecological burden

between the rich and poor countries (Alliance 90/The Greens, 1993).

That the overuse of natural resources reduces choices for future generations and restricts their opportunities for self-determination must be understood. We must now acknowledge that resources are finite, and that there are limits to growth. Environmental destruction today will restrict the lives of future generations. They inherit burdens such as the threat of climate collapse and nuclear active waste from nuclear power plants, which will continue to emit radiation for thousands of years.

This dry, often little understood concept is actually one of the few frameworks for cohesive decision making that effectively addresses competing economic, social, and environmental needs. At present, most decisions are made on an economic basis (i.e. the ‘economic bottom line’). This method ignores the detrimental social and environmental impacts that the modern world continues to both create and destroy.

We require a ‘socioeconomic–environmental bottom line’ of decision making, where social, economic, and environmental criteria are assigned equal consideration and importance. In fact, the environment is the fundamental bottom line, because without a safe and stable environment, no economy or society can exist.

Sustainable development basically involves common sense and treating the world as if we intend to stay. Ecological common sense suggests that flexible and adaptable technologies be given preference over irreversible large-scale technologies. The implementation of ecological policies is ineffective without first convincing people of the importance, as well as respecting their civil rights.

### **4 Sustainable Development in India**

India continues to struggle to achieve food, water, livelihood, and sociocultural security for

its people, even 67 years after independence. Official and independent assessments corroborate shortages of food, water and energy, persistent poverty, social discrimination, unemployment and underemployment, amongst other problems. These problems thwart the achievement of the Millennium Development Goals (MDGs).

The MDGs are a UN initiative. Eight international development goals were instituted following the Millennium Summit of the United Nations in 2000, subsequent to the adoption of the United Nations Millennium Declaration. All 189 UN member states at the time (there are currently 193) and at least 23 international organisations committed to help achieve the MDGs by 2015, which are as follows (Kothari, 2013) :

1. To eradicate extreme poverty and hunger
2. To achieve universal primary education
3. To promote gender equality and empower women
4. To reduce child mortality rates
5. To improve maternal health
6. To combat HIV/AIDS, malaria and other diseases
7. *To ensure environmental sustainability* [emphasis added]
8. To develop a global partnership for development.

Under MDG7, 'To ensure environmental sustainability', the targets for 2015 include the following:

1. Halve the proportion of people without sustainable access to safe drinking water and basic sanitation by 2015.
2. Achieve a significant improvement in the lives of at least 100 million dwellers by 2015.
3. Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources.
4. Reduce biodiversity loss by 2015, achieving a significant reduction in the rate of loss.

Not all targets set under MDG7 on ensuring environmental sustainability have been met; the

interconnections between this and other goals remain weak or are ignored.

According to Kothari (2013), a vitally different framework of development is the need of the day. He quotes the outcome document of the United Nations Conference on Sustainable Development (Rio+20) of 2012 and argues that, as indicated by the manuscript, ecological sustainability has to form a major basis for such a framework. Kothari proposes a new set of goals that could include impartial access to nature and natural resources for all communities. This would include the preservation and resilience of ecosystems and biodiversity. Other goals are to provide access to sufficient and safe water, food, energy, education, habitat, and health care, as well as to meet the needs of children, women, and people with special needs.

Kothari calls for urgent attention on the level of degradation of the natural environment that has reached levels beyond recovery, despite our dependence on it. In the Indian context, natural ecosystems are under strain, and decline is evident across the country, with exceptions only in the case of some conserved and protected areas. Other issues requiring immediate attention are agricultural and wild biodiversity, which are suffering from varying rates of rapid erosion. Kothari claims that more than half of all accessible waterbodies are contaminated beyond drinking, and occasionally beyond agricultural use. Two-thirds of land has been reduced to various levels of suboptimal yield. Air pollution has reached globally high levels in several cities. Modern waste such as chemical and electronic waste is being produced at a pace far beyond our ability to recycle and manage .

## 5 Design Challenge of Sustainability in the Twenty-First Century

'Design Science is the effective application of the principles of science to the conscious design of our total environment in order to help make the earth's finite resources meet the needs of all humanity without disrupting the ecological processes of the planet' – R. Buckminster Fuller (Brown, look and globel, n.d.)



Sustainable design does not concern a retrospective approach, 'a back to nature philosophy'; instead, it must focus on intelligent resource efficiency, cutting-edge aesthetics, and on meeting direct human needs, not trivial aspirational whims.

Brundtland's Report provides the standard definition of sustainability, as follows: 'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.' It comprises two critical concepts: the concept of basic needs of the world's poor, which should be assigned immediate priority, and the concept of obligatory constraints on the environment's capacity to meet present and future needs (World Commission on Environment and Development (WCED), 1987). Designers must understand the true meaning of sustainability, and be able to apply that knowledge to their professional work. This knowledge must go beyond a few theory classes in design education and must be adapted into practice.

## 6 Education as the Way Forward

Based on the popular belief that education can shape the world of tomorrow, an effective approach for society to confront future challenges is through education. Evolution is positively proportionate to the collective products of educated minds, which include instinct, invention, innovation, and research. This does not necessarily occur in laboratories and institutions, but in all walks of life. Although education cannot be a panacea, it is to be viewed, in the broadest sense, as a critical part of all efforts to ideate and create a range of interactions among people, and to cultivate respect for the needs of the environment.

In its holistic form, education would include both formal and non-formal instruction. In this manner, it would address important issues, and would generate awareness among people about taking responsibility for all life forms. The goal of education is to make people more knowledgeable, better informed, ethical, responsible, critical, and wiser. Such qualities and abilities would result in

addressing problems more effectively. Moreover, education is also a means for developing skills, disseminating knowledge, and perhaps developing a healthy appetite for continuous learning.

Through education, desired changes in values, behaviors, and lifestyles can also be brought about. Education can lead the way towards sustainability by promoting public awareness of fundamental changes. This would be required if humanity is to alter its course and leave the commonly trodden path that continues to escalate problems. Education can serve humankind by offering a critical reflection on the world, especially all of its failings, presenting solutions through an exploration of new visions and concepts, and facilitating the development of new techniques and innovation of tools (Alliance 90/The Greens, 1993).

Education is perhaps the most effective way forward to achieve sustainable development.

## 7 Modern Design Education

### 7.1 The Genesis of Modern Design Education

Design was originally practiced through craft traditions and apprenticeship processes. During the industrial revolution, this practice was steadily replaced by industrialisation, and modern design education emerged. The first school to introduce students to formal design education was the Bauhaus in Germany. Established in 1919, immediately after World War I, the Bauhaus was a creative centre home to some of the greatest design thinkers of the times. 'The founders of the Bauhaus tradition identified the qualities that had to be nurtured in art and design students, both in the form of skills and sensibilities as well in their conceptual abilities and attitudes when managing materials and the real world of design action' (Ranjan, 2005).

The Ulm School of Design (Hochschule für Gestaltung at Ulm) manifested as a continuation of the Bauhaus experiments in design education. A former student of the Bauhaus, Max Bill, established the Ulm School, and focused on art as

its foundation. However, under the leadership of Tomas Maldonado, its focus veered to science and society. The faculty, comprising eminent teachers and thinkers across disciplines, experimented with design education. They documented the results in a series of 21 journals published between 1958 and 1968. This research, theory building, and sharing had a lasting impact on design education, including on design teachers in India (Ranjan, 2011).

The closing of the Ulm School in 1968 resulted in the dispersion of its faculty and students across the globe, all infused in the Ulm ideology of public good with design theory and action. This resulted in significant accomplishments in new design education in Latin America by Gui Bonsiepe, in Japan by Kohei Sugiura, and in India by Sudhakar Nadkarni and H. Kumar Vyas, as well as numerous others in Europe and the United States, with continued influence even today.

### 7.2 *Inherited Ulm Heritage in India*

In India, modern design education originated in the latter half of the nineteenth century, with the opening of architecture and art (commercial and fine art) schools. Upon the request of the then Prime Minister Jawaharlal Nehru, Charles and Ray Eames' 'India Report' initiated industrial design practice and education in the post-independence period. Eames, who had drafted the guidelines based on which the National Institute of Design (NID) was founded, had spent time at the Ulm School. Despite Eames' report focusing on Indian design tradition and sensibilities, the design education programs in India, like those in many other countries, actually borrowed their pedagogy and thinking from the Bauhaus as well as from the Ulm tradition. This influence continued at the Industrial Design Centre (IDC), which was established in 1969 at the Indian Institute of Technology Bombay (IITB) in Mumbai, and later at the Department of Design (DOD) at IIT Guwahati, which hosts the first and only undergraduate program in design in India. Many early teachers at NID, IDC, and DOD were trained at the same school. This deeprooted connection between the

Ulm School and many design schools continues to influence the thoughts, ideas, and philosophy of the latter, including those of the foundation course which followed the NID model.

### 7.3 *Influence of Western Pedagogy in India*

Charles Eames, who had drafted the guidelines on which NID was founded, had spent time at the Ulm School of Design. Many of the first NID teachers were also trained at the same school. The foundation of NID was influenced by the philosophy of the Ulm School. Professor Sudhakar Nadkarni, who taught at NID, holds a diploma in industrial design from the Ulm School. He later left NID to establish IDC at IITB in 1969. He retired, and was tasked with establishing yet another school, this time in IIT Guwahati, which offered the first undergraduate programme in design in any IIT. Professor Kirti Trivedi completed his postgraduate work at IDC in Industrial Design, and later studied at the Royal College of Art (RCA), London. He later worked as a UNESCO fellow in Japan, under the guidance of Professor Kohei Sugiura, a guest faculty at the Ulm School. In 1984, Professor Trivedi initiated India's first master's degree programme in visual communication at IDC.

Professor H. Kumar Vyas was deputed to spend 10 months at the Ulm School before initiating the first product design programme in 1966 at NID. He had a long and deeply productive association with NID that spanned 30 years (1962–92). His early training as an industrial designer occurred at the Central School of Art and Design in Britain, where he subsequently worked as a professional designer for over 5 years. He joined NID in 1962 to start its Faculty of Industrial Design and commence programmes directed toward training the first cadre of Indian industrial designers and design educators. He retired, and is currently the chairperson of the Education Council at Maharashtra Academy of Engineering & Education Research's (MAEER) MIT Institute of Design, Pune.

Professor Mohan Bhandari joined NID and was deputed to Germany to work for 1 year with Herbert





Figure 1 Cross-section of (foundation course in design) work

Lindinger, a German industrial designer from the Ulm School. Upon his return, he was asked to coordinate the foundation programme. He left NID in 1982, and subsequently joined IDC. Within the field of modern design education, Professor Bhandari may well be considered the father of the foundation programme in India.

NID had trained the first generation of design teachers for India in the 1960s and 1970s, and some from the second generation were further trained at the RCA in the 1970s. The first to head to London was Professor Singanapalli Balaram, who was deputed from NID for a year-long training programme at the RCA in 1971. He returned to India and worked at NID until his retirement from the institute, after which he moved to Coimbatore to establish a new school of design, called the DJ Academy.

After completing his postgraduate diploma (Typography) at NID in 1967, Professor Mahendra Patel attended the Advanced Graphic Design course at the School of Design, Basel, Switzerland. He has retired, and is currently a guest faculty member at MAEER's MIT Institute of Design, Pune, and Symbiosis Institute of Design, Pune.

The National Design Schools in India were clearly directly influenced by the Ulm doctrine. NID, IDC, and consequently IIT Guwahati have produced generations of designers (and continue to do so), many of who subsequently continue their involvement in design education elsewhere in the country, with pedagogical ties to the original Ulm School of Design.

#### **7.4 Continued Influence in Design Foundation Education**

An extensive photo-documentation of students in the foundation programme from five design schools in India over a few years demonstrates a certain universality in design schools today. This apparent similarity in their works was observed not only among contemporary students across various

design schools but also in the case of students across several decades of design education. This could well be attributed to the pedagogy that has been followed, repeated, and replicated over decades, which may warrant a re-examination of the current learning process. Figure 1 displays a cross-section of the work.

## **8 The Current Design Paradigm**

Early industrial designers focused primarily on form and function, materials, and manufacturing. The current design paradigm practices a vision driven by short term economic goals. Design is currently dependent on technological, economic, and political interests in almost every area of production and construction (Fuad-Luke, 2002).

Findeli (2001) argues that design emerged to absorb the excesses of industrialisation, and to buffer its harmful consequences and make industrial products socially, culturally, economically, environmentally, and practically acceptable. Aesthetics was its rhetorical tool, followed by ergonomics in the mid twentieth century and semiotics in the late twentieth century. However, its central activity has remained the material product (Findeli, 2001).

Design makes objects desirable and reproducible, and through advertising it creates associations between products and particular lifestyles. Design is therefore increasing levels of consumption at the expense of everything else (e.g. the community, culture, poverty, natural resources, and social alienation). Contemporary design schools believe that popular courses such as automobile design, lifestyle design, retail design, and fashion design promise a quick entry into fashionable careers. These design disciplines do not equip students with skills to survive in the future economy as young professionals.

Yet, sustainable design, as governed by appropriate principles, could provide an alternative. Form, object, and artefact must meet the following requirements:



1. They must be fit a particular purpose and function, and be attractive and aesthetically pleasing.
2. They must contain a sustainable design factor: Where and how is the raw material procured, how is the object produced, how durable is it, and how will it be reused, recycled, or disposed of and stored?

These issues are substantially more complex and challenging in the present climate. Programmes in India currently expect students to offer services that meet diverse requirements. How does one train a student to design for a global village as well as real villages in India when the demands of global companies differ considerably from those of villages in India?

Since the 1980s, the field of design has undergone enormous changes in its approach. From form and function, designers have progressed to designing sense, meaning, and experience. The Bauhaus approach of functionalist design has been broadened to include culture, semantics, and strategy, among other aspects. The current shift from the product to systems and services and from linear design processes to networked design processes is changing the notion of design products and design practice. This is reflected in the shift in design problems from products to interfaces and experiences as well as the area of design intervention. The designer's domain has shifted from one of consumption to include, for instance, sustainability, cultural diversity, immersive environments, and lateral problem solving, thus making it truly inter- as well as multidisciplinary. The Stanford Design School, for example, '...draws on methods from engineering and design, and combines them with ideas from the arts, tools from the social sciences, and insights from the business world' (Rethinking Design Education, 2014).

In a developing country such as India, these changing design notions become even more significant not only because India has the largest market but also the most diversity for design intervention—a situation which reflects our unique needs. Broadly,

the country requires not only affordable production with an aesthetic sensibility but also cultural acceptability, sustainability, and the inclusivity of diverse user segments. However, does Indian design thinking as well as design pedagogy reflect this changing complexity?

## 9 New Paradigms for Design

Findeli (2001) defines a paradigm as a set of shared beliefs according to which our social systems (e.g. educational, technological, political, legal, and scientific) function. In an existing paradigm, these beliefs are never questioned or discussed. When challenged, a paradigm shift occurs.

The need to perceive concepts differently, to reframe our approach to complex systems, is a reality we must reckon with, and one which requires new pedagogical methods. Rather than simply focus on imparting knowledge, it is necessary to develop critical thinking approaches that generate new knowledge. Moreover, these methods need to lead to better solutions not only for business but also for humanity and the planet.

Since the time of the Bauhaus, modern design practice has been the model for design education. Defined as an object-centric process, the classical objective of design has been to produce an artefact or environment that solves a problem. In an art-based academic domain, the focus is on beauty and the humanity of such objects or environments. By contrast, academic programs based on engineering and the sciences focus on usability and efficiency. Between the two lie the social sciences, where social and culture issues are addressed. The limits of these disciplines have become fuzzy, but the paradigm they follow has different value systems and methods for designing objects and environments. The paradigm shift in the focus of the design process from objects to experiences, services, and process cycles necessitates different knowledge and methods to inform decision making. The present demands on design practice are clearly different from those of



the past, suggesting the need for a re-examination of the paradigm of design education (Davis, 2008).

Given the increasing complexity of the nature of design problems and design issues, the rapidly advances in technology, and a growing environmental crisis, there is a strong need for interdisciplinary teams composed of experts with different modes of inquiry to collaborate towards developing solutions. The scope of investigation now extends beyond interactions with artefacts, and includes the power of design within more complex social, economic, cultural, physical, technological, and environmental systems.

Mapping this paradigm shift in design practice to design education would involve not a minor course correction but a major shift. After decades of focusing on the progress of individual students, the focus must shift to collaborative team-based learning. The challenges of our era are overwhelmingly complex, and could either be on a local or global scale. Complex issues such as the goals mentioned under MDG7—'To Ensure Environmental Sustainability'—would require teams of experts from complementary fields to collaborate with almost frictionless effectiveness. The dichotomy here is that experts are trained sequentially. For educators, this dichotomy will always present stark challenges.

Four new NID campuses have been announced in India. Within this context, India has a unique opportunity to devise a fresh approach to design education. It is time for a variety of new courses and learning models which can be piloted and adapted to India's diverse contexts in terms of content, form, and business models (Thakara, 2011).

Most design schools in India have been stand alone enterprises (or institutions). Traditional industrial design requires skills in sketching, drawing, and rendering as well as an in-depth knowledge of forms and materials. The latest spaces in design, however, require an understanding of applied behavioural and social sciences, in addition to an understanding of human emotions and cognition. For example,

interaction design, experience design, social design, and service design are not concerned with the creation of physical objects; instead, they require basic drawing skills and a knowledge of materials or manufacturing. In addition, they require knowledge of narrative construction, of the social sciences, life sciences, processes, interactions, operations, technology, and more. In addition, knowledge of scientific methods and experimental design enables designers to test the validity of their innovative ideas before utilising them (Norman, 2010).

## 10 Conclusion

India is an emerging market that has grown rapidly, thus generating both aspirations and anxieties regarding the potential socioeconomic and environmental repercussions. Shifts in society, technology, and the environment are changing the world in ways that are difficult to anticipate. The resulting challenges are complex, ambiguous, and unrelated. This has yielded new opportunities, both in rural and urban spaces, for designers, entrepreneurs, activists, policymakers, investors, and so on.

We still require classically trained industrial designers, because the principle of the ethical use of materials will always remain relevant. Design students need to experience the advantages of engaging in collaborations where the components of design are central. A transdisciplinary approach broadens the 'objective' of design, and the rising complexity of contexts necessitates new multidisciplinary knowledge. Future design schools could follow a model of participatory and collaborative design.

Eco/sustainable design should not be a niche—it is important to make this a mainstreaming concept. It should not remain a simple theoretical input in education. Information on sustainable development is often inaccessible, complex, and elusive. The current focus on environmental profile or process often overlooks the more significant impacts in a product's life cycle. The

context of design training must be delineated or redefined. Considering the forecasted global population of 10 billion by 2050, the magnitude of change required would be complex. Changes must be integral and not only tacked on, and small incremental changes to the current approach may no longer suffice.

Based on a study of conferences and seminars on future concerns in design and of interviews conducted with design educators in the past three years (2010–2013) during in-progress research, a list of recommendations is proposed:

Design education today must be based on current values by considering future generations; must prepare students for the future economy, and not the current 'dying' one; must emphasise social and service innovation; must enhance local and regional self-reliance and understand global relevance; requires inputs on appropriate technologies, both indigenous and cutting edge; must design new learning spaces to nurture effective learning; and must challenge traditional educational silos and explore transdisciplinary learning arenas.

More than half a century ago, Albert Einstein declared, 'We cannot solve our problems with the same thinking we used when we created them.' This statement resonates today. This paper calls for an urgent re-examination at the current constitution of the foundation course in design education in India.

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paper

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What Sustainable Design Means for Novice Creative  
Designers: An Exploration of Their Perceptions and  
Mental Models in the Indian Context

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# What Sustainable Design Means for Novice Creative Designers: An Exploration of Their Perceptions and Mental Models in the Indian Context



## Abstract:

In literature, the evolution of the concept of 'sustainable design' is seen as a broadening of scope beyond green design and eco-design. However, many researchers believe that this broadening of scope remains hypothetical; thus, the general understanding of sustainability usually stops at material usage, carbon emissions, eco-design, etc. Researchers have suggested that this scenario may be the result of a flawed mental model that students develop during design training. This research paper summarises an attempt to understand design students' current mental models regarding sustainability and sustainable design. A study was conducted among 70 novice designers studying to become product and communication designers in three design schools in India. Initial exploration in this study covered current understanding and perceptions of novice designers about the concepts of sustainability and sustainable design. Then, an attempt was made to understand how novice designers approach a sustainable design problem and how they draw the related mental model in relation to the dimensions of sustainability (i.e. people, planet, profit).

The study revealed that most students' understanding of sustainable design was limited to the environmental dimension. In practice, their solution space for sustainable design was generally limited to green design and eco-design. This information can be helpful in taking corrective measures to equip students with a better understanding of sustainable design during design training.

**Keywords:** *sustainable design, mental model, creative design*

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## 1 Introduction

In recent times, achieving sustainability has become the greater goal of humanity for survival on Earth. Consequently, the Brundtland Commission (1987) proposed the philosophy of sustainable development. At present, various governments, organisations, institutions, and academic disciplines are attempting to incorporate this philosophy into their practices (Gagnon, Leduc, & Savard, 2012). Design disciplines have incorporated this philosophy as sustainable design (SD). It is a concept that on one hand closely corresponds with the philosophy of

sustainable development, while on the other hand it appears to have evolved as a result of the broadening of scope from earlier concepts of green design and eco-design (Knight, 2009). Regarding theory, the relevant literature reflects this broadening of scope in research papers that promote a comprehensive understanding of SD (Gagnon et al., 2012). Further, the evolution of various models, methods, and tools supports this broadened scope (Lewis & Gertsakis, 2001). Yet, there are many researchers who believe that this broadening of scope is limited to theory and has not materialised in actual practice (Kjøllestadal, Asheim, & Boks, 2012). They

argue that sustainability education for designers has its roots in environmental issues; in practice, an adequate understanding usually ends at material considerations, eco-design principles, compliance with government regulations, etc. (Kjøllestad et al., 2012; Lindley, 2010). This realisation has pushed researchers towards exploring the possible reasons for this situation. According to Frisk and Larson (2011), one of the prominent reasons is an incorrect interpretation and conception of knowledge. Vanasupa et al. (2010) suggested that this incorrect or partial conception of knowledge is reflected through the mental models of designers. They argued that since most of our actions and decisions are guided by the mental model of reality that we consciously or unconsciously carry, a flawed or a partial mental model of SD among designers will result in decisions and actions that are biased and partial (Vanasupa et al., 2010). Moreover, they deduced that one of the possible points where these flawed and limited mental models are conceived is during design training. With this background, the present study explores the mental models conceived during design training by novice designers (design students) about the concepts of sustainability and SD.

In the past, several studies of novice designers have been conducted towards understanding their approaches to designing (Atman, Cardella, Turns, & Adams, 2005; Stauffer & Ullman, 1988). However, limited studies have been conducted towards understanding designing while considering sustainability issues (Collado-ruiz & Ostad-ahmad-ghorabi, 2010). The present research represents an attempt to study this effect. Initially, this research explored the perceptions and mental maps of novice designers towards sustainability and SD. Then, these designers' approaches towards a SD problem were examined. A questionnaire and a problem-solving exercise were used as instruments for the study, which was conducted with 70 design students from three locations in India.

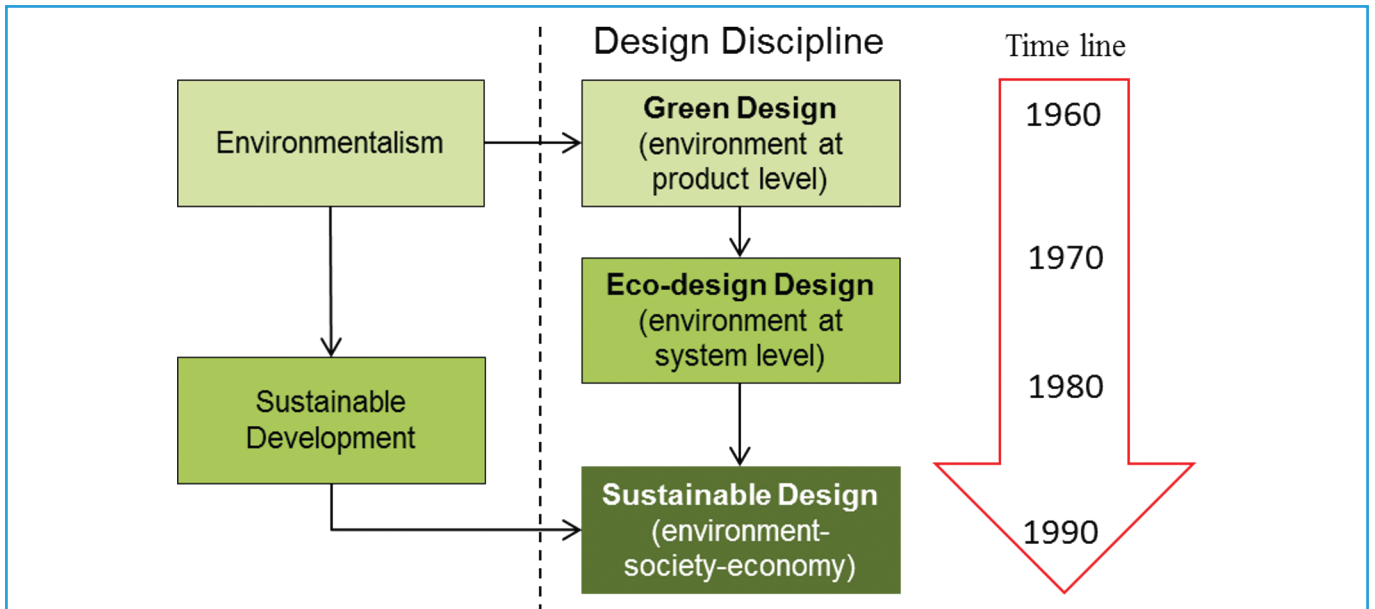
The first part of the paper presents the evolution of SD in relation to different related concepts such

as green design and eco-design. This evolution was expressed through a working conceptual model of SD and was used as a reference for exploring the perceptions and mental maps of novice designers, discussed in Section 2. Section 3 presents the objectives of the study, instruments of data collection, study locations, and subjects. The analysis of the collected data and its major inferences are covered in Section 4. Finally, the paper concludes with a discussion on gaps in understanding of the concepts of sustainability and SD.

## 2 Sustainable Design (SD)—Broadening of Scope

In the literature, the concept of SD seems to have evolved from two philosophies. On one hand, it is seen as a concept that closely corresponds with the philosophy of sustainable development, while on the other hand, it is seen to have evolved from a broadening of scope beyond that of earlier concepts for green design and eco-design (Knight, 2009).

The concept of green design evolved during the 1960s and 1970s; it has its roots in environmental consciousness. It is a product-centric approach towards reducing the environmental impact through waste prevention, toxicity reduction, better material management, remanufacturing, energy recovery, life extension, etc. (Knight, 2009). In a very short time, it was realised that these approaches were not sufficient for curbing the negative impact of products on the environment; thus, the broader concept of eco-design was conceived. Initially, eco-design was concerned with environmental efficiency of products, but the approach widened to lifecycles. This approach is focused on reducing resource consumption (e.g. materials, energy, and water) and reducing the impact on the environment (e.g. pollution and toxicity) throughout the lifecycle of products (Knight, 2009). Environment-degrading factors from cradle-to-grave or cradle-to-cradle were taken into consideration. Developments during the latter half of 1980, especially the proposal regarding sustainable development, further widened the environmental scope to the 'system level' and

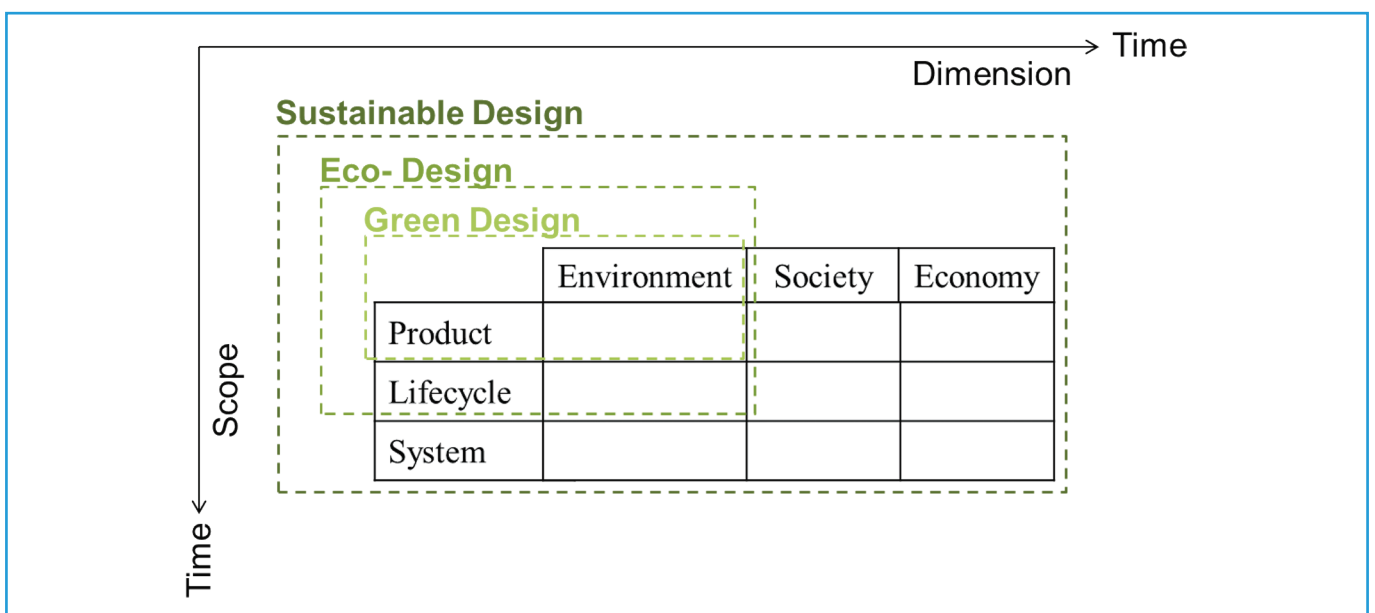


**Figure 1** Evolution of sustainable design (SD): widening of scope and dimension of time  
**Source:** Author-generated based on relevant literature

led to the concept of SD. Because of its close correlation with SD philosophy, the dimensions of society (people) and economy (profit), along with environmental (planet) concerns, were added to the concept (Elkington, 1994; Walker, 2002). This evolution is illustrated in Figure 1.

This broadening of scope (from product to lifecycle to system level) and dimension (environment, society, and economy) presented a bigger and comprehensive picture of SD that can be seen

as an encapsulation of philosophies. Figure 2 presents this encapsulation in the form of a matrix where the interacting space between product and environment represents the concept of green design, and the interacting space between the lifecycle and the environment represents eco-design. The matrix as a whole represents the SD concept. The present study uses this interaction matrix as a working conceptual model of SD to explore the perceptions and mental maps of novice designers about the concept.



**Figure 2** Encapsulation of philosophies (green design, eco-design, SD)

As a concept in literature, SD acknowledges this evolution, as evidenced by various research papers published towards developing a comprehensive understanding of the concept (Gagnon et al., 2012) and various models, methods, and tools that support it (Lewis & Gertsakis, 2001). However, many researchers believe that this evolution is limited to theory and has not been demonstrated in actual practice (Kjøllestadal et al., 2012). They argue that in practice the understanding of SD usually stops at material considerations, eco-design principles, compliance with government regulations, etc. (Kjøllestadal et al., 2012; Lindley, 2010). According to Frisk and Larson (2011), one of the prominent reasons for this situation may be the wrong interpretation and conception of knowledge developed during design training, which remains deeply rooted in environmental issues. Vanasupa et al. (2010) suggested that this wrong or partial conception will be reflected through the mental models of designers. A mental model is an internal symbol or representation of reality that plays a significant role in cognition, reasoning, and decision making. Therefore, a flawed mental model of sustainability and SD may result in decisions and actions that are biased and incomplete (Vanasupa et al., 2010).

This study assumes that one of the possible points where flawed and partial mental models are conceived is during design training.

### 3 Objectives of the Study

Based on the above discussion, following are the two objectives of the study:

1. To explore the perceptions and mental models of novice designers about the concept of sustainability and SD against the background of their design training and existing literature
2. To explore how novice designers approach sustainability when given a SD problem

## 4 Materials and Methods

The study employs both qualitative and quantitative approaches. An instrument consisting of a questionnaire and a problem-solving exercise was designed for data collection, and it is discussed below. The actual questionnaire is shown in Appendix 1.

### 4.1 Instrument of Data Collection

The instrument used for the study consisted of two sections. Section 1 was a questionnaire comprising both objective and subjective questions. Section 2 presented a problem regarding SD.

#### Section 1

This part of the instrument comprised 12 questions—both objective and subjective. Part of the questionnaire was adapted from a similar survey conducted in 2005 for engineering students (Azapagic, Perdan, & Shallcross, 2012). Most of the questions were modified to suit the needs of this research. Following are the main parts of the questionnaire:

1. **Basic information regarding participants** was covered in questions 1 and 2, including age, gender, educational background, design experience, academic degree, and name of educational institution.
2. **Exposure to sustainability education** was covered in questions 3 and 4. Sustainability education is imparted in a design program, either as a separate course or as parts of other related courses. The other means of exposure is through short-term courses, workshops, seminars, and conferences.
3. **Participants' perceptions and evaluations of their respective degree programs** regarding sufficient input for SD were covered in question 9.
4. **Participants' definitions of sustainability** and SD were obtained from question 5 (subjective-type question).

5. **Self-evaluations of knowledge** about SD and its perceived importance in design were covered in questions 7 and 8.
6. **Perceptions about related concepts and their influence on SD** were explored in question 6; participants were asked to describe how concepts such as green design, eco-design, and environmental design relate to SD.
7. **Participants' attitudes towards using sustainable products** were covered in questions 10 and 11.
8. **Participants' opinions about the sustainability of certain existing products** were covered in question 12.

## Section 2

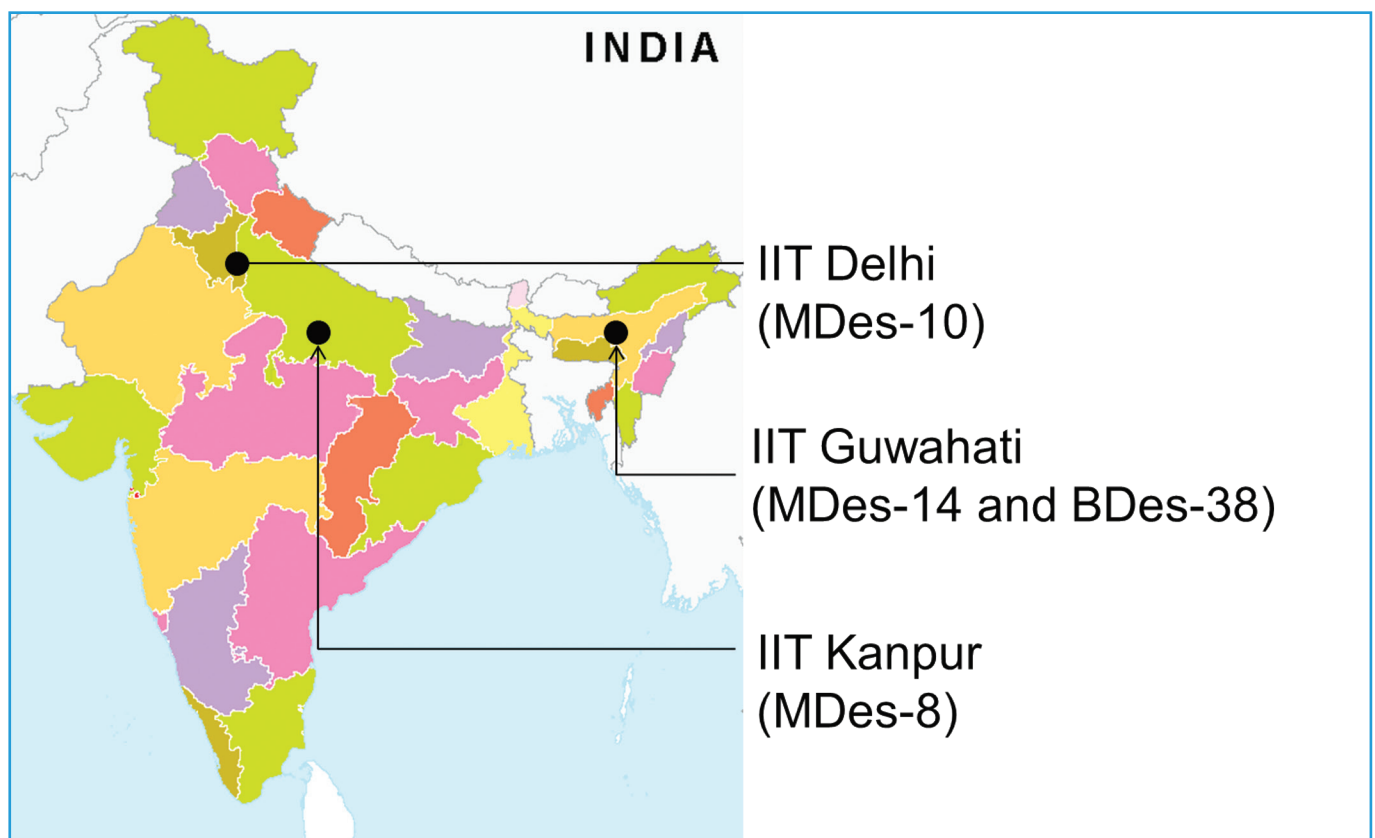
This section contained a design problem. Following are the main parts of the instrument, aimed at studying how SD is approached in practice by creative designers:

1. **A design problem with relevant information:** To design a sustainable mobile phone, participants

- had to suggest ways of improving sustainability through problem solving and conceptualisation.
2. **A fill up sheet to list variables related to sustainability:** Participants were asked to prepare a list of design variables that significantly affect product sustainability, including variables that the participants considered during conceptualisation or which they felt should be considered.
3. **Process flow map/diagram:** Once the problem-solving exercise was over, respondents were asked to re-think how they solved the given problem and draw a process flow diagram.
4. **Blank sheets** were provided for subjects to explore various solutions and problem-solving methods.

## 4.2 Study Locations and Subjects Involved

The study was carried out at three locations in India with 70 participants, as shown in Figure 3. Participants were undergraduate (Bachelor of Design, or BDes) and postgraduate (Master of Design, or MDes) students with two or more years



**Figure 3** Study location and subjects involved

**Source:** Adapted from (<http://www.dreamstime.com/royalty-free-stock-photography-map-india-more-authentic-image4884257>)



of design experience. Ultimately, the following categories of students were selected:

1. Master of Design (MDes) students: Final semester students
2. Bachelor of Design (BDes) students: Third year and above

### 4.3 Study Setup and Procedure

**Study setup:** The study was carried out during physical visits to all institutes. Design studios at each institution were used as setups for the study. A typical setting is shown in Figure 4.

**Procedure:** Before the study was initiated, prospective participants were informed of its purpose and the necessary time commitment. Those who voluntarily agreed to take part in the study were selected to participate. Initially, the questionnaire (Section 1) was distributed to participants, and the moderator provided explanations regarding the questions. Respondents were given 30 minutes to fill out the questionnaire. Once Section 1 was completed, Section 2 (problem-solving exercise) was distributed. Once again, the moderator explained the problem statement and reviewed the sheets to complete. The time given for Section 2 was 2 hours and 30 minutes. During the problem-solving exercise, participants were

allowed to ask questions and express any concerns. They were permitted to take breaks during the session as needed. An announcement that only 30 minutes remained was issued. At the end of the session, all sheets were collected and marked. Caution was taken not to disturb the sequence of conceptualisation as it reflected how participants solved the problem.

## 5 Analysis and Inferences

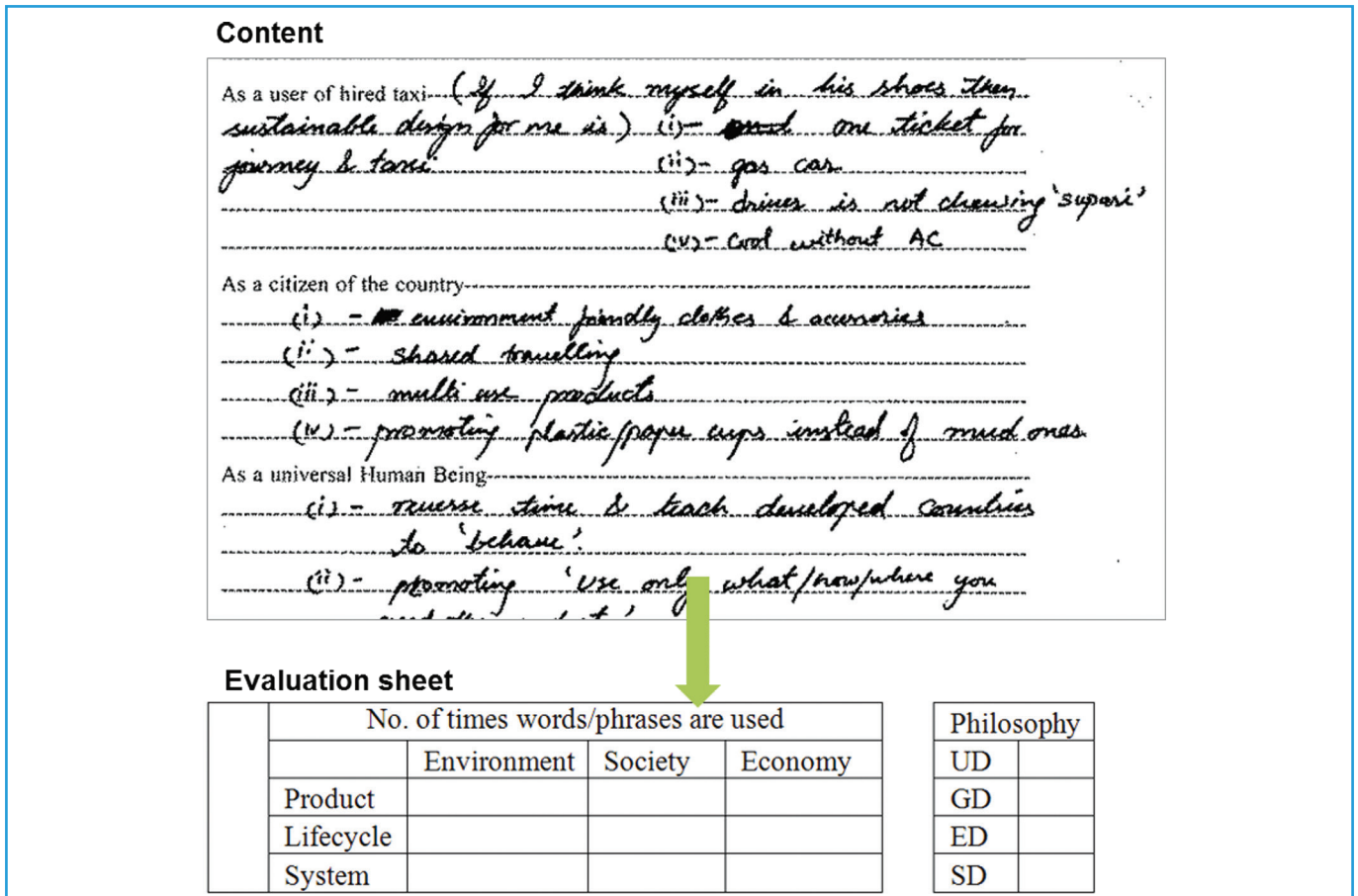
The analytical method was both qualitative and quantitative, as discussed in the following sections.

### 5.1 Method of Analysis

For objective questions in Section 1, descriptive statistics were used for analysis. For the subjective questions in Section 1 (i.e. question 5), a content analysis was performed. Initially, the entire content was read by two evaluators (E1 and E2), and keywords and phrases were underlined. Then, both evaluators separately evaluated content according to the evaluation sheet shown in Figure 5. The working conceptual model of SD discussed in Section 2 was used for this purpose. The evaluators compared evaluation sheets and discussed any differences; then, they continued to evaluate such cases separately. Both evaluators were senior researchers in the field of SD.



Figure 4 Study setup



**Figure 5** Sample content taken from a participant's response and the evaluation sheet (UD: undecided, GD: green design, ED: eco-design, SD: sustainable design)

Section 2 of the instrument required problem-solving skills, and it was qualitatively analysed from the sketches and drawings. Each response sheet was thoroughly studied and coded into an MS Excel worksheet according to the overall methodology followed, methods used (e.g. brainstorming, mind mapping, or lifecycle mapping), concepts expressed through mapping and doodling, variables considered, and the variables list on the fill up sheet. Figure 6 provides a snapshot of the procedure. The following section discusses briefly the major results and inferences of the data collected.

### 5.2 Results and Inferences from the Analysis

#### Section 1: Results and Inferences

1. **Basic Information:** The total sample size was 70, of which 49 were males and 21 were females; age range was 19–30 years. Further, 32 subjects

- were enrolled for MDes degree, and 38 were enrolled for BDes degree.
- Exposure to sustainability in the design program:** More than 60% (43 of 70) of respondents reported that their degree program did not have any course/courses related to SD.
  - Exposure to sustainability through other sources:** More than 50% (36 of 70) of students had attended sustainability-related conferences/seminars/workshops.
  - Evaluation of degree program:** About 36% (25 of 70) felt that their educational program offered input regarding sustainability 'somewhat', whereas 24% (17 of 70) assessed input as 'quite a bit'. Moreover, 24% (17 of 70) felt that their educational program was 'not at all' supportive, according to a scale with possible responses of 'not at all', 'somewhat', 'quite a bit', 'sufficient', and 'a great deal'.
  - Self-Evaluation:** About 57% (40 of 70) of subjects evaluated themselves as beginners,

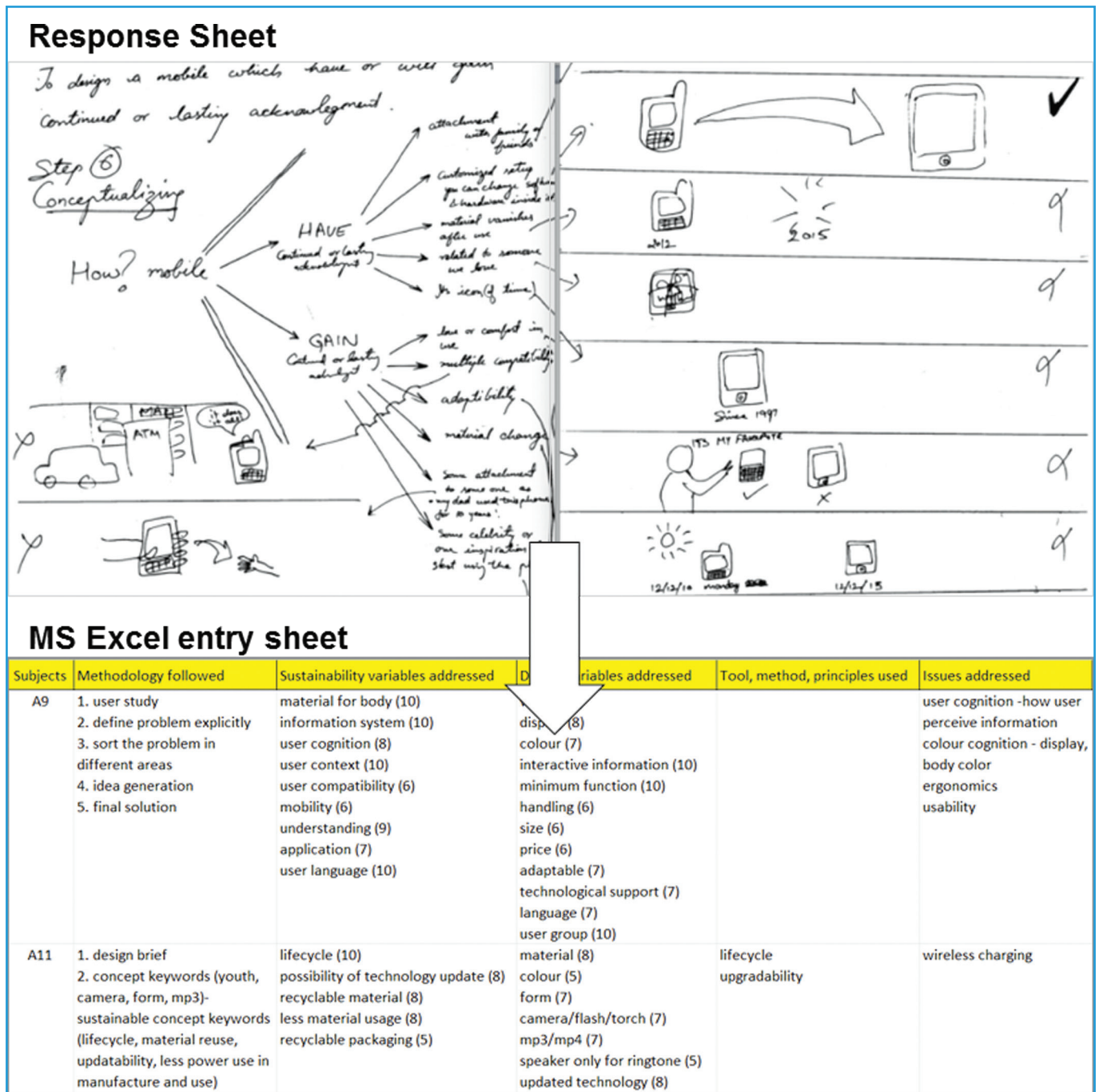


Figure 6 Snapshot of data entry procedure

whereas 21% (15 of 70) assessed themselves as competent (Scale: 'novice', 'beginner', 'competent', 'proficient').

- Importance given to sustainability in relation to the rest of the design factors (subject's perception):** Findings of the study showed that 47% of subjects felt that sustainability should be given an importance of 21–40%, whereas 23% estimated its importance as 41–60%.
- Willingness to pay more for sustainable products:** More than 44% (31 of 70) of subjects

responded that they were 'sometimes' willing to pay more for sustainable products, whereas 30 subjects said that they were willing to pay 'often' for such items (Scale: 'sometimes', 'often', 'always', 'not sure').

- Influence of related concepts on sustainability of a product:** More than 37% (26 of 70) of subjects perceived that green design, eco-design, and environmental design affected sustainability of the product by 60–80%, indicating that they perceived that these concepts were associated more closely with the concept of SD.

9. **Perceptions about sustainability of products:** Subjects were shown three products (bio-degradable milk packaging, reusable shirt packaging, and a nano car). Most rated sustainability of the paper bottle as 6 or 7 out of 10, whereas they assigned a rating of 8 or 9 to the reusable hanger. There was no consensus regarding sustainability of the Tata Nano, indicating that subjects clearly identified bio-degradability and reusability as important parameters for sustainability; however, they could not comment on the car because of the complexity associated with determining its sustainability.
10. Regarding content analysis for question 5, two evaluators reflected that subjects generally used words or phrases related to environmental issues when describing their understanding of sustainability. This finding reveals a limited understanding of the concept, as shown in Figure 7. One of the probable reasons for this level of understanding may be the historical roots of SD in environmental issues. Moreover, concepts such as green design and eco-design are established concepts, but SD is still in its evolutionary phase. The other possible explanation may be the subjects' lack of exposure to the comprehensive nature of SD.

11. **Mental models of subjects regarding sustainability (philosophy):** More than 30 subjects indicated that their understanding of sustainability was closer to the concept of eco-design, and 15 subjects indicated that their understanding was closer to green design (Fig. 8).
12. These results indicated that most subjects showed a bias towards the environmental dimension of sustainability, presumably because of the background of existing literature and their design training. The inferences also indicated that the subjects associated the earlier concepts of green design and eco-design with the much broader concept of sustainability.

**Section 2: Results and Inferences from the Analysis**

- Four of 24 subjects' methodologies were similar to French's descriptive model (Cross, 2008).
- Sixteen of 24 subjects' methodologies diverted from the conventional design method. They employed methods such as mind mapping and lifecycle mapping to understand sustainability issues. An additional component of mobile phone mapping was used to develop their concepts (Fig. 9).
- Most subjects (16 of 24) attempted sustainability analysis at the point of conceptualisation using

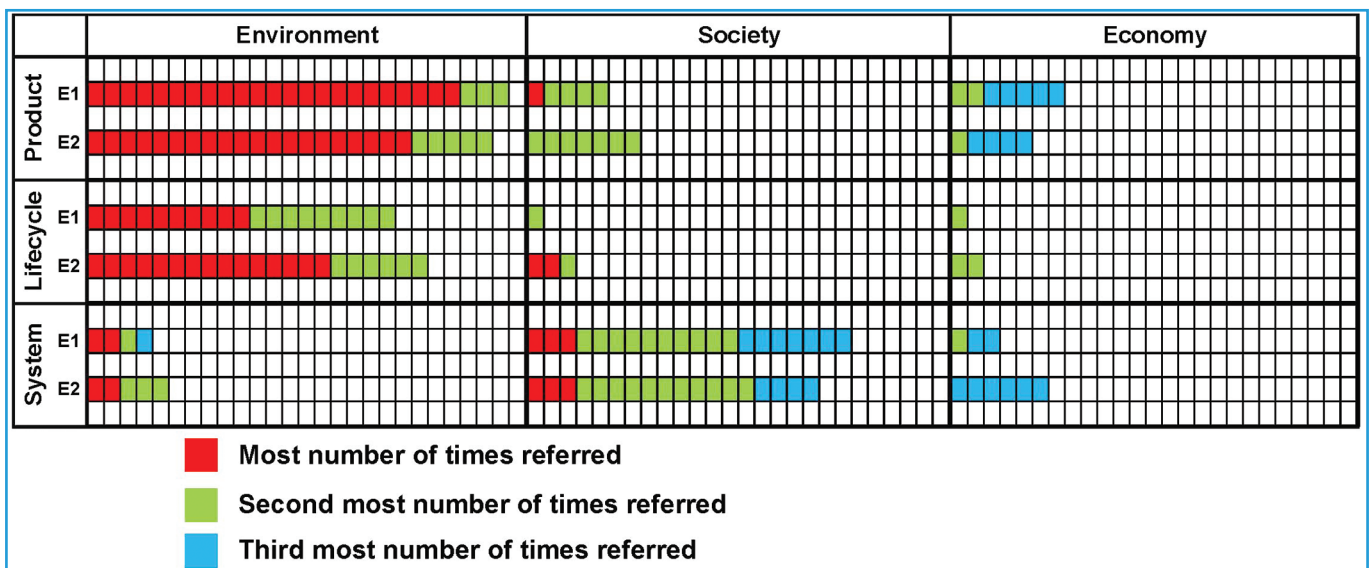
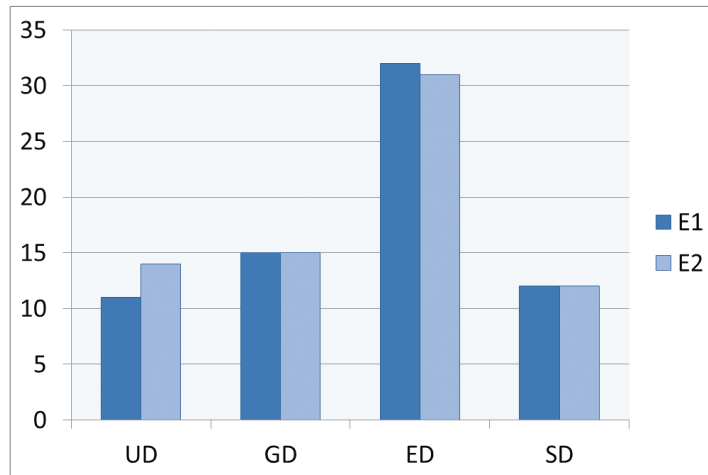


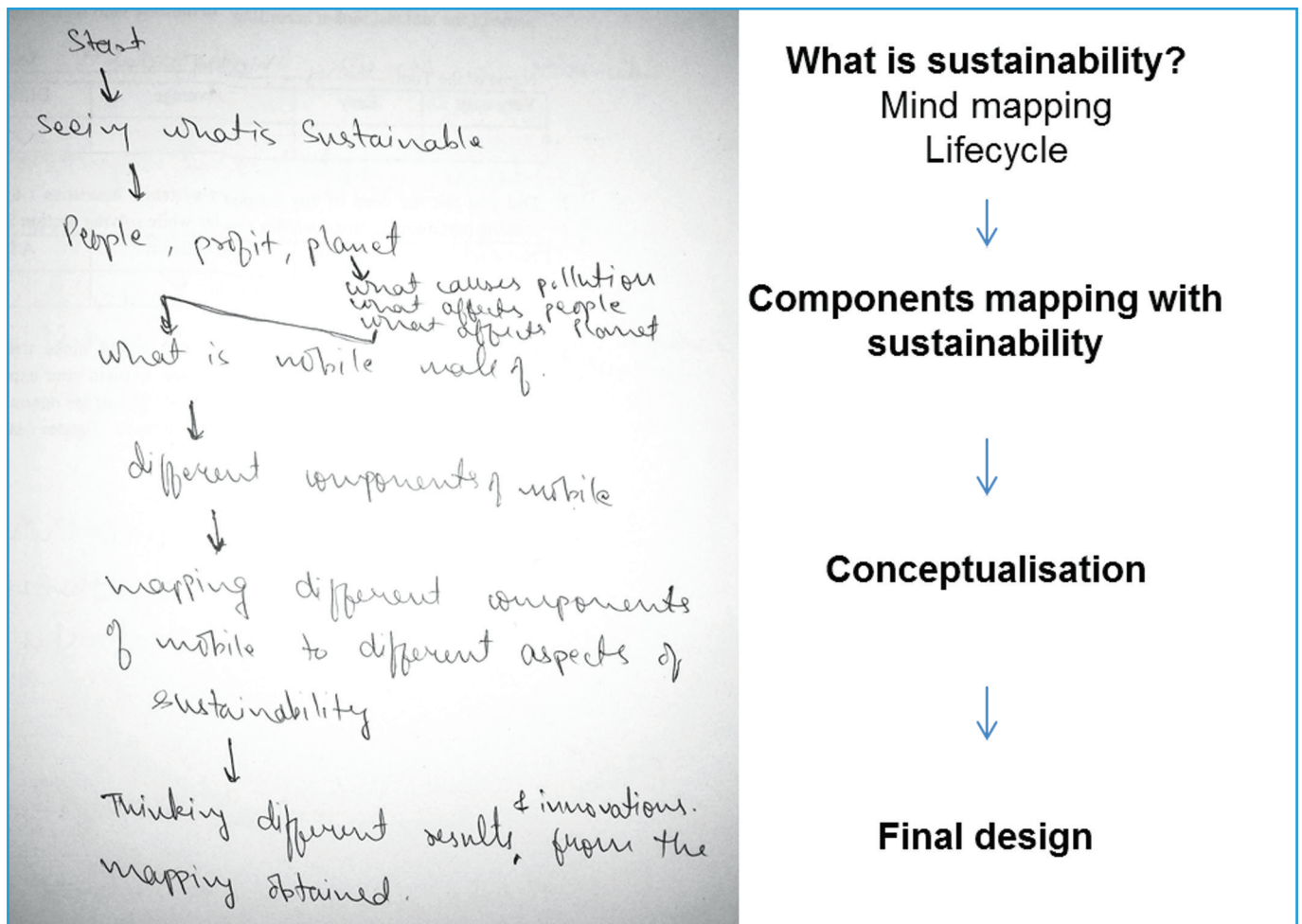
Figure 7 Content analysis regarding subjects' understanding of sustainability



UD = Undecided  
 GD = Green Design  
 ED = Eco-design  
 SD = Sustainable Design  
 E1 = Evaluator 1  
 E2 = Evaluator 2  
 Total No. of Samples = 70



**Figure 8** Philosophical approaches of subjects towards sustainability



**Figure 9** General methodology adopted by most of the subjects while problem solving



various methods including mind mapping, brainstorming, etc. However, it was observed that most of them were focused on environmental and lifecycle aspects only.

4. All subjects attempted to design a new/improved mobile phone.
5. Most of the variables affecting sustainability were not under the direct control of a designer. However, during the analysis phase, they were mapped extensively.
6. The most common approach adopted for increasing sustainability was limited to the philosophy of green design (material reduction) or eco-design (reusability, life extension, multiple uses, lifecycle, recycling).

Based on the analysis of Section 2, it was observed that most of the subjects entered sustainability through the environmental dimension, and nobody attempted to enter SD through the social dimension. Common approaches were limited to material reduction, reusability, life extension, multiple use, manufacturing, etc.

## 6 Conclusion

This study indicates that despite the broadening of scope in literature from green design to SD, the mental models of novice designers regarding the latter were limited to the environmental dimension of sustainability. They perceived the concepts of eco-design and environmental design as SD. Most students approached solving a SD problem through the environmental dimension, and they lacked an understanding about other dimensions of sustainability. Although the study was conducted with a small group of 70 students, it has highlighted the gaps in SD education.

## Acknowledgements

The authors gratefully acknowledge IIT Guwahati, IIT Delhi, and IIT Kanpur for allowing us to conduct the survey on their campuses.

**Dear Participant**

Thank you for volunteering and consenting to take part in this data collection exercise. The data being collected here are part of an ongoing research which will help us in understanding the perceptions and conceptual maps of designers about the evolving philosophy of design for sustainability (DFS) (and sustainable design). Design for sustainability is now becoming imperative given the pressure from government and consumers for reducing resource consumption, pollution, and carbon footprints for any product to be manufactured. Creative designers have a huge potential role in contributing to sustainability of any product as they are the ones who conceptualise the product and makes decision on 60 to 80 percent of factors that affect sustainability. This research study-data collection exercise is being conducted by the Department of Design- IIT Guwahati. We are trying to understand how and when sustainability variables (factors affecting sustainability of a product) are influencing the designer’s thought process regarding Design Methodology. We wholeheartedly thank you for your cooperation and valuable time. **Please respond to the following questions as honestly and carefully as possible.**

Vikash Kumar, Research Scholar, DoD IITG, *vikash.k@iitg.ac.in*  
 (Supervisor: Prof. Pradeep G. Yammiyavar, DoD, IITG)

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Name (optional): .....

Gender: ..... Age:.....

E-mail id: .....(Required for clarification, if necessary)

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**Section 1**

The main objective of this section is to comprehend your understanding and perception about the concept of ‘Sustainable Design’.

1. Please fill in the table below:

	Degree name with discipline	Name of the university or institution
Currently enrolled in		
Last degree completed ( if any)		

2. Number of years you are associating yourself with the discipline of ‘Design’ (including academics and work experience). .....yrs.
3. Did your current degree have any course/courses related to sustainability in design? (Circle one) Yes/No
4. Have you attended any conference/workshop/seminar/short-term course/symposium etc. related to ‘Design for sustainability’ in the last four years? (Tick) Yes/No
5. In two or three sentences, describe your understanding of ‘sustainability’ in terms of the following perspectives. If your answer is the same in all cases mentioned below, please write ‘same’.

As a creative product designer -----  
 -----  
 -----  
 -----  
 -----  
 -----

As a user of a hired taxi-----  
 -----  
 -----  
 -----  
 -----

As a citizen of the country-----  
 -----  
 -----  
 -----

As a universal human being-----  
 -----  
 -----  
 -----

6. Various terms/words are associated with the concept of DFS, including green design, eco-design, environmental design, etc. (see below). Put a check mark (✓) beside the terms which you are familiar with. Please list any other words/terms associated with sustainable design that are not shown here in the blanks provided at the end of the list. Then, rate each of them (%) according to their influence on product sustainability. Shade the boxes as shown in the example.

Example:

Terms/ words	Ratings (in percentage)										
	0	10	20	30	40	50	60	70	80	90	100
XYZ Design (✓)											

Terms/ words	Ratings (in percentage)										
	0	10	20	30	40	50	60	70	80	90	100
Green Design											
Eco-design											

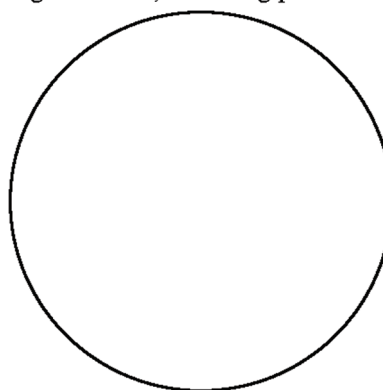
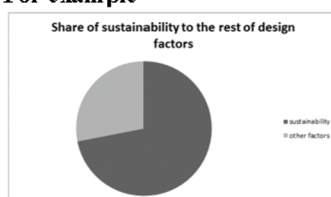
Design for environment																				
Carbon footprint																				
Ecological footprint																				
Design for sustainable development																				
Design for disassembly																				
Design for cleaner production																				
1.																				
2.																				
3.																				

7. Self-evaluate your knowledge about the concept of ‘Sustainable Design’.

novice	beginner	competent	proficient	expert

8. Designers are supposed to consider many factors while designing; some of them are ergonomics, aesthetics, function, manufacturing, etc. In recent years, sustainability has become one more factor to be considered while designing. Please assess the importance of product sustainability in relation to other factors by including it as a variable in the blank pie chart. Please give this matter some thought; then, complete the chart with your assessment of the importance of each design variable, including product sustainability.

For example



9. Please describe how your education program’s curriculum equipped you to incorporate sustainability principles into your professional work.

not at all	somewhat	quite a bit	sufficient	a great deal

10. Are you as a consumer willing to pay more for a product that fulfils the norms of sustainable/eco-friendly/environment friendly?

never	sometimes	often	always	not sure

11. Name any product that you are using/used recently/bought that reflects the manufacturer's consideration of sustainability.

(a) Name of product: ..... (b) Cannot recollect.

12. In your opinion, how sustainable are the products shown below? Rate them on a scale of 1 to 10 where 1 means 'Unsustainable' and 10 means 'Ideally sustainable'.

a. Bottle made of paper



1	2	3	4	5	6	7	8	9	10
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Extended Comments-----

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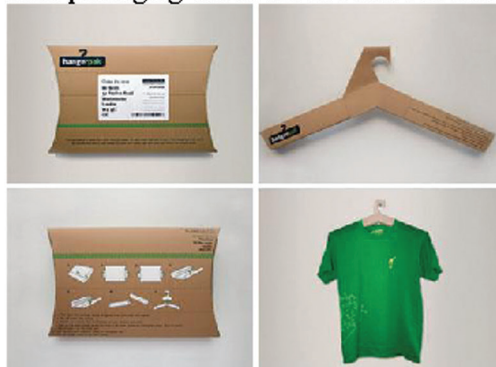
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b. Shirt packaging which can be reused as a hanger



1	2	3	4	5	6	7	8	9	10
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Extended Comments-----

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c. Tata Nano Car



1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

Extended Comments-----

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## Section 2

This section comprises a design problem. The brief is given below. Sketch and explain your design solutions/concept in the sheet provided to you. Try to generate as many concepts as possible within the given time. The main aim of this section is to understand how you as a designer approach sustainability-related issue in a design problem and what methodology you follow. It is an attempt to understand how you incorporate sustainability aspects while you conceptualise/solve a design problem. It does not intend to either evaluate you or your proficiency and skills as a designer. It is an attempt to capture your mental models of incorporating sustainability based on your respective level. **The end result of your output should take into consideration sustainability as an equally important parameter along with other aspects such as aesthetics, ergonomics, function, feasibility of final solution, etc.** A high quality rendering/sketch is not desired; the sketch simply needs to be at a level to communicate the concept. You are advised to go through Appendixes A and B before beginning the conceptualisation, filling them in as you solve the problem and generate the concept. **Please feel free to ask any questions that come to your mind.** Given below is the problem statement.

### Problem Statement

A mobile phone (also called cellular phone, cell phone or hand phone) is a two-way radio, which sends and receives radio signals, carrying voice and data in personal communication with other mobile phones and telephones (Nokia, 2005). The traditional mobile phones were used only for voice transmission but modern mobile phones also support a wide variety of other services such as text messaging, MMS, email, internet access, short-range wireless communications (infrared, bluetooth), business applications, gaming and photography. In the near future with development of technologies like cloud computing, mobile phones are expected to support more general computing and thus could be replacements for many more computing devices. The device is expected to support many new businesses and services, indicating its versatility (e.g. M-commerce, M-healthcare, and M-banking). These predictions suggest that the device is very important from the sustainability perspective.

Recent studies claim that mobile phones are not sustainable products. Few of the arguments given in its support are high obsolescence rate, consumption of toxic and rare materials, health effects etc. A few of the arguments, for example one study found that small-scale electronic devices like mobile phones have significant environmental impact which is distributed along its lifecycle as shown in the Figure 1.1 below. The size of the box shows the amount of impact, which is maximum during use phase and minimum at end of life phase.

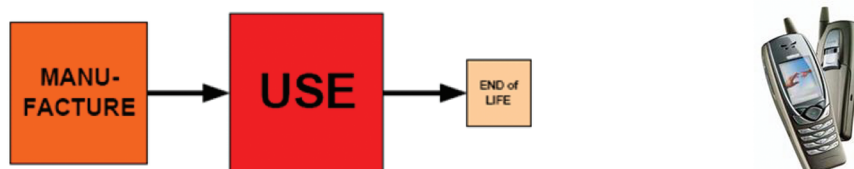
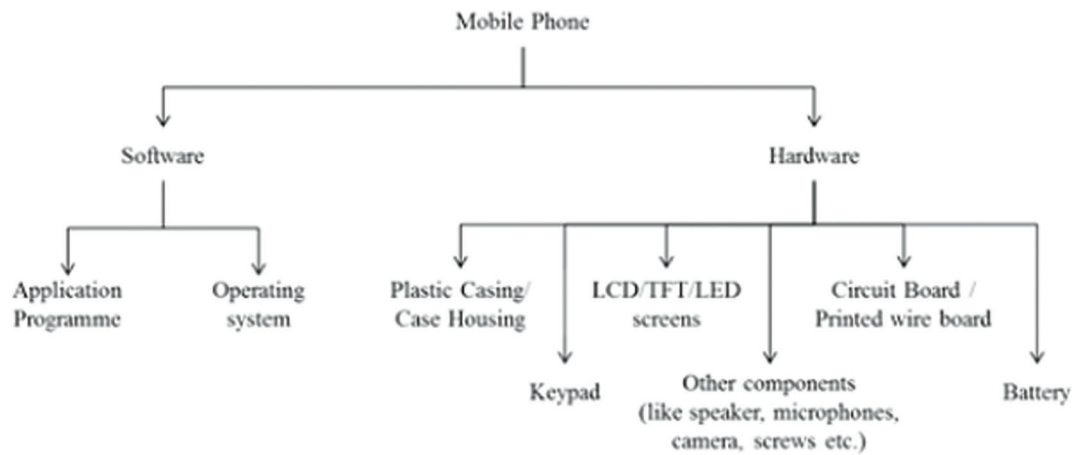


Figure 1.1: Environmental impact of mobile phones during different stages of life

A general classification of the parts of a mobile phone is shown in figure 1.2.



