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Editor

Sustainability in the Built Environment in the 21st Century: Lessons Learned from India and the Region

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Preface

This book is a compilation of papers presented at the second Sustainable Development Research Symposium in the Asia-Pacific Conference held at the Madhav Institute of Sciences, Gwalior, India, in December 2019. This second symposium followed from the inaugural one held at RMIT University in Australia in 2017. The symposium is supported by the United Nations One Planet's Sustainable Buildings and Construction Programme, one of six programmes under the One Planet Network. The symposium was designed to foster and facilitate the exchange of information, ideas and experiences acquired in the execution of projects with sustainability outcomes.

While the focus has been on India, experiences, case studies and practices from India and other countries, relating to sustainability education, cities, buildings and circularity in the built environment, were welcomed. The intent of the book is many, not least of which is to share ideas and experiences, learn from each other and start developing a set of proactive actions so that our combined efforts to meet our sustainability goals are fast tracked.

In a recent report co-published by the United Nations, Asian Development Bank, United Nations Development Programme (2020), the need to consider a transformative plan of action to deliver the SDGs has been highlighted. As noted in this publication, the Asia-Pacific region is home to 2.3 billion urbanised people, living in cities. This figure is expected to rise to more than 2.8 billion and 3.5 billion in 2030 and 2050, respectively, calling to attention urgency of these issues. Close to 400 million people live in extreme poverty, and close to 1.2 billion people live close to the poverty line. The Asia-Pacific region uses twice as many resources as the global average. The share of young people not in employment, education or training is over 40 percent (United Nations, Asian Development Bank, UNDP 2020). To top all this, the region is vulnerable to climate change, and already, bio-diversity impacts due to air, water and land pollution are being felt in the region. The region has also been subjected to natural disasters.

The book presents research from Australia, India, Indonesia, Malaysia and Sri Lanka. It has been organised based on a chronological sequence of papers, whose core themes respond directly to the SDGs.

Iyer-Raniga and Dalton's paper on built environment curricular change in the Indonesian context responds directly to SDG 4 on education. The country has a large young population that need a strong foundational platform for bridging the gap between demand and supply of current and future industry needs. A case study approach is used to understand the disjoint between built environment educational programmes, industry and government responses. The study revealed that capacity building needs can be met through developing knowledge sharing platforms and aligning government and industry with academia to bring curricular development in the built environment programmes to meet the needs of this century.

Also, focusing on SDG 4, the importance of community participation for education has been highlighted by Ang, Ramadevi and Nawawi in their research across India, Australia and Malaysia. Using sustainable integrated architectural parameters, including space efficiencies, environmental understanding and impacts, children's functional needs and cultural value, the research on *Aganwadis* (community centres) as a case study highlights the use of various key ideas such as pedagogy and cultural attributes in providing appropriate design response that is fit for purpose for the community.

The issue of water management is a key problem in urban areas and responds directly to SDG 6 on water. Rapid urbanisation in countries like India has also brought with it problems associated with basic amenities including water and sanitation. Khadse's paper focuses on the importance of design-sensitive approaches to ensure water management becomes a part of the urban planning and design responses. A range of strategies are presented, and its effectiveness is evaluated for both new and existing urbanised areas.

SDG 7 focuses on affordable and clean energy. Shah, Pandit and Gaur's paper consider the role of building design in sustainable green developments. They emphasise the importance of building energy efficiency, to ensure both cost efficiencies and negative environmental impacts while meeting the goals of sustainable green developments. Design variables such as shape, orientation, building envelope characteristics all impact on energy efficiency which they highlight using simulation techniques and parametric studies.

Energy use directly impacts thermal comfort, and SDG 7.3 focuses on improvements in energy efficiency. Climate influences energy use. At the building level, Malik and Bardhan examine the thermal comfort of low-income group dwellers in India. They explore the role of occupant behaviour on thermal comfort improvements within the slum rehabilitation sector of housing in Mumbai. Household survey, energy simulation and comfort assessment techniques were used. Adaptive actions involving human intervention such as opening doors and windows to promote cross-ventilation, using fans and planting, to support cooling were investigated. Characterised by warm humid climate in this part of India, it was found that adaptive actions can bring improvements in thermal comfort, particularly, by using ceiling fans.

SDG 9 is about building resilient infrastructure, promoting inclusive and sustainable industrialisation and fostering innovation. Focusing on infrastructure at the city level, Bhagwat and Devadas use the SAFE (Sustainable Accommodation through Feedback Evaluation, developed by IIT Guwahati) model for understanding urban carrying capacities, using Gwalior in India as a case study. The premise of their research is based on the number of desired people in urban populations to maintain desired quality of life. They focus on land use and the limited availability of land in cities such as Gwalior, reeling under the impact of rapid urbanisation. Land occupied by infrastructure is used in the SAFE model. They find that the carrying capacity of Gwalior is inadequate for present and future population increases. This paper also relates directly to SDG 11 on making cities and human settlements safe, inclusive, resilient and sustainable.

Kini, Choyimanikandiyil, Charan and Osman focus on the importance of developing guidelines for *Anganwadis*, in particular, their importance in responding to the SDGs. This paper, while centred on SDG 9 and 11, also relates directly to SDG 3 on health and well-being, SDG 7 on affordable and clean energy, SDG 8 on economy and employment, SDG 9 on resilient infrastructure, SDG 13 on climate action and SDG 17 on partnerships. *Anganwadis* or child-care centres were established as maternal and child health centres, catering to needs of mothers and new-born babies up to pre-school children. While the Indian government has recognised that *Anganwadis* need to be upgraded, there is still a dearth of design and construction guidelines for them. Using the warm and humid climate of Karnataka state in the southern part of India, a pilot study was undertaken to understand passive design impact. It is essential that such guidelines are developed for different regions to ensure thermal comfort conditions are appropriate for vulnerable sections of the population.

Banks as a corporate entity are a yet unexplored area of sustainability in developing countries such as India. Responding to this theme under SDG 9, indicator 9.3 on access to financial services is the theme of Shamshad, Zaini and Akhtar's paper. Their research investigates the role of banks in supporting green loans, green investments and other green services and as tenants and owners of buildings. Using a survey method for banking professionals, especially senior managers, their research sought to understand if sustainability is part of their vocabulary and to determine approaches for further engagement for sustainable outcomes. The main areas that Indian banks can develop from are banking structures and sustainability such as impacts of lending decisions, borrower's ability to meet financial obligations focusing largely on green credits, green products and services that focus on the social and environmental considerations and sustainability of banks service channels such as paperless transactions and digitalisation.

Several papers focus on SDG 11. Safety, affordability, accessibility to planning and designing, while safeguarding cultural and natural heritage, is the first of these. Focusing on Sri Lanka, Slyva and Sylva's paper explore the intent of retaining indigenous practices, which have somehow been lost in the globalisation of the building and construction industry, affecting the delicate balance of sustainability from a triple bottom line (TBL) perspective. The use of vernacular knowledge has been subverted over several generations, and yet, going back to these basics can support future planning in the country.

Supporting positive economic, social and environmental links under SDG 11 is the next entry along this theme. Satish and Pujara's paper on social sustainability contributes to the third leg of the triple-legged stool of triple bottom line sustainability: economic, environmental and social. Social sustainability is perhaps the most neglected of these three pillars of sustainability. The paper explores, from an urban design perspective, planning and design responses to enhance sociability as an important element of social sustainability. It draws comparisons between the components of sociability of public realm and elements of social sustainability.

Continuing the urban theme and SDG 11 is a paper focusing on one of the main metro centres in India. This paper by Shrivastava and Singh focusing on the city of Delhi examines the assessment of urban quality of life in the built environment as a means for understanding and resolving city-level challenges. By an investigation of the quality of life indicators used world wide, the study undertakes a macro-level analysis of the master plans of Delhi over a period of decades. Various planning strategies coupled with other robust policy measures are required to support a good quality of life in Delhi.

Also, at the city level, Siddiqui and Pandit's paper explores the connections between Smart Cities Mission of India and circular economies, responding directly to the targets of SDG 11 on cities and SDG 12 on sustainable consumption and production. The Smart Cities Mission deals with how smart cities may be implemented in the Indian context focusing on resource management, a central tenet of circularity. For such a mission to be truly successful requires changes across all levels: at the government levels to develop and implement policies, capacity building at institutional and higher education and vocational levels, improvements in infrastructure; all underpinned by a supportive resource mobilisation platform. They suggest using the ReSOLVE framework developed by Ellen MacArthur Foundation and Arup as a starting point and suggest that a new inclusive policy focusing on CE aligned with sustainability outcomes should be developed and implemented in India.

In the context of the built environment, material use is critical and responds to SDG 12 on efficient use of natural resources. As material use is expected to continue to increase in the future, it is essential for countries such as India who are building a large proportion of green fields development to reconsider the impact that materials, particularly the use of virgin materials, have on the sector. This paper by Ghosh, Behal, Tuteja, Seth and Gupta concentrates on social housing in India. As the country is expected to rapidly build houses in the 'Housing for All' programme by 2022, the importance of social housing is highlighted. The impact of building materials and technologies on electricity consumption for heating and cooling, particularly cooling in a country like India, is significant regarding energy use. Simulations undertaken for 17 buildings across India show that the use of buildings materials plays an important role in reducing electricity use and can save up to 50% of the electricity used for cooling.

SDG 12.6 is about companies adopting sustainable practices and integrating sustainability information in their reporting cycles. Focusing on Sri Lankan industry, Somachandra, Sylva and Dissanayake discuss the importance of corporate social responsibility (CSR) in the construction industry's business environment, business processes and in the philanthropic activities undertaken by businesses. Using grounded theory, supported by focus groups, their paper presents a framework for incorporating CSR into the business processes, culture and strategies of Sri Lankan construction industry businesses.

Using *Anganwadis* again as a case study, Ang, Nawawi and Ramadevi also explore the impact of the power of partnerships providing another dimension to their research on *Anganwadis*. This corresponds with SDG 17 on partnerships for sustainability and on SDG 4 with respect to education. The social engagement outcomes as well as the process of community engagement in the design process for architecture students provides value-add outcome for students in the learning process and the community through getting better design outcomes. Such processes of situating teaching and learning in a community situation provides better spaces and environments that reflect the needs of the community while also engendering trust, respect and shared ownership.

It is envisaged that these papers are a good starting point to start engaging at regional, national and local levels, the importance of some proactive and contextualised responses to transition to low carbon sustainable futures. Without commitment and a willingness to trial solutions, the intent of our actions will not be transformed to reality.

Melbourne, Australia
July 2020

Prof. Usha Iyer-Raniga

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While the symposium was predominantly face to face, we did have several speakers who connected online to deliver their papers and keynotes due to various reasons. Little did we realise at the time that within a matter of months, businesses would move predominantly to an online mode of operation.

I would also like to thank my colleagues and co-chair of the first successful symposium held at RMIT University in Melbourne July 2017, Judy Rogers. I would like to thank Priyanka Erasmus for her time she put into organising administrative issues at the RMIT end, especially after the symposium in December 2019.

On the wings of the success of the first symposium, the second symposium was planned and held in India. We are hoping that a third symposium will be held sometime in the future, also in some country that urgently needs to challenge the status quo and find a way to fast track its transition to sustainable futures. This is urgently required, now, more an ever in a world that is hit by the impact of the pandemic and the realisation that global supply chains are grinding economies to a halt. Nature is taking the time to heal during the pandemic. The 'new normal' in a post-pandemic world offers a perfect opportunity to take stock, reconsider options and convert challenges into opportunities.

Melbourne, Australia
July 2020

Prof. Usha Iyer-Raniga

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Chapter 1
Bridging the Gap Between Industry and Academia: The Case of Indonesia

Usha Iyer-Raniga and Tony Dalton

Abstract As a country, Indonesia is becoming increasingly urbanized and has a large proportion of its population under the age of 25 years, at slightly over 100 million. Developing this fairly large proportion of its population from a human capital perspective is essential for the future of the country. Currently there is a 40% gap between supply and demand; and is expected to grow to 70% by 2025. Building an educational platform for effective learning and skills formation is urgently needed. This entry presents the outcomes of a case study aimed at understanding the disconnects between academia, industry and government in the context of Indonesia's built environment programs. In particular, the architecture profession and architectural education have been considered as one of several built environment programs under pressure to change. Built environment suite of programs have various disciplinary underpinnings: architecture, building, engineering, planning, quantity surveying, project management and others such as interior design and transportation engineering. The case study focuses on the results of a workshop in Indonesia, where various stakeholders responsible for city planning and building came together to determine the current challenges and seek solutions. The entry delves into the education of the architecture profession in Indonesia and presents the results of the workshop with some recommendations for the future. The results show that the various sectors and stakeholders are prepared to work collaboratively and support joint ownership of meeting curricular outcomes.

Keywords Education · Built environment · Climate change · Sustainability · Indonesia

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1.1 Background

The research presented in this paper is part of a broader research project examining how environmental, economic and social perspectives for sustainable development may be more systematically integrated into higher education institution built environment professional education in the Asia Pacific region. The project, Built Environment Curricula in the Asia–Pacific region: responding to climate change, aims to present a framework and an argument for a systemic greening of the built environment curriculum in higher education institutions in the Asia–Pacific. The project was funded by ProSPER.Net (https://prospernet.ias.unu.edu/) under the umbrella of the United Nations University, an alliance of leading universities in the Asia–Pacific region committed to integrating sustainable development into postgraduate courses and curricula. The network alliance was founded in June 2008 with 46 members (as of late-2018) mostly in the Asia–Pacific, committed to education and research focusing on sustainable futures (ProSPER.Net 2018).

The principal goal of Built Environment Curricula in the Asia–Pacific region: responding to climate change is to propose ways for increasing the capacity of future built environment professionals to design and build low carbon cities in the Asia–Pacific. Some work has already been undertaken in some higher educational institutions, but a lot of this work is very fragmented. The project does not distinguish between the various disciplines comprising the built environment as the related disciplines need to work together to ensure quality outcomes for the built environment. The countries and professions chosen for Built Environment Curricula in the Asia–Pacific region: responding to climate change, are Indonesia (Architects), China (Architects), Thailand (Architects and Engineers), Sri Lanka (Engineers) and Philippines (Planners).

While the goals of the overarching project are many, the ones specifically related to this paper are to develop a method for analyzing the institutional development of built environment professions and their relationship to higher education in the context of new expectations that these professions contribute more to climate change, mitigation and adaptation. Supporting this aim also requires improved capacity building of the academic staff that are involved in teaching in these universities and exploring pedagogies that support learning outcomes for students.

As part of this project, institutional analysis of built environment professions in five countries, including Indonesia was undertaken. The case study method was used to understand institutional disconnects between industry and academia; using this method enables better in-context and cultural understanding to be gained in the research. The findings arising from the Indonesia case study were then tested through a workshop. Hence, this paper focuses only on testing the findings of the research for Indonesia, undertaken through a workshop comprising industry, government and academic participants; limiting the scope to the final step of the Indonesian case study. Other papers have reported on the research outcomes leading to this point: architectural educational program in Indonesia (Iyer-Raniga and Dalton

2017a) and interviews with selected academics and industry professionals to understand the architectural programs and their structure (Iyer-Raniga and Dalton 2017b) and the gaps in the architecture educational program. A report for Built Environment Curricula in the Asia–Pacific region: responding to climate change has also been prepared (Dalton and Iyer-Raniga 2018).

The workshop in Indonesia brought together forty built environment and higher education professionals from universities, industry associations, professional associations and government agencies with responsibility for city planning, building and economic development that were committed to the development of low carbon cities.

This chapter commences with an overview of the education system in Indonesia, followed by how architecture programs are currently situated, particularly, for dealing with real-world associated built environment problems. This is followed by a description and outcomes of the workshop in Jakarta. These sections are followed by the discussions and conclusions.

1.2 Education in Indonesia

Before delving into the education system in Indonesia, it is important to first consider the context of the country. As a country, Indonesia is rich in natural resources, minerals, oils and has fertile agricultural lands; yet also plagued by natural disasters. The country is an archipelago stretching between the Indian and Pacific oceans consisting of about 17,500 islands, of which around 6000 are inhabited. It is the third largest country in Asia and has a population of nearly 264 million (2017 figures) (World Bank Group 2018) spread over 34 provinces comprising of 502 regencies, 6543 districts and over 75,000 villages. In terms of economy, it is the 16th largest in the world and the largest economy in ASEAN (Association of Southeast Asian Nations) (World Bank Group 2018). It is the world's most populous Islamic nation (worldatlas 2018).

The country is becoming increasingly urbanized and has a large proportion of its population under the age of 25 years, at slightly over 100 million (OECD/Asian Development Bank 2015). Developing this fairly large proportion of its population from a human capital perspective is essential for the future of the country. Currently there is a 40% gap between supply and demand; and is expected to grow to 70% by 2025 (Thomases 2016). Building an educational platform for effective learning and skills formation is urgently needed.

The rapidly urbanizing context of Indonesia creates tensions with traditional educational programs and pathways responding to the current and future demands of a built environment that needs to incorporate new knowledge and professional practices mindful of environmental, social and economic impacts of the built environment. Built environment professionals need skills in appropriate design and planning responses for mitigation of greenhouse gas emissions and ensuring low energy and water use during construction and operation. In addition, materials, products and services need to systemically ensure low overall carbon inputs and outputs; and consider the tensions between mitigation and adaptation responses as a result of a changing climate. To make matters more complicated, the country has been threatened by a series of natural disasters drawing urgent attention to the quality of current and future built environment.

The educational system in Indonesia is the third largest in Asia, after China and India. It is the fourth largest in the world, if the US is included to the list (OECD and ADB 2015, p. 69). The technical and vocational education and training centers across Indonesia are fragmented. They need to improve coordination and employer involvement, and they need to be more industry driven. In terms of higher education, about a third of the relevant aged Indonesian youth are enrolled (OECD and Asian Development Bank 2015). While the public universities fare okay, many of the private universities do not fare well. The facilities are poor, academic staff are not qualified and their remuneration rates are not on par with market expectations either. The country has 92 public and 3078 private institutions, and 52 Islamic institutions (OECD and Asian Development Bank 2015, p. 185). The large number of unaccredited higher education institutions of over 2500 in number have no clear outcomes for student learning and graduate attributes, quality of educational qualifications; all impacting on job prospects (OECD and Asian Development Bank 2015).

The main issue identified in the report by OECD and Asian Development Bank (2015) was that the graduate supply is not in sync with the emerging labor market requirements. Particularly with the built environment sector only 16% of graduates studied engineering, manufacturing and construction while growth in construction in the period from 2001–13 increased by 52% (OCED and Asian Development Bank 2015, p. 64). Employers complained that graduates lacked relevant language and skills and this siloed approach is largely due to a disconnect between institutional governance and industry. A key finding of the report was that outside the main island, Java, there is very little development in the educational institutions particularly in the far-flung regions of the country. Research budget for the country is one of the lowest amongst ASEAN countries, at less than 1% of the GDP in 2012 (OECD and Asian Development Bank 2015, p. 198). That said, the budget has increased by more than 3 times from the period 2006–12. The aim of the government is to reach 1% of GDP by 2025. As a result of expenditure on research and development in Indonesia being confined to the public sector, domestic Indonesian companies have not attracted research and development due to its low skills base.

Indonesian universities do not do well in international rankings (OECD and Asian Development Bank 2015; Thomases 2016). Traditional didactic teaching is the main form of educational delivery and underpins the teaching and learning model of education in the country. To support critical thinking and higher cognitive skills, the current approaches to teaching and learning need to change. The current capacities of higher education teachers need to be harnessed and nurtured to support such change. The government needs to support this by undertaking a major programme of diversifying tertiary education and improving the quality and selectivity of research aligned with the country's national priorities. The government also needs to expand the accreditation capacity of the BAN-PT (*Badan Akreditasi Nasional Perguruan Tinggi,* National

Board for Accreditation of Higher Education) set up in 2008, and to ensure that independent professional accreditation boards (LAM-PT) are also included as part of this process (OECD and Asian Development Bank 2015). LAMs have been planned for health, engineering and agriculture.

Accreditations of various programs usually last for 5 years. Among other recommendations by the report are building capacities through higher degrees such as doctorates catering to both industrial and professional doctorates, development of institutional capacity building and increase in the proportion of external experts and professionals in university board appointments. Particularly for polytechnics, practical industry experience needs to become a pre-requisite criterion for appointment in polytechnic institutions.

Setting up the National Qualifications Frameworks in Indonesia by the government is a fairly new undertaking but one that the country urgently needs. Under the Higher Education Law in Indonesia, there are flexible pathways to achieve various qualifications. For degrees, the current system provides bachelors (S1), masters (S2) and doctoral (S3: PhDs) degrees (academic or applied) and professional degrees (e.g. architecture). The length of study for a bachelor's degree is four years, with a further two years for a master's degree. PhD degree is three years on top of a Masters' degree. For vocational qualifications, programs provide diplomas after one to four years of study (D1–D4).

The next section examines how built environment programs, in particular architecture programs have responded to current challenges and how these are situated in the educational context of Indonesia.

1.3 Architecture Programs and Indonesia

As already noted, environmental disasters have plagued Indonesia since the last millennium. Indonesia has had its fair share of natural disasters such as earthquakes, tsunamis, volcanic eruptions, typhoons and other human related environmental challenges such as floods and landslides as a result of environmental degradation. These are expected to continue to affect lives currently and in the future.

At the time of writing this paper a recent natural disaster hit the country on Oct. 1 2018. Palu and Donggala in Indonesia was hit by a powerful earthquake and tsunami with deaths (as of Oct. 3) at over 800 and over 50,000 people displaced by the disaster (Associated Press 2018). Just a few months earlier, multiple earthquakes also hit Indonesia, the most recent one hit Lombok on July 29, 2018. Over 10,000 homes were destroyed in this earthquake. The Indonesian government announced assistance for supporting houses damaged by the earthquake to rebuild their own homes without the support of a builder or a building contractor. The ministry of Public Works and Housing were training residents to build their own homes (Nugroho 2018). The government has agreed to provide funding to procure building materials such as cement, wood, etc. The training for building houses takes 1–2 days and male and female residents are expected to contribute to house building. Thus, a strong educational platform is required to ensure appropriate skills for building and rebuilding in the country.

UNESCO, being the specialized agency for education is leading and coordinating the Education 2030 agenda. Sustainable Development Goal 4 aims to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" by 2030 (UNESCO 2018). The International Union of Architects (UIA) is the only global organization representing the world's architects. It was founded in Lausanne, Switzerland in 1948. UIA is representing approximately 3.2 million architects globally. The aim of the UIA is to advance policies and programs that improve communities through design (UIA 2018).

With the UN SDGs coming into effect in 2016, the role of architects has become more important than ever. With impacts of climate change and population shifts becoming more and more urban, the challenges to the architecture professionals and other professions related to the built environment are enormous. Planning, construction, development, management and improvement of cities weave a complex web of linking the physical built environment with socio economic opportunities and supporting better quality of life. The UIA aims to support architects through a responsive and responsible roadmap supporting prescriptive implementation of the UN SDGs (UIA 2018).

Broadly, within the literature, there is not much by way of knowledge exchanges between academia and industry. This is not restricted to the construction industry alone and can be seen in other professions, for instance, health (Lomas 2007). However, it is possible to bring academia, industry and government together. In the industry research schools set up in Sweden, it has been shown that industrial doctoral students can act as innovator and bridge connectors (Dahlgren and Owe 2007). However, the process has not been particularly smooth for all the students. A similar study over a decade ago in the UK also showed a similar degree of success (Williams 2004, 2005; Broadfoot and Philippa 2003), as has been the case with the Cooperative Research Centres (CRCs) in Australia.

With reference to construction in particular, Moncaster et al. (2010) indicate there is very little empirical evidence to show the impact of research on construction practitioners and their practices and vice versa. But, they say that industry and academia need to work together and ensure efficient and effective knowledge production. They also show that there is a strong traditional approach of knowledge access through academic journals and attendance at academic conferences, and given our current challenges are not effective for innovation, change and co-production of knowledge. They suggest that industry and academia should work together, particularly in the context of developing research knowledge. They also suggest that programs should be developed, that directly benefit growth and integration of not just knowledge networks but also communities of practice.

Using the case of Malaysia, Tan and Sarimin (2011) discuss the significance of universities in contributing to a knowledge-based economy in a developing country context. To develop and support a fully functioning knowledge city, a coordinated effort from public and private sectors, and academia is needed not just for the physical planning but also for development of a functioning city from social, economic, environment and institutional perspectives into the future. Another example in Thailand (Chookittikul et al. 2011) discusses the impact of gaps between education and industry in the context of IT education. They suggest the interests of both education and industry may be possible if agile technologies are used. In a study of India, it was found that industry-academia collaboration was particularly weak, considering the growth of the building and construction sector and the rising interest and pressures on green building (Arif et al. 2010). There is a lack of industry-academic collaboration in India and young graduates are not ‘armed’ with knowledge to deal with green building challenges. Curricula has not changed to meet with the changing industry expectations and research agenda does not really work towards bridging the existing gaps.

Franz’s (2008) paper considers practice, pedagogy and partnership central to the issue of employability and continuing relevance of professional education. Teaching, learning, research and application are integrally interconnected at both undergraduate and postgraduate levels. Work integrated learning models for built environment students represent an untapped opportunity that needs to be fully explored for the benefit of students and the profession.

Chau et al.’s (2017) paper discuss the misalignment between university-industry in the UK. They say that the strategic visions of the university and industry are not aligned, and coordination within universities is essential. Universities need to rethink their role in knowledge transfer and think clearly about the role of universities in the twenty-first century. Another study states that for university-industry collaboration to be successful, individual rather than institutional levels of motivation are required (Rajalo and Vadi 2017).

An example of academic-industry collaboration can be seen by interior design students where recycled materials were used to design and build light fixtures for a company’s product line using social media. While the experience was beneficial for the students across several pedagogic, teaching and learning fronts; the primary limitation of the industry-academic collaboration was the duration of the timelines for the course (Asojo 2013).

Historically, the link between environmental or sustainable design and architectural education in Indonesia is quite weak. As indicated by Tanuwidjaja and Leonardo (2016), Indonesia has a long way to go in terms of integrating environmental challenges in the architectural education system. The socio-economic context underpinning sustainability solutions also needs to be included in this understanding.

Iyer-Raniga and Dalton (2017a) discussed and mapped the importance of aligning educational curricula with other institutional agencies to drive, complement and support changes for low carbon futures in Indonesia, particularly driven by the peak architecture professional body, the Indonesian Architects Association (*Ikatan Arsitek Indonesia*, IAI). This research focused on understanding how the architecture education in Indonesia evolved. Following this was an exploration, through semi-structured interviews of the educational concerns with the current approaches as to how architecture programs are taught, the quality of graduates, engagement with other built environment disciplines, the structure of the building code, lack of self-regulation of the profession and quality of the professionals themselves, reported in Iyer-Raniga and Dalton (2017b).

Thus, the two phases of the research provide the background to the next part of the research continuum, the workshop. The next section focuses on the workshop as the final step in the case study research on the architecture profession in Indonesia. The workshop was designed to seek ideas from participants on how to systematically integrate environmentally sustainable development thinking into a university's built environment professional education in the rapidly urbanizing context of Indonesia.

1.4 The Workshop

The workshop was designed to seek ideas from participants on how to systematically integrate environmentally sustainable development thinking into a university's built environment professional education in the rapidly urbanizing Asia–Pacific region, with a focus on Indonesia. The authors engaged an Indonesian project manager on the ground to support the organization of the workshop, identify the right participants and organize formal invitations in Bahasa and follow up with various government and industry participants.

Participants in the workshop were drawn from:

- Indonesian government agencies with built environment, environment and education responsibilities.
- Professional and industry associations including the Indonesian Institute of Architects, Indonesian Association of Schools of Architecture and the Indonesian Green Building Council.
- Academics from architecture and engineering departments in Indonesian universities.
- ProSPER.Net member universities undertaking case studies on built environment professions. These universities were from China, Sri Lanka, Philippines, Thailand and Indonesia.
- International agencies including the International Finance Corporation.

The work undertaken during the earlier phases of the project examining the nature of built environment professional education stakeholders, attendant opportunities and constraints assisted with a really good understanding of the background of the project with respect to the role of built environment professionals and identification of possible gaps with industry. This led to an understanding of what possible actions need to be taken to ensure currency of built environment professional education. It was also possible to establish a set of priorities for possible actions that could maintain support for developing a collaborative change program.

While the workshop was held in Indonesia and most of its participants were from Indonesia, the workshop also had a regional orientation informed by the participation of representatives of the ProSPER.Net universities from some of the countries involved in the project.

1.4.1 Workshop Design

Arising from the background work undertaken, three main observations guided the current context for built environment professions in the Asia–Pacific region and provided a starting point for the workshop.