**Figure 1.2: A general classification of components and parts of a mobile phone.**

A dissected view of three mobile phones has been shown in figure 1.3 just to give you an idea of what is there under the shell. The three samples shown in figure 1.3 belong to different price range but all from the same manufacturer. It can be observed that a mobile phone is structurally very complex with high number of components, most of which is made up of large variety of material composition (Nokia, 2005).

	Product Samples	3.1 Case Housing	3.2 Frame / Plate	3.3 PCB / PWB	3.4 TFT / LCD	3.5 Battery	3.6 Keypad
Sample A							
Sample B							
Sample C							

**Figure 1.3: Dissected mobile phones of different price ranges.**

You as a designer have been given the task of designing a mobile phone for urban youth who are in college like yourself. Since there is pressure from customers and the government to improve mobile phones from the perspective of sustainability, you have been given the task of conceptualising a sustainable mobile phone and suggesting necessary improvements. Briefly explain the features in your concept (along with sketches) which can increase the sustainability of the mobile phones.

Fill in Appendix A and B as you go along conceptualising such a mobile phone. You may use any design methodology/steps/sequence you may wish to adopt.

### **Appendix A**

In the table below please list the design variables that came across your mind while thinking of the concept of a sustainable mobile phone. You have to do a listing of the variables as they occur in your mind during conceptualisation.

A **design variable** is any *quantity* or *attribute* or *choice* directly under the control of the designer. In other words, a design variable is a specification that is controllable from the point of view of the designer. Therefore, for a coffee cup, some of the design variables may be height, material, colour, etc.

Now make a list of all the **Design Variables** that you have considered or should be considered while designing the solution i.e. a sustainable mobile phone. Many of these variables are likely to pop up as information required while you start conceptualising the mobile phone. Make a list of all the variables in the table below

### **Appendix B**

After finishing the exercises think about the steps/sequence/methodology which you have followed and draw a work flow diagram in the space provided. The researcher is interested in understanding how step by step you as a designer have gone around solving the problem. What you did first, then what you did next. If the sheet provided is not sufficient then draw it on a separate sheet and attach it. You don't have to be rigid in thinking. If you are not comfortable in making a work flow diagram then simply write it in steps. Feel free to ask any questions.

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paper

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Improving Sustainability by Capturing Tacit Knowledge of  
Artisans as Digital Information for Design Practices

Sai Prasad Ojha, Pradeep G. Yammiyavar



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# Improving Sustainability by Capturing Tacit Knowledge of Artisans as Digital Information for Design Practices



## Abstract:

Tacit knowledge is knowledge which is very difficult to code or explain. It can only be gained from working in an industry or developing a skill by performing work with the kinaesthetic senses. Industrial companies search for tacit knowledge in the workers they hire; consequently, they spend less time and funds training new employees. This paper presents ways to capture and document tacit knowledge by encoding it into a digital format. The north-eastern part of India has abundant talent in the handicraft industry (e.g. handlooms, bamboo, and jute). We propose a possible method for studying, capturing, and converting the tacit knowledge of artisans involved in the handloom sector and similar sectors. We suggest that once this digital information is available, tacit knowledge that would otherwise become extinct because of difficulties associated with transferring it to new workers will be available to future generations. Our core argument is that greater product sustainability can be expected if tacit knowledge and current technological knowledge are embedded into products and stored digitally for industries. The assumption is that future generations will experience the emergence of modern machines that are capable of using captured knowledge to reproduce the same or better results as those produced in the past. Captured tacit knowledge in combination with modern assembly systems will not only mimic the artisan but also give an advantage to workers in terms of enabling greater innovation towards improving product sustainability.

**Keywords:** *tacit knowledge management, digital manufacturing, smart assembly, design for sustainable empowerment*

**Citation:** Ojha, S. P., and Yammiyavar, P. G. (2015). Improving Sustainability by Capturing Tacit Knowledge of Artisans as Digital Information for Design Practices. In Mani, M., and Kandachar, P., *Design for Sustainable Well-being and Empowerment*, IISc Press and TU Delft, 357-364.

## 1 Introduction

Communicating and representing one's thought process remain priorities of human beings. The first form of representation was pictures. Generally, methods of communication are divided into two categories—verbal and non-verbal. Verbal communication is the way in which one tries to explain his/her thoughts by speaking. Non-verbal communication is represented with pictures, plans, and writings. With the invention of computers, methods of communication have changed drastically.

Modern machinery operations are performed with the help of codes understandable by computers. The art of communication helps to build new knowledge. In a similar fashion, a child learns language from birth. This process can also be seen in education, where a teacher imparts a lesson both verbally and non-verbally. The implementation of knowledge is remarkable, yet considerable knowledge has not been articulated; rather, it has remained only with individuals because of long-term practices, habits, or training. This asset for individuals is known as implicit or tacit knowledge. If this knowledge can

be imparted with less time and energy, it becomes sustainable.

Knowledge is used for building both small components and large products. In the past, products were simple and contained fewer components. With advances in technology, components are becoming larger and more sophisticated. For example, bullock carts have been replaced by contemporary cars and airplanes. Modern products may contain a few or a large number of components. Because more resources are required to produce these products, there is a fear of damaging the earth's ecosystem. Companies are moving towards more sustainable ways of manufacturing new products with existing resources. The effect of inefficiency, stress, and discontentment is to slow down humans' grasp of knowledge.

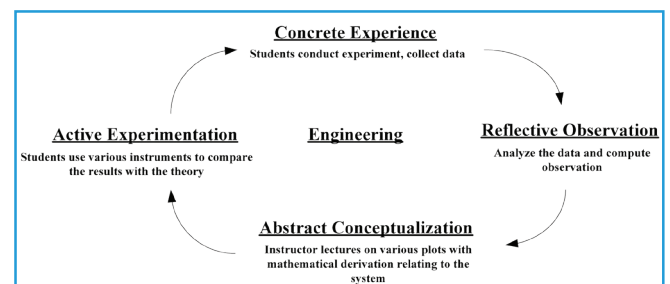
Sustainable development, as defined by the World Commission on Environment and Development, is that which meets 'the [human] needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987). Companies are slowly acknowledging the concept of sustainable development and moving towards more sustainable production methods to use the earth's resources wisely. Sustainable development is achieved through innovation, a product of creative thinking and knowledge.

Lawson and Lorenz (1999) discussed the ease of transferring tacit knowledge when labour is reassigned from one organisation to another. The daily coordination of production and marketing is tacit in nature; it depends on the experience of an employee in an organisation. The authors of this study have suggested that the combination of tacit knowledge and collective learning leads to product innovation. Codifying tacit knowledge requires time and modern technology.

Tacit knowledge is classified into three categories, according to Michael Eraut (2000): people and situations, routine actions, and intuitive decisions. However, Eraut did not consider lessons learnt

from mistakes. Knowledge regarding the behaviour of nurses towards learning a surgical practice was studied by Fessey (2002), according to an ethnographic approach. Fessey used digital photographs and knowledge maps to compare the learning curves of an individual when alone and when socialising.

Svinicki and Dixon (1987) studied Kolb's learning model and modified it for classroom activities. Figure 1 is a representation of a modified Kolb's model used by the authors. It gives an understanding of how knowledge is transferred in an engineering discipline. The instructor lectures on theory, which helps students use various instruments to compare it to theories learnt previously. Students conduct various experiments in the Concrete Experience stage. The next stage is followed by analysing data obtained from the experiment. The results are documented and observed. Thus, the learning cycle helps students grasp knowledge of the theory.

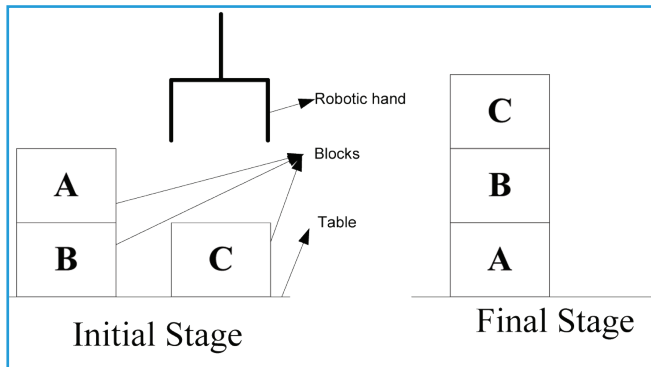


**Figure 1** Sample experimental learning sequence for engineering disciplines

**Source:** Svinicki & Dixon (1987)

Capturing tacit or implicit knowledge has always been a challenging task for researchers who used various tools in this quest. One way to capture knowledge is to use ontology. Ontology, as defined by Gruber (2008), gives a specific description regarding the representation of a model for knowledge in any domain. Mizoguchi (2003) creatively explained ontology with an example of a table with three blocks. The three blocks were to be arranged on top of each other hierarchically, as shown in Figure 2. For this task, the robotic hand and the table may or may not be considered as independent objects. There is no discontinuity of contact between the blocks and

the table. The blocks B and C have contact with table. Hence, the relationship between the blocks and the table can be defined hierarchically, i.e. first table, then block A, then block B, and then block C. This gives the robot a systematic understanding of the arrangement of the blocks on the table.



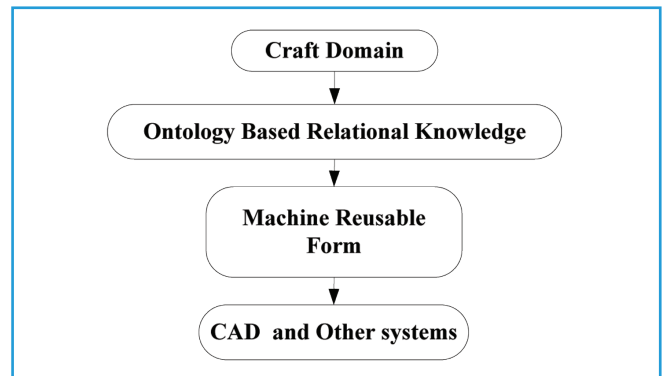
**Figure 2** Block arrangement problem  
**Source:** Mizoguchi (2003)

Mizoguchi explained that ontology refers to the conceptualisation of knowledge based on relations and concepts. Ontology was used in the development of a device known as the Convincing Human Action Rationalised Model (CHARM) for training novice nurses using the implicit knowledge of experienced nurses (Sasajima et al., 2013). Ontology can be light or heavy depending on the type of domain. In this paper, we have tried to capture the essence of tacit knowledge with the help of lightweight ontology.

## 2 Framework for Capturing the Tacit Knowledge of Artisans

A large number of researchers have different frameworks for capturing tacit knowledge. In this paper, an approach to capturing implicit tacit knowledge is presented with the help of the craft industry. Further, we propose a possible method for studying, capturing, and converting the tacit knowledge of the artisans involved in the handloom and similar sectors. Figure 3 shows the proposed framework used for this research.

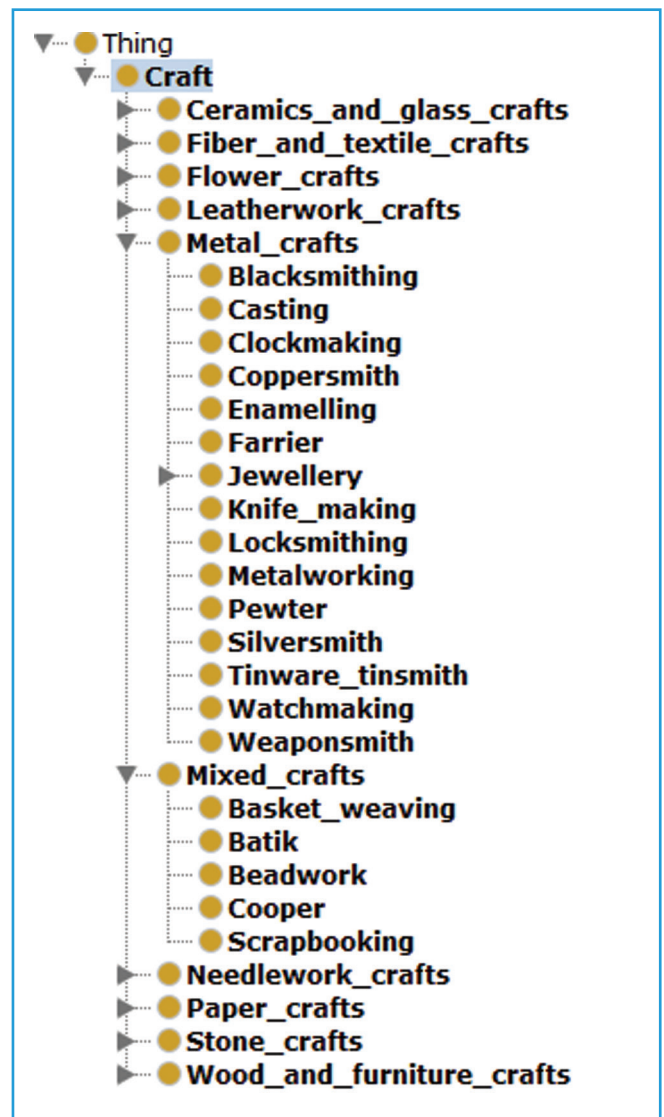
The craft domain consists of different categories based on materials used, ethnicity, and geographical regions.



**Figure 3** Framework for capturing craft domain knowledge

## 3 Ontology of the Craft Domain

Different tools have been developed for representing ontology in different domains. Protégé (2014) has been of help in developing the craft model. Protégé is a free, open-source ontology editor with



**Figure 4** Ontology of the craft domain in Protégé software

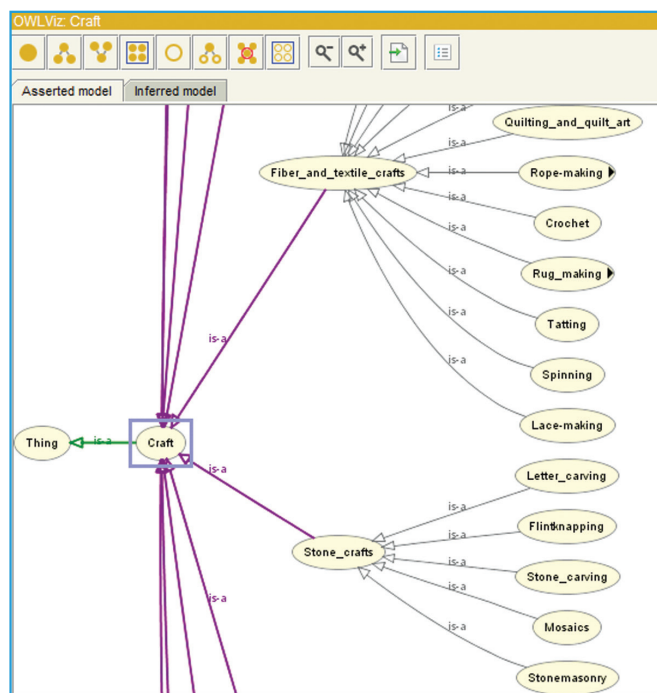


a knowledge-based framework software developed by Stanford University. Protégé helps in building concepts in different areas to capture knowledge. It helps build ontology in a schematic manner.

### 3.1 Ontology: The Craft Model

Ontology of the craft domain is classified as a ‘craft’ or a ‘thing’ in Protégé.

The craft class contains subclasses such as ‘ceramic\_and\_glass\_crafts’, ‘fiber\_and\_textile\_crafts’, and so on.



**Figure 5** Asserted model of the ontology craft in Protégé software

An ontology model of the craft domain contains the subclass ‘bamboo\_craft’ which has properties including ‘size’, ‘material\_behaviour’, ‘radius\_of\_bend’, ‘deflection\_angle’, ‘length’, and ‘gap\_between\_strip’.

## 4 Implementation of the Craft Ontology

The CAD software uses different curves and surfaces in 2D and 3D interfaces to build a model. Surfaces are increased in thickness to give a solid feel to the model. After the model is prepared in CAD, the rendering effect gives a real look to it. Various CAD software programs are available commercially, but none are capable of capturing the implicit knowledge of the

craft model. In this paper, we use the example of bamboo basket making. The artisan who is involved in creating a bamboo basket applies his or her tacit knowledge to develop the basket’s unique shape.



**Figure 6** CAD model of a basket

Figure 6 shows a simple basket which was built with the help of SolidWorks® (2014), without the implementation of the relations obtained by craft ontology. In Table 1, various forms of tacit knowledge obtained from the creation of a bamboo basket are shown.



**Figure 7** CAD model of a basket after relations were applied to it

As noted above, the ontology model of the craft contained the subclass ‘bamboo\_craft’,

**Table 1** Different applications of tacit knowledge during bamboo basket making

Sl. No.	Operation	Tacit knowledge used			Tacit knowledge captured in knowledge system
		Lessons learned	Learning by doing	Unique property	
1	Artisan starting with 'Jati' bamboo	Knowledge of physical and material behaviour of bamboo	Choosing the correct bamboo	Touch and feel of bamboo	Material property
2	Cutting bamboo to approximate sizes	Understanding of different bamboo sizes	Cutting to accurate size	Size and thickness of cut pieces	Size of bamboo
3	Constructing the form of the basket by stitching primary and secondary strips	Understanding regarding how to mould the preferred shape	Moulding accurately by hand	Stitching (precision artistry)	Stitching shape or curve and gaps between strips
4	Unconsciously making an error in crafting, thus giving a unique shape to the basket	Tolerance and adjustments for human error	Minimising the error	Unique shape of basket	Shape of the basket

characterised by properties such as 'size', 'material\_behaviour', 'radius\_of\_bend', 'deflection\_angle', 'length', and 'gap\_between\_strip'. These properties were applied to build a model of the bamboo basket in the CAD environment (Figure 7).

## 5 Discussions and Conclusions

In this paper, we have proposed an ontology model for the crafts sector, with a particular focus on basket making. With the evolution of technology, the gap between tacit knowledge and codified knowledge will decrease in the future, as seen in bamboo basket making. Tacit knowledge will remain an asset for any skilled worker in a company. The craft industry will gain the advantage of retaining the tacit knowledge of its workers. Implementation of the above ontology to capture tacit knowledge will reduce the energy and time needed to train new workers; further, it will promote sustainable development in the industry. Additionally, workers with implicit knowledge of crafts will continue to have excellent employment opportunities in the craft sector.

## Acknowledgements

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Aalto LAB Mexico: Exploring an Evolving Poly-disciplinary  
Design Pedagogy for Community Well-being and  
Empowerment with(in) a Mayan Community

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# Aalto LAB Mexico: Exploring an Evolving Poly-disciplinary Design Pedagogy for Community Well-being and Empowerment with (in) a Mayan Community



## Abstract:

Aalto LAB Mexico (ALM) is a design-led project for social and environmental sustainability. It has been developed as a project-based learning experience, where feasible projects emerged directly and in coherence with a community called '20 de Noviembre' (20 NOV) located in Campeche, Mexico. ALM is set within the context of an evolving pedagogical and practice-orientated exploration of Aalto LAB, an outreach programme founded in 2010 by Aalto University, Finland, which has previously been reported on by Nousala and Garduño (2013). By combining design theory with theory from social complex adaptive systems, this paper discusses the exploration and approach employed by ALM and the community that has generated mutual exchanges from which both parts benefit, in a respectful, sustainable, and positive manner. This approach has also been about learning to co-design project briefs that are feasible and can effectively enlarge the capabilities with(in) a community.

**Keywords:** *empowerment, co-design, poly-disciplinarity, with(in) a community, learning*

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## 1 Introduction

Following the questioning started by Papanek (1972), and continued by Buchanan (2001), Fuad-Luke (2009), and Oosterlaken (2009), along with many others, we acknowledge the need for an ethical grounding of design practice. We identify an opportunity to offer students the possibility to assume a moral responsibility at a moment when the experience could positively influence their professional careers. This paper describes an emerging design pedagogy and practice for improved well-being and empowerment through encouraging autonomy within a 'marginalized' community. It also explores how Aalto LAB Mexico has developed the model initiated by Tuuli Sotamaa at Aalto LAB Shanghai in 2010.

The first characteristic of this framework is that it takes place within a specified location; the concepts of well-being and empowerment are seen as highly contextual and local, as specific sociocultural constructs (Sen, 1989) that should be achieved mainly through locally available resources, if aimed within the ideology and agendas of sustainability (United Nations, 1992). The betterment of the context is understood as a project, rather than as a 'problem versus solution' dynamic.

Secondly, the project is poly-disciplinary (Nousala, Moulet, Hall & Morris, 2012), in as much as it is a network constructed out of undergraduate, graduate and postgraduate students from various disciplines and institutions (the 'LABBERS'), and is supported by professionals from the private and public sectors,

including research academics. This group of people (i.e. 'the design team'), are outsiders; they do not live within the context, and are therefore differentiated from the local people, whom we refer to as 'participant end users'. Throughout the process, the two groups form a network that solidifies to become first a community of interest and then, ultimately, a community of practice (Nousala et al., 2012).

The project is longitudinal, meaning that it happens throughout an extended period of time. When designing with(in) communities – the phrase 'with(in)' implies designing 'with' communities while simultaneously designing 'within' them, i.e. being situated in the living community (Fuad-Luke, 2013b) – the level of engagement of (participant) end users is essential, and depends upon building trust, which takes time. Additionally, the project aims to generate knowledge and learning, which are linked to longer periods of reflection (Nousala et al., 2012).

Interaction in the field has been facilitated through design tools and methodologies (brainstorming, role-playing, storyboarding, prototyping, co-design workshops, and design ethnography methods including observation, documentation, and informal or semi-structured interviews).

By gathering testimonials from both the design team and the participant end users, through observation and by experiencing and designing in the field, Aalto LAB Mexico (ALM) has identified challenges and subsequently generated design projects which are necessary and help raise the capabilities of individuals and the community. Moreover, while doing so, members of the design team have enlarged their own capabilities.

## 2 Capabilities Approach: Sen and Nussbaum

The 'capability' perspective was first introduced by Sen (1989). Inspired, although not totally convinced by John Rawls theory of justice (Sen, 1989; Nussbaum, 1997), he aimed to push forward the idea that economic growth cannot be the ultimate end of development (Sen, 1989, 1997, 1999). When

contrasting human capital and human capabilities, he states that the former values human qualities insofar as they promote and maintain economic growth, but fails to clarify 'why economic growth is sought in the first place' (Sen 1997). Meanwhile, the latter emphasizes 'the expansion of human freedom to live the kind of lives that people have reason to value' (Sen, 1997).

Sen's proposal of 'a more foundational understanding of the process of development as the expansion of human capability to lead freer and more worthwhile lives' (Sen 1997) was a breakthrough within development studies. In fact, the approach was adopted by the Human Development Report of the United Nations Development Program (UNDP) in 1993 to assess and compare the quality of life among countries (Nussbaum, 1997).

Almost simultaneously, but independently from Sen, Martha Nussbaum was reflecting on Aristotle's perspective on 'the goals of good political organization', and in fact articulating her views in terms of human capability and functioning (Nussbaum, 1997). Both concepts are difficult to grasp, especially because they are relatively new and are still under development. Functionings, as a concept, account for the achievements of persons – the 'doings' and 'beings' (Sen, 1989), or what a person is and what a person does; in fact, functionings are 'what render a life fully human' (Nussbaum 1997). However, both Sen and Nussbaum focus on the capabilities, or the 'combination of functionings a person can achieve' (Sen, 1989).

The capability approach focuses on what people are 'able to do and to be' (Nussbaum 1997). Sen (1989) sees capabilities as expressions of freedoms themselves, and considers those freedoms to be both intrinsically and instrumentally important. The choice itself is valuable so that a person can choose not to be or do something she is actually able to (Sen 1989, 1999). The recurring example is the difference between starving and fasting. Nussbaum (1997) supports this view and states that 'they [capabilities] support our powers of practical

reason and choice, and have a special importance in making any choice of a way of life possible’.

Sen and Nussbaum have maintained a major distinction between their works, perhaps purposefully. Sen (1997) seems more interested in the capabilities as an instrument of social development, and he tends to be imprecise in defining or classifying capabilities. In line with

Rawls, he supports the ‘fact that different people have different ends... and people should have the freedom to pursue their respective ends’ (Sen 1989). Nussbaum (1997), on her part, conducts research in multiple countries with the aim of assembling a list by ‘select[ing] those human capabilities that can be convincingly argued to be of central importance in any human life, whatever else the person pursues or chooses’. The strongest argument in favour of a

1. LIFE	Being able to live to the end of a human life of normal length; not dying prematurely, or before one's life is so reduced as to be not worth living.
2. BODILY HEALTH	Being able to have good health, including reproductive health; to be adequately nourished; to have adequate shelter.
3. BODILY INTEGRITY	Being able to move freely from place to place; to be secure against violent assault, including sexual assault and domestic violence; having opportunities for sexual satisfaction and for choice in matters of reproduction.
4. SENSES IMAGINATION AND THOUGHT	Being able to use the senses; being able to imagine, to think, and to reason and to do these things in a "truly human" way, a way informed and cultivated by an adequate education, including, but by no means limited to, literacy and basic mathematical and scientific training. Being able to use imagination and thought in connection with experiencing and producing expressive works and events of one's own choice, religious, literary, musical, and so forth. Being able to use one's mind in ways protected by guarantees of freedom of expression with respect to both political and artistic speech and freedom of religious exercise. Being able to have pleasurable experiences and to avoid non-beneficial pain.
5. EMOTIONS	Being able to have attachments to things and people outside ourselves; to love those who love and care for us, to grieve at their absence; in general, to love, to grieve, to experience longing, gratitude, and justified anger. Not having one's emotional development blighted by fear and anxiety. Supporting this capability means supporting forms of human association that can be shown to be crucial in their development.
6. PRACTICAL REASON	Being able to form a conception of the good and to engage in critical reflection about the planning of one's life. This entails protection for the liberty of conscience and religious observance.
7. AFFILIATION	A. Friendship. Being able to live for and to others, to recognize and show concern for other human beings, to engage in various forms of social interaction; to be able to imagine the situation of another and to have compassion for that situation; to have the capability for both justice and friendship. Protecting this capability means, once again, protecting institutions that constitute such forms of affiliation, and also protecting the freedoms of assembly and political speech. B. Respect. Having the social bases of self-respect and non-humiliation; being able to be treated as a dignified being whose worth is equal to that of others. This entails provisions of non-discrimination on the basis of race, sex, ethnicity, caste, religion, and national origin.
8. OTHER SPECIES	Being able to live with concern for and in relation to animals, plants, and the world of nature.
9. PLAY	Being able to laugh, to play, and to enjoy recreational activities.
10. CONTROL OVER ONE'S ENVIRONMENT	A. Political. Being able to participate effectively in political choices that govern one's life; having the right of political participation, protections of free speech and association. B. Material. Being able to hold property (both land and movable goods); having the right to employment; having freedom from unwarranted search and seizure.

**Figure 1** Martha Nussbaum's list of capabilities.

**Source:** Drawn by Claudia Garduño – all the information appears unmodified, as written by Nussbaum (1997)

list is that it overcomes the adaptive preferences phenomenon, according to which people become familiar with their living conditions, to the very extreme of the contented (happy) slave. Nussbaum (1997) states that while adaptive preferences can be found within the wealthy and privileged, they are more commonly found within groups of people who have persistently been marginalized or discriminated against. Therefore, Nussbaum (1997) insists that her list (Figure 1) should be regarded ‘as a list of very urgent items that should be secured to people no matter what else we pursue.’

Nussbaum (1997) argues that although the list might be perceived as restraining, the availability of an optional life plan does not force a person to choose it. However, she has also stated that the list is not definitive and is open to modifications. Within this philosophical roundabout, Sen and Nussbaum seem to have agreed to advance both contrasting perspectives, in parallel.

When an Aalto LAB project states that it aims ‘to make the world a better place’, rather than preferring Nussbaum’s or Sen’s perspective above the other, it acknowledges that this tension exists.

### 3 ALM: A Transitional Poly-disciplinary Design Pedagogy and Practice

#### 3.1 Context

Each Aalto LAB (AL) focuses on the betterment of a particular community; therefore, its particular structure and processes emerge directly from the context. This parallels the focus in Malmö Living Labs (MLL), where value is found in ‘open[ing] up for constructive and sustainable questions and possibilities within a specific geographically and historically located situation’ (Björgvinsson, Ehn & Hillgren, 2010).

The context for ALM is a community called ‘20 de Noviembre’ (20 NOV), located in the Municipality of Calakmul in the south-eastern Mexican state of Campeche; it was selected due its potential for

exploring and envisioning a way out of the paradox of development. On one hand, the Mexican evaluation system for measuring poverty and marginalization, CONEVAL (2010), considers Calakmul an area of high marginalization, due to its inadequate access to services like healthcare, education, and other supporting infrastructure. On the other hand, 20 NOV is located nearby the largest protected biosphere in Mexico; part of their communal land has been voluntarily subscribed to national environmental programs aimed at the preservation of the forests. At least theoretically speaking, every program or project conducted within 20 NOV – including those focused on social development – is by default subjected to environmental sustainability criteria.

20 NOV is, therefore, an interesting setting within which to explore both the capability approach as an instrument for social development and the dilemma of a fixed (list of capabilities) versus an open (no list of capabilities) framework. Moreover, it is a place where the adaptive preferences phenomenon could be explored.

The inhabitants are indigenous (Mayan). According to Jorge Volpi (2004), the historical struggle of the Mexican indigenous towns includes their right to determine their own ways of living. However, their ideal of a better life could be as modest as consolidating their family land, establishing schools, gaining access to fresh water, and selling their coffee (crops) for better prices (Krauze as cited in Volpi, 2004). Hence, the indigenous are at the same time a historically marginalized group that has consistently resisted development.

ALM by no means intends to resolve the tension between Sen and Nussbaum. Rather, the intention is to enter the field with recognition that the lives local people might have reason to value could be very different from ours, but that it is also possible that they will not be able to name some capabilities that *should* be universal but they lack access to. Moreover, we could try to understand 20 NOV’s conception of well-being by asking, in design terms,



what is to be designed (if at all). Visiting the place and achieving the engagement of its people are therefore of primary importance to ALM.

### 3.2 Empowering the community and designers through co-design

A key underlying assumption of Aalto LAB is the necessity of participation of diverse stakeholders in design in a (project) context. This is informed by a forty-year history of participatory design (PD) and attempts to democratize design to wider stakeholder involvement, leading to more recent developments around co-design (Sanders and Stappers, 2008). The traditions of PD are embodied in Malmö Living Labs (MLL), as it aims to be political and seeks radical change through the democratization and empowerment of the marginalized (Björgvinsson, Ehn & Hillgren, 2010). Since MLL and ALM share some similar structures and processes, some would argue that the pedagogical approach of ALM is based upon PD, but we differ. PD presupposes that the designers are completely free agents, but we see them as carrying their own implicit assumptions, leading to their own (inadvertent) marginalization. The discipline of design is in fact restricted by certain ‘unfreedoms’. For example, design is typically a market and/or technologically driven activity, even in the design of public services. The role of designers is to envision innovative ways to directly or indirectly contribute to economic growth or deliver the best economic value from public funds, while, typically, more human or societal issues remain of secondary importance in the vast majority of design briefs.

Therefore, we take the following definitions of co-design to inform the evolution of ALM:

*Co-design embraces multi-stakeholder involvement, where the stakeholders-as-designers, and the designers themselves, learn and create together* (Fuad-Luke, 2007);

and

*Co-design is inclusive, encompassing, collaborative,*

*co-operative, concurrent, human-centred, participatory, socio-technical and community design among others* (CoDesign, 2014).

There is a tendency in PD and certain co-design approaches for contributors other than designers to be considered as resources in the process (Mattelmäki & Sleeswijk Visser, 2011). In these circumstances, co-designing tends to occur *after* the brief has been set in advance by only a few stakeholders. ALM perceives co-design as a process of collective understanding, exploring, designing, deciding, and actioning (Fuad-Luke, 2009, p147-149), in which it is paramount that the design brief is co-designed.

ALM is a project-based learning experience developed through a wide array of design methods and tools, such as IDEO’s HCD Toolkit (2011), Mattelmäki’s Design Probes (2006), or Fuad-Luke’s Design Capitalia (2012). It seeks to constantly increase the level of engagement from the people of 20 NOV and, ultimately, achieve the co-design of products, services, or systems. By placing 20 NOV at its core, ALM offers the team of LABBERS (students) the possibility to assume a moral responsibility, and to potentially enhance *their* capabilities simultaneously with improving the capabilities of other stakeholders with(in) the community. Hence, designers and designers-as-stakeholders can be mutually empowered through transitional practice, operating by consensus – and occasionally dissensus – on the edge of the (existing) paradigm (Fuad-Luke, 2013a). As a pedagogical methodology, the experience of knowledge generation and assimilation has to be explained through another theoretical approach.

### 3.3 Poly-disciplinarity

The complex nature of Aalto LAB’s *problematique* (Fuad-Luke, 2013a) requires the involvement of many disciplines. The LAB was originally described as interdisciplinary by Sotamaa in 2010; however, according to Nousala et al. (2009, 2012), poly-disciplinary is a more suitable term for describing



knowledge network structures like the one that is developing in ALM (formed by ‘participant end users’ (people from 20 NOV), the ‘design team’, and other facilitators and experts (outsiders)).

ALM embraces LABBERS (students) in the fields of architecture, engineering, business, and the humanities and social sciences from Aalto University, the Architecture Faculty of the National Autonomous University of Mexico, and the Mexico City Campus of the Monterrey Institute of

Technology, as well as practicing experts from all those fields from industry and NGO’s in Finland and Mexico. Designers have been spread throughout all participant layers, in order to facilitate the implementation of (co-)design methods and tools along the whole process; therefore, co-design and poly-disciplinary theory mingle freely at ALM.

This ‘team’ is in constant flux and evolution; it is seen as a living autopoietic organism, meaning in a biological sense to ‘self-produce’ (Maturana & Varela,

	BIOLOGY	HUMANITIES	ART	DESIGN	ARCHITECTURE	ENGINEERING	BUSINESS
UNDER-GRADUATE		ITESM LHSC ITESM LMI		UNAM CIDI ITESM LDI	ITESM ARQ	ITESM IDS	
GRADUATE		Helsinki University Anthropology	Aalto ARTS	UNAM PDI AALTO ARTS	AALTO ARTS	AALTO Sci AALTO Chem AALTO Eng	AALTO BIZ AALTO IDBM
POST-GRADUATE				AALTO ARTS			
LECTURER	Universidad Ibero-americana			UNAM CIDI ITESM LDI AALTO ARTS	Universidad Ibero-americana	AALTO DESIGN FACTORY	
RESEARCHER				AALTO ARTS			AALTO SERVICE FACTORY
NGO		Fundación Idea		DYA ISLA URBANA			
PRIVATE SECTOR			filmmaker photographer	IDEO PEEK TOYS FINLAYSON	Taller de Arq. Sustentable Muotohiomo	Proyecto Tierra FCG Proyecto Yectlahuilli	Greenfain
FUNDING		Aalto Global Impact		AALTO MEDIA FACTORY UNAM CIDI ITESM LDI		AALTO DESIGN FACTORY ITESM EIA	AALTO SERVICE FACTORY COCA COLA ITESM

Figure 2 The members of the design team and experts in ALM.

Source: Drawn by Claudia Garduño

1980; Nousala & Hall, 2008; Nousala et al., 2009, 2012). Here, we would like to extend the meaning of the process to include ‘self-create’. In the beginning, the team was left to self-organize around and for the betterment of 20 NOV. They identified knowledge gaps and therefore defined research topics and identified the types of expertise needed to compliment the team. The initial fieldtrip in 2012 allowed ALM to identify general and relevant areas of study for 20 NOV; the team for ALM 2013 was modified accordingly. At this moment, ALM has registered participants from the areas and organizations illustrated in the chart presented in Figure 2.

### 3.4 The longitudinal aspect

It has been observed that the establishment of this type of structure, where an ‘action group’ first transforms itself into a community of interest and ultimately becomes a community of practice, can only be achieved over an extended period of time (Nousala et al. 2009; Nousala & Hall, 2008). The project-based learning approach of ALM can potentially be restricted by factors like funding, but it is ultimately dependent on 20 NOV’s approval. In other words, the aim is to learn by doing/making, but the right to do/make requires building a trusting relationship between

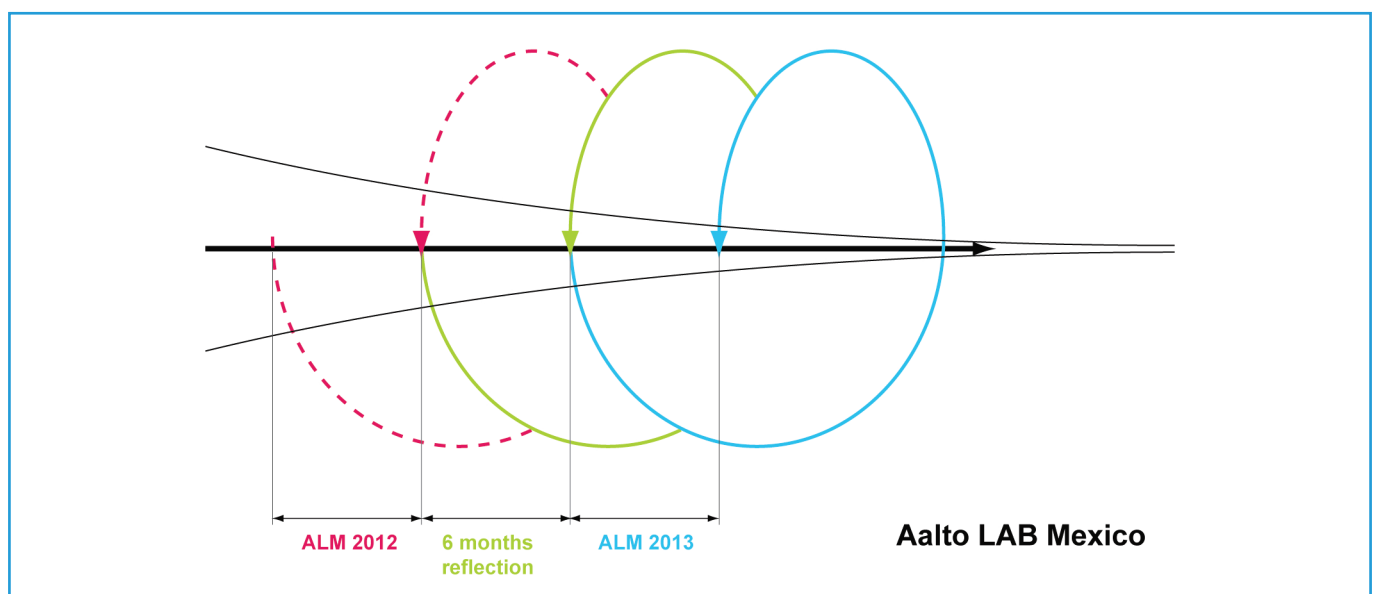
the design team and the participant end users. The assimilation of knowledge, on its part, requires the research, the making, and the reflection.

ALM is developed in active periods that last around five months (which include a preparation period and a visit to the site), separated by equally long reflection periods that allow participants to assimilate the acquired knowledge (Figure 3). Three main processes take place throughout ALM: co-exploration, co-designing, and co-actioning (Fuad-Luke, 2009). It has been observed that more divergent processes (co-exploration) can take place remotely, while more convergent ones (co-designing and co-action) must happen in situ.

## 4 Preliminary Results

### 4.1 20 de Noviembre

During its first visit to 20 NOV, ALM learned two things: (1) people living in the community appreciate many parts of their lifestyles, such as their capacity to grow their own food, the fertile condition of their environment, and their community life, and many of them are passionate artisans; and (2) they acknowledged everyday complex challenges. The



**Figure 3** Each ALM lasts around five months (from August to December), and includes a trip to the site in November. The time before the trip is called a preparation period and the time following the trip, including the inactive months, is the reflection period

**Source:** Nousala & Garduño (2013), based on Nousala & Hall (2008)

experts that travelled with the LABBERS reported on some specific matters that people were not aware of and that students could not observe; therefore, their participation was acknowledged as crucial. Overall, in 2012, the ALM team understood that the projects to be generated had to fulfil the requirement of helping community members tackle the big issues while maintaining their (alternative) lifestyles.

In 2012, all the LABBERS worked together as a team to identify areas of opportunity; however, the 2013 team was split into three so that each team would oversee one of the project briefs that had been generated from what was learned in 2012. Therefore, in 2013, each team had a journey of its own, including its own team of experts.

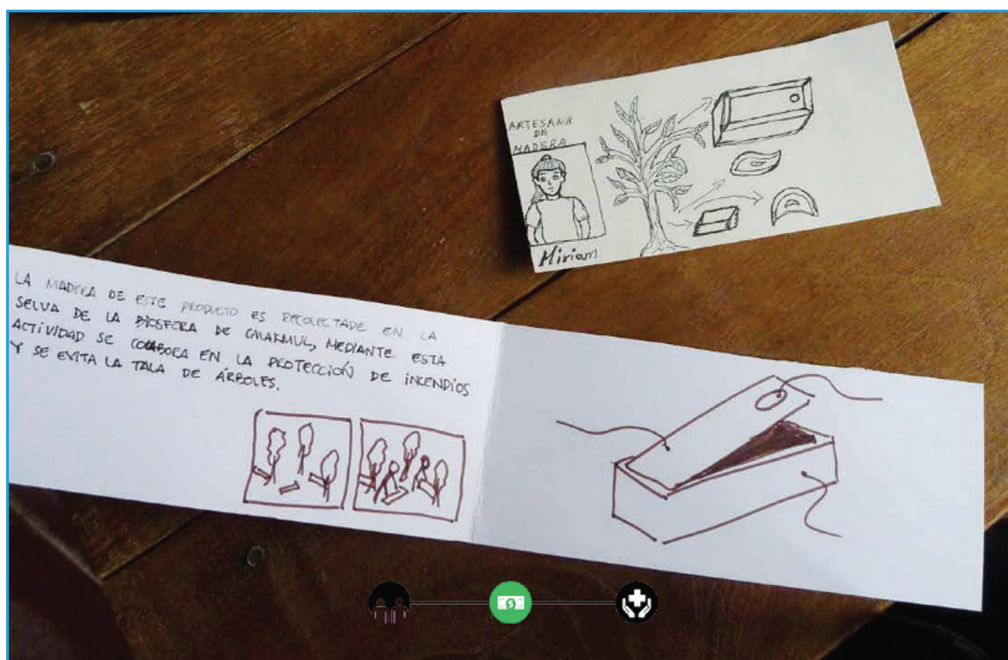
### Cultural Brand /Artesanía para el Bienestar

The 2012 field visit helped the design team understand the role of money in 20 NOV. Whilst nourishment did not seem highly related to money, it was evident that the cost of some (perceived as) basic services (such as transportation) mismatched their income level. A concept called ‘Cultural Brand’ emerged from the need to increase financial

resources and the opportunity observed in the passionate artisanal production.

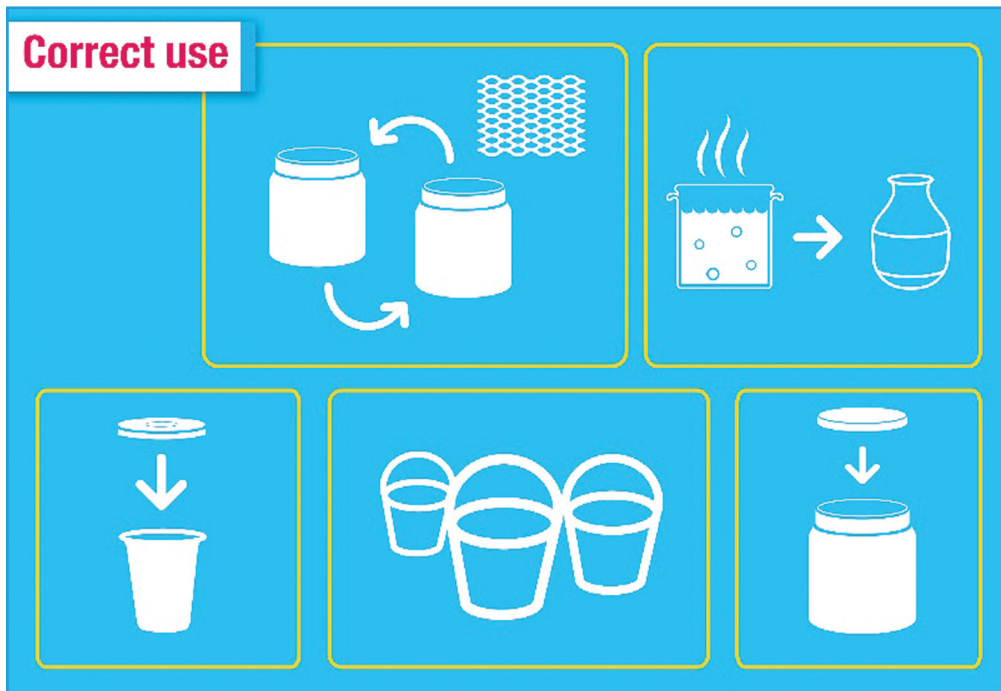
The concept was originally an umbrella brand that was intended to help the artisans of 20 NOV optimize costs by sharing logistics and benefit from getting publicity from each other’s sales. However, the reflection period between the LABs allowed the facilitators to define a more ambitious project brief: linking the concept of Cultural Brand with access to healthcare services.

The LABBERS of 2013 argued that artisanal products could vary a great deal and therefore should not be branded together. Moreover, they decided to approach the project from an income increase rather than cost optimization perspective. Whilst in the field, the team conducted workshops with people (Figure 4) and co-developed a ‘health stamp’ concept, where artisans could select some items to be labelled with the stamp. The price would be higher, with the extra income allocated to a common health fund. The team also proposed a long-term plan divided into stages, where the first monies to be raised covered individual health emergencies, but over time, the savings would pay for everyone’s social security contribution. The team renamed the



**Figure 4** Prototypes of labels telling the stories behind the projects as a strategy to increase profits.

**Source:** Slide made by the LABBERS for ALM 2013 presentation, with a picture by Jan Ahlstedt



**Figure 5** Best practices for the use of water in 20 NOV  
**Source:** Slide made by the LABBERS for ALM 2013 presentation

Cultural Brand project ‘Artesanía para el Bienestar’ (Crafts for Well-being); they continue working with the artisans and with Peek Toys, designing the stamp, and getting ready to test it.

### Water system

The water system project brief for ALM 2013 was conceptualized in response to the concern expressed by the biologist expert on the 2012 trip. The information he collected in the field showed that the community was fully dependent on rainwater, both for all household activities (consumption, washing, and cleaning) and for agriculture (note that 20 NOV is a subsistence farming community). The two primary focus areas were the quality of rainwater and the development of an irrigation system.

The LABBERS were able to map some sources, uses, and users before going to the field, but it was only during the fieldtrip that they could verify that the information was correct. They developed some cultural probes (Mattelmäki, 2006) that helped them collect information in an easier and

faster manner. They soon learned that there were many practices in the community related to water sources, uses, and users, and that some were better than others (Figure 5). In the end, their official talk to the community was used to spread the news of better practices that they could easily follow. At the time of writing, this project continued to be in its exploratory phase.

### Eco-hostel

The presence of visitors is cherished in 20 NOV; they represent an income opportunity and keep artisanal production alive (a significant portion of every sale is invested back in craft materials). The archaeological sites and the biosphere attract tourists; Calakmul is becoming an eco-tourism destination. However, given that 20 NOV is the only community of Mayan origin in Calakmul and they have kept alive their traditional artistry and food (apart from recent incursions in responsible forestry and apiculture), the 2012 LABBERS concluded that 20 NOV should promote itself as a destination for community tourism, rather than mainstream eco-tourism.



At the same time, engineers, architects, and designers observed a mismatch between the climatic conditions, the Mayan traditions, and the materials that the current government was providing to the people of 20 NOV under a federal program that sought to develop the most highly marginalized areas of the country.

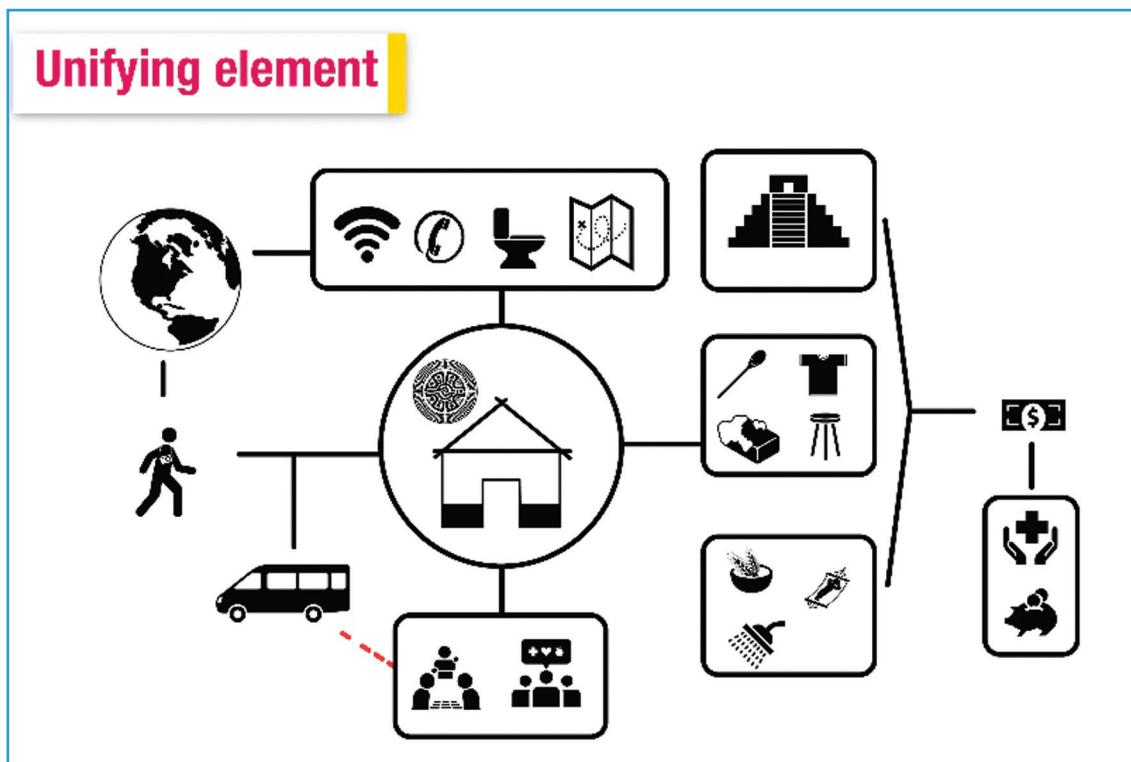
Therefore, the Eco-hostel project brief resulted from combining the proposals of the LABBERS and the observations of the experts with the community experiences from ALM 2012. The brief stated that the project should be both (1) an architectonic experiment that could honour traditional Mayan building technologies and potentially become a model of self-sustainable construction for the region, and (2) a means to support community tourism.

The 2013 LABBERS conceptualized the whole of the community of 20 NOV as a ‘distributed’ hostel in itself. Some of these LABBERS had been part of ALM 2012 and therefore knew from first-hand experience that some people were able to provide different services. During their exploration in 20 NOV, the LABBERS found out that rather than

introducing their idea as new, they could build on existing plans. Sketches were drawn with various participant end users before showing a plan to a bigger audience (Figure 6). The architectonic program was completed with ideas from the people of 20 NOV; for example, it was proposed that the reception or administration areas of the Eco-hostel could also be used by children to do their homework. Out of the three projects, this was the most actionable. The concept was submitted to a crowd-funding platform (transformadora ciel), where the rewards for sponsors were local artisanal crafts from 20 NOV. On the last day of 2013, the project reached the goal of 200,000.00 MXN. Until that moment, the crowd-funding campaign was the activity in which the design team and the participant end users reached the highest level of engagement. An extraordinary fieldtrip was scheduled to take place in April 2014 in order to continue the design and construction process of the hostel.

## 5 Discussion

ALM is a longitudinal project where designing for the enhancement of capabilities within a community



**Figure 6** The Eco-hostel’s administration as a unifying element  
**Source:** Slide made by the LABBERS for ALM 2013 presentation



is meant to be learned by doing. While it seems impossible to theoretically resolve the tension between Sen and Nussbaum concerning whether a fixed set of capabilities can or should be defined, acknowledging this tension before entering the field is seen as positive.

Rather than imposing a vision of what a better life should look like, the team set out to explore how the people of 20 NOV lived, and try to figure out if people wanted some changes in their lives or not. The first fieldtrip in 2012 allowed the tem to realize that people valued their lifestyles, but that they were able to identify some gaps; they lacked access to some services. Moreover, experts from various fields were able to identify some things that should be different because they represented a risk (water quality and electrical installations).

Perhaps the experts' observations, when considered in relation to the capabilities approach, support Nussbaum's statement that a list is necessary. In fact, the list can be used to assess if the projects generated at ALM at the very least envision capabilities expansion (given that two of them are in earlier stages of development), as shown in the chart in Figure 7.

For example, both the Artesanía para el Bienestar and the water system project draw on the first capability in Nussbaum's list: 'Life', which includes not dying prematurely. In the former, having access to a healthcare system is no guarantee of good health, but it helps prevent someone dying of a curable disease; in the latter, assuring access to clean(er) water might help them avoid one of their most common illnesses: kidney stones.

The chart also shows that the design team is learning to design projects that can potentially enhance the capabilities within the community, which proves that the capabilities of the design team are also being enhanced. The LABBERS are also learning to design within a community; the level of engagement of the community has grown with every visit, and a relationship of trust and friendship is being developed between the design team and the participant end-users.

The Eco-hostel's objective of maintaining cultural heritage and paying respect to traditional local wisdom, as a capability of the community as a whole, is difficult to place it within Nussbaum's list (which is oriented to the individual).

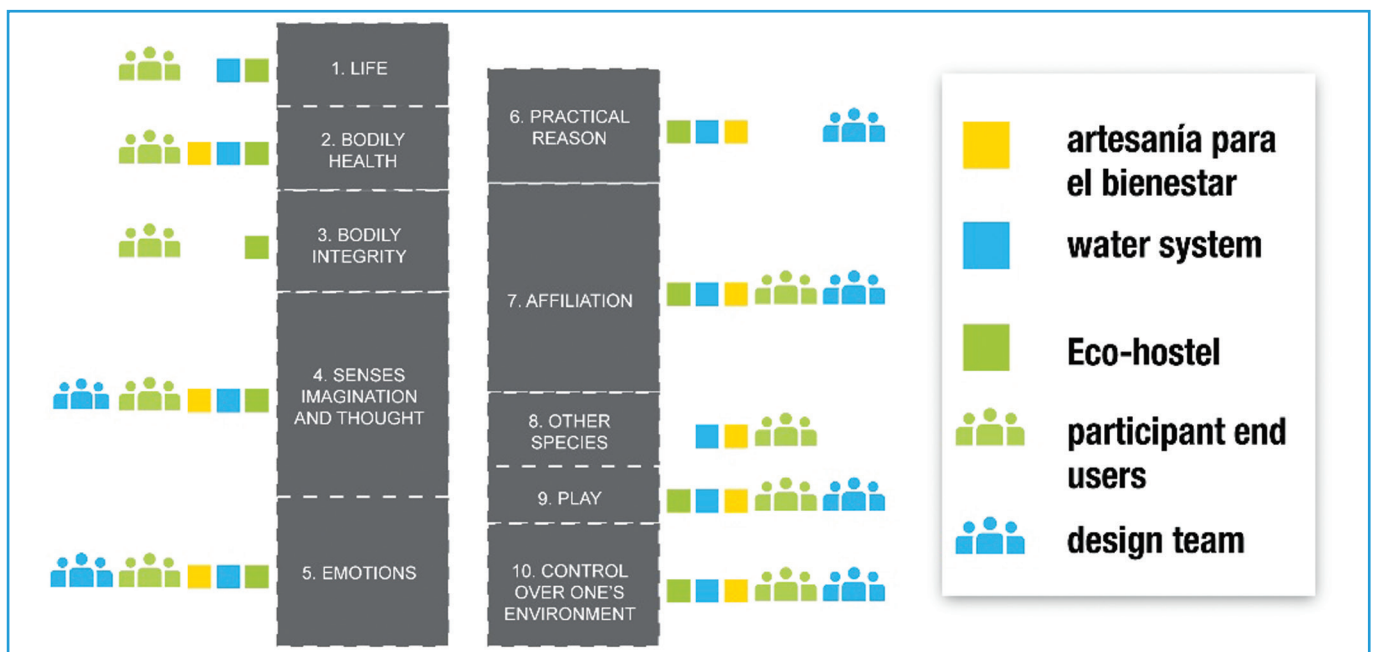


Figure 7 The capabilities from Nussbaum's list that each project can potentially enhance.

Source: Drawn by Claudia Garduño

It could also be argued that if the network constantly adds external actors, rather than being empowered, the community might struggle to develop its autonomy and develop a dependence on external contributions. However, if knowledge and learning are produced within and throughout all its members, it is expected that the participant end users will become comfortable confronting their constantly changing environment themselves.

In terms of the pedagogical and practice-based issues raised by ALM, we can say that these are embryonic transitional design practices, which designers and designers-as-stakeholders co-evolve within larger platforms of experience and learning.

## 6 Conclusion

The fact that one of the projects (Eco-hostel) is being implemented while this paper is being written proves that the design team and the participant end users have engaged in knowledge exchanges and are learning to co-design projects that are actionable and have potential for effectively enhancing the capabilities with(in) the community *and* within the designers themselves. Collectively, they are empowering each other, and, in doing so they contribute to mutual well-being.

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paper

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Equity, Ethics, and Profits in an Ecotourism Social Enterprise:  
A Case Study of ecoLogin

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# Equity, Ethics, and Profits in an Ecotourism Social Enterprise: A Case Study of ecoLogin



## Abstract:

'Tourism constitutes a positive element for social development in all the countries where it is practiced irrespective of their level of development', states the Manila Declaration on World Tourism of 1980. The demand–supply proposition was identified as the quest of the urban customer for a true experience in less touristy locations and search of people in remote locations for market linkages for their produce. Besides, people living at extreme ends of the economic spectrum often hold disparaging opinions of each other, largely because of lack of spaces for mutual interaction. However, ecoLogin provides a platform to facilitate such engagement. It was conceptualised to facilitate the transfer of wealth between its economically well-endowed urban clients seeking genuine adventure and cultural experiences in remote corners of the state (Tamil Nadu, India) and marginalised/isolated communities living with a wealth of biodiversity, culture, crafts, and tales. This leads to the question of what brings about an equilibrium, which would benefit protected areas, local communities, and tour operators (Stronza and Gordillo, 2008).

A hybrid organisation structure, an improvised form of the integrated rural tourism model (Cawley and Gillmor, 2008), is in place. The involvement of local communities in service delivery enriches the experience of the traveller and provides an alternate source of livelihood for these communities. Managing the conflicting needs of its customers, local people, and profits was critical to the success of the model.

**Keywords:** *rural tourism, community - based tourism, hybrid organisation model.*

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## 1 Introduction

ecoLogin is conceptualised as a one-stop solution to enable discerning customers and others to experience a well-informed tour or trek to remote and offbeat locations at affordable prices. It demonstrates social and environmental sensitivity in pursuing its mission and offers seamless service to ensure a hassle free tourism experience for the client. Today, as people experience stress, both at home and at work, travel is an option to unwind. However, there is substantial evidence regarding the lack of reliable service providers who give tourists the desired hassle free

travel experience. ecoLogin fills this void in tourists' expectations by offering various tailor-made and affordable solutions that ensure a unique, fun-filled, and enriching tourism experience for them.

ecoLogin's operations are guided by an eminent pool of advisors including academics, businesspersons, and environmentalists. It develops destinations, acquires customers, and organises tours. Basecamp Social Research Foundation (BSRF) is funded by grants and works towards enhancing rural livelihoods. ecoLogin caters to more than 75 remote locations in and around Tamil Nadu, has served

more than 5,000 tourists in the last five years, and has forged partnerships with NGOs and other entities to make its locations community-based and community-operated.

This paper presents the case study of ecoLogin as an ecotourism social enterprise that was conceptualised, designed, and executed to maintain a fine balance among equity, ethics, and profits.

## 2 Defining tourism

World Tourism Organization, 1993 defines tourism as ‘people travelling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business, and other purposes’.

Tourism can be classified into

- recreational tourism, cultural tourism, historical tourism, ethnic tourism, environmental tourism, and adventure tourism, based on purpose of tourism;
- domestic/internal and international, and further into inter-regional and intra-regional, based on place of travel; and
- holiday, business, or common interest tourism, based on purpose of visit.

## 3 Ecotourism

Sustainability is an overriding principle being adopted off late in tourism. The World Tourism Organization (WTO) defines sustainable tourism as ‘leading to management of all resources in such a way that economic, social and aesthetic needs

can be fulfilled while maintaining cultural integrity, essential ecological processes, biological diversity and life support systems’. Sustainable tourism requires that the demand of increasing number of tourists be satisfied such that tourists continue to get attracted to the area and the host population enjoys improved standards of living while safe guarding the destination environment and cultural heritage. As such, ‘sustainable tourism’ need not be confused with ‘ecotourism’. Ecotourism refers specifically to recreation in natural landscapes or threatened ecosystems such as rainforests or coral reefs.

Haphazard and uncontrolled growth and free riding multiple stakeholders can create a typical scenario of ‘tragedy of commons’, eventually destroying the very base of natural and sociocultural endowments on which tourism is built. Hence, tourism development should incorporate socio-economic, cultural, and environmental safeguards. Local participation is also important for a successful ecotourism programme.

The social and environmental relevance of the ecoLogin model emerges from the definition and principles of ecotourism established by The International Ecotourism Society (TIES) in 1990. According to them, ecotourism refers to ‘responsible travel to natural areas that conserves the environment and improves the well-being of local people’ (TIES, 1990). This definition indicates that the three pillars of ecotourism are the tourist, natural environment, and local community.

There is considerable debate over what encompasses ecotourism. Miller and Kaae (1993) view these diverse definitions and connotations associated

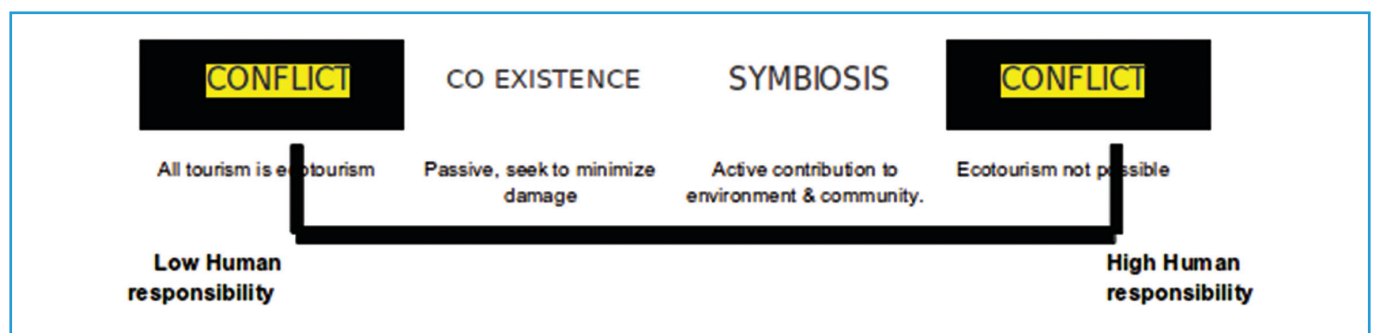
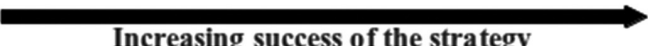


Figure 1 Definition of ecotourism.

Source: Miller and Kaae (1993)

Effect on Component	Passive approach	→	Active approach
Ecotourism	Enjoyment, satisfaction	→	Behavior lifestyle change
Natural environment	Minimize disturbance and damage to natural environment	→	Actions that contribute to the health of the environment
Local communities	Minimize disturbances to social fabric of local communities	→	Actions that contribute to socio economic upliftment of local communities
 <b>Increasing success of the strategy</b>			

**Figure 2** Effect of the change from passive to active strategy on the components of ecotourism.  
**Source:** Miller and Kaae (1993)

with ecotourism as a continuum, bound by polar extremes as depicted below:

As shown in the figure above, at one end, all tourism activities including ecotourism interventions are considered to negatively affect the natural and social fabric, making ecotourism impossible. At the other end, human beings are considered part of the ecosystem and there is no difference between the ‘natural environment’ and ‘human (built) environment’, qualifying all tourism activities as ecotourism. These two positions represent extreme and unrealistic views, and ecotourism interventions and management strategies lie somewhere between these polar extremes.

The success of an ecotourism regime can be measured in terms of how effective it has been in moving from conflicting scenarios to co-existence, and subsequently, to symbiosis, as illustrated below:

## 4 The ecoLogin Business model

A hybrid organisation structure, an improvised form of the integrated rural tourism model (Cawley and Gillmor, 2008), is put in place. This structure encompasses a private limited company (i.e. ecoLogin) and a Section 25 non-profit trust (BSRF). ecoLogin develops destinations, acquires

customers, and organises tours. BSRF is funded by grants and works towards enhancing rural livelihoods.

The following sections describe the model and explain how it proposes to fill the gaps observed in existing models.

### 4.1 End-to-End Service Offering

The model proposes an end-to-end service offering, where everything from the start to the end of the tour is taken care of, so there is complete control over the experience delivered to tourists (i.e. all services such as transportation, food, and accommodation are provided by the company).

### 4.2 Exclusive and Offbeat Locations

We observe that tourist locations are more or less standardised and very few pristine locations are part of the available tours. By collaborating and forging friendly and long-term relationships with the local community, who are well versed with the terrain and local customs, access to locations that are otherwise unknown to the outside world becomes possible. In this way, the local community stands benefitted and clients are able to enjoy access to various pristine locations.

### 4.3 Asset Light Strategy

This rural tourism model is based on the asset light strategy, which offers several advantages. Operations are in collaboration with the local communities, whose trust is built over time. These reliable local sources make the experience more appealing as well as exotic as they have sound knowledge of their homeland. Moreover, expenditure in such a set-up is low, as it is not capital-intensive and the company need not procure land to build infrastructure to run its operations. This asset light strategy enables scaling up of operations with comparatively lower investment, and most importantly, the company shares the profits with the local community for their participation in the exercise.

The relationship built with the local community is not just for their guidance and help during the tours, but for a larger objective. The relationships will be forged for the long-term, in which the community will

be helped in various ways such as through training programs and other such social initiatives taken on their behalf to help sustain the model. One activity feeds on the other, thus making it sustainable over time. The light asset component helps reinforce the trust component in local communities and the model in essence is built on trust and mutual support.

### 4.4 Hybrid Rural Tourism Model (HRTM)

The Hybrid Model attempts to operationalise rural tourism through its hybrid organisational structure comprising a private limited company and an NGO. A simplified pictorial representation of this hybrid model is shown in Figure 3 below.

The private company is an experience-based tourism service provider offering activity-filled tourism experiences in offbeat locations. It provides end-to-end, customised, guided tours with a range of themes including adventure, jungle, heritage, and culture.