- A priority policy objective for all governments in the rapidly urbanizing Asia–Pacific region is to meet global commitments to mitigate and adapt to climate change by decarbonizing the built environment, making it more energy and water efficient, and more resilient for changes due to the climate.
- Professionals who design, procure, finance, renew and maintain the built environment are being challenged to incorporate new knowledge and practices into the way they produce less carbon and water sensitive built environments.
- Universities that educate professionals, such as architects, engineers, project managers, and planners, are being challenged to renew their curriculum so that graduates can produce less carbon and water intensive built environments.

The workshop was facilitated by the project leader and the lead author of this paper. Four short presentations were used to set the context for the workshop and support the workshop outcomes. These presentations focused on four main areas to set the scene for the workshop. These were, reshaping higher education in the region, the work undertaken by the authors in understanding the academic-industry context explored through the background to the current project, setting the context, the assumptions and primary arguments underpinning the research, and knowledge sharing from other ProSPER.Net case study countries on the built environment. With respect to the knowledge sharing, architects and architecture education in China, and engineers and engineering education in Sri Lanka were considered.

Reshaping higher education: Responses to twenty-first century challenges and demands, was presented by a peer undertaking research on quality assurance in universities for the ASEAN region. SHARE is the European Union Support to Higher Education in the ASEAN Region, and is a four-year EU and ASEAN initiative. SHARE is supported by a consortium of the British Council (leader), Campus France, DAAD, EP-Nuffic, ENQA, and EUA. SHARE aims to support ASEAN in harmonizing regional higher education by sharing European expertise (Neidermeyer and Pohlenz 2016). It does this through strengthening regional cooperation, enhancing the quality, competitiveness, and internationalization of ASEAN higher education for institutions and students, and thereby contributing to a closer ASEAN Community in 2015 and beyond.

The workshop began with the higher education context and the fluid nature of quality assurance in the Asia–Pacific region. The ASEAN region in particular is characterized by a rising number of programs and universities to respond to the education needs of large numbers of young population. The first presentation explored the possibilities for integrating the science of climate change and sustainability knowledge into teaching and learning in the educational institutions. The key question underpinning the presentation was the future of higher education in the region in relation to competencies, balanced with technical knowledge, co-production in teaching and learning, study programs, thinking and learning, and development of curricula in a way that is qualifying students to understand and practice in a sustainable paradigm.

Broader issues and challenges of the built environment professions and professional education in the Asia-Pacific Region was then presented with a specific focus on Indonesia, followed by the state of the profession and education in Sri Lanka and China. The key themes guiding the development of each of these presentations were:

- *Built environment regulation*: the development and implementation of regulations and their systems of administration
- *The profession*: the development of the association and engagement with urban sustainability issues
- *Curriculum governance*: arrangements used for the revising curriculum in higher education (HE) built environment professional programs
- *ESD (Environmentally Sustainable Development) in the curriculum*: sustainability integration in case study undergraduate and post-graduate professional programs
- *Expectations of the profession*: evidence from stakeholder debate about challenges in the context of climate change.

For the general context of the Asia–Pacific region, and focus on the architecture profession in Indonesia, the project co-lead presented to the workshop participants. The presenters for the Sri Lanka and China case studies were the invited ProSPER.Net participants from the relevant universities in these countries. The Sri Lanka study focused on the engineering profession and the China study focused on the architecture profession.

These presentations were followed by three facilitated sessions of round table discussions. Each table was briefed before-hand on their role by the workshop facilitator to maximize interaction and exchange of ideas in each group. As government organization representatives were included in the workshop, representatives of two government organizations; the Ministry of Environment and Forestry and the Ministry of Public Works and Housing formally 'opened' the workshop.

Five discussion groups were formed out of the 40 participants with approximately 8 participants in each group. Care was taken to ensure there was a balance of industry, government and academic stakeholders in each group. Group membership was adjusted across the three rounds of discussion so that group-think was avoided and interactions between the participants was maximized.

The three main themes of the workshop (as outlined in the assumptions) were discussed in the groups over three main sessions, each lasting about 1.5 hours in a logical progression. Prior to each round, the facilitator posed questions to the workshop participants to be further discussed in each group, with 3-minute presentations following from each group; shared with all the participants of the workshop.

For the first round (Round 1) of discussions, the following questions were posed:

- Who are the stakeholders that need to be considered for built environment higher education?
- What are the opportunities?

- What are the constraints?

Participants moved to the next round (Round 2) of discussions, while table facilitators remained the same. Care was maintained to ensure that the diversity of participants was maintained in this round. For the second round of table discussions the following questions were posed:

- What bridges can be connected between the stakeholders?
- What actions can be taken?
- What is realistic?

For the final round (Round 3), participants were requested to also undertake some personal reflections before undertaking discussions at their table. The guiding question for this last activity was:

- What are the possibilities for action?
- Participants had to come up with up to three action items, which they then discussed within their groups to be presented to the wider workshop.

1.4.2 Workshop Outcomes

As a result of the desktop research, anticipated outcomes planned were:

- Commitment for built environment curriculum change that extends beyond current bottom-up approaches to a system wide change.
- Commitment from an agency or agencies for leading initiatives promoting system wide change.
- A modest list of feasible initiatives with the potential to inform and develop system wide change in built environment professional education.
- Review of the methodology being used in the ProSPER.Net project to research and analyze built environment professional education.

A summary of the workshop outcomes of the table discussions in each round are presented here. For Round 1, where participants had to come up with a list of stakeholders, with opportunities and constraints, almost all the groups identified a similar set of stakeholders. Not surprisingly, the stakeholders identified were similar to the stakeholders present at the workshop. Other stakeholders in particular that participant's felt needed to be included were a range of building industry developers, owners, manufacturers in the supply chain, and specific types of consultant stakeholders. Some of these are provided below:

- Building owners and the community
- Ministry of Energy, Ministry of Higher Education and Ministry of Manpower
- Professional bodies such as IAP (Institute of Planners), IABHI (Institute of Green Building Professionals) and APTARI (Building Science teachers in universities)

Table 1.1 Opportunities and constraints identified

Opportunities	Constraints
Better access to global knowledge	Lack of alignment of codes and regulation
Development of a locally customized curricula	Outdated standards
Cooperation with other stakeholders and professionals in developing curricula	Lack of specialists
Collaboration with local and international universities	Lack of harmonization of professional standards and qualifications
Dissemination of case studies and best practice	Resistance of curricular change from universities
Involvement of practicing professionals to create interest and awareness among students	Lack of professional lecturers
	Lack of elective courses
	Local wisdom not incorporated
	Fragmented decision making
	Fragmentation/siloed approach to building design and construction

- Non-government organisations (NGOs) and development institutions such as BISA (Association of Building Science educators in Indonesia), LPJK (Professional Regulatory Authority), WALHI (Environmental organizations)
- Supply chain manufacturing industry
- Experts: built environment experts and related such as environmental experts
- Consultant/contractor organizations such as INKINDO (consultant companies), GAPENSI (Contracting companies) and GAPENRI (Energy performance contracting Companies).

The Table 1.1 presents the opportunities and constraints identified by the participants.

In the second round, where connections with stakeholders were sought, there were some diversity of outcomes and this is presented in Table 1.2. Overall seventeen different ideas were presented by the participants.

The final round (Round 3) on prioritizing actions were surprisingly quite consistent amongst the groups and a list of these has been provided in Table 1.3. A total of eight priorities were narrowed down by the five groups.

1.4.3 Workshop Evaluation

An evaluation form was provided to the participants to seek feedback on all stages of the workshop. All the speakers were considered to be good and the participants felt overall that they got value for the time spent at the workshop. The participants supported the workshop outcomes. Improvements for workshop included; 'excellent

Table 1.2 List of realistic actions to be taken to bridge the gap between academia and industry

1.	Clearly defined learning outcomes for specific courses and programs
2.	Strengthening licensing procedures
3.	Providing incentives for uptake of green buildings where possible
4.	Balance between theory and practice in university education
5.	Developing quality through ESD competencies and curricular development
6.	Creating and maintaining knowledge materials from specific industries
7.	Forming partnerships with industry on research projects
8.	Creating a repository of knowledge materials on green buildings (to be shared within, and between universities nationally and globally)
9.	Encouraging and supporting interdisciplinary and multidisciplinary thinking and practice in the university programs
10.	Capacity building for professional development/Online training for continuing education
11.	Building research capacities in universities
12.	Capacity building for academics, government officers with respect to standards and certifications
13.	Capacity building for the construction work force
14.	Setting up campaigns where appropriate to bring awareness and support for green buildings
15.	Knowledge sharing through benchmarking/demonstration/pilot projects and technology transfer
16.	Aligning construction companies and their work force, government agencies at national and regional levels (and also local levels), NGOs, academe, and goods and services industries
17.	Investment in design and performance evaluation, with learning by doing and demonstration activities

Table 1.3 List of priorities identified by the workshop participants

1.	Need to identify funding agencies/resources
2.	Undertake a mapping exercise to determine gaps to commence with capacity building
3.	Align with and prepare a clear roadmap including all the relevant stakeholders
4.	Enforce regulation
5.	Capacity building/continuing education for all stakeholders
6.	Support the development of private projects for benchmarking/showcasing/awareness
7.	Development of a knowledge platform
8.	Industry and government engagement in curriculum development with incentives where appropriate

job', 'keep up the good work', 'keep contact and share knowledge, information', and 'include life [sic] streaming and audience from various universities network, e.g. UN Sustainable Development and Solutions Network Indonesia (26 universities)'.

1.5 Discussions

As indicated, a large proportion of Indonesia's higher education institutions are unaccredited and there is an urgent need to address low quality providers, according to a recent report by OCED/Asian Development Bank. Capacity in higher education institutions and institutes of technology need to be strengthened by taking a focused approach to internationalization of research (OECD and Asian Development Bank 2015).

Lifelong learning requires a coordination and collaborative process of long term thinking and far reaching changes to be put into implementation. Formal and non-formal education system and workplace and other social organizations need to be designed, organized and used as learning opportunities. This is not easy to achieve; there are natural tensions between models of lifelong learning and higher educational institutions that operate on a narrow economic perspective. Currently, there is fragmentation in the provision of higher education and there is also a disconnect between demand and supply touted by key documents and reports by multilateral agencies such as the Asian Development Bank and the World Bank (OECD and ADB 2015, p. 242–243). While the formal education system is critical, the non-formal and the vocational system of education are important particularly with respect to the development of skills and training for the built environment.

Within this background the research was undertaken with the aim of exploring how best to integrate sustainability in built environment higher education programs, with a particular focus on Indonesia. It was anticipated that there would be a common focus on building a commitment for built environment curriculum change that extends beyond current bottom-up approaches in individual universities or programs to a system wide change. From this perspective, there was alignment amongst the workshop participants to focus on working together with various stakeholders, beyond universities, with government agencies and industry to build a programme of change together.

In addition, it was also acknowledged that commitment from agencies are required, not just the universities. To this end, the International Finance Corporation (IFC) has undertaken a commitment to re-engage with BISA (Indonesia Building Sustainability Alliance) to take the project forward.

Engaging with government departments; in particular, the Ministry of Housing and Public Works and the Ministry of Environment and Forestry supported the idea of bringing government, industry and universities together. Further discussions with other government departments—the Ministry of Higher Education and the Ministry of Energy are planned in the near future.

Overall, the discussions amongst the workshop participants presented a priority for capacity building, developing knowledge sharing platforms and aligning government and industry with academia in curriculum development.

1.6 Conclusions

The paper has attempted to understand the fragmentation between academia, industry and government with respect to the nature of built environment programs in Indonesia, focusing particularly on architecture. The current disconnects between the various sectors that comprise the way education in Indonesia, particularly built environment education needs to be developed and implemented for meeting current and future challenges of climate change and sustainability needs to be carefully considered. It was therefore imperative to seek input from various actors to share ownership of curricular outcomes.

To make the curriculum renewal meaningful, a workshop was proposed to understand how industry and government agencies may be able to support the development of curriculum renewal. While certain competencies need to be met, it was also critical that potential built environment practitioners are able to ground their theoretical understanding with practical applications where possible. The workshop undertaken with academic, industry and government stakeholders support the foundation for institutional engagement for sustainability in higher education. The workshop confirms engagement and alignment with a range of diverse but related stakeholders to commit to sustainability and climate change thinking and practice in built environment higher education programs.

This research supports previous studies demonstrating the gaps between pressures to meet current built environment challenges and the status of built environment education currently. Urgent attention is needed to focus on curricular engagement; not from a traditional perspective, but one that is cognizant of stakeholders' needs now and in the future. A long-term approach is needed to set the course for planning now before it is too late.

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Chapter 2
Evaluating Architectural Design Schemes for Anganwadi Centre in Ajjarkad, Karnataka, India by Architectural Students Through Community Participatory Methods

Susan Ang, Nandineni Ramadevi, and Norwina Mohd Nawawi

Abstract Anganwadi is a holistic health and education initiative that provides basic health care, nutrition and educational programs to rural mothers and children. It is part of the Indian Government's Integrated Child Development Services (ICDS) Scheme, introduced in 1975 and is today one of the largest child development initiatives in the world. The early developmental years of children aged 0–6 years are spent in an Anganwadi or equivalent early learning centre that influences children's physical, emotional and intellectual development. A child not only engages in active learning but also engages in passive learning from its physical and environmental surroundings which are manifested in the architectural design of the building. A collaboration between architecture students from three universities in India, Australia and Malaysia as well as the office of the Deputy Director of Women and Child Welfare, Udupi District was initiated in 2018 for the proposed design of a purpose-built Anganwadi centre in Ajjarkad, Karnataka. The project was executed through a student global learning program known as iDiDe (Intercultural dialogue through design). This study evaluates the seven design schemes created with Ajjarkad community input and co-design participatory methods based upon sustainable integrated architectural parameters, including space efficiency, environmental resilience, children physical rating scale and cultural value. The issue of "fit for purpose" and "architecture design robustness" and subsequent construction of an Anganwadi centre are rarely interrogated at an integrated design level. In evaluation, this paper discusses

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the synthesis of architectural design, the pedagogy and cultural attributes that aid the formulation of architectural design parameters for Anganwadi building. The study found that through co-design participatory methods, the design process was shaped through community engagement and the outcomes thus satisfied the stakeholders as fit for purpose.

Keywords Intercultural dialogue through design · Anganwadi · Participatory method

2.1 Introduction

India is home to more than 1.34 million Anganwadi Centres (AWC). The term 'Anganwadi' means 'courtyard shelter' in the Indian language. It offers a typology of social architecture initiated as part of the Indian Government's national health scheme as per the Integrated Child Development Services (ICDS). Anganwadi Centres cater to 84 million children (ICDS 1975) across the nation. In the Indian state of Karnataka alone, there are 61,000 Anganwadi with 5.5 million beneficiaries (ICDS 1975). Anganwadis play a vital role in the communities. Original intentions of Anganwadi centres (AWC) are to make social health and welfare, early learning education support and medical services accessible to India's poorest communities, typically located in remote and difficult to reach locations. The centre strengthens the fabric of rural community neighbourhoods and boosts foremost learning skills, creativity, self-determination, and health outcomes for children. It also serves as a pathway for awareness of people's rights through interactive learning, vocational training, and educative camps based upon a sense of safety and security, and building strong connections within the community. The centres run programmes tailored to educate and support young women aged sixteen and above and provide maternal health care needs to lactating mothers. In the state of Karnataka, local governance is led and managed by Gram Panchayat (local government). Funding allocations for new AWCs sit around INR 8 Lakhs, (Approximately $11.5 K USD) although in direct consultation with the Gram Panchayat in the Udupi district, there was a clear preference for the centre to cost around INR 5 Lakhs approximately $7K USD) due to funding cuts and uncertainties. This could only be achieved through local builders using local materials, low cost techniques and with volunteer contribution.

Not uncommonly, national level government initiatives such as the AWC schemes relies heavily upon on ground support coming from informal community based organizations, primarily comprised of volunteer effort. The local community who comprise senior women, mothers, grandmothers (connected to the families of the Anganwadi centre) take up much of this contribution to keep these centres running, with some engaged formally as Anganwadi workers and teachers.

In reviewing several different approaches to Anganwadi centre designs to understand the value of community engaged processes and their relationship to maternal health welfare and children's early learning, it was observed that government initiated reports (none of which were publicly accessible) on assessment of the operational aspects of the services in relation to health and nutrition run in existing centres across the country, but very little heed was paid towards how the physical infrastructure component of these centres played a role in promoting community education and children's learning. The communal spaces where children spend most of their day were reduced to just one single room. The authors found informal sources of media news articles frequently featured how Anganwadis had or had not delivered on the full intentions of the original initiatives. There was an absence of research conducted on the design and construction of Anganwadi buildings. Upon visiting and conducting context analysis research of three existing case studies of AWCs located in Ajjarkad, Udupi, as part of a larger research study, the authors noted that the each of the three building premises were inadequate. The physical layouts lacked spatial accommodation that could cater to major functions understood to be critical to an AWC. These were: (1) private space for dispensing of maternal care and the nursing of lactating mothers; (2) secure kitchen storage; and (3) child friendly spaces that enabled children's play and early learning (Fig. 2.1).

With more than a million Anganwadi centres in operation today, and plans for thousands more, there is wide scale opportunity to appreciate the critical role AWCs play in initiating and enabling community education and community health. In 2018, the design for a purpose design Anganwadi centre for Ajjarkad, Udupi, India was undertaken as a university-led built environment design education program education program, referred to as iDiDe or "i-dee-dee" which stands for "Intercultural Dialogue through Design" and is an international collaborative learning program founded by Ang (Ang 2017b). Involving architecture students from three universities from

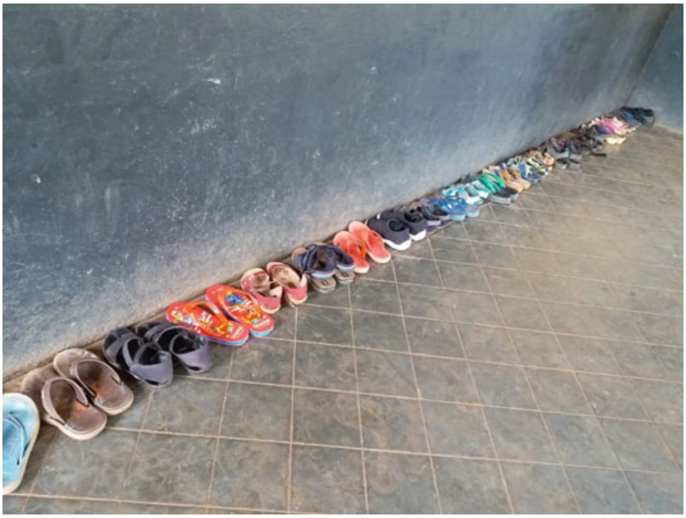


Fig. 2.1 Photo taken from Anganwadi case study visit undertaken by iDiDe team, 2018. *Source* Photo by N. Manepure, 2018

Australia, Malaysia and India. The outcomes were seven design proposals for a resilient design for an Anganwadi centre in Udupi, Karnataka. The proposals were a collaborative effort including stakeholders in the design conception stages for a more informed result. With the need to consider the design aspect of AWCs that have too often been overlooked, this study analysed the quality of the physical environment of iDiDe's design outcomes to explore what design features could impact the needs of women and children who are the primary users of an Anganwadi Centre.

This paper explored university leadership in facilitating community participation in architectural design and construction of Anganwadi Centre and focused upon evaluation of the physical attributes of spatial design and accommodation of design proposals for a new Anganwadi Centre to be located in Ajjarkad, Udupi. The target audience for this research will be built environment researchers, architects, educators and children. This research will assist a global audience interested in social policies in the awareness of the Indian government's ICDS initiative and architects and educators to view the state of Anganwadi with more consideration and appreciate the role design has in facilitating community participation. The outcomes of our evaluation showed that all seven iDiDe Anganwadi designs addressed key spatial needs of the Anganwadi program and the requirements of the Anganwadi community in Ajjarkad. They showed that the strong relationship of spatial layout and physical attributes in these co-designs have high potential for positive impact upon Anganwadi users. Additionally, the university educational agenda through collaboration with local government in the design of Anganwadi Centre offered capacity and potential to achieve community engagement and possible future community ownership.

2.2 Literature Review

2.2.1 Current Scenario and the Need for Community Centered Design Approaches in AWCs

The scope of literature review conducted that informed this study included understanding the concept of Anganwadi and its role in serving the communities in India. Literature surrounding community participation in design was consistent in demonstrating evidence of participatory methods as an emergent trend for addressing community aid and engagement. A precedent international project known as The Anganwadi Project or TAP project which began in 2006 as a partnership between local not for profit organization and an international not for profit organisation led by Australian architects offered useful insight into the impacts of interventions in the space of construction and design of Anganwadi Centres.

2.2.2 Understanding the Concept of India's Anganwadi Centres (AWC): Facilities for Infants that Serve Rural and Urban Communities Alike

As per the Government of India initiatives, the ICDS under the Ministry of Women and Child Development and the WCD department in each state has been in place since 1975. It was restructured under the 12th Five-Year Plan to ensure holistic development of children aged six and below. The aim was to reduce anaemia and child mortality rate by giving supplementary nutrition specially to malnourished children and to improve early learning outcomes. The food is to be distributed to children up to six years, pregnant women and nursing mothers in the neighbourhood (Source: Media article by Shradha Chettri, June 2017, Indian Express). The perception of providing a package of services is primarily based upon the consideration that the overall impact will be much greater if the different services develop in an integrated manner since the efficacy of a particular service depends upon the support it receives from the related services. For better governance in the delivery of the Scheme, convergence is one of the key features of the ICDS Scheme. This convergence is in-built in the Scheme which provides a platform in the form of Anganwadi Centres for providing all services under the Scheme (ICDS 2009). Basic health-care activities including contraceptive counselling and supply, nutrition education and supplementation, as well as pre-school activities are included. The ICDS Scheme offers a package of six services as listed below:

1. Supplementary nutrition
2. Pre-school non-formal education
3. Nutrition and health education
4. Immunization
5. Health check-up and
6. Referral services.

Anganwadi Centres are used not only as early learning centres but do quite quickly become vibrant community hubs, for young and old to meet. These centres provide the community with public spaces, gardens, and beautiful multi-purpose spaces especially for women and young girls for their education needs. They have also been a home to health clinics and used as a street school as well. The program provides essential developmental services to children (0–6 years) and bring maternal health care services to pregnant women and lactating mothers. AWCs perform as the early learning childcare and maternal health centre in rural communities. A study conducted by the National Institute of Public Cooperation and Child Development (NIPCCD) in 2006, based on a sample of 750 AWCs found that there has been considerable reduction in the percentage of severely undernourished children and significant improvement in birthweights of babies. However, uptake of immunisation and other health services are still limited by ignorance and superstition. The majority of AWCs had access to safe drinking water, although only 41% had toilets. In 1992 merely

43% of AWCs were accommodated in *pucca* (permanent well-engineered) structures, which had increased to 75% by 2006. However, the report does not discuss what proportion of the total population is served by AWCs and ICDS and what proportion of the population is missing out. A report dated 31st March 2015, showed that 1,346,186 AWCs are operational across 36 States/UTs, covering 1022.33 lakh (102.2 million) beneficiaries under nutrition (women and children) and 365.44 lakh (36.5 million) children between 3–6 years under pre-school component (Integrated Child Development Services 2009) whereas the 2011 Census shows 158.8 million children in the age group of 0–6 years (India, 2011). Independent research in 2012 showed that the number of beneficiaries through Anganwadi has increased from 1,212,000 children aged 0–3 years and 1,222,000 children aged 3–6 years in 2001 to 1,775,881 and 1,603,856 children respectively in 2010. This covers 74.70% of children in the 0–3 age group and 67.90% of the 3–6 age group. Yet there are still too many children who have not been provided with an AWC.

Based on the information as of 31 March 2015, from among 12.15 lakh (1.2 million) AWCs/mini-AWCs, about 81.19% AWCs are running from the *pucca* buildings and remaining 18.81% from *kutcha* buildings (temporary non-engineered structure made of non-traditional materials); 30.62% running from Government owned buildings; 21.62% running from school premises; 4.54% running from Panchayat buildings; 32.56% running from rented including 5.90% from AWWs/AWHs house; 9.79% running from others; 0.87% running from open space. 65.91% AWCs are having drinking water facilities within the premises and 50.01% AWCs have toilet facilities (Integrated Child Development Services 2009). Since an Anganwadi Centre is a focal point for activities of ICDS programme it has always been emphasised that as far as possible AWC should be built with community involvement and low-cost design using local materials and indigenous construction techniques. Further, it should be owned and maintained by community/village panchayat/urban local bodies. This type of centre is also required to organise other activities related to different women's programmes, as a forum for youth activities and use for meetings of frontline workers, and also for gatherings of mothers and children. Ministries of Rural Development and Panchayati Raj may play a major role in collaboration with State Governments to provide this facility. Voluntary organisation(s) working in the field of rural development can also act as a catalyst in mobilising the community. AWCs are operated by different organisations including: ICDS, State Governments, the World Bank, and NGOS. Initially the program was intended to garner much local participation, through the use of local women as Anganwadi Workers and Anganwadi helpers (AWH) as volunteers with honoraria. This did not eventuate, with users seeing AWCs as essentially government-provided services, but it was hoped, with the introduction of local self-government (Pancayati Raj Institutions) in 1992 that this would improve. A study in Kashmir in 2014 showed a low level of awareness of the ICDS services provided by AWCs, however this paper is not well referenced.

2.2.3 Literature Surrounding Community Participation in Design

According to Sanoff (2006), community design has been defined as a movement for discovering the possibility of people's involvement in shaping and managing their environment. He further defined community architecture as an activist term used in England, which embraces community planning, community design, community development and other forms of community technical aids. Social architecture, according to Sanoff (2006), is also used for the same concept in the United States but creates to bring critical awareness among citizens on the needs of the community. Community participation, on the other hand, is defined to cover all the scales and techniques in reference to the processes involving professionals, families, community groups and government officials in shaping the environment. Another approach, i.e. facilitation, uses participatory methods for both problem definition and design solution generation through design assistance techniques. Facilitation, according to Sanoff (2006), is a means of bringing people together to govern what they wish to do and helping them find ways to work together in deciding how to do it. As the industry players in the built environment, architects hold the responsibility to design and create an environment for people to live in. These designs influenced people's culture and identity of a place (Abdul Latip et al. 2013). Palliyaguru et al. (2018) indicated that experiences from the iDiDe programme at an iDiDe project called Building Ampara in 2016, where disparities between real community needs and top down policy driven development initiatives in combination with sporadic volunteer and funding efforts by both local and international not for profit organisations, provided a clear and critical need to empower rural communities to achieve United Nation's Sustainable Development Goals 2015–2030. Although there are many views on the definitions of sustainable development, the most widely accepted definition by Du Pisani (2006), p.89, "*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs*".

Ali et al. (2009) in Palliyaguru et al. (2018) elaborate that sustainable development includes three broad components i.e. social, environmental and economic, often known as the 'triple bottom line', which brings environmental responsibility, social awareness and economic profitability objectives to the fore in the built environment and facilities for the wider community. Anthony (2002) highlighted the need for diversity in schools of architecture and to go beyond affirmative action requirements to promote a climate that values differences and manages diversity for the twenty-first century. Mobility and exposure to different cultures and environment, as accorded by Berardi (2013), and Long et al. (2010), thus support the effort of iDiDe and the choice of Anganwadi as an educational project. The pre-school not only provides education and a sanctuary for children but allows their older siblings to attend school. It further provides a resting place and a social centre for rural mothers who walk many miles to bring their older children to school and wait while they attend (extracts from personal notes made by the authors during the context analysis of three case study visits of operating AWCs in Udupi, Karnataka in 2018).

The Anganwadi Centre is not a new phenomena. As mentioned in the introduction, Anganwadis have existed since 1975 as a holistic health and education initiative that provides basic health care, nutrition and educational programs to rural mothers and children. Hence the adoption of Anganwadi Women and Children (AWC) as the project for iDiDe to educate young architects and professional in the built environment, as the case study for participatory approach to design, may provide the necessary linkage for stakeholder engagement as interactive, and intercultural outcome that considers the sensitivity and needs of the target community. A design brief described in a subsequent section will highlight the required standards and design considerations that will influence the design of the built environment and children outcomes, influence of culture in design and benefits of sustainable design. Challenges of design participation practice lie in the approach to the design process and in recapturing the aesthetic processing of design in order to produce better designs to pass on to future generations a stock of capital assets that will allow the quality of life to be maintained (Broome 2005) for 'sustainable development' (Brundtland Report 1987).

2.2.4 Lessons Learnt from 'The TAP" Project in Ahmedabad

'These projects have not just been about a building, but about strengthening a community through dedication to a project and love.' **Ciara Tapia** (TAPvolunteer) (Source: https://www.anganwadiproject.com/bholu-anganwadis date accessed 3 May 2019).

The "TAP" (The Anganwadi Project) was a partnership between an international not-for-profit organisation with a local not-for-profit organisation known as Manav Sadhna and Rural Development Trust. TAP was founded in 2006 in a coincidental meeting of the two co-founders, Jane Rothschild, ~~a~~ former Director of Architects Without Frontiers and Designer, Jodie Fried. TAP has worked with slum communities of Ahmedabad since 2007 alongside local builders. The initial project was the re-building of one small school and a partnership that led to the founding of The Anganwadi Project. In 2011, the Anganwadi Project became an independently incorporated not-for-profit association and appointed Board of Directors. TAP has built over 16 Anganwadis which have positively affected the lives of more than 500 children. These projects have been achieved through the work of volunteer architects and designers. However, TAP could not undertake this work without the collaboration of the Indian project partners, Manav Sadhna and Rural Development Trust. (https://www.anganwadiproject.com/ date accessed 15 February 2019).

TAP projects have seen incredible benefits in the lives of the local children. The challenge identified by TAP lies in understanding the needs, wants and wishes, through community participation, similar case studies and developing innovative sustainable design ideas to fulfil the aspirations of the users through low-cost construction techniques, local materials and working skills. The acute shortage of AWCs across states creates the need to ramp up construction so that 4 lakh AWCs can have children-friendly buildings by 2019. The need is compounded by the fact that 32.56% of existing AWCs operated out of rented buildings while 18.81% do not even have *pucca* buildings. These facts are commensurate with the observation of the case study visits made by the authors during the iDiDe Anganwadi Ajjarkad project. Running the centres on rented accommodation raised issues of lack of space and hurdles in check-up for the women beneficiaries. More than 50% of AWCs in NCT of Delhi, Jammu & Kashmir, Andhra Pradesh and Bihar were reported as not having their own premises. To address these concerns, WCD has specified that the new centres should have the infrastructure, like a sitting room for children, a kitchen and a minimum of 600 square feet space for playing, once again reflecting the same observations by the iDiDe Anganwadi team. As per Ministry's regulation, child-friendly toilets and drinking water facility are the basic minimum requirements for the effective functioning of an AWC. The absence of these basic amenities creates unhygienic conditions and adversely affects the quality of services provided to the intended beneficiaries. Such conditions can result in high absenteeism and low enrolment. The Demand for Grants Report (2015–16) of the Ministry of WCD observes that in terms of toilet facilities in AWCs, barring a few States like Nagaland, Uttarakhand and UTs like Chandigarh, Delhi, Daman and Diu and Lakshadweep, almost all the States have a long way to go to achieve this target. From 13.42 (1.3 million) lakh operational AWCs in the country, only 6.48 lakhs (648,000) AWCs have one toilet in the premises. An even lesser number of Anganwadis have drinking water facilities. Despite a consistent increase in the allocations over the last three years, the allocation for 2015–2016 for ICDS has been reduced by 45% from INR 15,128.77 in the previous year to INR 8335.77. It remains to be seen whether the Ministry can meet its targets to ensure the required infrastructure and delivery of services in the Anganwadi centres. With the deteriorated state of Anganwadi centres identified by the TAP project and through various media reports across India, the physical infrastructure of these centres was identified as a spatial criterion that needs priority address. The lived experiences of TAP teams and iDiDe teams highlighted the mismatch of aforesaid objectives and many challenges associated with design and construction of Anganwadi Centres.

2.3 Methodology

2.3.1 Intercultural Dialogue Through Design (iDiDe) Community Design Methodology

Collaborative Design Studio requires participation of individuals, coordination of information and tasks to work in teams. Team organization is one of the most important activity in collaborative studios (Chiu 2002). Collaborative Design studio could be inter/multi-disciplinary, inter-institutional or cross-cultural. Lawson (2005) states that "*collaborative design studio provides an opportunity to advance cultural competence through a reflective, interactive design process*". Research suggests that cultural and experiential hurdles in collaborative studios, can be overcome through engagement techniques (Lawson 2005).

The concept of Intercultural Dialogue through Design (pronounced “i-dee-dee”) or iDiDe materialized in the years 2007–2008 by architect and senior academic Susan Ang of the School of Architecture and Built Environment, Deakin University, Australia (Ang 2017a). Emergence of such a concept was a response to the need to inculcate architectural students towards developing global citizenship and to have better understandings of world cultures outside of their own, ultimately with the objective of preparing students to be responsible future architects. The collaborative studio of iDiDe Anganwadi in 2018 along with cultural immersion for the benefit of the students was carefully planned to achieve the design of Anganwadi Centre. Quick paced design charrettes were introduced in the studio to enable cultural differences among students and community to be addressed, which were initially affecting the proposals (Lawson 2005). The students as participants were led by faculty staff and exposed to conducting context site analysis, engagement with stakeholders, work on the design project as a team, and present the outcome as stages of the design development to stakeholders and assessing panelists. Integrated with the learning experience, the students experience cultural immersion of local culture and study architecturally significant sites situated in the host destination. The interaction with the stakeholders contributed to the process of developing the final criterion of the design as a design outcome. The accompanying faculty staff and facilitators of the programme attended research workshop as collaborators to ongoing research as well as provide the necessary input to the design development of the student’s project. With iDiDe’s growing stature as a global community engagement brand, it has positioned itself as a robust model for global engagement in Asia. Future iDiDe programmes will continue to refine the model of international mobility in conjunction with its academics, practice and government partners to be of service to the community through projects similar to the Anganwadi Centre.

iDiDe (refer Fig. 2.2) in summary is a collaborative intercultural and international workshop involving participants of diverse cultural backgrounds who are able to drive the agenda to not only activate but witness cultural knowledge exchange and shared understandings among participants. Each site and project context demands a call to take up active interaction and the mediation of difference in situations that are both real and significant for all architecture design students, incorporating personal, interpersonal, cultural and social orientations. All in all, the process seeks to encourage cultural exchange of knowledge through design engagement, design collaboration and through cultural immersion that would be life rewarding experience even beyond architecture and built environment.

In 2018, Faculty of Architecture, Manipal Academy of Higher Education approached the Ministry of Women and Child Development (MWCD) Udupi district to discuss how a meaningful partnership could be forged around new designs for Anganwadi Centres and that university involvement for education purposes could transpire into meaningful contribution to community empowerment. The Deputy Minister of MWCD identified that an AWC was operating on a portion of the existing Ajjarkad School, and there was a need for a separate building and infrastructure and

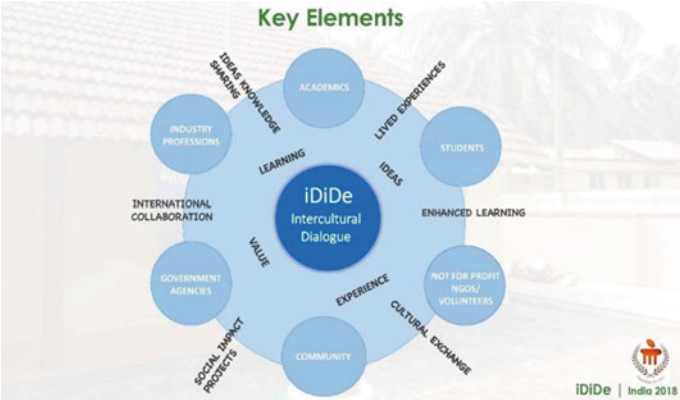


Fig. 2.2 The iDiDe model of collaborative design and education for sustainable built environments. *Source* Ang (2017)

to create a stand-alone Anganwadi for the Ajjarkad community. The project was deemed an appropriate educational project for the iDiDe program where students led by faculty academics and professional architects would undertake a design evaluation that included assessment of an existing AWC that operated on a portion of the existing Ajjarkad school and a community stakeholder led design brief for the new centre. The iDiDe Anganwadi Project aimed to propose several options for sustainable and innovative design for the new AWC. The design was to respond to the integrated development of mother and child with the social, emotional, physical well-being of a supportive and healthy environment. Further, the design of a new AWC for Ajjarkad would demonstrate systematic and holistic design approaches and adopt vernacular style and local methods of construction as a priority design strategy. The project method is an integrated one that aims to adopt sustainable principles at a holistic level (Refer Figs. 2.3 and 2.4).

iDiDe teams were made up of 35 students from three Universities along with mentors, comprised of faculty academics and professional practitioners, collectively worked in teams of 5 and produced 7 design proposals for the AWC at Ajjarkad. The students gave due value to the culture and context of the community and faced the challenges posed by the government and the community collaboratively through User participation in design. Preliminary requirements were disseminated to the participants prior to their arrival in Manipal, India as pre-project reference which will be further explained in the next section. Detail requirements of the project were delivered at site and as lecture input in the host university. The designs explored the effects, responses, and practicality of adaptable, accessible and aesthetic architecture through design as a key deliverable. Assimilation of precedent case studies and stakeholder views are reflected in order to support and complement the design challenges encountered while planning the project. The key spaces (but not necessarily limited) to be part of the proposed design included play and recreation area, space for food storage and preparation, health care facilities and other supporting amenities

Fig. 2.3 The Anganwadi project methodology adopted in iDiDe—design considerations. *Source* iDiDe Deakin University, Manipal Academy of Higher Education and International Islamic University Malaysia (2018)

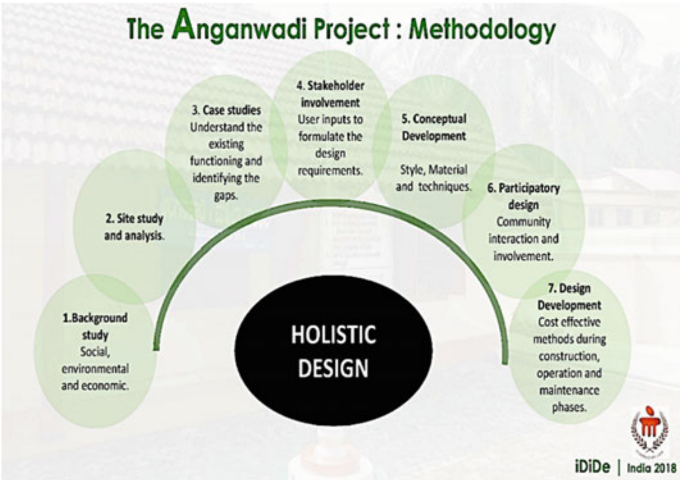


Fig. 2.4 The Anganwadi project methodology adopted in iDiDe. *Source* iDiDe Deakin University, Manipal Academy of Higher Education and International Islamic University Malaysia (2018)

(landscape, services etc.) A land area of 120 sq. m. was provided and a budget of Rs. 8,00,000/- was specified by The Deputy Director of Women and Child Welfare, Udupi District, for the proposed development (Figs. 2.5, 2.6, 2.7, and 2.8).

The project site is located in Ajjarkad suburb of the main town of Udupi within an existing school ground (Refer Fig. 2.3). The site coordinates -13°19′51.53″ N,

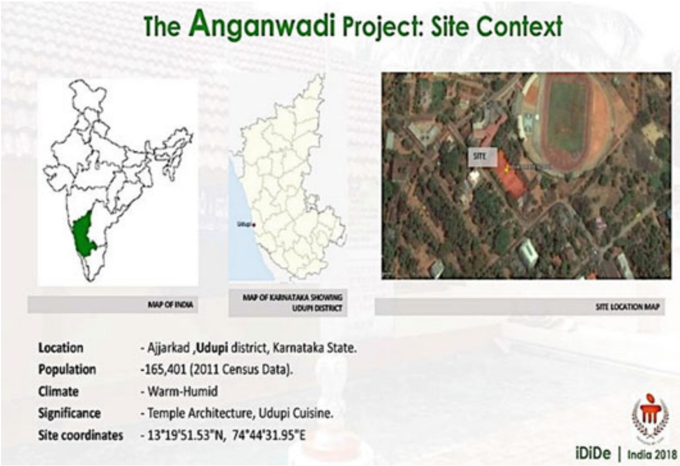


Fig. 2.5 The Anganwadi project site context in Ajjarkad, Udupi District, Karnataka, India. *Source* iDiDe Deakin University, Manipal Academy of Higher Education and International Islamic University Malaysia (2018)

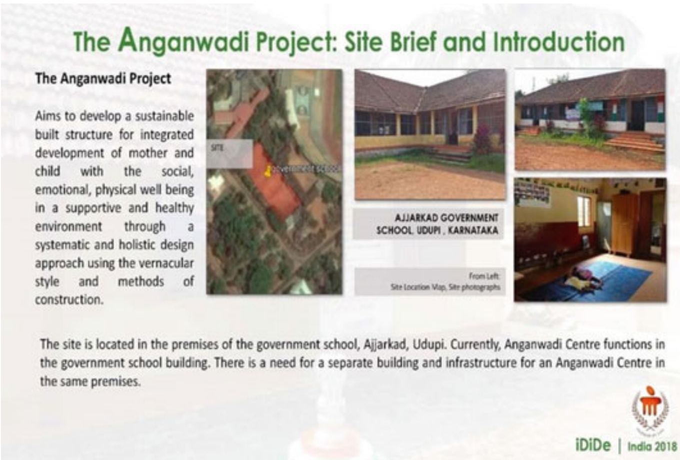
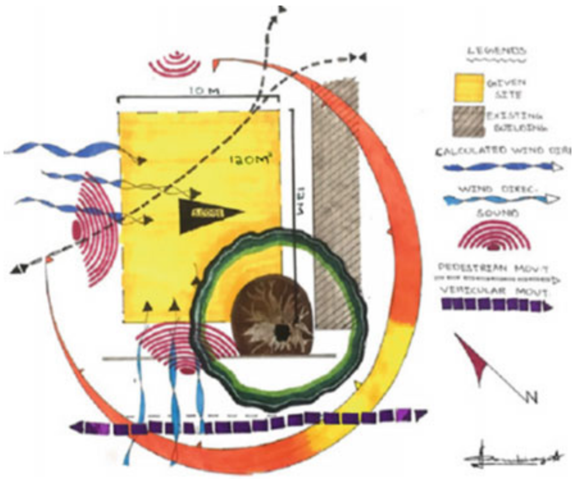


Fig. 2.6 Introduction to The Anganwadi project and site conditions. *Source* iDiDe Deakin University, Manipal Academy of Higher Education and International Islamic University Malaysia (2018)

Fig. 2.7 Site for Anganwadi at Ajjarkad, Udupi, India. *Source* iDiDe Deakin University, Manipal Academy of Higher Education and International Islamic University Malaysia (2018)

Fig. 2.8 Site analysis plan. *Source* iDiDe Deakin University, Manipal Academy of Higher Education and International Islamic University Malaysia (2018)



74°44′31.95″E, Population -165,401 (2011 Census Data); Climate: Warm-Humid. The design process started with the students doing a thorough research on AWCs, its systems, stakeholders and beneficiaries to understand the constraints to overcome in planning and construction. The teams conducted site context analysis and met the people from the community as well as the beneficiaries informally to assess the needs and requirements for the project. To complement the study, the students visited a few AWCs in the region as case studies to understand if the design and function was conducive to the community and the users. Further, the students conducted hands-on-workshops for the children and community to make them feel at ease as well as to

Fig. 2.9 Hands-on-workshop activity to promote engagement between iDiDe architecture design students with Ajjarkad Anganwadi children. *Source* iDiDe Deakin University, Manipal Academy of Higher Education and International Islamic University Malaysia (2018)

understand their needs and aspirations to be reflected in the proposed AWC designs (Refer Fig. 2.9).

Preliminary designs and models were prepared and presented in the community to the Government representatives, stakeholders and beneficiaries for their comments. All of them participated actively and suggested certain changes and expressed other requirements and needs to be incorporated, while appreciating the overall design. Thorough revision was done onto the designs under the mentorship of the faculty and professionals from the industry (Fig. 2.10).

Following a thorough evaluation of the proposals of AWCs by the community, the changes were incorporated in the design and finally seven proposals were exhibited for the public in a formal event at Manipal Academy of Higher Education, involving the University officials, Government officials, students, community stakeholders and beneficiaries, to take them forward for construction aided by the Government. The event received wide coverage with all invited dignitaries appreciating the outcome of the rigorous collaborative studio process. The officials expressed the need and significance of such collaborative studios for social outreach projects and the mutual benefit for academia, industry, Government and community.

2.3.2 Evaluation of iDiDe Anganwadi Design Concepts

All designs restricted themselves to the recommended plot area of 120 m^2 to meet stringent budget constraints. The functional requirements incorporated in the program brief were (1) play and recreation area (2) food storage and preparation area (3) maternal health care facilities and (4) supporting service amenities. The students' designs adhered to sustainable built structure guidelines. The seven design proposals

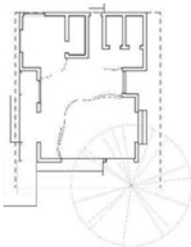
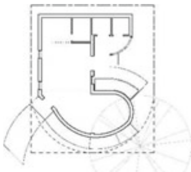
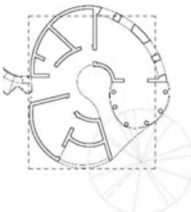
Fig. 2.10 Stakeholder input was sought through iDiDe teams presentation of design ideas. *Source* iDiDe Deakin University, Manipal Academy of Higher Education and International Islamic University Malaysia (2018)

are summarised in Table 2.1 below with an explanation of how the concepts were derived.

2.4 Findings and Discussion

In this paper, it is proposed that the understanding of meanings about participation is critical to design, particularly regarding cross-cultural design. Societies and groups based on other value systems hypothesize “participation” differently, and this understanding directly affects the intercultural design process (Winschiers-Theophilus 2012). In the iDiDe Ajjarkad Anganwadi project, the cultural aspects of the design were created by understanding the needs of the stakeholders, i.e. rural children, parents, teachers, community physicians and the centre management. The integrated patterns of human behaviour as users were explored by being in close interaction and direct engagement with the community. The design proposals produced by teams of architecture students offered creative, sensitive, situation specific, and contextually defined synergies of the proposed design solutions with its environment. The concepts derived by the seven design proposals demonstrated synthesis of architectural design, the pedagogy and cultural attributes that aided the formulation of architectural design parameters for the proposed Anganwadi centre. The evaluation performed offered analysis of how the designs responded to the community needs and

Table 2.1 Evaluation of seven iDiDe design concept ideas for Anganwadi in Ajjarkad

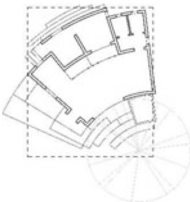
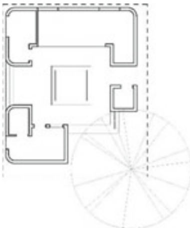
Design proposal 3D View	Plan view (Not to scale)	Concept
Design 1: "Chinnara Mane" 		The concept was inspired by a guiding principle of comfort and security of home with the use of local materials. The roof profile adopted vernacular style and was inspired from the leafy canopy of the existing tree
Design 2: "Abhivrd'dh" 		The design responded to the core behaviour and climate patterns. Subsequent spatial configurations, roof profiling, are based on this core concept where the roof acted as a water harvesting strategy to collect and store water for the needs of the centre
Design 3: "Seridamane" 		The design concept was driven by the functionality of spaces where the children's area reflected a more playful shape and introduced a fluidity in the space through organic shapes to minimize unsafe sharp angular building corners
Design 4: "Kuti" 		A form that stood proud and offered uniqueness was the main inspiration for the design. A child's fingerprint inspired the overall form and layout and allowed the building spaces to form a natural curvilinear shape and framed indoor, semi-open and open spaces within

(continued)

how they synthesised the design brief throughout the collaborative and participatory methods.

This paper has been dedicated to elaborate on the design methodology adopted in the iDiDe collaborative design programme, rather than the design outcome, as it was more important to assess the approach in meeting the community needs and feedback received from the stakeholders throughout the process as the first paper that reported on the research outcomes of iDiDe's efforts in instigating community centred design.

Table 2.1 (continued)

Design proposal 3D View	Plan view (Not to scale)	Concept
Design 5: “Trikona” 		The design takes the symbolism of the existing tree on the site, and centred the building around it. The word “Trikona” meaning triangle, refers to Growth, Nourishment and Knowledge. Three points of the building touch the site boundary encouraging connectivity with the adjacent existing school buildings
Design 6: “Khulaapan” 		The concept of the design offered segregation of dedicated function driven spaces through transition and focus on visual connectivity to strengthen and promote the children’s engagement with the outside spaces. The tiled roof design unified the segregation of spaces and created in between circulation /corridor spaces that offered informal play and learning spaces
Design: “Sahasa” 		The design focusses upon the essential concepts for a sustainable Anganwadi Centre which were safety, fit for purpose, functionality, aesthetics, accessibility, sustainability. The design integrated holistic elements of children’s development throughout the building featuring colourful and child friendly architecture experience through play and adventure

Source iDiDe Deakin University, Manipal Academy of Higher Education and International Islamic University Malaysia (2018) reproduced in Sukanya Mishra, original thesis supervised by Ang (2018) in completion of Master of Architecture degree, Deakin University

As such, further levels of analysis, which might evaluate design performance criteria are excluded in the scope of this paper, and a future paper will look at expanding upon that. Similarly, this paper has also excluded the learning outcomes of the students.

As previously mentioned, very little formal research has been done on construction and design of Anganwadi Centres and the authors will put forward that this is the first research study on this topic. In that light, it became very important for this paper to highlight and raise awareness of the potential scale of impact Anganwadis have upon India, and that a community participatory approach to the process community stakeholders have opportunity to provide input into the outcomes created better engagement amongst the communities. The intervention and leadership of universities that entered the scene with a primary educational agenda in providing learning experience for architecture students need to be commended as they have also proven to be worthwhile with the seven designs produced being "out of the box" from previous Anganwadi buildings that lack inspiration and responsive to children's learning needs and climatic conditions. In the context of research, the authors have concluded that academic led research is fundamental to sustainable development and to advance progress as new methods in social architecture research. The field of "sustainability and higher education" (SHE) is a late comer to the research field. The Anganwadi project learning engagement outcomes which included community sustainability, designing in the Indian context, collaboration across cultures and integrated design have merely been summarised briefly here. Future design research will aid in illuminating and furthering this work.

2.5 Conclusion

This paper's most valuable contribution to the field of knowledge in relation to Anganwadi and designs for children is in the original content created and collected on ground through the iDiDe programme and from the lived experiences of the authors. As mentioned earlier, there are very little peer-reviewed research publications available to inform this topic and most of the available sources of knowledge are informal or published in media or through private organisation websites. Further, design research, especially that which regards participation in design, is being conducted by other experts such as psychologists, sociologists and anthropologists, who are more concerned with the effects and influence of design rather than its forms. Through co-design participatory methods, the design process was shaped through community engagement and the outcomes thus satisfied the stakeholders as fit for purpose. Sanoff (2008), a seminal source of reference for this research study stated that, "*experiences in participation processes show that the main source of user satisfaction is not the degree to which a person's needs have been met, but the feeling of having influenced the decisions*". Hence, the re-emergence of the epitome of a participatory democracy at the national level is effective, only if people have been prepared for participation at the local level, such as the workplace and community; as it is at this level that people learn self-governance and perhaps self-reliance.

To conclude this educational paper, the reflections on the iDiDe Anganwadi design method are offered below:

> *An intensive community engagement through the iDiDe participatory approach in this context enabled the student architects to include cultural behaviour such as hygiene, ablutions, storage, gender separation and intangible operational cultures of the community. These cultural frameworks were shaped by understanding the needs of the stakeholders which results in the formation of unique spaces, forms, colours, textures, tectonic styles, material*

choices and the desired environment in the Anganwadis. (Co-author and iDiDe Academic Norwina Mohd Nawawi, 2018*).*

"Such an experience with the stakeholders or the co-design approach reframes the minds of the student designers to plan with a sense of purpose that touches the heart and soul of the real people with real needs." (Co-author and iDiDe Academic Nandineni, 2018*).*

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Chapter 3
Parameters for Quantitative Evaluation of Non-structured Sustainable Strategies for the Management of Water in Urban Area

Ar. Aishwarya P. Khadse

Abstract Rapid urbanization has led to the changes in the natural water systems in the urban areas resulting in problems related to management of water in urban areas such as flooding, droughts, ground water depletion, conservation of water bodies and waste water management. The global water crises states that only 2/3rd of the people have access to safe water. In India, the growing demand and the rapid urbanization makes India most vulnerable to the risk of water crises in the near future. This study aims to manage water in urban areas using non-structured water sensitive urban design strategies and evaluation of the effectiveness of the proposed strategies. A design set of water management strategies on building, neighborhood and community level has been studied where water management techniques become a part of the urban design to form a sustainable water management system. The identification of a set of water management strategies and the study of their design implications are proposed to address the problems. Further evaluation of their effectiveness is based on the parameters identified for different tools individually to achieve the needs for management of water. Strategies such as green roof, bio-retention, swales, watershed, rainwater harvesting techniques, implemented along with their design implications, are mapped based on the main functionality of the tool as to which problem it addresses in relation to urban design at different scales. The paper focuses on techniques for successful integration of sustainable water management strategies with architecture and urban design.

Keywords Urbanization · Sustainable water management system · Water sensitive · Urban design · Integration

3.1 Introduction

This paper discusses the concept of water management in urban areas in integration with urban design. Different issues related to water management are highlighted

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and different water management systems from 1960s are stated. These systems are identified in urban areas all over the globe. Different water management systems are discussed with specific urban context. The non-structured sustainable water management techniques are explained with their urban design implications. The parameters of management techniques are stated so as to form a relation between implementation of a strategy and improvement of the effectiveness. These parameters also help in evaluation of the strategy. The study focuses on the quantitative management of water at source, storm water management and wastewater management. The selection of the strategies and the evaluation of the effectiveness of the strategies have been considered. The paper ends with a discussion on the identification of combination strategies, which could work with the existing infrastructure as well as new settings overseeing both centralized and decentralized sustainable water management systems. The strategies implied are taken into account for both new construction and as a retrofit to the existing building.

3.2 Issues Related to Water Management in Urban Areas

Water in urban areas has been significantly deteriorating in terms of quality, quantity, conservation and management. The hydrological cycle changes are due to the different aspects of urban lifestyles. The changes in land-use then result in a change in the hydrological cycle which further results in retaining excess water in these areas causing urban flooding. High storm water runoff, low retention rate, low permeable surface, blockage of wind moment, low evapo-traspiration rate etc. have led to problems such as flooding, water shortage, water course heals, affordability of water, connection of people with water and increase in the urban heat island effect.

The poor management of water in these newly developed urban areas, results in the scarcity of water and at the same time urban flooding in monsoons. In such a case considering wastewater as a resource is a paradigm shift in the approach to manage water. In addition, managing water and capacity building for future generations to meet their needs is essential. In such a scenario, sustainable water management practices are essential to meet the ever-increasing demand in these areas. Not many studies are available where the hydrological planning and design interventions together evaluate the water management practice. The study was carefully considered under the light of water management strategies in coherence with the urban design implications, which could further initiate in evaluation of given strategies.

For the effective management of water in urban areas there is a need to manage water at the source. To this end, storm water management and wastewater management must be considered. Different set of strategies are used for the management of water in such urban areas. However, the selection of the strategies and the effectiveness of the selected strategies must be considered. In addition, the effectiveness of those strategies in regard to changes in the demographics in the near future, the change in the use of non-potable water, quantitative demand changes in the need for water in the near future needs to be addressed. Hence the identification of a combination strategies which could work with the existing infrastructure including both centralised and decentralised strategies to give a correlation between those strategies is needed.

3.3 Urban Water Management Systems

Urban water management systems are related to the water management in urban areas based on wastewater, potable water and storm water. The urban water management systems date back in historic times when different strategies were used in different parts of the world to solve different issues based on the site-specific needs and contexts. Historically storm water management had set goals for these systems, over time different systems have been proposed and implemented all around the globe and they have been studied. These systems are studied in further detail and they are analysed to see which system could be used to the site-specific content of a project or proposal. The overall comparison of all these given systems, their strengths and weaknesses could be taken into consideration and a water management system which implies the best-case model for the chosen site is considered.

3.4 Study of Water Management Systems Around the Globe

3.4.1 Low Impact Development (LID) and Low Impact Urban Design and Development (LIUDD—1977)

In North America and New Zealand, the cost of storm water management had to be minimised with the increased urban growth. Thus, storm water management in these areas were named as low impact development. The LIDS take a design with nature approach where the natural setting of the site is in coherence with the site layout and integrated measures to manage the given area are taken into consideration. The natural hydrology explains the site's original form to balance the natural runoff, evapotranspiration and infiltration volumes could be attained through providing urban water systems. The large end catchment solutions do not give a catchment wide hydrological restoration. This traditional practice is discouraged by the implementation of LIDs.