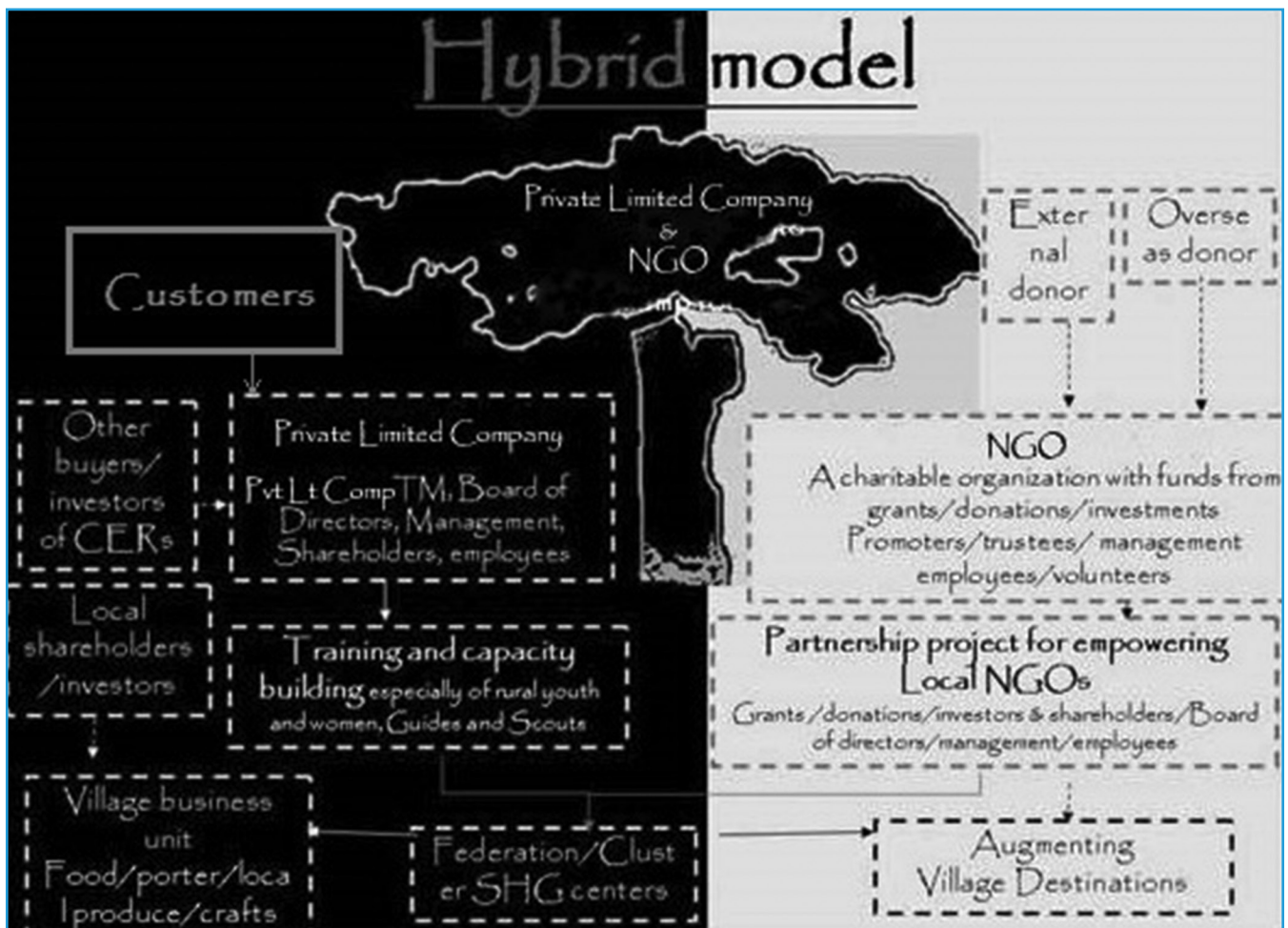
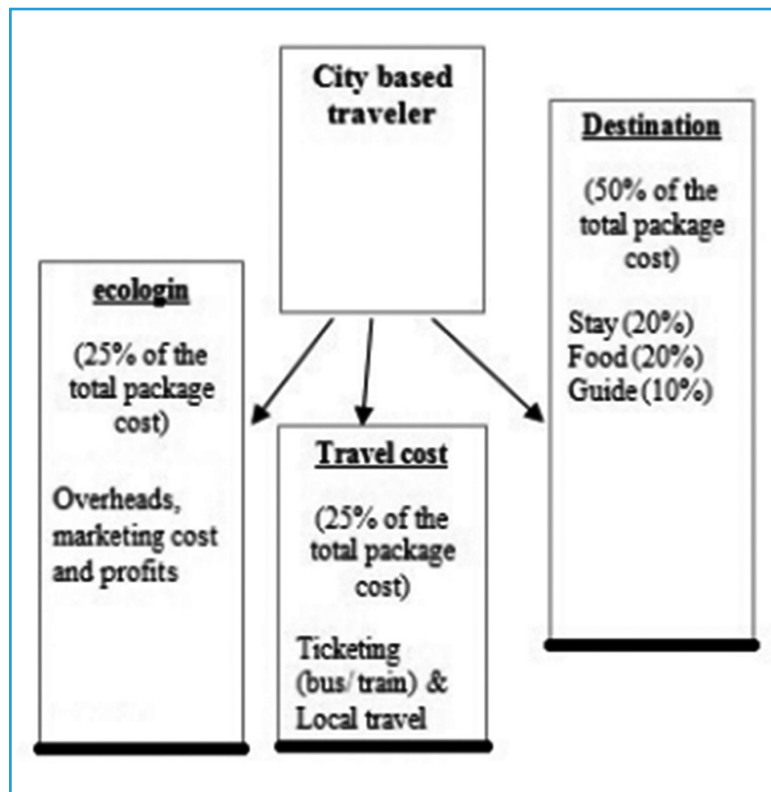


Figure 3 Hybrid Rural Tourism Model (HRTM).





**Figure 4** Cost breakup for a typical ecoLogin trip

The experience encompasses the involvement of local people and communities in service delivery, which enriches the experience of travellers and provides an alternative source of livelihood for the community.

The NGO focuses on the following areas: 1) environmental conservation and promotion of local arts, crafts, and culture through community-based ecotourism interventions; 2) promotion of innovative, appropriate, and sustainable technologies among marginalised communities; and 3) education in tribal areas.

The twin organisations would strive to achieve the following objectives, which would result in better eco-tourists, environment, and local communities. The NGO would initiate the following activities:

- Creating awareness and supporting interventions for environmental conservation in marginalised communities;
- Undertaking active research through field-based interventions to build sustainable and replicable

models for the development of marginalised populations in remote areas;

- Collaborating with local NGOs and community-based organisations for implementing community-based interventions in marginalised communities;
- Mobilising resources and support from donors, corporate houses, NGOs, technology providers, experts, reputed research organisations, and individuals;
- Promoting volunteering in schools, colleges, and corporate houses; and
- Facilitating CSR interventions for corporate houses.

## 5 Equity, Ethics and Profits Involved in the Core Objectives of ecoLogin

While focusing on enriching the tourism experience of customers through professional service delivery at a nominal cost, ecoLogin contributes passively towards natural environment conservation and the development of marginalised communities. The

company identified some key business objectives to enable it realise its vision. These are described below.

### **5.1 Maximise Earnings of the Local People**

The travel and tourism industry has a maximum multiplier effect on the economy. ecoLogin has implemented some measures to ensure that benefits accrue to the local population, with which it has collaborated. It has recruited local community members as staff members in its zone offices. Community members are empowered and employed as trek/tour guides. Further, it has tie-ups with local community members, estates, farmhouses, homestays, bungalow owners, local CBOs and NGOs, local businesses, lodging and boarding facilities, restaurants, hotels, etc. ecoLogin pays fair prices for the goods and services sourced locally, ensuring that the local economy benefits directly as well as indirectly from the business opportunity that ecoLogin is exploring. For example, the flow of money spent in a typical ecoLogin weekend trek is shown in Figure 4 below. The approximations are based on statistics from the past one year of ecoLogin's operations. It shows that at least 50% of the total package cost paid by the customer is spent at the destination (diffused into the local economy), and thus, the profits are equitably shared.

- Expenses borne directly by the customer during the travel—the money spent on purchase of local artifacts, crafts, delicacies, etc.;
- Investments made or rent paid by ecoLogin for its offices and establishments in these local areas; and
- Money spent by ecoLogin or BSRF for various other development initiatives at these destinations.

### **5.2 Maximise Diversification of Local Livelihood Opportunities**

In addition to creating employment in the tertiary sector (service industry), tourism encourages growth in the primary and secondary sectors. As

discussed above, ecoLogin has recruited local community members and established local tie-ups for logistics, ensuring that the local communities in these areas, which mainly depend on the primary sector (agriculture and allied activities) for employment, will have a wider choice for primary and secondary employment in the service industry. Local businesses also expand their services to cater to the needs of the floating tourist population. ecoLogin ensures that enough avenues are created to showcase local crafts and products of artisans, providing a wider market for the local produce. In such a win-win scenario, local communities are actively seeking to sustain and encourage tourism operations and contribute to a positive tourism experience. Supporting local economic growth is therefore important in the long-term success of tourism operations in these destinations. This again shows us that profit and equity are maximised in a symbiotic manner.

### **5.3 Minimise Ecological Footprint**

ecoLogin minimises the usage of non-renewable resources and the generation of non-biodegradable waste in its operations. To this effect, it encourages the use of mass transportation where possible, especially between zones. In ecologically sensitive areas, the group size is restricted to twenty so that the carrying capacity of the area is not exceeded. Travellers are strictly advised to minimise the use of plastic and not dispose of any non-biodegradable substances during travel. All solid wastes generated during tourism activities are segregated at the source and disposed of appropriately. Profits can be increased by simply removing the cap on group size, which is a direct trade-off between profits and ethics. In this case, environmental ethics is clearly a priority over profits.

### **5.4 Maximise Awareness and Mobilisation of Human Capital for Environmental Conservation**

In India, social norms, community imposed self-regulations, religious beliefs, and customs have

existed to ensure that resources are conserved and ecosystems protected. As these social regulations changed and led to fewer restrictions over time, the state began playing a more active role in conservation through various policy and regulatory frameworks. However, we repeatedly see that top down conservation efforts have not been very successful, and along with development interventions, have led to further marginalisation of the groups, which were dependent on local natural resources for subsistence, thus creating conflicts for natural resources. With development, modernisation, and globalisation, the impact of externalities on local systems are also much more pronounced. ecoLogin believes that there is a need for a paradigm shift in the approach to conservation. The human being/humanity is a participant in the ecosystem; hence, conservation should focus on stewardship of the natural environment through changes in individual behaviour.

A community depending on natural resources for subsistence has a direct stake in its conservation. The tangible and perceivable, direct and indirect benefits/economic returns of tourism and activities related to the local community should act as an incentive for them to preserve the ecosystem. This ensures not only equity to the local communities but also their ownership and involvement.

ecoLogin believes that educational institutions have a major role to play in environmental conservation. Classroom-based environmental studies should be supplemented by involving students in assessing and monitoring the quality of the natural environment in their surroundings, documenting biodiversity, assessing the impact of development interventions, etc. ecoLogin consciously engages with educational institutions and students to increase their awareness about environmental conservation. It promotes eco-clubs in schools and colleges to nurture a group of young environmentalists with a passion for environmental conservation.

ecoLogin also sensitises its clientele (mostly young urban professionals) to the value of these unique

ecosystems to mankind in terms of the ecosystem services—provisioning services (food, species, raw materials for industrial and pharmaceutical products, energy), regulatory services (climate, pollution, nutrient cycle), supporting services, cultural services, and preserving services—and the threats faced by these unique ecosystems. Urban-rural disparities in resource use and degradation of ecosystem services are also highlighted. ecoLogin hopes that this will help them appreciate the repercussions of their present resource use patterns, learn better ways of living on planet earth, and resonate the conservation agenda.

ecoLogin also facilitates events and activities as a part of its tour packages to regenerate/revive the natural ecosystems in these destinations through activities such as litter collection and disposal, awareness drives in destinations on waste management, and planting local species of plants/mangroves.

### **5.5 Respect Local Values**

Clients are briefed on the local customs and values of the host community and appropriate/acceptable behaviour. This helps guests have more meaningful interactions with the local community and ensures that both the guests and the host community have a more enjoyable experience. ecoLogin is aware that tourism can also create a negative social impact in the local community, as inequitable distribution of benefits can create conflicts within the host community. Moreover, the floating population with higher income levels could exploit local community members—especially the more vulnerable such as the poor, women, and children. Exploitation could include prostitution or other forms of sexual exploitation, forced labour or services, and slavery or practices similar to slavery.

ecoLogin will equip their staff, who generally belong to the local community, to act as watchdogs to prevent exploitation of all forms and protect the interests and well-being of their community. They are capable of identifying and responding

to situations where children, women, and other vulnerable groups in the community may be at risk of sexual exploitation. Travellers will be provided with information related to ecoLogin policies on preventing exploitation of all forms, and transparent processes will be implemented to deal with any incident of such nature. Here, ethics and equity take priority over profits.

## 6 Achievements

ecoLogin was conceived with the idea of giving a unique and exotic travel experience to its customers. It has brought about a synergy between local residents and the tourists to enable mutual benefit. The company has strived to give a delightful experience at affordable costs without compromising traveller safety. Of 3,500 clients over a period of three years since 2009, feedback from over 1,500 clients was taken for validation of ecoLogin's fulfilment of its core objectives. When the question of clients finding the locations exotic, remote, offbeat, and yet exciting was posed, a majority of them (59.8%) stated that their tourism experience was 'totally different' and 36.1% of the respondents rated it 'quite different'. This revealed that the company fulfilled its core objective rather tellingly with over 95.0% of the respondents expressing their appreciation on this count.

The question of safety is rather important when travelling to such remote locations. All clients were taken to 'different' destinations and brought back safe and sound. Safety measures were planned and implemented with utmost care, considering the risks involved during treks to remote places, the associated unpredictable weather conditions, and possible encounters with wild animals. This was possible largely due to the strong relationships forged with the local communities, who had rich knowledge of the local regions, as well as the extensive knowledge of guides about remote locations.

As stated earlier, one of ecoLogin's core objectives was to provide an offbeat experience at a very reasonable price to enable even middle class

families enjoy 'different' experiences with nature. Just about 1.5% of the clients felt dissatisfied, while the majority (71.2%) reported that the tour prices were worth their experience. In fact, about 6.3% of the clients felt that the tours were priced economically. When the question of return treks organised by ecoLogin was posed, 94.0% of the clients expressed their willingness/preference to return. Past data show that the company has a high client repeat rate, implying that clients appreciated the quality of service and their experience.

ecoLogin's other core objective concerned the empowerment of local communities while sensitising city-bred clients about the realities of people living in remote areas. Around 71.8% of the clients agreed to contribute to the development of the remote or rural location that they had visited.

Despite the remoteness of the locations, a majority of the clients considered the food and accommodation to be good. Around 18.2% of the clients rated the food as excellent while 26.9% remarked that the accommodation was excellent too. In essence, clients were served acceptable food and provided with proper accommodation in spite of the difficulties faced in fulfilling basic needs in the remotest of locations.

The knowledge of the guides is very valuable to clients and contributes greatly to an excellent experience. Guides were trained to meet emergencies and be responsible for client welfare on every tour. A majority of the clients (54.2%) reported that the guides' knowledge was excellent, while 39.3% stated that it was good. These results show that ecoLogin has met its core objectives of providing clients with a unique experience, safe trips, and nominal costs as well as ensuring that local communities realise economic and social value.

Other major achievements of ecoLogin are listed below:

1. ecoLogin was shortlisted by RTNE (Rural Technology Network Enterprise), promoted by

the ICICI Foundation as its partner for tourism in South India.

2. ecoLogin won the third place in GENESIS 2010—an international social business plan competition organised by IIT Madras.
3. Sridhar Lakshmanan received the ‘Star Entrepreneur Award’ on behalf of ecoLogin at the 4<sup>th</sup> Indira India Innovation Summit 2011.
4. ecoLogin was featured as one of the 25 best social businesses in India by Outlook Business magazine.
5. One of the largest trekking symposiums in India, Trek Polama 2011, was organised by ecoLogin in collaboration with the Chennai Trekking Club (CTC) on 27 March 2011 at IIT Madras campus in Chennai.
6. ecoLogin has received wide coverage in India’s leading newspapers such as The Hindu, The Times of India, Business Line, Live Mint, The Economic Times, and Deccan Chronicle. It had also partnered with NDTV—a Hindi news channel—for a two-part travel series on ‘Discover Tamil Nadu’. Its coverage in Outlook Business as one of the 25 best social businesses in India and in a French magazine is also notable. These media exposures have created an impact more positive than could be achieved through big-budget advertisements.

## 7 Conclusion

ecologin has catered to more than 75 remote locations in and around Tamil Nadu and served more than 5,000 tourists in the last five years. It has met its core objectives of providing clients with a unique experience, safe trips, and nominal costs and has ensured that local communities realise economic and social value. It forged partnerships with NGOs and other entities to make its locations community-based and community-operated. The involvement of local communities in service delivery enriches the experience of travellers and provides an alternative source of livelihood for these communities.

It has been a challenge to remain true to the conflicting needs of customers, local people, and profits. From the feedback received, it is clear that customer needs have been met, as 77.5% of them reported that their trips gave them value-for-money. In fact, 6.3% of them reported that the tours were very economical. Over 95% of the respondents expressed their appreciation for the offbeat experience, and about 59.8% reported that the ecoLogin tour experience was completely offbeat and thus satisfied their quest for an offbeat experience. ecoLogin shared one-third of its revenue directly with the local people in return for their services on tours and ensured that their tours did not have any negative effects on the locals. At the same time, ecoLogin earned sufficient profits to sustain operations.

During the few years of ecoLogin’s operations, it has had to make minor trade-offs to keep itself relevant for customers and sustain financially. However, it has maintained its core ethics even in times of bad business.

Moreover, ecologin has expanded and diversified its business into consulting practice, while BSRF has successfully facilitated several CSR initiatives for corporates such as Timberland and Cognizant Technology Solutions in remote tribal villages and urban slums. It facilitates training programs for tribal groups and local people to become guides, and is finding markets for non-timber forest produce, for example, honey, bamboo furniture, minor millets, organic fruits, and vegetables. The above achievements were a result of the attempt to maintain a fine balance among equity, ethics, and profits.

This project was started as an academic requisite for completion of MS (Entrepreneurship) program at IIT Madras. It has demonstrated the potential to be replicated in other strategic locations for community-based environment education to provide livelihood to local communities and promote ecotourism.



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Designing Tangible Interactive Learning Aids for a  
Pre-primary School Teaching Environment:  
A Sustainable Approach

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# Designing Tangible Interactive Learning Aids for a Pre-primary School Teaching Environment: A Sustainable Approach



## Abstract:

Pre-primary school instruction and teaching methods in Indian schools are classified into two categories, as dictated by existing resources. While schools with more resources have adopted teaching aids that follow Bloom's Taxonomy, schools with fewer resources have been left behind in enhancing student's experience as well as raising teachers' satisfaction levels. All of this is reflected in the quality of students and teachers' output. Although numerous devices are available at the high school level and above, a survey revealed that few teaching aids are accessible for pre-primary schools in India. This paper presents a way to incorporate simple and inexpensive technology to embed intelligence into objects, which in turn can be used in classrooms to enhance the teaching and learning experience. We adapted two tangible interactive objects and prototyped and tested them in three local schools. We show how these devices can constitute a sound educational pedagogy by demonstrating how they embody Howard Gardner's theory of multiple intelligences. The methodology discussed in this paper presents possibilities for further work in the area of embedding intelligence into objects, leading towards cognitive development in children in a learning environment. We posit that designing such learning aids contributes to sustainability.

**Keyword:** tangible interaction, bloom's taxonomy, multiple intelligences, pedagogy, children

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## 1 Introduction

Interest in the field of tangible interactions and embodied cognition has been increasing lately. Research (Antle, 2007; Marshall, 2007) in these areas suggests that the use of tangible devices helps enhance student learning. With the increasing use of sensors and actuators in educational toys, studies have started to focus on children's use of interactive products that are not only entertaining but also educational. This branch of human-computer interaction, which is known as child-computer interaction, focuses on how to embed intelligence in objects that can be used by children for a more engaging and joyful learning experience. Although many studies have been conducted on

developing interactive tangible devices for pre-primary schoolchildren in Western countries, our understanding of how these types of products are used in other countries and cultural settings is lacking (Jamil et al., 2012).

In India, although there exist many private and central-government-funded schools, for which costs and technology are not barriers, many other schools cannot afford such technology. Major findings such as those obtained by Campbell, Mehr and Mayer (2013) showed that factors such as resource limitations, a limited infrastructure and limited knowledge of technology's potential are obstacles in the successful adoption of technology in the field of education.

Since financial costs and the availability of required materials are practical considerations for a developing country such as India, design intervention is required to create novel technologies and methods that complement the pedagogy used in schools lacking resources. We posit that compared to disposal devices, which are not only costly but also ecologically unsuitable, the design approach in such learning devices needs to be sustainable.

This paper proposes a sustainable approach that can be used to embed intelligence in everyday objects for use in pre-primary classrooms. We conceptualised and designed two prototypes that we tested across three pre-primary schools in Guwahati, India.

## 2 Prior Research

With the advent of tiny sensors and actuators embedded in everyday objects, computing has assumed a ubiquitous form. Various examples can be quoted from diverse areas such as museum tours, conferences, and storytelling. Over the past three decades, researchers have explored the possibility of embedding intelligence into children's physical world (Montemayor, Druin, Chipman, Farber & Guha, 2004).

O'Malley (as cited in Antle, Wise & Nielsen, 2011) presented a report summarising studies that have included prototypes, applications, and evaluations of tangibles as learning tools for children. Antle (2007) presented different cognitive developmental theories that can be used in designing tangibles for children. Antle (2009) also examined the effect of embodied interactions on cognitive development in children. Marshall et al., (2009) presented various frameworks on tangible and embodied interactions, and investigated the behaviour of children during their use of physical and digital representations. Antle et al., (2011) studied design features that are critical for enabling interactions that support children's learning.

Kolb's experiential learning theory, Piaget's theory of cognitive development, and, more recently, Howard

Gardner's theory of multiple intelligences provide a platform on which we can connect learning, intelligence, and experience. Gardner's theory of multiple intelligences is considered one of the most influential learning theories. According to this theory, a person's intelligence consists of eight distinct types, to which they can relate their internal strengths and capabilities. These categories of intelligences are (a) linguistic (understanding of different words and languages), (b) musical (understanding of sound and music), (c) logical-mathematical (the ability to apply logic, critical thinking and number crunching), (d) spatial (the ability to understand forms, shapes, colours and space, and visualise them in the mind), (e) bodily-kinaesthetic (having control over physical actions and bodily movements), (f) intrapersonal (understanding oneself), (g) interpersonal (social skills), and (h) naturalistic (awareness of the environment and classification skills) (Becker, 2005).

Becker (2005) outlined how this learning theory is embodied in good educational games. The revised levels from simple to complex thinking are Remember, Understand, Apply, Analyse, Evaluate, and Create. Nobel (2004) presented a detailed study on integrating the revised version of Bloom's Taxonomy with Gardner's theory of multiple intelligences for curriculum planning. He also suggested how the theory of multiple intelligences and the revised Bloom's Taxonomy can be used as important tools to strengthen intellectual capabilities and challenge children's critical thinking abilities.

## 3 Prototypes

We consciously developed these prototypes to be inexpensive and sustainable by keeping in mind during production the fact that they were for underprivileged schools in India. They also involved group interactions among children. Since such devices are unavailable on the market, we had to conceive them and create prototypes.

This section presents two prototypes embedded with intelligence which can be used to teach pre-primary



schoolchildren. We constructed these prototypes from readily available everyday materials such as aluminium foil, cardboard, tires and a bicycle wheel. The first prototype is called an ‘interactive board’, and the second is a ‘round piano’. In the following section, we describe the steps involved in developing these prototypes, which had to be produced with embedded activity in order to enable experimentation with schoolchildren.

### 1.1 Interactive Board

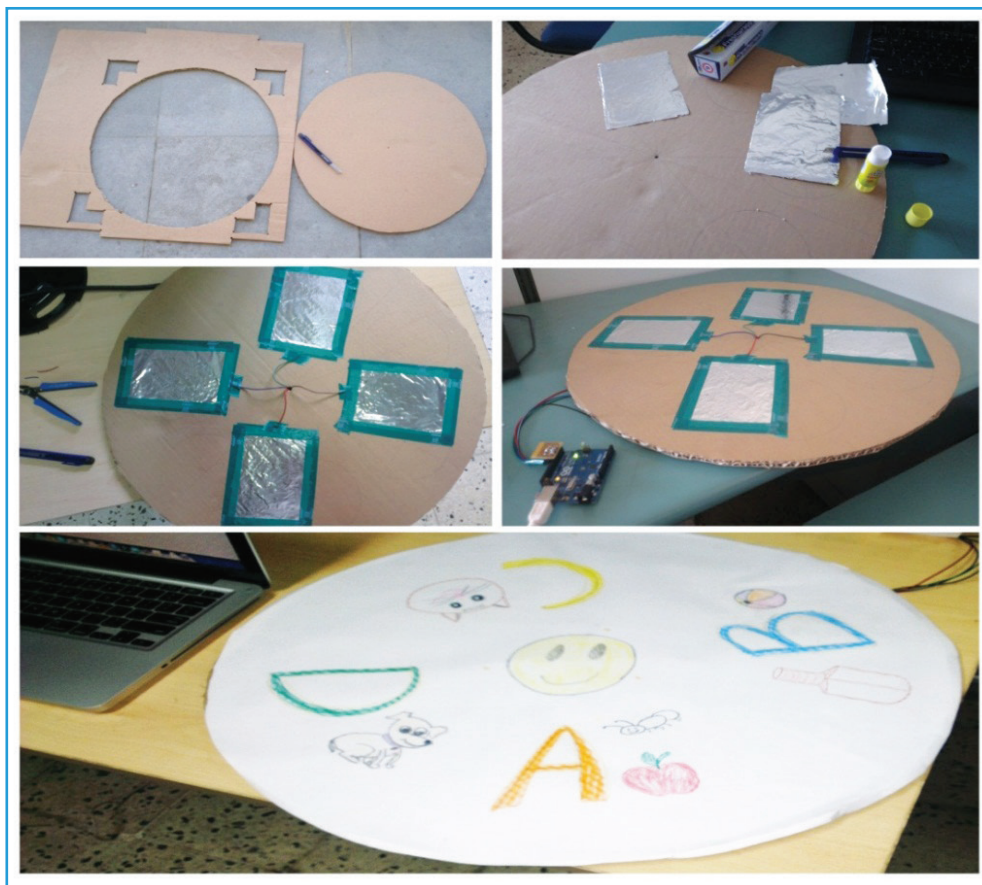
We constructed the interactive board by using easily accessible materials such as cardboard, aluminium foil and a microcontroller (Arduino Uno). Capacitive touch sensors were created from several pieces of aluminium foil by using Arduino’s capacitive sensing library (Badger, 2013).

Four such sensors composed of aluminium foil were placed at an equal distance from each other on a round cardboard base with a diameter of 53 cm. These sensors were connected with the Arduino

board, which transmitted the data serially to the computer whenever touch was sensed on any of the four sensors. These data values were read by software in order to play the sound that was triggered when a particular sensor was touched. The main objective of this prototype was to teach the alphabet through sound to children in nursery schools. Since it was a prototype, it consisted of only four consonants (i.e. A, B, C, and D). Figure 1 shows the steps involved in creating the first prototype as well as the final version.

### 3.1 Round Piano

We constructed the round piano by using a bicycle wheel. Eight sensors composed of aluminium foil were installed at an equal distance around the circumference of the wheel and then connected to a microcontroller. Once the sensors were pressed or touched, the speakers mounted on the device produced musical notes. The main objective of this prototype was to teach various musical notes to children in upper-kindergarten (UKG) class. We



**Figure 1** Interactive board prototype created from readily available materials, connected to a computer through the Arduino board



**Figure 2** Round piano prototype with an Arduino board mounted at the centre in order to allow the rotation of the wheel with touch-sensitive aluminium foil on the sides

developed applications for both prototypes by using Processing 2.0 and Arduino IDE. Figure 2 shows the construction of this prototype.

## 4 Study Description

Our main objective was to find the interplay between Bloom's taxonomy and the theory of multiple intelligences when children interact with tangible devices. In order to understand how students interact with these devices, and how they would derive learning content on their own by using these instruments, we conducted a study in three schools in Guwahati, India, over three full days. Observations were made by recording the behaviours of 30 children (10 from each school) in an age group of three to four years (i.e. nursery class) and 30 children (10 from the first school, and 20 from the second) in an age group of four to six years for the UKG class. We also interviewed 10 teachers, and qualitatively analysed the data.

### 4.1 Methodology

Each group of children from the nursery consisted of 10 students from the same class who were guided by their class teacher. The nursery class students were given the interactive board prototype. The second

prototype was provided to a group of eight students from the same UKG class under the supervision of their class teacher. We recorded videos and took photographs for each session in order to capture the physical behaviours and learning activities of the students. After they completed the activities, we interviewed the class teachers; the interview was recorded for content analysis.

The activity allotted for the interactive board to the nursery class involved touching a specific consonant, one student at a time, and singing along with the song that played through the computer. The song taught the students how to enunciate the letters as well as various objects and animals related to alphabets. We also instructed the children to perform actions and mimic the sounds of animals and objects mentioned in the song. When the song was nearly finished, the children were asked to turn around while standing in one place, and then to sit and stand quickly while clapping. We then asked them to reproduce and show what they had learned through actions (e.g. a balloon is round, and therefore, they moved their hands by forming a big circle in the air). Figure 3 shows the activity performed by the children using the interactive board.





**Figure 3** Children performing the assigned activity by using the interactive board

The second prototype, the round piano, was allotted to the UKG children. In our first survey, we left the children alone with the device after explaining its functionality. We then observed their behaviours and video-recorded the event. In the second survey of this prototype, we observed three groups of eight children interacting with the device, and asked them to stand

near a particular key. We then allotted a particular musical note (e.g. 'Sa', 'Re', 'Ga' or 'Ma') to children, and asked them to sing the different notes as they pressed the keys. Figure 4 shows this activity. The first group of children were asked to create music on their own. In the second group, children were asked to sing the notes whenever they pressed the keys.



**Figure 4** Children interacting with the round piano by touching the sides with touch-sensitive aluminium foil

## 5 Analysis and Findings

### 5.1 Analysis

We conducted our analysis by qualitatively analysing the audio and video data that was obtained by recording interviews with teachers and children's activity. Several observations were noted regarding the overall behaviour of the class and children who had completed the activity. Video data was collated to identify the vital aspects of the classroom dynamics and gain insight into how

the children coordinated amongst each other and interacted with the devices.

We video-recorded a series of activity sessions conducted during the study. These recordings were reviewed repeatedly and then interpreted as discussed in a study on interaction analysis by Jordan & Henderson (1995). The collected data showed the different levels of thinking involved in learning, as described by Bloom's Taxonomy. Similarly, the children displayed different types of intelligence when using the prototypes through this process. Further, using

Pictures/Clips	Description	Intelligence Type
	Children exploring the device and its functions by pressing different keys. (Still Photo)	Logical, Musical, Bodily-Kinaesthetic, Naturalistic
	All of the children start knocking on the tire together (12:03)	Bodily-Kinaesthetic, Musical, Interpersonal
	The girl presses the tire hard while making a face. This indicates that she is exploring the material the device is composed of. (12:17)	Musical, Bodily-Kinaesthetic, Naturalistic, Intrapersonal
	After sometime all children left but two remained and explored the device. (13:27)	Intrapersonal, Musical
	The child is curious regarding the device, and looks under the hood. He is also exploring the material composition of the tire (15:39)	Naturalist, Musical, Intrapersonal
	After 20 min, the child in the picture is the only one remaining, and he continues to rotate the device and press keys to produce sounds. (20:05)	Bodily-Kinaesthetic, Musical

Figure 5 Interaction process analysis of the round piano.



the content analysis technique described by Bruce (2001), we transcribed the audio data recorded when conducting the interviews and identified keywords highlighting intelligence and types of learning upon repeated listening. The steps involved in this process are described in the following section.

## 5.2 Findings

Figure 5 shows important actions, with a description of the scene and the type of intelligence being displayed by the children when operating the prototype. The dashed white circles in the photographs indicate these actions in the clips.

Regarding the two boys shown in the last three images in Figure 5, we enquired from their class teachers about their attitude in class. We found that these boys are usually silent, and do not socialise much because they are new to class. However, they were relatively observant compared to the other students. Their observant nature is mentioned in the fifth row of Figure 5 as 'naturalist'. The teachers also informed us that these boys did not show much inclination towards musical activities conducted in school. This indicates that they became interested in operating the device, which was presented to them. The class teachers confirmed this inference as well.

We found that children explored the elasticity of the tire by pressing hard on it and knocking on it. This indicates a direction to explore the materiality of the tangible interfaces. The children eventually lost interest in the prototype after 16 minutes and returned to their places, thereby showing that the

device should be more engaging because children have a short attention span.

It was also observed that the group of children that was taught the musical notes sang them repeatedly after they returned to their seats, and some of them pretended to be pianists. Figure 6 shows the expression and action of a girl captured in one of our videos after the activity.





The interaction process analysis for the first prototype is shown in Figure 7. The children took some time to understand the device. After we provided them with instructions, they adapted quickly. We observed that the children were relatively inquisitive in touching the board. Whenever the song was played upon touching the board, they felt exhilarated. In addition, if one child touched the board, another would do the same, thus interrupting the song that was being played. Upon observing this, we instructed the children to press a letter only after the song ended. Upon completion of the song, we observed that many children were willing to press the letters, and nearly all of them pushed their hands forward. It was also noted that the involvement of the teacher or researcher was necessary for the children to perform the activity.

After the activities, we interviewed the class teachers and principals of these schools to determine the effectiveness of the devices for learning, in addition to how well they suit their current pedagogy and practices. The response of each teacher was labelled R1, R2,..., R8 and placed on the horizontal axis of



Figure 6 A girl acting as a pianist after operating the round piano



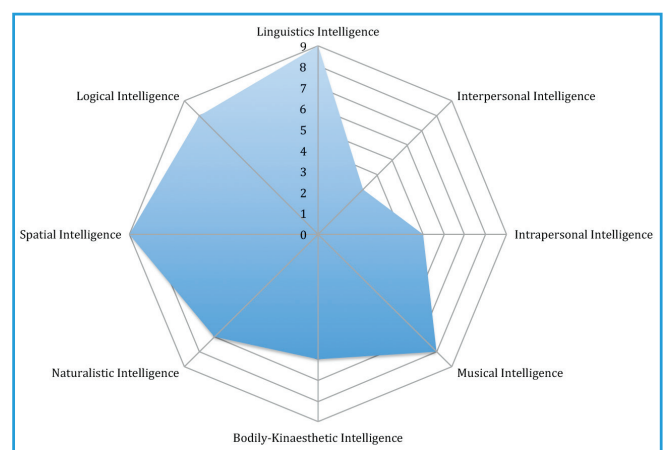
Pictures/Clips	Description	Intelligence Type
	A child interacting with the device. (Still Photo)	Bodily-Kinaesthetic, Spatial
	Children repeat the letters of alphabet once the song is over (3:28)	Musical
	Children spinning around, as instructed by the song (4:05)	Bodily-Kinaesthetic, Musical, Linguistic
	The children clapping once the song is over (09:55)	Bodily-Kinaesthetic, Musical

**Figure 7** Interaction process analysis of the interactive board

the table, and the vertical axis indicated the type of intelligence, as shown by their statements. Similarly, we then quantified all other responses through content analysis.

Table 1 shows the number of intelligences, as indicated by the teacher responses. Table 2 shows the quantified data obtained using this method. Figure 8 shows radar plot that was constructed based on the data obtained from a content analysis conducted on similar responses from the interview. We can infer that the effectiveness of these prototypes based on the type of multiple intelligences embodied in them.

During our sessions, we observed that, because children can be rough with technological tools, schools are occasionally reluctant to purchase such products. We suppose that this is another



**Figure 8** Radar plot showing the types of intelligence embodied in the prototypes

reason technology has not been applied in Indian pre-primary schools. However, our prototypes were relatively durable, and were able to sustain rough usage without resulting in any disruption in their working process.

**Table 1** Teacher responses indicating different types of intelligences emerging as the children interact with these prototypes. Only two of eight responses are shown for brevity

Intelligence/Response	R1	R6
Linguistics	‘...matching capital letters and lowercase letters...’	‘...children know the alphabet; they can see and touch it. It also comes with sounds...’
Spatial	‘...draws attention because it is big and large letters...’	‘...children know the alphabet; they can see and touch it. It also comes with sounds...’
Bodily–Kinaesthetic		‘children will like it... the game way of learning’
Musical		‘...children love music... this utilises it’ ‘...children know the alphabet; they can see and touch it. It also comes with sound ...’
Interpersonal	‘...children can stand in a circle... counting up; counting down...these games can be played’.	
Intrapersonal		‘...the fear will go away at the time of learning’
Logical–Mathematical	‘...matching capital letters and lowercase letters...’	
Naturalist	‘...they can learn different animal names and sounds...’	

One important suggestion we received from a teacher, thereby increasing the opportunities for sustainable performance, was that the song that is being played should not only be in English. He suggested that the devices support different types of vernacular languages. Overall, the teachers were satisfied with the effectiveness of the devices, and stated that they could readily adopt such types of equipment as a teaching aid.

**Table 2** Word count of intelligence types as indicated by the teachers; obtained from content analysis of interview data

Intelligence	Word Count
Linguistics	9
Spatial	9
Bodily–Kinaesthetic	6
Musical	8
Interpersonal	3
Intrapersonal	5
Logical–Mathematical	8
Naturalist	7

## 6 Implications of these Devices on Child Development and Classroom Dynamics

Through our research, we wanted to understand the implications of our devices for children and overall

classroom dynamics. We posited that the heuristic of embedding intelligence in learning aids could be developed eventually. This is a critical factor from the perspective of educational psychologists and educators. Studies (Grob-Zakhary & Kristiansen, n.d.) have shown that the preschool years are critical for brain development in children, and that children start developing areas that are key to executive functions when they reach the age of three. These are critical cognitive processes such as problem-solving, sustaining attention, monitoring performances as well as planning and directing various activities, which shape how they will turn out in school (Kanani, 2014). A presentation on sensitive periods of childhood by Dr. Randa Grob-Zakhary, CEO of the Lego foundation, showed that the ‘sensitivity of brain development’ is maximised towards numbers, peer social skills, conceptualisation, language, emotional control, habits as well as vision and hearing for children between three and five years, which are the preschool years. After this period, this sensitivity begins decreasing as they advance towards their school years. By age 7, this sensitivity becomes limited to only a few things (Grob-Zakhary & Kristiansen, n.d.). This study shows that during these initial years, specifically between the ages of three and five, a significant amount of learning can occur in children if this learning is nurtured

properly. Devices with embedded intelligence can therefore be introduced to children aged three to five.

shows how children utilised various intelligences and derived learning contents when interacting with these devices.

We adopted a matrix combining Gardner’s theory of multiple intelligences and the revised Bloom’s Taxonomy, as suggested by Nobel (2004), to understand various activities and higher-order cognitive processes that combine when children use tangible learning aids. Figure 9 shows the analytical result obtained from interaction and content analysis, mapped onto the matrix grid. It

The proposed matrix provides insight into how tangibles can be designed to obtain greater depth for achieving cognitive and sensorimotor activities that lead to learning. The matrix shows that engaging children in various activities by using tangibles invokes different levels of thinking as well as intellect. This analysis shows that children tend to explore new areas when they interact with such

MI\BT	Bloom’s Taxonomy: Six Thinking Levels					
	Remember	Understanding	Applying	Analysing	Evaluating	Creating
Verbal	Speak different alphabets represented on the device					
Logical-Mathematical		Compare different musical notes		Be able to differentiate between objects shown on device		Create different tones
Visual/Spatial	Recognize the alphabets and objects shown on the device		Be able to indicate objects starting with particular alphabets			
Bodily-Kinaesthetic		Compare different notes by moving around the piano	Creating different tones			Create different actions through body for these nouns
Musical	Recognize different musical notes	Create the sounds of these alphabets and the objects or animals shown on the device	Creating different tones			Creating different tones
Interpersonal			Collaborate with other children to create tones	Collaborate with other children to create tones		Be able to synchronize with the actions of students and teachers
Intrapersonal		Observe different sounds and be able to compose them			Differentiate between alphabets and be able to judge if the given answer is right or not	
Naturalist	Operating the devices  Exploring materiality of the tire				Compare different notes by moving around the piano	
	■ Interaction with Interactive Board ■ Interaction with Round Piano					

**Figure 9** Matrix showing the interplay of multiple intelligences and Bloom’s Taxonomy when children interact with these prototypes. The vertical axis shows multiple intelligences, and the horizontal axis displays the six levels of thinking from Bloom’s Taxonomy

devices. Introducing such tangibles can also help nurture quiet students in class (Figure 5).

## 7 Inferences

During our activity sessions, we found that any break in interaction suddenly resulted in a child losing interest in the task. Designers need to understand that wherever children are involved, they should be careful not to interrupt the stimulus signal where the interaction is taking place. Thus, any tangible device designed for child learning must not cause any disruption in attention when children are interacting with such devices.

## 8 Conclusion

This study showed that introducing tangible learning aids with embedded intelligence at a preschool level (three to five years) can prove beneficial for children. The findings also suggest that the introduction of these devices can help teachers plan better activities in class, thereby assisting them in imparting improved instructions to students. We also found that it is possible to construct tangible devices suited to underprivileged schools by using simple everyday materials. If designed properly, these devices can be used as an efficient and sustainable instructional medium. Unlike flat-screen-displayed contents on devices such as tablets and mobile phones, tangible devices specifically built with embedded intelligence offer a superior learning approach. Our findings also indicated that there is considerable scope to introduce design interventions for developing suitable instructional technology for preschools.

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paper

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A learning tool 'Help Pinky' for empowering  
adolescent girls in rural Assam

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# A learning tool 'Help Pinky' for empowering adolescent girls in rural Assam



## Abstract:

Adolescent girls, especially those living in rural areas of Assam, India, face severe hygiene and emotional problems during puberty. Myths, ignorance, lack of knowledge, and prevalence of silence around issues related to adolescence (menstruation in particular) are some of the reasons underlying this condition. We present our empirical research aimed at understanding the scenario amongst adolescent girls and their mindsets in rural Assam. This paper describes an attempt to design a learning system that acts as a self-learning tool to bridge information gaps, and enables adolescents' sharing of their own knowledge in their socio-cultural context. The paper outlines the basic parameters of interface design of a learning application on a topic that is of prime importance to the future of maternal health and self-care.

**Keywords:** *health, adolescence, learning, game*

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## 1 Introduction

The World Health Organization defines adolescence as the period of life between the ages of 10 and 19 (WHO, 1999). Chaudhary and Dhage (2008) refer to it as the period of life when the maximum amount of changes take place in humans physically, psychologically, and behaviourally. The majority of adolescents from low economic strata face many problems during this period. Moreover, these problems tend to multiply for adolescent females as opposed to males.

Females undergo many physical changes during this time. Due to the lack of prior knowledge of such changes, their adjustment can be very difficult, causing feelings of shyness and discomfort among the girls. A very high prevalence of anaemia has been observed in adolescent girls belonging to lower economic strata in rural India (Siddharama, Venketesh & Thejeshwari, 2010), showing that

nutrition also poses a major problem for the people of this region. According to a study conducted in Rajasthan (Chaturvedi et al., 1996), the inhabitants' diets were deficient in major nutrients, such as calories (26%–36%) and proteins (23%–32%). The nutritional status as assessed by body mass index revealed that many of the adolescent girls suffered from chronic energy deficiency, 43.6% of the participants had signs of vitamin B complex deficiency, and about 73.7% of them were anaemic.

Several studies (e.g. Rao, n.d) have been conducted on adolescent girls' responses to the menstrual cycle. In many communities, girls undergo very negative emotions such as anxiety, shame, fear, and depression due to menstruation (Deo & Ghattargi, 2005). El-Gilany, Badawi and El-Fedawy (2005) described a study in Egypt, which found that the media, followed by mothers were the main sources of information about menstrual hygiene among the adolescent schoolgirls. However, a large majority of

girls still felt the need for more information. Most of them were unaware of menstruation prior to its occurrence, and the information they were given was sparse. A ring of silence prevails around menarche. Facts about menstruation have long been cloaked in myth, mystery, and superstition (Deo & Ghattargi, 2005). Menstruation is associated largely with taboos leading to restrictions on work, sex, food, bathing, and religious practices (Garg, Sharma & Sahay, 2001; George, 2012). This taboo impedes any discussion or information-seeking behaviour, which results in poor menstrual health among the girls.

In the approximate 3,000 days of menstruation that a woman experiences during her lifetime, her requirements include proper materials for absorption of blood and its appropriate disposal (Chanam, 2012). Many women experience cramps, irritability, and other symptoms during their menses. However, they are ignorant about the reasons for them, and of effective ways to deal with them. Many females in India are subjected to the societal pressure of early marriage as soon as they attain puberty. Having an adverse effect on the girls' education, menstruation also accounts for the high maternal mortality rates in rural India. In addition, inadequate provision of sex and health education puts adolescent females at risk for sexually transmitted diseases and unwanted pregnancies (Brabin et al., 1995).

Different regions in India have different religious practices and beliefs associated with menarche. In Assam, for example, Tuloni Biya is a religious practice typical of, and unique to the Hindu Tai Ahoms and many other Assamese groups. It is a ritualistic symbolic wedding that is performed a few days after a girl has her first menstruation, and signifies the attainment of womanhood and her coming of age. As part of this ritual, the girl is secluded in a room where she is not allowed to meet anyone, and finally is married off to a banana tree on the date deemed suitable by an astrologer. In the Muslim community of Assam, a different set of rituals prevail. Bhartiya (2013) mentions that Muslim women are not supposed to enter a mosque, touch the Quran, or even have sex with their husband while menstruating.

Similarly, other parts of India have their own sets of rituals and practices, and frequently resort to further enveloping adolescents in myths and superstitions although they sometimes are harmless.

There is a very clear need to provide education to young girls on these subjects at the right time. Considering the taboos associated with menstruation, education must be imparted in ways that are acceptable to their community to allow girls to speak openly and raise their own concerns about them. The next section describes the initiatives that have been undertaken by various organisations to address these concerns. It is followed by a description of our empirical research and the subsequent health game aimed at alleviating these problems.

## 2 Related Work and Initiatives

Some initiatives to address these issues have been undertaken by government and non-government organisations with very encouraging results. Decode Global, a Canadian company, launched the 'Not Just A Piece of Clothing' initiative (Project Inspire, 2013), in partnership with Goonj (a non-government organisation aimed at solving the clothing problem of the underprivileged), to spread awareness about menstrual hygiene and women's health. In a joint initiative by MasterCard Worldwide and the UN Women's Singapore Committee, Project Inspire promotes women's empowerment. They have collaborated with Swayam Shikshan Prayog (SSP), which works with Sakhi Retail, a rural marketing and distribution company that produces affordable sanitary pads.

Aiming at breaking the silence around menstruation and menstrual hygiene management, WASH United, – a Berlin-based organisation, started 'May Menstravaganza' (Keiser, 2013), a 28-day awareness cycle. To keep the momentum going, it also has initiated a movement to assign the 28th of May, Menstrual Hygiene Day. HEEALS (2013), a non-profit organisation under its Water Sanitation Hygiene and Girl Education Project, helps girls

learn hand washing and hygiene practices through games and multimedia. The Nirmal Bharat Yatra (Patkar, 2013), which spreads awareness through games, has travelled 2,000 km across the rural areas of 5 Indian states. 'Maya's 7 day Challenge' (Sengupta and Mannella, 2013) is a collaboration between Boond and Decode Global, which aims to increase the awareness of menstrual hygiene and to improve access to feminine hygiene products in rural India.

Arunachalam Muruganatham (Gupta, 2014) designed, created, tested, and implemented a sanitary napkin-making machine to improve the menstrual hygiene of millions of women in India and around the world. Amit Virmani's 'Menstrual Man' (Virmani, 2013), is a 63-minute documentary that narrates Muruganatham's journey to empowering rural women in personal menstrual hygiene.

The effects of all of these initiatives have been limited and have not reached all parts of the country. Assam in particular, has not witnessed the implementation of any of these initiatives. This situation is ironical considering that the maternal mortality rate in Assam is one of the highest amongst all of the states in India (Rao, n.d). Given the socio-cultural context, there is a dire need for interventions in this part of the country to bridge the information gap amongst the girls about issues related to hygiene, and to open their minds to the phenomenon of menstruation.

### 3 Field Study

Using grounded theory, we conducted a series of dialogues in the form of open interviews to understand, in depth, the mental models and problems of adolescent girls in rural Assam. Interviews were conducted with 10 girls, ages 13 to 23, living near the Agthori railway station near Amingaon, Guwahati. Almost all of the girls were too shy to talk about menstruation and pubertal changes. Giggling and trying to run away from the discussion, they mentioned that they never talked about it with anyone, except a very close friend or mother or elder sister. The elders and their friends in their community, discouraged discussions about puberty, and schools avoided teaching them about adolescence. They either had many misconceptions about menstruation or were completely ignorant about issues related to it. A considerable number of superstitions, such as not going into the kitchen, not eating certain kinds of foods, not going near God's idols, and not touching anything during menstruation were prevalent among them. Feelings of fear and depression revolved around menstruation. Almost all of them were surprised, scared, and confused when they had their menarche. Generally, they missed or dropped out of school after menarche because of the school's improper facilities and their own shyness and hesitation. Due to their hesitation and shyness, they faced overwhelming challenges managing their personal hygiene, which took a downward turn.



Figure 1 A glimpse of the field study (community)



Apart from these girls, we interviewed one health worker, an Accredited Social Health Activist (ASHA), and visited the Mariyapatti sub-centre and the North Guwahati PHC (Primary Health Centre) in that area. The auxiliary nurse mid-wife (ANM) at the sub-centre explained a few measures that the government had implemented for adolescent girls. Girls receive free iron tablets and sanitary napkins through the ASHAs. However, the ASHA's reach is very limited. The nurse also mentioned that in some schools, communities are formed to discuss adolescent girls' issues. At the PHC, the ANM supervisor discussed the initiatives she developed as a part of her responsibilities for the adolescent girls in her community. She visits nearby schools and educates the girls about adolescent issues. She tries to build a relationship of trust with the girls and makes an effort to educate their parents as well. However, we observed that even she did not impart factually correct information about the reasons behind menstruation to the girls. They are told, 'bhagwan ki yahi marzi hoti hai. Isise ladka aur ladki mein farak hota hai'. (This is God's will. This is how you differentiate between a boy and a girl). She also mentioned the reluctance of people to discuss these matters in public.

Through the study, we realised the dire need to fill these prevalent information gaps. The

girls' misconceptions need to be corrected, and correct information needs to be imparted. Their attitude towards menstruation needs to change. Menstruation should be regarded as just another natural phenomenon, and all taboos associated with it should be eliminated. An intervention is required to bring about this behaviour change, along with an open mind to sharing their experiences/problems with their peers. It is necessary to keep in mind their socio-cultural context while planning and implementing all of these interventions. With these ideas in mind, we designed a game, 'Help Pinky!' Fogg (2003) discusses how games are a popular and powerful storytelling medium for persuading individuals and bringing about a behaviour change in them. They offer an optimistic and solution-oriented perspective for solving social challenges, which rarely are discussed in public. Because of these characteristics, games seemed like a promising way of addressing taboo health issues. In addition, the Akash Tablet was chosen as the medium for the game because we believe that in the future, cheap tablets will be as pervasive as mobile phones are today. The Government of India is planning to spend around Rs 30 billion from the universal service obligation fund (USOF) to provide free tablets to over 90 lakh rural school students (Ghose, 2013). Therefore, we see tablets as a sustainable medium for providing this information.

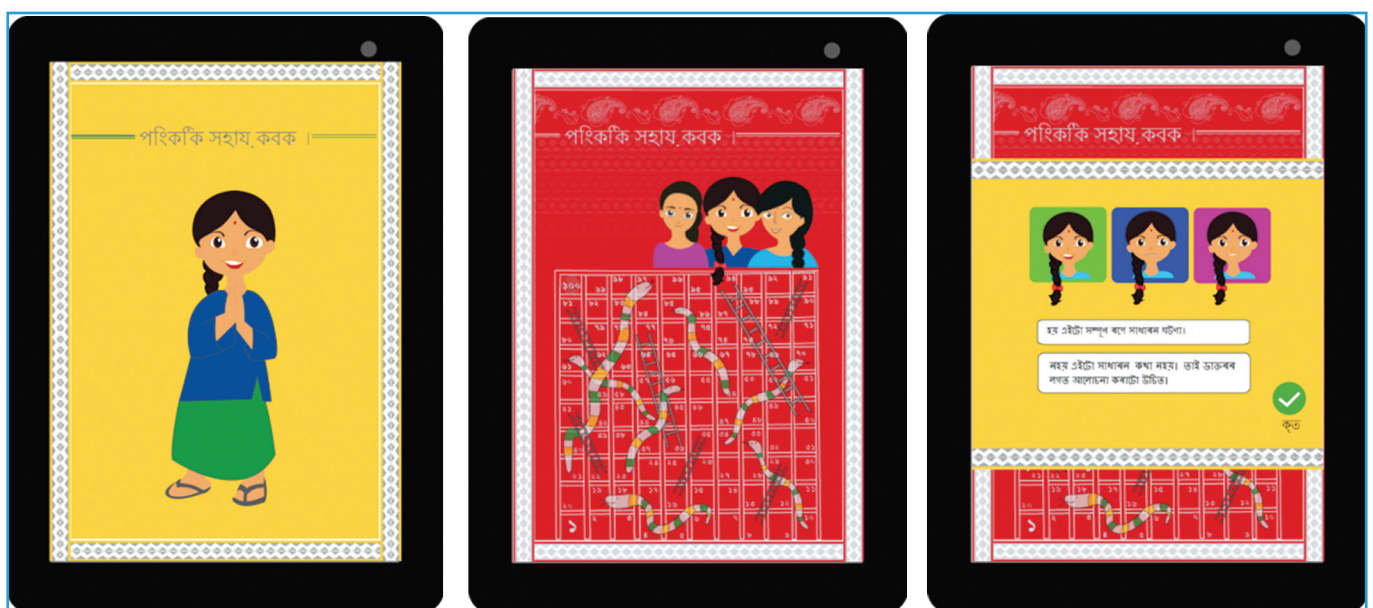


Figure 2 Screenshots of Help Pinky!

## 4 Help Pinky! Game Design

'Help Pinky!' is a game based on the famous game of 'Snakes and Ladders', which was chosen because of its popularity as an indoor game in rural Assam. This is currently a 2-player game in which the aim of the players is to help Pinky through her puberty. Similar to Snakes and Ladders, players take turns on the roll of a dice. Upon their arrival at the mouth of a snake or the lower end of a ladder, players receive information and are introduced to a question/dilemma that Pinky is facing. With the help of the other player or sometimes alone, they have to provide Pinky with the correct advice. If the advice is correct, the player is saved from being eaten by the snake or allowed to climb the ladder, as the case may be. The game describes Pinky's journey from the time before her menarche, covering all aspects of puberty, and some other aspects of sex education, such as information about HIV/AIDS. The player who wins the game receives incentives, such as free internet services, to encourage them to play the game again. The content of the game has been adapted from the Booklet on Menstrual Hygiene Management by UNICEF (Nair, 2012).

Three points were considered critical by us in designing this learning tool: 1) modelling health behaviour, 2) designing persuasion, and 3) cultural relevance. These considerations have been recommended previously (Grimes & Grinter, 2007), when health technologies for low-income African-American communities were designed.

## 5 Game Design Mechanics

### 5.1 Modelling Health Behaviour

The Transtheoretical Model (TTM) (Prochaska, Velicer, DiClemente, & Fava, 1988) and Health Belief Model (HBM) (Redding, Rossi, Rossi, Velicer & Prochaska, 2000) are two of the most prominent health behaviour models. We used them in our study to scaffold the process of behaviour change in the players.

The Transtheoretical Model outlines three stages of individual change, ranging from precontemplation (when one is not thinking about a change), to preparation (when one is getting ready to make changes), and maintenance (when an individual has adhered to changes successfully over a period). The model also describes 10 processes that help mediate the progression through the different stages thereby helping an individual to bring about a behaviour change. Here, our target behaviour was the adoption of healthy and hygienic habits, openness to discussions of issues related to menstruation, and correcting misconceptions. We adopted 5 constructs from the Transtheoretical Model: 1) consciousness raising (receiving knowledge about how to manage oneself during puberty), 2) self-re-evaluation (assessing the healthfulness of one's current behaviours), 3) developing helping relationships (discussing health issues with others and taking their help in changing behaviour), 4) counter-conditioning (substituting new and healthy activities for old activities), and 5) reinforcement management (providing incentives or reinforcement for healthy activities).

In the game, information is provided to the players about pubertal changes, menstruation, maintenance of hygiene, HIV/AIDS, and other topics when they arrive at blocks leading them up the ladder or down the snake's tail. This information should help fill the current gaps in knowledge that adolescent girls have, and eliminate their myths and misconceptions. Questions have been added to prevent the passive reception of information and to involve the user in an active dialogue. For a sustained attitude change, conscious processing of information is very effective (Petty & Cacioppo, 1986). Thus, active participation is an application of the construct of consciousness raising. In addition, counter-conditioning is done by providing players with alternatives to their current choices of unhealthy and unhygienic practices. Throughout the game, the player is supposed to help Pinky, who assumes the role of another adolescent girl in her locality with her problems. By using her discretion, the player is supposed to

select the correct advice from several options. While doing so, the player also ends up re-evaluating her own behaviours and adopting healthier habits. This is the construct of self-re-evaluation. This game intentionally was designed to have multiple players, to encourage the sharing of knowledge and openness amongst the girls about these issues. Many questions also have to be answered after discussion with the other players. Therefore, interaction has been made mandatory, with the aim of encouraging discussion. The mobility of the game can be an important factor in stimulating discussions and using the tablet increases the likelihood of their occurrence. Through these features of the game, we try to integrate the construct of helping relationships. A player receives small rewards, such as climbing up the ladder and saving herself from the snake for answering a question correctly. When one player helps the other player, she is allowed to move forward a few spaces. For every correct answer, the system informs the players how they helped Pinky, and this information provides further reinforcement. The system also offers incentives, such as awarding free internet service (for a fixed limit on the players' tablet) if the player wins the game or gets her friends to start playing the game (This aspect of the game will be developed through collaboration with the government of Assam and telecom operators; it is currently a proposition). Such small incentives are expected to motivate the adolescents to play the game as much as possible and to bring in more of their friends to play it. We have employed these reinforcement techniques to sustain players' mediation through the stages of change.

The Health Belief Model highlights four perceptions, which determine the likelihood that a person will take steps to prevent an illness: 1) perceived susceptibility (the belief that he is vulnerable to the illness), 2) perceived severity (the belief that the effects of the illness will be severe), 3) perceived effectiveness (the belief that the preventative action will be effective in preventing the illness), and 4) perceived cost (the belief that the benefits of reducing the risk of illness outweigh the cost of

engaging in the preventative behaviour) (Redding et al., 2000). We have implemented the construct of perceived severity and perceived susceptibility by attempting to increase the players' awareness of the health consequences of their negligence. Perceived severity also increases through the mention of AIDS and its spread, especially amongst the young population.

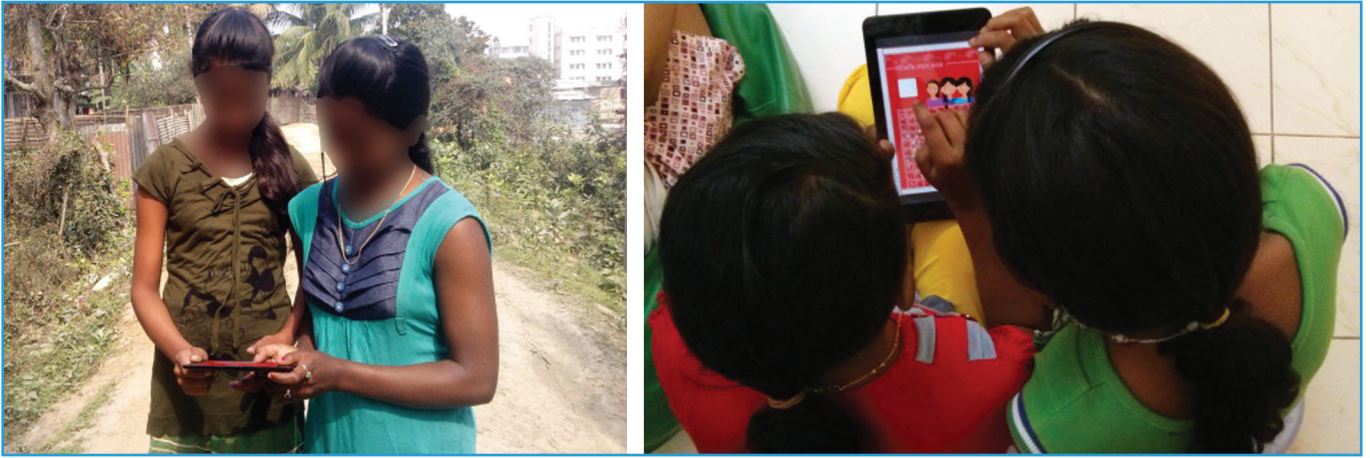
## 5.2 Cultural Relevance

By keeping in mind and subsequently reflecting a group's needs, behaviours, norms, practices, and beliefs, one can achieve cultural relevance, which increases the likelihood of an intervention being culturally meaningful to the target population (Williams et al., 2006). Williams et al. (2006) deem this point critical because if ignored, the technologies and programs might be unsuccessful in their attempts to persuade people. Therefore, in this game, we have tried to provide culturally relevant information. The overall aesthetics of the game also were designed with reference to the culture of Assam.

## 5.3 Designing Persuasion

Players need to be persuaded to adopt certain habits and change their attitude. In 'Help Pinky!', we apply two methods of persuasion that have been suggested by the socio-psychological persuasion research – Attitudinal Advocacy and Issue Framing. Studies (Chaiken, Wood & Eagly, 1996) in attitudinal advocacy examine how an individual's opinion changes after engaging in any particular behaviour. Research suggests that a person eventually starts accepting or believing a fact after they begin to express vocal support for it. We try to employ this method through most, if not all of the game. We believe that the player in the game, while advocating suggestions to Pinky, will start internalising them and adopting them in her own life. The prospect theory (Tversky & Kahneman, 1981) suggests that people's responses to a message are dependent on the way it is framed. To emphasise the benefits of a behaviour, 'gain-framed' messages, (i.e. those framed to include the gains associated with the





**Figure 3** A glance at the pilot testing

behaviour) should be used, whereas loss-framed messages should be used to highlight the potential costs of not engaging in a particular behaviour. In our game, the information is framed with this theory in mind. For example, gain-framed messages are used to promote the behaviours that we want the player to adopt (e.g. eating iron-rich food to maintain haemoglobin levels).

## 6 Pilot Testing

A small pilot test was conducted with 6 girls (two at a time) in the Amingaon region in Guwahati. The aim of this study was to elicit their initial feedback on the game and its importance to them as an information source. After they were briefed about the purpose of the game, they were given a tablet and introduced to the interaction of tapping through a test application built specifically for this purpose. After they were comfortable with the mechanics of the game, they received the application and were asked to play the game together. There was minimal intervention from the moderator during the game. After the game, a semi-structured interview was conducted with both of the users together. At first, the participants were shy due to the content of the game and were a little hesitant. However, they gradually developed interest and were engaged in playing the game. They participated in active discussions with the other player and answered the questions in the game. During the interview, they asserted that they were unaware of the information that was provided as part of the game, and that they never went to their

friends or mother to ask questions. They mentioned that they also learned from the other player through the discussions they had in order to answer the questions. They expressed their desire to play again. Some of the participants' mothers and aunts also inquired about the game and showed interest in it. Overall, we received very positive feedback.

This study was a small pilot test to gather some feedback from the users. A full-fledged longitudinal study is being planned to assess the effects of the game on the users and to examine whether learning and behaviour changes will occur.

## 7 Conclusion

Design Interventions are required for particularly sensitive issues such as menstrual health in rural areas. Due to the sensitive nature of the topic, these interventions should be designed very carefully. Based on the example of our game, 'Help Pinky!', we have outlined a few recommendations for designing such interventions.

## 8 Future Work

The game should be tested extensively with its users to ensure its effectiveness. Therefore, the next step in the research process should be to conduct a longitudinal study with the adolescent girls of rural Assam to analyse the effects of the game. The next step is to expand the game to include more than two players at a time, and add more information.

The game also can be expanded to include different types of players apart from friends, parents, and teachers.

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Empowering an entire population to participate in preventive healthcare by using voice analysis to quantify stress

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# Empowering an entire population to participate in preventive healthcare by using voice analysis to quantify stress



## Abstract:

Innovations directed at promoting stress awareness has generally remained restricted to expensive smart phones apps that are typically inaccessible to most Indians. This study was conducted to determine if voice attributes could be used to determine the stress levels in the human body, and thus, offer a measure of stress easily accessible on any type of mobile telephone. Voice samples collected from the study's participants correlated with their blood cortisol levels, which have been established clinically as a reliable indicator of stress. This finding provides preliminary evidence for the application of voice-based stress measures as part of an overall program of stress reduction. This voice-based measure of stress consists of an index of voice attributes of varying weightage that measure stress. These weightages were arrived at using the line of best fit.

**Keywords:** *stress, measurement, voice-analysis, quantification, scale*

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## 1 Introduction

Currently, non-intrusive methods of measuring stress in the human body are limited. However, numerous studies have noted that self-awareness of stress is linked to better outcomes and a tendency towards an overall reduction in stress (CESH, 2007).

Studies have reported that stress causes variations in voice output (Grossman, Nieman, Schmidt, & Walach, 2004) across different environmental conditions. Our study aimed to compare an acceptable and clinically validated method of measuring stress—via blood cortisol levels—to a voice measure of stress designed in our laboratory. Cortisol is an established biomarker for stress. The body is designed to respond to stressful situations by releasing cortisol. Hence, cortisol is an ideal benchmark for comparing a new method of quantifying stress (Sapolsky, 1994; Talbott, 2007). Our hypothesis was that a combination of voice attributes would correlate with blood cortisol levels.

### 1.1 How does the stressMobile tool serve empowerment through design?

The World Health Organization and the United Nations clearly state that the first step in the management of stress is to create an awareness of it. An awareness of stress typically remains in our subconscious unless some measure of it is performed periodically that brings it into our awareness. Our measure of stress, i.e. the stressMobile instrument, was designed to be convenient, within an arm's length, ubiquitous, instantly available, and able to provide quick feedback, similar to measures of temperature and blood pressure.

In addition, we offered short-term (instant) methods of reducing stress that also were enabled over the mobile phone. After using a stress reduction method, customers could measure the outcome of the stress reduction method, immediately and once again, receive 'instant' feedback. The stress reduction methods and instant feedback features



not only provided added credibility to the stress measure but it also offered ways for individuals to alleviate their stress.

Stress measurement for the masses means preventive healthcare. Chronic stress causes or contributes to life-threatening diseases, and we have sophisticated equipment and metrics to tell you what is wrong with you, should you receive bad news about your health. However, we do not have easy or immediate and non-intrusive methods to measure your stress.

Voice activated commands are common in phones today, but they do no more than obey commands. A preventive tool to empower users with information – both immediate and historical – about their stress levels is a sure-fire way to empower the masses. It also can help to build a case for a preventive approach to healthcare, which has operated in the reactive mode for the most part. A major problem with the average human is the tendency to avoid acting on health concerns until a number is placed in front of them. A blood pressure (BP) exceeding 120/80 is an unacceptable reading. Likewise, a

pulse rate above 72 beats a minute also is cause for concern. Because stress eventually leads to cardiac and BP problems, a measure of it is needed to ‘stop people in their tracks’ so to speak, and direct their attention to their lifestyles. Today, we tend to abuse our bodies by sheer neglect. You may be a teetotaler and a non-smoker. However, stress stemming from work schedules, poor fitness, poor sleep patterns, or poor diet can ruin your health. This study was designed to develop a proprietary algorithm placing the power to manage individual stress levels in the hands of the common man. (Feature phones are sufficient for use of the stress Mobile; smart phones are not needed), as used in other studies that have established the voice-stress correlation (Rabbi et al., 2012).

## 2 Method

### 2.1 Participants

Volunteers for the study were recruited amongst a group of working professionals. The majority of the volunteers were from the software services industry. There were no inclusion criteria for

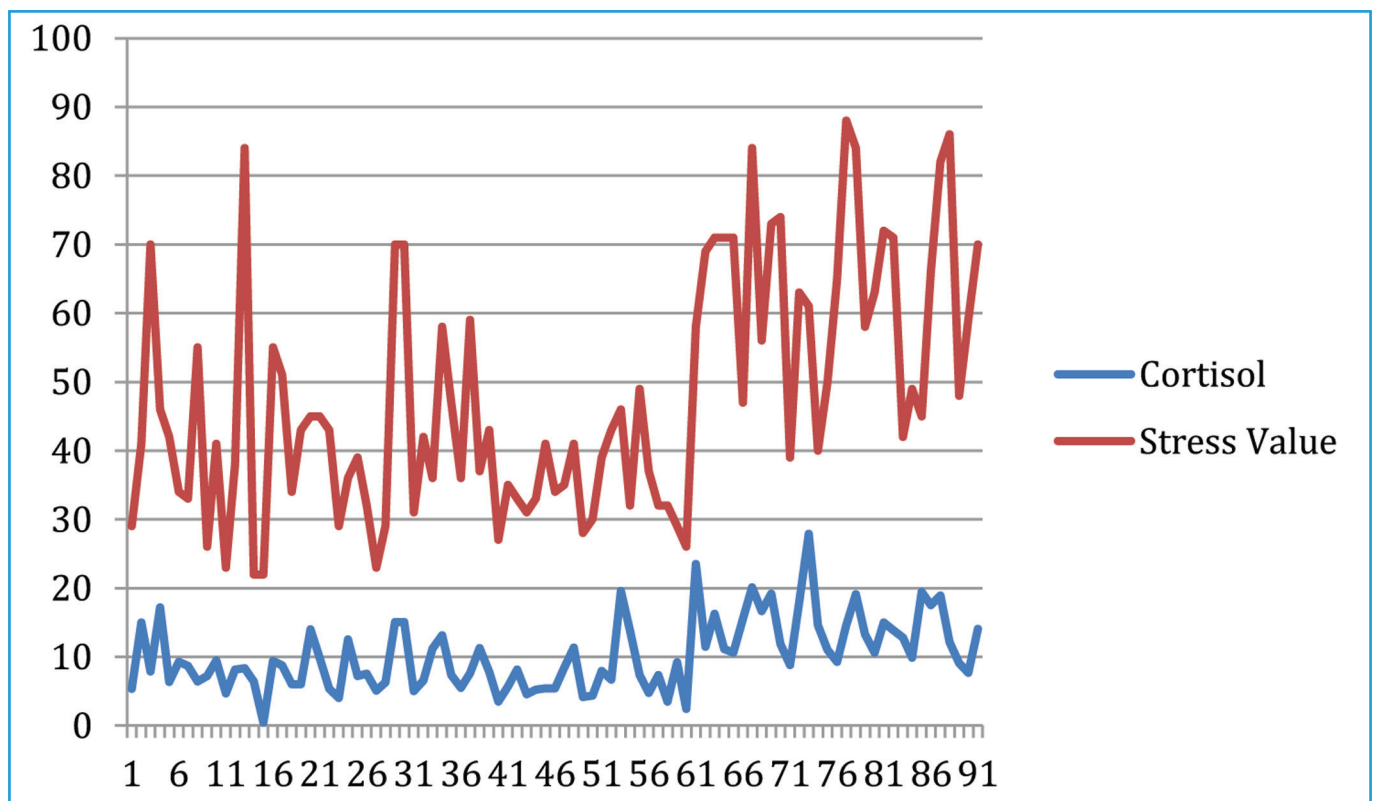


Figure 1 Stress value vs Cortisol (voice analysis)

gender, age, or other demographic characteristics. Generally healthy males constituted the majority of participants in this sample, with a total sample size of 91 participants.