3.4.2 Water Sensitive Urban Design (WSUD—1990)

In Australia, an integrated approach to manage water was initiated. This included the process of integration of water cycle management with the built environment through planning and urban design. This process included all chains of water management such as, storm water, potable water and wastewater management on all scales. It was named as water sensitive urban design.

3.4.3 Integrated Urban Water Management (IUWM—1981)

Water management, which relates to all parts of the water cycle within a catchment, is called integrated water management. It combines the management of water supply. It was a step towards holistic involvement of planning and urban design to come to terms with water management as an issue and find an integrated solution to the given issue. It was in a local context looking towards site-specific solutions for the management of water and integrated all parts of the water cycle to initiate sustainable parameters with which water management is discussed in this technique.

3.4.4 Sustainable Urban Drainage Systems (SUDS) or Sustainable Drainage Systems (Late 1980s)

These are used to drain the storm water or surface water and is a solution to manage these with a range of technologies. These technologies are not necessarily sustainable, but they are used where the effectiveness of the technology is required to function on the best-case scenario that is around 100% water management as a target.

3.4.5 Best Management Practices (BMPs—2011)

BMPs are practices used to manage pollution in a structured manner on the different levels and is a concept that evolved in North America after rapid industrialisation caused pollution to increase on a large-scale affecting water bodies and storm water pollution increasing on a large scale. BMPs have been used over a long period of time but the term best for any proposed practice is debatable.

3.4.6 *Alternative Techniques (ATs—1980) or Compensatory Techniques (CTs)*

An approach to the economy with water management first started in France where in the early 1980s the urban expansions had a great effect on the water management techniques. These techniques were used to balance the effect of urban expansions by optimising land use by keeping in mind the cost, which is used to implement the proposed practice. These were also called as compensatory techniques as they balance the impact the urban growth has caused.

The evaluation of all the water management systems show that the systems are developed for specific problems related in that area at a certain time. Each system has its own unique character and is mostly integrated with the water cycle of the urban areas. However, only water sensitive urban design considered water management as a part of the urban design and the design implication of water management are considered in the given context. It is also unique in its application as it deals with different application levels for the implementation of the strategies.

The water management systems dominate in the management of storm water management in the urban area but water sensitive urban design is the only water management system which deals with all aspects of water management in an urban landscape namely, storm water management, potable water management and waste water management. It is seen that WSUD takes a long time in the evaluation of the effectiveness of the strategies but also considered the most sustainable water management system. It tends to bring closer the urban water cycle to the natural water cycle. The results are partially analysed when using WUSD systems and the effectiveness is mapped based on the need of the user. This also gives the user a control to implement strategies based on the issues related to the identified area and partially integrate the existing water management techniques with the proposed new to attain the required result. Hence, WSUD is used to develop a base case for this proposal to implement the water management system due to its flexibility in terms of selection of aspects as well as implementation of tools in integration with the existing infrastructure and make design a part of the water management cycle in that area.

3.5 Sustainable Water Management Strategy

Different strategies are used to address different water management problems. Each strategy is unique in its own function but does not specifically satisfy just one issue and overlaps are found in terms of its functionality. However, the decision of selection of the strategy must be taken into consideration for which aspect of water is to be addressed. All these strategies are classified as rainwater harvesting which is used for storage of water.

The treatment of water is seen in relation to the management of water; detention and infiltration, which deals with the aspect of quantification and runoff. Conveyance and decentralised systems which form an integral aspect of water management systems and evapo-transpiration, which is a passive water management system, used to form a base case in a WSUD implementation scheme.

3.5.1 Rainwater Harvesting

The rainwater harvesting techniques could be applied at various scales. It deals with the quantity management of water. These systems also help in designing a landscape and architectural forms. It is achieved by different tools as listed below. These are used to incorporate above ground storage systems.

The major problem in urban areas related to storm water runoff is the quality of water that undergoes infiltration. The storm water treatment is significant before use as well and the runoff should meet the quality standards of the specified guidelines. Different options are available to achieve the sustainable treatment of storm water. The tools could be modified to achieve the desired result of the implied strategy.

3.5.2 Detention and Infiltration

The detention systems are used in various ways to help to mitigate the urban runoff as well as help in increasing the infiltration volumes in an area. This strategy is used to reserve the water and then allow the water to penetrate the ground. Usually, these systems are also used with the conventional system to move excess water to different areas. This strategy is encouraged because of its economic viability in places where there is availability of land resources. Listed below are the tools used to inform the given strategies.

3.5.3 Conveyance

Conveyance of water is a very important part of the water management system since conventional times. Efforts are made to make this system sustainable finding alternatives to underground sewers. One such alternative is open storm water channel, which can convey from impervious surfaces.

3.5.4 De-centralised Management Systems

The de-centralised management systems are the most sustainable systems. These aim at management of water at different levels to bring the urban water cycle close to natural water cycle. These systems prove to be more manageable in terms of its operational maintenance.

3.5.5 Evapo-Transpiration

Evapo-transpiration is a significant part of the natural water cycle. This effect helps to mitigate the urban heat island effect. This effect is based on the mechanism of the green cover to send water back into the water cycle with an effect on the precipitation levels. It also responds to the temperature of the space as well as humidity. The only consideration while incorporation of the given strategy is the availability of space.

3.5.6 Techniques Used for Water Management and Evaluation Parameters

The evaluation parameters for the given strategies are the designing parameters and not qualitative parameters of design. Each technique is explained with its urban design implication, the scale to which it could be implemented and the parameter which could affect the efficiency of each technique.

3.5.7 Bio Retention

The demographic depression in a region which may be natural or manmade which are typical drains made of engineered systems and are usually covered with vegetation. These bio retentions help to filter and remove pollutants and reduce runoff. The bottom area is covered with gravel followed by a layer of media ponding on the topmost area.

3.5.8 Urban Design Implication

Bio retention systems are of a variety of sizes. They fit in any map of the system. Adapted in landscaping they could be used on all levels of strategic management. They have the potential of place making and people can be a part of the process. Bio retention forms a significant part of landscaping and is generally used in integration with other water management technique to be implied on site.

3.6 Parameters for Evaluation

The efficiency of bio retention systems depends on designing parameters as—Ponding depth, media depth, media porosity, gravel depth, gravel porosity, and bottom area. Infiltration could be adjusted depending on the following parameters.

3.6.1 Rooftop Retention (Green Roof System)

Layered retention systems are designed according to the size and design of the roof. This system has its application on the smaller level but is most implacable in urban areas. The lower base is the drainage depth followed with a top layer of media.

3.6.1.1 Urban Design Implication

This system has helped to change the face of the urban areas. It works on various levels of designing scales and helps in collection of storm water and mostly is a reservoir system. This system has an impact on the urban heat island effect. Studies have also shown a positive impact of these systems on human health.

3.6.1.2 Parameters for Evaluation

The design parameters of evaluation of the green roof system are—percent roof area, media depth, media porosity, drainage depth, drainage porosity in percent. The infiltration rate is zero for as it has no capability.

3.6.2 Permeable Paving

These are the pavements on the areas with increased infiltration rates. They are made of different porous materials to allow the storm water to infiltrate into the ground. They are designed such to have a reservoir on the bottom or the water is directly infiltrated to the ground. Generally due to high pollutants in the storm water of urban areas reservoir is proposed.

3.6.2.1 Urban Design Implication

These pavements are designed for medium as well as heavy load. They are used individually or in combination with normal pavement in the area. These are used on all levels of mapping of strategies and could form a future of state making.

3.6.2.2 Parameters for Evaluation

The design parameters for the evaluation of the permeable pavement are—Reservoir depth, reservoir porosity and area cover. The infiltration rates are high and vary on given areas.

3.6.3 Infiltration Zones and Trenches

These are naturally formed or artificially made zones which have very high amount of infiltration rates. They are the most efficient systems of retention, filtration and infiltration. These systems use different materials natural and artificial to suit the needs of the site and are used on very large-scale urban projects. The small application of these systems is designed but the effectiveness decreases.

3.6.3.1 Urban Design Implication

Infiltration zones are used on different levels of public and private settings. They are used in public infrastructure to deal with storm water management in these areas. Infiltration trenches are used with various forms of urban design techniques. These are aesthetically pleasing and have proved to promote social infrastructure in these areas. They are economically viable and help in increasing the ground water levels of the area.

Trenches can be incorporated into diverse settings including public and private gardens, roadside planters, parks, driveways, sidewalks, median strips. These installations can be used in conjunction with street quieting measures and other traffic control installations. Infiltration zones and trenches can be used to beautify a neighbourhood, especially those that are heavily paved.

3.6.3.2 Parameters for Evaluation

The design parameters for evaluation of infiltration zones are—reservoir depth, reservoir porosity and area cover. The infiltration rates are high and vary on given areas and are based on the demographics of the region and the depth slopes.

3.7 Selections of Tools to Form a Strategy for the Management of Water

The application of the intended strategy on a specific area remains the most significant part of the applied research. The characterisation of the given strategy remains specific to the identified area of implementation of strategy. The scale to which the strategy is applied also forms an important aspect of the selection of the technique for a specific region. Which tools to use in the specific case depends on what aspect of water management must be addressed on the site-specific context. The identification of the available source of water and its implication on the site could be evaluated to select the strategy for the given area. The demand supply chain for water could help in identifying the potential gaps in the chain to be addressed in the proposal of the strategy. The unique map of techniques could be formed based on these aspects of water to form management strategies for a given region.

Based on different requirements the identified area, the tools could be mapped using the following criteria to what gap is to be addressed on the site:

3.7.1 The Estimation of Demand Supply Gap on Various Levels

The estimation of the needful quantity which is needed forms a prerequisite to any strategy proposed. This also implies the quantification of how much water is needed to be satisfied by the given strategy. It addresses both structures and strategies like the dams, reservoirs, channels etc. as well as non-structured strategies like the green roofs, bio-swales, detention trenches etc. This criterion acts on the global scale of quantification of water on all levels of any given region.

3.7.2 The Quantitative Water Management

The implication of the strategies selected under these categories are very site specific. The strategies selected or formed are based on the context of the demographic and the techniques exploit the maximum potential of the site. The strategies applied are at the first stage of design and are usually proposed on new construction sites. These strategies are applied after the estimation of the demand supply gap which needs to be addressed on all the scales.

3.7.3 Location Identification for the Specific Site to Aspects of Strategy Needs to Be Implemented on the Assigned Context

The management of water on site on a construction level and the types of structured strategies proposed to meet the demands is evaluated under this level. The strategies are mapped at different levels which could be structured as well as non-structured or combination of both. These proposed strategies only affect the needs of a specific site in general and are totally dependent on the location to effectively perform to meet the required needs on a local level.

3.7.4 Place Making Strategies on the Identified Site

The strategies which promote public participation for use or for maintenance are to be proposed in a region form place making interventions. These set of strategies to deal with the social implication of the given context. This states that the given set of strategies are used for promoting public participation in each region.

3.7.5 After Impact Evaluation

All tools together form a multi-criterion approach where in different tools can have differently defined user parameters to form a best case. The multi criterion assessment of the tools are based on the parameters of social, economic or environmental impacts. The impact evaluation is significant for the quantitative water management needs of the future and the potential gain of strategies for the future.

3.7.6 Application of Strategies on Different Scales

The applications of strategies on different scales are used to address different problems studied in the case study. For the application of the identified strategies the site-specific scale to which these strategies could be used are considered. The optimised balance of the strategy gives the benefit of a systematic approach to the application of the tools. A mix of actions on various spatial scales helps in effective management of water where in the approach of design could be such that the user's demand and the supply capacity of the water system at a given spatial scale could be managed.

The application of water management strategies on different scales allows different parties to be the stakeholder of different water management strategies. The different scale application of strategies all owes a short-term action plan for different

Table 3.1 Mapping of the tools used for the water management at different scales

Design Implications of strategies on which scale	Building	Porch	Yard	Street	Open Space
Green roof	■				
Rain-water harvesting	■				
Bio Retention		■	■		■
Permeable pavement		■	■	■	■
Swales				■	■
Wet land					■

Source Author

strategies and a long-term action plan for different ones where in the operation and maintenance of the given strategy are looked after. This also allows the evaluation of the given measures where in the short-term benefits are easily quantifiable and the effectiveness of the given strategy is measured.

The mapping of the tools used for the water management at different scales in the Table 3.1.

The benefit of using water sensitive urban design techniques is the application scales to which it is implemented. When explored to the maximum potential it helps in mapping the best social, economic, environmental and technological parameters to consider according to the given needs of the specific area. The mapping of the application scale potential needs to consider the baseline of the current needs and the growth in the future needs and the operation and maintenance of the proposed strategies. Not all the strategies used could be accounted based on quantitative harvest in the given site.

3.8 Conclusions

The concept of water management in urban areas has been independent of urban design and the design implications of planning. In recent times it has been observed from the studies that the non-structured strategies of water management have often taken a polarized approach. However, water itself contains life. It cannot be treated as a commodity to be utilized. Studies show that water quality remains greatly affected by artificial interventions of conservations by structured means of management such as dams, closed channels etc. In this scenario, management of water using non-structured strategies and decentralized techniques remains the best alternative for the management of water. Also, public participation remains the most significant part of the cycle. Aesthetic interventions help in playing a big role in bringing people close to water. The most important concern of people's participation is the contamination of water led by mishandling the resource. For this small initiative of aesthetic design implications in public areas bringing people closer to blue footprint in urban areas acts as a strong initiative.

Water management through integrated approach in relation with management of water on different scales of design helps in meeting the end-to-end approach for the cycle. The urban design interventions for the blue footprint in the demographics of urban areas propose a paradigm shift in the approach to the management of water in these areas. Also, the techniques used for management as a retrofit in areas has been seen to achieve effectiveness of up to 50% (Water sensitive urban design—Australia 1998).

This has given a new approach to how water management is concentrated within scales of designing and planning to increase the efficiency of the model achieving the best-case scenario in a specific context. It should be noted that the sustainable strategies increase the efficiency over a long period of time and no immediate gains should be expected. However, with the help of collaborative structured and non-structured strategies the use of sustainable strategies could be gradually increased over a period of time to effectively meet the demand supply chain of water in conjunction with minimum impact on the natural hydrological cycle. It acts as a significant factor in managing the urban risk and lowering the environmental impact factor.

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Chapter 4
Role of Building Design in Sustainable Green Development: A Review

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Abstract The building stock in most of the countries has been accountable for consequential portion of energy use. Due to global climate change and sustainable green development concerns, an emerging trend in recent years towards building energy efficiency has been observed. To significantly reduce high cost of energy consumption in buildings, endorsing energy efficient technologies and strategies is still an ongoing challenge. Thus, research in cost-efficient strategies to minimize energy load of buildings is conducted by several researchers in compliance with global fundamentals of sustainability. To avail the maximum potential of a building's capacity leaving minimum environmental impact, understanding the role of design in buildings is a necessary step towards sustainable green development. The work represents the linkages between energy efficiency, sustainable green development and building design strategies. The objective of this paper is to review the interactions between building design and energy efficiency with respect to studies based on optimization of building performance. This research work is pivoted upon studies conducted on simulation-based approaches to optimize buildings. Building envelope, roof and wall insulation and building shape are major design variables which has impacted buildings found in the literature review. The most popular optimization method used by researchers is parametric study coupled with most applied simulation techniques like EnergyPlus and TRNSYS (Transient System Simulation Tool).

Keywords Design · Materials · Energy efficiency · Thermal performance · Sustainable green development

Nomenclature

ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
CFD	Computational Fluid Dynamics

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BEopt	Building Energy Optimization
DOE-2	Building energy use and cost analysis software developed by Department of Energy (DOE), USA
GenOpt	Generic Optimization programme
IDA—ICE	IDA Indoor Climate and Energy
IES—VE	Integrated Environmental Solutions—Visual Environment
TAS	Thermal Analysis Simulation
THERB	Thermal Environment Simulation

4.1 Introduction

It is projected by United Nations' *"The 2018 Revision of World Urbanization Prospects"* that by 2050 more than half of the population will be residing in cities (World Urbanization Prospects 2019), which will have a direct impact on energy consumption, part of which will be because of the maintenance of indoor thermal environment. This creates a challenge to strive for sustainable green development. The global climate change scenario in recent times has clearly reflected the need to review the existing technologies and present evolutionary concepts through research and development. In retrospect, various research and development efforts in creating sustainable solutions like passive design strategies have been studied and implemented. But with the consistent and rapid rise of the construction sector, need for optimization design strategies and intelligent use of building materials are required.

This manuscript represents the relationship between energy efficiency, sustainable green development and building design. Section 4.1 provides a brief overview of simulation techniques and software used by researchers to optimize energy efficiency of buildings. Section 4.2 showcases the review of optimization studies conducted by researchers taking multiple design variables and simulation techniques into account; Table 4.1 contains the summary of the investigations reviewed. Based on the reviewed literature, Sect. 4.3 presents the analysis of the effect of design strategies and further present summary of simulation studies conducted for building envelope and glazing being most common optimized design variables through Table 4.2. Inferences from Tables 4.1 and 4.2 are presented in Figs. 4.2, 4.3 and 4.4.

4.2 Relationship Between Sustainable Green Development and Energy Efficient Design

With the rise in global climate change metrics and the amount of contribution of the building sector to climate change, several international and national organizations have proposed agendas and targets to reach a benchmark for reducing carbon footprint and achieve sustainable green developments. Despite varied nativity of these policies,

Table 4.1 Summary of studies on whole building design optimization

Authors	Simulation method	Design variables	Optimization objective	Location
Florides et al. (2002)	TRNSYS	Thermal mass, overhang shading depth, glazing type, roof insulation, aspect ratio, ventilation rate, building orientation	Cooling load, lifecycle cost	Cyprus
Gratia and Herde (2003)	TAS	Thermal mass, windows-to-wall ratios, insulation level, ventilation rate, internal gains control, air tightness,	Cooling load, heating load,	Belgium
Wang et al. (2005a)	ASHRAE toolkit	Glazing type, windows-to-wall ratio, building shape, Building orientation, wall type, overhang depth, aspect ratio, and wall tilt	Environmental impact, life cycle cost	Canada
Cheung et al. (2005)	TRNSYS	External wall color, shading devices, glazing type, window size, thermal mass, insulation level	Cooling load	Hong Kong
Wang et al. (2005b)	ASHRAE toolkit	Walls and roof structure, windows-to-wall ratios, insulation levels, window types, aspect ratio, building orientation	Lifecycle cost, environmental impact	Canada
Verbeeck and Hens (2005)	EN 832	Hot water production, space heating system, photovoltaic panels investments, solar collectors, glazing type, wall and roof insulation thicknesses	Retrofit cost	Finland

(continued)

Table 4.1 (continued)

Authors	Simulation method	Design variables	Optimization objective	Location
Tavares and Martins (2007)	VisualDOE	HVAC system, mechanical ventilation rate, external shading device, infiltration rate, window glazing, window types, wall types, roofing	Cooling load, heating load, thermal comfort	Portugal
Charron et al. (2008)	TRNSYS	Heating system type, photovoltaic system, solar thermal collector, windows-to-wall ratios, insulation level, building form, building orientation,	Construction cost	Canada, USA
Eskin and Turkmen (2008)	Energy plus	External wall color, shading devices, glazing type, building aspect ratio, insulation level, window size, thermal mass	Heating load, cooling load	Turkey
Hasan et al. (2008)	IDA ICE	Windows U-value, roof and floor insulation thicknesses, wall types	Life cycle costs	Finland
Bichiou and Krarti (2011)	DOE-2	HVAC system type and efficiency, aspect ratio, air-tightness, roof and wall insulation, windows-to-wall ratio, building shape, building orientation, building shape, glazing type, thermal mass, heating and cooling set points, overhang depth	Life cycle costs	USA

(continued)

Table 4.1 (continued)

Authors	Simulation method	Design variables	Optimization objective	Location
Asadi et al. (2012)	TRNSYS	Solar collector installation, window types, roof insulation, external wall insulation	Retrofit cost, energy savings, thermal comfort	Portugal
Asadi et al. (2012)	RCCTE	Window types, external wall insulation, solar collector installation, roof insulation	Retrofit cost, energy savings	Portugal
Ochoa and Capeluto (2008)	Energy plus	Ventilation rate, glazing type, lighting type, lighting control, blinds control	Cooling load	Israel
Wang et al. (2009)	Energy plus	Windows-to-wall ratios, building orientation, external wall U-values	Heating load	UK
Zhai and Previtali (2010)	DOE-2	Roof type, wall type, infiltration rate eaves depth	Operating energy cost	22 Locations around world
Yildiz and Arsan (2011)	Energy Plus	35 building design parameters	Cooling load	Turkey
Porritt et al. (2011)	IES-VE	External walls color, solar gain control option, insulation type, ventilation rate	Cooling load	England
Gong et al. (2012)	THERB	Sunroom depth/overhang depth, window orientation, glazing type, windows-to-wall ratio, roof and wall insulation thicknesses, wall thickness	Heating load, cooling load	China

(continued)

Table 4.1 (continued)

Authors	Simulation method	Design variables	Optimization objective	Location
Ruiz And Romero (2011)	Energy plus	External facade color, windows-to-wall ratio, overhangs, eastern facade shading, wall insulation thickness, building orientation	Lifecycle energy use, CO_2 emissions	Spain
Jabber and Ajib (2011b)	TRNSYS	Ceiling and walls thermal insulation thickness, shading, windows-to-wall ratios,	Lifecycle cost	Jordan
Bambrook et al. (2011)	IDA ICE	Thermal mass, wall thickness, roof and wall insulation thicknesses, ventilation rate, shading, window types	Lifecycle energy cost	Australia
Griego et al. (2012)	DOE-2	Window type, eaves presence, roof and wall insulation, color o f the exterior roof, infiltration rate	Lifecycle energy savings	Mexico
Ihm and Krarti (2012)	DOE-2	Building orientation, heating and cooling system, air infiltration level, glazing type, efficiency of lighting appliances, windows-to-wall ratio, wall and roof insulation thickness	Lifecycle cost, energy demand	Tunis
Roetzel and Tsangrassoulis (2013)	Energy plus	Building design type, occupant behavior type,	Thermal comfort, cooling load, heating load	Greece

Source Author

agendas and organizations, their unified motto is to reduce carbon footprint of the building sector. The amount of technological potential for energy efficiency in buildings is enormous. The application for energy consuming devices can be eliminated

Table 4.2 Objective function, optimization method and simulation tools used in glazing and building envelope optimization studies

Glazing			
Authors	Objective function	Optimization method	Simulation tools
Zemella et al. (2011)	Cooling and heating load, CO_2 emissions	Genetic Algorithm	EnergyPlus
Poirazis et al. (2008)	Heating, cooling, lighting and ventilation loads	Parametric study	IDA ICE
Wright et al. (2009)	Heating, cooling and lighting loads	Genetic Algorithm	EnergyPlus
Gasperella et al. (2011)	Cooling and heating load	Parametric study	TRNSYS
Jaber and Ajib (2011b)	Cooling and heating load	Parametric study	TRNSYS
Tsikaloudaki et al. (2012)	Cooling load	Parametric study	EnergyPlus
Susorova et al. (2013)	Cooling and heating load	Parametric study	EnergyPlus
Palmero-Marrero and Olieveira (2010)	Cooling and heating load	Parametric study	EnergyPlus
Datta (2001)	Cooling and heating load	Parametric study	TRNSYS
Hammad and Abu-Hijleh (2010)	Cooling load	Parametric study	IES-VE
Gratia and Herde (2007)	Cooling load	Parametric study	TAS
Gratia et al. (2004)	Cooling load	Parametric study	TAS
Wang et al. (2007)	Thermal comfort	Parametric study	TAS
Hassouneh et al. (2010)	Window energy equilibrium	Parametric study	ASHRAE Toolkit
Aldawoud (2013)	Atrium energy equilibrium	Parametric study	DOE -2
Building envelope			
Masoso et al. (2008)	Cooling load	Parametric study	EnergyPlus
Shi (2011)	Energy savings	Genetic algorithm	EnergyPlus
Sailor (2008)	Energy savings	Parametric study	EnergyPlus
Jaffa et al. (2012)	Cooling and heating load	Parametric study	TRNSYS
Li et al. (2007)	Lighting load	Parametric study	EnergyPlus

Source Author

when design parameters can be assessed during initial stages of designing. Sustainable green development requires the incorporation of climate-responsive design with appropriate functioning of the building.

The role of design for sustainable development has been explored by researchers since past decades. In the 1980s, researchers sought to show that the quantum of energy savings of a building is determined by building envelope, orientation and building shape. Arumi (1981) showed that with appropriate size of insulation for different climates, building lifecycle cost can be reduced. Likewise, Wilson and Templeman (1976) analyzed that total operating and capital costs can be minimized through effective design for thermal insulation (Gero et al. 1983). Since these studies, there have been a plethora of literature available advocating the positive role of effective design for energy efficiency.

But for the reason that building sector represented 55% of global electricity demand based on the World Energy Statistics and Balances database of 2018 (International Energy Agency 2018), it is still essential for engineers and architects to understand importance of building design and utilize the strategies appropriately in the initial stages of design. Design strategies featuring building thermo physics through building form, geometry, envelope, and fenestration can contribute immensely to low energy buildings. The importance of employing effective design strategies has been emphasized in existing literature of sustainable green development. Many authors have investigated the relative impact of individual design parameters as well as holistic impacts while considering their interactive effects. To achieve this goal, architects and engineers need definitive values on the interaction between the design variables which can be operated for the desired performance. These can be effectively gained using optimization methods and simulation tools.

4.3 Optimization Methods and Simulation Techniques

Building performance is usually influenced by parameters such as design strategies used in implementing the strategies. These parameters can be thought over, and implemented. But their success rate varies depending upon factors such as climate, geography, building size, building shape etc. and therefore cannot entirely depend on trial and error method. Using optimization techniques these strategies and building materials can be decided upon and applied for optimum energy efficiency (Fig. 4.1).

Fig. 4.1 Major steps for building design optimization. *Source* Authors

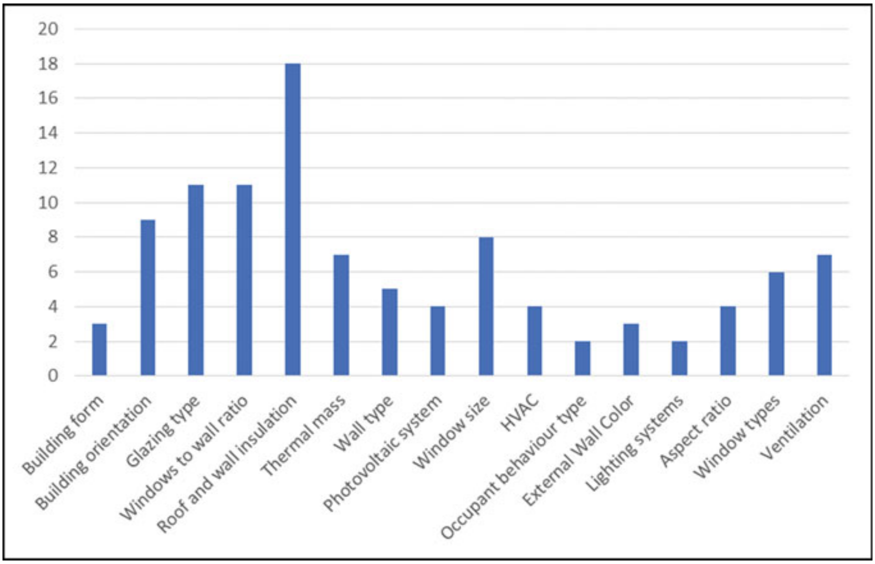

Fig. 4.2 Graph depicting most and least common design variables with respect to their selection in above studies. *Source* Author

Simulation techniques play an elementary role in determining the desired energy efficient status with respect to design strategies. Optimization is the process to find out the maximum or minimum value of a parameter or function by identifying certain number of variables conditional to a set of constraints. The parameters to be optimized are called optimization function, objective function or fitness. Simulation tools are usually used to calculate these objective functions.

A number of design parameters such as building thermal comfort, building lighting systems, heating and cooling loads, thermal mass, life cycle costs, structural design, building form and orientation and energy consumption can be assessed using optimization methods. Generally, an optimization problem can be represented in mathematical form as:

$$\min x \in X^{f(x)} \tag{4.1}$$

where, "$x \in X$ is the vector of the design variables, $f : X \rightarrow R$ is the objective function and $X \subset R^n$ is the constraint set". When additional optimization functions are considered with previously selected objective functions at a time, then the optimization is known as multi-objective or multi-criteria optimization problem. Usually, there are two wide spread ways for multi-criteria optimization problem or multi-objective optimization problems. The first one normalizes each of the objectives and adds them with associated constraints to achieve only one cost function. Classic optimization algorithms may be applied further to solve the problem but the relationship of interaction between other objectives is difficult to extract. Thus, this

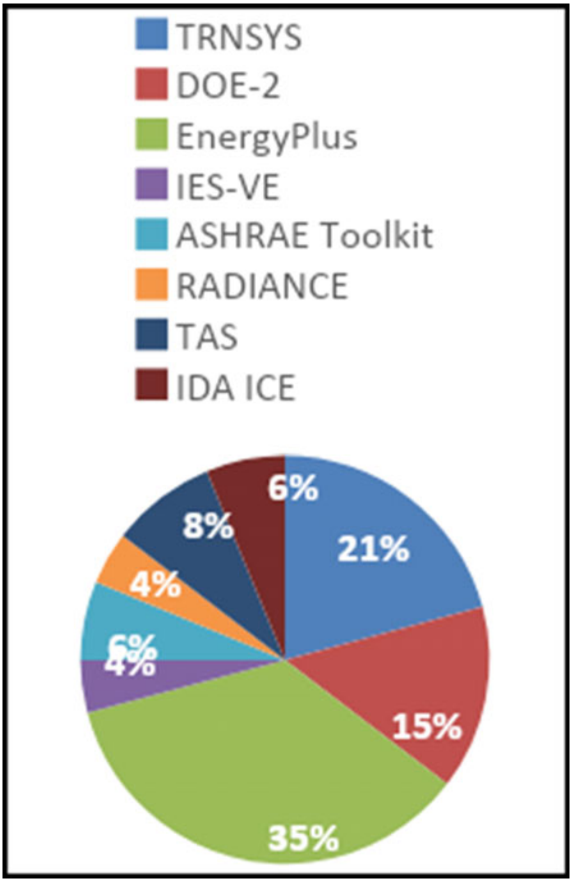

Fig. 4.3 Percentage of applied simulation tools in reviewed literature. *Source* Author

approach is not widely used after Pareto proposed the other way for optimizing multi-objective functions. Through this approach the optimal solution is derived when there is not any other attainable solution that generates one objective without degenerating other objectives, this solution acquired is known as "Pareto Optimal" (Machairas et al. 2014).

Though the algorithms that give Pareto solutions have the possibility of exploiting the various solutions, they often are found to exhibit inadequate efficiency (Cao et al. 2012). Thus, the need to overcome computation of approximate derivative solutions, direct search and probabilistic evolutionary types of algorithms are applied and are also known as "derivative-free" algorithms. One of the widely used evolutionary algorithms is the Genetic Algorithm (GA). Genetic algorithms as stated by Holland are "population-based algorithms and they can efficiently handle non-linear problems with discontinuities and many local minima" (Holland 1975). Ant colony optimization, the simulated annealing (SA), sequential search method and particle swarm optimization (PSO) are also types of evolutionary algorithms. They

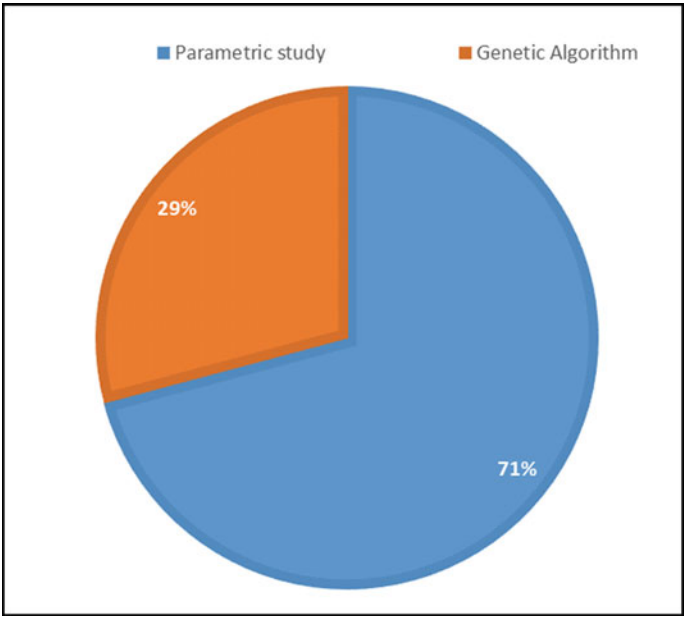

Fig. 4.4 Percentage of applied optimization method in reviewed literature. *Source* Author

are commonly popular for optimization but seldom in research papers based on the building design optimization. Another acknowledged way for performing the optimization of building design is the application of two or more optimization algorithms, known as the hybrid mode of optimization. An example of this hybrid mode has been executed in GenOpt optimization programme (Wetter 2011).

Generic Optimization Program, also known as GenOpt is a cost optimization programme, which yields the specific design measurements regarding annual energy demand. It takes in the simulation template and based on simulations, reproduces new simulation templates, repeating the process until the objective function is achieved. It presently consists of examples for simulation techniques like EnergyPlus, IDA-ICE, TRNSYS, Radiance and DOE-2 (Machairas et al. 2014).

Another optimization tool is BEopt. BEopt's graphical interface allows the selection of predefined choices in different groups (Christensen et al. 2006). It uses sequential search method as the optimization algorithm and Energy Plus or DOE version 2.2 as the simulation engine. The increasing need and effectiveness of simplified optimization tools has brought before us some commercial products that recently presented the optimizing community with building simulation suites (Christensen et al. 2006).

Among the most widely exercised building simulation programmes that execute building performance computations found in the existing literature are EnergyPlus, TRNSYS, DOE2, IDA-ICE, Radiance, Ecotect, and CFD tools. Many building physics phenomena can be simulated using these mentioned tools. Typically, building form and geometry, orientation, climatic data, HVAC operating data and occupancy are the required input functions and thermal comfort metrics, daylight and visual comfort metrics, building footprint like quantum of CO_2 emission, energy consumption are their typical output function.

Algorithm based optimization may be relatively new to architects but parametric studies have been fundamental in designing sustainable infrastructure. In this fundamental type of optimization a number of parameter values are optimized, keeping others constant at each step. But parametric study is limited to optimization at local level. To understand the role in finding solution for optimized energy efficient buildings, the different types of optimization methods need to be known although the objective is not to review the literature available on them.

4.4 Studies on Understanding Building Design and Its Role

The global building sector consumed 30% of the total energy use in 2016. About 38% and 10% total energy use was consumed due to maintenance of building envelopes and building performance respectively (International Energy Agency 2018). Owing to this critical situation, decision making on effective design strategies need to be incorporated in initial phases of designing. Understanding the role of various parameters of building design can influence the performance of buildings to a great expanse, such as building envelope, form, orientation, shape, window to wall ratio etc. By determining the values of these parameters will orient the process of building design towards a more environmentally friendly product.

One of the earlier studies on determining and optimizing these parameters using different optimization and simulation techniques were conducted by Gero et al. in 1983. The authors used Pareto optimization to study the interdependency of thermal load and multi objective criteria of carpet area of the building and cost. They concluded that low height buildings showed higher efficiency of thermal performance as compared to high rise buildings. Then, Bouchlaghem and Letherman (1990) used hybrid method to optimize thermal performance taking indoor environment as objective function and building envelope as design variable. In 1992, Sullivan et al. (1992) established the idea of simulations based optimization. Using DOE-2 the authors produced database of energy performances of various lighting systems and building envelopes, based on electrical energy consumption (Gero et al. 1983).

The studies conducted in past two decades were systematically reviewed on the basis of whole building design optimization. Florides et al. (2002) investigated a building as a case study from Nicosia, Cyprus. The authors performed parametric study using TRNSYS. They studied the causes of annual cooling load through life cycle cost analysis. Their results showed that out of overhang shading depth, roof insulation, glazing type, ventilation rate, aspect ratio, thermal mass building orientation; roof insulation and glazing type were most effective parameters for cost efficiency (Florides et al. 2002).

With an intention to develop design recommendations for office buildings in Belgium, Gratia and De Herde (2003) carried a parametric study linking with OPTI and TAS on two office buildings in Uccle considering thermal mass and building envelope as main parameters (Gratia and De Herde 2003). Wang et al. (2005) conceptualized a framework to calculate building load taking ASHRAE toolkit as a base. Using that framework, they studied an office building in Montreal and found that the optimal design was rectangle and orientation towards South and minimum windows to wall ratio for North and South walls (Wang et al. 2005a).

In another study the authors calculated environmental impact of building's life and its energy savings. An office building in Montreal was taken as study; the design variables were windows-to-wall ratio, roof and wall structure, insulation levels, building orientation, aspect ratio and window type. The authors combined ASHRAE Toolkit with genetic algorithm for energy load calculations of the building to determine impact on only heating and cooling loads. They concluded that as per optimization results a South facing long side of building, rectangular in shape would minimize lifecycle cost and almost a square shaped building would be efficient in reducing building's environmental impact (Wang et al. 2005b). Cheung et al. (2005) examined impact of thermal mass, shading devices, glazing type, external wall color, window size and insulation on the energy consumed due to the load by the way of parametric study of an home unit in multi storied building in Hong Kong using TRNSYS (Cheung et al. 2005).

Charron (2008) optimized construction cost for four case studies of residential buildings in Sacramento in USA and Montreal, Iqaluit and Nanaimo in Canada. The author observed that window area and active heating and cooling systems are dependent on building orientation. Tavares and Martins (2007) performed an early stage parametric study in Visual DOE on an early design stage of a public building in Portugal to evaluate thermal comfort and building performance. Optimizing each design variable one by one, the simulation results presented solutions for each variable cumulatively leading to reduction by 78% and 46% in heating and cooling load respectively (Charron 2008). Heating and cooling loads were investigated by Eskin and Turkmen for office buildings at four different climatic zones in Turkey. The parametric study was linked with EnergyPlus (Eskin and Türkmen 2008).

Hasan et al. (2008) coupled GenOpt with IDA ICE to minimize life cycle costs single family residence in Finland. Building envelope insulation, U value of windows were taken as design variables (Hasan et al. 2008). Bichiou and Krarti studied five single family residences at San Francisco, Chicago, Phoenix, Miami and Boulder to optimize life cycle costs based on building envelope design variables and concluded that rectangular, low thermal mass and minimum feasible window to wall ratio required for North, West and East facing walls (Bichiou and Krarti 2011). Ochoa and Capeluto (2008) conducted three parametric study with EnergyPlus to optimize cooling load. They investigated an office building in Hiafa, Israel. Active devices, passive solar design strategies and combination of both were taken into account in respective three studies. The results showed that combination of active and passive design solutions yield energy savings in terms of cooling loads (Ochoa and Capeluto 2008).

Using EnergyPlus and parametric study, Wang et al. examined the viability of attaining a near zero energy house design in Cardiff, UK. Predefining design variables as windows-to-wall ratios, the U-values of external walls and building orientation; the authors were able to identify minimized heating energy load through an optimal façade design. Tthe authors simulated the building performance, underfloor heating system, solar hot water system and photovoltaic system and wind turbine using TRNSYS; their conclusions were that it is theoretically plausible to design zero energy homes in the UK (Wang et al. 2009).

Zhai et al. reviewed trial and error based vernacular design strategies from eleven climatic zones around the world. They used BEopt tool to optimize operating cost using the traditional design elements and concluded that earth walls, thick plastered mud walls or timber walls help in achieving low costs, due to their low thermal storage. Thus, pointing that low thermal mass improves energy efficiency and cost efficiency (Zhai and Previtali 2010).

Yildiz and Arsan performed EnergyPlus simulations on 10 storey residential building in Turkey, to established most important design features amongst 35 parameters from building design, lighting system and HVAC. The study indicated most influencing factors were building aspect ratio, U value of glazing type and total window area (Yildiz and Arsan 2011). Porrett et al. (2011) studied nineteenth century Victorian house and its range of new interventions for reducing summer time overheating. The optimization done through IES-VE simulation software indicated that considering predicted weather conditions in the decade of 2080s, and occupancy in only morning and evening the overheating problem can be solved only by implementing passive design solutions (Porritt et al. 2011).

Using THERB as a simulation tool, Gong et al. (2012) tried to find optimal combination of seven design variables for 25 locations in China using square shaped model without any heat source and only a window; which came out to be same for all 25 cities (Gong et al. 2012). Ruiz and Romero (2011) ran EnergyPlus simulation with parametric study for double storey residence in Cantabria, Spain to assess the effect of design on lifecycle and carbon dioxide emissions (Ruiz and Romero 2011). Jaber and Ajib used TRNSYS to minimize lifecycle cost of a residential building in Amman, Jordan. Design variables included window size, shading and thermal insulation. The results showed that presence of shading on South façade and adequate thermal insulation on roof and walls reduced energy consumption and lifecycle costs by 25.31% and 11.67% respectively (Jaber and Ajib 2011a).

Roetzel and Tsangrassoulis (2012) examined the effect of the estimated climate change after twenty, forty and seventy years through EnergyPlus integrated with a parametric study of a room in an office building situated in Athens, Greece and three prototypes of building design: internal shading and low glazed façade, internal shading and standard glazed solid façade and external shading with overhangs and low glazed façade with supplemented thermal mass. The study considered extreme ideal and worst occupant behavior types. Thermal comfort during natural ventilation, heating and cooling loads was the objective functions of this study. The authors observed that optimal thermal comfort is directly influenced by the building design with respect to the effect of climate change, and occupant behavior impacts the reduction capacity of greenhouse gas emissions (Roetzel and Tsangrassoulis 2012).

Bambrook et al. (2011) integrated GenOpt with IDA-ICE, to minimize lifecycle costs due to heating and cooling loads in single storey residential unit in Sydney, Australia. The study revealed the building's cooling and heating energy requirement and cost can be decreased though optimal solution effectively by about 94% in contrast to the present architectural practice in Sydney (Bambrook et al. 2011). Griego et al. (2012) investigated four types of case studies for new construction, for unconditioned residence, for retrofit and for conditioned residence in Mexico, using BEopt+. The studies revealed that design variables considered according to existing policies increased energy consumption (Griego et al. 2012). Ihm and Krarti (2012) ran DOE simulations for single family house in four Tunisian cities, to maximize the energy saving and minimize lifecycle cost. It was again revealed that annual energy consumption can be cost-effectively decreased up to 50% in comparison to regular architectural practice in Tunis through optimal building designs. On the basis of these simulation studies it is clearly implied that the existing design policies and general practice in Sydney, Mexico and Tunis require revision and upgrade according to current climate change context (Ihm and Krarti 2012).

Although building new net zero buildings is a step closer to reduce footprint of building sector, it will take years to reach significant expression. Thus building retrofit can be a way to achieve energy efficiency in existing building stock. A wide range of policies and guidelines were introduced by different governments and international organizations to realize energy efficient building retrofits like "Energiesprong," a programme launched by government funded innovative scheme in Netherland. The programme is present in The Netherlands, UK, France, Germany, Italy, New York State, Ontario, and British Columbia (International Energy Agency 2018). Therefore, many researchers utilize optimization techniques to estimate retrofit costs and optimize the design parameters for better building performance warranty after renovations.

Taking retrofit costs as objective function Verbeeck and Hens (2005), ran simulations on EN 832, for five buildings in Belgium. The parameters for retrofitting optimization included heating devices, photovoltaic devices, solar water heaters and building envelope insulation. The results indicated that proper insulation measures are the most effective investment measure for retrofitting, integrating genetic algorithm with TRNSYS (Verbeeck and Hens 2005). Similarly, Asadi et al. carried two studies taking same case study of single-family semi-detached residence in Portugal, one using TRNSYS simulation method and other with RCCTE simulation method. The authors observed in optimization results of first study that one optimized design variable does not necessarily solve multiple objective functions i.e. solutions leading to better thermal comfort may have high retrofit cost. In the other study authors observed that small investment in retrofit costs may lead to energy savings but for substantial improvement more investment was required in retrofit (Asadi et al. 2012).

Optimizing a wide range of design variables, aiming to optimize whole building performance advantageously produce the energy efficient designs. The various design variables used in the mentioned studies are detailed in Table 4.1, along with the optimization objectives of the respective studies and which simulation tool was used to achieve those objectives. But optimizing such comprehensive variables may be majorly demanding for existing soft computing resources. Therefore, it is necessary to approach a proper equilibrium between a number of design variables, their interdependence and their cumulative effect of building performance.

4.5 Effect of Properties of Design on Energy Efficiency

The above studies indicate that the most common design parameters which were studied to analyze whole building performance are design strategies for building envelope such as glazing type, wall and roof insulation, building façade, wall type, thermal mass, windows to wall ratio, aspect ratio and exterior color as illustrated in Fig. 4.2. From the above studies the following correlations are characterized:

1. Low thermal mass leads to higher energy efficiency of buildings.
2. Lower the height of buildings, higher their capacity to be energy efficient.
3. Rectangular shapes and square shaped buildings offer minimal life cycle costs.
4. Orientation of buildings towards South (in the northern hemisphere) minimizes and maximizes building heating and cooling load according to cold and hot climates respectively; this also influenced by the size of windows.
5. Adequate roof insulation can reduce around 25% lifecycle cost and around 12% energy consumption.

Most popular design parameters from the above studies were found to be building envelope, glazing and shading therefore further literature review is conducted to find most popular simulation techniques used for optimizing building performance. Summary of research of these studies stating optimization objectives, the simulation tools and optimization method used to achieve those objectives is presented in Table 4.2. On the basis of studies summarized in Tables 4.1 and 4.2, most popular simulation techniques and optimization method among researchers is depicted in Fig. 4.3 and Fig. 4.4 respectively. Figure 4.3 implies that EnergyPlus is the most popular simulation tool used in 36% of the reviewed studies and 71% of reviewed studies use parametric study as their optimization method as illustrated in Fig. 4.4.

4.6 Conclusion

The manuscript reviews existing literature from past decades on simulation studies done for whole building optimization. Using simulation techniques along with optimization algorithms has been evidently effective in providing optimal solutions for energy efficient building designs. For higher performances and efficient results these studies are required to be conducted in initial design phases. A wide range of optimization methods are coupled with simulation tools, most dominant is parametric study (used in about 70% of reviewed studies) in comparison to genetic algorithm (used in about 30% of reviewed studies). These optimization methods are widely applied in comparison to other optimization methods owing to their easy use and less time consumption. As per the reviewed literature EnergyPlus is most widely used simulation tool (36% usage), followed by TRNSYS (21% usage), DOE2 (15% usage), TAS (8% usage), IDA-ICE (6% usage), ASHRAE Toolkit (6% usage), Radiance (4% usage) and IES-VE (4% usage). It is evident from the studies conducted through the application of the above mentioned optimization methods and simulation tools that in context with climate, lower height of buildings, low thermal mass have been energy efficient design parameters. Rectangular shaped buildings leads to lower lifecycle costs. Adequate roof insulation can immensely impact retrofit cost and maximize thermal comfort. Although the studies indicate the dependency of energy efficiency and lifecycle costs on design variables mitigating greenhouse gas emissions is mostly dependent on occupant behavior type. The inferences from these studies represent different climatic conditions, thus their results though informative, cannot be generalized. Therefore, to improve building energy performance for sustainable green development it is ultimately necessary to realize the importance of role of design by studying the impact of building design in conceptual stages with respect to climatic data, operating costs, energy savings etc. to mitigate rising contribution of building sector in energy consumption.

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Chapter 5
Integrating Occupant Behaviour in Thermal Comfort Assessment of Low-Income Dwellings

Jeetika Malik and Ronita Bardhan

Abstract Thermal comfort actions in low-income group (LIG) housing are often dictated by the adaptive occupant behaviour coupled with socio-economic and socio-cultural regimes. This work aimed at exploring the influence of occupant behaviour on thermal comfort improvements within the slum rehabilitation housing located in Mumbai, India. The study focused on the adaptive actions for thermal comfort in mixed-mode residential buildings located in the warm and humid climate of India. A methodological framework involving a combination of household survey, building energy simulation and comfort assessment technique was employed. Six frequently practiced adaptive actions were identified from a transverse survey which served as an input for building simulation. Thermal comfort potential of each adaptive action was investigated through a systematic method involving "*Comfort Hours*" as the evaluation metric. The results revealed that the adaptive actions, requiring zero or minimal amount of energy, could improve thermal comfort in the case study unit from 16.5% to 34.3%. Some interesting qualitative insights about the potential constraints in adopting thermal comfort were also elucidated through this work.

Keywords Thermal comfort · Occupant behaviour · Adaptive actions

5.1 Introduction

The ambitious goal of Paris Agreement 2015 aims to limit the global rise of temperature to 2 °C (United Nations 2015). To achieve this goal, a substantial and sustained reduction of greenhouse gases (GHG) emission is required. According to fourth assessment report of Intergovernmental Panel on Climate Change (IPCC), building

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sector has the highest potential to reduce these emissions (IPCC 2014) since buildings account for 40% of the global energy consumption and contribute over 30% of the carbon dioxide emissions (Costa et al. 2013; Yang et al. 2014). A significant amount of building energy is used to maintain indoor thermal comfort and thus it is imperative to study how buildings can achieve thermally acceptable environment while reducing the carbon cost. This study aims at exploring the influence of occupant behaviour on thermal comfort improvements within the low-income group (LIG) housing. It is important to study the LIG housing segment, specifically that of the energy-intensive developing countries of Asia where considerable affordable housing stock is yet to be built (Un-Habitat 2011).

The occupants of the low income group (LIG) dwellings mainly rely on low-energy or passive measures for achieving thermal comfort. Thermal adaptation plays a significant role in determining occupant comfort in LIG dwellings, where the adaptive actions are often dictated by the socio-cultural, economic and contextual factors (Malik and Bardhan 2020). This study intends to integrate the comfort-related occupant behaviour for assessing thermal comfort. The key objectives of this study are:

1. To understand occupant behaviour for seeking thermal comfort within the low-income group (LIG) households.
2. To investigate the potential of adaptive actions in thermal comfort improvements.

The emphasis of this work lies on the adaptive actions for thermal comfort in mixed-mode low-income residential buildings located in the warm and humid climate of India. This study is limited to slum rehabilitation housing and takes into consideration the socio-cultural and economic aspects affecting adaptive comfort.

This study is the first-of-its-kind to examine the thermal environment in low-income dwellings through the reported occupant behaviour rather than relying on standardized occupant patterns. It adopts a contextualized simulation approach to assess thermal comfort environments. The broader goal of this work is to establish the role of occupant behaviour in thermal comfort domain. This would be helpful in predicting better comfort thereby enhancing occupant health and well-being, leading to improved quality of life and reducing building energy consumption for combating climate change.

5.2 Study Area

Slum rehabilitation housing (SRH) colonies of Mumbai were selected as the study area for this work. SRH are low-cost housing units provided free of cost to the slum dwellers under the slum rehabilitation scheme by the State Government of Maharashtra (Nijman 2008). These rehabilitation housing units are typically one-room with an area of 269 sq. ft. consisting of multi-purpose space and an integrated cooking area along with an attached toilet (Bardhan et al. 2015). The ground floor of SRH buildings is generally occupied by retail or community activities while the housing units are spread across the upper floors. SRH was envisioned by the government of Maharashtra as the solution to tackle the proliferation of slums and improve the living conditions of the occupants (Bardhan et al. 2015; Zhang 2018). However, previous researches have characterized these housing blocks as 'vertical slums' with hyper-dense occupancy and inadequate indoor environment (Nutkiewicz et al. 2018; Zhang 2018). Studies have also shown that the poor living conditions in SRH housing units pose a serious threat to the health, well-being and quality of life of the occupants (Bardhan and Debnath 2018; Bardhan and Jana 2018).

5.3 Research Methods

5.3.1 Household Survey

Two of the slum rehabilitation housing (SRH) colonies situated in Mumbai; India were selected for conducting household surveys as shown in Fig. 5.1. The households chosen for the survey were randomly stratified based on the floor location, orientation, condition of house and occupancy. One respondent from each of the selected household was interviewed, preferably the non-working adult member who spent most of the time in the housing unit. The respondents were screened based on the years of residency such that those living for more than a year were targeted for obtaining realistic comfort-related behaviour. A paper-based questionnaire survey method was employed to understand occupant behaviour and determine the frequently practised adaptive actions for thermal comfort. The survey process was administered in the month of February 2018 from 11:00 a.m. till 6:00 p.m. and the interviews were conducted in the Hindi language.

The occupants were questioned about the commonly practiced actions for improving thermal comfort, the restraining factors while adopting those actions, occupancy hours and the operating schedules for household equipment. The authors also carried out the in-situ measurements of physical parameters such as building dimensions and thermal conductivity of building envelope materials during the surveys.

5.3.2 Simulation Approach

A contextualised thermal modeling approach has been employed to simulate the adaptive occupant behaviour in one of the surveyed Slum Rehabilitation Housing (SRH) for assessing the thermal performance. The case study building selected for this work was an existing 6-storey SRH located in Mumbai, India built in 2005. The typical building floor arrangement comprised of thirteen units arranged in a linear

Fig. 5.1 **a** SRH locations selected for household survey. **b** Glimpses of selected locations. *Source* Authors

fashion around a double-loaded corridor with a common staircase. For the purpose of analysis, a housing unit situated on the second floor of the case study building was considered as illustrated in Fig. 5.2. The chosen unit, facing south-west, is representative of the worst-case scenario due to unfavorable orientation resulting in high solar heat gains.

The study building was modeled using OpenStudio2.4.1 SketchUp plug-in which allows for creating and editing the building models (OpenStudio 2015). Although this study is limited to a single representative housing unit, the entire building was modeled as per the actual dimensions and building materials obtained from the field survey. The thermal conductivity of the building envelope material was measured using Testo 653–2 thermohygrometer set (Testo, Lenzkirch, Germany) while the

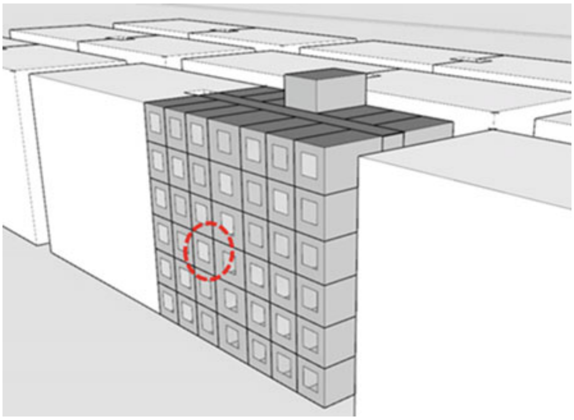

Fig. 5.2 3D view of the Open Studio model indicating the location of the selected housing unit for analysis. *Source* Authors

other building material properties were imported from the Indian database ‘Assembly U-factor Calculator Tool’ available at www.carbse.org/resource/tools (CARBSE 2019).

Each of the adaptive action determined from the household survey was considered as a distinct case for simulation. The simulation input parameters, as described in Table 5.1, were kept constant for all the simulation cases. Annual simulations were performed for each case with an hourly time step using *Energyplus v8.8*, a widely accepted building energy simulation engine because of its quick and accurate results (US Department of Energy 2010). The weather data file was imported from ISHRAE

Table 5.1 Input parameters for simulation

Parameter	Material	Thickness (in mm)	U-Value (W/m2-K)	Source
External Walls	Brick-kiln fired	200	1.8	As per actual
Roof	Concrete	150	3.6	CARBSE 2019 (CARBSE 2019)
Floor	Concrete	150	3.6	
Parameter	**Description**			**Source**
Household Size	Five			Household survey
Occupancy	Separate weekday and weekend occupancy schedule			
Lighting	Two T8 fluorescent light operational for 16 h a day (7:00 a.m. to 11:00 p.m.)			
Cooking	One LPG cookstove operational for 3.5 h a day			
Equipment	Television, Washing machine and Refrigerator (one each)			

Source Authors

for the city of Mumbai (Indian Society of Heating Refrigerating and Air Conditioning Engineers 2019). The output parameters were set to the hourly space averaged values of indoor air temperature, relative humidity and Fanger's Model of Predicted Mean Vote (PMV).

5.3.3 Thermal Comfort Assessment Method

A comfort assessment method has been developed to evaluate thermal comfort based on the simulated occupant behaviour within the case study building. "*Comfort hours*", *CH* was used as the quantifying metric which represented the number of comfortable hours within the housing unit out of the annual 8760 hours. Figure 5.3 illustrates the logical flow of the assessment method where simulation results in the form of PMV were used as the input.

Predicted Mean Vote (PMV) is a 7-point thermal sensation scale that predicts the votes of large groups of persons and varies from +3 when feeling hot to −3 indicating cold sensation (International Organization for Standardization 2005). The first step involved the extraction of hourly PMV values for the chosen housing unit from the building simulation results.