## 2.2 Procedure

Sixty participants were tested between 3:30 pm to 5:00 pm across 3 different days, and 31 participants were tested between 8 am to 10 am on the fourth day. All participants had their BP levels, body temperature, and pulse rates recorded, and consented to have their blood drawn to measure their cortisol levels. After these measures were taken, they telephoned a specific phone number to leave a recording of their voice by reading aloud a prepared paragraph. The entire exercise took approximately 10 to 12 minutes for each participant.

## 2.3 Measures:

At least 27 voice attributes were extracted through digital signal processing of the voice samples. The attributes were compared and a score was arrived at using our algorithm that searched for indicators of stress levels in the body. The attributes that were identified were *pitch variance*, *energy variance*, *spectral slope*, *f0 mean*, *jitter*, and *loudness*.

## 3 Results

In the first iteration, when equal weightage was assigned to all of the voice attributes, a marginal but not significant correlation was found between the attributes and the blood cortisol levels. Even with these readings, the correlations between the cortisol levels and other physiological measures were very low. However, when the weightages assigned to the selected attributes were varied, a statistically significant correlation with cortisol was found ( $r = .75$ ). An index was developed to measure stress using the varying weightages of the following voice attributes: *pitch variance and spectral slope*, *energy variance*, *f0 mean*, and *jitter*.

Although the algorithm in its entirety is proprietary and is patent-pending, a sample of the weightages

assigned to the selected attributes is provided below:

(Intercept)	8.98467
Energy_Mean_Value_Joule_m2	0.31878
F0_Slope_Value_in_Hz	0.00148
Intensity_Mean_Value_in_dB	-0.08746
Kurtosis_Value	-0.02596
Voiced_Breaks_Value_in_Percent	-2.65034

## 4 Discussion

Preliminary evidence suggests that the laboratory-designed voice measures of stress comprising an index of voice attributes of varying weightage may be a valid and non-intrusive way of measuring stress at a given moment. With different weightages assigned to selected attributes of voice, rank correlations with blood cortisol levels were as high as 0.70, suggesting a high correlation between the gold-standard physiological measure of stress (i.e. cortisol levels) and the voice measure of stress designed in our laboratory.

A major outcome of this study is that unlike other techniques of measuring stress that are available to psychologists on the Web, this one does not depend on the individual's perception of his or her own stress levels, nor does it depend purely on event-based indicators that many tools use, for example, bereavement, empty-nest syndrome, and recent health problems. Different people have different reactions to the same source of stress. The assignment of the same weightage without considering the nature of the person may promote a 'one-size-fits-all' approach to this measure. Our study does not depend on any of these measures or the individuals' perceptions of their stress levels. It used a biological measure that is globally accepted as the best known bio-marker for stress as a benchmark to develop a tool that is cheap, widely available (at least 600 million mobile phone users can access this information in India), and sets a standard of preventive healthcare that others in this field have yet to establish.

A major question that arises from our results is why similar correlations between the voice scores and the other physiological measures, such as blood pressure were not observed. This finding could be due to the study sample, which consisted of predominantly young people. Chronic stress is not common in this age group and it is possible that these participants have not had the opportunity to experience sustained high levels of cortisol. Another possibility is that voice measures of temporary changes in stress are mirrored rather quickly in blood cortisol levels but not as quickly in blood pressure.

Since the intent of this pilot study was to examine a concept, the authors used a single-administration of the newly designed voice test. It also is possible that the standardised acoustical environment in which the testing took place removed the usually prevalent confounding factors. External acoustics in real-world situations would interfere with the readings

#### 4.1 Details of the existing service

The stressMobile tool is an existing, patent-pending service available as a call-in facility. A user dials in, leaves a voice mail in the form of answers to questions through an interactive voice response service (IVRS), and receives a message through short messaging service (SMS) with a stress score in a matter of minutes after the call ends. There is no hardware design or device available to the user. The proprietary algorithm is at the back end of the providers' server while the end-user equipment is merely his or her mobile phone. Currently, the service is available in English and shortly will be made available in Hindi and four South Indian languages.

This study was conducted with participants from the working group since the objective was to establish a link between voice measures and cortisol levels. To test this relationship, a random sample of

participants (with the exception of those who were otherwise healthy) was used for the study.

The authors believe that the design is user-friendly and interactive since all it takes to measure one's stress is to dial a number, leave a voice mail, and receive an SMS with a stress score almost immediately. We believe that this level of simplification will help the service reach the masses. This is only a pilot study and this group of authors is planning multiple studies, including stress inducement, as well as intervention with larger sample sizes.

### Acknowledgements

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paper

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## Development of Self-Defence Devices for Women

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## Abstract:

This research analyses the situations faced by women in India that can lead to physical and sexual assault (groping, rape, stalking, and other forms of physical violence) and investigates the physical features of a self defence device that can deter these attacks. A review of the available self defence devices, including those available in the US and Indian markets, highlighted the absence of any handheld and easily reachable portable device that could effectively deter or protect the person from sexual and physical attacks. For example, pepper sprays inside a handbag are difficult to access under distress/emergency. Designers of the devices on the market have not yet adequately understood and responded to the complexity of physical and sexual assaults on women. For this paper, 364 women were surveyed to explore the complexities: the context of the crime, reaction mechanism of the victim, avenues for deterring attacks, and access to safety/help. The possible design features which emerged from our survey results are loud alarms; help-beacons/signals that could be integrated with a deterrent (immobilisers like chemicals or electric shocks) to provide a larger window of opportunity to escape; something that can be used to call for help, preferably that can be integrated as a single wearable device (e.g. watch, bracelet, locket, footwear, belt, mobile apps, and handbags); or a combination of multiple devices. These results support the need for developing a self-defence safety device for women.

**Keywords:** women; safety, self defence; device; design features

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## 1 Introduction:

The increased rate in sex crimes against women in India is alarming. The most recent and much talked about Delhi gang-rape case is one of the many brutal and disturbing incidents which drew our attention towards the necessity of safety devices for women in India.

The research deals with the development of a self-defence device for working women which will protect them and give them a better chance of defending against sexual assaults such as groping,

molestation, and rape. The crimes against women in India have been rapidly increasing, and the response from the law is deteriorating day-by-day. Thus, the safety and security environment for women in India presents a grim scenario requiring immediate attention. Table 1 provides the details of the crimes against women in India. Most of the reported cases suggest that the problem occurs mainly because of the criminal instincts in the minds of frustrated youth, poor personality development, and a difficult social background. The attitude towards woman is made worse by the objectification of women in the media, film, and fashion industries. The lack of strict

laws and poor implementation of existing laws for the safety of women are other issues which need immediate attention.

An extensive market survey of existing products and patents classified these devices into six categories, as follows:

- **Mobile apps:** The mobile apps generally inform others of help needed in a distress situation.
- **Pepper sprays** (different shapes and sizes): Pepper spray is the most commonly used products. It comes in various sizes, shapes, and colours. Some of the products are disguised in the form of lipstick, key rings, etc.
- **Chemical-based devices** (e.g. dye-based, gas-based): Chemical-based devices are used for assailant marking and tagging. Some of them are gas-based systems which are used to irritate the assaulter.
- **Electric shock-based devices** (e.g. stun guns, tasers, etc.): Electric shock devices generally stun the assaulter. Police officers may use such devices to cause neuromuscular incapacitation.
- **Weapons and firearms** (knives, cutters, guns): These are an extremely dangerous category of self defence devices with high chances of being used on the victim herself. These are difficult to carry, especially in public transport and other public places.
- **Concealed devices** (e.g. lingerie, shoes with GPS, etc.): These are a category of disguised devices that may be in the form of rings, shoes, lingerie, etc. These devices are integrated with

**Table 1 Incidence of Crimes Committed Against Women During 2012**

Sl. No.	State/UT	Female Population* (in lakhs)	Rape* (Sec. 376 IPC)			Kidnapping & Abduction (Sec.363-369,371-373 IPC)*		
			I	R	P	I	R	P
1	ANDHRA PRADESH	426.49	1341	3.14	5.38	1403	3.29	3.67
2	ARUNACHAL PRADESH	5.97	46	7.71	0.18	58	9.72	0.15
3	ASSAM	151.26	1716	11.34	6.89	3360	22.21	8.78
4	BIHAR	479.59	927	1.93	3.72	3789	7.90	9.90
5	CHHATTISGARH	122.99	1034	8.41	4.15	350	2.85	0.91
6	GOA	8.69	55	6.33	0.22	16	1.84	0.04
7	GUJARAT	284.75	473	1.66	1.90	1527	5.36	3.99
8	HARYANA	119.3	668	5.60	2.68	900	7.54	2.35
9	HIMACHAL PRADESH	33.61	183	5.44	0.73	152	4.52	0.40
10	JAMMU & KASHMIR	56.79	303	5.34	1.22	1041	18.33	2.72
11	JHARKHAND	155.58	812	5.22	3.26	786	5.05	2.05
12	KARNATAKA	296.86	621	2.09	2.49	1070	3.60	2.80
13	KERALA	178.57	1019	5.71	4.09	214	1.20	0.56
14	MADHYA PRADESH	352.52	3425	9.72	13.74	1127	3.20	2.95
15	MAHARASHTRA	547.55	1839	3.36	7.38	1140	2.08	2.98
16	MANIPUR	12.34	63	5.11	0.25	133	10.78	0.35
17	MEGHALAYA	13.16	164	12.46	0.66	24	1.82	0.06
18	MIZORAM	4.95	103	20.81	0.41	3	0.61	0.01
19	NAGALAND	10.86	21	1.93	0.08	10	0.92	0.03
20	ODISHA	203.92	1458	7.15	5.85	1364	6.69	3.56
21	PUNJAB	129.63	680	5.25	2.73	689	5.32	1.80
22	RAJASTHAN	331.07	2049	6.19	8.22	2697	8.15	7.05
23	SIKKIM	2.92	34	11.64	0.14	10	3.42	0.03
24	TAMIL NADU	338.81	737	2.18	2.96	1693	5.00	4.42
25	TRIPURA	17.93	229	12.77	0.92	114	6.36	0.30
26	UTTAR PRADESH	971.76	1963	2.02	7.88	7910	8.14	20.67
27	UTTARAKHAND	49.62	148	2.98	0.59	256	5.16	0.67
28	WEST BENGAL	440.15	2046	4.65	8.21	4168	9.47	10.89
	<b>TOTAL (STATES)</b>	<b>5747.64</b>	<b>24157</b>	<b>4.20</b>	<b>96.93</b>	<b>36004</b>	<b>6.26</b>	<b>94.10</b>

\* I - Incidence R – Rate of Crime; P – Percentage share

Source: National Bureau of Crime Records (n.d.)

**Table 2 Analysis of existing devices and designs**

Category	Strengths	Weaknesses
1. Mobile apps	Informs of help needed	No active resistance
2. Pepper sprays	Instant use	Taking out and pointing
3. Chemical based devices	Chance to escape	Highly controlled/restricted
4. Electro-shock devices	Highly effective	Dangerous and restricted
5. Concealed devices	Innovative and disguised	Untested and unavailable in the market

normal daily use accessories to hide them from attackers.

Each of these designs has certain features and many gaps that restrict its effectiveness to a large extent. Mobile apps merely inform the friends and family, but do not provide instant support to the victim. Pepper sprays are difficult to use, and the victim has to point and shoot at the attacker. Moreover, the chances of misuse or use of the device on the victim herself is very high. Because chemical-based devices have poisonous chemicals, the sale and production of these are generally highly controlled and restricted, which makes the products difficult to buy and sell.

Electric shock-based devices can have battery problems and can shock the user, too. Concealed devices are the most innovative category of self-defence devices. The main problem is that many of them are untested and are not available in the market.

## 2 Circumstances of physical attack on women: A review

Approximately 80% of reported rapes are committed by unarmed assailants through physical force, coercive power, and intimidation (U.S. Bureau of Justice Statistics, 1988). People who believe they cannot manage such threats experience high levels of anxiety, which also distresses them, constraining and impairing their level of functioning (Beck, Emery, & Greenberg, 1985; Lazarus & Folkman, 1984; Meichenbaum, 1977). Perceived coping inefficacy is accompanied by high levels of subjective distress, autonomic arousal, and plasma catecholamine secretion (Bandura, Reese, & Adams, 1982; Bandura, Taylor, Williams, Mefford, & Barchas, 1985).

Hursch (1977) concluded that in most successful instances of resistance, the resistance was immediate. Methods of successful resistance included fighting (45%), screaming (24%), running (10%), and talking (10%), the remainder being either interruption by another person or unknown methods (12%). Quinsey and Upfold (1985) found that women untrained in physical self-defence terminate about half of the attempted assaults if they resist verbally and scream for help. Of the few who resisted physically, all escaped being raped without increasing injury. Thus, resistance early in an attempted sexual assault can decrease the likelihood that the assault will be completed and it does not increase the risk of escalating injury. In comparing the resistance efforts of raped women with those who had escaped being raped, Bart and O'Brien (1984) reported that screaming, combined with physical resistance, was the modal strategy for women who escaped sexual assault.

General risk factors and characteristics for rapists include male predominance, young adult age, low socioeconomic status, low educational level, unstable employment history at unskilled jobs, and prior criminal history. Approximately half of incarcerated rapists are rearrested within three years for a sexual offense or other crime (Ahlmeyer et al., 2003; Amir, 1971; Bard et al., 1987; Craissati, 2005; Dickey et al., 2002; Gannon et al., 2008; Grubin & Gunn, 1990; Polaschek et al., 1997; Scully, 1990; Segal & Marshall, 1985; Stermac & Quinsey, 1986; Walters, 1987). Although they are not usually as young as their victims, rapists are often young males, with 46% being under age 25, 17% under age 18, and 15% under age 15 (Gannon et al., 2008). The criminal histories of rapists tend to be diverse and generalised, and typically include theft, burglary,

assault, and drug-related offenses, in addition to sex crimes. When they recidivate, rapists are just as likely to reoffend violently as sexually. Thus, it appears that for most rapists, their violent sexuality is a feature of their overall violent antisocial lifestyle (Elliott, 1994; Gannon et al., 2008; Hanson & Bussiere, 1998; Hunter et al., 2000; Lalumiere et al., 2005; Looman et al., 2004; Miller, 2013; Quinsey et al., 2005; Simon, 2000; Smallbone et al., 2003).

### 3 Methodology of investigation

We conducted an online survey, addressing issues pertaining to the safety and security environment for women and the various devices and methods deployed in case of a physical and sexual attack. The survey comprised 20 questions especially designed for better understanding the needs of women in India across various class, age, and social backgrounds. A four-step process was followed:

1. Expert opinions and interviews were taken from psychologists, trauma specialists, medical practitioners, police personnel, and other people who work with such cases in order to understand victim psychology (for example, reaction time, state of mind, and perception of attack) and patterns in types of assaulters (for example, background and inclination to attack). Data were also used from the Bangalore police headquarters and Vanitha Sahaya-Vani (a women's helpline).
2. Based on information derived from the above, two workshops were conducted with women in order to understand what features would be critical for them if attacked.
3. Using the feedback from steps 1 and 2, we identified 19 questions, multiple choice as well as descriptive, according to the following parameters:
  - Age
  - Work timings
  - Frequency of going out
  - Time of attack
  - Preference of company
  - Mode of transportation

- Accessories
- Use of existing self defence devices
- Price of product
- Control and effectiveness of product

The questionnaire was hosted online, using social media, e-mails and standalone websites. A snapshot of the first part of the questionnaire is shown in Figure 1.

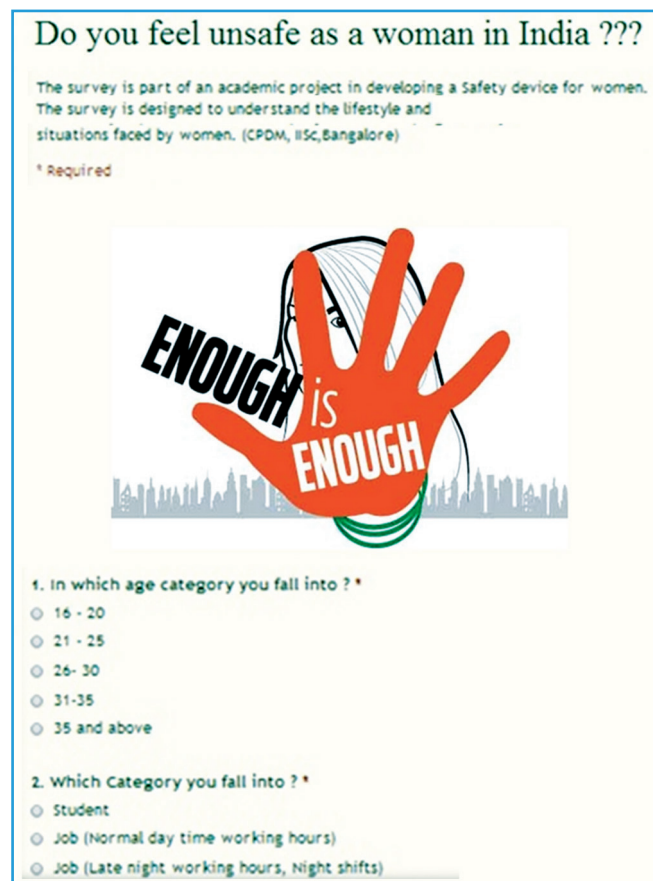


Figure 1 Snapshot of the beginning of the survey

4. Post data collection, a rigorous brainstorming session with 40 design students was conducted in order to identify the functions/devise features. Various Triz methodologies (Altshuller, 1946 cited in Barry et al., 2006) – namely, mind mapping, morphological analysis, lateral thinking, and rank ordering of criteria selections – were used for selecting the concepts.

The data was analysed using the Statistical Package for Social Sciences (SPSS) to understand the context and circumstances, explore the complexities of the context of crime, reaction mechanisms of the victim, avenues to deter attacks and access to safety/help. Triz methods

**Table 3 Morphological analysis of functions and alternate ideas**

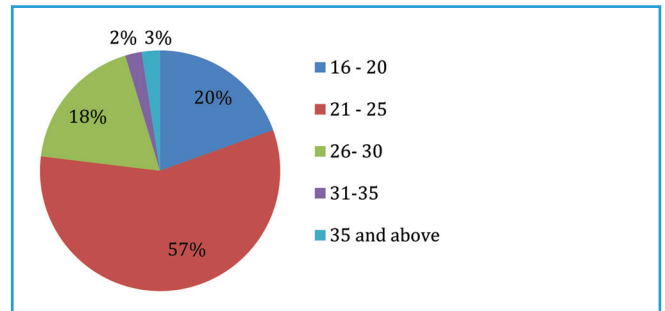
Function s		Alternate Ideas						
Alarm	Sound alarm	Light	Police siren	Whistle	Smoke	Vibration	Flag	
Defend/ shield	Camou-flage	Smoke emitting device	audio record	High Temperature	Call police	Fake call	Voice record	Monitor by device
Immobilise	Chemical spray	Chemical injection	Bad odour	Electric shock	Micro-needle	Fainting gas	Blast shield	Cover face with jelly
Counter-attack	Knife/ cutter	Tear gas	Taser	Hit groin	Chili powder	Biting gadget	Burning laser	Acid bulb
Inform	SMS	GPS tracker	GSM tracker	Wi-fi	Bluetooth	Auto call	Phone call	Internet

(Altshuller, 1946 cited in Barry et al., 2006) were used to arrive at main functions which were considered suitable for solving the existing problem. These functions were transformed into various ideas alternatives (i.e. potential solutions) through brainstorming and morphological analysis of various combinations of design concepts (see Table 4: Potential Options Emerging from the Morphological Analysis).

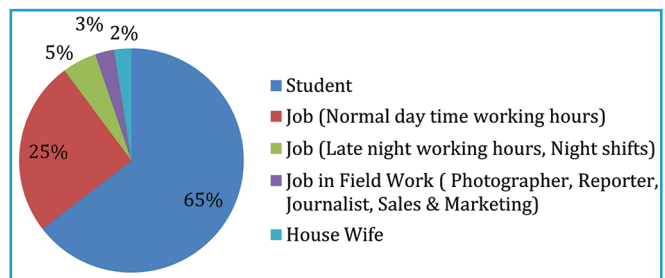
Further, we integrated the ideas to arrive at product level solutions which could fulfil all these functions together. The solution concepts generated were evaluated against each other with the help of rank-ordering the criteria of selection (Hazelrigg, 1996), which led to the selection of the most promising design concepts.

#### 4 Sample Characteristics

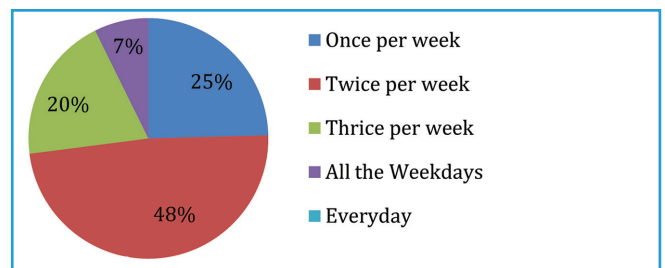
The SPSS analysis provided insight into the common user patterns and habits of the survey respondents. These were 364 women of various age-groups including students, housewives, and working women (including those who need to travel extensively as part of their job and those who tend to work late night shifts); of these, most were students and working professionals from all over India. The respondents also revealed the nature of harassment experienced in various travel scenarios. Further, the survey included instances of actual victims who have been stalked/ followed/ teased or attacked. The age of the respondents was between 16 and 45 years. Figures 2–5 show some of the sample characteristics of the respondents.



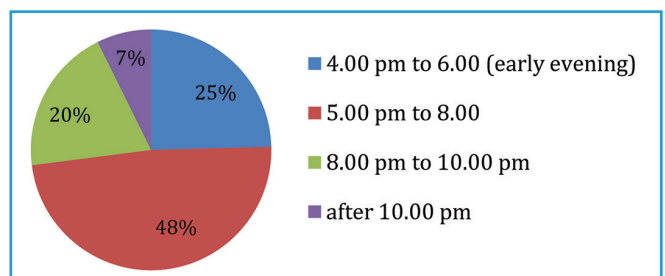
**Figure 2 Survey statistics - Age distribution**



**Figure 3 Survey statistics - Distribution of Occupation**



**Figure 4 Survey statistics - Frequency of going out**



**Figure 5 Survey statistics - Distribution of going out times**



## 5 Results

### Who is affected?

The analysis of data generated by SPSS software shows that students going to college or school (65%) and women taking private transport or lifts (48%) were the most vulnerable to incidents of assault. In addition to this, women returning from work (25%) and women using public transport (35%) were also often affected. Other reported incidents were from women in parking garages or bus stops and college girls living in dormitories.

### Where it is a problem?

The analysis shows that bus stops at night (16%), empty streets/roads (28.5%) and auto/bus waiting areas (26%) are the most vulnerable places. Other places with more than average vulnerability were railway stations (3.9%), poorly lit lanes or narrow streets (4%), empty housing, factories (1%), club/

party (2%), highways (1%) and offices (1%). Moreover, places with some occurrence of assaults were distant empty spaces on college campuses, deserted places, and parks.

### When it is a problem?

The times of most frequent occurrence are evenings (8pm-10pm; 87.1%) and late nights (after 10pm; 17.9%). Most of the cases occurred when women were travelling alone (5%).

Most of the affected people are Students going to school/College (65%) and Woman travelling in public (35%) and private transport (48%). Moreover, the places where the attacks took place were a) Auto/Bus/Railway stations (26%) b) Empty street (with insufficient lighting) (28.5%). In addition, 79% of the respondents commented that they have been in situations where they have been stalked/teased/followed/attacked Most of the attacks took place in the evening [6pm to 10 pm](87.1%)

**Table 4 Results of the survey**

No	Theme		% responses
1	Who is affected	College or other school students	65%
		Women taking private transport or lift	48%
		Women returning from work	25%
		Women using public transport	35%
2	Where it is a problem	Bus stops at nights	16%
		Empty streets/roads	28.5%
		Auto/bus stop	26%
		Railway stations	3.9%
		Less lit lane	(4%)
		Empty housing, factory	1%
		Club / party	2%
		Highways	1%
		Offices	1%
		3	When it is a problem
Late nights (after 10pm)	17.9%		
Travelling alone	5%		
4	Where defensive device should be incorporated	Handbags	19%
		Mobile	27%
		Watch	18%
		Bracelet	5%
		Shoes/Sandals	100%
		Jewellery	15%
		Lingerie	100%
		Garment	100%
Keychain	-		

**The functions identified to be incorporated in the device, therefore, are as follows:**

**Alarming:** Raising an audio alarm (of 120-130 decibels) – for example, beeping alarm or police siren.

**Defending/shielding:** Providing a means of defence in any threatening situation or attack. Giving victim enough time to escape the situation. For example, an auto SMS to the police with locations.

**Counterattacking/immobilizing:** Neutralizing any threatening situation or attack by counterattacking, which could result in immobilizing the attacker – e.g. laser, sharp edge, electro shock device.

Our data analysis indicated that the most used accessories/objects of daily use carried by most of the women were as follows: mobile, handbags, watch, bracelet, shoes, jewellery, lingerie, other garments, and keychain. The shoes/sandals, lingerie, and other garments (100%) were the most used accessories followed by mobile phones (27%), handbags (19%), watches (18%), bracelets (5%), and key chains.

**6 Discussion**

The results above reveal the need for a portable, handheld device to deter physical and sexual attacks on women. The device should be an integral part of the natural work flow for women so that it is not a hindrance to their daily chores. Moreover, the device has to be easily disguisable and usable under duress. The literature analysis suggests that

generally high levels of anxiety and distress impair victims’ levels of functioning, which in turn surprises and frightens them, making them more vulnerable (Emery & Greenberg, 1985; Lazarus & Folkman, 1984; Meichenbaum, 1977; Bandura et al.,1982;Bandura et al., 1985).

In addition to that, Hursch (1977) found that screaming, running, talking, and interruption from others were the most successful methods of resistance, but fighting, which was the most successful (45%) in that study, was found to be a less-used method owing to lack of self defence training. The background history of criminals, as analyzed with the help of statistical data from the NCRB (National Crime Records Bureau), suggests that mostly young males having lower education levels, poor social status, and unstable or no employment were more likely to indulge in such crimes. (Ahlmeyer et al., 2003; Amir, 1971; Bard et al., 1987; Craissati, 2005; Dickey et al., 2002; Gannon et al., 2008; Grubin & Gunn, 1990; Polaschek et al., 1997; Scully, 1990; Segal & Marshall, 1985; Stermac & Quinsey, 1986; Walters, 1987).

The possible opportunities which emerged, therefore, from our analysis were that functions like loud alarms and help beacons/signals could be integrated with a deterrent (immobilisers like chemicals, electric shocks) to provide a larger window of opportunity in which to escape and/or seek help. These features, in turn, preferably could be integrated in a single wearable device (e.g. watch, bracelet, locket, footwear, belt, mobile app, or handbag) or a combination of multiple devices.

**Table 5 Potential Options Emerging from the Morphological Analysis**

No.	Alarming	Defending	Immobilis-ing	Counter-Attacking	Informing	Where
1	Sound alarm +			Laser		Watch
2	Sound alarm +	High temperature				Sleeves
3	Sound alarm +	Call police +	Electric shock +		GPS/SMS	Watch
4	Sound alarm +	Call police +	Electric shock +		GPS/SMS	Watch/ handbag
5	Sound alarm +		Chemical spray+		GPS/SMS	Handbag
6	Sound alarm +	Smoke +			Cracker	Belt
7	Sound alarm +	Voice recording+	Electric shock+	Sharp edge +	GPS/SMS	Shoes
8		Needle +	Anaesthesia +		SMS	Hand band

The study clearly shows that many factors affect crime against women, demonstrating that only one function or feature would not be effective in all situations and with various user groups. Hence, the possible device should be a combination of the most effective and complementary functions or features. Table 4 lists the possible concepts that would fit our requirements. The device should fulfil such functions as alarming, defending, attacking, and Informing. For example, the first possible variation could be a sound alarm with an electric shock function and something that transmits location information to the police.

## 7 Conclusions: Effectiveness of a device

Our research attempts to understand what would be an effective device for women under physical assault. Several features emerge as critical. For example, informing and GPS tracking could help victims overcome their distress and anxiety by increasing feelings of security because they could have requested help as soon as they could sense that something was wrong. The device should also incorporate sound-making and help-seeking options because, as Hirsch (1977) concluded, screaming is helpful in successful resistance. Moreover, it could have an immobilizing/counterattacking option to assist the victim in fighting the attacker as fighting (45%) constituted the most successful resistances.

The various concepts can be further analysed based on the criteria given below, which were elicited in the survey:

- Technological Feasibility (62 responses)
- Effectiveness (Operation) (54 responses)
- Natural workflow of user (61 responses)
- Safety of user (22 responses)
- Aesthetics (17 responses)
- Wearable (16 responses)
- Disguisable (19 responses)

These concepts and their embodiments need to be rigorously tested for effectiveness. The need of real time testing and analysis is absolutely necessary, if such concepts are to be transformed into usable and revolutionary products. Such a product may be too

heavy after integration of all the desired technologies and systems; hence, it could be developed as a set of devices. Integration of technologies like laser, micro-needle patches, electric shock, and chemical injections should also be tested against ethical, legal and safety parameters.

In addition to the device, there is also an ever-increasing need for rapid improvements in the security infrastructure of our transport system. Street lighting and policing need enormous improvement. Considering the worsening conditions of law and order and the porous security infrastructure, however, it would be very time consuming to move ahead with such infrastructural solutions; hence, a technological solution in the form of a portable, wearable, and disguisable device could be a lifesaver to women.

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paper

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Height- and movement-correcting orthopaedic shoe-pad for people with impaired legs

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# Height- and movement-correcting orthopaedic shoe-pad for people with impaired legs



## Abstract:

The 'Height- and Movement-Correcting Orthopaedic Shoe-Pad' may offer the possibility of a daily life with socio-visual equality for the community of people with locomotor-related physical impairments. It can cover leg height and foot length differences of less than 15 mm each when physical development is otherwise normal. Initially, this project was initiated to provide a remedy for a physically challenged individual with 'post-polio with deformities of the right limbs with talipes equinovarus of the right ankle and foot' of a permanent nature. The research process was extended to provide a remedy for a broader population with similar permanent disabilities. Use of this product can offer ready-to-wear shoes with a flat shoe base. The aim of this project was to provide locomotion-impaired individuals with an opportunity to 'walk with a feeling of social equality'. This kit can be used by both men and women. The estimated product life in normal daily life conditions (i.e. smooth roads (Oxley, Charlton & Fildes, 2005) and normal Indian room temperature) is around 6–8 months. The estimated life of the material used is around 8–12 months. The estimated production cost is INR 12.9/unit. This product can be supplied as a packet of components along with a printed instruction chart for end users so that they can assemble the provided components themselves. It may also be assembled by an orthopaedic or rehabilitation agent or by a manufacturer to be supplied to the end user. The kit can be produced and forwarded for mass supply under both business-to-business and business-to-customer models.

**Keyword:** *design for locomotor impairment, social equality through design, design for sustainable wellbeing, one-leg-affected locomotor disability*

**Citation:** Jha, S. K., and Mishra, K. (2015). Height- and movement-correcting orthopaedic shoe-pad for people with impaired legs. In Mani, M., and Kandachar, P., *Design for Sustainable Well-being and Empowerment*, IISc Press and TU Delft, 437-450.

## 1 Introduction

In India, several girls remain unmarried due to minute locomotor impairments (Ellur, 2012). They might also face social avoidance and negligence as a result. We have seen several empty eyes in search of answers for their 'whys'. This was the primary inspiration of this project, which was a 'Do-It-Yourself' project. There was continued one-to-one interaction with the disabled individual throughout the research process.

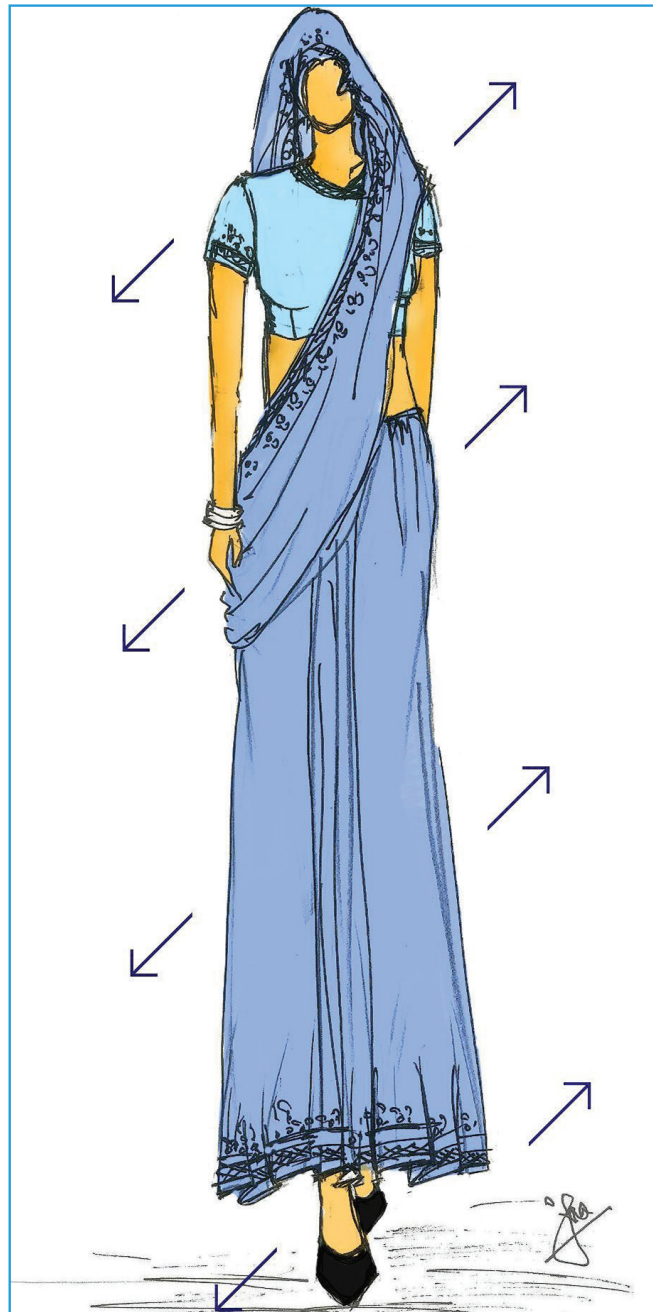
Thus, we focused on taking the initiative towards creating a barrier-free life for people

in need, which covers a range from 1% to 45% of disabilities under the 'one-leg category' of disability, and only covers temporary visual-physical corrections in locomotor height and movement correction to offer this community social equality with comfort.

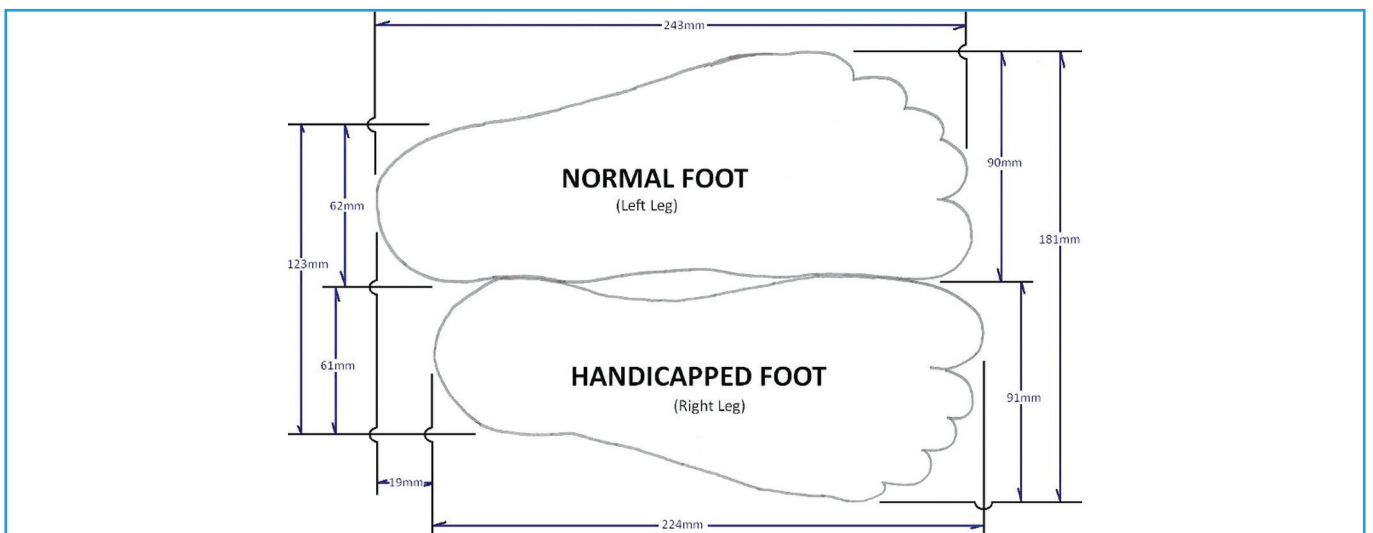
## 2 Part-I: Case Study

### 2.1. Patient Details

Patient (Burschka et al., 2012) details were catalogued in terms of their age, gender and type of disability as illustrated in the following table.



**Figure-1** A girl with an imbalanced walk on the street



**Figure-2** Difference in foot length

Age: 29 years  
Gender: Female  
Type of: Post-polio with deformities of the  
Disability right limb; talipes equinovarus of the right ankle and foot (Orthopaedic-OL Category) of a permanent nature.  
Occupation: Service

## 2.2. Disability Study

The patient's right leg was affected by polio about 2–3 years after birth, a condition identified as 'post-polio (PP) with deformities of right limb with talipes equinovarus (TEV) of the right ankle and foot', which is categorized under 'Orthopaedic-OL Category' of a permanent nature by a competent medical officer after proper examination (according to her Disability Certificate).

As observed, her left leg had normal functioning as well as muscle and bone development, as compared to normally developed individuals of her age group. Although she was able to complete her normal activities of daily living independently (i.e. without help of others or any accessories or external aids), she had an imbalanced walk.

### Primary Observations

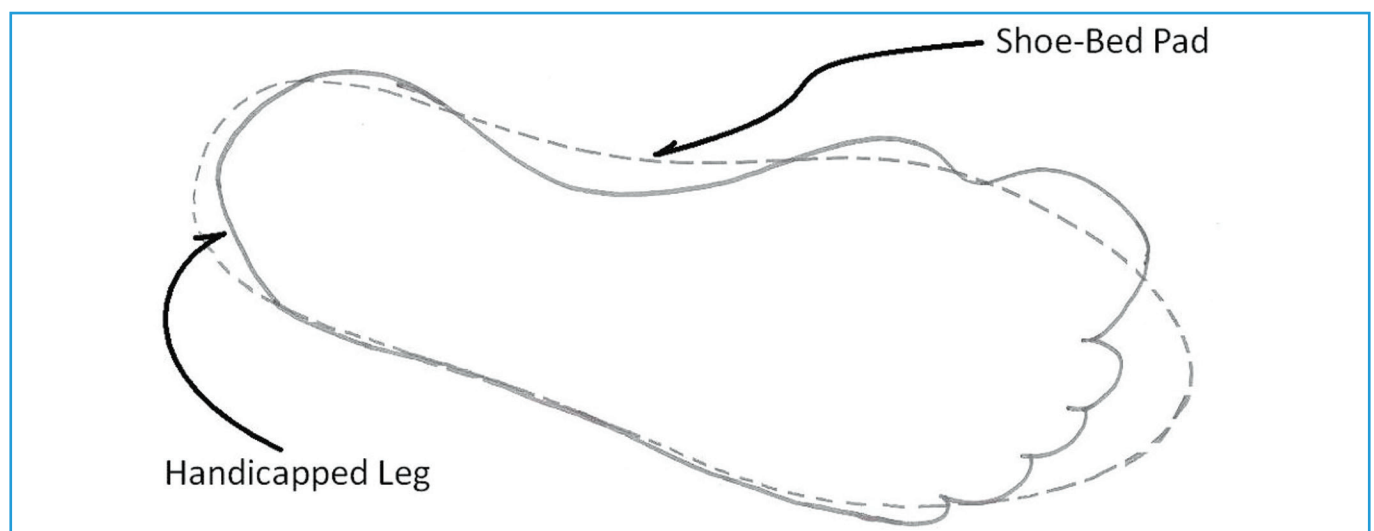
Because of the above issues, she has faced the following problems in daily life:

- Imbalanced walking and leaning on her left side, clearly visible from a distance due to the difference in height, thickness, and width between both her feet.
- Lack of grip in the right foot.
- Pain in the right knee and ankle.
- The right leg was weaker and thinner in dimensions as compared to the left leg (as specified above).
- Patient's inclination to use fancy shoes in daily life, as she was a working professional. She hesitated to wear traditional, unfashionable, user-specific orthopaedic shoes.
- The height difference between her two legs was 12 mm, the length difference between her two feet was 19 mm, and the mid curve of her handicapped leg was measured at 21 mm.

### Problem Statement and Identification of Path to a Solution

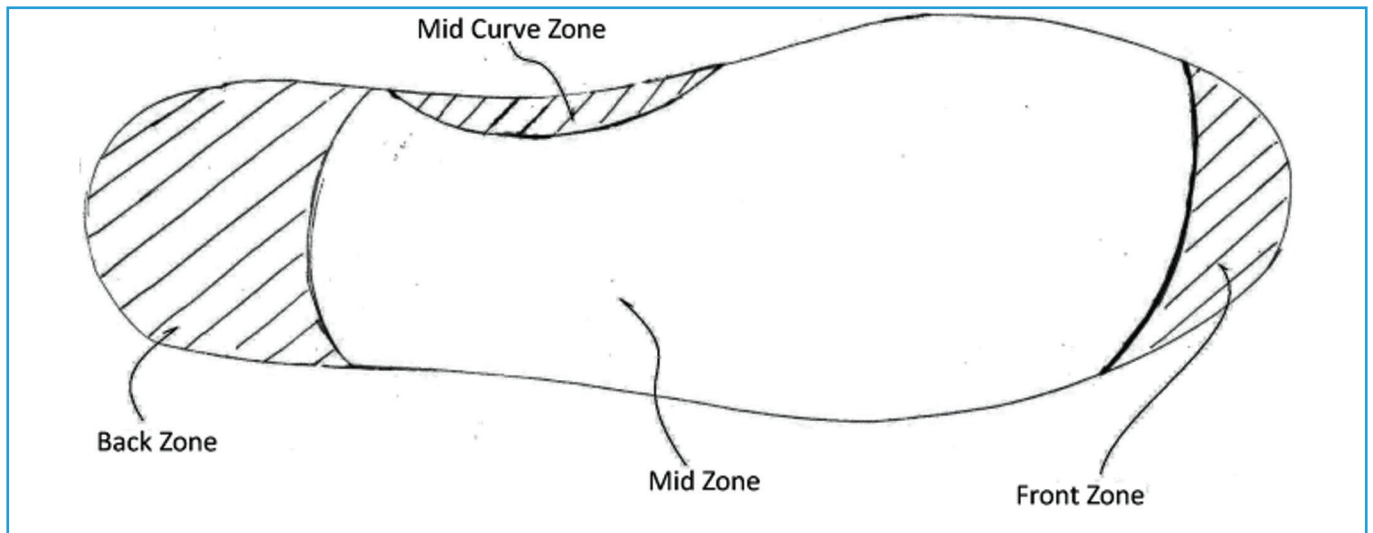
After studying and identifying the above problems, we came to understand that a shoe-pad with specific corrections may solve the issue. For this, we required to focus on internal bottom changes in a ready-to-wear standard pair of shoes available on the Indian footwear market.

The need for correction in the right foot was observed after comparison. Further, we received the marks of corrections over the shoe-bed pad



**Figure-3** Length and form difference between the shoe-bed pad of a normal foot and a handicapped foot





**Figure 4** Correction required zones identification

(dimensions found to be 5 ½”, OUN-1890 as per Footwear Design and Development Institute [FDDI] standards of foot-last). No bottom-line change was required for the left foot.

### 2.3.3. Identification of Shoe-Pad Zones for Further Development

The height had to be increased by 12 mm. The mid-curve zone and the front zone were to be increased diagonally along with the height. The back zones did not need to be worked on in this specific case. Further, we increased the height of both zones by 3 mm to control the movement of the handicapped foot inside the shoe cavity.

### 2.4. Primary Concept Development Phases

Phase-1: This phase included the problem study and primary documentation leading to the formulation

of ‘Problem Statement’. In this case it was found that the right leg was handicapped due to polio, and 45% of the problem was permanent as per the ‘Disability Certificate’ of the patient. The left leg was normal in function.

Phase-2: Here the patient’s foot deformity was traced over an old newspaper for further development (i.e. over a 2-D surface; Figure 6(a)), and then subsequently transferred to an A-4 sheet for further development. (Figure 6(b)).

Phase-3: This involves a market study of suitable existing women’s footwear. As foot 2 is shorter in length than foot 1 (Figures 5(a, b) and 6 (a, b)), there is a need to use a posterior shoe, which covers the top. This will allow it to look better when used (Figure 7 (a)). A comparative study is conducted of the shoe-bed of foot 1 with that of foot 2 (Figure 7 (b)).



**Figure-5** Foot length difference (study 1)

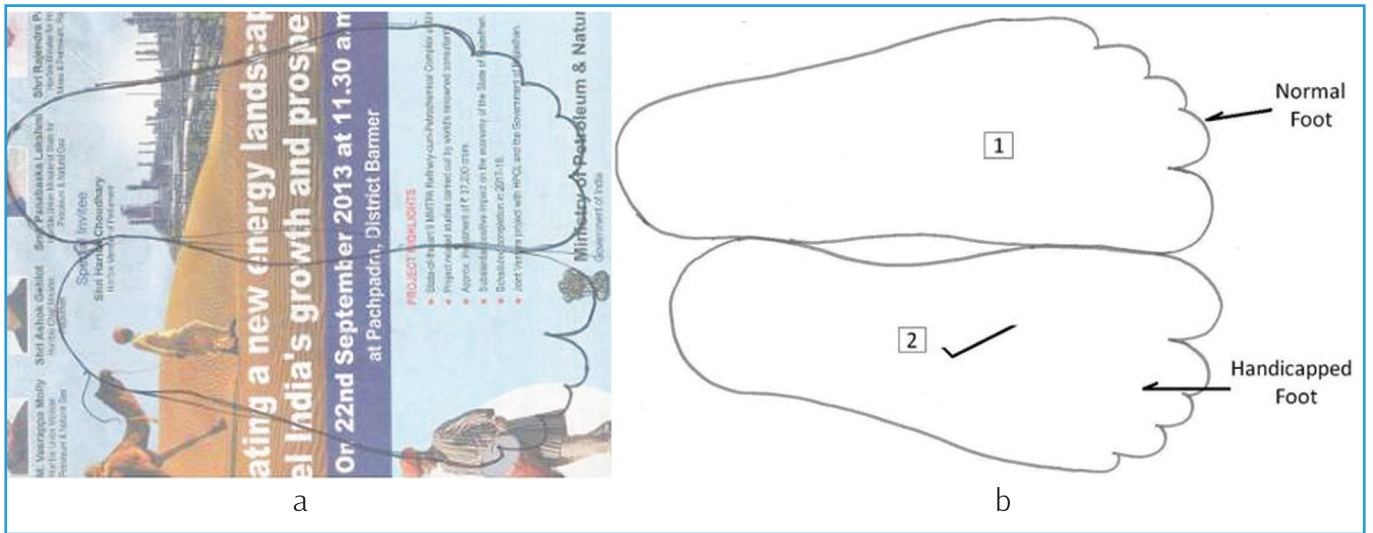


Figure 6 Foot length difference (study 2)



Figure 7 Foot length difference (study 3)

Subsequently, from existing shoe-beds in the women's market, the base was taken with reference to the unaffected leg. The need for listing of height was understood and the size was identified as  $5\frac{1}{2}$ ", OUN-1890, as per FDDI standards.

Phase-4: We then entered into the surface stress-management phase where we explored various

movements generated during use, and began the stress-management process for the top-sheet layer of the product. After these explorations, we realized that tessellation forms could work better for stress-control function as well as for simplification in the manufacturing process. For surface generation purposes, we focused on regular tessellations. We explored all three types of regular tessellations: (i)

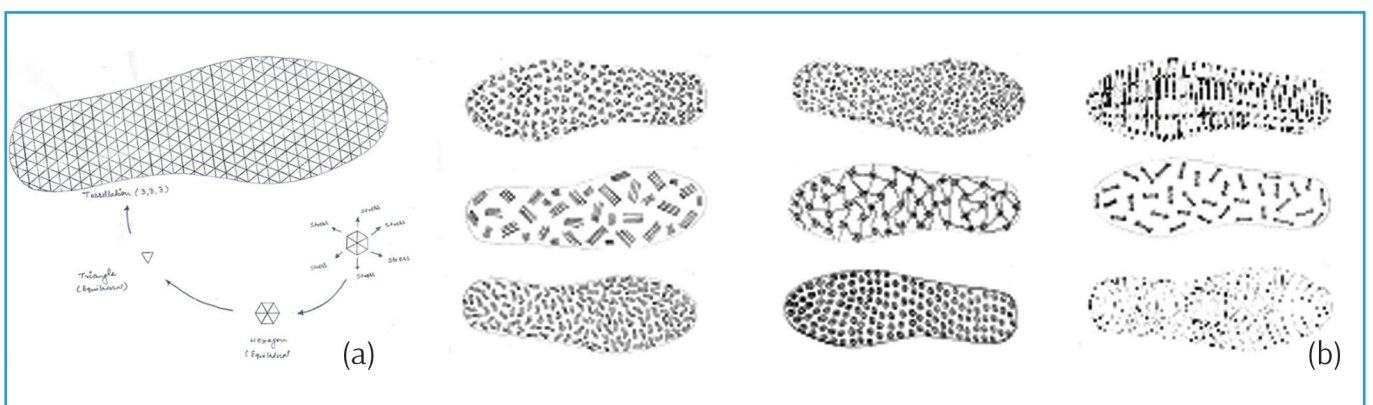


Figure-8 (a) Surface stress study, (b) Surface texture explorations

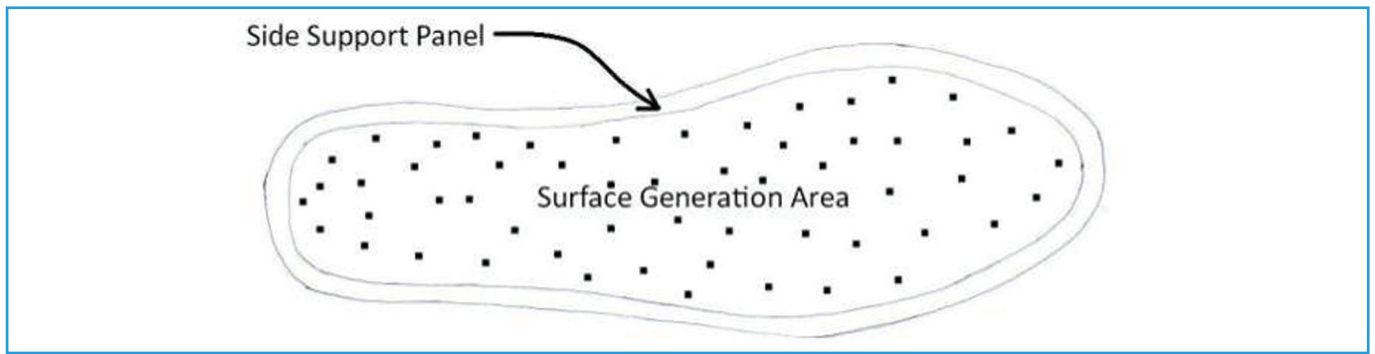


Figure-9 Side support panel

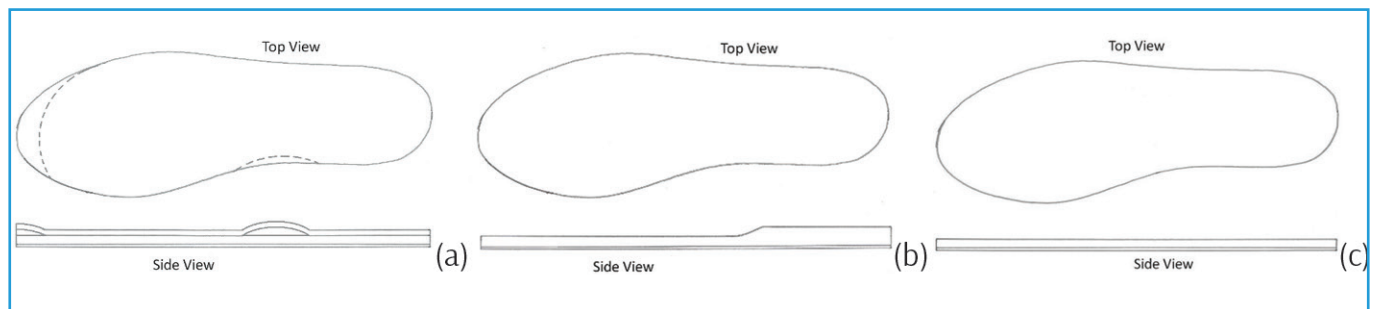


Figure-10 Top and side views of shoe-pad possibilities

$3^3$  (or  $3 \times 3 \times 3$ ), (ii)  $4^4$  ( $4 \times 4 \times 4 \times 4$ ), and (iii)  $6^6$  (or  $6 \times 6 \times 6 \times 6 \times 6 \times 6$ ). We also explored motion and stress-based curve surfaces in this phase of exploration.

Phase-5: During the last phase of the exploration, we also observed the need for a side support panel. This would provide additional strength for the generated surface, which is the major functional area of shoe-pad (Figure 9).

Phase-6: According to the specific requirements of this patient, we developed this form with consideration of height and surface management (Figure 10 (a)). As the problem persisted on both the horizontal and vertical axes of the affected leg, there was a need for a height-increasing segment (this option was developed as 'exploration-1' for generalized mass production; Figure 10 (b)). As the patient community with similar deformities does not essentially require a specific height rise, we reconsidered the flat surface as well (this option was developed as 'exploration-2' for mass production; Figure 10 (c)).

## 2.5. Observations

As the need for locomotor balance correction was

more important than the fashion statement, so we did not include any fashion trend-related forecasting during this concept development phase. These trends can, however, be followed as per specific requirements of end users. In such cases, pads can be designed as per ongoing fashion forecast trends.

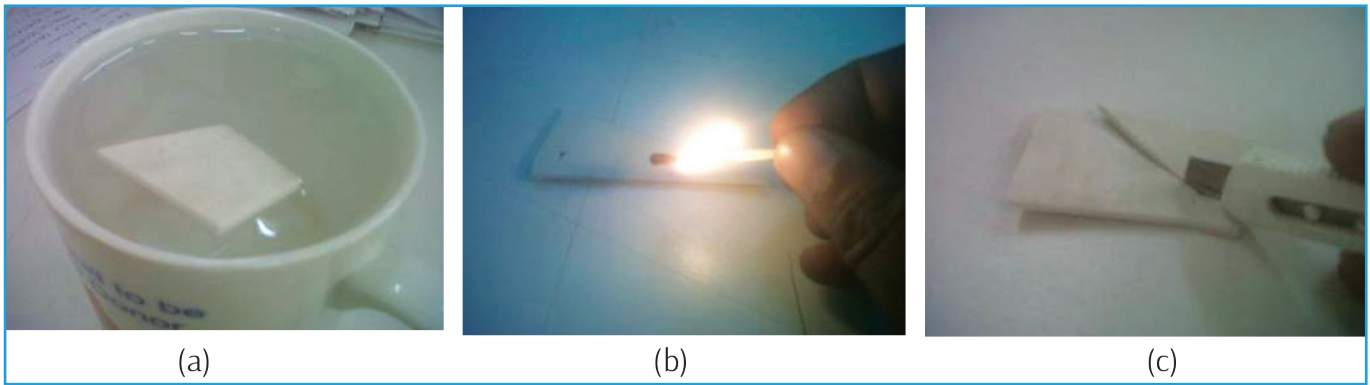
## 2.6. Materials Study and Tests

Eva sheet is a type of high-density foam material. The sheet used was 4 mm thick. It comes in various thicknesses in the market and is readily available at *Chowri Bazar* in New Delhi. It comes in rolled-sheet form as well as in the form of per-cut sheets of different specifications. Usually, these sheets are used by shoemakers to develop shoe-beds with additional support in combination with other materials, such as fabrics and canvas.

### Water-Resistivity Test

According to the primary studies and observations, the following results were received: (i) Not to be dipped in water, (ii) Not water-absorbent, (iii) Non-water-soluble, and (iv) Material volume is higher than drinking water at room temperature ( $\sim 10^\circ\text{C}$  to  $\sim 40^\circ\text{C}$ ; Figure 10(a)).





**Figure-11** Top and side views of shoe-pad possibilities

### Fire-Resistivity Test

- i. This material is fire-sensitive and becomes deformed when heated with fire, and
- ii. It produces a residue if caught on fire and leaves unpleasant odour (Figure 10(b)).

### Cutting- and Stress-Resistivity Test

- i. The sheet tears only if excessive stress is applied to the horizontal axis,
- ii. It is not fragile in nature,
- iii. It bounces back when thrown at hard surfaces, and it is elastic enough to be used as a shoe-pad or shoe-bed,
- iv. The sheet is easy to cut using a paper cutter by applying slightly more vertical force than would be necessary for 75 GSM A-4 paper, and
- v. It is easy to make punch holes in the material. After completion of this phase, we proceeded to the next phase of research and development (i.e. prototype development; Figure 10(c)).

## 2.7. Prototype Development Process

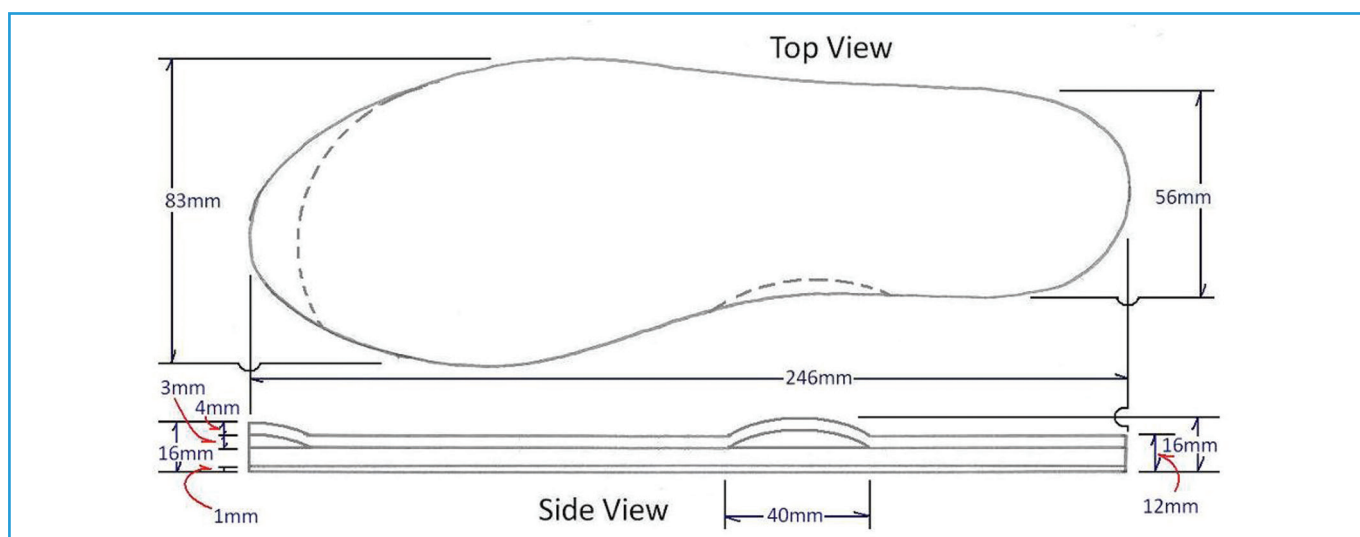
### The prototype development includes

- Identification of 5 ½", OUN-1890 of FDDI standard foot-last.
  - Development of sole mask using masking tape.
  - Transferred the sole mask to A-4 ivory sheet paper and drew outlines with pencil.
  - Cut the template at a 1:1 scale on the ivory sheet.
  - Transferred the proper drawing of the shoe-pad over Eva sheet (the primary raw material for prototype construction).
  - Primary form generated, with a flat surface, by providing it a height of 16 mm and
  - Compared the shoe size with the foot base frame in order to check if they were both in proper proportions.
  - Surface texture generation (based on stress test results). The findings of the texture-generation exploration were as follows:
    - o This surface was based on 3<sup>3</sup>, but also equally justified 6<sup>6</sup> regular 2-D geometric tessellation.
    - o This surface was based on 4<sup>4</sup>, but also justified 6<sup>6</sup> regular 2-D geometric tessellation.
    - o Based on curves with functional foot movement-generated stress.
  - Flexibility and material strength after texture-cut explorations.
- Observations: There was a need for canvas-like support between two surfaces of Eva sheet, as a sandwich placement. Alternatively, it could be affixed to the bottom surface of the orthopaedic shoe-pad in order to create flexibility and strength.

**Table** Cost sheet, Source: author generated

SN	Particulars	Rate/Unit (INR)	Units Used	Cost Involved/ Shoe-Pad (INR)
1.	Eva sheet	180	Per Sheet	5.6
2.	Canvas	80	Per Meter	0.4
3.	Neoprene	280	Per Kilogram	0.3
4.	Masking tape	60	25 Meters	2.4
Total Raw Materials and Depreciation Cost				8.7
5.	Labour cost (@ INR 250 for 8 hours/day, @ per day production capacity 100 units)	250	100	2.5
6.	Electricity (one fan + one bulb for 10 hours)	4.75	2	0.5
7.	Tools and machine depreciation @ 5% of raw materials	-	-	0.4
Total Production Cost Per Unit				12.1
8.	Packaging (@ 2% of total production cost)			0.2
Cost after Packaging				12.3
9.	Miscellaneous Expenditure/Overheads (@ 5% of total on-site price/unit)			0.6
Grand Total				12.9

E&OE



**Figure-12** Orthographic drawing of corrected orthopaedic shoe-pad (case study-based ready-to-wear shoe-pad)

## 2.8. Product Cost Sheet

The total production cost per unit of the 'Height- and Movement-Correcting Orthopaedic Shoe-Pad for Handicapped Persons (One Leg with up to 45% Polio-Led Deformity)', which may enable use of market-ready fancy shoes in daily life, was INR 12.9 when crafted by hand.

## 2.9. Final Drawings with Dimensions (with Height Management)

## 2.10. Product Placement, Use by the End User, and Observations

### 2.10.1. Observations

The patient found the shoe-pad quite comfortable on day 1 and enjoyed walking. However, the next morning, she reported pain (Nursing source center, 2010) in her right-side lumbar bone due to readjustment. This pain continued from day 2 through day 6 with increasing intensity. It gradually reduced from day 7 to day 12. From day 13 onwards, she felt no pain. She also felt the need to walk with balance by following her normal left leg. As she reported, she could then achieve this balance through regular practice.





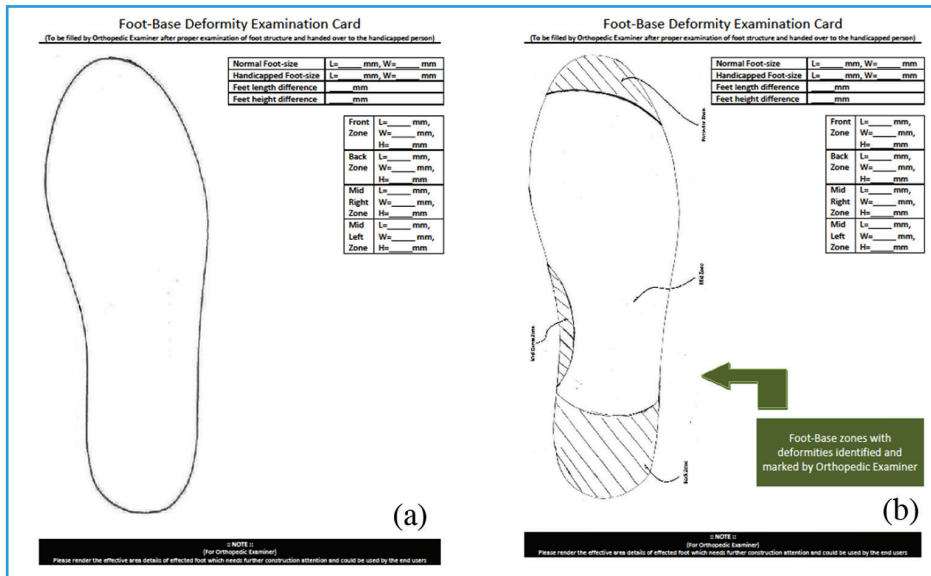
**Figure-13** Visual flow chart for an orthographic drawing of corrected orthopaedic shoe-pad (case study-based ready-to-wear shoe-pad)

### 3 Part-II: Further Extension of the Primary Concept

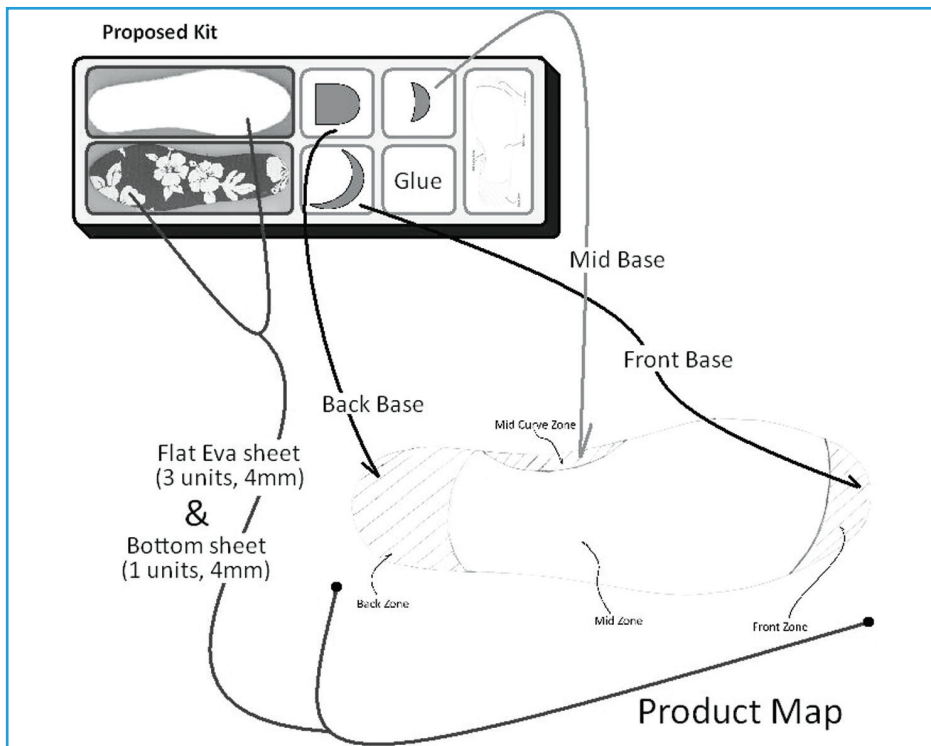
#### 3.1. *The Concept of the 'Customizable Orthopaedic Shoe-Pad-Making Kit'*

It is a customized and self-assembled system developed for persons with locomotor impairments (Motl, Goldman & Benedict, 2010) of the same or a similar nature. According to our studies, each person's legs differ in length. However, grip and contact with the ground make a functional difference. When these differences are more pronounced and begin negatively effecting locomotion, the human body becomes much weaker and less efficient in perform daily life activities. Such individuals are categorized as handicapped, differently able, or disabled persons with locomotor or OL-affected deficits. This remedial kit aims to provide solutions

for the community of these people. According to our studies, cases of disability differ from person to person. Accordingly, we recognized the need for a customizable kit. This product will provide a majority of end users an enjoyable life characterized by social pride and recognition. We believe that this product will provide a 'life of equality' to locomotion-impaired individuals. We understand that this issue is broad and full of specific dimensions at the individual level of diverse end users. However, we cannot solve the wider horizon of all possible disabilities. Thus, we only sought to solve height differences between legs with a maximum difference of 2–3 cm with normal and near-normal foot structures. This product is not a complete solution, nor did it try to remedy any complex orthopaedic issue – these issues require customized examination and solutions, and I strongly believe that a common method cannot work for these aspects of orthopaedic disability.



**Figure-14** (a) Blank shoe-pad card (to be supplied), (b) shoe-pad card (filled by orthopaedic expert after examination)



**Figure-15** The kit and assembly process

### 3.2. The Kit and Assembly Process

### 3.3. Important Facts

- This product can be placed over the insole and below the shoe-pad. It was developed for individuals with PP with deformities of the right limb with TEV of the right ankle and foot (or similar deformities) of a permanent nature’.
- The kit can be produced and forwarded for mass supply under either a business-to-business or

business-to-customer model.

- This product can be supplied as a pack of components with a printed map for use so that an end user may assemble it (business-to-customer model). Alternatively, it can be assembled at an orthopaedic or rehabilitation agency or by a manufacturer to be supplied to the end user.
- The assembly plan should follow according to the product map. Supplying a product map along with the product pack will make the assembly

- user-friendly and make the process easier.
- During this research and design development process, we came to understand that the top surface of the shoe-pad requires textures in order to control foot movements while travelling over rough streets. However, the process we followed (the handcrafting method) may be replaced by an industrial casting process to enhance product life.
- As the production cost was INR 12.9/unit, it is quite affordable to end user(s).
- The estimated product life in normal daily life conditions, on the road, at room temperature can be estimated at around 6–8 months. The estimated life of the used material is around 8–12 months when used regularly on a daily basis.
- Thus, the market demand of this kit may rise in a demand cycle, making it a potentially commercially sustainable wellness product.