The next step comprised of the adjustment of the PMV values, which was initially developed for air-conditioned spaces, acceptable for mixed-mode buildings through a suitable modification factor (Linden et al. 2008). Literature suggests that an expectancy factor of 0.7 is suitable for residential buildings located in warm and humid climate with few air-conditioned buildings to sidestep the under prediction

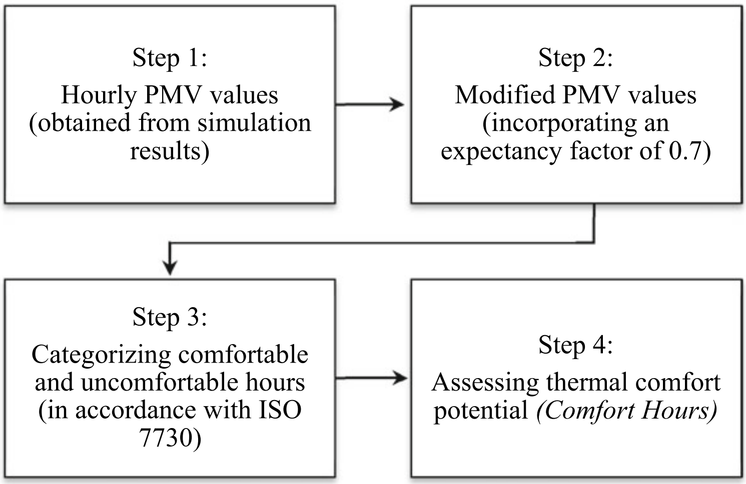

Fig. 5.3 Thermal comfort assessment method. Source Authors

of PMV (Fanger and Toftum 2002). The modified PMV values, referred henceforth as mPMV, were then assessed for calculating comfortable hours in accordance with the international standard ISO 7730 (International Organization for Standardization 2005). The hourly mPMV values, ranging from −0.5 to +0.5, which are representative of the 90% thermal acceptability, were considered in the comfort range.

The corresponding hour was considered as comfortable while the rest were treated as uncomfortable. *"Comfort Hours"* (CH) was then calculated as the sum total of comfortable hours within a year. The assessment procedure was repeated for each of the simulated cases. The resultant *Comfort Hours*, a surrogate to the degree of thermal comfort, were then compared to assess the potential of each case i.e. the adaptive action in thermal comfort improvement.

5.4 Results and Discussion

5.4.1 Selection of Commonly Practiced Adaptive Actions for Thermal Comfort

The survey responses were analyzed using the statistical package IBM SPSS v24 to identify the frequently practiced adaptive actions for thermal comfort (George and Mallery 2003). A total of 65 households participated in the survey of which 43 valid survey forms were obtained. The demographic characteristics of the respondents are presented in Fig. 5.4. The age of the respondents ranged from 16 to 70 years with a majority of respondents belonging to the 26–40 years' cohort. About 66% of the surveyed respondents consisted of female members since females were the non-working adult members in a majority of households who spent most of their time inside the housing unit. The average household size was found to be 4.78 and the occupancy responses revealed that the housing units were occupied by at least one member at all times.

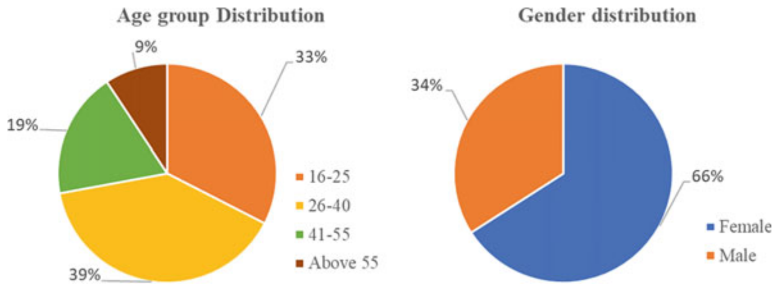

Fig. 5.4 Demographic characteristics of respondents. *Source* Authors

The respondents were asked to select the frequently practiced actions from a list of fifteen thermal comfort-related adaptive measures. The list was prepared from the previous works focusing on the adaptive actions for thermal comfort in similar climate conditions (Indraganti 2010a; Rajasekar and Ramachandraiah 2010; Manu et al. 2016). Adaptive actions related to the use of environmental controls such as the opening of windows or doors, use of ceiling fans or exhaust fans and the passive measures such as roof wetting, use of plants etc. were considered. The responses revealed that most common actions adopted by the occupants were the use of ceiling fans and opening of windows. Opening of doors was also found to be frequently practiced. However, it was associated with the issues of security and privacy during the night. The dense arrangement of SRH units with a building-to-building distance of 3 m further restricted the opening of doors or windows attributable to contextual issues of noise, dust and bad odour. Other commonly practiced measures included the use of exhaust fans, plants near windows and window curtains to avoid direct solar heat gains. Energy-intensive measures such as the use of air-conditioners or evaporative coolers were limited to only 6.9% of the surveyed household owing to the affordability constraints. The respondents further reported lack of information, associated capital cost, socio-cultural practices and unhygienic building surroundings as the major factors restricting the adoption of effective actions for thermal comfort. Figure 5.5 demonstrates the adaptive actions identified from the survey responses and the percentage share of households practicing those actions.

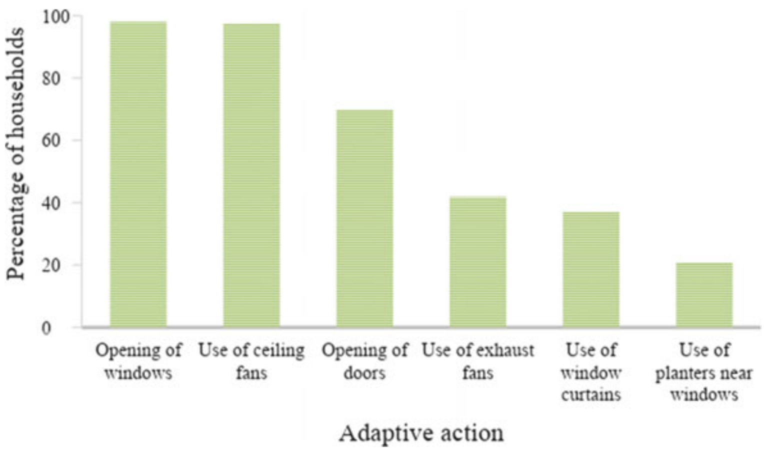

Fig. 5.5 Adaptive actions identified from the survey. *Source* Authors

5.4.2 Development of Cases for Simulation

Each of the six adaptive actions identified from the household survey was developed as distinct cases for simulation. Opening of windows, being the most frequently practiced action and associated with zero energy usage, was treated as the base case, C_{bc}. The other five actions, referred as Case 1 (C_1) to Case 5 (C_5) were simulated in combination with the opening of windows to assess the potential of each adaptive action with respect to the base case scenario. The operational hours, material specifications and other related aspects, as identified and observed during the survey, were considered to develop each case. The particulars of all the cases in order of frequency of practice are presented below:

i. Opening of windows, base case (C_{bc}): 70% of the window area was kept open either at the time of cooking or when the indoor temperature exceeded the temperature set point of 26 degrees Celsius. The temperature set point was determined from the previous studies in similar context for residential buildings (Indraganti 2010b; Rajasekar and Ramachandraiah 2010; Kubota et al. 2018).
ii. Use of ceiling fans, case 1 (C_1): A ceiling fan was operational throughout the day, as identified from the survey, resulting in an average air velocity of 0.7 m/s (Verma et al. 2018).
iii. Opening or closing of doors, case 2 (C_2): 70% of the door area was kept open throughout the day to allow the exchange of air across the corridor. During the night, the doors were kept close owing to the security concerns.
iv. Use of exhaust fans, case 3 (C_3): An exhaust fan with a maximum flow of 60 l/s was operational for 3.5 hours a day during the time of cooking (Nix et al. 2015).
v. Use of window curtains, case 4 (C_4): Window curtains having a solar transmittance of 0.05, solar reflectance of 0.3 and material conductivity of 0.1 W/m–K made out of polyester fabric were drawn when the incident solar gain exceeded the value of 0.7.
vi. Use of plants near windows, case 5 (C_5): 600 mm high plant assembly (leaf, air gap, water vapour) with thermal conductivity of 18 W/m–K were positioned at the window sill level (Yoshimi and Altan 2011).

5.4.3 Thermal Comfort Assessment

The simulation results for the case study unit were analyzed in two stages. Firstly, an investigation of indoor air temperature for the base-case was carried out to understand the thermal environment which would be compared with the other cases. The second step involved the evaluation of thermal comfort potential of each case with respect to the base-case scenario. Figure 5.6 depicts the hourly simulated indoor temperature for the selected housing unit under the base case scenario. It is apparent that the indoor temperature fluctuated between 23 °C in the winter months of December, January and February to 42 °C in the summer months of April, May and June.

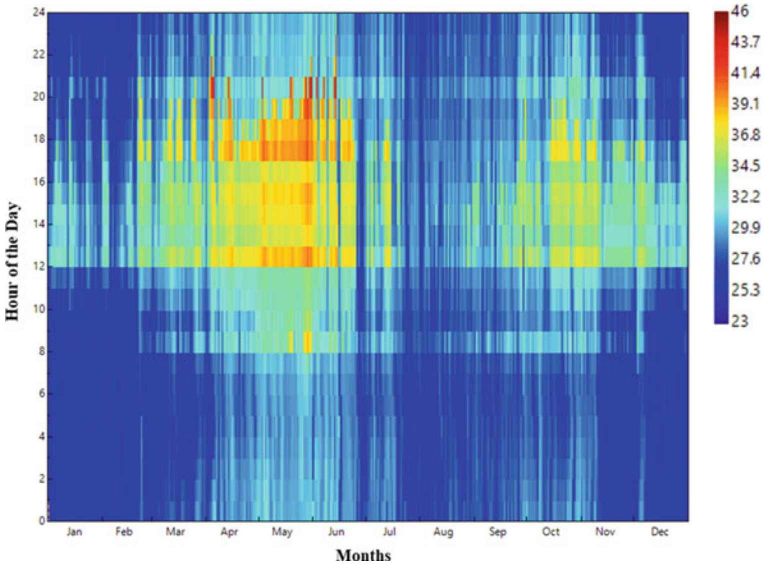

Fig. 5.6 Simulated indoor temperature for the base case, C_{bc}. *Source* Authors

Findings from previous research in a similar context suggest that the occupant's comfort temperature band for the warm and humid climate within Indian residences is in range of 26–32 °C (Indraganti 2010b; Rajasekar and Ramachandraiah 2010). Thus, it could be concluded from Fig. 5.6 that the most uncomfortable time of the day was from 12 noon till 8:00 p.m. when the temperature was above 32 °C for most of the months. However, for assessing thermal comfort a comprehensive approach, not limited to indoor temperature, involving all the environmental and personal variables is required. Hence, the next section elucidates the thermal comfort assessment based on Fanger's PMV model for all the representative cases.

In this stage of analysis, thermal comfort potential in terms of *Comfort Hours*, CH was calculated for all the simulated cases. The evaluation was done based on the systematic process as explained in Sect. 5.3.3. A relative assessment with respect to the base case was then carried out to understand the effective adaptive actions contributing to thermal comfort in low-income housing. Figure 5.7 demonstrates the seasonal and annual CH values for the base-case and the five developed cases. The simulation results yielded CH in range of 1443 for the base-case to 3011 for case 1 (use of ceiling fans) indicating significant variation in comfort levels among the cases. The seasonal CH values for all the cases indicate that the summer (March to May) and monsoon (June to September) months were the least comfortable months while the winter (December, January and February) months were the most comfortable ones. The base-case simulation witnessed that the occupants were comfortable for only 16.5% of the year. The most uncomfortable season was found to be the monsoon, with humidity levels as high as 99%. The use of ceiling fans, case 1, was attributed with the highest comfort potential having an annual CH value of 3011. Ceiling fans

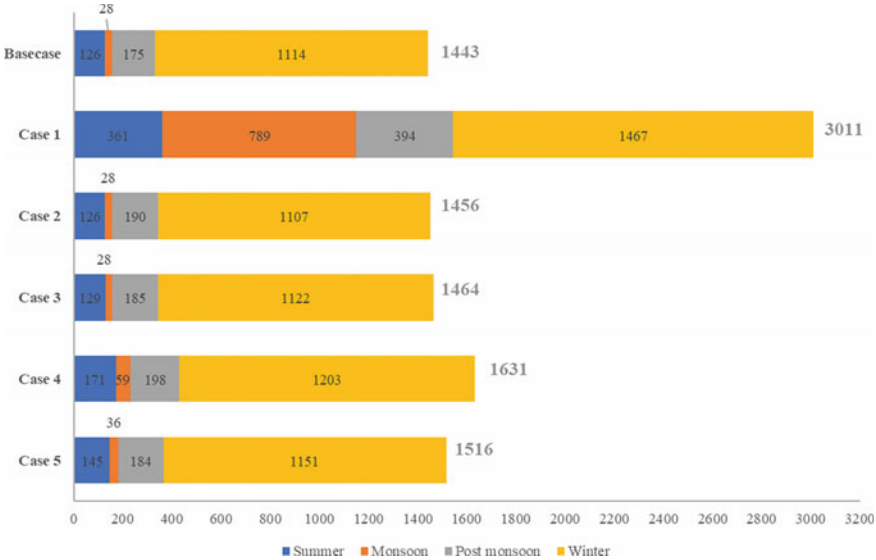

Fig. 5.7 Annual comfort hours for different cases (adaptive actions). *Source* Authors

aid in improving comfort sensation through the increase in air velocity and hence it proved to be beneficial particularly in the summer and monsoon months. About 34.3% time of the year was found to be comfortable with the use of ceiling fans, and a considerable improvement for the monsoon months, with an additional 761 CH, was witnessed as compared to the base-case. Case 2, the opening of doors during the daytime had annual CH value of 1456 and contributed least to thermal comfort improvement in the case study unit. There was no significant increase (0.2%) in thermal comfort levels by adopting this case as compared to the base case. This was possibly because the building layout did not aid in improving the indoor thermal environment within the unit. The housing units were arranged such that external doors opened onto a double-loaded corridor with window openings at the ends leading to insufficient ventilation.

The use of exhaust fan during cooking, Case 3 also had minimal impact on thermal comfort level and demonstrated 16.7% of the year as comfortable. This action demonstrated little improvement in PMV for the reason that the exhaust fans were modelled in combination with the opening of windows and the heat generated by the cooking activity could have been dealt to a considerable extent only by the opening of windows. Better results could have been obtained if the occupants' practice of operating exhaust fans was not restricted to the cooking periods. The use of curtains for blocking solar heat gain, as modelled in case 4, proved to be effectual for the south-west facing unit especially in the months of summer and post-monsoon (October and November). This adaptive action resulted in 18.4% of the year as thermally comfortable and proved to be advantageous because of its zero-energy use.

The last case, Case 5 incorporated the use of plants near windows and had a considerable effect in enhancing thermal comfort with an annual CH value of 1516. When compared with the base-case, though this adaptive action had no significant change in comfort levels in the monsoon and post-monsoon seasons, but yielded beneficial results for the summer and winter months. About 17.3% time of the year was found to be comfortable through the use of plants near windows.

The results demonstrate that though the LIG housing is thermally uncomfortable for a larger period (7327 h) of time throughout the year, adaptive actions do improve their thermal environment from 16.5% to 34.3%. It is interesting to note that relatively lesser adopted actions, use of plants near windows (C_5) and use of window curtains (C_4), have a greater impact on improving thermal comfort than the frequently adopted actions such as the opening of doors (C_2) or the use of exhaust fans (C_3).

The potential constraints in adopting these effective actions such as lack of information, unhygienic surroundings or the associated capital cost could be alleviated by the government interventions in form of awareness campaigns, periodical assessment of surroundings and subsidized products. Additionally, the findings suggest that occupants' interaction with the buildings, not only in terms of the availability or adoption of a particular adaptive action but also in the way they are operated, coupled with the socio-cultural and economic constraints determine the indoor thermal environment.

This study also throws light upon the building characteristics such as orientation and the building layout which influence the effectiveness of the adaptive actions and could play a pivotal role in selecting the adaptive actions for implementation. The adaptive actions in consideration, requiring minimal energy, not only increase the comfort levels of the occupants but could also aid in reducing their economic burden of shifting to energy-intensive cooling devices. While this study examines the individual effects of each case or the adaptive action, but in practice, the occupants may possibly adopt a combination of such actions which would further improve thermal comfort leading to better health, well-being and productivity of the occupants.

5.5 Conclusion

This study aimed at investigating comfort-related occupant behaviour through a contextualized simulation approach in low-income dwellings, particularly for the case of slum rehabilitation housing of Mumbai. Six frequently practiced adaptive actions, identified from a transverse survey, were translated as an input for building simulation. The thermal comfort potential of each adaptive action was investigated through a thermal comfort assessment method involving *"Comfort Hours"* as the evaluation metric. The results revealed that the adaptive actions, requiring zero or minimal amount of energy, could improve thermal comfort in the case study unit by up to 18%, from 16.5% to 34.3%. Further, the significance of less frequently adopted actions such as the use of plants and the use of curtains in achieving thermal comfort was also recognized. In addition, this work provided quantitative insights about the contextual factors which restrict the implementation of effective adaptive actions in the subject dwellings. The possible limitations of this study were related to the scale of analysis and the cases developed for simulation. A single housing unit was taken as the case study however, analyzing multiple units could have improved the results. The other limitation was that each simulation considered the dual effects of the base-case and the adaptive action in consideration whereas in practice an occupant may adopt multiple measures simultaneously. This work aids in establishing the role of occupant behaviour in low-income housing within the thermal comfort domain. The study, limited to warm and humid climate zone, could be extended to other zones and building typologies. This work paves way for the incorporation of stochastic occupant behaviour in thermal comfort studies to reduce building energy consumption and improve occupant comfort.

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Chapter 6
Sustainable Infrastructure Planning by Using Carrying Capacity Assessment in Gwalior City

Jayeshkumar Maheshkumar Bhagwat and Varuvel Devadas

Abstract Cities are the engines of economic growth. The world population is getting concentrated in urban areas across the globe. In the year 2015, 54% of the population lived in urban areas, which contributed to 80% of the world's gross domestic product. It is a challenging task for planners to manage the urban system with the available resource constraints. The urban system has a certain carrying capacity to accommodate the population. Quality of life decreases due to increase in population in the urban system when it reaches beyond the carrying capacity. Carrying capacity assessment plays an important role in developing the urban system in a planned manner by restricting the growth in areas, where the carrying capacity had already reached. It is important to look forward to the carrying capacity assessment from a land use planning perspective to ensure integration of land use, infrastructure, and the carrying capacity. In this paper, an attempt is made to assess the infrastructure carrying capacity of Gwalior city, Madhya Pradesh, India by using Sustainable Accommodation through Feedback Evaluation—'SAFE' model, developed by the Indian Institute of Technology, Guwahati. In this approach, the land requirement for various uses in the urban system is considered. The carrying capacity is assessed based on the land requirement. GIS technique is used to make the necessary assessment of the carrying capacity of the system (the study area).

Keywords Carrying capacity · 'SAFE' approach · Urban infrastructure · Quality of life · Sustainable city · Urban infrastructure

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6.1 Introduction

Infrastructure is an important determinant for maintaining a desirable quality of life in an urban system. Carrying capacity helps in the assessment of the population that a particular urban system could sustain for a particular set of resources. The land is a limited resource. In this work, the land is used to assess the carrying capacity considering infrastructure as an important determinant. The work concentrates on the assessment of the existing carrying capacity based on the land-use in the city of Gwalior for the year 2017. The areas used for infrastructure in the city are accounted for the assessment. The 'SAFE' approach, proposed by the Indian Institute of Technology, Guwahati, is used for the said purpose. This includes delineation of the city based on the watersheds and ultimately making the assessment of carrying capacity based on each watershed considering the land under various infrastructure. The population that could be effectively carried will be ultimately determined.

6.1.1 Carrying Capacity and Infrastructure Planning

Carrying capacity concept evolved from the field of ecology. It is developed by Thomas Malthus in the year 1798. He stated that the earth can hold only a certain amount of population. This was an important intervention in the field of planning the ecology (Sarma 2012). Scholars from various fields redefined and used this concept in their own areas of research. The limit to which the size of the population is acceptable is termed as carrying capacity (Price 1999). The definitions vary but the central idea is the maximum population a particular area can attain (Ehrlich 1991; Catton 1981). All these discussions about the basic concepts of carrying capacity developed awareness among the researchers and policymakers to think about limiting population on the planet earth. Various ideas were developed to take care of the population increases in various parts of the world. The concept of carrying capacity has a single meaning with multiple connotations. Tourism carrying capacity (O'Reilly 1986), ecological carrying capacity (Wang 2010), water resources carrying capacity (Song 2011), social carrying capacity (Graefe 1984) are some of the connotations. The urban carrying capacity is one such connotation, this deals with the number of people in an urban system could carry and maintain the desired level of quality of life. The work done by the IIT Guwahati had produced the following graph related to the concept pertaining to carrying capacity (Fig. 6.1).

The graph shows two variables namely time (T) and population (N). Carrying capacity is the stable population for all time period. The degraded carrying capacity is a result of a decrease in resources in the urban system. The enhanced carrying capacity is a result of the various mechanisms followed in an urban system to overcome the limitations arising as a result of resource depletion. Population overshooting is a result of the sudden growth of resources in the urban system, for example industrial

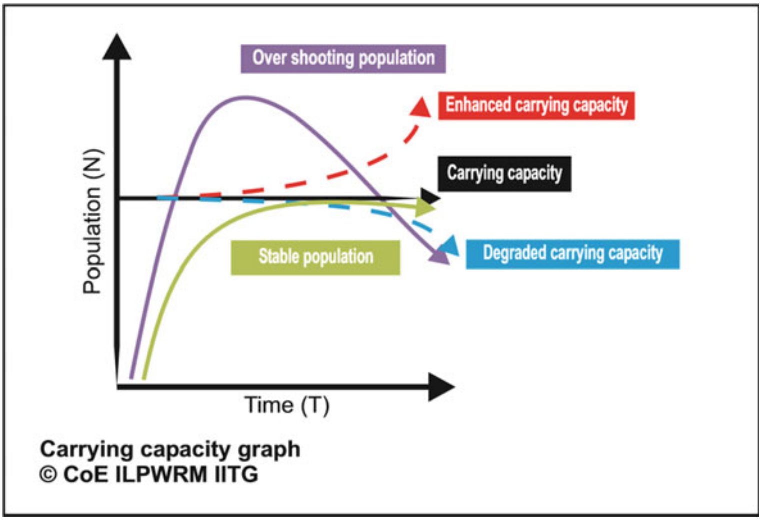

Fig. 6.1 Graph showing the relation between population rise and carrying capacity. *Source* Sarma (2012)

development. A stable population is an ideal growth of population, proportionate to the available amount of resources.

Infrastructure development is one of the important indicators of economic development in any city. Sustainability in infrastructure planning will play an important role in making the cities socially, economically, and environmentally inclusive. Infrastructure planning could be achieved sustainably only by accounting the carrying capacity of the urban system.

6.1.2 Carrying Capacity and Sustainable Development

Sustainable development is the prime concern of world leaders. The sustainable development goals set by the United Nations provide insights into the various components associated with achieving sustainable development. Goal eleven (SDG 11) deals with making cities and human settlements inclusive, safe, resilient and sustainable. The number of peoples living in informal settlements is increasing. The land under urban areas is increasing. Cities are becoming less dense and sprawl is increasing. The urban issues like pollution are attaining major threat to the ecosystem. The assessment of carrying capacity will play an important role in achieving this goal of the United Nations (Guterres 2017). Carrying capacity based operational framework would help in reaching the goal of sustainable development. The equitable quality of life of the people will be enhanced by upholding the ecological balance, minimize environmental degradation by maintaining socio-economic development.

Carrying capacity based sustainable development approach will help in a comprehensive understanding of the potential resources and optimal allocation of resource to gain the benefits of sustainable development (Khanna 1999).

There is a limit for the available resources in human civilization. It is important to understand this overpopulation and associated crisis. The centralization of resources and market-driven economic policies have created ecological challenges. The co-existence of nature and society is becoming a fiction than a fact. It is important in relation to sustainable development with carrying capacity in order to accelerate the co-existence between nature and society. The problems of the human civilization will be solved only by the conceptualization of carrying capacity based sustainable development approach (Victor 2009). Supply of additional per capita resources in the ecosystem, enhance the carrying capacity of a short term. This approach is not sustainable to plan the ecosystem. The developing countries have paid the least attention towards making policies to maintain the balance between available resources and population (Mahar 1985). The shortage of land resource and the availability of sufficient food grains is an important concern in human societies. Carrying capacity is assessed by various names like environmental, regional, ecological. All of these are comprehensive carrying capacity. Carrying capacity concept has a century-old history of progress and evolution. The important question is to mainstream the concept in the policy spectrum of human society (Tian 2013). Thus, carrying capacity and sustainable development are closely associated, both the concepts, if combined can help in formulating a better quality of life in the urban system.

6.1.3 Gwalior City

The historical city of Gwalior is an important primate settlement of Northern part of Madhya Pradesh. The city is located 320 km South of New Delhi, the national capital of India. The average temperatures in summer and winter are 31 °C and 15.1 °C respectively. Swarnarekha and Morar are the two rivers flowing through the city. Gwalior city is 39th most populous city of India and fourth in the state of Madhya Pradesh. The population of Gwalior was 1,069,000 people in 2011 and 1,375,000 people in 2017 (Census, 2015) (SPA, 2017).

6.2 Literature Review

Carrying capacity assessment is carried out by employing various approaches. It is important to understand these approaches and adopt the practically implementable approach for mainstreaming carrying capacity based sustainable infrastructure planning in Indian cities.

The development density of Seoul in the Republic of Korea was determined by using carrying capacity. Integration of urban management goals, area of concern, and urban management indicators were employed to perform an integrated urban carrying capacity assessment. The factors to assess carrying capacity were determined. An urban carrying capacity assessment system was developed by using various modules. The decision support by using GIS is the unique selling point of this assessment. Public perception is unaccounted in this approach, and this is one of the limitations of said approach (Oh 2005).

An empirical approach to assess the carrying capacity for sustainable urban development is developed by the researchers in the case study of Tokyo, Japan. In this quantitative approach, level of services combined with a prediction of the employee and living population was used. The capacity of urban facilities and services like water supply, sewerage, waste, railway capacity, road, housing, and air pollution were accounted for. The predicted living and employee population were related to the level of facilities and services. The resulting capacity was employed for the sustainable development of the city of Tokyo. Decentralization and management of business growth are the two major recommendations from this approach (Onishi 1994).

Social carrying capacity assessment approach is primarily based on social and economic models. A group of researchers tried to extend the scope towards environmental models. It was observed that the carrying capacity assessment is limited to the economic point of view (Wei 2016). The approach neglects the environmental impact due to changing resources consumption led by changing lifestyle (Summer 2004). The emphasis of environmental carrying capacity approach is to use the resource consumption driven environmental impacts to determine population limit. In environmental carrying capacity-based approaches the land resource required for a population is considered to determine the carrying capacity (Bicknell 1998). A group of researchers focused on environmental impact rather than resource availability in the process to assess the carrying capacity (Graymore 2010). A certain group of researchers used water, food, and energy within a definite land area to derive the carrying capacity (Cohen 1995). This approach, thus focuses on resource availability than on the environmental impact of population.

Sustainable Accommodation through Feedback Evaluation 'SAFE' carrying capacity approach is favorable for eco-sensitive areas. This approach was first applied in the hilly area of Guwahati city, in the Indian state of Assam. This approach could also be applied to any other urban area. Researchers have applied his approach to assessing the carrying capacity of Patna city in the Indian state of Bihar (Kumar 2017). In this approach, the ecological footprint is used to determine the sustainable carrying capacity of a watershed or group of watersheds covering the urban area under consideration. This approach finally accommodates a sustainable population, the method is denoted as 'SAFE'—"Sustainable Accommodation through Feedback Evaluation" (Sarma 2012).

6.3 Method and Calculation

Assessment of carrying capacity based on Sustainable Accommodation through Feedback Evaluation 'SAFE' approach. The approach employed for this work is discussed as follows:

Step 1: Delineation of the urban watershed: In this step, the watersheds are delineated by using tools like GIS. The delineated watershed is shown in Fig. 6.2.

Step 2: Demarcation of the developable & non-developable area: The city consists of both developable areas & areas having less scope (unsuitable) for development, i.e. non-developable areas. In this step, the non-developable areas of the delineated region are demarcated by using the latest geospatial tools. The non-developable areas mainly consist of land which was identified by the overlay method. Equal weight was assigned to six different parameters namely groundwater table, agricultural land use, land used under forest, proximity to an urban area, slope, and drainage (SPA, 2017). The usable areas with respect to various developmental activities can be identified.

$$\text{So,} \quad \text{AU} = \text{AD} + \text{AND} \tag{6.1}$$

$$\text{Therefore,} \quad \text{AD} = \text{AU} - \text{AND} \tag{6.2}$$

where

AU is the Total area available for development,
AD is the Area Suitable for development, and
AND Area not suitable for development.

Step 3: Determination of area required for different infrastructure and facilities (ADIF):

$$\text{ADIF} = \text{AIF} + \text{AR} \tag{6.3}$$

where

AIF is the area for infrastructure development, and
AR is the area for residential requirements.

Step 4: Calculation of the available residential area:

The net residential area available for settlement development can be calculated by using the following equation:

$$\text{From (1) \& (3) AU} = \text{AND} + \text{AIF} + \text{AR}$$
$$\text{Therefore,} \quad \text{AR} = \text{AU} - (\text{AND} + \text{AIF})$$

where

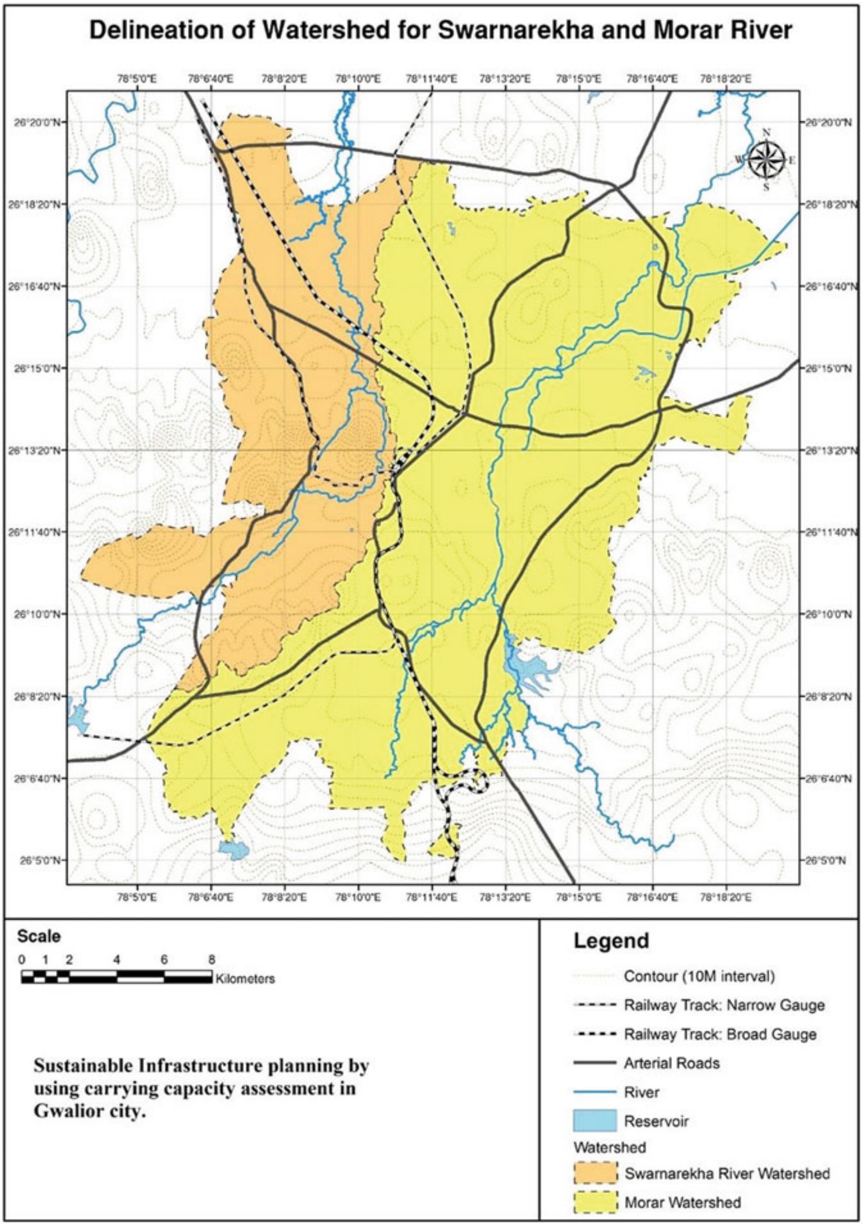

Fig. 6.2 Delineation of the watershed for Swarnarekha and Morar rivers. *Source* SPA (2017)

AU is the Total area available for development,
AD is the Area Suitable for development, and
AND Area not suitable for development.

Step 5: Socio-economic survey of the urban region & calculation of the floor area requirement per head:

A socio-economic survey is expected to be employed in order to determine the floor area required per head. The use of national level floor area standard values is considered. Analysis of the socio-economic status of the present population and considering the future prospects of an average floor area requirement is being considered as 0.002 ha per head (Sarma 2012).

Step 6: Determination of the Floor Area Ratio: Floor Area Ratio is defined as follows

$$\text{FAR} = \text{AF}/\text{AP}$$

where

FAR is the Floor Area Ratio,
AF is the total floor area, and
AP is the area of the plot.

FAR need to be determined by considering various aspects. The proposed 'SAFE' method itself will determine an acceptable FAR, one needs to provide an initial value of FAR. This value can be adopted from guidelines provided by the different organizations like the urban local bodies. In this case, we consider the FAR as 125 or FSI as 1.25, the permissible value for the city of Gwalior (Figs. 6.3 and 6.4).

Step 7: Calculation of carrying capacity: Based on the overall study, the carrying capacity of the area with respect to urban development can be calculated by using the following equation:

$$\text{CC} = \text{AU} - (\text{AND} + \text{AIF}) \times \text{FAR}/\text{S}$$

where S is the Floor area requirement per head. In this work, we consider 0.002 ha per head (Sarma 2012). The values of the area are in all above formulae are in hectares.

The area suitable for development (AD) in Swarnarekha and Morar watersheds within the city limit is calculated. The area not suitable for development (AND) is determined. The permissible FAR, in the city of Gwalior allotted by the municipal corporation is used for further calculations. The floor area required per head (S) is adapted from the research earlier carried conducted to develop the 'SAFE' approach (Sarma 2012). The total infrastructure includes the area used for physical, social, business and commercial activities in the city. The residential area in the city for Swarnarekha and Morar watershed is determined, refer to Table 6.1 (Table 6.2).

The carrying capacity for the area suitable for development in the city of Gwalior by employing 'SAFE' approach is 141,744 in the year 2017.

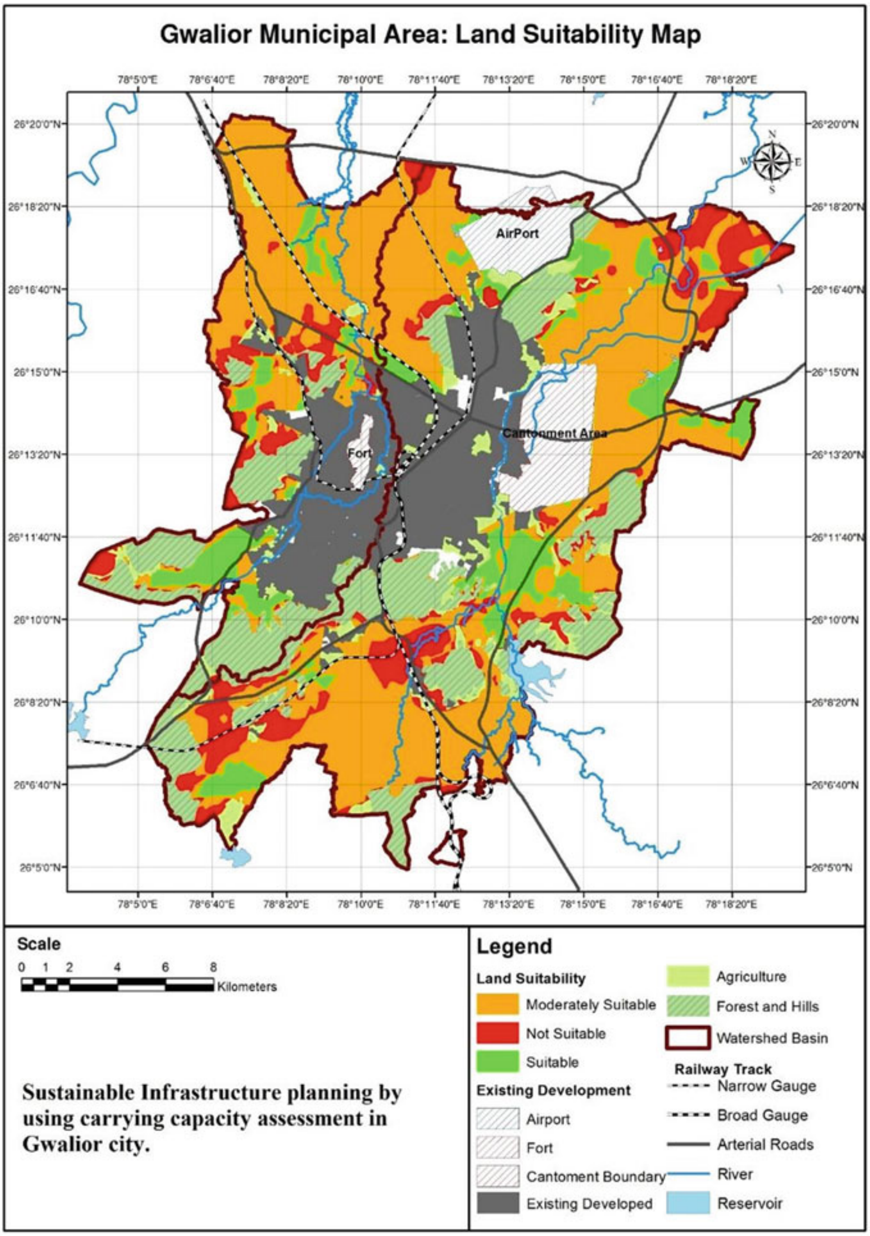

Fig. 6.3 Gwalior Municipal Area: Land Suitability Map. *Source* SPA (2017)

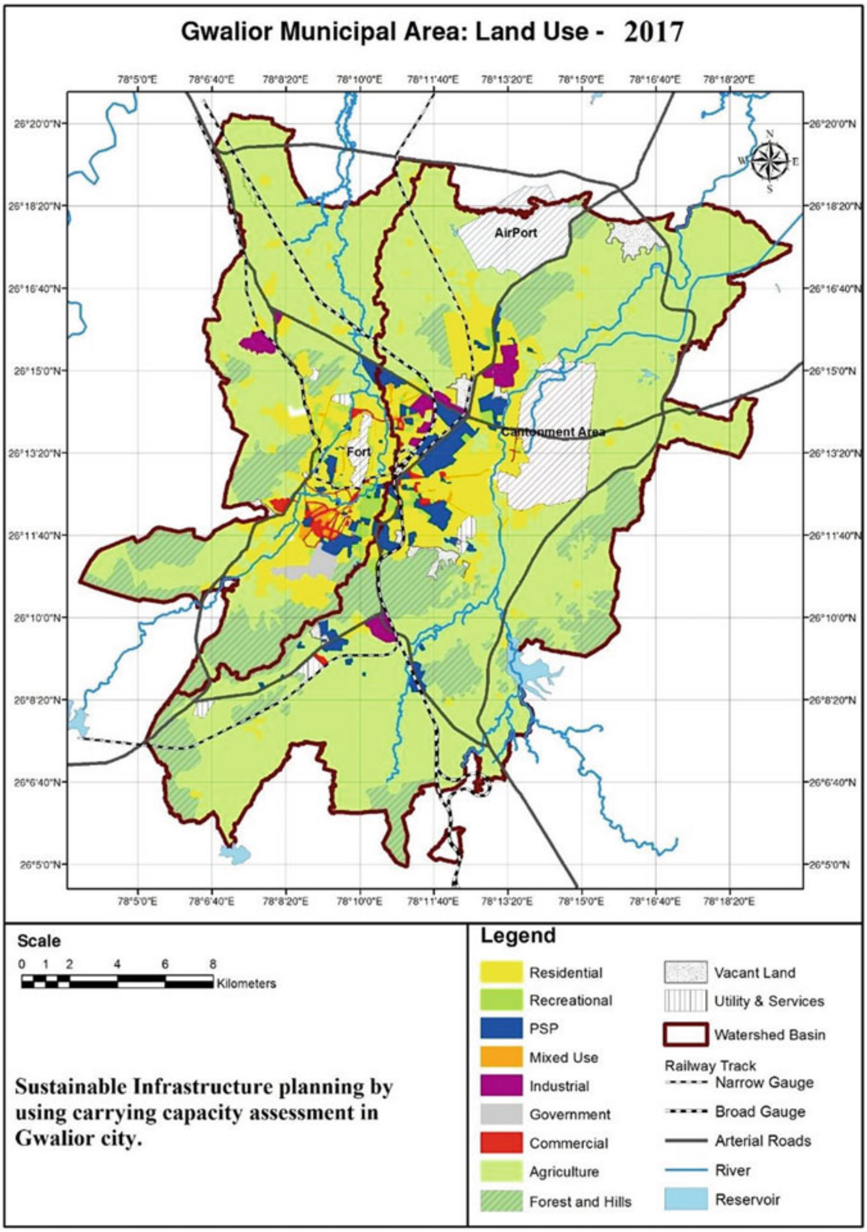

Fig. 6.4 Gwalior Municipal Area: Land Use—2017. *Source* SPA (2017)

Table 6.1 Land used for various Infrastructure in Gwalior

Description	Notation	Area (km^2)	
		Swarnarekha	Morar
Area of watershed suitable for development	AD	55.28	125.72
Area not suitable for development	AND	17.34	38.21
Floor area ratio	FAR	125	125
Floor area requirement per head	S	0.00002	0.00002
Infrastructure (includes physical, social, business and commercial)			
1. Physical infrastructure (includes water supply, sewage management, solid waste management, power supply, transportation, and mobility)		0.76	1.58
2. Social infrastructure (includes education, health, government offices, recreation parks, playgrounds, socio-cultural facilities, communication post & telecom, milk booth, fire stations, and open spaces)		2.54	8.67
3. Business and commerce		1.89	0.85
Total infrastructure area	AIF	5.20	11.11
Total residential area	AR	20.64	24.90

Source Authors

6.4 Result and Discussion

The population of Gwalior in the year 2017 was 1,375,000. The population as per the 'SAFE' approach employed for the purpose of assessment of carrying capacity is 141,000 persons. In India, access to infrastructure is decreasing due to various social, cultural, and economic constraints. The government of India is making efforts in improvisation of accessibility of infrastructure to the masses in the urban as well as rural settlements. The government interventions like Smart City Mission, Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Housing for All by 2022 mission, Heritage City Development and Augmentation Yojana (HRIDAY), Jawaharlal Nehru National Urban Renewal Mission (JNNURM), Swachh Bharat Mission (SBM), etc., are implemented to make infrastructural provisions in Indian urban system (MoHUA 2018). In the context of the rural system, Pradhan Mantri Gram Sadak Yojana, Sarv Shiksha Abhiyan, Sansad Adarsh Gram Yojana (SAGY) are implemented (MoRD 2018). The infrastructure provisions required in urban and rural India is found to be inadequate (FICCI 2011). It is an alarming circumstance, in the planning of infrastructure in Indian cities. Planning the infrastructure by using a sustainable approach can enhance the quality of life. The carrying capacity assessment by employing 'SAFE' approach proposed by Indian Institute of Technology, Guwahati could play a leading role in this regard.

A settlement has a capacity to carry the people who reside in that settlement. It is important for developing countries like India, to develop policy mechanisms which can incorporate the carrying capacity approach to plan cities. Mainstreaming such

Table 6.2 Carrying capacity assessment in Gwalior city for Swarnarekha and Morar Watershed

Description	Notation	Swarnarekha watershed		Morar watershed	
		In km^2	In Ha	In km^2	In Ha
Total Area available for development	AU	72.62	7262.46	163.94	16,394.66
Area suitable for development	AD	55.28	5528.45	125.73	12,572.93
Area not suitable for development	AND	17.34	1734.00	38.21	3821.726
Total Area available for development	AU	72.62	7262.46	163.94	16,394.66
Available residential area	AR	20.64	2064.99	24.90	2490.91
Area for Infrastructure Development	AIF	3.311	331.199	10.26	1026.11
Area required for different Infrastructure and facilities	ADIF	23.96	2396.19	35.17	3517.03
Net residential area available for development	ARN	51.97	5197.26	115.46	11,546.81
Floor Area Ratio	FAR	125			
Carrying capacity (number of persons)	CC	67,697		74,047	

Source Authors

approaches in the statutory documents like master plans and development plans can help to facilitate the quality of life in the urban settlement.

6.5 Conclusions

Urban infrastructure and land resource are key the determinants to assess the carrying capacity of a city. The quality of life is closely associated with the number of persons an urban system can carry. In cases where there are fewer resources and more persons the quality of life reduces. In the process of planning the cities by a sustainable carrying approach, capacity assessment can be a guiding path. In Indian cities due to the concentration of economic resources in the urban areas, there is a massive immigration. The cities are becoming poles of attraction for the population residing in rural areas. It is necessary to promote equity and equality for rural areas to reduce the pressure on resources in the urban system. The carrying capacity of Gwalior is inadequate with respect to the growth of population in the city. The city of Gwalior, which was once the capital of the Gwalior kingdom, has lost its glory. This city is presently acting like a primate city in the North-central region of India, due to lack of employment, education and other opportunities in the region. It is important for the city of Gwalior to rejuvenate, but the carrying capacity is not increased by making adequate provisions in the city and more importantly, replacing the old infrastructure provided by the Gwalior Kingdom. It is observed that most of the infrastructure, including social, physical, business and commercial was not developed since the Gwalior kingdom was annexed in India. It is the need of the day to accommodate the increase in population by making adequate provision for infrastructure based on such a carrying capacity approach. Thus, land-based sustainable infrastructure planning of Gwalior could help in improving the quality of life and planning sustainable infrastructure in the city.

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Chapter 7
Importance of Developing Guidelines for Built Environment of Anganwadis and Its Influence Towards Meeting Sustainable Development Goals

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Abstract The Indian government has the Integrated Child Development Scheme (ICDS) with a vision to improve the health and nutrition of children. In this connection the Anganwadi centers (AWC) were established with one such center for 800 population for the purpose of immunization, health check-ups, nutrition, health education and informal preschool education. According to a status report from 2015, there are totally 1.4 million (14 lakh) AWCs that are sanctioned and are operational and recently some negative observations were made towards the built environment of these centers relating to the poor lighting quality, thermal comfort, natural ventilation and construction methods adopted in these centers. The government has announced the upgradation of these centers, but in wake of inadequate guidelines for their design and construction, the built environment of these Anganwadis continues to be compromised. Due to the sheer scale of these projects and the impact with relation to UN Sustainable Development Goal (SDG) towards sustainable Cities and communities, it is essential to develop the guidelines by streamlining the design and construction processes of these centers. The design of built environment need to vary greatly depending on the regional climate. As a pilot project this research paper aims to highlight the importance of developing guidelines and policies towards the design and construction of the Anganwadi centers in the warm and humid climate of Karnataka and towards implementation of policies related to these centers at the national level.

Keywords Anganwadi · Environmental sustainability · Building energy simulation · Sustainable development goals · Warm and humid climate

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7.1 Introduction

According to Census of India 2011 data there are 164 million children in India who are aged between 0 to 6 years. Several constitutional and policy provisions have been made to uplift the quality of pre-primary programs. One of the examples for this is the 86th Amendment which was introduced as Article 45 for the various states to formulate a scheme called Early Childhood Care and Education Scheme- ECCE (Mohan and Singh 2008).

The Government of India launched the Integrated Child Development Scheme (ICDS) with a vision to improve the health and nutrition of children. In this connection, the Anganwadi centers (AWC) were established with one each for 800 population for the purpose of immunization, health check-ups, nutrition, health education and informal preschool education. Children below 6 years, pregnant and lactating mothers are the beneficiaries in the scheme.

According to a status report from 2015, there are totally 1.4 million (14 lakh) AWCs sanctioned in the country out of which 96% are operational. In the state of Karnataka, there are 64,558 AWCs which are operational and when the state government conducted unannounced visits to few of these centers many negative observations were made towards the built environment of these centers related to poor lighting quality, thermal comfort, natural ventilation and construction methods adopted in these centers (Awofeso and Rammohan 2011). The Government has announced the upgradation of these centers, but in wake of inadequate guidelines for their design and construction the built environment continues to be compromised.

The built environment has a significant impact on public health. The building industry is responsible for 30% of greenhouse gas emissions, generates large amounts of the waste and depletion of natural resources. The construction industry is an important focus area for the achievement of SDG by limiting environmental impacts.

In the design and construction of Anganwadi Centres more coordination of stakeholders is required to promote sustainable building practices. The quality of Anganwadi Centers is often overlooked as a major factor in a child's performance as these characteristics can also help or hinder the learning process. A research on built environment and public health (Lopez 2012) investigated how efficient designs can improve indoor environments. According to Fergus et al. (2012) both daylighting and thermal comfort are important criteria for indoor environment.

In 2015, the world set ambitious goals through the adoption of the Sustainable Development Goals (SDG) complemented by reaching a landmark international agreement on climate action at COP21 in Paris. It is important to turn that momentum into ground action to achieve the SDG, so that it can support inclusive growth, enhanced access to basic services, promote environmental sustainability, spur innovative design, promote material efficiency, thermal comfort and enhance indoor environment quality. The design and construction of Anganwadi Centers can contribute to meet the SDG.

As per 'SDG 3-Good health and wellbeing', sustainable Anganwadis can improve the health of the occupant. According to the research from the World Green Building

Council, the child centers with natural light and acceptable thermal comfort can increase the attendance of children. A recent Harvard study states that cognitive scores of kids spending time inside green buildings were 61% higher than those in conventional environments. ‘SDG 7-Affordable and clean energy’ states to ensure access to affordable renewable energy for all. Green Anganwadis can provide clean energy and as per the Indian Green Building Council (IGBC) can result in energy savings from 40 to 50% and water savings from 20 to 30% compared to conventional buildings. There are lots of advantages of these interventions as they will create jobs, decent workplace satisfaction and resilient infrastructure which would meet SDG 8 and SDG 9. SDG 13 calls for climate action through green buildings that produce fewer emissions helping in combating climate change. Sustainable AWC’s can meet SDG 17 through strong partnerships between the governments, communities and stakeholders towards building green construction.

As a pilot project this research paper investigates the built environment of existing Anganwadi centers and aims to highlight the importance of developing guidelines towards sustainable built environment of these Anganwadi Centers in the warm and humid climate of Karnataka.

7.2 Methodology

A study was carried out in 2017–2018 on existing Anganwadi Centres in coastal Karnataka to understand the design and construction practices adopted and to evaluate the indoor environment. The study revealed that most of these centres surveyed had total disregard for daylighting, ventilation and thermal comfort.

To understand the various aspects, an Anganwadi Centre in coastal Karnataka, India was taken for detailed analysis and demonstration. The demonstration Anganwadi Centre is located in Mangalore district, Karnataka.

The building is a single storey consisting of a veranda, classroom, kitchen and toilet. The study area falls under the identified warm and humid region and the location of the case study is a broad representative sample of this region. The reference baseline model was modelled as per the on-site physical built documentation. The simulation study was conducted using Design Builder as it uses validated energy plus simulation engine developed by department of energy, USA. The software, Energy plus has been validated under the comparative standard method of test for the evaluation of building energy analysis computer program BESTEST and ASHRAE Std 140. The results of field studies and simulation results have been analysed to study the indoor environment for heat balance, daylighting and thermal comfort.

Month	2002	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Outside Dry-Bulb Temperature (°C)	26.24	26.86	27.93	29.14	29.31	26.12	25.44	25.26	26.08	26.59	26.87	26.57
Outside Dew-Point Temperature (°C)	18.62	20.01	21.43	23.06	22.36	23.71	23.76	23.72	23.69	23.21	21.80	18.49
Wind Speed (m/s)	2.64	2.52	2.54	2.64	3.37	3.23	3.21	2.42	2.80	2.20	2.07	2.93
Wind Direction (°)	127.80	129.07	150.36	157.08	158.52	143.00	184.72	145.68	160.58	115.77	101.18	127.15
Solar Altitude (°)	-6.83	-4.82	-0.80	3.70	6.36	7.29	6.92	5.08	1.23	-3.32	-6.24	-7.28
Solar Azimuth (°)	179.22	176.41	174.27	176.07	179.99	173.54	172.63	173.63	176.95	179.28	179.99	179.96
Atmospheric Pressure (Pa)x10^3	100.69	100.89	100.49	100.42	100.54	100.16	100.16	100.54	100.16	100.62	100.87	100.91
Direct Normal Solar (kWh)	154.54	129.71	125.19	103.79	125.80	56.60	44.14	43.26	52.36	73.50	100.67	152.19
Diffuse Horizontal Solar (kWh)	50.37	57.40	77.77	90.32	87.23	92.24	96.14	95.09	93.84	84.22	63.07	49.97

Fig. 7.1 Climate data of the reference site location

7.3 Climate Study

The study location is in the warm and humid climatic location of Karnataka, India. This climatic zone gets intense solar radiation on clear days. During summers, the temperature can reach up to 30–35°C during the day and 25–30°C at night. In winter, the maximum temperature is between 25 and 30°C during the day and 20–25°C at night. The relative humidity is between 70 and 90% throughout the year (Nayak and Prajapati 2006; Kini et al. 2017). Precipitation is also high, being about 1200 mm per year. The wind is generally along the Southwest to Northeast direction with speeds ranging from extremely low to very high. The typical meteorological weather data for the reference site location is listed in Fig. 7.1.

The three main climatic elements characteristic of this climate are the temperature, the air humidity, and the air movement. These have an effect on the thermal comfort. The seasonal variation in temperature and humidity is small. The climatic data of the reference site location in the warm and humid climatic region are shown in Fig. 7.1. Case Studies of Anganwadi Centres were conducted in coastal Karnataka having warm and humid climate. The Anganwadi under study were located in Shirthady, Nellekaru and Ajjarkad in coastal Karnataka. The case studies were analyzed for their quality of the built environment considering spatial quality, indoor environmental quality and thermal comfort. The study found that all the Anganwadis in the Coastal Karnataka has total disregard for the climatic factors, daylighting and thermal comfort of the occupants.

7.4 Reference Building

The reference building is located in Mangalore district in Coastal Karnataka (Fig. 7.2) and is used for demonstration study purposes. The Anganwadi Centre is located on 404 m^2 land and operates as day care center for children from age (2–6) years. The building is a load bearing structure which consists of spaces arranged almost linearly. The entrance is through the semi open verandah and then to the classroom followed by the kitchen and toilet. The spaces in this Anganwadi are used for multi-functional activities.

Fig. 7.2 View of the Anganwadi chosen for reference study

The floor to floor height of the building is 3.2 m height and the window to wall ratio of the simulated Anganwadi space is 40% on north side, 20% on south, 0% on the west side and 20% on the east side. The north side of the classroom space is blocked because of the veranda. The windowsill height from finished floor level is 0.9 m. The floor plan of the Anganwadi is shown in Fig. 7.3.

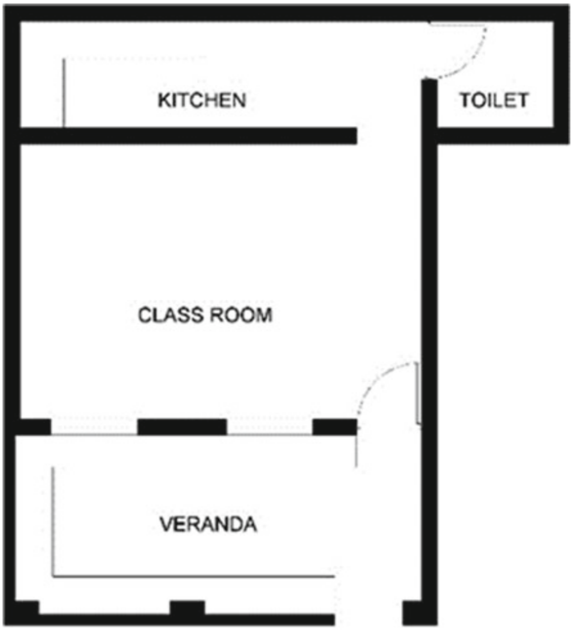


Fig. 7.3 Floor plan of the reference Anganwadi

The classroom is lit by only two windows, so children depend on artificial lighting for reading, writing and eating. As the Anganwadi doesn't have sky lights and proper placement of windows, it becomes difficult to have fresh air movement inside the building. The veranda is covered with PVC sheet; it attracts a lot of heat inside the building. The classroom occupant load is 25 children and a teacher who are cramped in 16 m^2 of space.

The following rooms are included in the Anganwadi with the veranda acting as semi open sit out area, teacher's cabin and place to leave the footwear. The Classroom is the main area where 25 children learn, eat and sleep. A small kitchen is used for preparing meals and storing the groceries.