### 3.4. Proposed Business Scenario for the 'Customizable Orthopaedic Shoe-Pad-Making Kit'

- Advertise the need and importance of a balanced walk in performing daily life activities and the availability of a customizable kit as a solution.
- Self-identification of the need for a rehabilitative solution by the person-in-need themselves.
- Consulting the nearest available orthopaedic doctor by the person-in-need.
- Identifying rehabilitative requirements of the person-in-need for a shoe-pad.
- Rehabilitative mark identification and indication of remedial dimensions (foot-zone-wise dimensions and pen marking) over the shoe-pad card after proper examination by the concerned orthopaedic doctor or expert (Figure 13 (a, b)).
- Purchase your first 'Customizable Orthopaedic Shoe-Pad-Making Kit'. This could occur in two ways:
  - Production by rehabilitation workers or agents or
  - Production by the end user (by following shoe-pad card instructions).
- Customized shoe-pad-making as per specifications provided by the orthopaedic doctor (please strictly follow marks and dimensions provided on the shoe-pad card when done by the user).
- Purchase a brand new, market-ready pair of fancy shoes of your choice.
- Place the newly developed customized shoe-pad below the removable shoe-bed of your shoe (of the affected foot).
- Start your trial by walking slowly with care!
- Observe! Please allow 1–3 weeks to for your body to accept the changes.
- Carefully observe, is there any pain in pelvic region, vertebral region, knee and ankle joints or in muscles? This might occur because of the end user's familiarity with compensating for disability and the correspondent re-adjustment of the body. Thus, allow 1-3 weeks for the end user's body to accept the changes.
- Use a daily observation chart to document facts and findings of the end user. (If any sudden and unexpected observations are noted, then the end user must contact the orthopaedic doctor or expert.)
- After 1-3 weeks, the body of the end user should adopt the new changes. At this point, they might feel social equality, which will increase the psychosocial confidence of the individual.
- Now, the end user may need to focus on their walking (Motl et al., 2010). This is an observation-based exercise (Motl et al., 2010). Thus, they may need the help of a caring friend or family member on a voluntary basis to devote 1–2 hours a day for around 1 week.
- Enjoy balanced walking!
- It is important for end users to remember that the material life of the shoe-pad is only around 1 year. Thus, it is expected that the end user may start feeling discomfort in using an old shoe-pad after around 8 months of consistent use.
- At this point, the end user again needs to visit the nearest outlet for the 'Customizable Orthopaedic Shoe-Pad-Making Kit'.
- Re-make the 'Customizable Orthopaedic Shoe-

Pad-Making Kit' by following the instructions provided on your shoe-pad card.

- Enjoy life with pride and with a feeling of social equality!

#### 4. Conclusion

With consideration to all of the above factors, we focused on a 'common system-design approach' to offer a common remedial kit that can be converted into a functional product (or accessory) and utilized on a daily basis by target end users. The 'Customizable Orthopaedic Shoe-Pad-Making Kit' can be assembled by end users themselves, as per an orthopaedic doctor's instructions. This creates a self-sustainable community. End users are assisted by orthopaedic doctors and/or orthopaedic experts to develop the customized shoe-pad if end users require their services.

The 'Customizable Orthopaedic Shoe-Pad-Making Kit' is a remedial product kit which provides end users a barrier-free life. As per our studies, the estimated life of the used material is around 8–12 months with daily regular use. Thus, the need for a new 'Customizable Orthopaedic Shoe-Pad-Making Kit' is a yearly cyclic requirement for all end users. Thus, the market demand for this kit may rise on a demand cycle, making it a potentially commercially sustainable product. The per-unit production cost of this case study-based product is around INR 12.9 per unit. Thus, it is easily affordable by individual end users. The regular supply chain can be maintained by kit manufacturers by following the dimensions of standard shoe sizes available in the Indian market.

The marketing channels may be developed by involving teams of orthopaedic practitioners and doctors, rehabilitation agents and workers at the grassroots level, non-government organisations involved in rehabilitation activities, community centres for handicapped people, special schools, shops for rehabilitation aids, and accrements. For advertisement, mouth-to-mouth communication would play a strong role in this context. Development

of public awareness through distribution and display of brochures, posters, banners, and telemarketing tools may also help to promote this product among geographically scattered target customers, so that they can gain the benefits of this product.

#### Acknowledgements

This project was initiated on a 'Do-It-Yourself' basis and then further extended for the wider social wellbeing purposes. For this project, no grants have been received, nor have applications for grants been submitted. A provisional patent application has already been filed in the office of Controller General of Patents, Designs & Trade Marks, New Delhi with the following specifications: AN-2859/DEL/2013, DN-16013, CBRN-10087, RN-E2/9955/2013-DEL, Date: 26.09.2013.

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## Development of a Sustainable Model for Cardboard Shoebox Lifecycle

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# Development of a Sustainable Model for Cardboard Shoebox Lifecycle



## Abstract:

Presently, the Indian paper industry is estimated to account for approximately 1.6% of the world's production of paper and cardboard. The demand for paper and cardboard in India is growing at a significant rate of 8% annually. However, due to the informal waste management system (specifically the collection and segregation of paper and cardboard), the recovery of wastepaper and cardboards is very low, i.e. approximately 26% in comparison to developed countries. It is evident that recycling significantly contributes to solving waste problems, through the sustainable use of natural resources and encouraging the best use of ecosystems. Recycled paper and cardboard pulp are important materials, used in up to 35% of the new paper and cardboard manufactured. The Indian paper industry imports about 50% of the recycled pulp of paper and cardboards used for manufacturing. The industry's dependency on imports to meet market demand is increasing; a significant amount of this cardboard is utilized for the transportation and packaging of shoes. Focusing on the utilization of a cardboard shoebox after its sale, this study is conducted at 12 shoe retail stores (BATA and NIKE) with 40 customers in Delhi. This paper explores issues such as the recycling and lifecycle of cardboard shoeboxes and proposes an alternate, sustainable cardboard shoebox lifecycle. Onsite interviews and observations of the customers and retailers at shoe stores were used as research tools for data collection and analysis.

**Keywords:** *shoebox recycle, waste management, future challenges, and systematic collection/segregations*

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## 1 Introduction

Worldwide, cardboard recycling is considered to be one of the most sustainable practices, provided it is collected dry and without any grease or oil contamination. Cardboard is one of the easiest and most environmentally effective materials to recycle since the fibre in it has already been processed. Therefore, making cardboard products from recycled material, rather than virgin fibre, saves not only trees but also large amounts of water (up to 99% less) and energy (up to 50% less). Manufacturing from recycled material also produces up to 90% less by-products, such as chemical wastes (Planet

Ark Environmental Foundation, 2012). Cardboard can be recycled along with paper and is remade into many different kinds of paper products. After each processing of wastepaper, the individual fibres become weaker, limiting the number of times it can be recycled. Usually, a paper can be recycled up to 8 times. The lowest grade of recycled paper is used for cardboard products.

If paper and cardboard are not recycled and instead end up in landfill to decompose, they release methane gas, a major greenhouse gas with a global warming capacity 21 times more powerful than carbon dioxide (Demand Side Management, 2004).

Major shoemaking companies around the world admit that of the total investment into their businesses, packaging with cardboard material has a profound share. A huge portion of this investment is used to buy cardboard for packing shoes individually, and then for the combined packaging of bulk shipments to the warehouses and retailers.

## 2 Methodology

It has been observed that the life of a shoebox ends once it is handed over to the customer. With an objective to estimate the aggregate average number of shoes with shoeboxes sold annually to Delhi consumers by the top 2 shoe brands, the study was divided into the following steps:

- Secondary research noted that BATA and NIKE are the most preferred brands by consumers in Delhi for the years 2012–2013.
- With the reference of store managers of some random shoe retail stores, researchers visited 12 retail stores of each brand (BATA and NIKE) in different localities of Delhi (snowball sampling).
- On the basis of average number of shoe sales (November 2013) from these stores, 3 stores of each brand were chosen for the study.

- The 3 stores chosen were those with the maximum, average, and the least number of shoe sales among their brand’s retail stores in the month of November 2013.

## 3 Sampling and Data Collection

There are numerous brands selling shoes with shoeboxes in Delhi, but in order to calculate the aggregate average number of shoes in shoeboxes sold annually just by BATA and NIKE brands to Delhi NCR consumers, a study was conducted (see Table 2). The number of shoe pairs sold to consumers were considered in order to estimate the quantity of shoeboxes. These numbers would help to establish that there is a massive amount of shoebox cardboard being risked for dispersal and the recovery of this cardboard for recycling is very marginal. As a result, most of the shoebox cardboards end up in landfill due to contamination by grease and/or moisture. This is more harmful to the environment than any other waste.

For the primary study, visits were made to 12 shoe retail stores of BATA and NIKE in Delhi, and onsite interviews of employees and 40 customers were conducted.

**Table 2** To estimate the number of shoes with a shoebox sold (annually)

Shoe Brand	Store’s Locality in Delhi	Approx. No. of Shoe Sales for Nov.’13
<b>BATA</b> (Number of BATA’s exclusive stores in Delhi NCR – 138)	Connaught Place	1800 - 2000
	Kashmere Gate	1200 - 1500
	Ashok Vihar	900 - 1000
Approx. no. of BATA shoe sales (Monthly) @ Delhi – (2000+1500+1000) / 3 = 1500 138 x 1500 = 207,000 Shoes		
• Annual Sales (in numbers) of Bata shoes (@ Delhi • = 207,000 x 12 = <b>2,484,000</b>		
<b>NIKE</b> (Number of NIKE’s exclusive stores in Delhi NCR – 32)	Select City Walk, Saket	1200 - 1300
	South Extension	800 - 900
	Ashok Vihar	350 - 400
Approx. NIKE shoe sale (Monthly) @ Delhi – • (1300 + 900 + 400) / 3 = 867 32 x 867 = 27,744 Shoes		
• Annual Sales (in numbers) of NIKE shoe @ Delhi = 27,744 x 12 = <b>332,928</b>		
Aggregated Average number of shoes sold (annually) by BATA and NIKE to Delhi consumers = <b>2,484,000 + 332,928 = 2,816,928</b>		

## 4 Analysis

It has been estimated through the study (see Table 2) that just by BATA and NIKE, the aggregate average number of shoes sold annually to Delhi NCR consumers is 2,816,928. Such an enormous number of shoeboxes are dispersed to consumers by just 2 brands of shoe manufacturers. The massive quantity is explained by observations that it is compulsory for a customer to take the shoebox, along with the purchased shoe; since the labelling renders it unusable for the retailer; the retailer would otherwise have to dispose the shoebox. There is also little awareness among these retailers about a model or system of how a used shoebox should be disposed of to ensure it is recycled.

Due to this fixed labelling system, the box cannot be retained by the retailers for reuse. The used box has to be disposed of immediately once the shoe is sold; otherwise, it will result in confusion for inventory records. As pointed out by a large number of customers, it is evident that the sole purpose of a shoebox is to deliver the shoe to the retailer

safely. Once the shoes are brought from the store, the shoebox is usually of no use for the customers.

In the absence of awareness about the importance of recycling or reusing paper and cardboard, there is a significant gap between the procurement and supply of recyclable material for the recycling industry. There is a shortage of this raw material (paper and cardboard pulp) for the industry. According to IPMA (Indian Paper Manufacturers Association), this is demonstrated by India's import of approximately 50% of its recycled pulp of paper and cardboards for new cardboard production, and this is increasing significantly over time. As a country, India is dependent on importing raw material for packaging rather than focused on maximizing waste paper recycling.

## 5 Significance of Paperboard/Cardboard Shoebox for the Industry

The purpose of a shoebox is the safe delivery of shoes to the customers from the manufacturing unit. Keeping this lifecycle of a shoebox in focus,



Figure 1 PUMA's clever little bag

major shoe manufacturing brands worldwide are investing more into research and development to identify more innovative and sustainable ideas for packaging materials and/or reducing the quantity of material used. One of many examples is PUMA's 'clever little bag', which replaces the traditional cardboard shoebox with a reusable bag made of recycled plastic. A single sheet of folded cardboard contained within the bag protects the shoes during transport, while also ensuring that the total amount of material used is significantly reduced.

Created by industrial designer Yves Béhar, the clever little bag uses 65% less paper than the traditional cardboard shoebox, resulting in an annual savings for PUMA of 8,500 tons of paper, 20 million mega joules of electricity, 1 million litres of water, and 500,000 litres of diesel. The company says that it hopes the built-in bag will also reduce the use of plastic by 275 tons by rendering plastic shopping bags redundant.

Another company, NIKE is also working in this area to reduce the material used for packaging. NIKE is one of the world's top shoe sellers, and the company admits that the shoebox and its shipping cartons

account for half of NIKE's investment (Nike Inc., 2010). Therefore, to reduce packaging waste, NIKE took fresh look at the shoebox.

NIKE applied innovative design to the challenge and came up with various alternatives to the traditional shoebox in order to reduce materials used, thereby reducing weight and shipping costs. Through innovative re-engineering, they developed a shoebox that is anticipated to use 30% less material than a 1995 vintage box, their first 100% recycled-contents box. The re-engineered shoebox is fully recyclable, lighter, and stronger. Nike started using these shoeboxes in 2011. The weight reductions translate to reductions in greenhouse gas and overall embedded energy (Nike Inc., 2010).

According to NIKE, innovative thinking was applied to shipping cartons as well. The new lightweight shoeboxes are shipped in cartons that are nearly 20% lighter than their predecessors. NIKE is exploring further reductions: changing shoebox sizes to better fit the shoes they hold, reducing wrapping tissue, and reducing other packaging such as the poly-bags used for samples.



Figure 2 NIKE's shoebox



## 6 Paper and Cardboard Industry in India

According to the IPMA, the paper and cardboard industry provides employment to more than 0.37 million people directly and 1.3 million people indirectly. Many of the paper mills in India have been in existence for a long time, and hence present day technologies fall in a wide spectrum of the oldest to the most modern.

The operating capacity of the industry currently stands at 12.75 million tons. As estimated by the IPMA, during this fiscal year (2013–14), domestic production of paper and paperboard is estimated to be 10.11 million tons. Market demand for paper has been around 8% for some time. The growth in the paper industry has mirrored the growth in GDP. In India, the paper and cardboard market is growing at a pace comparable to that globally, and it is creating an exciting scenario. Paper consumption has also increased with a big leap forward, in sync with the economic growth, and is estimated to touch 13.95 million tons by 2015–16 (IPMA).

## 7 Recycling Industry in India

According to estimates from the IARPMA (Indian Agro and Recycled Paper Mills Association), industry in India produces approximately 14.6 million tons of wastepaper every year, of which industry recycles only 26% in comparison to developed countries.

Recycling of resources from MSW (Municipal Solid Waste) in India is mostly undertaken by the

informal sector. The formal recycling set-up in India is a minor fraction, and is only in its initial stages, experimenting with different models (Annepu, 2012). Informal recycling in developing nations like India is a consequence of the increased gap in waste service provisions, and the resulting ease of access to secondary raw materials that have immediate economic value. The informal sector comprises of waste pickers (WPs), itinerant waste buyers, dealers, and recycling units. WPs constitute the largest population in the informal sector.

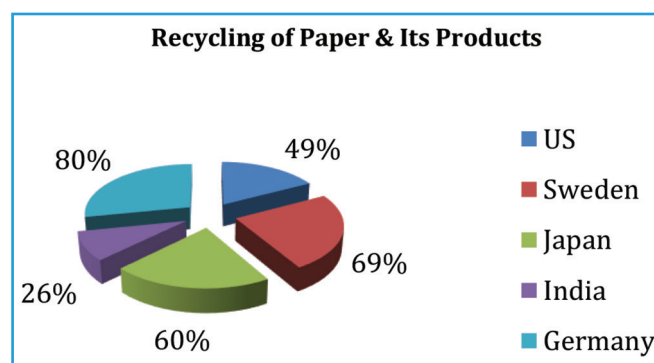


Figure 3 Recycling of paper

Due to unsystematic and informal methods of waste management, there is a sizeable gap in production of new cardboard and recovered waste cardboard. In India, low recovery is ultimately a result of:

- The lack of source segregation leading to waste paper and cardboard becoming contaminated and unusable.
- Reusing of paper in wrapping, packing, etc.

To understand the present system of solid

Table 1 Indian Solid Waste Management Institutions and their Functions

Source: Improving Municipal Solid Waste Management in India: A Sourcebook for Policy Makers and Practitioners, World Bank Institute

Responsible Institution	Roles and Responsibilities in SWM
Central Government	Make laws and rules, frame policies; prepare guidelines, manuals, and technical assistance; provide financial support; monitor implementation of laws and rules.
State Government	Make state-level laws and rules, frame policies; prepare guidelines, manuals, and technical assistance, provide financial support; monitor implementation of laws and rules.
Municipal Authorities and State Government	Plan for SWM treatment facilities
Municipal Authorities	Collect, transport, treat, and dispose of waste
Municipal Authorities with the approval of State Government	Frame by laws, levy, and collect fees
Municipal Authorities and State and Central Governments	Finance SWM systems

waste management in India, Table 1 explains the government institutions and their related functions, roles, and responsibilities.

## 8 Initiatives Underway in India For Paper Recycling Awareness

The Government of India has relaxed the rules and regulations, and de-licensed the paper industry to encourage investment into the recycling sector; joint ventures are allowed and some have started in India. The paper industry in India is looking for state-of-the-art technologies to reduce production costs and upgrade technology in order to meet international standards. Many government and private initiatives are creating awareness for the recycling and reuse of paper and cardboard.

### 8.1 Delhi Government's campaign for increasing the usage of recyclable paper bags

'Paper Recycling Machine' was set up on World Environment Day (5 June 2005) as part of the Delhi Government's Bhagidari scheme. In a first-of-its-kind initiative, Delhi has set up a 'Paper Recycling Plant' within the Delhi Secretariat Office Complex itself. 'With just three full-time staff, this unit helps recycle (per day) about 50 Kgs of paper on average and produces 200 - 250 sheets of recycled paper', as mentioned by Dr. B.C. Sabata, Senior Scientific Officer in the Department of Environment, Delhi Government.

Most file covers, invitation cards, and even felicitation certificates used in the Delhi Secretariat are made of recycled paper. The Delhi government also runs a scheme called eco-club in schools and colleges to sensitise the students to environmental issues.

### 8.2 The Indira Gandhi International Airport

Delhi Airport has initiated measures like using recycled papers at its premises in a bid to become a 'green airport'. After putting in place some of the green initiatives like rainwater, use of natural lights,

and efforts to reduce emissions, the airport operator Delhi International Airport Limited (DIAL) has now decided to use recycled papers in its offices. To do so, DIAL has entered into an agreement with an NGO 'Jaagruti', which will recycle the waste paper generated in its offices and use notepads and A4 sheet made from recycled paper.

This is estimated to save 17 trees, 26,281 litres of water, 264 kg of air pollution, 1,752 litres of oil, 4077 KW hours of energy, and 82.62 cubic feet of landfill space. As a part of the initiative, DIAL shared 1 ton of paper waste for recycling with Jaagruti.

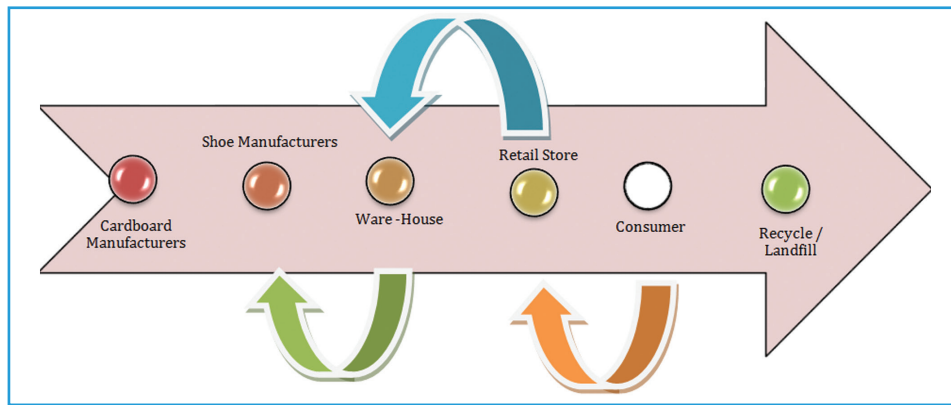
### 8.3 Other Private Initiatives

Some IPMA members have taken individual initiatives to procure the waste paper directly from institutes and corporations. For instance, ITC Paperboards and Specialty Papers Division launched the waste paper collection programme called Wealth Out of Waste (WOW) in 2012 in select areas in Hyderabad, Bangalore and Coimbatore, and is now expanding it to more areas in South India, including Chennai. In Chennai, it has partnered with between 30 and 40 IT companies, including Infosys, IBM, and Wipro, which will sell their waste paper to ITC for recycling. It also plans to connect with Residential Welfare Associations (RWAs), NGOs, and local bodies to expand the waste paper collection programme.

## 9 Suggestive Implementable Model for Cardboard Shoebox Lifecycle

One of the important aspects of sustainability is to delay the disposal of a product by reusing the product, beyond recycling or disposing. Evidenced by this study, shoeboxes are not reused by the shoe manufactures, and cardboard has to trickle down to the manufacturing process. Even if the cardboard is recovered for the recycling process, it is still an energy-consuming process.

International brands like NIKE and PUMA are taking greater interest in cradle to cradle processes for shoe design, but it is also necessary that shoeboxes



**Figure 4** Process: explaining reversal of shoebox back to shoe manufacturers

be given the same consideration. For some time now, at a very small level, PUMA began taking back the shoeboxes, from the customers, for recycling at some of its retail stores. Still though, if all brands would retain shoeboxes for reuse rather than immediately recycling, it would be a more sustainable practice.

Since none of these practices are followed in India, it is suggested that shoeboxes not be given as 'freebies' and should not end its lifecycle process once the shoes are sold. The shoebox is a valuable product for the industry as well as environment. Instead, it should be taken back and reused after removing the informative label. Consumers ought to be made aware of the importance of this process, and should be rewarded with a biodegradable

jute bag, which comes with a longer lifespan and versatility for multiple further uses.

This reversal of lifecycle (see Figure 4) would delay the lifecycle process and by reusing the cardboard shoebox, manufacturers would be saving a significant amount of investment. The foldable design of the shoebox would make it economical to transport, in large quantities, back to the manufacturing unit for repackaging more shoes.

## 10 Working Details for Implementation of the Model

A marketing proposal is explained through the infographic in Figure 5. It describes the process that



**Figure 5** Flow Chart to describe the Working Model

can encourage consumers to refuse the shoebox and instead accept a bio-degradable, long-life bag.

## 11 Addressing the Three Pillars of Sustainability

The three pillars of sustainability (economic, social, and environmental) are addressed by this lifecycle model of reusing the cardboard shoebox (Figure 6). It shows that in the long run, manufacturers will save on packaging material (cardboard), social awareness will be boosted with the availability of more raw materials for recycling, and manufacturing of jute bags would empower lower income consumers to be involved. Overall, the proposed process would create a more sustainable environment.

## 12 Discussion and Conclusions

Although there are already several efforts in practice in regular, day-to-day life by various individuals, industries, NGOs, and government groups for sensitizing the people of India for

environment awareness, still there is a need for a suitable mechanism that will result in increasing the effective recycling of post-consumer cardboard for manufacturing. There is an urgent need for awareness campaigns for recycling of paper and cardboard, like pulse polio and malnutrition campaigns running with government support. The concept of cardboard and paper recycling may be promoted using electronic media throughout the country.

More and more small industries should be encouraged to take up waste management in businesses, and given subsidies for starting such units. Big corporations have to be conscious of their huge spending on packaging and initiate the cradle to cradle process for transferring wastes like paper and cardboards to the recycling industry.

## Acknowledgements

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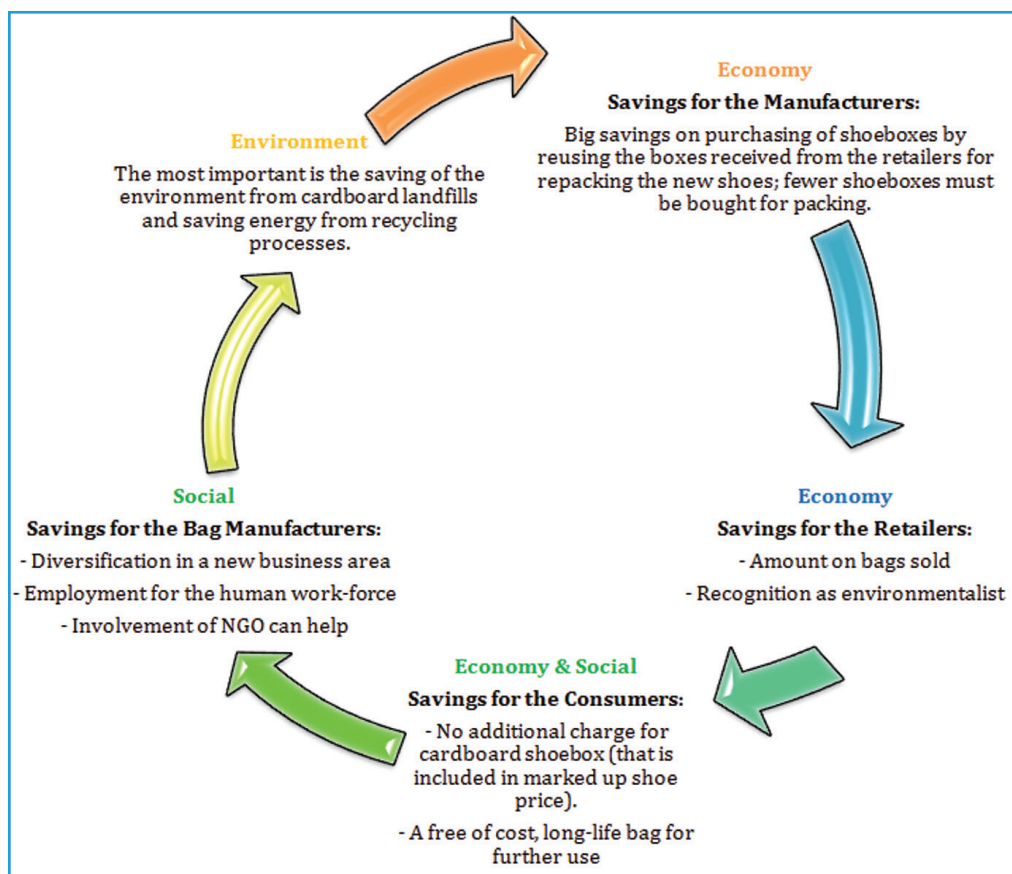


Figure 6 Addressing the pillars of sustainability

guidance, and constant supervision of Ms. Shalini Sud, Professor and Ms. Varsha Gupta, Associate Professor at NIFT, New Delhi.

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Effect of Light on the Wellbeing of  
People in the IT Industry

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# Effect of Light on the Wellbeing of People in the IT Industry



## Abstract:

This study explores the possibility of using architectural design to promote the positive effects of light on the health and well-being of people in the IT (information technology) industry. Design approaches to enhance the well-being and productivity of individual professionals is an emerging area of research to cope with the changes in lifestyle and work culture brought about by globalisation and the IT-based third industrial revolution. A thorough literature review revealed a possible connection between the biological clock, which is influenced by lighting, and IT-related health hazards. This association was supported by the preliminary findings of a pilot study that was conducted using the Office Lighting Survey on employees from an IT company based in Kolkata, India. Architectural solutions, such as space planning and fenestration design to incorporate more daylight were identified as the next step in the research process, which will complement the recent developments in dynamic office lighting.

**Keyword:** *biological clock, building design, information technology, non-visual effect, office lighting*

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## 1 Introduction

Since the 1990s, globalisation and the third industrial revolution, stimulated by the information technology (IT), have changed the traditional sunrise-to-sunset work patterns (Fitzsimmons, 1994). Projects from various sectors, especially in the case of IT, are now operated from various locations around the world. Many developing countries (more precisely non-G7 countries), including India have witnessed a remarkable growth in the IT industry from the beginning, and have been able to retain a double-digit growth over the last few decades (Arora & Gambardella, 2004). Currently, the IT, the business process outsourcing (BPO) and the knowledge process outsourcing (KPO) industry contribute to about 7.5% of India's GDP, of which 69% comes from the foreign market. In the financial year of 2012, the revenue generated from IT services was approximately 50.4% of the total industry,

resulting in an accumulation of USD 50.8 billion, and it employed about 2.8 million people directly while 8.9 million people indirectly, according to the National Association of Software and Services Companies (NASSCOM, 2013). Here, 97.4% of the IT professionals are between the ages of 20 and 30 years (Gupta, 2010).

Hence, the productivity and comfort requirements of this large workforce is of great concern not only to the corporate management but also to the building professionals who plan, construct, or operate modern office buildings where these IT professionals spend long working hours. To date, no specific emphasis has been placed on the healthy work environment for IT offices. The general recommendations pertaining to energy efficiency and indoor air quality may be a good indicator of the building performance. However, there have been recent reports of a number of health-related

problems among IT professionals, in spite of several IT offices with green certification. Considering this situation, the positive role of lighting and its possible connection with the health issues of IT professionals is explored in this study. The ultimate goal is to establish healthy day lighting in IT offices through special architectural design of such buildings.

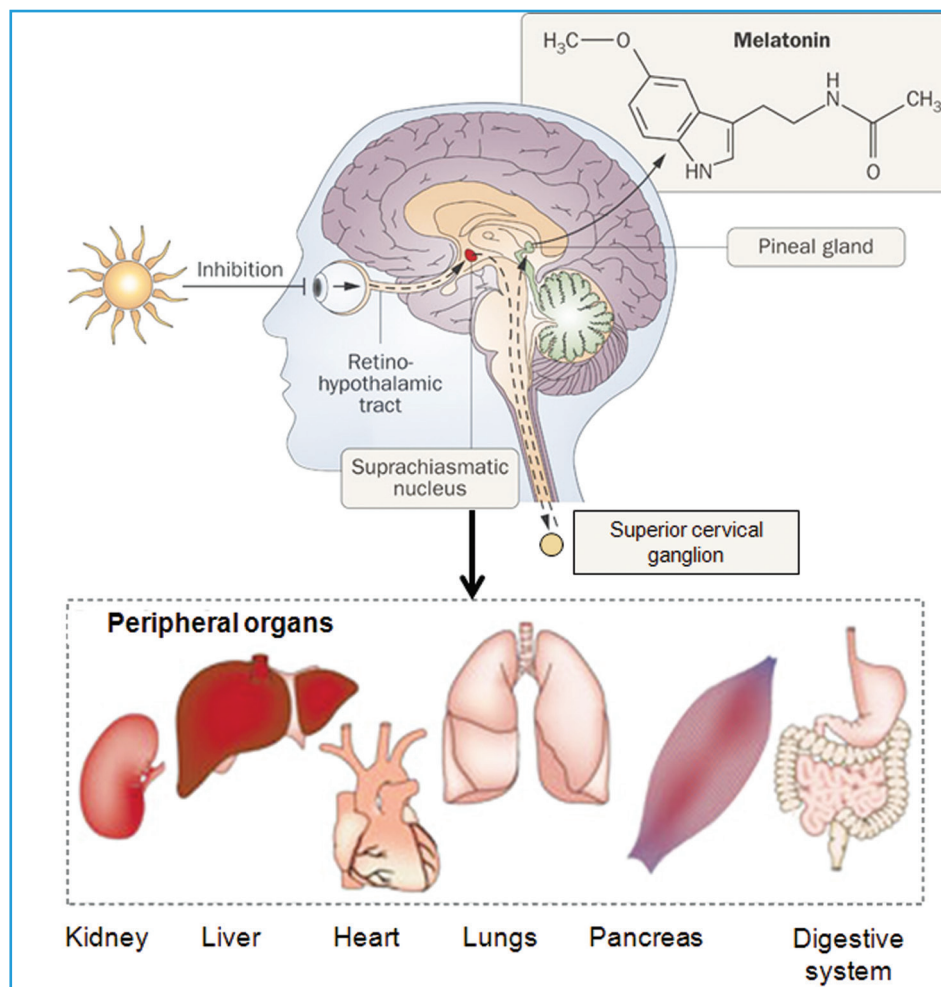
## 2 Effects of lighting on health

Traditionally, office lighting schemes have ignored the presence of daylight. The recent use of daylight harvesting on the other hand, combines natural and artificial light for energy efficiency (So & Chan, 2009). In both cases, quantitative and qualitative aspects of lighting for visual performance and visual comfort are considered. The quantitative aspect deals with illumination, lighting level, glare, uniformity etc., while the qualitative aspect deals with visual comfort through colour rendition, colour

appearance, composition, contrast etc (Van Bommel & Van den Beld, 2004). The definition of the basic parameters of illumination engineering can be found in the literature by Koninklijke Philips Electronics N.V. (2008) and Taylor (2000).

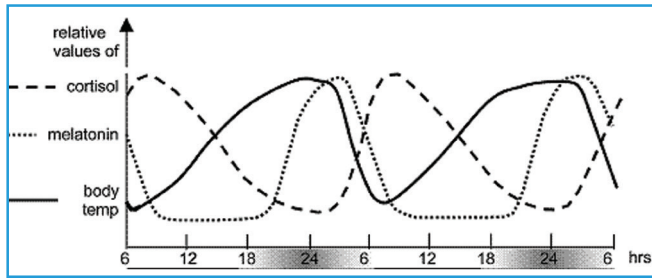
### 2.1 Non visual effects of light

Until 2002, scientists considered only the visual effects of light as perceived by rod and cone cells located in the retina of eye, and the non-visual effects of light on human's health was unheard (Berson, 2003). During the late 19th to mid-20th century Dr. Rollier recorded the unexplained benefits of 'heliotherapy' (treatment by sunlight) in controlling infection, blood pressure, blood sugar, cholesterol, and tuberculosis, and also reported that the sun's healing power was ineffective when the patients wore sunglasses (Metzger, 1926). Moritz (2007) argues that people with inadequate exposure



**Figure 1** The circadian clock in mammals  
**Source:** Derived from Kondratova and Kondratov (2012)





**Figure 2** Variations in body temperature, melatonin, and cortisol in humans according to the  $24 \pm 0.5$  hour cycle of the biological clock  
**Source:** Van Bommel & Van den Beld (2004)

to sunlight are physically and psychologically vulnerable. This finding explains why people in northern European countries, where months of darkness prevail every year, exhibit more irritability, fatigue, illness, obesity, insomnia, depression, alcoholism, and suicide tendencies than people from the sunny parts of the world. Many of these symptoms, known as seasonal affective disorder (SAD) or winter depression, appear each winter and are resolved automatically in the spring. Exposure to bright artificial light has been found to alleviate the symptoms of SAD patients (Eagles, 2003).

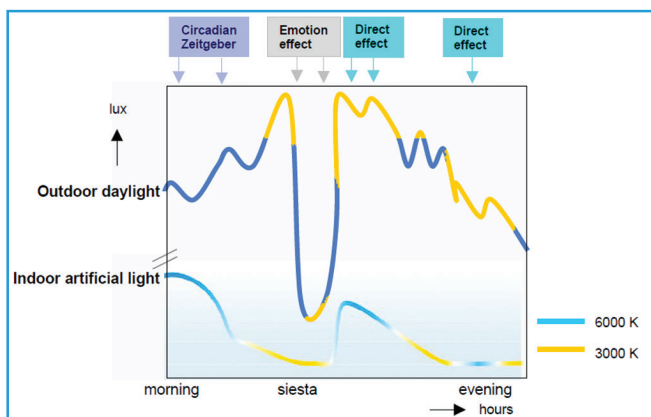
The non-visual effects of light on human health was scientifically explained for the first time when experiments on rats at the Berson laboratory of Brown University, Rhode Island (USA) revealed the existence of retinal ganglion cells as the third photoreceptor, which connects to the suprachiasmatic nucleus (SCN) of the brain (Berson, 2003). The SCN is considered the body's master pacemaker that primarily controls the biological or circadian clock by regulating the secretion of two hormones, namely, melatonin (sleep hormone) and cortisol (stress hormone) from the pineal gland - the hormone centre. The SCN also regulates local biological clocks throughout the body as shown in Figure 1. Moreover, the SCN is responsible for the electrophysiology i.e. the electrical signals sent through the neurons, for synchronized functioning of organs, such as the brain, heart, muscles etc. Hence, it is understandable that the disorders of various organs and metabolism can be traced back to the SCN and in turn to its photoreception.

The two hormones, cortisol and melatonin, work in tandem to balance alertness and sleep, respectively. Cortisol rises slowly in the morning, remains sufficiently high throughout the bright day, and starts falling at the day's end, dropping to almost zero after midnight. Cortisol releases blood sugar to supply energy and build immunity. However, high levels of the stress hormone for a prolonged period of time acts as a stressor and results in feelings of exhaustion. The same effect is achieved by excessive suppression of melatonin. In contrast to cortisol, the level of melatonin is lowest in the morning after a good night's sleep, remains low throughout a bright day, begins to increase in the late evening, and finally peaks at midnight. Therefore, people start feeling drowsy in late evening and sleep soundly after midnight. These hormonal patterns regulate the biological clock on a  $24 \pm 0.5$  hour cycle, and body temperature, accordingly (Figure 2).

With earth's 24 hour day-night cycle, this internal rhythm has evolved over ages and has become embedded in our genes. Every morning, bright blue sunlight resets the biological clock and allows the smooth running of the body's functions. However, if this light-dark cycle is disrupted due to natural causes (e.g. SAD, yellowing of the eye lens with aging) or induced causes (e.g. browsing the internet beyond daytime until or beyond midnight, shift work, or cross-country travels leading to jet lag), it may have short-term as well as long-term effects on health. Some of the negative effects on health that have been documented include micro-sleep (sleeping for short spells of 1/10 second), sleep disorders, irregular heart rate, lower immunity, depression, Alzheimer's disease, obesity, high blood pressure, high blood sugar levels, and cancer (Blask, Sauer, Dauchy, Holowachuk & Ruhoff, 1999; Figueiro, Plitnick, Wood & Rea, 2011). Many of these health issues formerly occurred with aging. However, it is shocking to note the prevalence of these issues in IT professionals of a much younger age, as illustrated in the next section.

## 2.2 Light therapy

Traditionally, the therapeutic properties of light have been used to cure Rickets Disease, with the help of Vitamin D synthesis (Liberman, 1991) and SAD (Eagles, 2003). As discussed earlier, cures for infection, blood pressure, blood sugar, cholesterol, and tuberculosis that were claimed by the school of heliotherapy were popular until the 1930s, but today, they appear mainly as a method of alternative medicine (Moritz, 2007). Van Someren et al., (1999) found that exposing Alzheimer's patients to bright blue artificial light or sunlight in the early hours of day could help in regularizing their sleep-wake pattern. On a similar line, Chellappa et al., (2011) found that alertness and cognitive responses in humans improved under the blue light of 6500K, even if the illumination level was as low as 40 lux, due to significant suppression of melatonin. Vandewalle et al., (2007 a, b) measured brain activity for memory tasks during the daytime and observed better cognitive performance under blue light, as compared to the adjacent colours, namely, violet or green. In this case, the temporary exposure to light had no significant effect on the biological clock although people's alertness increased considerably.



Note: Zeitgeber means timer

**Figure 3** Comparison of the effect of random variation in the colour temperature of outdoor daylight and the gradual variation in colour temperature of artificial indoor light on the work environment

Source: Van Bommel, (2006)

As mentioned earlier, excessive suppression of melatonin can cause an insomnia-like condition, and a lack of sleep at nighttime leaves people tired and exhausted when starting a new day. Hence, the prolonged exposure to bright blue light in late evening is harmful. In an experiment conducted by Wood, Rea, Plitnick and Figueiro (2013), subjects viewed self-luminous tablets for two hours at night through (1) the naked eye; (2) clear-lens goggles fitted with blue LED, and (3) orange-tinted glasses to cut-off melatonin suppressing rays. After two hours of exposure to the white blue light, melatonin was reduced significantly. Accordingly, they suggest that the electronic devices should incorporate a spectral power distribution to enhance or reduce stimulation of the circadian system, depending on the hour of usage.

Recently, researchers have tried to integrate both visual and non-visual effects of light into the designs of lighting schemes (Linhart, 2010). Accordingly, such lights are also commercially available (Philips, 2014). Apart from exposure-time and brightness, the colour and position of the light source have shown positive effects on well-being and comfort conditions. Aries (2005) reported that high levels of vertical illuminance could reduce fatigue and improve sleep quality. Van Bommel (2006) suggested 'dynamic lighting', in which both the illumination level and colour are varied throughout the day for synchronisation of the biological clock (Figure 3). Stimulating white light (6000 K colour temperature) is used in the morning to reset the biological clock, and again after the afternoon siesta time to re-energise the body. At the day's end, this cool white light is administered again at a low intensity for a short time, so that tired workers can freshen up for the trip back home. In between these times, the light remains warm white at a lower level 3000 K, mainly to conserve electricity. During lunchtime, the light operates at only 500 lux only to introduce a 'biological relaxation' effect, facilitating an ultra-brief siesta, which can result in an increase in alertness and cognitive performance in the late afternoon.

### 2.3 Healthy light in building design

The responses of illumination experts to the health requirements of workers have concentrated mostly on the design and evaluation of both natural and artificial lighting. The responses of architects to this issue in terms of building design, space planning, and fenestration detailing have been lacking, to the degree that it has remained a nascent area of research. Christoffersen and Johnsen (2000) have emphasised people's preference for windows providing daylight and a view. Schweitzer, Gilpin, and Frampton (2004) discussed light as a component of a healing environment. Veitch (2011) drafted a set of rudimentary guidelines for lighting in residential buildings that included: (1) architectural features to balance healthy doses of light with glare and (2) windows or skylights for the additional benefit of aesthetics. Wirz-Justice and Fournier (2010) recommended customisation through (1) personalised lighting near eye level for different age groups and (2) orientation of different rooms in a residence. These guidelines and recommendations can be followed as much as possible by using natural light in response to the direction and azimuth of the sun, in which minimising overshadowing and allowing distant views are essential. In all cases, researchers have recommended further exploration of the impact of light because the current guidelines, which are based on inadequate knowledge, may be quite harmful to the building occupants.

### 3 Health problems related to the IT industry

According to the WHO's Global Status Report on Non-Communicable Diseases 2010 (Alwan, 2011), cardiovascular illnesses, diabetes, cancers and chronic respiratory problems will emerge as epidemics in coming decades. In the countries falling within the low and middle-income categories, including India, these epidemics are expected to cause more than 70% of all deaths. The primary causes of deaths include sedentary life style, unhealthy diet, obesity, and raised cholesterol, which also are prevalent among IT professionals.

Hariram, Boopathy, Masi, and Kumar (2013) point to the untimely deaths of four IT professionals (34–37 years old) due to heart attack and noted their risk factors, including depression, workload, sedentary lifestyle with unhealthy food habits, and odd sleeping hours. Despite good health facilities provided by the IT companies, the majority of employees face work-related health hazards. Heart disease tops the list and may be responsible for 35% of the deaths among working professionals by 2030, and out-sourcing industries such as IT may be the most affected (The Economic Times, 2007).

Given this information, it is understandable why there has been a paradigm shift in studies on occupational health and safety in the recent past. The focus from blue-collar jobs, such as manufacturing, mining, and construction has now shifted to white-collar jobs, such as the IT industry where no apparent physical danger exists beyond a noisy environment in the call centres (Gilardi et al., 2008; Subbarayalu, 2013). Despite this fact, several recent studies have addressed the health issues pertaining to the IT industry. Apart from the noisy environment of the call centres (Gilardi et al., 2008; Subbarayalu, 2013), the most common hazards identified among almost all IT professionals are: (1) visual discomfort; (2) musculoskeletal disorders; and (3) psycho-social problems (Kesavachandran, Rastogi, Das & Khan, 2012; Saroshe, Sirohi, Pawaiya & Taneja, 2012; Saurabh, Shrivastava & Bobhate, 2012). Darshan, Raman, Sathyanarayana, Ram and Annigeri (2013) noted that IT professionals are more vulnerable to work-related stress and have a 10 times higher risk of developing depression. Vaghat (2014) compared the levels of anxiety between two groups of workers from IT and mechanical engineering. In spite of similar physical conditions, the IT professionals exhibited higher amounts of stress, because mental alertness is their main strategy of survival in their competitive and fast-changing industry. Suparna, Sharma, and Khandelkar (2006) identified poor ergonomics for computer-related health issues, such as morbidity, tiredness in the eyes, glare, and musculoskeletal discomfort. Accordingly, the researchers have recommended finding a solution

through conducive organisational set-up, good ergonomics, stress management techniques, health education, physical activities etc (Sailaja, Reddy & Kumar, 2013; Thirumaleswari, 2013).

As stated in the literature review, visual discomfort, depression, lack of alertness, and fatigue, which are common among even young IT professionals, can be traced to a disrupted biological clock and poor lighting installation. As per NASSCOM, it might be impossible for IT companies to control the personal lives of its employees and avoid night shifts for outsourcing jobs (The Economic Times, 2007). In such situations, building technologists can play a key role by designing the indoor environment in such a way that the healing effects of light as well as visual comfort can be achieved.

## 4 Methodology

This research was conducted as a pilot study for a project aimed at providing healthy or personalised lighting as an innovative solution for handling stressful work conditions in IT offices, without interfering with the business of the organization. The offices of a particular IT giant from Kolkata were approached for visual observation, and an opinion survey of its employees was conducted using the Office Lighting Survey (OLS) method. The OLS uses a simple and reliable questionnaire-based assessment method for occupant satisfaction regarding office lighting (Eklund & Boyce, 1996; Linhart & Scartezini, 2011). The majority of questions on this survey require dichotomous (Yes/No) responses. Because this was a pilot survey, the main aim was to find out if there was a need for bespoke architectural design for IT offices rather than drawing a conclusion. Therefore, rigorous sampling methods and statistical analyses of data were not planned.

### 4.1 The profile of the company

The IT company chosen for this pilot survey has more than 3,000 employees in Kolkata City, and has several branches in other cities of India and

abroad. The company provides various IT-related services and operates from different offices falling under two different categories of buildings, namely, the company's own buildings and rented space in commercial buildings in different locations of Kolkata.

The three types of projects that the company mainly runs include development, maintenance and support, and BPO-KPO. The usual office time of 9 hours per day for a 5-day week starts at different times for different types of projects and often is extended due to workload. For example, domestic projects may follow the usual 9 am to 6 pm schedule but for overseas projects, especially for the US, Canada, and Latin America with a time difference of 8–10 hours from Indian Standard Time, the workday starts little late and continues into the late evening hours, almost reaching midnight to overlap with the overseas team. Maintenance and support projects are active 24 hours a day, seven days a week but people work on the night shifts on a rotational basis. In brief, the peak office hours are from 12 noon to 10 pm.

### 4.2 Selection of respondents

Here, the workforce was found to have a deep hierarchy. At the junior level, developers, testers, module leaders, and team leaders work on a particular project and report to an immediate supervisor. Project managers and delivery managers are mid-level resources with 10–12 years of experience who run more than one project at a time and need to coordinate activities with clients, in-house team members, and the overseas team for all the projects under their supervision. This group often needs to continue working at home to meet their targets. Senior professionals at the executive level, such as global heads and global delivery directors are responsible for high-level business decisions and strategy making. They do not have a specific time schedule because they might to respond to situations anytime from anywhere, depending on its demands. As these high-ranking officials were not accessible for our discussions,



the respondents were chosen from the junior and middle levels of professionals.

### 4.3 Questionnaire

The questionnaire was very short and avoided asking for any confidential data. Respondents were asked to provide information only about: (1) age; (2) gender; (3) designation; (4) average time spent in office; (5) usual sleeping hours; (6) quality of daylight in work area; (7) quality of artificial light in work area; (8) whether they suffer from particular illnesses (e.g. high blood pressure, blood sugar, cardiovascular disease, headache, eyestrain etc); (9) presence of those illnesses in his/her family history; (10) regularity of morning walks; and (11) remarks if any. Other common issues related to corporate policies or musculoskeletal discomfort, as reported by previous researchers were not included. Although the respondents had never heard about the healing effects of light, they showed an interest because the survey addressed their common concerns. The questionnaires were circulated via email from the company's administrative section and received back through the same channel to maintain anonymity.

## 5 Findings

In order to maintain the security of project related data, no photography was allowed inside the office space. For the same reason, windows of the offices have either tinted glass or blinds, such that information on computer monitors and projection screens cannot be seen from outside the building. We were informed that such stringent data security was an obligatory clause in the projects' contracts, especially for healthcare and banking projects. The author observed that the workstations adjacent to the windows also did not receive normal daylight for security reasons, and the entire floor depended on an ample amount of general lighting that was mostly provided by compact fluorescent lamps placed in a regular grid. There was no provision of task lighting.

The 56 respondents consisted of people of the following age group (47% of 20–30 years, 34% of

30–40 years, and 19% of above 40 years), gender (62% male and 38% female), and rank (57% lower level and 43% mid-level professionals). The data were summarised as follows:

1. Office hours extend beyond 9 hours, very often to 11.5 hours on average per day, five days a week, and as a result, the usual 8-hours of sleep are reduced to 6.2 hours on weekdays. IT workers compensate for this reduction by waking up late on weekends.
2. Daylight barely enters through the windows because of tinted glass, blinds, or both. It is difficult to judge the sunlight's intensity from the inside, and to tell whether it is a bright or overcast day, a sunny afternoon, or dim dusk. Recognising the colour of the light is out of the question.
3. The work floor is flooded with bright white light 24 hours a day, 7 days a week, and the lack of any variation sometimes creates a feeling of a factory without any human touch. Yellowish light is absent, even in the cafeteria or rest rooms, except in a few locations, such as the entrance or reception areas.
4. Common health issues are high blood pressure (73%) and high blood sugar (68%). Headache (83%) and eyestrain (86%) are everyday issues, and sometimes the employees need to take medicine for it (55%).
5. Lack of sleep (34%) and sleep disorders (72%) were reported. People mentioned that after switching off the computer or laptop at night, it takes longer than expected for them to fall asleep despite being exhausted.
6. As a result, the next morning they wake up late and immediately rush to the office. There is limited scope of exercise even in the office gym due to their busy schedule and morning walks are almost impossible to fit into the daily routine. Sixty five percent of the people wanted to opt for a regular exercise program to lose weight and stay fit.
7. Lower immunity from various common diseases such as cold, cough, stomach upset, dust allergies, asthma, and fever were reported by



84% of the respondents, including those in the 20–30 years age group.

8. Although a family history of diseases was present in 42% of the cases, the affected blood relatives showed symptoms much later in life than the employees.

In brief, the respondents revealed that they felt burnt out or that they were aging very fast in spite of the good healthcare and stress management initiatives of the company. They always felt tired, and to cope with their fatigue, they felt like having extra food or beverages. Several people even stated that their friends or cousins of similar ages, but from different professions were in better health.

From the detailed literature review and the preliminary findings of the pilot study, it can be inferred that people in the IT industry have several health issues that directly or indirectly affect the functioning of their biological clock, visual comfort and in turn productivity. Many of these symptoms have the possibility of being treated with healthy lighting. However, the IT companies' restrictions on the transparency of windows or other openings pose a challenge for architectural designs involving space planning and façade design. If addressed properly, architectural design can complement the recent developments in illumination engineering in which day lighting is given special attention.

## 6 Conclusion

This research article reports the background and preliminary findings of a pilot study that explored the possibility of healthy lighting to promote the wellbeing of people in the IT industry through architectural design. Although different categories of professionals of different ages, genders, work profiles, health conditions, and building occupancies participated in the survey, they belonged to one branch of only one IT company. As a result, the generic nature of the findings is questionable and requires further research to draw probing insight. It was recommended that the next phase of the research should include

respondents from different companies and other geographic locations in the country. A comparative study of offices with similar work hours but different exposure to daylight could be beneficial. Furthermore there are plans to conduct a real life experiment in one of the offices (subject to permission), in which fenestration and artificial lighting will be synchronised along with personalised lighting to examine the beneficial effects on IT professionals. The architectural solution to allow daylight to penetrate the office without compromising the privacy of the workplace has the potential to be applied to other types of buildings, and thus, can complement the recent developments in illumination engineering to promote a healthy work environment.

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Comparative analysis of the thermal comfort and sustainability performance of traditional and modern buildings in the lower Himalayan region of

Himachal Pradesh, India

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## Abstract:

Vernacular architecture comprises building design and construction methods developed based on local wisdom and resources. These buildings passively regulate indoor thermal comfort even amidst extreme outdoor climatic conditions. However, contemporary construction practices have changed because of the availability of modern standardized building materials and methods, which dominate the market in the country. To achieve holistic sustainable development, local climate and environmental conditions must constitute the most influential parameters in the design of buildings, given the present scenarios concerning energy supply shortages and climate change. Himachal Pradesh is located at the base of the western Himalayas. Based on field survey data and the quantitative and qualitative comparison of the thermal performances of traditional and modern residential buildings located in lower Himachal Pradesh, this paper suggests appropriate architectural design criteria and materials for the present-day construction of buildings in this region that will contribute to a sustainable built environment.

**Keywords:** Himachal Pradesh, vernacular, modern buildings, thermal comfort, comparative analysis

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## 1 Introduction

Indigenous and traditional buildings have been constructed since time immemorial to create comfortable indoor living conditions for inhabitants, and these buildings were responsive to their local climate. In a traditional vernacular settlement, masons and builders use limited locally available resources to achieve maximum indoor thermal comfort conditions, and climate constituted the primary determinant of shelter design and form. The design and construction of buildings according to local micro-climatic conditions is termed 'bioclimatic architecture', which has been discussed elsewhere by one of the authors (Sarkar, 2010). It

is heartening to find that 'bioclimatism' is inherently present in the vernacular traditional settlements which have proven sustainable throughout the ages. Various studies conducted in countries with cold climates have highlighted the climate-sensitive passive design characteristics and other adaptive features of traditional architecture and construction methods that respond to local geoclimatic conditions (Jeffrey, 1996; Ooka, 2002; Ratti, Raydan & Steemers, 2003; Rijal & Yoshida, 2002; Rijal, Yoshida & Umemiya, 2005; Upadhyay, Yoshida & Rijal, 2006; Şerefhanoglu Sözen & Gedik, 2007; Maria, 2009; Zhai & Previtali, 2010). In India, quantitative and qualitative studies of vernacular settlements aiming to identify and understand

the passive architectural design features and construction techniques of these buildings have been conducted in various regions, including the coastal humid climate (Dili, Nasser & Zacharia, 2010; Priya, Sundarraja & Radhakrishnan, 2012), hot-dry climate (Gupta, 1984), composite climate of central India (Indraganti, 2010), north-east regions (Singh, Mahapatra, & Atreya, 2011) and western Himalayan regions (Jain, Singh & Sharma, 2005; Thakkar & Morrison, 2011; Sarkar, 2011 and 2013). The findings from these studies have been used to formulate passive design guidelines for present-day buildings in countries with tropical climates like India (Milne & Givoni, 1979; Koenigsberger, Ingersoll, Mayhew & Szokolay, 1984; Krishnan, Baker, Yannas & Szokolay, 2001; Nayak & Prajapati, 2006). Moreover, the energy crisis in the 1970s led to widespread awareness of the fact that all development work should be carried out in the spirit of maintaining environmental, social, and economic sustainability, and that designing and constructing buildings according to local climatic conditions should be the key for sustenance in terms of reducing energy consumption and maintaining the thermal comfort of the occupants inside the buildings.

With the advancements in construction materials and technologies, heating and cooling buildings has become easy. However, contemporary construction practices have changed because of the availability of modern standardized building materials and methods that dominate the market in India. The influence of the market economy and electronic media, along with a change in local socio-cultural outlook, has led people to accept gradual change in the design of architecture, even in remote, rural, or semi-rural places. These modern construction practices – which can create comfortable indoor living conditions if applied judiciously – are often executed without giving due consideration to local geo-climatic and cultural conditions; this may have negative implications on the energy consumption required to maintain comfortable living conditions inside the houses. The inherent logic of the vernacular precedent can be revealed through comparative studies between these dwellings and

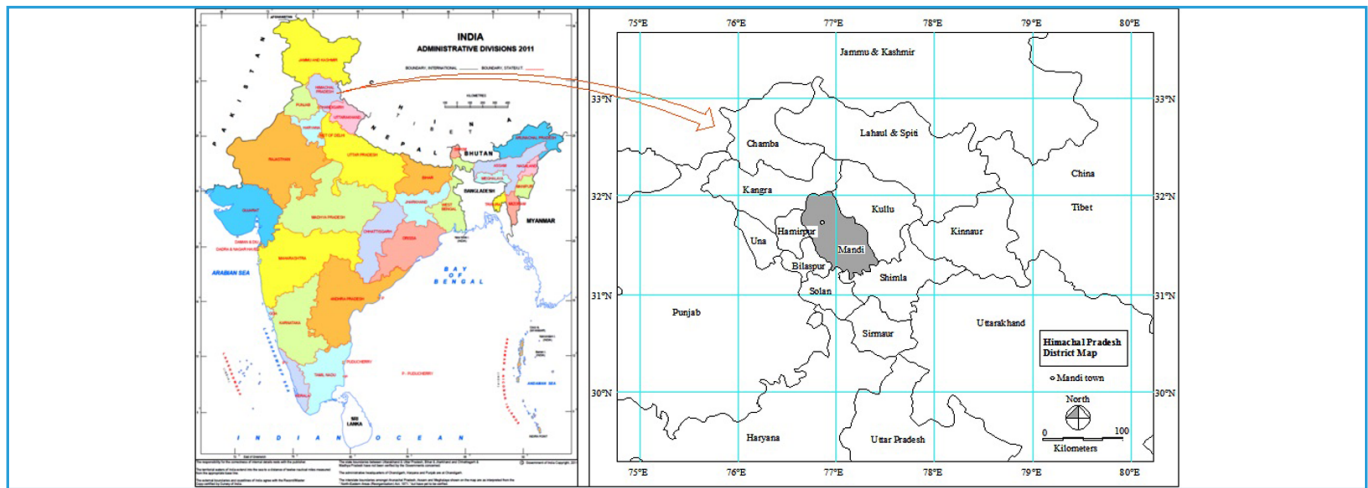
modern-day constructions (Plemenka, 1982; Kim, 2005; Şerefhanoglu Sözen & Gedik, 2007).

It is a known fact that buildings consume considerable energy during both construction and operation, and hence they are a significant source of CO<sub>2</sub> emissions to the atmosphere. Energy consumption in the building sector is expected to increase further due to the improvements in living standards and the increase in world population (BEE Bureau of Energy Efficiency, 2008). In India, the building sector is responsible for about 33% of national electricity consumption, with the commercial sector and residential sector accounting for 8% and 25%, respectively (BEE Bureau of Energy Efficiency, 2009). Understanding the implications of this situation for India's energy resources, the Government of India introduced the Energy Conservation Building Code (ECBC) in 2007, and made further additions to the Code in 2008 to stipulate minimum requirements for energy-efficient design and construction of buildings and their systems (BEE Bureau of Energy Efficiency, 2008). It is estimated that the nationwide mandatory enforcement of the ECBC will yield annual savings of approximately 1.7 billion kWh (BEE Bureau of Energy Efficiency, 2009).

Based on field survey data and the quantitative and qualitative comparison of the thermal performances of traditional and modern buildings located in lower Himachal Pradesh, this paper suggests appropriate architectural design criteria and materials for the present-day construction of buildings in this region that will contribute to a sustainable built environment.

### **1.1 Location of study area**

According to the State Statistical Data of Himachal Pradesh up to 2009-10(2010), the state of Himachal Pradesh (HP) is located in the western Himalayas, between the latitudes of 30.38° to 33.2° North and the longitudes of 75.77° to 79.07° East, covering a geographical area of 55673 km<sup>2</sup>. The state is divided into 12 districts, and is surrounded by Jammu and Kashmir in the north, Tibet in the northeast,



**Figure 1** Location of Mandi Town in Himachal Pradesh.

**Source:** Census of India 2011

Uttarakhand in the east/southeast, Haryana in the south, and Punjab in the southwest/west.

The study area is located in the Mandi district of Himachal Pradesh, in and around Mandi Town (31.32° N, 76.53° E, at an average altitude of 850 m above mean sea level). Figure 1 shows the location of the study area.

### 1.2 Climatic conditions

The climatic zones of Himachal Pradesh can be classified based on elevation above mean sea level and related biogeography. Parts of the Una, Bilaspur, Hamirpur Kangra, Mandi, Solan, and Sirmour districts in the western and southern

regions lie below 1000 m, and are characterized by tropical to subtropical climates. Some portions of the Solan, Sirmour, Mandi, Chamba, and Shimla districts are located at altitudes between 1000 and 3500 m, and experience climate conditions varying from subtropical to wet-temperate with elevation. The districts of Lahaul-Spiti, Kullu, and Kinnaur have altitudes that range from 3500 to 6700 m, and they form part of the dry-temperate, subalpine, and alpine zones, receiving very sparse rainfall.

Mandi Town has a ‘subtropical’ climate, with warm summers and cold winters, and receives an average annual rainfall of 135 cm. Table 1 shows the monthly average climatic data for Sunder Nagar, located near Mandi Town in Himachal Pradesh, India.

**Table 1** Climatic data for Sunder Nagar in Mandi, Himachal Pradesh: Monthly averages

Month	Air temperature	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed
	°C	%	kWh/m <sup>2</sup> /d	kPa	m/s
January	9	75	3.57	93.8	3.1
February	11	76	4.61	93.6	3.3
March	14	65	5.71	93.3	3.4
April	20	52	6.81	93.0	3.6
May	25	42	7.42	92.6	4.0
June	26	58	7.12	92.3	4.2
July	25	85	5.89	92.4	3.5
August	24	83	5.46	92.6	3.0
September	23	83	5.62	93.0	3.0
October	19	64	5.29	93.4	2.8
November	13	65	4.32	93.7	2.8
December	9	69	3.45	93.9	3.0
Annual	18.2	68	5.44	93.1	3.3

**Source:** Indian Society of Heating, Refrigerating and Air Conditioning Engineers (ISHRAE & ASHRAE-India, 1981) and Statistical Data of Himachal Pradesh up to 2009-10 (2010)

## 2 Research Methodology

The aim of this research is to evaluate the architectural design features, construction materials, and building forms used in both traditional and modern houses in the study area in terms of their thermal performance during winter months, along with indoor thermal comfort of occupants and their cultural acceptance. We have focused on the winter months because under-heating causes more discomfort to occupants than over-heating in this particular geo-climatic region. A comparative study of thermal performance during summer months will be presented in future work. In the data collection, ASHRAE Standard 55 (2010) Class II protocols for conducting field surveys of indoor thermal environments have been followed. For the study, 20 buildings with typical characteristics were selected as case studies, representing both traditional buildings and modern naturally ventilated buildings. Measurements of indoor air temperature, globe temperature, air velocity, lighting level, and relative humidity were recorded for one week during the winter months of December to February 2012-2013. The hand-held calibrated digital instruments used were placed on a table in the centre of the living areas to take the measurements of indoor thermal environmental variables like air temperature, mean radiant temperature, relative humidity, air velocity, and lighting level. The outdoor climatic data were collected from the state meteorological department and other secondary sources (ISHRAE & ASHRAE-India, 1981).

We conducted a comfort survey with 100 occupants of both traditional and modern houses, in order to collect data about their subjective indoor thermal sensations and thermal preferences based on ASHRAE scales. Data was also collected from the occupants about their socio-cultural acceptance of contemporary house construction methods. These subjective quantitative and objective qualitative data were analysed and compared with the existing thermal comfort standards and models for naturally ventilated buildings according to the National Building Code of India (BIS Bureau of Indian Standards, 2005) and other 'adaptive comfort models'.

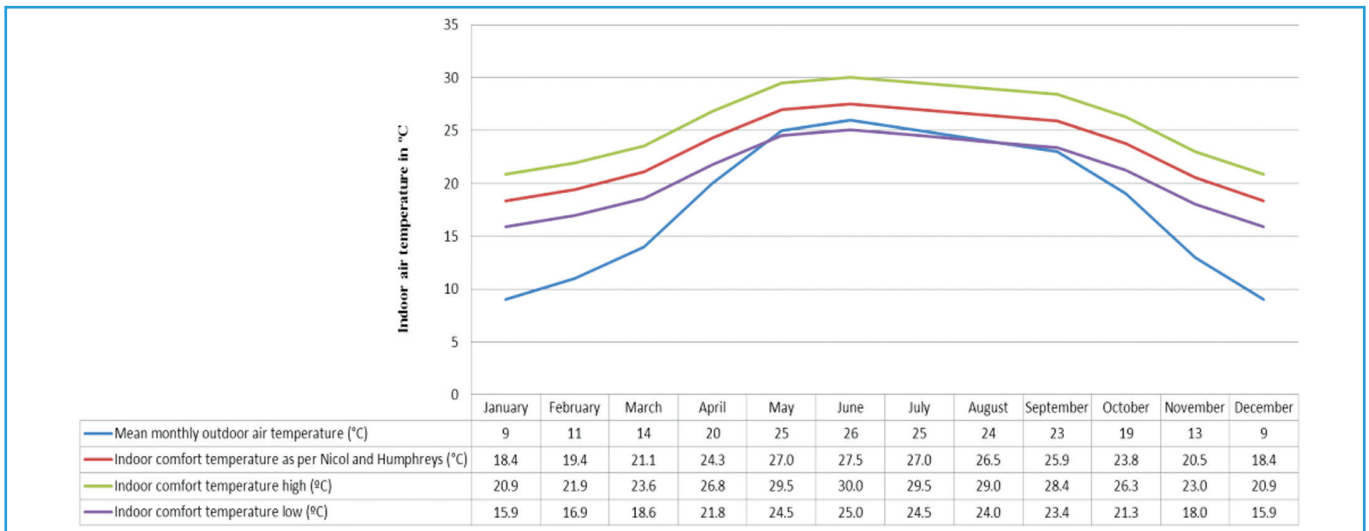
The findings from this comparative analysis of the thermal performance of traditional and modern houses are used to suggest suitable passive architectural design features in contemporary house construction in the geo-climatic study area, which will optimize energy consumption while providing thermal comfort to occupants during under-heating in winter months.

### 2.1 Indoor thermal comfort conditions

According to ASHRAE Standard 55 (2010), thermal comfort is defined as 'the condition of mind that expresses satisfaction with the thermal environment'. The comfort conditions of individuals depend on various physiological and environmental factors. Comfort may also be defined as the sensation of complete physical and mental well-being of a person within a built environment (Givoni, 1976). A survey of the literature found that most people are comfortable within a temperature range between 18-30°C and humidity conditions roughly between 30-70% relative humidity (RH), described as the 'comfort zone' on the psychrometric charts. Other factors that affect comfort conditions include environmental variables like mean radiant temperature and rate of airflow, and physiological variables like clothing and activity level (metabolic rate). In addition, the age, sex, state of health, cultural conditioning, and expectations of different people affect the 'comfort limit' by influencing their tolerances to discomforts.

To achieve thermal comfort for occupants, the The National Building Code of India (NBC) has recommended an indoor air temperature range of 18°C-22°C during winter months, with 50% RH and still air. The minimum acceptable comfort temperature for winter months is 15°C. Field studies by Humphreys (1976), Auliciems & de Dear (1986), de Dear & Brager (1998), and Baker & Standeven (1996) have established the dynamic 'adaptive thermal comfort model', which allows for a wider range of thermal comfort conditions, mainly because of physiological, psychological, and behavioural adaptation by occupants. The adaptive comfort model is most suitable for free-running





**Figure 2** Indoor monthly thermal comfort temperature range for naturally ventilated houses in Mandi, Himachal Pradesh

naturally ventilated buildings where mechanical cooling and heating is not present and occupants have total control over the operable windows. This model relates the indoor comfort temperature with outdoor mean air temperature. The adaptive comfort temperature equation proposed by Nicol & Humphreys (2002) for non-air-conditioned buildings is used in this study to calculate the comfort temperature range, shown in Figure 2. The equation is given below:

$$T_c = 13.5 + 0.54T_o \quad (I)$$

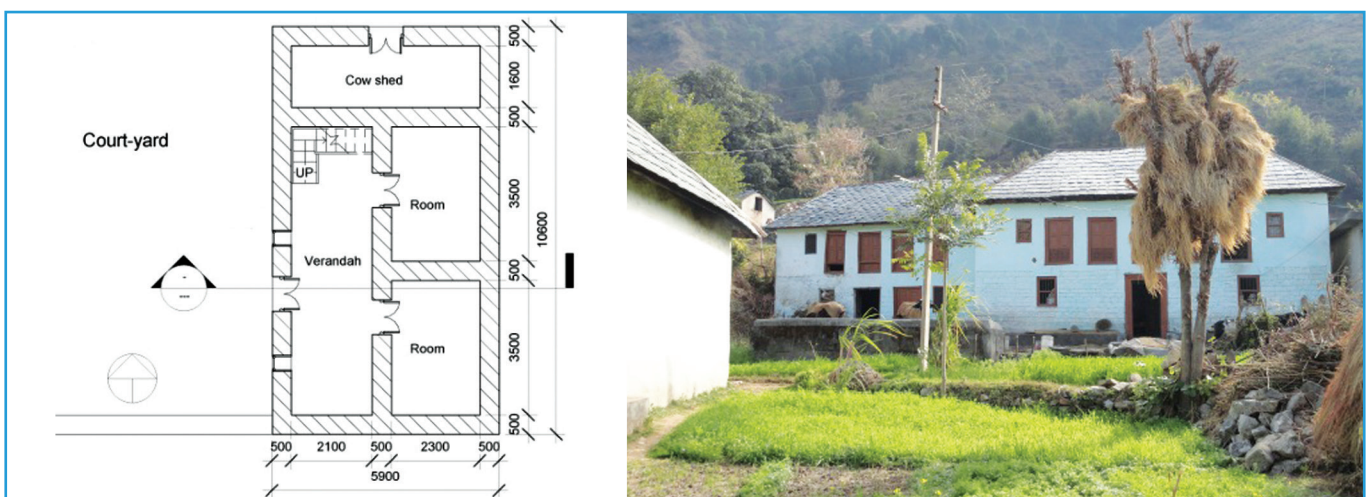
where  $T_c$  = comfort temperature and  $T_o$  = monthly mean of outdoor air temperature.

### 2.2 Description of a selected traditional house

Traditionally, houses are placed around a courtyard,

connected by narrow roads and alleys, in such a manner that the courtyard receives sunshine during winter months. This is a space where many activities (such as cooking, washing, outdoor sitting, and drying clothes) can take place during daytime, and it can be used for sleeping during hot summer nights. Courtyards are also used for drying crops/grains and for other occupational activities like cattle farming and animal husbandry. Toilets are also placed separately around the courtyard in most of the houses. Sufficient spacing was traditionally allocated between the clusters so that all houses had access to sunlight and air. Figure 3 shows the plan and view of the selected representative traditional house, along with the courtyard.

The selected traditional house is more than 50 years old, and features an east-facing orientation. It was constructed with a 0.5 m thick adobe and stone wall



**Figure 3** Plan (all dimensions are in mm) and view of selected traditional house in Mandi, Himachal Pradesh





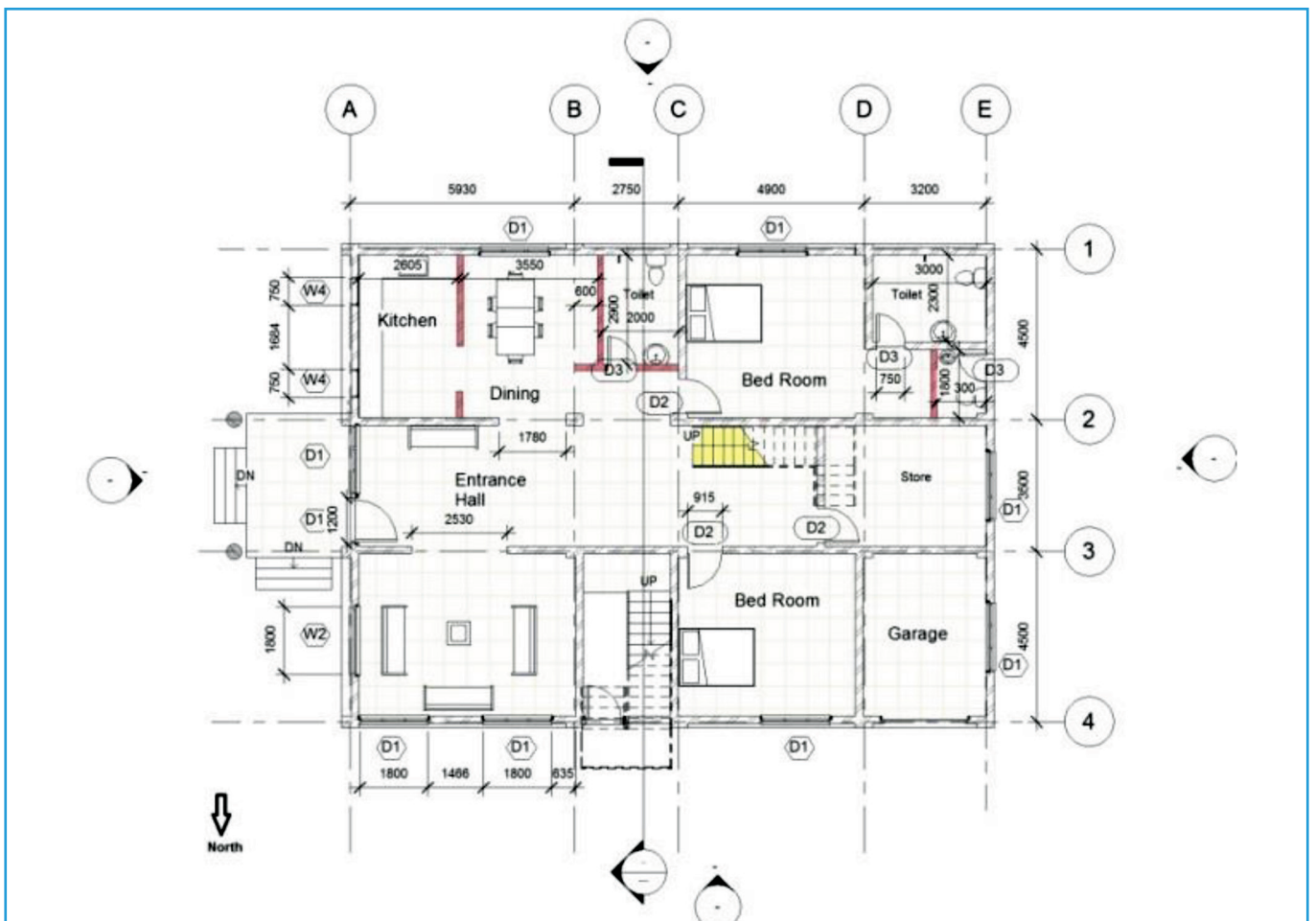
**Figure 4** View of ground and top floor of selected traditional house in Mandi, Himachal Pradesh

with mud plaster. Living rooms are situated on the ground floor, and the kitchen is located on the top floor. The flooring is constructed of wood planks supported on timber joists and finished with mud flooring. The height of the ground floor is 2.2 m and the top floor is 2.1 m high. The small openings are provided on the front side only; no other openings are provided in any room. The smoke from the kitchen exhausts outside through the roof via natural

convection. Figure 4 shows the ground and top floor details found in the selected traditional house.

### 2.3 Description of a selected modern house

Figure 5 shows the construction plan of a selected modern house, and Figure 6 shows a view of the house. The present construction uses a 23 cm thick burnt-brick external wall, an 11.5 cm thick internal



**Figure 5** Plan (all dimensions are in mm) of selected modern house in Mandi, Himachal Pradesh

wall made of burnt clay bricks, and a 10-15 cm thick reinforced cement concrete (RCC) roof. The floor height is 3 m and the windows are 1.5 × 1.5 m on all sides. In the selected modern house, the longer axis is oriented in an east-west direction, but the front façade and main entrance face east, due to prevailing cultural conventions.

Figure 7 shows a view of modern residential buildings in Mandi, Himachal Pradesh. The buildings have been constructed in a linear pattern, with a south/southwest orientation to allow the sunlight to reach the outdoor areas and living areas during winter months when the sun's position is low on the horizon. This construction practice represents

a beneficial continuity with the traditional way of arranging habitable rooms.

### 3 RESULTS AND DISCUSSION

#### 3.1 Architectural passive design features

Based on the physical on-site survey of vernacular houses in the hill settlement of Mandi Town in Himachal Pradesh, the aspect ratios of the houses were found to be near 1:1.6, which equals the 'golden proportion'. This is achieved through linear arrangement of two rows of rooms, with the front row being a deep enclosed verandah, which allows the sunshine to fall inside the house during



Figure 6 View of selected modern house in Mandi, Himachal Pradesh during January (winter)

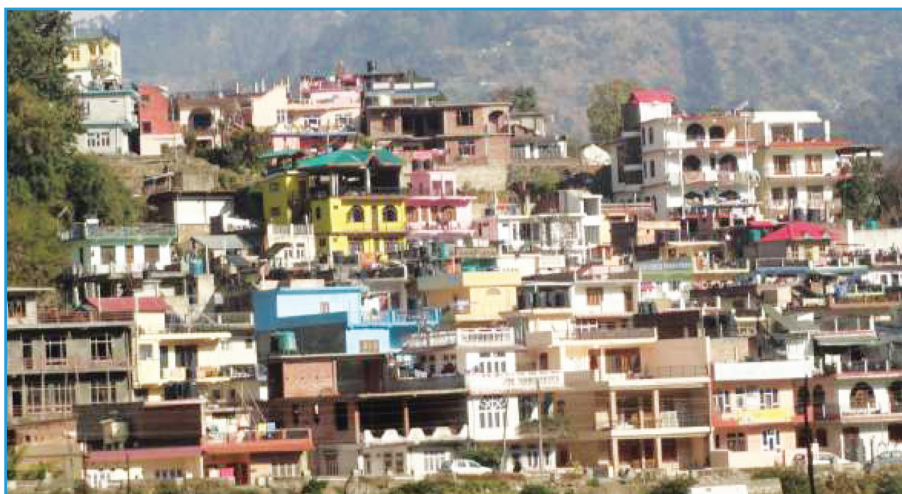


Figure 7 View of modern houses in Mandi, Himachal Pradesh during winter months



winter months and cool breeze to flow inside past the shaded verandah during hot, humid summer months. The shaded verandah and the thick walls also keep the interior cooler and more comfortable in hot months by cutting of the hot summer sun. The houses comprised two storeys, with the height of each floor not more than 2.2 m, and with an attic floor situated below the pitched roof. The exposed surface area to volume ratio of the selected traditional house is 0.6, which signifies the compactness that local builders have achieved in these vernacular houses by ensuring a low floor-height in the construction. The lower surface-to-volume ratio also helped the traditionally constructed houses to achieve less heat loss in winter months to clear night skies, and less heat gain in hot summer days. The area of openings is kept to less than 5% of the total floor area, which prevents heat loss during cool winter months. However, the daylighting conditions were found to be poor because of this small amount of openings. Moreover, the orientation of the houses were due east, due to cultural conventions; therefore, were not able to exploit the benefits of south orientation. However, the main drawback in the traditional construction style is that these houses provide much less carpet area – only 65% compared to the plinth area – which is not acceptable by the occupants in the present-day context. The reason for this drawback is that the houses were constructed with thick external and internal walls, which consume around 35% of the floor area.

In the modern houses, the architectural design has been executed with the aim of orienting as many habitable rooms as possible towards east

and southern directions, in order to allow daytime heating of the habitable rooms during winter months. The exposed surface area to volume ratio of the selected modern house is 1.4, which is compact enough and appropriate for this type of climate. This also demonstrates that when present-day buildings are designed with due consideration to local geo-climatic conditions, they can achieve the compactness required for the local climate. The larger size of the openings allowed more daylight in the interior of the rooms, but it also contributed to more heat loss, resulting in cooler interiors after sunset during cold winter months. Balconies and terraces with southern or eastern orientations are beneficial for direct solar heat gain during winter days, but may require protection against heat loss during cool winter nights.

### 3.2 Thermal properties of construction materials

Table 2 shows the thermal properties of the materials used for the construction of vernacular houses and modern houses in Mandi Town in Himachal Pradesh, India. It can be seen that the traditional construction methods, in terms of wall thickness, floor and roof construction, and materials used produce better thermal heat storing capabilities and higher time lag, which are suitable attributes to respond to the high annual mean temperature range from cold to hot and humid months that is characteristic of the region. By contrast, the present day construction methods do not provide the houses enough thermal capacity and time lag to maintain indoor conditions that are thermally comfortable for local geo-climatic conditions, especially during winter nights when

**Table 2** Comparing thermal properties of construction materials used in traditional houses and modern houses in Mandi, Himachal Pradesh

Function	Overall thickness (m)	U-value (W/m <sup>2</sup> k)	Thermal capacity (kJ/m <sup>3</sup> k)	Time lag (hours)
Brick wall (external)	0.25	2.6	1529	8
Stone wall with mud plaster (external)	0.5	1.47	1700	11
RCC roof	0.2	3.3	2013	4.5
Slate roof with attic	1.0	2.11	1604	10

Source: Koenigsberger et al., 1984

the outdoor ambient temperature drops below 2°C. These recent construction practices have resulted in the interior rapidly becoming cooler during winter months, especially after sunset, and hotter during summer months. This increases dependence on mechanical means of temperature regulation, like heaters and ceiling fans, to maintain comfortable indoor conditions for a large part of the year, resulting in more energy consumption and increased pressure on non-renewable energy sources.

### 3.3 Comfort of indoor thermal conditions

The field survey of the traditional and modern houses was carried out in the winter months between December 2012 and February 2013. It was found from the data and observation that December and January are the coolest months, when the average outdoor ambient temperature varies from a minimum 2°C to a maximum 16°C. Table 3 shows the comparison of indoor air temperatures found in the selected traditional and modern houses in Mandi, Himachal Pradesh during these cold winter months. It was found that the indoor air temperature of the traditional house is 2-3°C higher than in the modern house and closer to the adaptive indoor thermal comfort temperature range for the winter months. Especially during the night, the indoor air temperature in the traditional house was closer to the acceptable lower limit of comfortable temperatures in comparison to the indoor air temperature in modern house. Indoor relative humidity was within the range of 60-70% in both the traditional and modern houses, which is within the comfort range. Figure 8 shows a comparison of the daily indoor air temperature conditions found in

the selected traditional and modern houses during a winter month. As this figure indicates, the indoor temperature in the traditional house remained above 15°C – the minimum temperature deemed comfortable by the NBC – for almost 12 hours per day, i.e. 50% of the daily hours. This is due to the comparatively better heat-storing capacity of its construction materials, especially during cold winter nights, and to the larger thermal capacity and time lag properties of the construction methods. Conversely, the duration of indoor temperature above 15°C in the modern house was found to be only 4-5 hours during a winter day.

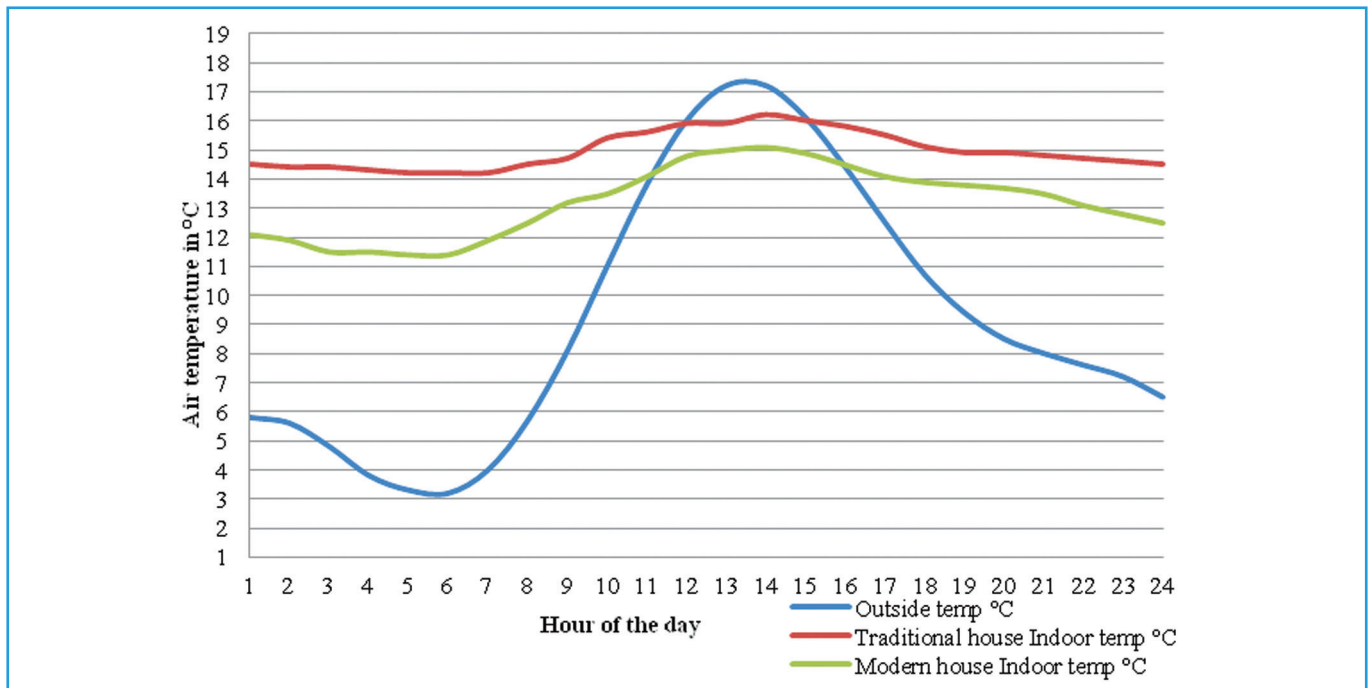
The indoor globe temperature, an expression of indoor mean radiant temperature, was found to be almost equal to the indoor air temperature in the traditional house. In the modern house, the indoor globe temperature was greater than the indoor air temperature by almost 1°C when the windows were kept closed and the rooms were filled with upholstery, and it was lower by 1°C when the window were kept open. Indoor thermal sensation was also found to be affected by the air velocity. Almost all the occupants who participated in the survey expressed their acceptance and satisfaction with the indoor thermal environment of the traditional house, whereas, in case of modern house, they preferred a higher indoor temperature during winter months.

### 3.4 Behavioural adaptations of the occupants

Field surveys (Nicol & Roaf, 1996) have previously reported that users' behavioural adaptations are crucial to achieve indoor thermal comfort in naturally ventilated buildings. In this study, we also observed

**Table 3** Comparison of indoor air temperature of selected traditional and modern houses in Mandi, Himachal Pradesh, India

Months	Outdoor air temperature °C		Indoor air temperature in traditional house °C		Indoor air temperature in modern house °C		Indoor min. comfort air temperature as per Eq. (1) °C
	Max.	Min.	Max.	Min.	Max.	Min.	
December	16	2	16.5	14.5	15.6	12.9	15.9
January	16	2	16.2	14.4	15.1	11.9	15.9
February	18	4	16.8	14.6	15.9	13.2	16.9



**Figure 8** Indoor air temperatures vs. time in the selected traditional and modern houses in Mandi town in Himachal Pradesh in month of January

that the occupants of these vernacular houses actively carry out various adaptation measures to maintain indoor thermal comfort in a sustainable manner. These important behavioural adaptations include: (1) clothing adaptations, like wearing heavy woollen clothing (1.6 clo) in winter and light clothing (0.5 clo) in summer months; (2) closing doors and windows in cold winter months; (3) conducting activities in the sunny outdoor courtyard on winter days; (4) staying near heat sources during cold winter nights; and (5) adaptive synchronization of activities with temporal environmental conditions, like carrying out heavy work in well-lit outdoor spaces in winter months and in shade at a slower pace during hot summer months. The design of the dwellings and the distribution of their rooms showed a great degree of connectivity between indoor-outdoor spaces, which evolved over time based on the activity patterns of the inhabitants of this traditional settlement, by adaptively responding to the geo-climatic conditions of the place for holistic sustainability. Similar observations were also reported by Rijal and Yoshida (2002).

During the study, inhabitants informed us that although they felt more comfortable in the traditional houses, they constructed new houses

using comparatively lighter materials, because of: (1) less carpet area available in traditional houses; (2) maintenance problems resulting from termites, etc.; (3) lifestyle changes; (4) availability of newer construction materials; (5) desire to maintain social status; and (6) non-availability of artisans who can practice traditional construction methods. It was quite disheartening to discover that the owners of these traditional climate-responsive, sustainable houses – which evolved from the years of wisdom and practice – who used to take pride in them, were at present changing their behaviour and attitude towards a preference for architecture that is not in full harmony with the local geo-climatic conditions. Similar trends were also observed by the other researcher (Upadhyay, Yoshida & Rijal, 2006). Because of diminished demand, the art of these traditional construction methods are slowly disappearing.

Modern RCC-framed structures can offer good resilience against adverse outdoor environmental conditions, if designed and constructed in harmony with local geo-climatic conditions. With advancements in building science, the design and construction of buildings should be more harmonizing with surrounding nature, and it



widely demonstrated that important answers lie in vernacular structures based on traditional climate-responsive architecture and sustainable construction methods. Modern buildings must also be designed, wherever possible, to provide comfortable indoor conditions for inhabitants without using costly mechanical means but ensuring the long-term holistic sustainability of the built environment. This can be achieved by adopting proven climate-sensitive, economical, and less energy-consumptive construction methods, and by using materials that are suitable for the particular geo-climatic location and are easily available locally without any negative impact on nature.

## 4 Conclusion

This comparative study has shown that the architecture and construction methods that have evolved in the vernacular settlement of Mandi Town in Himachal Pradesh are more thermally comfortable and more responsive to local climatic condition than modern houses. The high thermal mass of the traditional construction methods and materials made it possible for the indoor environment to remain comfortable for almost the entire year, even without using any mechanical means like ceiling fans or heaters, by damping the large daily and annual variation in temperature. Traditional houses were constructed to function like an 'organism', giving a third level of protection to its inhabitants against environmental extremities, after the protective layers of their own skin and clothing. In acknowledgement of the need to support the continuity of tradition in building design and construction, the HP Government has introduced amended building bye-laws (2009), making it mandatory to design public office buildings with passive design features, suitable for their geo-climatic locations. The Government of India also introduced the Energy Conservation Building Code in 2007 to make buildings more energy-efficient, thus saving energy and promoting sustainability. The valuable lessons learnt from this study should enrich knowledge on the topic and enable architects,

planners, urban designers, and administrators to establish a fine balance and synergy between traditional wisdom and modernization, in order to design sustainable buildings by empowering all stakeholders with necessary support. Further studies should be conducted to develop better understanding of suitable construction materials. Based on this comparative analysis of the traditional and modern building design and construction techniques, together with the results of bio-climatic analysis of local climatic data using Mahoney's table (Koenigsberger et al., 1984), the following design recommendations are recommended for contemporary building design and construction in the geo-climatic location of Mandi in Himachal Pradesh:

1. Buildings should be oriented due south, so that they can receive sunshine during winter months;
2. The aspect ratios of the houses should be kept near to 1:1.6, and the surface area to volume ratio of the building mass should be less than 1.4;
3. All habitable rooms should be single-banked, with south-facing openings;
4. External and internal walls should have more than an eight-hour time lag. They may be constructed with cavity-wall construction – brick walls (112.5 mm thick) with outside plaster, air cavity (50 mm thick), and an internal brick wall (112.5 mm thick) with internal plaster and finishes (U-value =  $1.7\text{W}/\text{m}^2\text{degC}$ , time lag = more than 10 hours);
5. Roofs and floors should be constructed with materials characterized by a more than eight-hour time lag. Pitched roofs may be constructed with tiles or slates on boarding, and finished with plaster ceilings and attics (U-value =  $1.70\text{W}/\text{m}^2\text{degC}$ , time lag = 10 hours);
6. Heavy floors may be constructed of concrete on the ground or hardcore fill, with either tile finish

(U-value = 1.13W/m<sup>2</sup>degC) or wood block finish (U-value = 0.85W/m<sup>2</sup>degC);

7. Opening areas should not constitute more than 15-20% of the floor area, and they should be primarily located on the southern wall;
8. Shading over openings should not obstruct sunlight from entering into habitable rooms during winter months;
9. External front open spaces/balconies/terraces on the southern side should be utilized for outdoor activity during daytime in winter months.

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paper

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Project GRIHA: An initiative for affordable  
housing in rural Karnataka

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# Project GRIHA: An initiative for affordable housing in rural Karnataka



## Abstract:

Our organisation is a not-for-profit architectural NGO that seeks to provide professional design and construction support for rural housing and infrastructure as a Design and Build Venture. Our vision is for every villager to live in his permanent home. In total, 65% of India's population lives in rural areas. A whopping 81% of rural India lives in temporary structures (Ministry of Rural development, 2011). Project GRIHA's approach is to analyse the climate, culture, vernacular design, local material availability, current needs, and usage patterns of people in various zones of Karnataka. Using this, a design template and palette will be developed for a core house module that will cater to flexibility of growth, give people access to design, technology, technical knowhow, necessary construction materials, and empower them to build their own homes. The cost of each core house must be achievable within government allocated funds. We have choreographed our research and design to prototype readiness.

**Keywords:** *affordable rural housing; core house; prototype construction*

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## 1 The need for affordable housing in rural India

India lacks 250 lakh units of rural housing. The rural area houses 75% of the population. Poverty is concentrated in the rural areas, where one in five dwellers live in a Kuccha house (impermanent and not-durable) (Ministry of Rural development, 2011). House builders in rural areas face potential roadblocks in the form of issues arising from land ownership, fund mobilisation, regulation, procuring of building materials, and access to skilled labour, carpenters, and other specialty tradesmen as well as a lack of knowledge of cost saving technologies. Since insufficient funds are provided by Indira Awas Yojana, people resort to private sources of finance to build permanent homes. **The houses are**

**'shabby, unsafe, and uncomfortable', and metal sheets add to climatic discomfort. Villagers lack access to technical knowhow, as there are no technology resource organisations to empower them. Neither do Panchayats possess or provide the same** (Bhide et al., 2009). Our focus is to address this lacuna.

## 2 Our organisation

Our vision is for every villager to live in his own permanent home. Ours is a not-for-profit organisation based in Bangalore. Established in January 2011, we seek to provide professional design and construction support for rural housing and infrastructure as a Design and Build Venture.

### 3 Features of rural housing (Shah, 2002)

- Self-built, self-managed, community-financed  
No public/private housing finance agencies until recently
- No master-plan to regulate development and no bye-laws to regulate construction
- No trained professionals, e.g. architects or engineers
- No real estate developers and contractors operate in rural areas
- The house builder solely controls the production process: Household's access to land, finance, skills, technology, and services determine quality
- Participatory social production process: a 'people's process'
- Declining access to biomass materials such as thatch, bamboo, wood, and cow dung
- Limited exposure and access to new building materials, construction methods, and technology
- Gradual disappearance of traditional knowhow on materials and methods

## 4 Project GRIHA

### 4.1 Our Dream

GRIHA is the necessary step in achieving our vision. Project GRIHA's approach is to analyse the climatic, cultural, vernacular, local material availability, current needs, and usage patterns of people in various zones of Karnataka. Using this, a design template and palette will be developed for a core

house module that will cater to flexibility of growth, give people access to design, technology, technical knowhow, necessary construction materials, and empower rural folk to build their own homes.

### 4.2 Why GRIHA

Housing is the most basic need after food and clothing. It ensures economic security and brings about profound social change, endowing people with identity, dignity, and integration with the social milieu. Most affordable housing solutions fail, as they do not consider the context or end user, and thus provide a cookie-cutter solution—a one-size-fits-all mentality. To the homeowner, the home has a very strong emotional and cultural connotation—it involves pride, self-worth, and a sense of achievement. To involve the homeowner in the decision-making process by offering a palette of solutions to choose from within budget constraints, and by involving him in the construction labour for his house, GRIHA hopes to realise the intangible need in housing: a sense of overall well-being. Depending on various factors, homeowners' aspirations are likely to vary across different villages. GRIHA provides an avenue for catering to these needs.

### 4.3 What is a core house?

A core house is an incrementally buildable house (Maly et al., 2013), where basic needs and spaces such as an entrance, multipurpose room, kitchen, WC, and bath are constructed to allow for vertical or

**Table 1** Potential Stakeholder Contributions

SL.NO.	ORGANISATION	AMOUNT	DESCRIPTION
1.	Government schemes and policies	Rs 1,25,000 (USD 2100)	The Indian Government's Indira Awas Yojana (IAY): 75% Central and 25% State Government of Karnataka's Basava Housing Scheme
		Rs 10,000 (USD 170)	Toilets: Rs 3,000 given by MGNREGS (Mahatma Gandhi National Rural Employment Guarantee Scheme), Rs 6,000 by the Total Sanitation Programme, and Rs 1000 by the beneficiary
2.	Beneficiary	Rs 25,000 (USD 420)	This amount can be taken on loan by the beneficiary. The National Housing Bank has been given a Rural Housing Fund of Rs 3000 crore allotted exclusively for this purpose.
<b>TOTAL =</b>		<b>RS 1,60,000 (USD 2700)</b>	At the rate of Rs 60 to 1 USD
3.	NGOs/Donors	As per funding	They are required to bring expertise in housing and infrastructure, and work with the community.

horizontal future expansion. Families can build on this base when their financial conditions improve.

#### 4.4 Why Rs 1.6 lakh (about USD 2700)?

There are 10 crore households in India that earn less than Rs 7,000 (USD 120; 1 USD = Rs 58) per month. About 60% of India's rural population lives on less than Rs 35 (USD 0.6) a day (Economic Times, 2012). As shown in Table 1, potential stakeholders have provided **Rs 1,60,000**:

#### 4.5 GRIHA research methodology

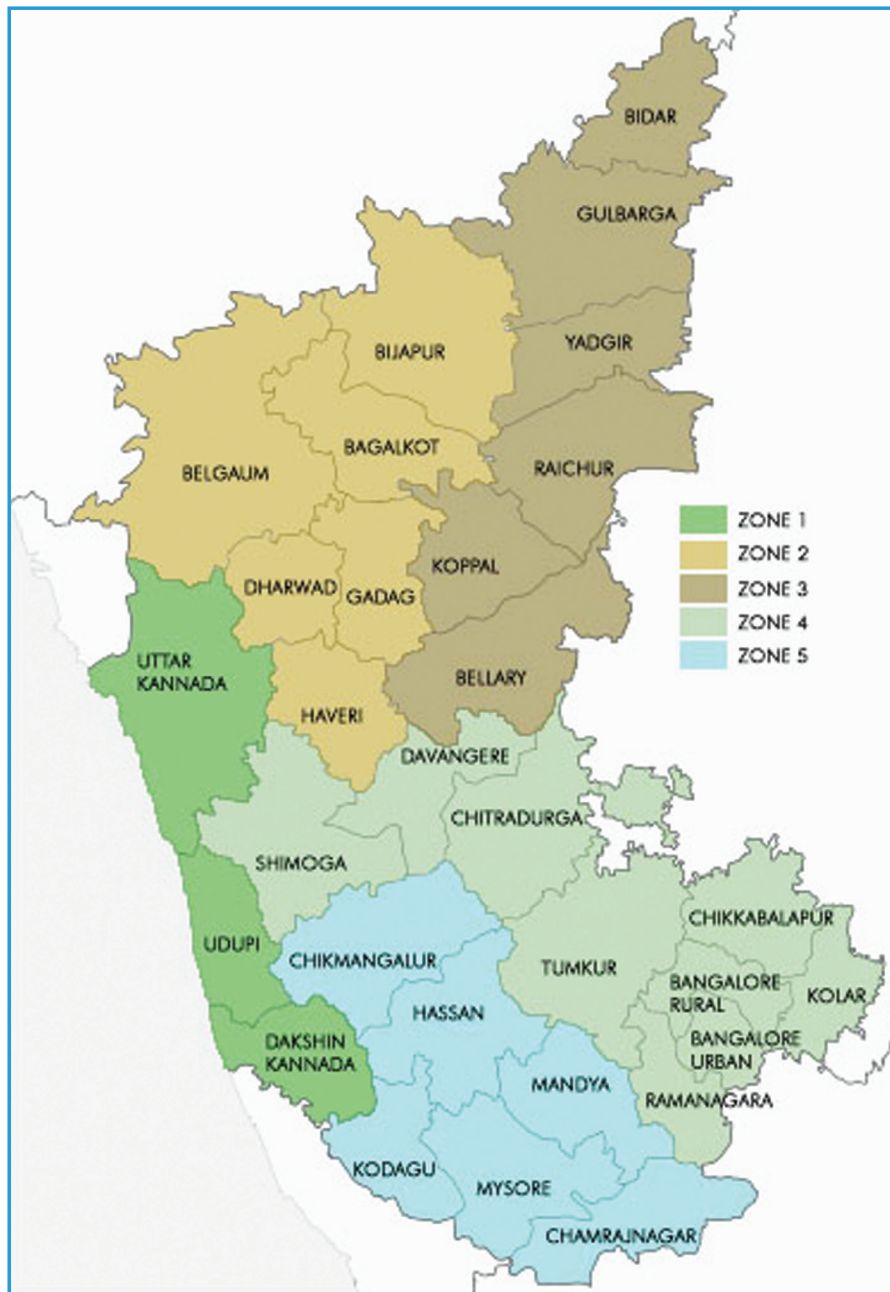
The 30 districts of Karnataka have been categorised into **five main zones** according to climate and administration as indicated in Table 2.

We plan to conduct our research and design according to zone. Our method is to:

- **Interact** > With the local community to understand cultural usage of space, cultural beliefs, and sensitivities. Study local materials, local skills, and building techniques. Study climatic conditions like natural light, thermal comfort, wind direction, and ventilation.
- **Collaborate** > With the Government, NGOs, self-help groups, international agencies, banks, institutions, corporates, and individuals for financial and non-financial assistance
- **Engage** > The architectural and structural community for research and development of alternative materials, construction methodologies, and volunteers

**Table 2** The five zones of Karnataka according to climate and administration (Karnataka State, 2013)

ZONE	DISTRICTS	ADMINISTRATIVE DIVISION	METROLOGICAL DIVISION	CLIMATE TYPE
Zone 1	Uttar Kannada Udupi Dakshin Kannada	Belgaum Mysore Mysore	Coastal Karnataka	Tropical Wet
Zone 2	Belgaum Dharwad Gadag Haveri Bagalkot Bijapur	Belgaum	North Interior Karnataka	Arid to Semi-arid
Zone 3	Bidar Gulbarga Yadgir Raichur Koppal Bellary	Gulbarga	North Interior Karnataka	Arid to Semi-arid
Zone 4	Davangere Chitradurga Tumkur Chikkabalapur Bangalore Rural Bangalore Urban Ramanagara Kolar Shimoga	Bangalore	South Interior Karnataka	Tropical Wet and Dry
Zone 5	Chickmangalur Hassan Mandya Mysore Chamrajnagar Kodagu	Mysore	South Interior Karnataka	Tropical Wet and Dry



**Figure 1** The five zones of Karnataka according to climate and administration  
**Source:** Karnataka State, 2013

- **Derive** > Specific, local, eco-friendly, long lasting, and cost-effective design solutions
- **Construct** > Help/Train/Empower people in building houses

## 5 Project GRIHA in action

### 5.1 Research and design of Zone 1

In April 2013, we organised a test trip to Zone 1, the coastal region of Karnataka, to chart the timelines

needed for such research, whether such a study was possible, to assess the need, and to determine the budget required for this type of research and development (R&D). We embarked on a one-week tour of Uttara Kannada and Dakshina Kannada, and accessed the community with the help and support of the well-connected and well-known NGO, SKDRDP (SKDRDP, 2006).

We studied local culture, customs, and space usage, and assessed the local character, materials available,



and construction techniques prevalent in the region, then started seeking funds for our R&D efforts.

## 5.2 Project GRIHA at Kundapur

In November 2013, we were approached by Selco Foundation to erect a Rs 2 lakh house prototype that included their solar component in Kundapur, Udipi District. The initial study in Zone 1 helped us jump-start the project.

## 5.3 Research, literature, and site study

We conducted an extensive literature study on vernacular architecture, and used questionnaires and surveys to research the architectural evolution of the region. We visited Manuru village—the probable site of our prototype—and met with the Panchayat, various neighbouring villages, and likely occupants with the aid of Selco and SKDRDP. We learnt about the site and soil conditions, people's views on construction, aspirations for their houses, their issues and perception on design, materials, and usage of space.

Furthermore, we met with a local contractor keen on affordable housing who had good knowledge on local techniques, current rates, and so on. This data was crucial in making our proposal financially viable.

## 5.4 Summary of our study (literature and site visit)

### a. Place

Kundapur is a taluk in the Udipi district in Karnataka, India. The three northern taluks of Udipi, Kundapur, and Karkal separated from the Dakshin Kannada District to form the Udipi District in August 1997. It is located about 36 km to the north of Udipi. We visited Giliyaru, Manuru, Manuru Padukere, and Kodi, which are part of the Kundapur Taluk.

### b. Climate

The district's climate shares the wider climatic pattern of India's other West Coast districts. The district is characterised by excessive humidity (78%). There are four seasons: (i) Four very wet months in June, July, August, and September, when the district encounters strong winds, high humidity, heavy showers, and a slight drop in temperature. The average annual rainfall during this time is close to 3500 mm; (ii) Two warm and damp months in October and November, when the southwest monsoon retreats; (iii) Three cool months in December, January, and February, when generally dry conditions prevail; and (iv) Three hot months in March, April, and May, when temperatures rise (Udupi Online Archive, 2014).

### c. History

This municipal town is renowned for its Kundeshwara temple. There are many references to the temple in 13<sup>th</sup> century inscriptions. Recorded as 'Kundapura', the name is derived from Alupa Kundavarma. Kundapura is at the mouth of the shore where five rivers join the ocean. The first reference to 'Kundapura' is found in an inscription from 1262 A.D., which was found in the Kundeshwara temple (Udupi Tourism, 2014). This was the principal port of the Rajas of Byndoor, who came to prominence after the decline of the Vijayanagara power. Portuguese and German missionaries settled here in the 16<sup>th</sup> century and built a fort. The British took over the town after the fall of Tipu Sultan in 1799 (Navada, 2013).

### d. Castes

There are about 40 different castes in this region, including Bilava, Mogaveera, Saraswath Brahmins, Gauda Saraswath Brahmins, Vishwakarma, and Bunts. Bunts are the most powerful community in the region. They belong to the military class, hence the community names as Bunts or Bantaru. They have 93 sects (clans) with names such as Alva, Rai, Shetty, Chouta, and Ballal (Udupi Tourism, n.d.).

**e. Vernacular**

At Dakshina Kannada, in Udupi district, we found independent houses and small hamlets of several houses. The houses are usually constructed near the fields to help people focus on agriculture. Dwellings are constructed to suit the climatic conditions of the area. A common feature of this area is the thatched roof, constructed to ward off excessive rainwater on the roof. There is sufficient open space around the house. The centre courtyard (kana) with mettikamba (a small pillar) is always kept clean. For strength and security purposes, the houses are built on an elevated platform (panchanga), which is 2-3 feet high. Stone or laterite bricks are used to construct this platform (Udupi Tourism, n.d.).

In the Tulunad region, 66 Guttu houses have been recorded. Note that in the Kundapura region, Bunts are a rich community who own the Guttu houses.

**f. Bunt community and relevance of Guttu houses**

Guttu houses are the showpieces of the Bunts' socio-political life in Tulunad. They have functioned as focal points of Bunt high culture, being the best advertisements to Bunt leadership in traditional society or in the formation of Tulu culture. Bunt culture is not exhausted with Guttu brands, but has passionately projected them (Udupi Tourism).

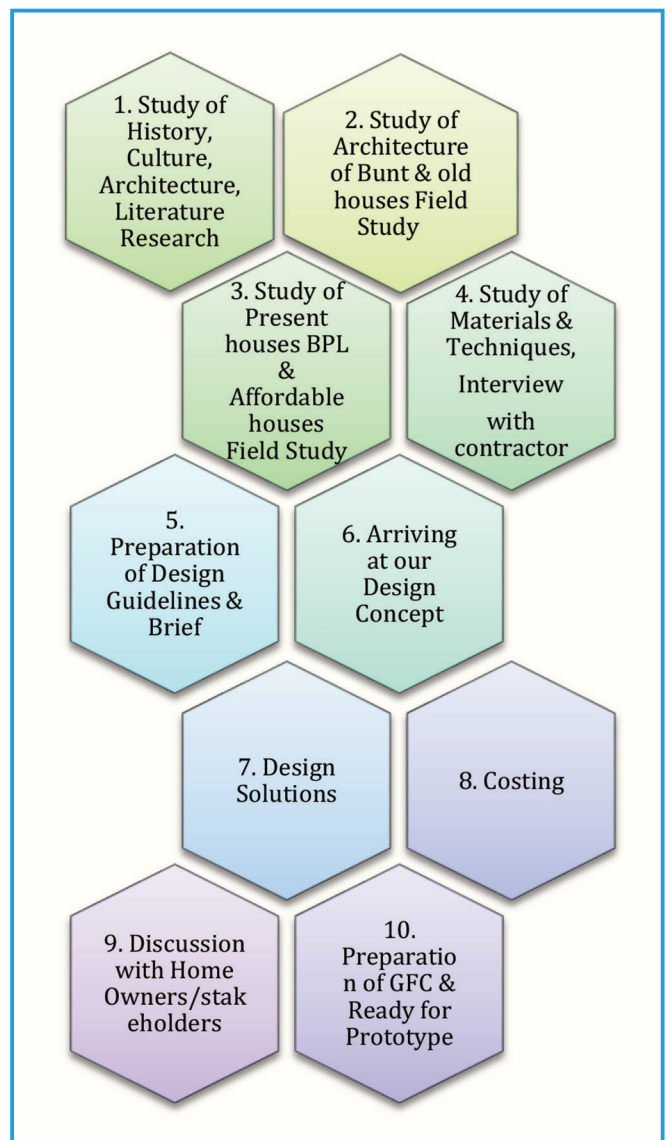
In his 'Traditional Houses of the Bunt Community, Dakshina Kannada: A Study of Guttu Houses', Sagar S. Shetty shows how religious beliefs and practices of the community, the agrarian predilections of the household, and the political and social leadership that it wielded are reflected in its architecture (Rao, 2010).

These houses must be studied to understand their heritage. Not all of it may be adopted in the changed context of time and space; however, they should be with us as mementos of history, as awareness, and as a link between the past and present (Rao, 2010).

**g. Our observations**

In Kundapur, the GRIHA project focused on building a prototype at Manuru village at the sites allocated to us. Hence, there was no need to study traditional settlement patterns and village culture, which might be 'ideal' holistic models for replication. The study was more focused on the underlying unobvious linkages between why a particular habitation comes up at any location. This would provide insight into different factors affecting different settlements.

As the Bunt community is the most predominant community in this region, we conducted a detailed



**Figure 2** Sequence of steps leading to the design solution.

study of Bunt or Guttu houses. Based on our visit, we now understand that other communities' traditional houses have borrowed the style of design and construction from the Bunts.

Our study on recent constructions to understand evolution in construction and people's current mind-sets indicated that people are enterprising, resilient, and open to new materials. They were keen to try new techniques (provided a knowledgeable professional was available to take the bottom line) and open to providing labour for building their own houses. They were particular about Vaastu, a more

recent phenomenon in the last 20 years. We did not discuss financial issues.

A in-depth study of Bunt houses conducted by Shetty (2010) provided deeper insight into its design.

## 6 GRIHA choreography

We orchestrated a series of steps graphically (see Figure 2): we converted our detailed analysis of the Bunt house into pictorial form, developed design guidelines, created a succinct design brief, conceptualised designed options, and calculated

### a. Site

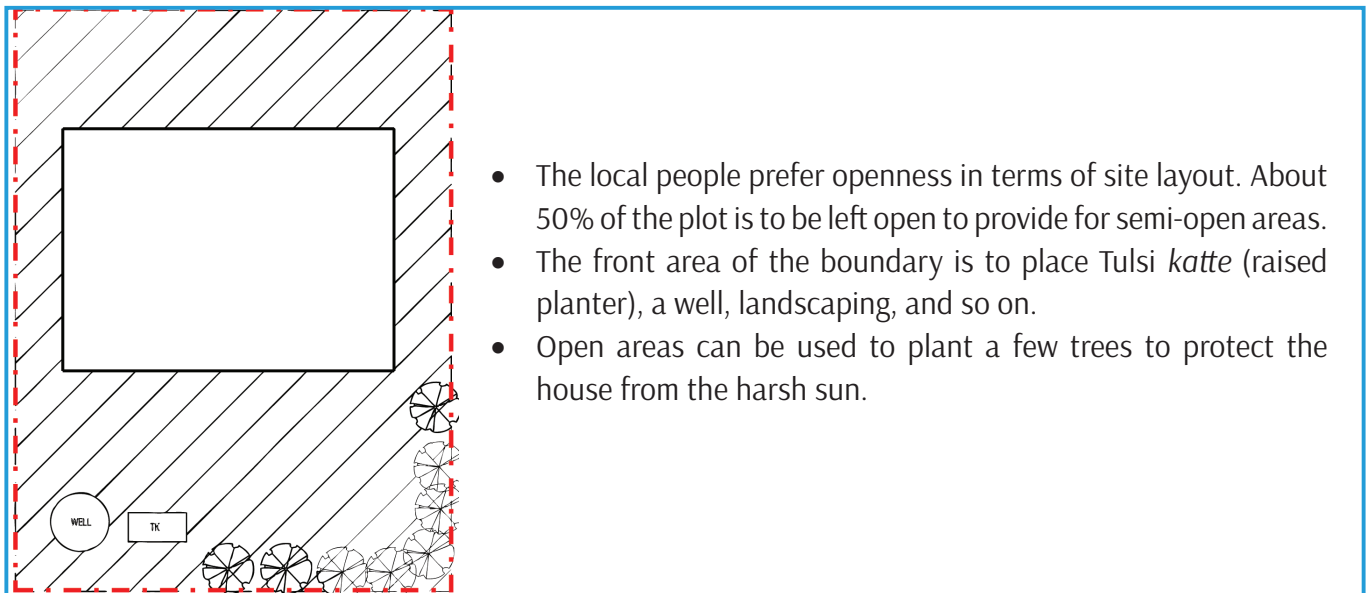


Figure 3 Depiction of open spaces

### b. Climate

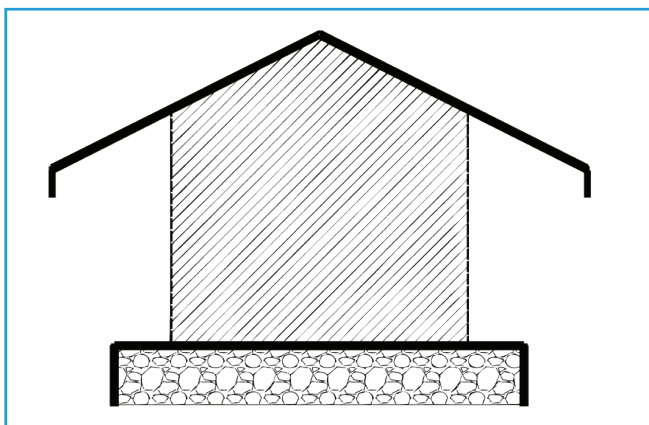


Figure 4 Climate-responsive design interventions

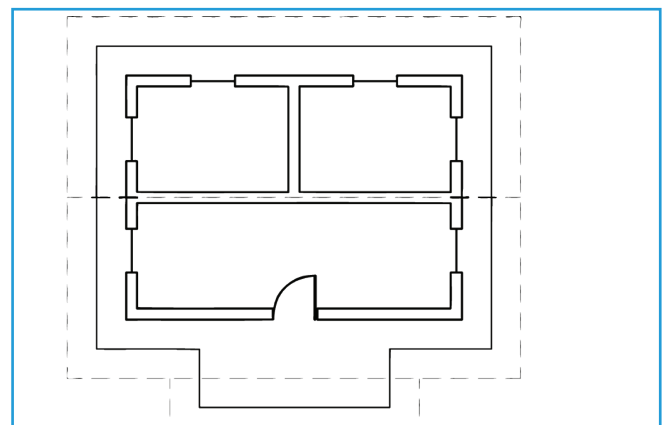


Figure 5 Plan indicating cross ventilation, walkable path around house, and front verandah

costs. This choreographed product will result in a set of detailed drawings needed for good construction.

## 6.1 Design guidelines for GRIHA Kundapur

### c. Materials

- Foundation and Plinth:
  - Most common is a plinth of 5'6" (with two courses below ground) constructed with size stone masonry.
  - Alternatively, random rubble masonry and laterite blocks (below ground undressed, above ground dressed) are also used depending on budget constraints, material availability, and proximity.
- Walls:
  - Older buildings are constructed in laterite, while newer extensions are constructed in solid cement blocks.
  - Cost of the laterite blocks depends on the proximity and finish of the blocks. Undressed laterite is cheaper than dressed laterite
- Roof:
  - Sloping Mangalore tile roofs with wooden supports are ideal as they ensure uninterrupted rainwater runoff. All subsidiary spaces (verandas, semi-covered stores, toilets, and so on.) have asbestos roofing with steel pipes/wooden members as supports.
  - Asbestos, a hazardous material, must be discouraged and replaced with a Mangalore-tiled roof with MS supports or galvalume sheets over MS members, depending on budget.

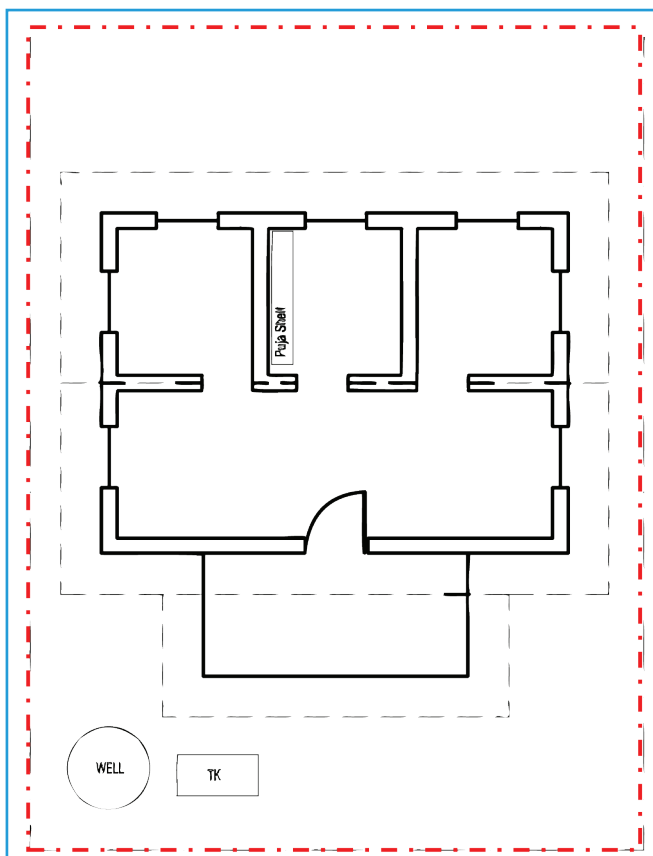


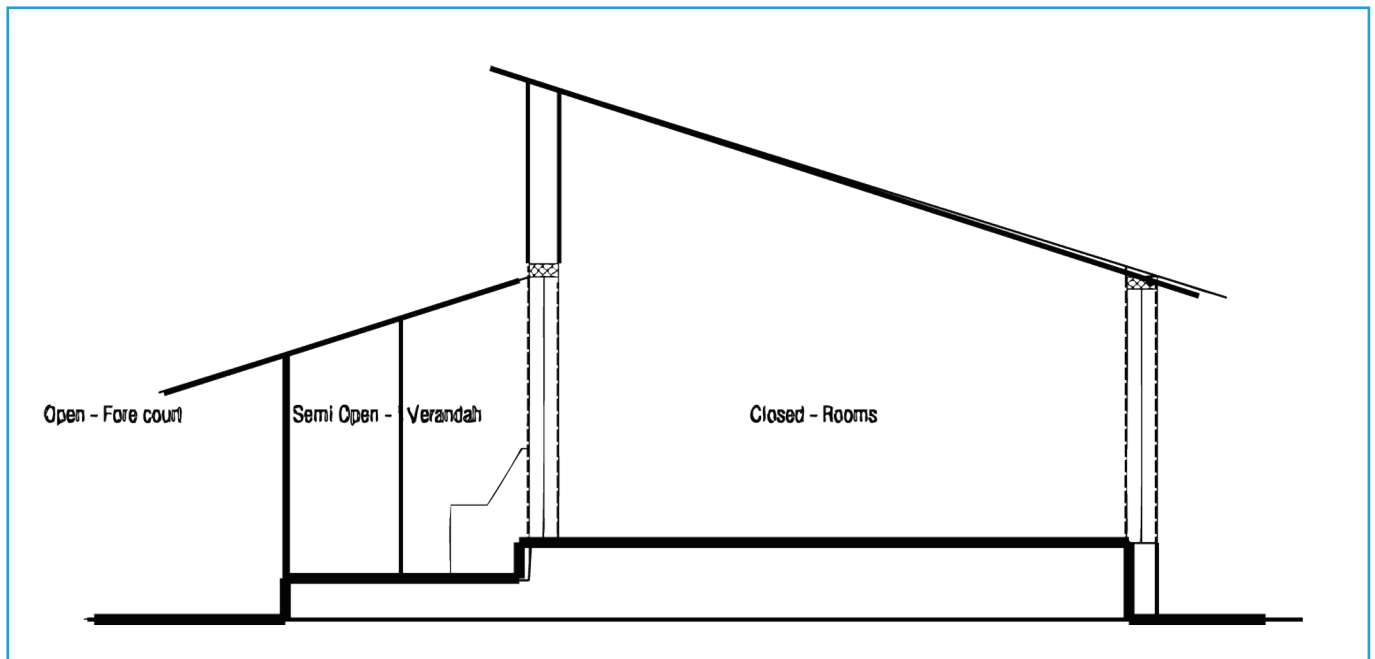
Figure 6 Vaastu considerations

### d. Vaastu

- Vaastu is broadly followed in this region.
- The well and the Tulsi katte are always placed to the right of the main door.
- The entrance door is placed at the centre of the front façade facing north or east.
- The puja is placed either west or east.
- East or north entry is ideal. The entrance mostly depends on orientation and access to the road.
- The internal door is off-centred from the main entrance door. In the case of two internal doors directly opposite the main door, these are centrally located.

### e. Tradition and culture

- Traditional houses emphasised social interaction in the form of 'hebbagallu' and 'jagalis' (built-in



**Figure 7** Reflection of occupational considerations in design

seating), also seen in present-day houses. It is important to maintain this, as it is in tune with the culture of the region and promotes social interaction.

- The house form needs to cater to occupational needs with more semi-covered (walkable plinth around house, verandahs) and open spaces (forecourt, courtyard, and so on.)
- Semi-covered spaces, which are protected from the rain and harsh sun, provide inhabitants with a space to mend their fishing nets, for example.
- The forecourt or courtyard can be used for drying chillies and other spices.

## f House and plan form

House form:

- Will be single storey with sloping roof
- Should take care of wall protection and provision of semi-covered spaces

Plan Form:

- Can be rectangular (common in this region) with a common hall leading to subsidiary rooms.
- Most people prefer two kitchens (one that allows firewood cooking).

- The bathroom can share a common wall with the kitchen, with a possible entry leading from it.
- Providing as many multifunctional spaces as possible allows for different types of activities.
- The bedrooms are dark spaces with small windows compared to the hall. Bedrooms can be improved by introducing better light and ventilation.
- Storage in terms of lofts and semi-covered spaces was a key point of focus, with provision for later additions.

## 7 Design brief for GRIHA Kundapur prototype

Based on the study, as explained earlier, we developed the following design brief.

**A house of Rs 2 lakhs including a solar component of Rs 20,000 with the following parameters:**

### Site parameters

- 30' x 40' plot
- Entry from the north
- Provision of transition spaces: forecourt, semi-open spaces, house, and internal courtyard



## Design parameters

- A core house comprising a living space, kitchen, bath, and toilet
- Flexibility for horizontal growth
- Rectangular house form preferred
- Vaastu: If two internal doors must be centred, then main door to centre; if one, it must be askew; no separate puja space; SE kitchen
- Provision of verandah with built-in seating
- Multifunctional spaces
- Bath with space for smoking Chula and accessible from inside or outside
- Toilet planned to be accessible from inside or outside
- Kitchen with raised *otta* (platform) for gas cooking, provision for Astra optional
- Provision for outdoor kitchen (proximity to internal kitchen)
- Provision for store and storage (e.g. clothing—not occupation related)
- Provision of attic
- Suitability for heavy rains (sloping roof, deep over-hangs, raised plinth, deep front verandah, plinth protection, SW wall protection from SW and NE monsoons)
- Suitability for high heat and humidity (cross-ventilation, thick walls)
- Climate-friendly courtyard
- Options for ideal scenario (larger houses with one or two bedrooms)

## Construction and costing parameters

- Quick construction period (settlement of foundation to be taken care of)
- Foundation: 2–5 courses below ground depending on soil condition (Note: three types and costing for the three soil conditions will vary)
- Two unskilled labourers per house

No internal plumbing, but provision for sewage (grey water) from kitchen and bath

Based on the above guidelines, the prototype solution developed is cost effective, culture

sensitive, and involves the homeowner in the final decision-making and house-building process.

## 8 GRIHA Kundapur prototype solution

### 8.1 The concept

Based on the study, it is clear that the solution must incorporate **expandability, flexibility, cost, and climate responsiveness**. This prototype has been developed considering four factors:

#### a. Expandability

The design caters to both horizontal and vertical expansion. A modular system allows the end user to accommodate different household sizes.

#### b. Flexibility

The internal layout, courtyard, and room sizes can be varied depending on the user's needs and budget.

#### c. Cost

Cost has been controlled by clever use of materials in the living space and utility areas. Living areas have been provided with thick mud walls and utility areas with a Ferro concrete skin that can be further insulated with materials when finances are available.

#### d. Responsive to climate

The design caters to both heavy monsoons and strong summers. High plinth and large roof over-hangs provide protection from the rain. Thick mud walls on the west side provide extra insulation and provide storage. Ventilators below the roof along the structure enable the exit of hot air.

### 8.2 Design options

Based on the above, two series of designs were conceptualised, each with three choices of material. Series 1 incorporates a courtyard with built area of 305 sq. ft. including the verandah. Series 2 is a smaller built area measuring 235 sq. ft. including the verandah. It does not incorporate a courtyard.

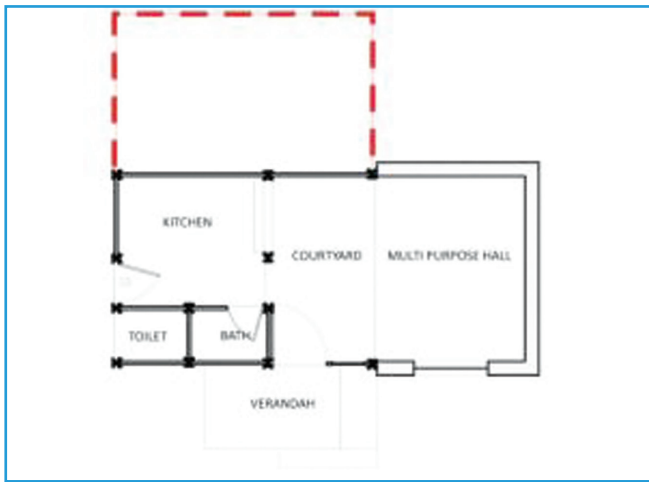


Figure 8 Expandability pattern

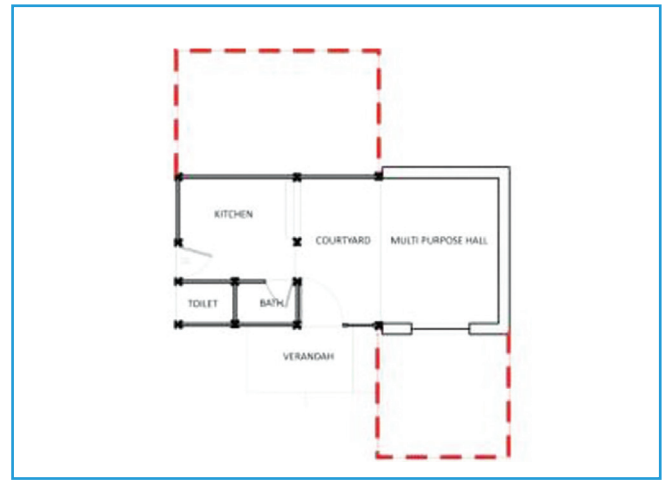


Figure 9 Expandability pattern

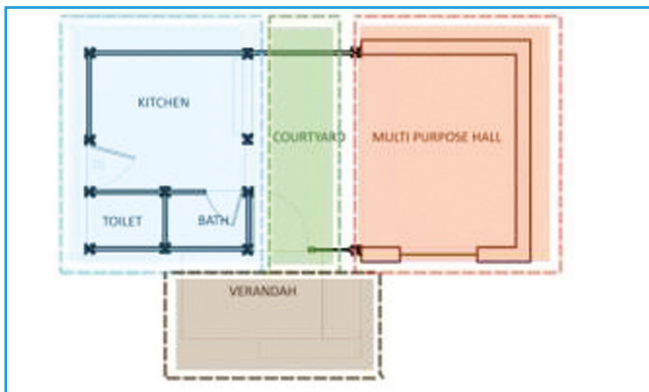


Figure 10 Flexibility pattern

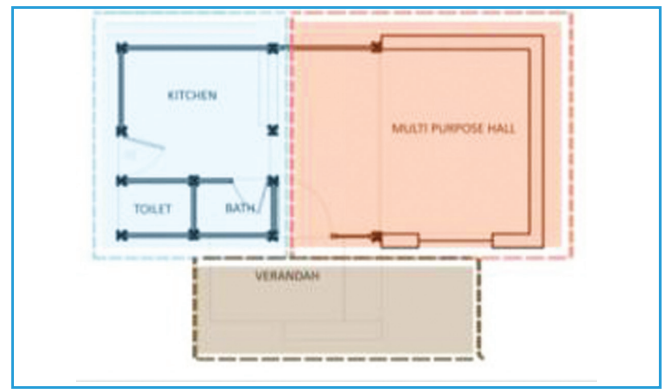


Figure 11 Flexibility pattern

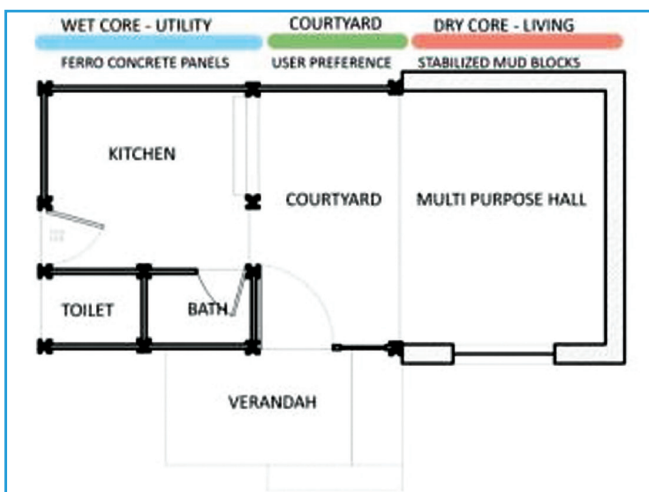


Figure 12 Materials

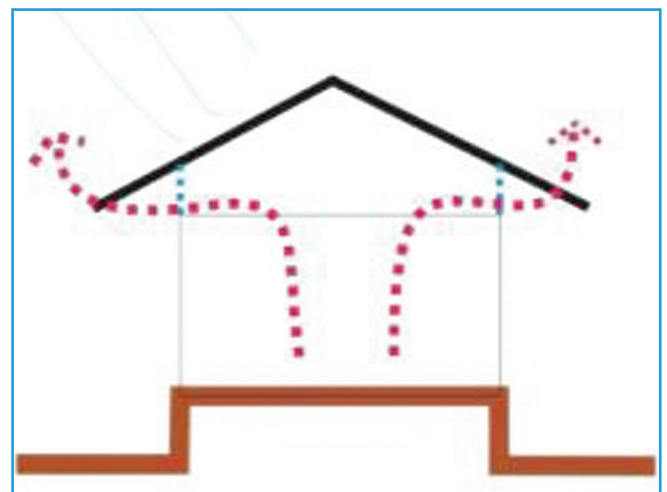


Figure 13 Climate responsive features

### Affordability:

The following measures have ensured the affordability of GRIHA Kundapur:

- A core house plan amenable to future growth horizontally and vertically

- Dividing the plan into wet and dry areas: wet areas (where people do not spend much time) can be constructed with Ferro concrete panels.
- The courtyard component, materials, and size are dependent on user affordability.
- The homeowner will provide unskilled labour, thereby reducing cost by **at least** Rs 20,000.

**a. Series 1: Option 1**

**b. Series 1 (all options with courtyard)**

Cost comparison of houses with different options for materials (all with courtyard)

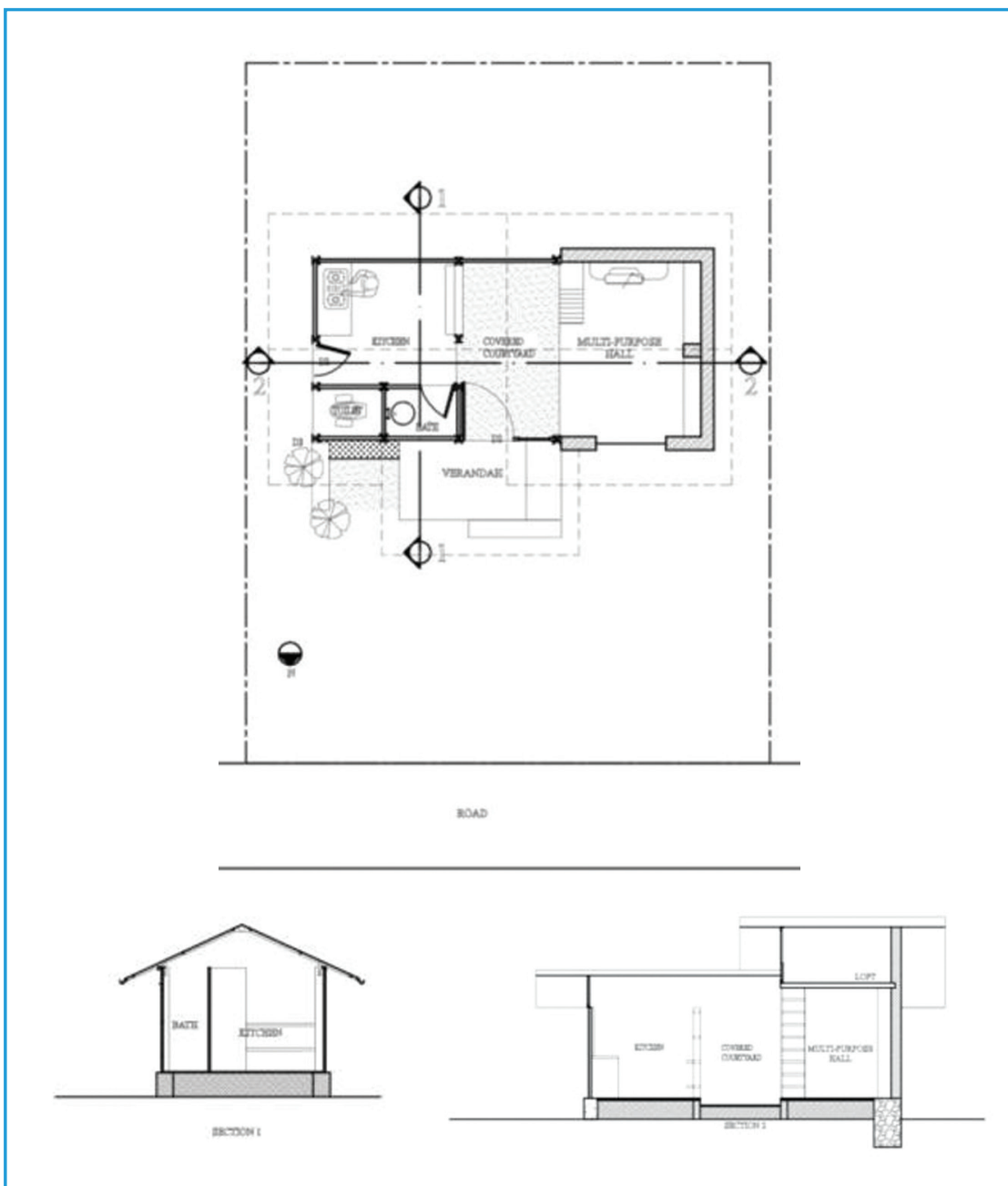
**c. Series 2: Option 1**

**8.3 Prototype**

We are ready to present these options to the donor so that the prototype can be constructed. We hope

to identify the end-user so that we can explain our approach, the research process, analysis, and data interpretation. By presenting the various options, we want to involve him in the decision-making process. We plan two prototypes to showcase the different options available.

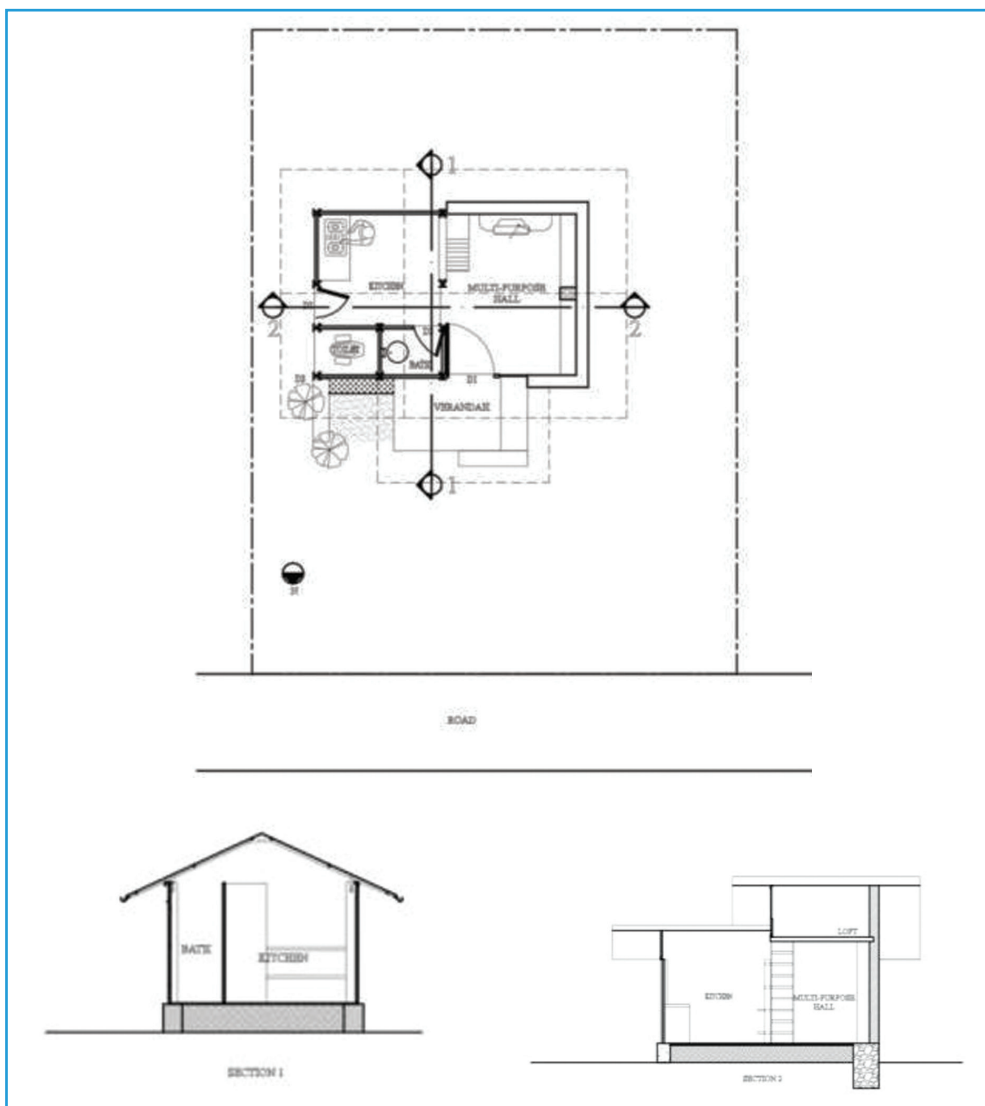
People offering their labour should increase the ownership quotient, while decreasing the cost, thus achieving the core house within the government-set budget in a culture sensitive, site-driven, cost-effective way.



**Figure 14** Combination of Ferro concrete panels and stabilised mud blocks

**Table 3** Cost Comparison for various materials

COST ESTIMATE COMPARISON				
Sl. No.	HOUSE Description	COURTYARD OPTION		
		S2a-Option 1 (Combination of CSEB and Ferro concrete)	S2a-Option 2 (CSEB only)	S2a-Option 3 (Ferro concrete panels only)
	House Area in sq. ft. (incl. verandah and loft)	265+40	265+40	265+40
1	DRY AREA	102,900	102,900	81,000
2	WET AREA	70,100	111,200	70,100
3	COURTYARD	46,000	61,800	46,000
5	VERANDAH	14,900	14,900	14,900
6	LOFT	15,300	15,300	18,300
	TOTAL	249,200	306,100	230,300
	Less unskilled labour	20000	20000	20000
	Less Loft	15300	15300	18300
	<b>GRAND TOTAL (LESS LABOUR, LESS LOFT) in INR</b>	<b>213,700</b>	<b>270,700</b>	<b>191,800</b>



**Figure 15** Combination of Ferro concrete panels and stabilised mud blocks

## 9 GRIHA Chitradurga: Sneak preview

**Table 4 Series 2 (all options without courtyard)**  
Cost comparison of houses with different options for materials (all without courtyard)

COST ESTIMATE COMPARISON				
HOUSE		OPTION WITH NO COURTYARD		
Sl. No.	Description	S2b-Option 1 (combination of CSEB and Ferro concrete)	S2b-Option 2 (CSEB only)	S2b-Option 3 (Ferro concrete panels only)
	House Area in sq. ft. (incl. verandah and loft)	195+40	195+40	195+40
1	DRY AREA	106,200	106,200	81,000
2	WET AREA	70,100	111,200	81,000
3	COURTYARD	NA	NA	NA
5	VERANDAH	14,900	14,900	14,900
6	LOFT	15,300	18,300	18,300
	TOTAL	206,500	250,600	195,200
	Less unskilled labour	20000	20000	20000
	Less Loft	15300	18300	18300
	<b>GRAND TOTAL (LESS LABOUR, LESS LOFT) in INR</b>	<b>171,100</b>	<b>212,200</b>	<b>156,800</b>

Chaitanya, a micro finance organisation operating in the Chitradurga region, is entering the housing loan sector. We plan to work with them in trying to provide affordable housing as part of project GRIHA Chitradurga. As in the Kundapur region, our study template for Chitradurga is ready for testing. A likely challenge is that its people are poorer and more conservative with regard to design and new technology. Their emotional connect to a home and lifetime investment is very strong. As such, dissemination of any new idea is likely to be a bigger challenge.

Our plan is to produce physical models of space interventions after studying their spatial usage. In addition, we plan to use locally available materials, conceptualise better local construction techniques, use local skill, and respect the local mind-set; a 'Delta X' approach is likely to work better here. We aim to impact and empower people through awareness and hands-on training programs on construction techniques.

## 10 The path forward

The proposal for GRIHA Kundapur shows how the design has addressed flexibility of growth and homeowner access to design options. By planning support in the form of training and involvement during the construction phase, and involving the owner in the unskilled labour technology, we empower them to build their own homes. Depending on the budget, different materials and technologies can be selected. The available design options are robust to skill variability and resource availability. We are currently trying to keep the construction process local and vernacular by not importing technology where machine supersedes man. We are also questioning what a local material is. People no longer accept some traditional local materials like mud. Our cities and rural areas have been infiltrated by materials such as GI sheets and Ferro concrete, which seem to be more easily, readily, and cheaply available. Considering this,



local materials should probably be redefined as the easily available pre-fabricated compound wall materials people accept. By involving homeowners in construction, we teach them new skills, which makes them self-sufficient when expansion is possible as finances improve. This empowers the user to improve standards of living on his terms, ensuring a sense of control, which adds to a sense of well-being.

## Acknowledgements

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## Chapter 3

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# Changing Perspectives in Design





paper

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Frugal and Reverse Innovations: What, Where and Why?  
Clarifying the Concepts and Creating a Research Agenda

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# Frugal and Reverse Innovations: What, Where and Why? Clarifying the Concepts and Creating a Research Agenda



## Abstract:

Frugal and reverse innovations are two very recent concepts in innovation discourse, receiving significant attention from academics and practitioners. There are numerous successful cases of these concepts in managerial articles. However, academic contributions on the topic are still in their infancy, although significantly burgeoning. We attempt to shed light on these concepts by investigating their antecedents and inter-dependencies, aiming to analyse how they are interlinked. The study presents a conceptual framework that combines drivers behind these concepts as well as two main paths to creating frugal innovation. We conclude by identifying possible future research areas that could enrich the knowledge base on frugal and reverse innovations.

**Keyword:** *frugal innovation, reverse innovation, innovation management, research agenda*

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## 1 Introduction

*“The Tata Nano may not have changed the world, but frugal innovation will.”*

(The Economist, 2012)

Innovation is a prerequisite for firms seeking growth and new opportunities in the current turbulent business environment. The body of knowledge of contemporary innovation management focuses mainly on new products and services targeted at markets in developed countries. That being said, the population is rapidly growing in emerging economies, where people are naturally seeking new ways to improve their lives. Due to their growing purchasing power, developing countries have become a focal point for new markets. Emerging markets are also increasingly providing new sources of innovation, which provides new opportunities for innovative and open-minded firms to find new business

opportunities. Western firms, however, need to be willing to adopt different business models, strategies, and offerings that suit customers in these emerging markets. In other words, the innovation loci and foci are changing and there is a need to re-investigate existing innovation management theories in the context of developing countries.

When an innovation meets the needs of customers with low purchasing power, typically located in developing countries, it is considered a frugal innovation (Simula, Takala, Yadav & Vuori 2013; Zeschky, Widenmayer & Gassmann, 2011). According to Zeschky et al. (2011), topics such as low-cost manufacturing, low-cost materials, design focusing on basic functionality, and minimal feature sets are key aspects of frugal innovation.

An interesting case occurs when an innovation originating in an emerging market moves to

developed markets. As Vijay Govindarajan postulates, we understand why a poor man wants a rich man's product, but why would a rich man want a poor man's product? (Govindarajan & Trimbel, 2013). This counter-intuitive phenomenon is coined reverse innovation and is discussed in this paper.

In any event, frugal innovation is a promising approach to serving customers with low purchasing power in emerging markets. Despite high potential, only a handful of firms are currently active in frugal innovation. This study explores both frugal innovation and reverse innovation, aiming to draw the attention of both practitioners and scholars to their growing importance. Cases of frugal innovation abound; it is prevalent in emerging economic areas such as India and Africa. Considering prominent cases of frugal innovation, we clarify the concept and suggest new avenues for future research.

## 2 Motivation and research design

Frugal innovation occurs in several contexts and industries, with many examples in the healthcare, energy production and transportation sectors. However, the dilemma is that the term is employed to describe a wide range of different products and services. We seek to clarify this and provide new insight on the concept of frugal innovation.

This paper is mainly conceptual in nature, reviewing selected examples from managerial and academic sources. The proposed research questions and typology for frugal innovation should be of particular interest to academics interested in sustainable well-being and empowerment. In addition, the ideas in this paper will hopefully inspire practitioners and give them ideas with which to address the growing phenomenon, while encouraging them to begin planning and implementing their own frugal innovation initiatives.

The main research questions of this paper are:

1. What are frugal and reverse innovations and where do they originate?

2. What are the drivers for frugal and reverse innovations?
3. What kind of avenues should be explored when looking at future research possibilities for frugal and reverse innovations?

## 3 Frugal Innovations

Frugal innovation is the practice of developing relatively cheaper products to create value for consumers (i.e. low cost solutions), which are aimed at customers with low purchasing power (Hossain & Simula, 2013; Tiwari & Herstatt, 2012). It is a concept that has been growing in India because it focuses on simplicity and frugality whereas, traditionally, innovation activities have been capital intensive, requiring large facilities and highly qualified personnel (Dutta, 2012). Although frugal innovation - also termed 'jugaad' innovation in India (Radjou, Prabhu & Ahuja, 2012) - as a phenomenon is not new, the relevant literature is still in its infancy. Companies have traditionally focused on structured tools, processes, and techniques to manage innovation, whereas 'jugaad' is less concerned with process and more interested in people and creativity (Radjou et al, 2012). For the sake of consistency, this paper employs the term frugal innovation going forward.

Frugal innovation stems from resource scarcity: utilising limited resources to meet the needs of low-income consumers (Sharma & Iyer, 2012). It is based on the idea of turning resource constraints (i.e. financial, material or institutional constraints) into advantages (Bound & Thornton, 2012). Some frugal innovations are grassroots innovations, created at the base of the pyramid out of necessity, hardship and challenges. Commercial frugal innovation targets the unmet needs of customers who otherwise are not on marketers' radar because of their low purchasing power and different needs. Frugal innovations can comprise both products and services (Simula et al., 2013). Previously, the growth wave was based mainly on innovation focusing on wealthy countries (Hart & Christensen, 2002); however, there is an

increasingly significant opportunity for Western firms to begin innovating for emerging markets, where over four billion people live on limited income (Prahalad, 2009).

Frugal innovation can be defined as “a product, service or a solution that emerges despite financial, human, technological and other resource constraints, and where the final outcome is less pricey than competitive offerings (if available) and which meets the needs of those customers who otherwise remain un-served” (Hossain & Simula, 2013). In sum, frugal innovation combines low cost solutions, low cost manufacturing, and low cost materials with design that focuses on basic functionality and minimal feature sets. In this context, key considerations include resource conservation, design simplicity, and environmentally friendly and lean practices.

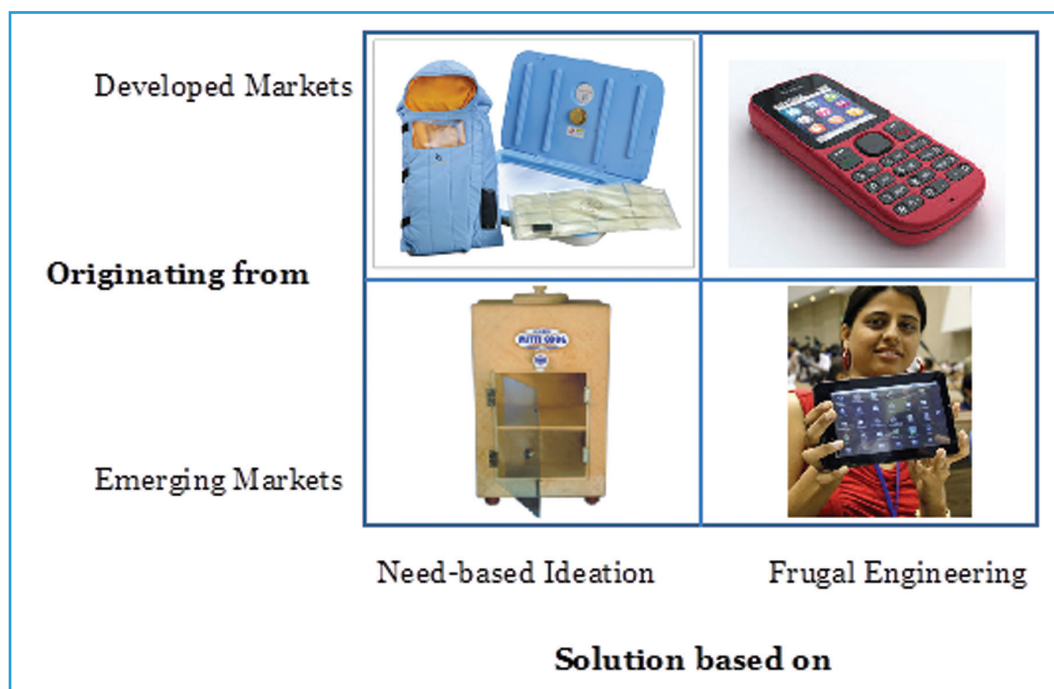
#### 4 Taxonomical Issues Relating To Frugal Innovation

Firms should be aware that emerging markets cannot be approached with the same mind set as would be the case with their traditional markets; they need to be willing to conduct experiments and employ innovative thinking and approaches to business. In other words, retrofitting business models designed

for a developed market is not sufficient, nor is making cheaper versions of products to be sold in developing markets (Govindarajan & Trimble, 2012; Prahalad, 2009).

Prahalad (2009) lists several prejudices held by large multinational firms concerning emerging markets, especially Bottom [Base] of the Pyramid (BoP) markets. One example is that the poor have no use for or cannot afford products and services sold in developed countries; that is, Western firms might think that their cost structures prevent them from serving BoP markets. In addition, firms might think that only developed countries appreciate and pay for technological innovations. This kind of logic inevitably leads to Western firms neglecting the potential of BoP markets. The solution is to innovate and work differently; merely stripping down existing products is not going to be a silver bullet.

Currently, trying to define frugal innovation is quite a difficult task. It covers a wide variety of down-to-earth solutions such as the idea of utilising old soda bottles to let light into buildings or even a high-tech football that generates and stores energy. These examples require totally different business models and diffusion paths. Categorisation based on technological novelty is one way to differentiate



**Figure 1** Conceptual difference between frugal innovations

**Source:** Discussed in text

frugal innovations; however, drawing a line between low- and high-tech is not without difficulties. Figure 1 illustrates different categorisations and is explained with examples in the following sub-sections.

#### 4.1 Need-Based Ideation

In “need-based” ideation, someone must spot and create a novel solution with which to address a specific need. Novel ideas can originate from emerging and developed markets alike.

For instance, MittiCool’s clay refrigerator (Fig. 1, lower left quadrant) is a remarkable innovation that was launched in 2002 and has been recognised all over the world for its ingenuity. All products developed by MittiCool are eco-friendly and can be produced at low costs. The MittiCool refrigerator does not require electricity for its operation and can keep vegetables and milk fresh for three days. This product is an excellent example of a need-based solution created by Mansukhbhai Prajapati, a high school dropout from the state of Gujarat in India.

Although originating from a developed market, Embrace (Fig. 1, upper left quadrant) is also a need-based solution. It was designed at Stanford University, where a group of graduate students had the idea of creating an inexpensive infant warmer that functions as a low-tech device. Embrace is described as having the potential to save thousands of babies in the developing world (Dooley, 2010).

#### 4.2 Frugal Engineering

The concept of frugal engineering relates to frugal innovation. The term is credited to Renault-Nissan’s CEO, Carlos Ghosn, and simply means achieving more with fewer resources (Kumar & Puranam, 2012). The example (Fig.1, lower right quadrant) is of the Aakash (originally called Sakshat) Internet tablet, developed by the technology company Datawind for the Indian government to provide low cost tablets to students in India. It was designed and developed with cost constraints in mind, costing approximately \$40, to be further subsidised

by the Indian government so that it could be sold to students at much lower prices. An additional and frequently cited example originating from India is Tata Motors’ Tata Nano car, which was launched as an ultra-low priced, safe, affordable and all weather form of family transport. The main objective in creating the Tata Nano was to develop a car that costs as little as \$2,500.

Nokia’s 101 phone is pictured in the upper right quadrant of Figure 1. While Nokia has faced problems in recent years and had to sell its mobile business to Microsoft, its 101 model was a great success in emerging markets, for which it was specifically designed. The phone has a built-in flashlight, which is extremely useful in areas where power cuts occur frequently. The phone also has the capacity to have more than one SIM card inserted at the same time and includes an MP3 player. Recently, Mozilla announced the development of a smart phone targeted at emerging markets with a sales cost of only \$25.

### 5 Reverse Innovation

*“Whether products are developed by Western firms in developing countries and then come to the West or whether they are developed by firms native to emerging markets such as India and China, these generally lower priced products are going to disrupt price structures that Western companies have enjoyed to date.”* Lindegaard (2011).

The main idea behind reverse innovation is the ability to apply frugal innovations to wealthy markets, where there are numerous customers to tap into. This is especially effective during an economic downturn, when potential customers are particularly cost sensitive and unwilling to pay for extra features and functions.

*“The West is doomed to a long period of austerity, as the middle class is squeezed and governments curb spending. Some 50 million Americans lack medical insurance; 60 million lack regular bank accounts. Such people are crying out for new*



ways to save money. A growing number of Western universities are taking the frugal message to heart.” (The Economist, 2012).

The concept of reverse innovation came into prominence in academic circles thanks to Immelt, Govindarajan, and Trimble (2009). They postulated that reverse innovations are low cost innovations that successfully diffuse to developed markets from developing markets. Similarly, according to Govindarajan and Ramamurti (2011), reverse innovation refers to cases whereby innovations are first adopted in emerging markets before they ‘trickle up’ to wealthy countries. Several other scholars have defined reverse innovation in a similar way (see e.g. Trimble, 2012). The reverse innovation concept focuses low price point innovations, which originate from emerging markets, on penetrating wealthier markets (Govindarajan & Trimble, 2012).

As mentioned, reverse innovation runs contrary to the traditional ‘flow’ of innovation. It challenges the common belief that wealthy countries are the hubs where innovation originates, prior to flowing to customers in developing countries as stripped-down versions. Developing countries are no longer merely recipients of innovation from developed

countries, with firms and individuals in developing countries innovating to meet their own needs at lower costs. These innovations then find ways to diffuse to neighbouring countries at a similar socio-economic level before making their way to other similar markets in geographically distant countries. Some innovations are then adopted by wealthier countries, seeing as they meet the needs of certain customers.

## 6 Conceptual Framework

As presented earlier, need-based solutions and frugal engineering are two basic sources for frugal innovations. They are also the basic building blocks in our conceptual framework shown in Figure 2. Frugal innovations sometimes become reverse innovations. There are, however, specific factors fundamental to both of these innovation concepts. These factors are inherently micro- and macro-level, which are discussed in the next sub-sections.

### 6.1 Macro-level drivers in developed markets

The economic downturn has cast shadows on many Western economies and recovery has been slower than expected. Export businesses have

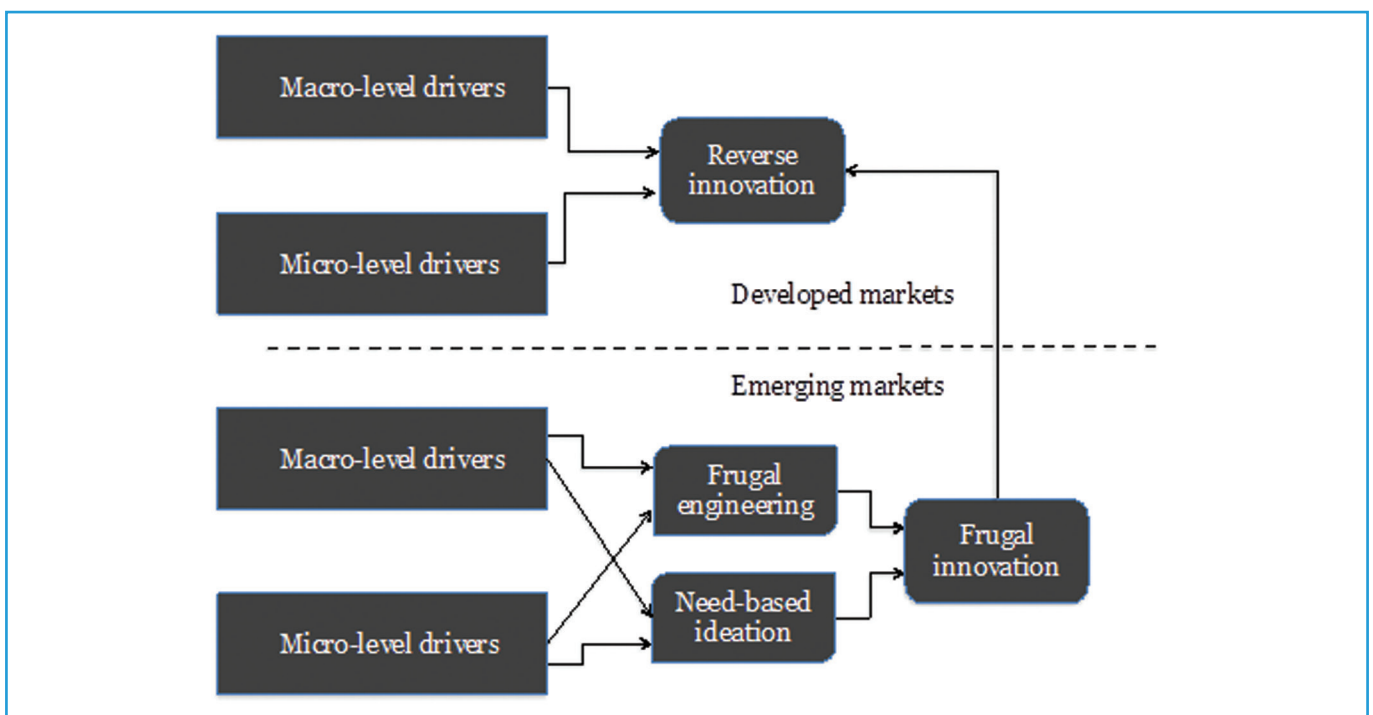


Figure 2 Conceptual model for frugal and reverse innovations.

suffered in many countries, with resulting high levels of unemployment. Combined with increased raw material prices, energy and transportation costs have created pressure to increase various products' retail prices. Political turmoil and aging populations are increasing insecurity and further aggravating crisis in welfare systems/schemes of many countries. As such, there is demand for novel products and services that deliver greater value with lesser inputs.

### 6.2 Micro-level drivers in developed markets

Many customers in both emerging and developed countries wish to save money, with cost awareness becoming a growing trend as the unemployment ratio increases in many emerging markets. In addition, many products have suffered from the so-called over-engineering syndrome, creating feature fatigue among customers. This means that they are not willing to pay for too many features that they do not perceive as adding value (Thompson, Hamilton & Rust, 2005). Innovation overload (Herbig & Kramer, 1992) is a comparable phenomenon that means "a consumer's response to the ever increasing speed of change in information, knowledge, and innovations." People are also starting to value topics such as sustainability and well-being to a greater extent.

### 6.3 Macro-level drivers in emerging markets

Population growth in emerging markets has been rapid, with economic development in emerging markets increasing at a faster pace than in Western economies. Urbanisation has increased and many cities are growing quickly, particularly in China, Latin America and several African countries, putting a strain on infrastructure sustainability. Resource scarcity remains a key macro-level trend in emerging markets. These markets are shrinking and an increasing number of people in them are moving from low income to middle class brackets, inviting multinational corporations to enter these markets in search of new business opportunities.

### 6.4 Micro-level drivers in emerging markets

Transformation of cities and living areas develops at unprecedented speed in emerging markets. Technological advancements, especially among ICT sectors, have changed the way people live, work and spend their leisure time, while global community networks influence people's tastes and preferences. People remain cost-aware and favour the idea that products do not need to be state-of-the-art but merely sufficient to meet basic needs. In other words, there is growing demand for good-enough solutions that provide value for money.

## 7 Research Agenda for Future Studies

*"We live in a world in which customers don't care where ideas come from; they only care about quality, value and price."* (Lindegaard, 2011).

In this paper, we have illustrated various established and successful examples to help both practitioners and scholars enrich their understanding of frugal innovation. Frugal and reverse innovations offer practitioners a few basic options, which are:

- A) Western firms make cheaper and stripped-down versions of their existing products and try to sell them in developing markets. This mechanism is likely to fail as the cost structure will still be too high, which will result in unaffordable product price tags for customers in emerging markets.
- B) Western firms design a completely revised low-end product by also utilising local R&D power. For example, GE developed a range of low cost ECG machines in India that it has sold in other emerging markets and in the West.
- C) Local firms understand local preferences and create low priced frugal products for local markets.
- D) Western firms adapt ideas from low cost market products and utilise these in their design, culminating in cheaper products for their home markets (i.e. reverse innovation).
- E) Firms originating from emerging markets will challenge Western firms in their home base

with disruptive innovation and unique business models (e.g. Mahindra & Mahindra in the USA)

In this study, we proposed a new taxonomy to distinguish different types of frugal innovation. We want to build on this discourse and propose a research agenda concerning frugal innovation in the future. Questions we hope will be addressed in future studies include:

1. What are the opportunities and barriers for Western firms in capturing revenue from emerging markets with frugal innovations?
2. How to make frugal innovations diffuse among emerging markets and what kinds of business models could support this?
3. How should Western firms build or restructure their business models and strategies to tap into underserved and un-served customers with frugal innovations?
4. How can Western firms collaborate with local players in emerging markets for frugal innovations?

## 8 Discussion

It is worth mentioning that frugality is not to be considered only in the context of product development. There are other business functions that can benefit from the same ideology, with some examples already in place. For instance, frugal marketing has been employed in the context of automobile marketing strategy in India (Jindal, Jee & Thakur, 2011). There are several other great examples of frugal innovations in Africa and other Asian countries. This study focused mainly on frugal innovations originating from India. Future studies could take on a more global perspective.

There seems to be a positive bias towards innovation in general, as well as an assumption that innovations are constructive and inherently good and that they

solve problems and are useful. The benefits and drawbacks of innovation is a topic that has not been extensively studied; studies by Knight (1967), Kimberly (1981) and Steele (1988) are rare examples that highlight the positive bias towards innovation. Some innovations can actually be double-edged swords, however, as they can provide benefits to a particular individual while simultaneously causing hardships to others. For instance, new production equipment might leave some workers without a job or force less competitive firms out of business (Rogers, 2003). Rogers and Shoemaker (1971) point out that there can be innovations that are harmful or uneconomical from the perspectives of an individual or social system. In any event, there are only a few authors who argue that innovation can be undesirable (Steele, 1988) and can yield negative outcomes (Knight, 1967). An area for additional research could be to study frugal innovation from this perspective. For instance, despite the obvious benefits of frugal (i.e. *jugaad*) innovation discussed in this paper, there are also critical voices. For instance, in his blog, Rao (2012) mentions that “many in India would argue that ‘jugaad’ is not just frugal or flexible innovation but sometimes also a makeshift workaround or ‘bandage’ solution and not true innovation.” Also, Radjou et al. (2012) note that there are particular creative but more or less “gaming the system” elements in ‘jugaad’ thinking. Birtchnell (2011) also criticises ‘jugaad’ and states that the underlying ideology impacts society in negative and undesirable ways.

We do not claim that frugal innovation is a silver bullet to global problems. It can create controversial situations in which benefits and drawbacks to different stakeholders conflict. Therefore, extensive studies from various perspectives and regions are necessary in order to understand frugal innovation adequately. We believe that more debate regarding the pros and cons of frugal and reverse innovation is certainly needed.

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paper

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If you build it, they won't necessarily come:  
Understanding and innovating social  
impact technology dissemination

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# If you build it, they won't necessarily come: Understanding and innovating social impact technology dissemination



## Abstract:

Despite their popularity, social impact technologies like affordable solar lanterns and smoke-reducing cooking stoves are failing to make a significant impact at the bottom of the pyramid. Merely inventing technologies is not enough. They must move from the lab to the land, into the hands of the people they are intended to benefit. Innovations in scalable, financially sustainable models for dissemination are desperately needed, lest these technologies be designed in vain.

This paper surveys the efforts of Indian social enterprises that disseminate social impact technologies through market-based means. These examples reveal that dissemination is a multi-faceted problem that requires different elements: 1) aspirational, village-level marketing, 2) fine-tuned supply chain for low-cost last-mile distribution, 3) after-sales service for brand loyalty, 4) customer finance that aligns with income flow, 5) local, trust-based relationships, 6) products that customers value, and 7) mutually dependent economic relationships with local communities.

**Keywords:** *technology, social entrepreneurship, dissemination, distribution, markets*

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## 1 Introducing the Problem of Social Impact Technology Dissemination for Bottom of the Pyramid (BOP) Development

Since the early 2000s, in the world of international development, there has been an increasing focus by the public, private, non-profit, and non-governmental sectors on using technologies designed for the poor to reduce poverty. Innovation-based initiatives for development are part of a growing technology, business, and social movement aimed at low-income communities, households, and individuals at the BOP.

Many international development ecosystems, especially those growing out of academia, have centred on product development. At MIT,

students interested in international development find themselves engrossed in a world of design, short-term service-learning projects, and grant competitions that earn them funding for prototype development and deployment. This university-initiated pipeline, beginning with a programme called D-Lab, encourages budding engineers to invent a diverse array of compelling, innovative technologies for development. These have included a bicycle-powered corn sheller, an off-terrain wheelchair that uses levers to shift gears, a non-electrified clay filter, and a solar-powered parabolic cooking stove.

There also exists a globally lauded incentive and support structure for innovation for development. International competitions like the Dell Social Innovation Challenge (now Verb) have support new

product initiatives for low-income users. Business plan competitions hosted at academic institutions boast ‘social business’ tracks. Organisations like Echoing Green offer fellowships for social entrepreneurs. Philanthropies like The Rockefeller Foundation award money to ventures that specifically innovate to achieve social missions. USAID gives grants for innovation-based solutions to development. In 2010, the Indian government even established the National Innovation Council’s India Inclusive Innovation Fund, a ‘venture capital fund that will back creative new solutions to developmental challenges – projects that innovatively improve quality of life for poorer Indian citizens’, which will ‘partner with public R&D programmes and laboratories to support the commercialisation and deployment of socially relevant technologies and solutions’ (National Innovation Council, 2013).

Obviously, there is growing commotion around bottom-up, technology-based, entrepreneurial-driven development efforts. However, as the late Alice Amsden noted, investment in grassroots innovation does not always align with economic development at the grassroots level (Amsden, 2012). There is a gap between the number of technology-based solutions for the BOP and the amount of social impact these solutions are actually having. The gap exists because there is an unbalanced emphasis on the core design of technologies for development instead of scalable and sustainable means for disseminating them. If you build a social impact technology, end users will not necessarily come flocking to buy it.

## 2 A Brief History of Social Impact Technologies and the Repeated Failure of Dissemination

### 2.1 Roots in Schumacher’s Intermediate/ Appropriate Technology

Until the 1970s, international development projects focused on engineering in the context of traditional large-scale infrastructure projects. Aid programs were designed to promote the same pattern of industrialisation previously exhibited by developed nations, namely through mechanised agriculture,

large factories, and infrastructure development like power plants (Pursell, 1993).

In the 1970s, British economist E. F. Schumacher proposed the concept of intermediate technology, symbolically defined as a technology that falls between an indigenous technology costing US\$1 and a Western technology costing US\$1000. It would be a US\$100 technology. Inspired by Gandhi’s visions of *Gram Swaraj* (self-sufficient but interlinked village republics with decentralised small-scale economic structure and participatory democracy) and *Sarvodaya* (Gandhi’s ideal political philosophy meaning ‘universal uplift’ or ‘progress for all’), Schumacher visualised the use of these ‘intermediate technologies’ in an alternative form of development that would occur alongside large-scale industrialisation. ‘Such an intermediate technology would be immensely more productive than the indigenous technology (which is often in a condition of decay), but it would also be immensely cheaper than the sophisticated, highly capital-intensive technology of modern industry’ (Schumacher, 1973). This concept later expanded to include any small-scale, inexpensive, easily maintained, and labour-intensive technology – with an emphasis on local development and production – that increases productivity and eventually bridges the gap to more sophisticated technologies. These technologies, often called appropriate technologies (AT), helped shape the current international development focus on technology as a means of reducing poverty.

Today, the phrase ‘appropriate technology’ carries some negative connotations due to AT’s failure to live up to its expectations as the silver bullet that ends poverty. The AT movement’s emphasis had always been more on technology development, not dissemination or implementation. Engineers were making ‘better mousetraps’, but few people were using them (Smillie, 2000). AT advocates assumed that appropriate technology would be readily adopted once end users saw its usefulness. They did not realise that appropriate technologies, despite their simple designs, needed the support of training, maintenance, and administrative assistance (Leland, 2011).



However, the belief has persisted that more appropriately designed technologies can provide a way out of poverty for many of the world's poor. This is reflected in the efforts of organisations in today's technology-for-development space.

## **2.2 The Current Misguided Focus of Core Design and the Current Challenge of Dissemination**

International development organisations and initiatives focusing on core design are abundant. The first national Engineers Without Borders organisation was founded to 'promote the implementation of sustainable development through critical practice of engineering' (Helgesson, 2006). iDE is a non-profit that creates income-generating activities in rural areas through the use of agricultural technologies (iDE, 2011). D.light Design invents low-cost solar-rechargeable LED lanterns (Jolly, Raven, & Romijn, 2012), and doing the same are many other social enterprises (SEs), which are small to medium enterprises that use a business model to achieve social goals. University programmes that teach students how to design for the BOP context have also emerged, including the Indian Institute of Science's Centre for Sustainable Technologies.

The public eye is consistently drawn to the core design of social impact technologies, not their more complex and less appealing dissemination model. However, no matter how well designed social impact technologies may be, there is no guarantee that they will reach the millions of people for whom they were created. Technology dissemination, not technology invention, is the real challenge to impacting BOP lives through innovation. As yet, no organisation has been able to disseminate in a way that is scalable and financially sustainable:

- From 1983 to 2002, the government embarked on the National Programme on Improved Chulhas (Cookstoves). Although R&D was contributed through programmes like the Indian Institute of Science's Centre for Sustainable Technologies, some considered the national scheme a failure. The custom-built stoves were not appropriate for customers' energy needs or

cooking habits, and scalable dissemination was impossible because stoves were made on-site by local artisans and entrepreneurs. Quality control and user education were non-existent, program administration was cumbersome, monitoring was nil, and government subsidies for the stove seemed to decrease use and maintenance. Additionally, there was no accountability for poor program performance (Barnes, Openshaw, Smith, & Van der Plas, 1994; Jagadish, 2004).

- After receiving millions of dollars in grants, multiple sources reported numerous broken PlayPumps (water pumps that were designed to use playing children's energy to operate) and dysfunctional maintenance lines (Costello, 2010). UNICEF (2007) published a report highlighting many problems associated with PlayPumps, including high costs, difficulties and inefficiencies in pumping, maintenance challenges, and reliance on child labour. In 2010, PlayPumps International acknowledged failure and transferred all of their assets to a charity called Water for People, which is funded by the Case Foundation (Case, 2010).
- Released in 2005, the Lifestraw is a handheld water filter that was designed to be used like a straw. Vestergaard-Frandsen, a Swedish manufacturer, invested \$30 million in producing the Lifestraw in exchange for carbon credits (Starr, 2011) – a move that many philanthropists have criticised. Ten months after Vestergaard-Frandsen distributed 900,000 free Lifestraw units in Kenya, Kevin Starr, Managing Director of the Mulago Foundation, visited 20 recipient households. Only three filters were still in use. Why? The product was poorly designed, filtered too slowly, had no available replacement parts, and, if it were going to be sold, was far too expensive (Starr, 2012).
- MIT D-Lab's total project count is unknown but includes hundreds of projects developed between 2000 and 2014. The number of projects that have been carried forward beyond the program is not well documented, and the author is familiar with fewer than 15 projects that have spun out

into businesses or non-profits (e.g. Global Cycle Solutions' bicycle-powered corn sheller and One Earth Design's parabolic solar cooker).

Because of the failures in social impact technology dissemination, there are a number of advocates for innovations in the technology for development space. One vocal proponent is iDE founder and author Paul Polak, who wrote in September 2010:

'Over the past 30 years, I've looked at hundreds of technologies for developing countries. Some provided elegant solutions for challenging technical problems. Some were big and clumsy. Some were far too expensive. Some of them were beautifully simple and radically affordable. But only a handful were capable of reaching a million or more customers who live on less than two dollars a day. If you succeed, against all odds, in designing a transformative radically affordable technology, you still have addressed only 25% of the problem. The other 75% is marketing it effectively, which requires designing and implementing an effective branding, mass marketing, and last mile distribution strategy'.

### 2.3 Why the Market as a Means of Social Impact Technology Dissemination

The demise of the Appropriate Technology movement, which relied on donor subsidies, hand-outs, and unpaid volunteers, has taught us that financial sustainability must be a crucial consideration for today's technology-for-development initiatives. According to Paul Polak, 'Developing practical and profitable new ways to cross the last 500 feet to the remote rural places where poor families now live and work is the first step towards creating vibrant new markets that serve poor customers' (Polak, 2013).

The idea that profitable business ventures could be created while generating social value at the BOP was first articulated in August 1999 by management professors C.K. Prahalad and Stuart Hart. Prahalad later published his influential book, *The Fortune at the Bottom of the Pyramid*, in 2004. These writings initiated multinational corporations' attempts to

enter BOP markets through repackaging and low price points (Simanis & Hart, 2008).

Around the same time, Clayton Christensen, a Harvard Business School professor, was applying his theory of 'disruptive innovation' to the BOP with Hart (Hart & Christensen, 2002; Christensen, Heiner, Ruggles, & Sadtler, 2006). 'Disruptive innovations' are new technological innovations, products, or services that create new markets and new value networks while eventually surpassing and disrupting dominant paradigms (Bower & Christensen, 1995). They, too, could be applied to the BOP – a huge market that most multinational corporations ignored.

The ideas of Prahalad's BOP businesses, Christensen's disruptive innovation, and Schumacher's appropriate technologies have morphed and merged overtime. The emphasis on multinational corporations has decreased, and small companies and social enterprises began implementing these ideas.

Known BOP scholars have written that these new BOP initiatives should see low-income individuals as not just consumers, but also as entrepreneurs (Karnani, 2009), business partners (Simanis & Hart, 2008), and co-inventors of goods and services (Simanis & Hart, 2009). However, after their survey of 1999–2009 BOP literature, Kolk, Rivera-Santos, and Rufin discovered that the vast majority of initiatives view the poor primarily as consumers (2014).

This paradigm shift from seeing BOP individuals as rights-bearing beneficiaries to seeing them as value-driven customers has caused some discomfort in development professionals and academics (Blowfield & Dolan, 2014). However, this shift should be seen as empowering for low-income populations, who are now treated as active agents within a consumer market instead of passive recipients. Companies that want to do business with the BOP must address their customers' spending needs, demands, desires, and constraints. As described by the director of

UK-based Business Fights Poverty: ‘for too long development has been about treating poor people as recipients, as dependents [sic], and actually for the first time we’re seeing them treated as agents of their development ... as customers for the first time’ (Kuriyan, Nafus, & Mainwaring, 2012).

### 3 Lessons from Social Entrepreneurial, Market-Based Efforts to Disseminate Social Impact Technologies in India

At this moment, many social enterprises are experimenting with diverse business models and strategies for social impact technology dissemination. This is particularly the case in India, which is a nation that has been deemed a hotbed for social entrepreneurship and technological, social, and business model innovation (The World Bank Institute, 2011).

In this section, the social impact technology dissemination efforts of 15 Indian SEs in southern India have been broadly surveyed. Their experiences have given us seven different elements of commercialising social impact technologies: 1) aspirational, village-level marketing, 2) fine-tuned supply chain for low-cost last-mile distribution, 3) after-sales service for brand loyalty, 4) customer finance that aligns with income flow, 5) local, trust-based relationships, 6) products that customers value, and 7) mutually dependent economic relationships with local communities.

#### 3.1 The Context: The Difficulties of Rural India

India’s BOP is defined as households in the bottom four expenditure quintiles that spend less than US\$75 per month on goods and services. This represents 114 million households (Bairiganjan, Cheung, Delio, Fuente, Lall, & Singh, 2010). Analysts predict that consumers earning over US\$5 a day will increase from 50 million to 150 million by 2020, and the dynamics of rural consumption are changing rapidly in the favour of businesses.

However, India’s BOP is highly fragmented and riddled with obstacles. There are 627,000 Indian

villages spread over 3.2 million square kilometres (Anderson & Markides, 2007). These villages experience financial hardships, difficult living conditions, and lack of basic information for making informed decisions. Income levels are low and volatile, and ready access to financial institutions and services is unavailable. Restricted mobility and limited travel patterns slow the dissemination of knowledge. Language and literacy variations across regions prevent cost-effective marketing and communication materials. Because of variations in settlement type, income levels, expenditure, and culture, households at the BOP have unique preferences (Shukla & Bairiganjan, 2011). In some cases, ill-planned, poorly executed, and intermittent government schemes have adversely affected BOP customers, priming them to avoid market-based initiatives. Rural markets’ lack of infrastructure, such as roads, water channels, electricity, and communications, also creates barriers to entry for all products. Geographical challenges such as extreme weather conditions and hostile terrain present transportation difficulties, and sparse population density prevents easily attainable economies of scale.

#### 3.2 Lesson 1: When Creating Awareness, Practice Aspirational Marketing at the Village Level

For many social impact technologies, raising awareness and generating demand are the biggest obstacles to scalable and sustainable dissemination. The costs of customer acquisition are incredibly high.

In-person, village-level demonstrations are, by far, the most common way to market social impact technologies to the BOP. For example, iDE India and ONergy (distributor of solar lighting technologies) have permanent demonstration centres where technologies are stocked, users are trained, and demonstrations are held (Center for Science, Technology, and Society, 2014). In another example, Essmart (distributor of life-improving technologies in southern India that works through existing retail stores) sets up temporary demonstrations in stores, weekly markets, and other commercial areas to draw

attention to new offerings. In yet another model, marketing occurs on a peer-to-peer (often female-to-female) basis, through rural entrepreneurs or sales forces. These demonstrations happen in households or at group meetings organised through NGOs, microfinance institutions (MFIs), self-help groups (SHGs, which are groups of 10 to 15 women who voluntarily come together to save regular amounts of money individually while contributing to a common fund), or farmers' groups.

The use of mass media is not very common among SEs because of the sky-high costs. For example, Paul Polak's new water distribution venture, Springhealth, recently spent US\$25,000 on a Bollywood movie to promote its new service (Polak, 2014). Additionally, mass media is also difficult because all advertising must be adapted to regional languages.

Some SEs take a bottom-up approach that involves future end users in identifying and validating new products. Villgro Stores works with an organisation called User-Centered Innovation Development (UCID) and nearby farmers to identify and validate new technologies before introducing them to stores (Jue, Sinha, & Shanmugam, 2011).

Additionally, impactful are marketing materials that look and feel aspirational (that is, aimed towards the existing or emerging middle class instead of the BOP). No one wants to buy products that look like they are made for poor people. Marketing materials from companies like Duron Energy (solar home lighting) and Greenway Grameen Infra (improved cooking stoves) all feature happy, smiling, middle-class families.

### **3.3 Lesson 2: Fine-Tune a Supply Chain that Enables Consistent, Low-Cost Last-Mile Distribution**

SEs must consider how to cost-effectively make their products physically available in rural areas. Using rural entrepreneurs or 'village-level entrepreneurs' (VLEs) is by far the most common way for SEs to distribute technologies. One commonly cited VLE

model is Hindustan Unilever's Project Shakti, which is an Avon-style sales model. As of July 2013, the program had over 75,000 male and female VLEs reaching three million households in 100,000 villages in 15 Indian states (Shashidhar, 2013). However, it is important to note that Hindustan Unilever's VLEs distribute a product mix that is very different from social impact technologies. They sell low-cost, 'push', fast moving consumable goods like soaps. These already have high demand, unlike relatively higher priced 'pull' durables and life-improving technologies.

Although some product-focused SEs have set up their own VLE models for direct sales (e.g. Greenlight Planet, manufacturer of solar lanterns), most rural entrepreneur networks come from partnerships between manufacturing SEs and NGOs/SHGs. For example, Adharam Energy Private Limited, for-profit spin-off of the Madurai-based NGO network Covenant Centre of Development, identifies potential VLEs through SHGs. These women give live demonstrations of First Energy Oorja cookstoves and sell them door-to-door by collecting monthly intents of purchase from customers (Kumaresh, personal interview, August 12, 2010).

However, despite these successes and these attempts, VLE networks are not a panacea for the distribution problem. During field visits with the now disbanded Rural Energy Network Enterprises in Vellore, Tamil Nadu, this author has seen the difficulties in identifying, training, and managing effective VLEs. In other cases, VLEs are expected to invest in inventory. This puts an additional financial burden on the entrepreneur. Additionally, VLEs can only reach a limited number of customers; so reaching millions of customers through them requires finding tens of thousands of high-quality entrepreneurs – a significant task.

The rural trade network seems to be an obvious network for product-focused SEs to take advantage of, as rural stores are already capable of storing and selling products. Some product-focused SEs have tried to go this route but have failed. For example,

Envirofit tried to sell cookstoves in stores through the rural network of distributors and retailers, even producing a television commercial (Adappa, Joshi, & Anchan, personal interview, July 20, 2010) to bolster sales. The efforts did not catch on with customers, and now the company focuses primarily on institutional sales (Anchan, personal interview, January 19, 2012). Obstacles to selling through the existing trade network are 1) shop owners have limited time and space to promote and store products, 2) mass advertising is expensive, and if the SE has no on-the-ground presence, then there's no one actively promoting the new product in villages, and 3) after-sales service is rarely available in the area, and the shop owner will not invest in a product if the quality is untested, because they do not want to deal with returns. Essmart is working with existing shops at rural levels but is addressing these obstacles by having Essmart sales executives tend to the needs of shops as primary customers. Essmart provides stores with the support they need to sell technologies.

Other SEs have tried establishing their own shops or centres to sell at the local level. Villgro Stores is building a chain of decentralised, brick-and-mortar stores in rural Tamil Nadu. As of April 2013, there were 10 stores that catered to the 8 km radius around them (Bairiganjan & Sanyal, 2013). As of February 2014, SELCO, which installs solar home lighting systems, had 42 branches across six Indian states, with 37 of those in Karnataka (Nair, 2014). These branches are located in far-off rural areas, which gives end users direct access to SELCO employees.

### **3.4 Lesson 3: Provide Excellent After-Sales and Customer Service to Build Brand Loyalty**

When a SE sells a social impact technology but does not provide after-sales service, it negates the technology's potential benefit to customers. Broken technologies abuse poor end users' already limited budgets, and they become village trash. This is one reason why selling to the BOP has been criticised: companies sell products that break, and there is no means of repairing them. For example, so-called

'China' products are met with scepticism, as they come without warranties or a close connection with the manufacturer. Many have broken and have no way of being repaired.

After-sales service is expensive at the BOP, where there is a limited availability of spare parts for custom-made products. There are also large distances to cover for repairs, replacements, and training. However, after-sales service is crucial because it maintains long-term social benefits to end users and a SE's brand.

Some of the less expensive social impact technologies, like solar lanterns and cookstoves, come with manufacturers' warranties. For example, Greenlight Planet's lanterns come with a one-year warranty. Envirofit's G-Series cookstove comes with a five-year warranty on the combustion chamber and a two-year warranty on all other components (Shell Foundation, 2012). Essmart, which acts as a third-party distributor for both companies, facilitates manufacturers' warranties for end users. Faulty products are replaced out of Essmart's inventory, and the warranty is used to replenish Essmart's stock. This system ensures that end users experience immediate, locally available service and that manufacturers' warranties function as advertised.

For SEs selling larger products, like SELCO's solar home lighting systems, after-sales service has become a major reason for success. Now, there is a rural branch/service centre within a 50 to 60 km radius of any Karnataka village. The company will not sell anywhere where it cannot provide service within 24 hours (SCU, 2014).

### **3.5 Lesson 4: Make the Technology Affordable by Arranging Innovative Customer Financing that Aligns with Cash Flow**

One of the main takeaways from Prahalad's writings is that businesses have to create the capacity to consume by selling products in a way that is appropriate for BOP customers' limited and



unpredictable income streams. For Indian BOP households, 30 dollars a month may be expensive, but one dollar a day is affordable. This is why single-serving, one-rupee shampoo sachets are the norm in rural stores instead of larger bottles, although the per-unit cost is higher for sachets.

While it is near impossible to sell a solar lantern in pieces, financing schemes allow the customer to pay for durables over time. This matches the customer's income stream and profits the financier.

In India, only financial institutions are allowed to offer interest-bearing credit. Thus, the financial burden of loans falls on rural banks and microfinance institutions (MFIs) that work with SHG financial intermediaries. For example, Thrive Energy Technologies (solar lighting distributor) partners with MFIs, SHGs, rural banks, and international financial institutions (Jolly, Raven, & Romijn, 2012). Additionally, SELCO's success is greatly due to the company's ability to convince rural banks to provide India's first solar lighting loans in the mid-1990s (SELCO, 2009).

Despite all of these efforts, there are mixed views on the potential of third-party financial institutions to provide BOP end users with financing. In a 2013 report, authors Bairiganjan and Sanyal wrote that more financial institutions must be brought into VLE initiatives to make them viable. But a different 2013 report by Graf, Kayser, and Klarsfeld recognised that financial institutions have a limited household reach, are difficult to build partnerships with, pressure the user to purchase, and burden their partner SEs with default payments.

Customer financing can also be provided through other means. For example, Simpa Networks developed software-enabled electronics to facilitate pay-as-you-go mobile micro-payments for solar home lighting systems. This has the potential to eliminate the product's upfront cost (Koch & Hammond, 2013). Novel daily rental schemes also enable the use of high-cost life improving technologies by BOP users (Rao, Miller, Wang, & Byrne, 2009). Finally,

companies like Essmart piggyback on the financing that already occurs in rural markets: the informal financing that shopkeepers give to their most trusted and loyal customers.

### **3.6 Lesson 5: Utilise Trust-Based Relationships to Commercialise Innovative Products**

The greatest barrier to commercialising social impact technologies is lack of trust, not the technology's relatively high price. Customers ask themselves: Do I trust the person who is selling the product to me? How do I know that this product is worth the price? Will the product break after a few uses?

An active local presence, with an emphasis on responsive after-sales service, is very effective at creating trust. This is especially necessary when a pre-existing relationship cannot vouch for the product.

Most SEs partner with people in the local community. This is one reason why door-to-door rural entrepreneurs and existing retail shop owners can be effective communicators, advocates, and sales people for social impact technologies. In addition to brick-and-mortar stores, Villgro Stores uses farmers as rural entrepreneurs so that they can market Villgro Stores' products to peers. Essmart sells through existing rural retail stores, which are rural customers' primary portals to consumer goods. These trusted buying relationships are already established; Essmart just uses them to move different types of products.

Establishing trust is no easy task, and it is an extremely long and high-touch process. Product-centred SEs have described the extent to which field staff work to build relationships with customers. This generally involves home visits, multiple cups of tea, and in-depth conversations. When Essmart sales executives begin working with new shops, they must be available at nearly all times for inquiries and demonstrations. By providing mobile numbers and an office address on all marketing materials, Essmart's staff assures all customers that they are reachable in case any problem arises. All this creates

an atmosphere of trust and worry-free purchasing, so that BOP customers do not have to ‘buy at their own risk’.

### **3.7 Lesson 6: Design a Product that Brings Value to Customers (Which Does Not Necessarily Mean Lowest Possible Cost)**

When multinational companies first approached the BOP as a market, their strategy was overly simple and inherently flawed (Simanis & Hart, 2008). These companies pushed ‘stripped down products’, or existing products without extra features, onto BOP markets. There was little consideration of users’ sophistication and desire for quality products at an affordable price to meet higher order needs, such as the building of social capital and bonds with community members (Subrahmanyam & Gomez-Arias, 2008). It was eventually learned that products must be designed specifically for the demands of BOP customers, meeting their criteria for functionality, cost, and appearance (Immelt, Govindarajan, & Trimble, 2009). This was even true if the products cost more than the stripped-down ones.

In Essmart’s January 2014 catalogue, products ranged from Rs. 60 (US\$1) to Rs. 19,800 (US\$330). The average product price was Rs. 2,560 (US\$43), and one of the most purchased products was a solar lantern priced at Rs. 1,600 (US\$27). It was discovered that although the price of a product may be high (though not prohibitively so), peri-urban and rural customers are willing to invest when they see value in the product.

What constitutes value for a BOP customer? There are multiple components: 1) the product’s ability to meet understood pain points, especially if multiple needs can be met through a single product (e.g. a solar lantern that can also charge mobile phones), 2) the perceived risk-mitigation associated with investing in a higher-priced product, due to its increased durability, more reputed brand name, and warranty (Graf, Kayser, & Klarsfeld, 2013), and 3) the professionalism in the product’s appearance, promotional materials, and in-person marketing, which contributes to its aspirational quality.

### **3.8 Lesson 7: Embed SEs in the BOP by Establishing Mutually Dependent Economic Relationships**

When multinational companies tried selling products to the BOP, their efforts failed because they created one-way selling relationships (Eyring, Johnson, & Nair, 2011; Garrette & Karnani, 2010). A SE with longevity at the BOP embeds itself in the local context and grows its business hand-in-hand with their customers (Jue, 2012). Pervez, Maritz and De Waal (2013) labelled this process as ‘BOP engagement’, which is when ‘the value offered [by the enterprise] is perceived as a collaborative economic and social success’. When the SE needs the BOP, and the BOP needs the SE, then both parties are invested in the SE’s success.

SEs like Villgro Stores and others using VLEs build mutually dependent BOP economic relationships by relying on entrepreneurs who depend on their supply of products. Essmart creates these relationships by increasing the incomes of local retail shops and those of rural end users. The company’s top-performing shops sold about 90 units of Essmart products and earned an additional Rs. 10,500 (US\$175) in their first 18 months. Additionally, many of Essmart’s first end customers were small businesses that used solar lanterns to lengthen their work hours or improved cooking stoves to save restaurant fuel costs.

### **4 Conclusion: ‘The Product is King, but Distribution is God’**

A representative of a social impact technology SE said this during the 2013 Action for India Forum for social entrepreneurs. Throughout this author’s interviews, multiple SEs expressed similar sentiments. If a product-centred SE builds a social impact technology, end users will not necessarily come flocking to buy or use it. The technology-for-development space’s focus needs to shift away from invention towards scalable, financially sustainable, market-based dissemination.

Fortunately, the cries of dissemination advocates are being heard, to an extent. New awards, like

the D-Prize, are being offered to SEs that focus specifically on distribution (D-Prize, 2014). New dissemination-focused SEs are creating sustainable businesses to get these technologies to people. BOP customers are becoming empowered, as designers and companies respond to their needs and constraints. From their experiences, academics, engineers, impact investors, and other SEs can learn more about what it takes for technology to improve long-term empowerment and wellbeing at the BOP.

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Lessons learned when doing things backwards:  
the case study of Aalto LAB

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# Lessons learned when doing things backwards: the case study of Aalto LAB



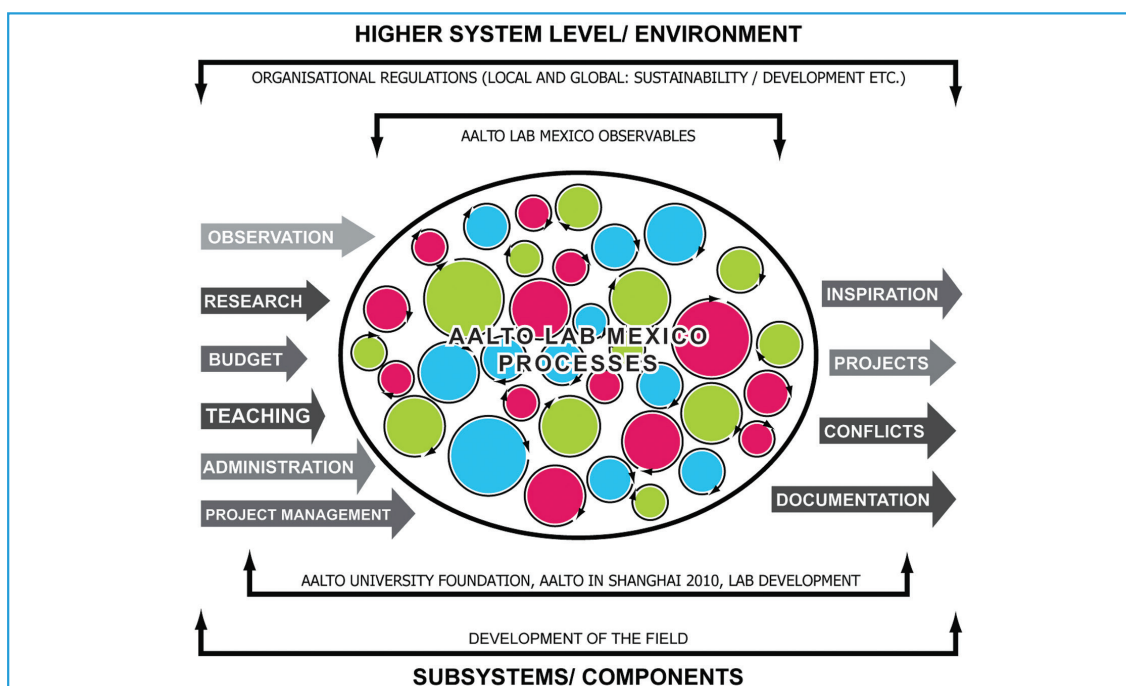
## Abstract:

Sustainability is a global call for action. Not that everyone should act in the same manner, but more precisely, that there is a need for local actions to be designed all over (United Nations, 1992). Aalto LAB Mexico (ALM) is almost a counterintuitive project that approaches the subject in a bottom-up and emergent manner. This pluralistic, non-reductionist approach provides the basis from which a rich variety of dynamic interactions can occur (Nousala, Moulet, Hall, & Morris, 2012).

As an interdisciplinary and intercultural project, Aalto LAB had its beginnings with Shanghai (ALS) in more formal settings (more of a top-down approach) with Aalto and Tongji Universities signing a memorandum of understanding (MoU), supplying a large budget, and setting a formal timetable. ALS also left room for a bottom-up approach, as the participants designed its content starting from an ambiguous brief ('to make the world a better place') (Nousala, 2008). The project was successful for a period but was discontinued due to external factors.

**Keywords:** *bottom-up, emergent, community of practice, capabilities, mutual exchanges*

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**Figure 1** Higher-level system environment (interactions of ALM group process). Diagram developed by Nousala and Garduño (2013) based on Nousala and Hall (2008) and Nousala, Moulet, Hall, and Morris (2012).

However, the project concept did generate learning and inspired a vision (to a small group that had been involved) of what could be achieved through this type of approach. This is the case study of a project that began from the bottom up and applied the LAB concept to achieve that vision—a story about how ALM came into being out of nothing.

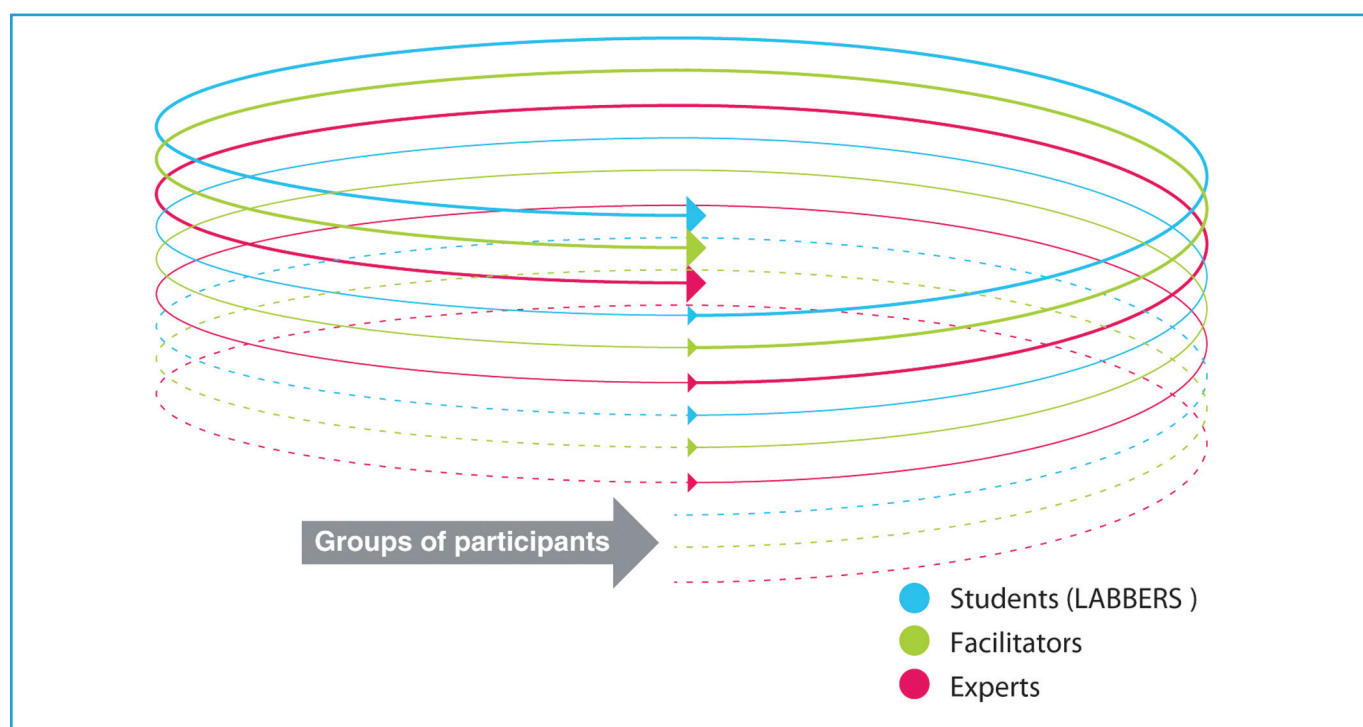
Rather than gathering institutions through official MoUs, ALM invited individuals within large world-class institutions to be part of the team. The members of the team are students, academics, and staff members of universities, NGOs, and the private and public sectors in Finland and in Mexico, but none of them holds a position of power within their organization. Instead of establishing a formal collaboration, ALM formed a committed network that is in the process of becoming a solid community of practice (Nousala & Hall, 2008) (perhaps more powerful than an MoU).

ALM embraces co-existing alternative livelihoods (non-urban global, capitalist societies), and takes one of these ('20 de Noviembre', a Mayan community in Campeche, México) as a starting point. ALM is about mutual exchanges (that honour

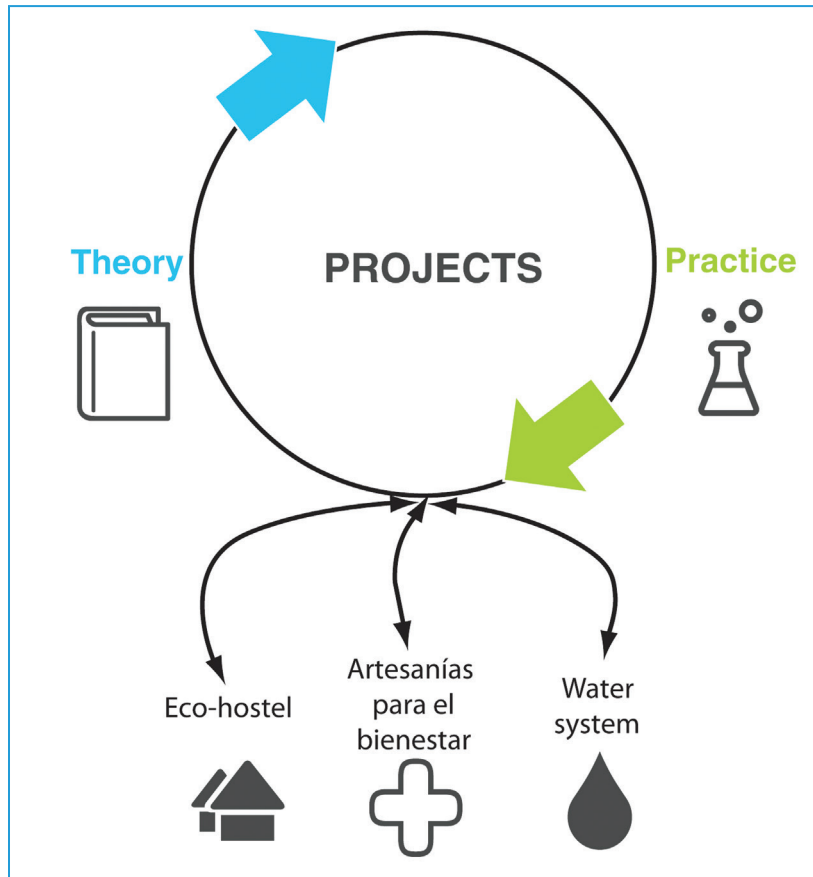
the richness of existing complexity) between academic knowledge and traditional wisdom; for this reason, greater levels of engagement of the local people in co-designing feasible projects are sought, maintained, and increased with every visit (Nousala & Garduño, 2013).

By gathering testimonials from experts and local people, through ethnographic observations and fieldwork, ALM has subsequently identified challenges (lack of access to healthcare systems, inadequate new infrastructure, water scarcity and quality, and insufficient income) and designed relevant and feasible projects (Artistry for Wellbeing, Eco-hostel, and Water System Project). It is then (rather than before making a diagnosis) that specific companies are invited to participate in the construction of win-win relations, to make the network structure solid, and to give continuity to the projects.

Suffering from a lack of official support brought to ALM its greatest learning: making a change with(in) a community fully depends on the level of engagement. Trust has to be built amongst the individuals, and therefore, it is grassroots work.

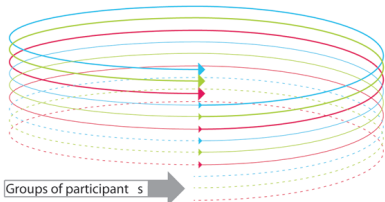


**Figure 2** ALM's dynamic interaction. Diagram developed by Nousala and Garduño (2013) based on Nousala and Hall (2008) and Nousala, Moulet, Hall, and Morris (2012)



**Figure 3** Projects that emerged from ALM. Diagram developed here based on Nousala and Hall (2008) and Nousala, Moulet, Hall, and Morris (2012)

## Lessons learnt when doing things backwards: the case study of Aalto LAB Mexico



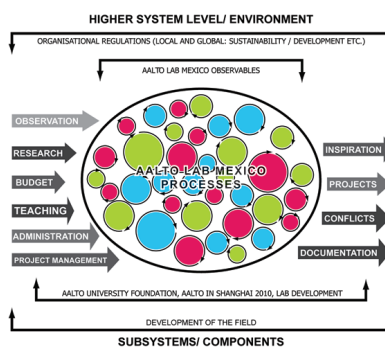
### + Introduction

Sustainability is a global call for action, through variety, more precisely, local actions to be designed all over (United Nations 1992). Aalto LAB Mexico (ALM) is a response to building engagement through a community in Mexico. This is almost a counter-intuitive project that approaches the subject in a bottom up and emergent manner. As a counter-intuitive, pluralistic, non-reductionist approach, it provided variety, subtle and dynamic interaction (Nousala et al. 2012). This project applied the LAB concept to achieve a vision, a new eco-system from out of nothing. ALM formed a committed network that is in the process of becoming a solid community of practice (Nousala et al. 2012; Nousala and Hall 2008; Nousala and Garduno 2013).

### + The Key Concepts and lessons

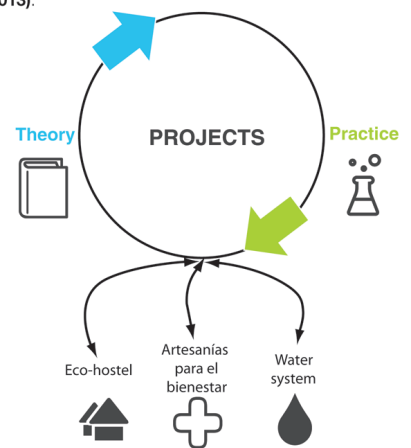
The ALM concepts embraces co-existing alternative livelihoods (non-urban global, capitalist societies), and takes one of these as a starting point. As an interdisciplinary and intercultural

project, Aalto LAB had its beginnings with Shanghai (ALS) in more formal settings (top down approach) with memorandum of understanding (MoU), a large budget, and formal timetable. The project was successful but discontinued due to external factors. However, the project concept did generate learning and inspiration to a small group, working from the bottom up, followed a vision of what could be and designed an ambiguous brief, 'to make the world a better place' (Nousala and Hall 2008; Nousala and Garduno 2013).



This bottom up approach is what ALM tried and tested in the field (rather than using official MoU's) by inviting individuals from large world class institutions, to mix with many others, as part of the team, eg; students, academics, staff members of universities, NGO's, private and public sector in Finland and in Mexico (none of them holds a power position within

their organizations). Regarding any critique that this type of project may follow an imperialist practice, in response, the ALM builds layered, dynamic designed networks with (in) communities. ALM is about mutual exchanges (that honour the richness of existing complexity) between academic knowledge and traditional wisdom; for that reason, greater levels of engagement of the local people in co-designing feasible projects are sought, maintained and increased with every visit (Nousala and Garduno 2013; Nousala, et al. 2013).



### + Conclusion

Established institutions hardly take risks (Brown 2009), but this methodology developed interest, support and growing involvement. Working without official support brought ALM to its greatest learning: constructing our capability to make a change in the world (while we still believe we can't).

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**Figure 4** Visualization of the poster, graphic work of Juan Vértiz and Gabriel Calvillo



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Design driven social enterprise:  
The Kuderu experience

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# Design driven social enterprise: The Kuderu experience



## Abstract:

Artisans develop products with the right combination of shape, materials, techniques, and colour. Because they are capable of moulding the very character of the society through their artistic skills, the craft plays a crucial role in the Indian socio-cultural development. Every artisan is self-employed and an independent decision maker in his business.

Sustainability as an idea is intrinsic to craft practices. These practices go beyond our knowledge of the world and its scripts. Even during the proto-historic period, for which there is no written record, there are still evidences of artefacts that demonstrate artistic skills. Craft practices moulded by the human mind and hand have evolved over time to make them more contextual as per today's needs and perceptions. Cultural aspects of communities can be defined by the crafts that their members practice. Thus, crafts can play a key role in the creation of identity.

Craft practices have survived because of a continuous process of innovation at all levels of the eco system; the paper explores the nature and impact of the same, which we accessed during our collaborative design practice at Kuderu Mole, an ethnic (tribal) hamlet in Chamrajanagar, Karnataka. We identified the craft practices by mapping design-centric empowerment at the grassroots and investigating the opportunities created in achieving economic and social self-reliance.

Bringing in entrepreneur skills to empower artisans and craft practitioners has been explored since India's struggle for independence. Self-reliance and other constructive value systems were introduced to mobilise people. The social effect of empowerment can be seen among the community through various parameters of development. Using crafts and local skills as a central medium to foster empowerment was also one of the key concepts

**Keyword:** *social enterprise, craft, community centric design.*

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## 1 Introduction

The word 'design' is often assumed to refer to the creation of fashionable outfits, sophisticated gadgets, good looking buildings, stylish cars, and so on. In actuality, design is more than the creation of mere physical artefacts; in fact, it is people centric. It

revolves around people's lifestyles, making their lives much more sustainable. Thus, the central purpose of design is to articulate a means to create a better future for co-living. Design is all about bringing a balance between people and nature by leveraging the appropriate technologies and innovations. Such interventions are community centric in an attempt

to address community development needs, in this way touching on latent social concerns.

Because design is intended to create social sustenance, 'social design' needs to focus on the tangible and intangible products that enhance the value of life. (Rai & Jha, 2004). Social design is the new paradigm of focus across design-oriented communities. Design applications are articulated toward strengthening the community, driving their economies, enhancing social status, and instilling sustainability in their lifestyles without the loss of their traditional essence.

Ideal design solutions need to encompass thoughts, investigation, action, ethics, wisdom, and practical means for their own realisation. Such solutions require not only objective thinking, but also skilful handling and ethical considerations. Establishing design within a community requires a people-centric approach if one wishes to channel and control the community and to make considerable and meaningful contributions to people's lives.

The World Bank notes that the rural non-farm sector has traditionally been viewed as a low-productivity sector which produces low quality goods. It is often expected to wither away as a country develops. Recent years have seen a shift away from this position towards recognition that the rural non-farm sector can, and often does, contribute to economic growth, rural employment, poverty reduction, and a more spatially balanced population distribution (Burkett, n.d.).

In India, National Bank for Agriculture and Rural Development (NABARD) – through its rural non-farm sector initiatives – has been involved in enabling grass root artisans with the direction and capacity to sustain their livelihoods in concurrence with global thinking. Such schemes are a mechanism for sustaining the micro-business models developed and nurtured for the artisans. These models are targeted at artisan enterprises, aiming to develop local economies and generate local jobs for local people using local resources. The products designed and developed by these micro-business units

strongly reflect the local traditions and cultural values while simultaneously accommodating urban market trends and expectations.

## 2 Context

Our pilot project was supported by NABARD to apply this strategic thinking at the implementation level. During the initial deliberations, we chose the most backward district in Karnataka – i.e. Chamrajanagar District – which had many ethnic groups who were evacuated from the forest to create a healthy space for the wildlife. This project was implemented to provide life sustenance to the displaced communities by leveraging the power of design.

### 2.1 Partner community

Chamarajanagar (Arikottara Chamaraja Wodeyar) is the southernmost district in the state of Karnataka. Most of the district lies in the leeward region of the Nilgiris and consists of mainly semi-arid, rain-dependent flatlands along with forested hills. The district, which has a high population of forest-dwelling tribes, is considered backward, and it receives low rainfall. We collaborated with a local ethnic group, the majority of the participants being women. The community members had been relocated from the forests, which were traditionally their habitat, in order to preserve the wildlife. These groups had always depended upon the forest for their sustenance, and their life revolved around nature and its resources in the basic innate form. Their traditional co-existence in the wild revealed an art of living with nature in perfect harmony. After being relocated to Kuderu hamlet, their very idea of existence had to be transformed to accommodate other ideas of ways to survive. As tacit knowledge, they retained a strong sense of identity; the ability to understand, appreciate, and manipulate natural materials; and an aesthetic sense that gave rise to exclusive and exceptional skill sets, which were very different from those of urban dwellers or the native residents of the village. This unique individuality of the community spurred us to work with them for this project.





**Figure 1** Kuderu tribal artisan settlement

## **2.2 Electing the strategic medium: Craft**

Craft as a practice is very individualistic in its approach because it is influenced by persons' cognitive abilities. Because of the medium, which involves both the hand and the mind, the result varies not only from individual to individual but from one product to another, even if fashioned by the same person. The unique background of the community and its strong identity and closeness to nature provided us with a distinct set of skills: for example, their understanding of colour interactions, material interactions and their combinations, sensitivity towards the manipulation of materials, and so on. We also observed that because of relocation, the Kuderu community were still trying to establish themselves in the area, as they needed to earn their livelihood without foraging from nature because their previous ways of living was not permitted anymore. In addition, they did not possess any land and were still tentative about the kind of work they wanted to do to earn money. Considering the scenario and the skill sets of the community, as well as the abundance of resources, handicraft was chosen as a medium not only to rehabilitate them and get them into the mainstream way of life but also to provide them with a strong sense of identity, which the community can choose to carry on for generations. Because the primary stakeholders were

the Kuderu community, we discussed the plan with them and decided to turn sisal into a form, which would increase the value of sisal fibre and transform it into a 'desire object'.

## **2.3 The local material**

In India, sisal has traditionally been used as a means to fence the fields. Sisal is an indirect crop, an indigenous plant that grows with very little or no care – a truly self-sustaining plant. It is replanted, when necessary, as an informal boundary marker. Thus, sisal has not been cultivated as a cash crop. However, looking at the potential of the sisal plant and its fibres, we initiated discussion with diverse development agencies. We also observed that a few enterprising farmers, realizing its high tensile strength, have been fostering sisal plantations for producing ropes to tie up the cattle. We clearly saw the promise of this new sustainable material and proposed various applications of sisal to maximise its benefits. Sisal is currently found on bunds and roadsides, serving the purpose of soil conservation and protection as hedges. Presently sisal fibres are collected and used for conventional purposes such as ropes, anchors, and cordage. They are not being used optimally or commercially exploited, considering their abundant availability, superior characteristics/quality, and wide applicability.



**Figure 2** Sisal plants grown as fence for fields in Chamaranagar, India



Harvesting sisal



Sisal fibre extraction



Sisal fibre processing



Natural fibre raw material

**Figure 3** Processing of sisal plant for fibre

Full grown five-year-old sisal plants (see Figure 2) may be seen on the roadside in Kuderu village of Chamranagar District in Karnataka. The plant grows without any special attention or chemical fertiliser. The older leaves are cut for fibre extraction,

but the young and tender leaves of the plant are not cut, as they will help the plant to grow further. This plant is the basis of neighbourhood economic stability among the rope makers and farmers of this backward, low rainfall region.



### 3 A participatory approach to function in the design development

A well-articulated and defined brief was developed for the sisal fibre craft artisans from the Kuderu tribal rehabilitee settlement of Chamarajanagar district in Karnataka. There was a strong urge from various governmental agencies to support these groups and enhance their ability to evolve into a sustained livelihood.

In this case, we were working with people who are skilled, and the design development of the products

is based on the mapped skill sets. It was of extremely important for us to carry out the task so that it could evolve as co-design and co-creation. We had come up with a few concepts and ideas to begin with, but the ideas were not finalised at the beginning.

A spin-off advantage of the field workshop at the settlement was that it helped the people to identify the opportunity in sisal, a raw material which is around them, and to leverage its fullest potential through design intervention. The workshop launched with a great deal of hope, and various stakeholders, including the media, acted



Figure 4 Interaction and workshop with the community

as evaluators and contributors. The workshop was financially supported by NABARD. Our project work commenced with providing information and awareness to all the stakeholders. The focus groups were involved in briefing the people, which gave them exposure to the raw material and raised their awareness of the product's potential for development, which has global appeal. Skill mapping was done so that we would understand the inherent skills each of them possessed. Based on the skill mapping, groups of artisans were divided according to individual strengths (aptitude for material choice, hand motor skills, communication, and selling). These specific skilled groups were organised into individual micro-business units called self-help groups (SHG).

The artisans were then given an opportunity to explore the urban markets and interact with their

potential customers, to whom they would need to cater with their product offerings. Through meeting their customers, they were able to comprehend and articulate these customers' choices. The artisans were trained and monitored as the design brief was developed, which was based on observation and post-customer interaction. The artisans explored a variety of natural materials and their fibres. They also tried hands-on material manipulation and different techniques like twisting, braiding, crocheting, weaving, etc. Each of the artisan groups was attached to a small group of cross-domain students from design, communication, technology, and business. The intention of the collaboration was to obtain perspectives from multi-functional spheres of influence in order to evolve a viable product. The artisans were also introduced to the formal process of design drawings and form development, and were trained to work artistically



**Figure 5** The Corporate Accessory Collection



on hard and structural materials. The utmost care was taken during this phase of training not to dilute or morph the traditional essence of their cultural values. Most of the forms and motifs they developed were directly relevant to their culture and lifestyle, and care was taken to preserve those elements. The entire process was carried out in the local language and with an experiential method of pedagogy.

#### 4 Outcome

The collaborative design experiment became manifest in the products developed, which were market oriented, matched customer expectations, and possessed a high style, trend, and fashion quotient, making them appealing. These products were developed with sisal and colouring agents, which were essentially natural dyes extracted from herbs and vegetables. The product was made with twisted ropes of sisal, which had been intertwined with cotton threads in order to soften the texture. The resulting raw material was thus more pliable for twisting, braiding, stitching, piercing, and other processes. Many of the techniques used for making the products emerged out of the skills already applied by these people in their everyday activities. They had mastered hair braiding techniques over several generations, which were an essential design feature in the products.



Figure 6: The social brand logo

#### 5 The social enterprise

Having long-term future goals with foresight and vision is the key aspect in developing a

sustainable community-centric business model. With this as a backdrop, we laid out a business plan by involving the community. This project was very clear in its approach of focusing on commercial feasibility before moving on to skill enhancement and product development. If a social enterprise is to become established and sustained, it is important to transform the surrounding resources clearly into meaningful products that represent the cultural diversity and traditional knowledge of the place. These basic thoughts were considered as a building block for developing the brand we called 'Aarambh', which means 'to start' in Sanskrit. It also signifies the beginning of a new movement for the artisans of Kuderu hamlet. The Aarambh brand name provided the group with the necessary ideology and identity to design, produce, and market the products. The formation of the SHG ensured that the artisans would be treated not as employees but as business partners with the self-interest of becoming financially independent. It also gave an identity to the community, which they seemed to have lost after being rehabilitated. We used a participatory approach, which allowed the development of the brand while complete ownership lay with the contributors. This also gave them more responsibility in terms of managing and enhancing the brand. The products designed are marketed through various channels under the Aarambh brand name, which is owned by the community of SHGs.

The project was initially conceived with an exit policy, and the objective was to train the crafters in all aspects and to 'hold their hands' so that they would become self-reliant and able to carry on the business activities after our withdrawal from the project. Thus, over time, all the key decision-making aspects were slowly handed over to them. Handholding was done for about two to three years in a phased manner as envisaged in the exit policy. During this process, the preliminary concerns and the apprehensions of the artisans were addressed. The objective of empowering the community and equipping them with a commercially viable social enterprise was achieved by leveraging design.



## 6 Tangible and intangible results

### 6.1 Tangible

- Skill development
- Sisal fibre development
- Combination of sisal with new materials
- Manipulation of sisal for products beyond ropes
- Emergence of fashionable and trendy lifestyle product line

### 6.2 Intangible

- Conferring the community with an identity and a recognisable entity status, enabling them to achieve more
- Strength through mainstream partnership with banks and government schemes
- Transformation of unskilled into skilled manpower
- Improved quality of life
- Global business potential channelled into developing the local economies
- An adaptable business model, which can be replicated or adapted in a similar backdrop and context

## 7 Insights and inferences

Environmental behaviour has changed its tactics to incorporate design considerations as a key strategy. The interface between design and human behaviour as a transforming agent is well established beyond doubt. As a field, it is still at its nascent stage, but its ability to improve the quality of life is already verified on a much larger scale. At the same time, the prospect is open to correlate design solutions to

a variety of challenges now at the social level, and the same will be true in the future.

We realised the power of design thinking in this mission of creating a social enterprise where it acted as a basis for morphing the tacit skills of people and local materials into a large business movement. In this project, the experience of design was realised beyond its notional understanding of developing conventional cosmetically modified artefacts; it changed the perception of people about their own capabilities. The key elements, which played a significant role in this entire project, were society, skills, surrounding materials, politics, and local dynamics, and the experience enriched us greatly by providing knowledge about design academics and practices.

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Social entrepreneurship with design in  
Southern India: Lessons for Australia

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## Abstract:

Design schools and agencies have developed responses to the need for socially responsible design and sustainability in developing world contexts, albeit often with a technology-driven and donor NGO attitude. Such approaches are however inadequate for the environmental, economic, and social constraints of sustainable, 'frugal' design in agricultural and transforming nations like India, now being driven by models of social entrepreneurship. In the context of curriculum renewal in design in Australia and in view of closer engagements with Asia, more needs to be learned about these contexts from international collaborations. An on-going collaboration between IIT Madras (Chennai) through its Centre for Social Innovation and Entrepreneurship (CSIE) and Swinburne University has helped identify mutual learning about human-centred and technological needs for Design Schools wishing to contribute meaningfully to social impact. Based on insights drawn from the collaboration and a small interview study, this paper identifies the education challenges for programmes that integrate design, social entrepreneurship, and development theory and practice.

**Keywords:** *social entrepreneurship, design education, curriculum*

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## 1 Social entrepreneurship in India

A recent ADP-Asia Development Bank (2012) report paints a positive picture of the growth and potential of social entrepreneurship (SE) to contribute to alleviating poverty in India through sustainable business models and innovation, although simultaneously suggesting more investment, evaluation, and awareness is needed. Increasingly, such SE models adopt a triple bottom-line approach to social impact ventures that contribute to sustainable change (Cohen & Winn, 2007). Social entrepreneurs and organisations, including both global, such as Ashoka Foundation, and regional players, such as Villgro, have been active in India for some time, and are seeding 'home-grown' innovation and helping to create new private-

public partnerships (Sen, 2007). Given the scope of development issues in areas like health, education, gender equity, and poverty reduction, there is no lack of scope and need for the establishment of enterprises that address excluded or disadvantaged sectors of a population of 1.2 billion (e.g. Datta & Gailey, 2012).

Alvord (2004) suggests that although there is a range of activities which qualify as having social impact, the most sustainable model is one focusing on 'contextualised' social transformation: 'Social entrepreneurs in this tradition need to understand not only immediate problems but also the larger social system and its interdependencies, so they can introduce new paradigms at critical leverage points that lead to cascades of mutually reinforcing

changes in social arrangements' (p. 262). We believe this is the context within which sustainable innovation for wellbeing should be understood.

It is in this context of sustainable social impact that technology and service innovation is offering hope and challenge to existing donor and NGO approaches. The failure of technology-driven ventures, such as the one laptop per child (Kraemer, Dedrick & Sharma, 2009), that paid insufficient attention to socioeconomic and cultural constraints, and best practice examples such as the Aravind Eye Clinic have demonstrated the potential and challenges of the moment to addressing poverty reduction and growth strategies (Mair & Marti, 2006). The recent Australia-India Institute (2013) report on technology innovation and cooperation comes to the same conclusion about different models, including social impact, being necessary for successful collaboration.

However, there are challenges for design. Design agencies and schools contributing to sustainable social impact will be faced with challenges in understanding the contexts for frugal innovation (Zeschky, Widenmayer, & Gassman, 2011) and 'Indovation' in economies in transition (see Birtchnell, 2011), which is no longer dependent on the West. Contrary to the creative genius discourse that is still found in design practice and education (e.g. Coyne & Snodgrass, 1991), social innovations emerge and develop through the contribution of multiple stakeholders (Corner & Ho, 2010). The primarily technology-driven discourse of design innovation needs to be supplemented by a more holistic human-centred approach to innovation for sustainable livelihoods, including but going beyond capability-centred design.

Such changes will have direct consequences for higher education and design in particular. The future higher education landscape in the Asia-Pacific is uncertain, and international collaborations in teaching and research are critical (Shin & Harman, 2009). Transnational higher education between Australia, the UK, and the USA already shows

some inability to learn from its partners, adopting a 'control' not collaboration discourse (Smith, 2010). An approach that sees India leading change and (social) innovation is required. Similar to the failure of the Washington Consensus to predict development in Asia and beyond (e.g. Gore, 2000), it is time to revisit the assumptions behind North-South relations in design practice and education. We believe that international collaborations in design and technology innovation, as described in this paper, point up the changes required in attitudes and practices in socially responsible design.

## 2 Socially responsible design: Promises and limitations

With the substantive expansion of design into services and other business and social domains, the need to incorporate broader understanding of the human-centred contexts of design has made new demands on the nature and content of design education in such multidisciplinary environments. These new demands include sustainability (Spanenberg, Fuad-Luke, & Blincoe, 2010) but also social impact, developing world demands (Oosterlaken, 2009), and participatory co-design (Sanders & Stappers, 2008). It is not clear that design schools have yet translated these new demands into responsive programmes (e.g. Ramirez, 2006). Although many architecture, urban design, and industrial design schools and departments offer courses integrating sustainable development concerns with practice it is not clear that the resource constraints, rural and urban poor perspectives, and frugal innovation practices typical in the 'South' are fully represented. Since Victor Papnek's original call for responsible industrial design, designers have developed a stream of thought about socially responsible design beyond normal market and business considerations (e.g. Morelli, 2007). Socially responsible design (SRD) has demonstrated some weaknesses in its understanding of the developed and developing world contexts of its work (Melles, de Vere, & Mistic, 2011). More recently, this is a discussion which argues for greater engagement of design in social innovation in the developing world (e.g. Brown &



Wyatt, 2010), and ultimately demands we revisit the nature and content of design education (Melles, de Vere, Bisset-Johnson, & Strachan, 2010), and the graduate attributes and profiles we are educating designers toward, including entrepreneurship (Hynes, 1996).

Thus, Cooper (2010) notes, 'There is now a need to shift from the focus on single issues toward taking a more holistic approach. Designers often have to take into account a complex range of issues and develop methods of considering trade-offs between, for example, crime and inclusiveness, or the economy and social inclusiveness' (p. 17). The failure of particularly well-intentioned design products, such as the one laptop per child programme (Kramer, Dedrick, & Sharma, 2009) lacking an understanding of bottom-up realities is another reflection of this inadequate theoretical understanding.

Most recently, Oosterlaken (2009) has suggested that the relevant paradigm for this work is capability-sensitive design. From this perspective, design decisions should contribute to capabilities; Amartya Sen's notion of capabilities places emphasis on the capacity of individuals to achieve certain ends, for example, functioning as being well nourished (Sen, 1988). Hence, well-being and quality of life are not measured by income and consumption, such as GDP or GNP per capita, as in standard economic models, but rather by one's capacity to be and do things (Gasper, 1997). This integration of a key concept from the sustainable development discourse (see Baker, 2006) is apposite but demands that in addition to overcoming university wide gaps between rhetoric and reality (Moore, 2005), design practice and transnational partnerships effect real change in theory and practice of design education (see Melles, de Vere, Bisset-Johnson, & Strachan, 2010). With these ends in mind, we believe that India and potentially other economies in transition (EIT) are already developing appropriate innovation constraints and frameworks, from which the North must learn.

### 3 Centre for Social Innovation and Entrepreneurship (CSIE) IIT Madras: History and context

The Centre for Social Innovation and Entrepreneurship (CSIE) at IIT-Madras (IITM) was founded in August 2010 by alumni with a focus on teaching and research related to social enterprise in India. A grant from Villgro Foundation, a local rural innovation group (see Sonne, 2012), helped establish the minor programme of four units, which is the focus of this paper. The Centre is not unique in India, as other universities and associated education institutions have also developed such models. CSIE is well known and is networked to a broader network of innovation and social impact activities than others. It forms part of a constellation of activities and associated centres, including research parks and incubation units that constitute the (social) innovation ecosystem of IITM.

IIT Madras has been involved in the field of social entrepreneurship since 2002, when it partnered with the Lemelson Foundation's RAMP for social entrepreneurs, as well as Villgro Innovations Foundation, a Chennai-based social business incubator. A programme of socially relevant projects (<http://srp.iitm.ac.in/>) preceded the current ecosystem of activities and institutions, and two other organisations – the Rural Technology Action Group (RuTag, see <https://sites.google.com/site/rutagtn/>), and the Telecommunications and Networking Computer Group (TeNet, see <http://www.tenet.res.in/>), which focuses on ICT infrastructure – and many other departments are run by or with the expertise of IITM faculty. The multidisciplinary mix of courses constituting the minor and some indication of the topics covered, gives some indication of the scope and content of the course. It should be noted that the third component is a choice between rural field study and a laboratory-based study; the majority of students take the last option; at the time of this study the lead author taught in the second module.

CSIE aims to focus on delivering social enterprise knowledge primarily to engineering students, with the aim of developing their ability to develop and deliver technology solutions that create social impact and focus on academic research that will seek to address problems exclusively within the Indian context. There is an agenda for education – academic programmes on social innovation and entrepreneurship for students across disciplines and degrees at IIT Madras, research – CSIE provides an enabling environment for both student and faculty researchers interested in social enterprise research within the IIT campus, innovation – encouraging young innovators and entrepreneurs by assisting in the development of socially beneficial products and ideas, and collaboration – creating an ecosystem that extends to other technology institutions, including IITs.

## 4 Context for this paper

During my visit in January 2014 (accompanied by two other colleagues), I met representatives of the centre and related institutions, such as the incubation cell, the research park, RTBi, as well as teaching about human-centred design in the minor programme (current cohort n = 35), and the MBA programme. I also spoke at a campus conference on medical humanities on human-centred design contribution to assistive technologies and sustainable development. During this visit, I also conducted an interview study with faculty at all levels (n = 7) to gather their impressions on three issues: the meaning and nature of social entrepreneurship, the need for this in India and Tamil Nadu, and the successes and challenges to the existing programme; follow-up visits and research collaborations in engineering,

**Table 1** CSIE Minor Sequence, IITM

Course Units	Coverage	Output from students
Introduction to Social Enterprises in India	Theory (conceptual understanding of SE domain, management concepts, frameworks for design/evaluation of SE) - by Prof LS Ganesh  Case studies (Ashoka, Grameen Bank, Barefoot College, Phulki, Water Health International, Amul, Selco, Fabindia)  Guest lecture by practitioners (Mr Kannan Narayan, Mr Joseph Thomas (CSIE), Ms Latha Suresh (CSIM), Mr Sundaresan (Gnanadarshan Seva Trust), Ms Marie Banu (CSIM), Mr Shekhar Raghvan (Rain water harvesting), Mr Ravi Shankar (AID India), Mr Muralidharan (Sevalaya), Mr Elango (Kuthambakkam))  Rural field visit/visit to SE is planned from next academic year	Case Studies
Product Design & Business Models	Creative Problem Solving (TRIZ techniques by practitioners at Mindtree, Honeywell, Cognizant)  Engineering Design and Prototyping (by Prof Sandipan Bandyopadhyay, Engg. Design Dept.)  Entrepreneurship (by Prof Ashwin Mahalingam, Dept. of Civil Engg.)  Finance (by Prof Ashwin Mahalingam, Dept. of Civil Engg.)  Business models and strategy (by Prof L Prakash Sai, Dept. of Management Studies)	Business Plans
Laboratory Study  Field Study	Centre for Innovation Lab (by Prof R Nagarajan, Dept. of Chemical Engg.)  Review by practitioners  Rural visits (by Prof John Bosco Lourdasamy, Dept. of Humanities and Social Sciences)  Self-help groups  Participatory Learning and Action  Review by domain experts (internal and external)	Prototypes  Business Plans

Source: <http://csie.iitm.ac.in/Education.html>

biotechnology, and design through 2014–2015 are already planned. These interviews in the context of conversations in the School of Design and Swinburne University about future collaboration are the focus of this paper. Interviews were conducted in a range of locations on campus, and with faculty representatives in the CSIE programme from the social sciences, management, and engineering departments at a range of levels from project officer to associate professor. Three questions drove the interviews, and were related to the review of the literature. Responses are summarised below.

### Definitions of social entrepreneurship

One common observation from all respondents was that entrepreneurship and social entrepreneurship form a continuum and the divide between approaches that were specifically for social impact and those leading to commercial innovation was a difficult line to draw sometimes. Some respondents deferred to existing definitions of the concept by leaders in the field, and others offered concrete examples in the region. The question of the sustainability of models and practices typically at SME level was also an issue of some debate in terms of the extent to which all three dimensions of the TBL were observed, especially environmental sustainability. It was also not clear that the model was in fact having the success that some media reports suggested in India, and this was also tied to the need for a higher profile and legitimacy of the CSIE centre on campus. All respondents, however, suggested that it was a shift from both philanthropic ‘charity’ approaches and mainstream commercial business propositions – it was the creation of markets using different mechanisms and with social impact.

For one respondent with 8 years of experience in the sector, it was critical that the social impact was ‘bold’ enough to transform lives or otherwise it did not meet the criteria. As another respondent suggested, the exclusion of sectors of society meant that often the intended beneficiaries often were not even coping with life; so social impact meant providing support to survive rather than an impetus

for personal or household development. Also, the failure of innovation was due to not considering the system constraints; for example, affordable toilets failed because open defecation was common and integrating the toilet into the house was rejected for cultural reasons. In another example of lighting in homes through solar power, the reach of innovation was extended to system, not just product innovation.

### Significance to India and Tamil Nadu

The model had clear applications in India, given poverty reduction as a global aim, but also in terms of creating sustainable livelihoods for BoP. The question of global and regional boundaries also touched on the issue of scalability, that is, the extent to which village or community level innovation should scale. Conventionally, in discussions of social entrepreneurship, scaling is critical, but respondents noted a tension here between problems with regional circumscription that would not necessarily scale and other problems, such as violence against women, which were national considerations. In all of these discussions, the need for adaptation to the Indian context – sensitivity to cultural mores etc. – were deciding factors in the success and failure of initiatives.

Several respondents referred to a priority area being infrastructure, such as electricity, water, roads, etc., as enabling conditions. Although Tamil Nadu in comparison to other states, for example, Kerala, was relatively better off in terms of human development, such as mortality, the need to address the resource limitations as ‘enabling’ conditions was a priority. Another key issue was that self-help groups and similar mechanisms for collective action had arisen to support women in particular. The view of one respondent directly involved with these entities was that social entrepreneurship was a way of stepping up the potential from survival and support to economic development for such groups. Thus, scalability, gender, collective action, infrastructure, cultural mores, and creating platforms for development were all key characteristics of current work.

## Success and challenges for the CSIE programme

At the time of the interviews, a fourth cohort of students was enrolled in the programme. The CSIE minor was heavily subscribed and not only had the centre achieved its goal of raising awareness across campus but it had also produced graduates who went on to become social entrepreneurs. Even those who did not, (and this was a thought expressed by some current students), but went initially into mainstream business, had a seed planted that some would later take up. A practical challenge was that the centre and the programme were staffed by 'volunteers', that is, faculty from other programmes who had some interest in teaching this elective.

A key challenge, however, was improving the profile of the centre across the university as a first port of call for the mainly engineering disciplines. It was, however, important, as another respondent noted, to see CSIE and its three aims – outreach, research, and education – as part of a larger ecosystem, and not judge its potential and achievements in isolation. A practical challenge was also keeping the centre economically sustainable through consultancy services and other means. Thus, the way forward is not without challenges and it is here also that international collaborations can contribute. These deliberations and others formed the basis of a reflection on the current nature of the collaboration and its contribution to educational change.

## 5 Discussion

The demand for design education programmes that are more responsive to the needs of the bottom of the pyramid (BoP) is an on-going discussion. While a few schools have developed programmes exploring the broader holistic constraints of social, economic, and environmental sustainability, it is not clear yet that it has been mainstreamed into design schools. The implications of the substantive expansion of design beyond products, the multidisciplinary nature of design projects, and the implications this has for education have only begun to be explored. The question remains, what should be

the relevant framework of sustainable development for design? We believe innovation through social entrepreneurship may hold the answer. In institutions with a strong technical focus, such as IIT Madras, human-centred design approaches add to the capacity of students to understand context and design accordingly.

It is clear that fostering innovation across campus through incubation centres and other supported research ventures is critical to success. Education programmes that address the triple constraints of social impact and economic and environmental concerns, while fostering innovation in technology and services, are part of this new network. This innovation ecosystem is far better developed in Madras than in Melbourne. As alternative economic models, such as private-public ventures and social enterprises, take increasing centre stage for economies in transition, and these countries increasingly determine the economic, social, and political landscape of this century, OECD countries and the North need to look closely at their assumptions about the context for innovation.

The clear lesson for design programmes in the North is a better understanding of the constraints of frugal innovation in India, where indigenous innovation is developing without the need for the West to chart the path to success. This implies integrating, but ultimately going beyond weak sustainability modules or more holistic models such as design for sustainability (Spangenberg, Fuad-Luke, & Blincoe, 2010), industrial ecology (Ehrenfeld, 1997), and philosophical propositions like capability-centred design (Oosterlaken, 2009). Broader training not focused only on technology-driven but broader social needs and constraints, including models of social entrepreneurship, is required. International collaboration through study tours, and research and teaching collaborations should contribute not only to new opportunities for teaching and research but encourage change, especially in a global trend to favour the South (UNDP, 2013). Including training in social entrepreneurship, social innovation, and frugal (affordable) design may help

the industrialised North practically contribute to (but not dictate) a capability-centred innovation model. Design schools ignore this at their peril.

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paper

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Learning from the Timmaiyanadoddi Village  
Intervention: An Ongoing Experiment

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# Learning from the Timmaiyanadoddi Village Intervention: An Ongoing Experiment



## Abstract:

We have been visiting Timmaiyanadoddi, a small hamlet since 2011. We have built a community centre and are in the process of building roads, drains, and water tanks while providing for rainwater harvesting and tree plantation. We are planning to build houses, toilets, and kitchen gardens as needed. The Timmaiyanadoddi model is an experiment conducted with the intention of assessing whether it is a replicable intervention model. The model seeks to ascertain the impact of a holistically designed built environment on the human psyche – our premise is that once you are involved in the rebuilding of spaces around your house, the feelings of overall wellbeing, self-respect, and responsibility toward one's self and toward the surrounding environment are likely to increase.

While we are not sure whether our inclusive process has achieved the same, the design product of the Community Centre seems to indicate a link between wellbeing and design.

**Keywords:** *village development, rural housing, rural infrastructure, rural house design*

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## 1 Introduction

Unequal dignity and heterogeneity are expressed in every strand of life in India. The reflection is stark in the housing sector. It is our dream that in rural India, home to 70% of our population, every person should have a roof over his/her head and live a life of dignity. Improving the quality of people's lives in the villages in a holistic manner is an effort where a few like-minded organizations with complementary skills have to come together in an egoless manner to bring about meaningful, lasting change.

Our idea is to build the houses in a sensitive, democratic manner, incorporating the villagers' way of life and introducing sound construction methodology and techniques to ensure good

quality homes that are a source of pride for their owners. We began visiting Timmaiyanadoddi, a small hamlet, 21 km from Electronic City, Bangalore in 2011. We built a community centre and are in the process of building roads, drains, and water tanks while providing for rainwater harvesting and tree plantation. We are planning to build houses, toilets, and kitchen gardens as needed.

Any dream is meaningful only if it is translated into reality. The redevelopment of Timmaiyanadoddi hamlet is a pioneering effort to convert this dream into brick and mortar, house by house, village by village. This paper traces our journey, from the advent of our intent to intervene, to our introduction to the village, and to the execution of our vision along with the trials, tribulations, travails, and lessons thereof.

## 2 The Approach for Intervention

The approach we used for intervention is based on the Swami Vivekananda Youth Movements' (SVYM) 3H Approach – heart to feel, head to think, and hands to work. This is translated into an 'observe, interpret, intervene' method.

The methodology we used is described below:

**Interact** with the local community to gain an understanding of cultural usage of space, cultural beliefs, and sensitivities;

**Collaborate** with the government, NGOs, self-help groups, international agencies, banks, institutions, corporations, and individuals for financial and non-financial assistance;

**Engage** the architectural community for the research and development of alternative materials, construction methodologies, and volunteerism;

**Derive** specific, local, eco-friendly, long lasting, and cost-effective design solutions; and

**Construct** housing and rural infrastructure in a holistic manner.

## 3 The Project

### 3.1 A Brief Account

We were introduced to Timmaiyanadoddi through a fledgling NGO, Samagraha. Samagraha was working on vermi-culture as well as community development in the village hamlet, Timmaiyanadoddi. They organized focused group discussions with those in the small community who expressed their keenness to have their houses rebuilt. This was in February 2011. We then decided to conduct the pilot project at this village. The villagers were keen on infrastructure development in their village. Many NGOs had visited, only to stop any initiatives after a few initial visits. The villagers expressed their eagerness for

some sustained help with development. Being a small hamlet, holistic intervention in terms of housing, toilets, and infrastructure development, like roads, trees, rainwater harvesting, etc., would be possible with donor support. This was an important consideration in choosing the hamlet, apart from the fact that the community expressed keen interest. We promised to help, and while continuing our research activities, we met with government officials to gain an understanding of the available schemes and looked for possible donors. We kept visiting once every few weeks to study the village, establish a rapport with the people, and assure them that interventions would happen over a course of time. Samagraha stopped their work in the village in the subsequent months. We were at a loss without any local NGO presence, but had to continue their work, having given our word to the community.

The official project launch happened in the village on 1 April 2012.

YogaKshema (n.d.), an NGO whose vision is 'To improve quality of life of people and help them make lifestyle changes', announced their intent to work with the village along with us in late 2012. They have been instrumental in seeking and appointing a community development worker and introducing Canara Bank to the village.

Construction of the Community Centre started in November 2012. This was considered a strategic entry point to introduce an alternate technology on neutral grounds. The clearance to construct was obtained from the Gram Panchayat. We also made a Memorandum of Understanding (MOU) with the village that allowed us to work with and for them there. A few people from the village were trained in block making, and later a couple of them worked as unskilled labourers.

### 3.2 Location and History of Settlement

Before deciding on any intervention, we obtained a brief history of the village.





**Figure 1.** Satellite imagery location: Timmaiyanadoddi is located 21 km away from Electronic city, Bangalore, at 12°43' N latitude and 77°36' E longitude

**Source:** Google Maps

In the 1950s, a couple settled in this village from the neighbourhood where they worked as bonded agricultural labourers. The others joined them over a period of time. The land was a forest then. They built thatched huts. The Government later sanctioned farm land for them. The people procured bamboo from the forests freely, and built and sold baskets. This became their heritage.

It became clear that there were no historical or traditional patterns of house building and settlement for us to adopt in our solutions. We got a bamboo expert to assess the bamboo used by the villagers for basket weaving and construction, **and we realized that the bamboo was neither strong enough nor were the people keen to use it in mainstream construction.**

### 3.3 The Village

Timmayanadoddi hamlet is located in Anekal, Bangalore Urban district. It falls within Indlawadi Gram Panchayat.

The nearest facilities, such as the hospital, middle and high schools, colleges, etc., are about 10 km away. The village has 24 plots of 30' x 40' parcels of land for housing, over 1.5 acres of which were donated by the government nearly 50 years ago. The

houses are located on either side of a central spine, which acts as a community space – all activities, like basket weaving, tying cattle, children playing, meetings, etc., take place in this street.

## 4 The Design

### 4.1 Design Intervention Proposal

We plan to build a Community Centre, houses, toilets, and kitchen gardens in a holistic manner along with community rainwater harvesting. We will approach roads, drainage, tree plantation, etc., using a design-driven approach for cost effective, yet aesthetic, solutions.

### 4.2 Consultants

We have utilized the services of Ashoka Fellow Aiyappa Masagi for rainwater harvesting solutions for the entire village. Structural inputs and guidance on the stabilized block technology are provided by Professor Yogananda (formerly IISc).

### 4.3 Villagers' Stated Needs

All of the villagers live in houses away from their fields. They have general beliefs in Vastu. They all want a verandah outside the house for activities

like sitting, chatting, sleeping, entertaining guests, storage of grains, drying clothes, etc. They all prefer to have a puja area, but are very comfortable with placing pictures of gods over a wall with a small ledge below. No specific designated area for puja is required. They all prefer separate kitchens inside the house; most of them use firewood and eat inside the kitchen. All houses have a dearth of storage spaces, especially in rainy seasons; they have very few belongings, yet they desire storage areas. All the villagers prefer that the bathroom and toilet be accessible from outside the house.

#### 4.4 Master Plan Level Highlights

The villagers expressed the need for road drains and extra water tanks.

We worked out cost-effective design solutions at a master plan level for the following:

- **Approach road:** This is built with chapdi stones.
- **Drainage:** The drainage is proposed to be an open U-shaped drain, which will encourage people to keep it clean. It will follow the natural slope of the road.
- **Rainwater harvesting:** All roofs are inclined to the road so that the water flows to the open drains. For every 3 houses, one gallery pit is proposed within the drain, which will help recharge the water.
- **Rural toilets:** Since the villagers are not keen on the dry toilet system, we are planning to build a twin-pit system as an efficient solution.
- **Kitchen gardens:** These are proposed at strategic areas where the grey water can be led to the gardens, and the villagers can be taught to grow vegetables.
- **Cow sheds:** These are planned at the rear of the plots, away from the main access spine.
- **Tree planting:** These are planned with use of local species at strategic locations.
- **Biogas plant:** Though there are enough cattle, there is inadequate space for a biogas plant in this village. A common Sewer Treatment Plant (STP) will not work either, for the same reason.

#### 4.5 House Design Highlights

The design options were developed, after closely interacting with the villagers, to maximize the space available within the donor-given cost restrictions. Getting the villagers to make their own blocks and provide free unskilled labour for the construction will bring down the costs to approximately Rs 10,000 (USD 165). The owner also has to pay approximately Rs 11,000 (USD 185), based on a survey of their financial ability conducted by a micro finance organization. This amount is being offered as a loan by Canara Bank. This is expected to create owner involvement and pride.

The cost of each one bedroom (BR) house, comprising a 375 sq ft built up area, a verandah of 50 sq ft, and a loft of 50 sq ft, is at Rs 2.5 lakhs (USD 4125). The size has been derived by keeping costs in mind as well as the fact that the existing owners are used to living in spaces of a certain size, albeit of poor quality.

Special features of the housing at Timmaiyanadoddi are as follows:

- A square of 20' x 20' can accommodate four design options, from one BR to four, with the addition of lofts.
- Houses are Vastu compliant, which accommodates the local belief system.
- The design is flexible. Even a 1 BR can be upgraded by building additional floors when the villager's financial status improves. The foundation and the walls are designed to bear a future load.
- The roofs of houses slope toward the road to facilitate rainwater harvesting.
- The kitchens are sized for an Astra-designed smokeless stove that facilitates their specialized way of cooking.
- The cowsheds, bathrooms, storage, etc., will reuse existing bricks, thereby minimizing wastage.
- Existing roof material will be salvaged for cowsheds.
- The loft, doors, and windows are proposed to be of recycled crate wood.
- Stabilized adobe blocks will be used, which the



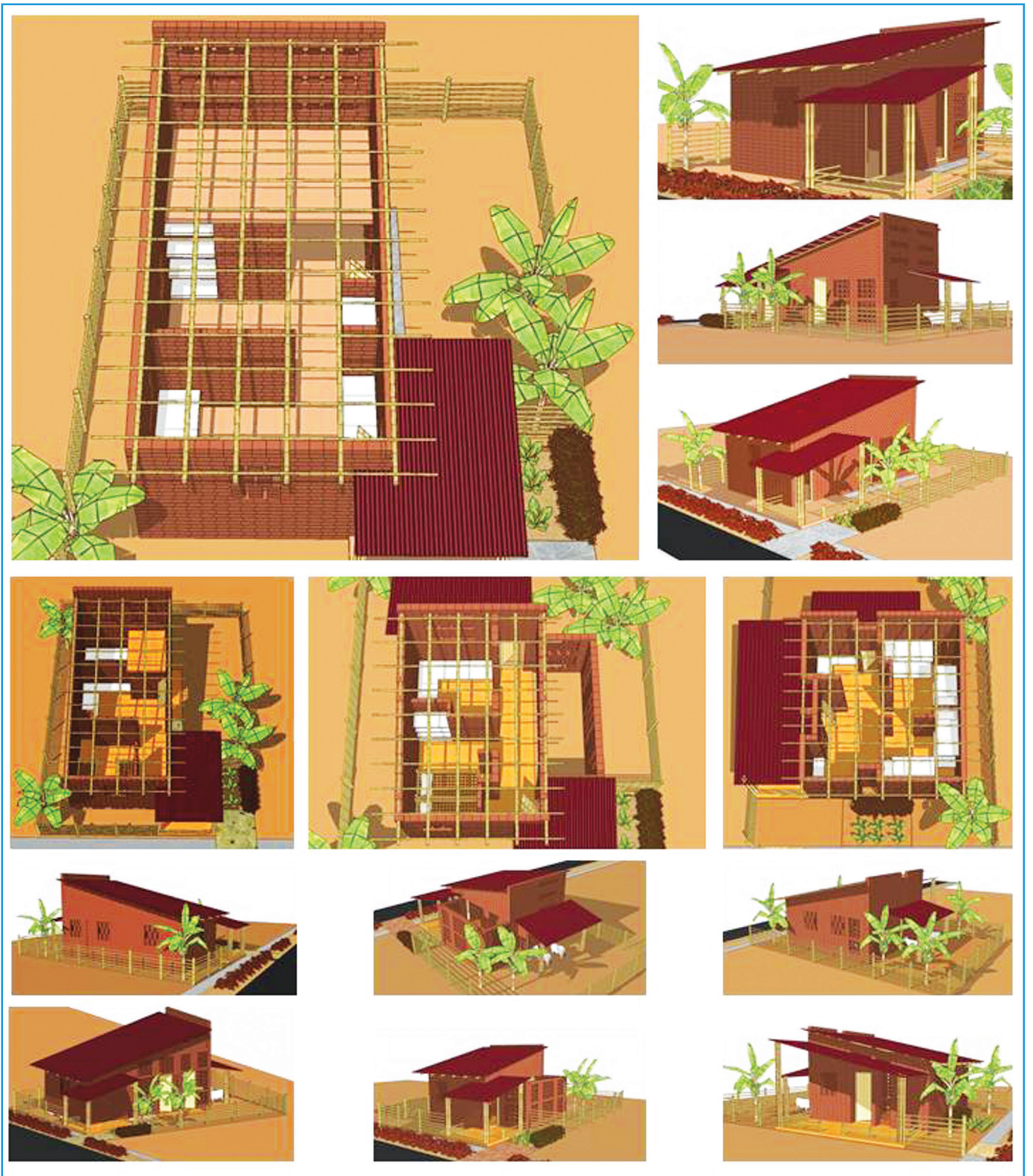


Figure 2 House design options

villagers learn to make on their own. They will become self sufficient if they were to build more rooms incrementally.

- The stabilized adobe block does not need to be plastered or painted.

- The homes have a sturdy structure with a long shelf life.
- The roofing is proposed to be made of galvalume that is recyclable.

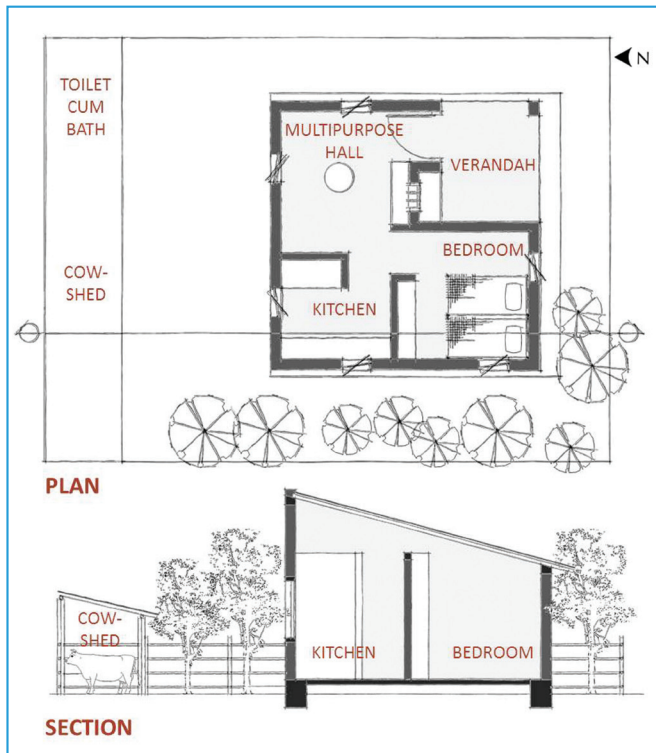


Figure 3 One bedroom option

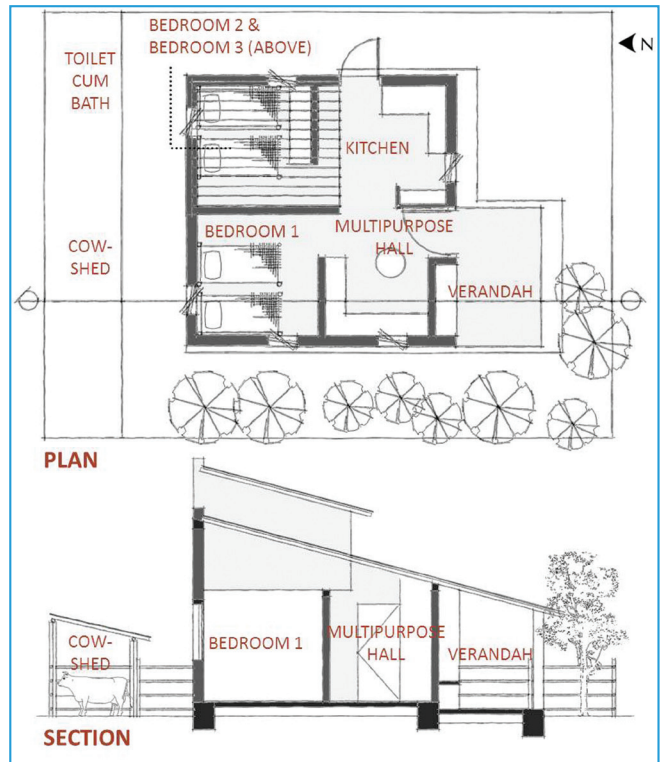


Figure 5 Three bedroom option

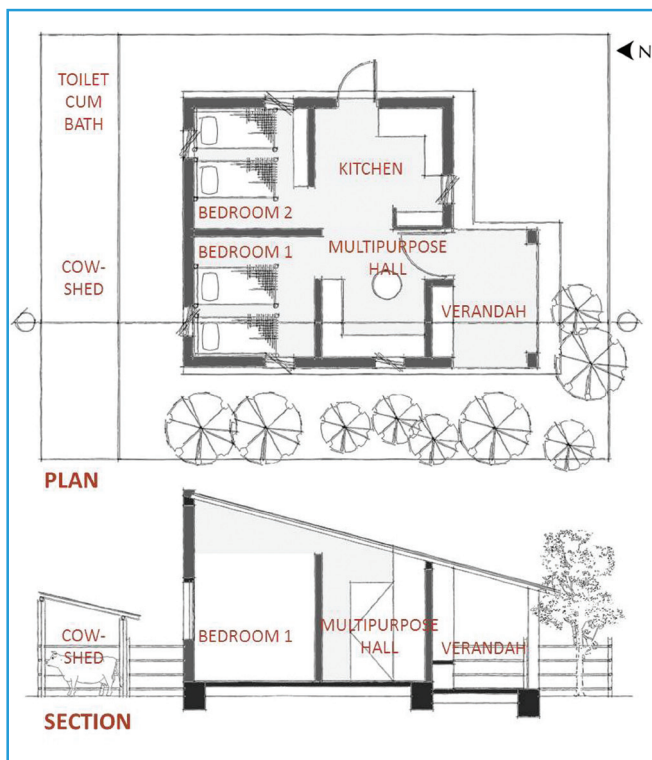


Figure 4 Two bedroom option

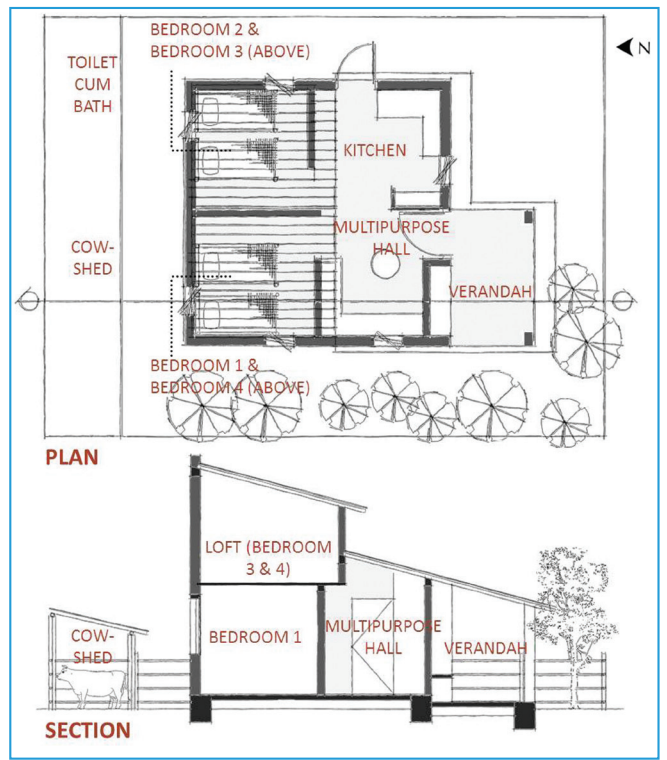


Figure 6 Four bedroom option



## 4.6 Community Centre

The Community Centre has been designed so that there are three segregated 'rooms', though the space is small. It is meant for community activities, meetings, village functions, etc. It is a multipurpose space to accommodate any future needs. It is now complete.

## 5 Execution Strategy

The Community Centre building is the entry point to the village.

The subsequent focus is on building up the community infrastructure, which will benefit the community as a whole. Houses and toilets will be built as needed. Labour was sourced from the village for the Community Centre; the villagers were given training, and nearby materials were used. This is a sound intervention, where money on transportation is saved and income is generated for the people. The villagers were involved by recommending the mason and the vendors. Thus, they do not suspect our organization of any ulterior motives.

### 5.1 The Community Centre Execution Experience

By building the Community Centre first, we could uncover the difficulties of operating in a remote village scenario. Involving the villagers in construction and instilling a community feeling, though a necessary process for the long-term meaningful development of the village and its people, slow down the construction timelines. The villagers do not turn up on many occasions, like festivals, death, injury to cattle, etc.

Since only a few villagers were involved in the construction, asking them to volunteer was not a workable option. They had to be paid. The sense of ownership towards a community building is coming, though slowly. Additionally, the village has no leader, and the only educated person taking a leadership role is more feared than respected. With

the YogaKshema-appointed community worker's involvement since January 2013 and Canara Bank's involvement since March 2013, this situation is gradually improving.

There was resistance to using the stabilized blocks; the villagers were sceptical of the block's strength and performance. It was a good approach to introduce a new technology during the building of a common property, where no individual's money was risked. Once the construction progressed, the villagers embraced this technology and expressed their keenness to have the same used for building their houses.

There is a fine line tread by organizations like ours in finding a balance between imposing a new method/technology and deferring to villagers, who are very conservative and cautious in their outlook. Any solution should come from where the intervention is happening – the climate, materials, issues in accessibility, availability of materials and labour – rather than a one-solution-fits-all approach. The solution to the adoption of any technology must be derived after a study of the place.

Any intervention must happen only after the community development aspect/local NGO presence is in place, but we had no other option in this case but to carry on since the NGO who introduced us left the village after a few months. This has been a struggle for us, as well.

### 5.2 Community Development Work

Many issues, such as obtaining a copy of the khata certificate for one's own land, getting electricity connected to the Community Centre, preparing the villagers to provide labour, instilling a civic sense and pride, raising them from apathy to responsibility and a drive to do more, and encouraging their children to study and their families to prosper, are related.

Economically weak villages need external help to make them self sufficient. If we 'adopt' a village, the villagers tend to relax and expect us to do everything. Any decision must not be made unilaterally; all



decisions made by consensus ensure participation, and in the case of problems, the villagers take responsibility in solving them.

People do not feel close to a building constructed through donations or government money; their mentality is that if others have constructed it, they can repair it as well. This rural mentality, coupled with dependence on the government, has brought development in these areas to a standstill (Hazare, 2011).

## 6 Introspection: Many Questions, Some Answers

### 6.1 Community Development Work

#### 6.1.1 Our Intent

The Timmaiyanadoddi model is an experiment conducted to assess whether it is a replicable model for intervention. Apart from providing shelter, the model seeks to ascertain the impact of holistic design used for a built environment on the human psyche. When you are the proud owner of a house and involved in the rebuilding of the spaces around it, your feelings of overall wellbeing, self-respect, and responsibility for yourself and the environment increase.

We started our work in Timmaiyanadoddi with what we saw as a democratic process and good intentions – to build and showcase our ideas and belief that design can impact wellbeing. This was our need, one that has arisen from what we thought and still think of as societal lacuna in rural housing.

#### 6.1.2 Why Intervene in the First Place?

In Bell's (2004) essay on finding clients, he related the story of architect Samuel Mockbee's (Director of Rural Studio) experience with finding a second client for whom he could build a house.

"I approached a house that appeared to be in bad shape and knocked on the door. Anderson Harris

answered the knock, and I asked him if he wanted us to build him a new house. He said, 'Not today, thank you'. That made me feel like a door to door salesman."

Mockbee pressed on, and Harris and his wife now live in the second Rural Studio project. Furthermore, **Harris is now an advocate of design.** It is hard to imagine he ever was not.

#### 6.1.3 Our Process

We are forever questioning ourselves, our approach, our intent, and living in overpowering doubt. Operating in fields of our incompetency has lent us the necessary humility to face unnecessary and humiliating frustration. Our approach in the community has been matter-of-fact and non paternalistic, but an equal-plane relationship has boomeranged on us. We have been taken for granted because of our patience and perseverance. Do we desire to approach things differently? We do not have all of the answers yet, but we are not yet looking at changing our approach towards community participation, as we feel that these societal ills stem from many years of receiving the government's doles and olive branches during elections. We need to give the community a choice between options, rather than giving them an open-ended brief.

#### 6.1.4 What we did: Observe, Interpret, Intervene

We volunteer to build houses where people have come to us with their need – we are not intervening where it is not needed or desired. This is an idealistic approach, as it leads to overhead costs that cannot be easily explained to those who are paying. However, defining outward success by the number of houses built within a certain timeline rings untrue and shallow, as the complexities involved are intricate, interdependent, and intermingled.

After a series of meetings, the niggling thought was that, though they say they want new houses, for those whose houses seemed in decent condition, it

made sense to do additions and alterations (A&A) rather than build new homes. Wanting to showcase our ideas did not justify ‘wasting’ donor money. Therefore, we asked a contractor to visit the houses and check whether he could make corrections to internal walls which were crumbling and whether any layout changes could be implemented. He surmised that any A&A will cause it to cave in, and the cost would be as high as that of building a new house. The question that arose was, ‘What do the people want?’ We determined that, as long as people wanted a new house, we would not question any further. We still do not know whether we should question their desire for a new home, and if so, how much and why.

To obtain another opinion, we asked a structural consultant to gauge the structures. He noticed the frailty of the construction and suggested we recycle and reuse the materials to avoid wastage and to bring down our costs. In summation, we have given reflective pauses at every stage, which is why we are still in the village after three years.

### 6.1.5 What is our Purpose?

Our organization’s vision is for every villager to live in his/her own permanent home. Our purpose is to redefine rural landscapes through culturally sensitive, site-driven, cost-effective design and construction. The five major areas of our intended impact in villages are housing and infrastructure, education, skill development, health and hygiene, and access to finances. It is our belief that long-term, sustainable changes can be made to any society if a group of organizations with specialised skills in these five areas work together to bring about that change. We believe that those who work in their zone of competence can effect meaningful change by working together on different aspects of development. We would like to focus on our strength, housing and infrastructure. We think we must contribute in our own zone of competence – as architects/designers – and focus on how design can enhance wellbeing.

The tried and tested way of effecting change is how

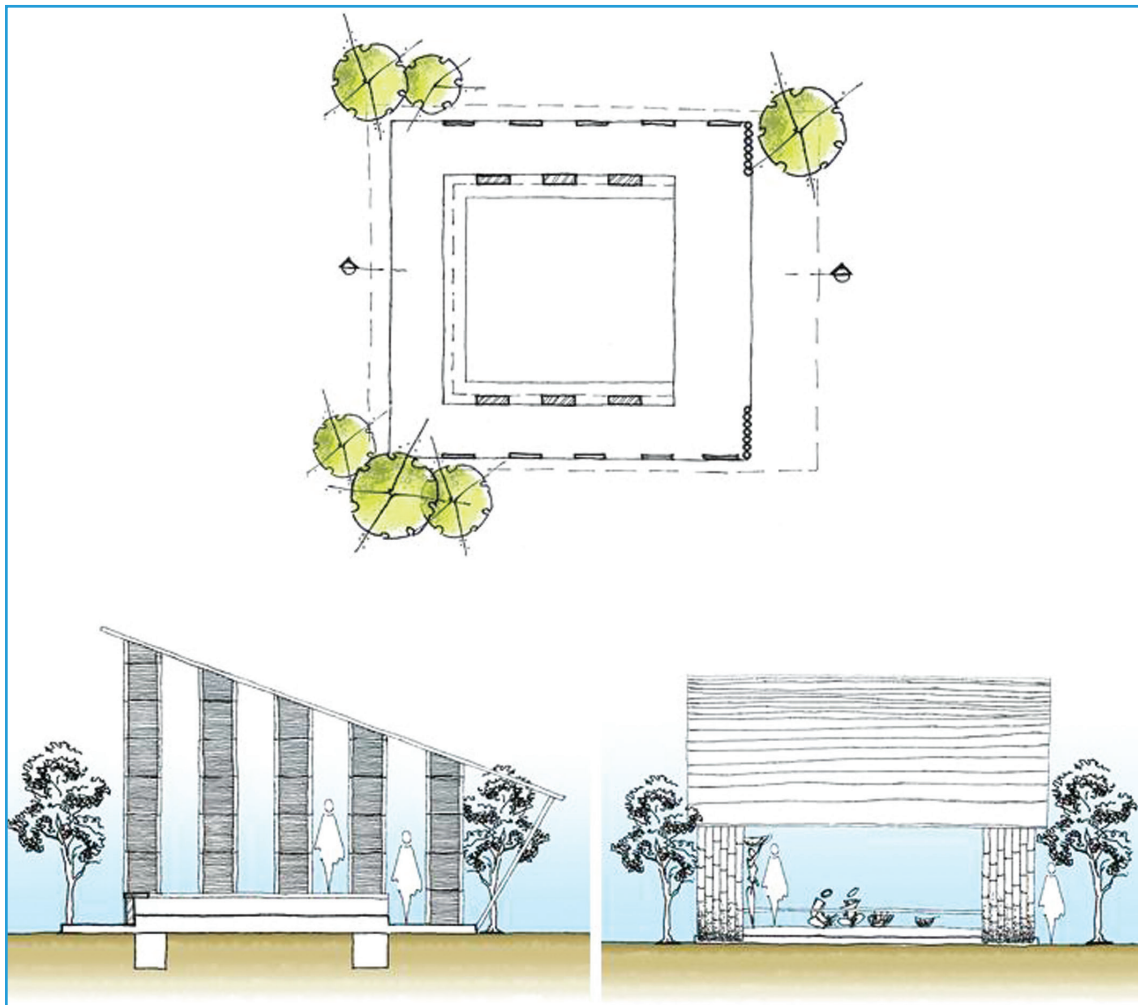
Ralegan Siddhi’s Anna Hazare, Hiware Bazar’s Popat Rao, Kuthambakkam’s Ashoka Fellow Elango, BR Hills’s Dr. Sudarshan, and Sargur’s SVYM operate – they stay in these villages and are a part of them. It takes 20–30 years to effect development by working on the different aspects of impact.

## 7 Introspection on Wellbeing: How does one Define and Assess it?

We have separated this section into the design process and design product.

### 7.1 The Design Process

During the construction of the Community Centre, and now the roads, we intuitively involved the community in both the development of design and in the construction. We treaded the thin line between an approach of ‘largesse’ versus the conviction that ‘anything free kills the soul’. We had to contend with queries from the villagers, such as, ‘When the government does things for free, why do they need volunteer labour?’ They demanded a 10-foot-wide road when an 8-foot-wide one, which was the standard, was budgeted for. We managed to get a construction company to donate a few cube stones to us to use in the road works. The community protested that cows may slip on the stones, which was a point we had not considered. The community wanted the iron grille windows and doors that they saw in a nearby village to be used in the Community Centre. Since their village was low-lying, they wanted entire site levels to be raised, a costly and disastrous solution. We had to explain that the solving of problems in a technical manner should originate from the engineers. A politically inclined man in the village, who was disappointed with the lack of opportunities for commercial gains from us, was and is instigating the villagers and creating road blocks for us. Including them in all of the decision-making seemed like a doctor asking a sick person what medicine he wanted to be administered. Making the decision-making process too inclusive leaves a very open design brief, and the people are confused about their choices.



**Figure 7** Initial architecturally driven sketches of the Community Centre

Where does one draw the line in community participation? In which decisions do we do so? How does one establish such a boundary?

People do not want to contribute even a minimal amount of money or labour, and a sense of ownership is late in coming. What do we do? Do we leave the village, or stay? How do we know when to leave? We are still figuring these things out.

Are the people happy with the process? We do not know. But no one is responsible for another's happiness. Wellbeing is not making the other person happy. By making the process inclusive, with a non-top-down approach, did we achieve what we set out to do? Namely, did the design process affect the villagers' 'human psyche and feeling of overall wellbeing'? This is very difficult to ascertain given the dynamics of the village.

Do we have any clear-cut ideas inferred from this process to apply to our next intervention? Not yet.

### **7.1.1 User Perception of their Community Centre: The Process**

The Community Centre design changed a lot from what we as architects wanted and designed to what the community wanted for themselves – from an open pavilion with ladders delineating the pathway to what it is at present. Our concern about the closed building was the escalating cost, yet we incorporated many suggestions that the community had – adding a gate, closing long windows to prevent high winds – all the while desperately looking for a donor. We are very fortunate that Canara Bank has promised to fund all of our community-based intervention.



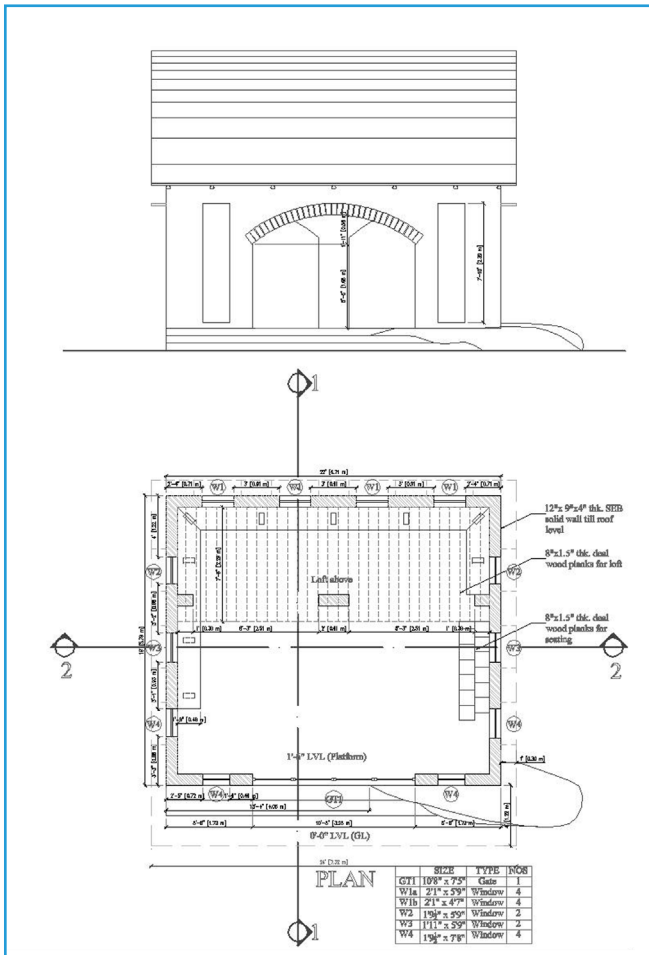


Figure 8 The final design as per execution



Figure 10 Pictorial essay The building of the Community Centre

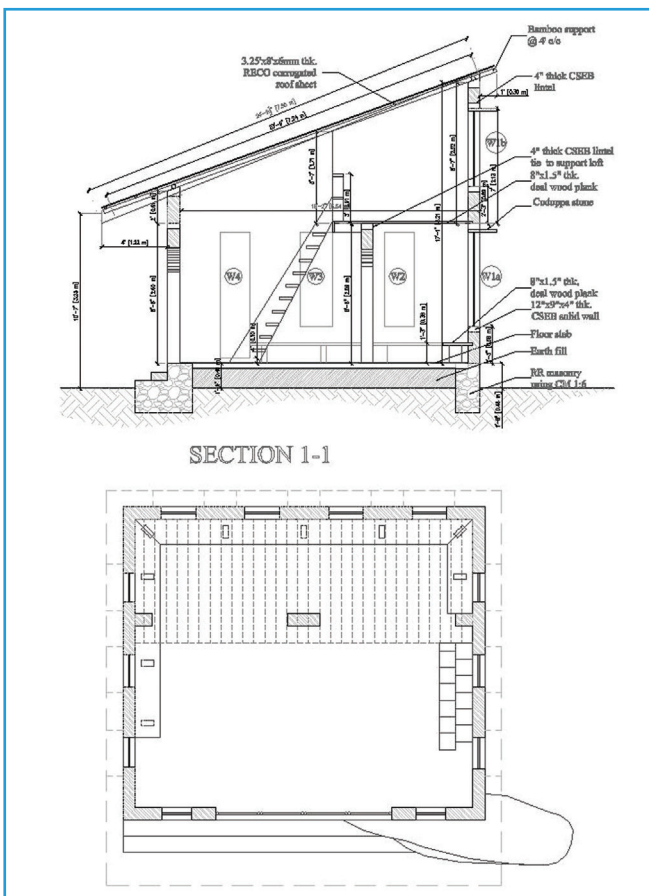


Figure 9 The final design as per execution

### 7.1.2 User Perception of a House: The Process

We have started the construction of one house. The owners wanted the same size and shape of blocks as those that had been used for the Community Centre. We felt that a square size would help us reduce breakage of blocks and a smaller size would look more attractive in a small house, but they felt otherwise.

We showed them models of three plans: a square option which is compact and gives the owner more space for the back yard, a 'T' shaped plan where the owner could build two additional rooms at a later stage by adding two walls for each instead of the usual three walls, and an 'L' shaped plan where the owner could construct an additional room by building two walls. We drew the plans to scale on their plot and explained the designs to the house owners, as they did not understand the model. They did not want a size of 19 ft; they wanted a size that was similar to the community centre! They decided

how much set back was to be left between the site line on the sides and in the front, though we guided them, saying that the Panchayat rules mention a minimum of three feet. They selected a square plan, but they wanted the kitchen in a different location than what we had designed – the interpretation of Vastu is manifold! We mirrored the plan onsite, and we explained the constraints of this option, as the verandah was located in the rear. They then selected one of our plans, and the construction progressed, the excavation was completed, and then they changed their minds and wanted to go back to their version because their neighbours warned them against ours. They were adamant about the change and dismissive of the mason having to redo his work, as they were providing labour, as well. The first two weeks were spent with them resenting the fact that the mason was paid for his work, whereas they are not. They did not want to reuse any existing materials in the new construction, saying that it was bad omen. We had to insist on using mud and stone after a few arguments, as our costs were getting high. After the building was built up to a few courses, they regretted not placing the verandah in the front, but realized that it was too late to make any changes. We involved them in the location of doors and windows in each room, but restricted them on the total number of both. They did not want ventilator ‘jaalis’, as they felt that it was weak. There was no loft provision in our one BR option, but the family requested that we provide one similar to the one in the Community Centre. This was difficult to achieve in their floor plan option, but we are trying to accommodate them despite the cost climbing high. Their trust is steadily increasing, though, as the construction progresses at a regular pace. Their pride of ownership quotient is growing, though slowly. Their level of resentment, about making them pay what we see as a nominal amount, is decreasing.

## 7.2 The Design Product

Where the design product is concerned, it is easier to define wellbeing.

### 7.2.1 User Perception of their Community Centre: The Product

All of the villagers like the arches. They dislike the look of long windows and are not enthralled with the non-conventional architectural design. They like the amount of light inside the building, but dislike the amount of wind (we later closed the extra windows). The younger generation loves the loft, since it gives them a space to gather together, smoke, and socialize; the older generation dislikes it for the very same reasons. They like the high roof and the sturdy bricks, which they realize are better than the conventional construction in villages, and therefore want it for their houses. People did not like bottles as a wall feature, as they feared they might break. Though they live in unfinished, uneven mud floors, they did not like the granite flooring we had done, as it was patchy. We had acquired amoeboid granite pieces from a nearby factory for a cheap price, thinking people would be happy with the finish.

In the village survey we conducted and submitted to the government, all of the individual households mentioned the “Community Centre” in the miscellaneous section! It has become a matter of pride, especially when there are many people from nearby villages coming to see the Community Centre for the materials and design used.

## 8 The Path Forward

Where the process of intervention is concerned, we do not yet know what the correct approach is. Could the redevelopment at Timmaiyanadoddi be a holistic



model for development work? It has naturally led the way to project GRIHA – our solution to a replicable model for intervention in rural housing.

Project GRIHA's approach is to analyze the climate, culture, vernacular design, local material availability, current needs, and usage patterns of people in various zones of Karnataka. Using this information, a design template and palette will be developed for a core house module that will cater to flexibility of growth, give people access to design, technology, technical knowhow, and necessary construction materials, and empower them to build their own homes. The non-obvious linkage between the vernacular and the design is especially addressed in GRIHA.

We feel this is a replicable model for intervention and that we could get access to communities through established NGOs doing development work. We would work on training people in construction techniques, have a palette of designs

for them to choose from, open a Technological Resources Centres, and give need-based construction support.

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