The reference building details are listed in Table 7.1, the location coordinates are 13° 05′ 07.2″ N 75° 04′ 57.8″ E. The building floor plan is 9 m long and 4 m wide. The centre is open from 9 am to 4 pm from Monday to Friday. The occupancy of the building is 1 person per 0.5 m^2, and the lighting power density is 9.5 W/m^2. The building envelope details are listed in Table 7.2.

The wall consists of 200 mm thick masonry wall and 15 mm cement plaster on the internal and external surfaces. The roof consists of 30 mm thick Mangalore tiled roof with 100 mm wooden rafters. The flooring is 150 mm slab with red oxide flooring. The above data as per Tables 7.1 and 7.2 is used for input towards the simulation model and validated as per the onsite documentation.

Table 7.1 Reference building details and operation schedule

Building information	Details
Location	13° 05′ 07.2″ N 75° 04′ 57.8″ E
Building floor plate	9 m long, 4 m wide
Building orientation	North
Office schedule	9 am to 4 pm (5 days a week)
Occupancy	1 person per 0.5 m^2
Lighting power density	9.5 W/m^2

Table 7.2 Building envelope details

Building component	Details
Wall	200 mm thick masonry wall + 15 mm cement plaster on the internal and external surfaces
Roof	30 mm thick Mangalore tiled roof with 100 mm wooden rafters
Floor	150 mm floor slab with thick red oxide flooring
Surface	Dark Cream colour exterior and interior paint
Window type	Wooden Casement Windows
Window Frames	100 mm thick wood

7.5 Simulation and Results

The Anganwadi was documented with field study pertaining to the built information available at the site. The simulation model is shown in Fig. 7.4 modelled in CAD software and simulated in Energy Plus. The baseline case was validated and calibrated as per the field recordings.

Figure 7.5 shows the heat gains through the roof of the building during a typical summer day. The heat balance was 0.16 kW at 8 am, 0.30 kW at noon and at 4 pm it was 0.38 kW.

The conductive gains through the walls is shown in Fig. 7.6. It was 0.61 kW at 8 am, 0.5 kW at noon and it was at its peak at 4 pm with 0.65 kW. The heat balance due to natural ventilation was −0.12 kW at 10 am, −0.1 kW at 2 pm and −0.19 kW at 6 pm.

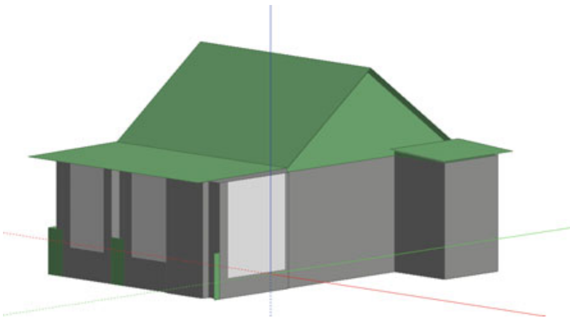


Fig. 7.4 Simulation model of the reference building

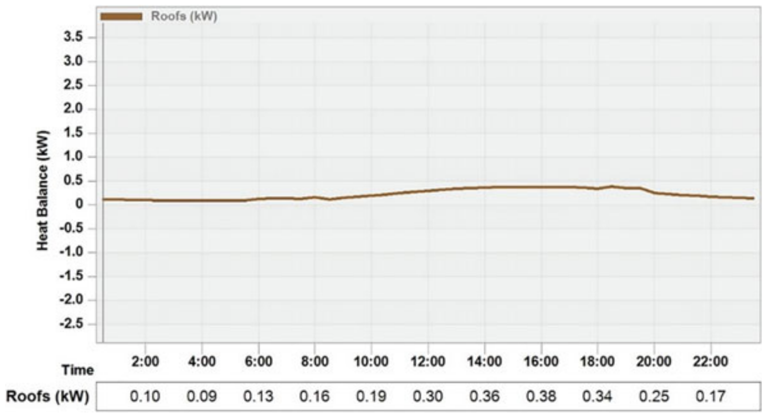


Fig. 7.5 Heat gains through the roof at the study location

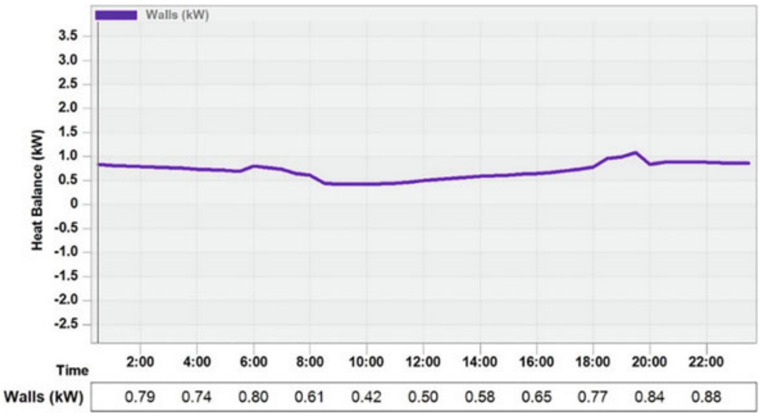


Fig. 7.6 Heat gains through the walls at the study location

The heat balance due to natural ventilation is shown in Fig. 7.7. Due to windows along the veranda wall there is a heat balance of −0.22 kW at 10am, −0.15 kW at 12 noon and −0.19 kW at 4 pm.

The indoor temperature on a typical summer day is shown in Fig. 7.8. The comfort temperature or operative temperature is 33.95 °C at 10 am and reached its peak of 36.18 °C at 4 pm. This was way above the ASHRAE comfort band of 23–26 °C and above the adaptive comfort band of 32 °C for this climate.

Figure 7.9 shows the daylight factor mapping for the classrooms, the daylight factor is marked in grid layout and at the working plane of 0.75 m and working plane height tolerance of 0.3 m. The band shows the color band from red to blue with the corresponding lux levels.

Figure 7.10 shows the annual illuminance in the classrooms, the daylight autonomy map shows the distribution of natural light availability for a horizontal slice through the current zone over the year. The % values represent the proportion

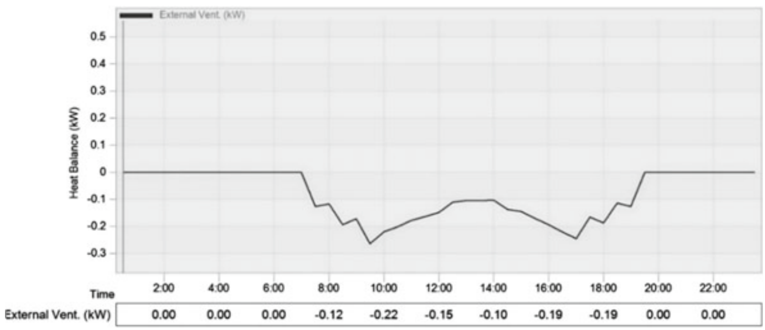
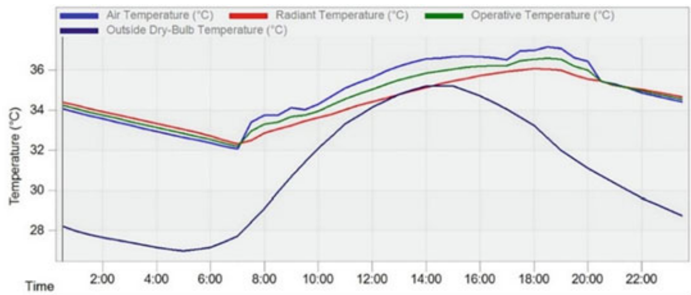


Fig. 7.7 Heat balance due to natural ventilation



Time	2:00	4:00	6:00	8:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00
Air Temperature (°C)	33.56	32.92	32.36	33.74	34.29	35.63	36.57	36.66	36.98	36.44	34.86
Radiant Temperature (°C)	33.92	33.32	32.70	32.85	33.61	34.41	35.12	35.71	36.08	35.55	35.03
Operative Temperature (°C)	33.74	33.12	32.53	33.29	33.95	35.02	35.85	36.18	36.53	35.99	34.95
Outside Dry-Bulb Temperature (°C)	27.66	27.16	27.16	29.13	32.08	34.13	35.20	34.71	33.23	31.10	29.62

Fig. 7.8 Indoor temperatures on a typical summer day

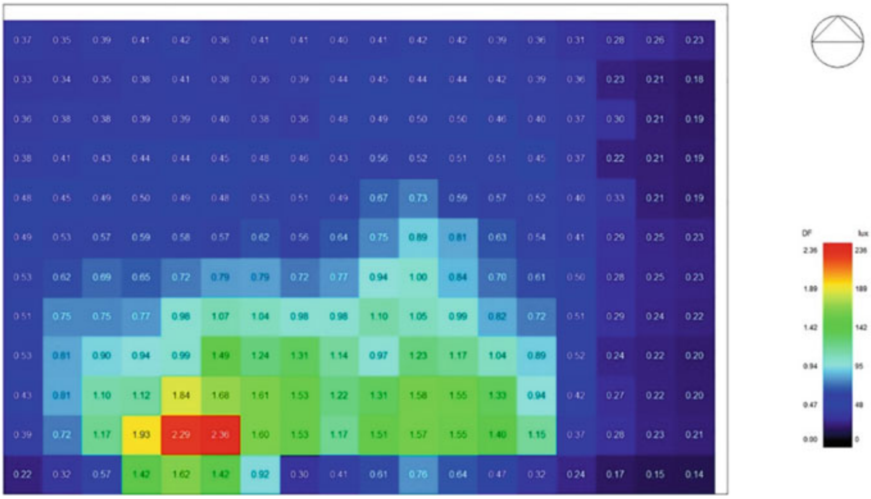


Fig. 7.9 Daylight factor at the classroom location

of time during occupied periods that the daylight levels are above the lower daylight illuminance threshold of 300 lx.

7.5.1 Simulation by Rotating the Reference Building

Simulation was conducted with the veranda on the west walls and the heat gain was found to be 0.11 kW at noon, 0.16 kW at 2 pm and 0.23 kW at 4 pm. The heat gain through the walls is shown in Fig. 7.11.

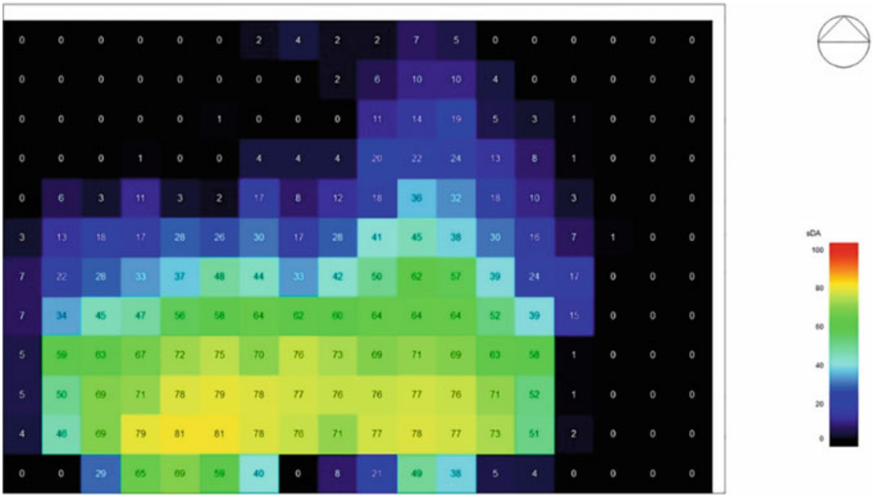


Fig. 7.10 Daylight autonomy map showing annual illuminance at the classroom location

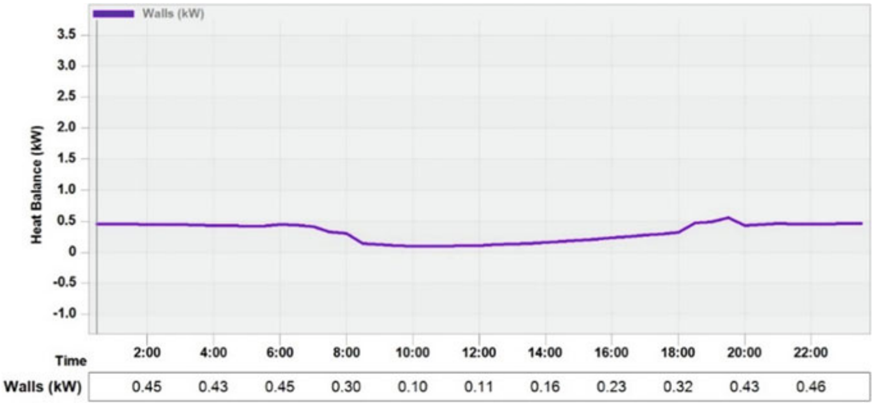


Fig. 7.11 Rotating the buildings heat gains through the walls

The model was further simulated with rotating the building and providing the veranda on the west side protecting the west wall and providing windows and shading deveices on the South and North walls 2.5 m × 1.2 m. The roof was also provided with insulation. The combination of these measures resulted in the indoor temperature to 30.48°C at 2 pm and 30.98°C at 4 pm on typical summer day (Fig. 7.12).

Figure 7.13 shows the indoor thermal comfort for the entire year which is well within the adaptive comfort zone and many studies have shown that in this climate occupants are comfortable till 32°C.

Further simulation studies were conducted with windows on the south and north side. Figure 7.14 shows the daylight factor of the classrooms.

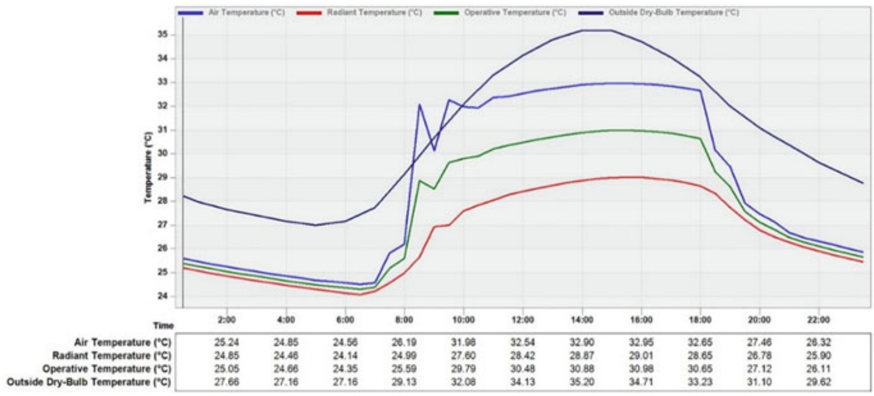


Fig. 7.12 Rotating the building with west verandah and shading devices

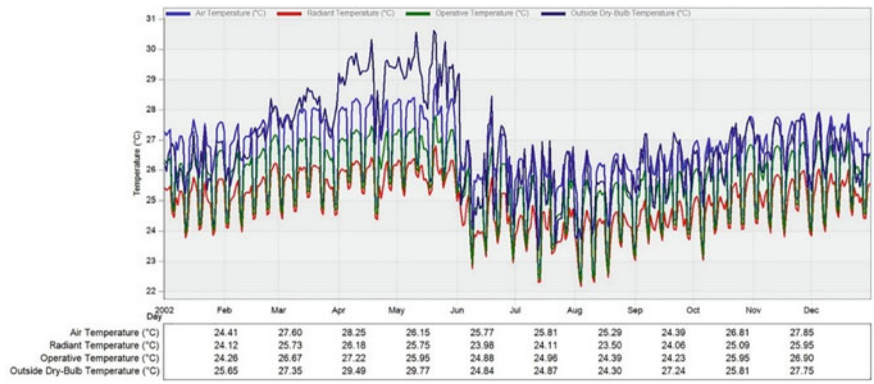


Fig. 7.13 Average monthly indoor temperatures at study location with design modifications

Figure 7.15 shows the daylight factor of the classroom with windows on the south and north side and with the incorporation of 0.6 m horizontal shading devices.

Figure 7.16 shows the annual illuminance at the class room with the design modification. The daylight autonomy map shows the distribution of natural light availability for a horizontal slice through the current zone over the year. The % values represent the proportion of time during occupied periods that daylight levels are above the lower daylight illuminance threshold typically 300 lx.

7.6 Discussions

From the Figs. 7.5 and 7.11, it is clear that once the building is rotated with the veranda on the west side of the building, the heat gains from the walls reduced from

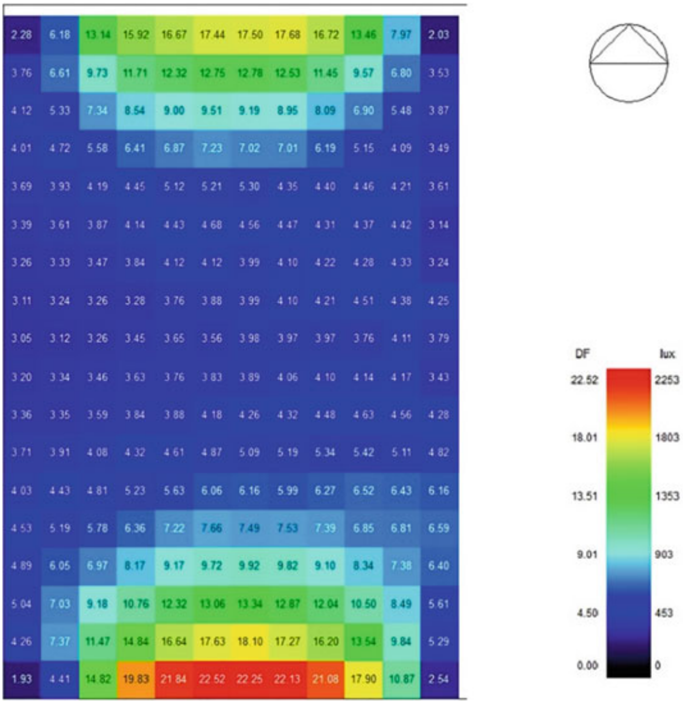


Fig. 7.14 Daylight factor with windows on north and south side

0.61 kW to 0.11 kW at 8 am, 0.50 kW to 0.16 kW at noon and at 4 pm it was 0.65 kW to 0.23 kW. The orientation of the building is one of the key aspects to reduce the heat gain inside the building and to reduce energy consumption. The model was simulated by providing windows and shading devices on the south and north walls with dimensions of 2.5 m × 1.2 m. The roof was also insulated with a 25 mm felt insulation below the tiled roof. These design modification resulted in reducing the indoor temperature in the class rooms on the typical summer day from 33.48°C at 10.00 am (Fig. 7.8) to 30.36°C at 10.00 am with varendah and shading devices for the western walls (Fig. 7.12) reducing the indoor temperature by 3.12°C, and also indoor temperature at 4 pm reduced from 35.81°C to 31.91°C. Furthermore, from the Fig. 7.13 it can be concluded that by providing insulation to the roof, shading devices to the windows and providing cross ventilation the building was within the adaptive comfort zone of the thermal comfort annually. As per the Fig. 7.9 in the reference building envelope the average daylight factor of the south wall was 0.36. Along the north wall the daylight factor was 0.59, the daylight factor along the east wall is 0.41 and the west wall 0.2. As per Fig. 7.10 it can be seen that the daylight factor and the illuminance in the classroom is inadequate, the annual illuminance was very poor on the south, west and the east side ranging from 0% to 10%. The model was then simulated for day lighting and illuminance as per the design modifications.

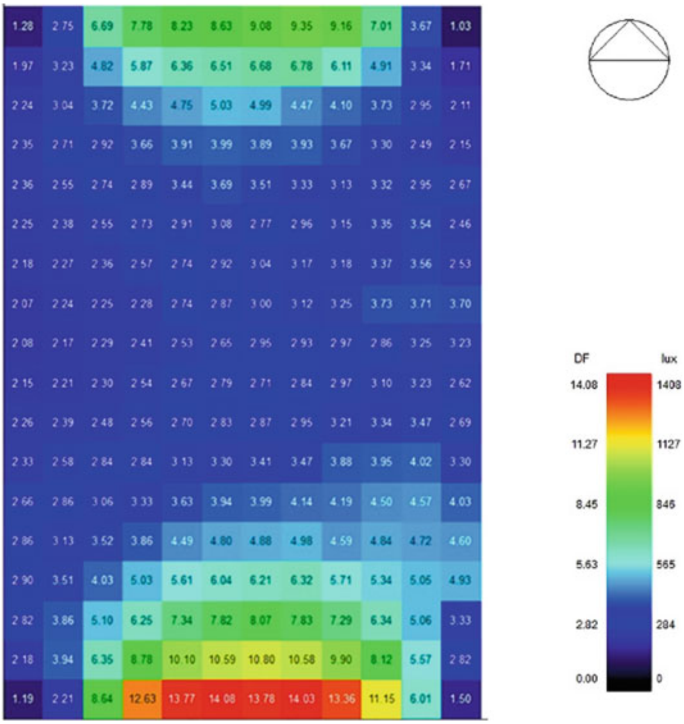


Fig. 7.15 Daylight factor with windows on north and south side and shading device

As shown in Fig. 7.14 when windows were provided on south and north walls the daylight factor improved to 4.26 on west side, 3.64 on east side, 10.11 on north side and 12.09 on south side. Due to the effect of glare, shading devices were added to the windows and the daylight factor was 6.21 on the south side, 9.36 on the north side, 2.22 on east side and 2.82 on west side as shown in Fig. 7.15. Figure 7.16 shows the results of the improved daylight factor and illuminance in the classroom with annual illuminance of over 90%.

7.7 Conclusion

There are 1.3 million Anganwadis in the country and there are no specific guidelines for their design and construction, resulting in occupants health and comfort to continue to be compromised. This research demonstrates that efficient design decisions result in improved heat balance, ventilation, improved thermal comfort perception and daylighting, and this can improve health and wellbeing of the occupants as per SDG 3. Construction of green Anganwadis can create jobs and boost the economy due to the large volume of these projects and influence the SDG 8, decent

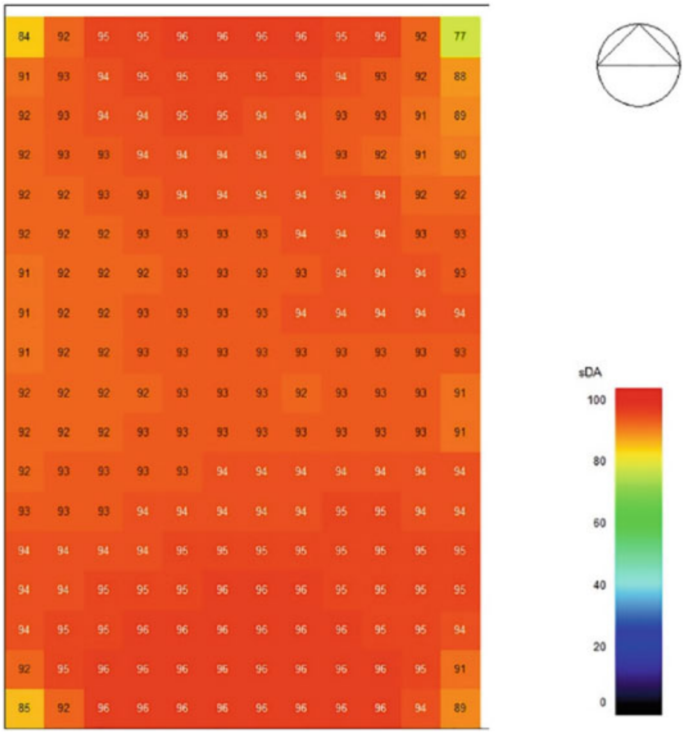


Fig. 7.16 Daylight autonomy map showing annual Illuminance at the Classroom Location with windows on north and south side and shading devices

work and economic growth. Also, the study undertaken in this research can be used for creating guidelines and policies related to the design of these centers in a warm and humid climate. This is possible by fostering strong partnerships between various stakeholders directly addressing SDG17, partnerships for the goals.

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Chapter 8
Sustainable Banking—Scale Development and Validation

Mohd Shamshad, Syed Hameedur Rahman Zaini, and Asif Akhtar

Abstract Sustainable banking is a relatively new term which is concerned with the various measures adopted by the banking sector towards meaningful contribution to the triple bottom line (people, planet and profit). This study is aimed at developing a framework for sustainable banking. Towards achieving this objective, a comprehensive review of literature has been conducted to identify the variables of sustainable banking. These variables are then structured in the form of a questionnaire. Data is collected from banking professionals through survey method. The process thus entails the formation and empirical validation of a scale for sustainable banking. Since such a comprehensive framework is not known to exist, this study is unique and presents value to both researchers and banking industry professionals.

Keywords Sustainable banking · Scale development · Exploratory factor analysis · Confirmatory factor analysis · Green products and services · Banking structures · Service channels

8.1 Introduction

The concept of sustainability is gaining prominence since it is recognized as a key driver that contributes to the development of an economy. There is widespread acceptance for the integration of sustainability principles into policy to ease their adoption

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by all stakeholders in the society. From a business perspective, the impact on the environment and effect on society needs to be considered before engaging in any activity. With this realisation, most of the large business corporations have re-engineered their processes to have minimal impact on the natural environment and thus contribute to the overall betterment of society (Shamshad et al. 2018). Similarly, other stakeholders have also started realising the importance of sustainability and are showing more interest in the adoption of sustainability parameters by following the principles laid down by the triple bottom line approach.

These principles include the overall welfare of people, planet and prosperity by inculcating sustainability (Adams and Frost 2008). Since the last two decades, many studies have highlighted the important role played by corporate sustainability for the achievement of overall sustainable development of a nation (Dyllick and Hockerts 2002; Salzmann et al. 2005; Weber et al. 2008).

The impetus gained by sustainability can be further enhanced by the contribution of the banking sector. Through what is being termed 'Sustainable Banking', banks can play a vital role by integrating sustainability procedures in their routine activities. Sustainability from a banking perspective concerns the contribution of banks towards the economic, social and environmental development of a nation without compromising the needs of the future generations. It includes the adoption of new and innovative techniques such as green loans, green credit cards, green service counters, less paper and electricity consumption, hospital and education facilities for the poor and underdeveloped, green investment opportunities and many more. The concept of sustainable banking has a very wide scope. It also envisages promotion of projects which are aimed at reducing their carbon production by applying innovative techniques, and thus helps in environment building. It is felt that the term sustainable banking is all-encompassing to include the 17 Sustainable Development Goals (SDGs) towards achievement of Agenda 2030 (Lindenberg and Volz 2016). The contribution towards achievement of the SDGs by a large developing country like India is likely to have a crucial impact on the success of the program globally (Zaini and Akhtar 2019).

In the modern world, the banking industry plays an important role in promoting sustainability for the overall economic development of a nation (Jeucken and Bouma 1999; UNEP FI 2016). Banks, after realizing the importance of sustainable development, have now started adopting sustainability practices through incorporating the triple bottom line approach of environmental, social and governance (ESG) in their day to day operations and have moved beyond the concept of traditional banking (Hermes et al. 2005).

A large number of rules and regulations regarding sustainability have been developed in the last two decades. Many organisations have started implementing these in daily operations to improve their social and environmental conducts. Some of these codes include United Nations Environment Programme Finance Initiative (UNEP FI), Global Reporting Initiative (GRI), United Nations Global Compact (UNGC) principles, Equator Principles etc. (Gupta and Mohanty 2014; Isaksson and Steimle 2009; Mitra and Schmidpeter 2017).

In developed nations, the area of sustainable banking has been explored widely by some of the renowned scholars of this field (Jeucken 2001; Amacanin 2005; Scholtens 2009; Roca and Searcy 2012; Weber 2016; Caré 2018). On the other hand, developing countries are still facing the problem of scarcity of literature on such an important issue (Khan et al. 2011) and in the Indian context, this concept is still unexplored (Prakash et al. 2018).

The Indian banking sector is slow in the adoption of sustainable banking parameters and is lagging far behind their counterparts (Sahoo and Nayak 2007). Most of the Indian banks have limited their green banking practices just to internet banking, paperless transactions, installing solar panels, use of Automated Teller Machines (ATMs) etc. (Biswas 2011). The Indian banking sector's indifference towards the adoption of sustainability parameters is evident from the slow pace of adherence (Rajput et al. 2013). The Reserve Bank of India (RBI), India's central bank, should take the initiative to develop some codes of conduct to promote the concept of sustainable banking in the country in a regulated manner.

The approaches of green banking followed by Indian public and private sector banks to safeguard environmental sustainability were examined in a recent study conducted by Yadav and Pathak (2013). Most of the studies on sustainable development of banks in India are focused on green banking strategies (Bahl 2012; Bihari 2010; Jha and Bhome 2013; Tara and Singh 2014) and Corporate Social Responsibility (CSR) actions followed by the Indian banks (Narwal 2007; Sharma and Mani 2013).

The concept of sustainable banking is still evolving and there is ample scope for addition to the existing literature. In the context of a developing country like India, there is limited implementation of sustainability practices in the banking sector. The present paper attempts to address this gap by developing a scale on the dimensions of sustainable banking, which are identified with the help of extensive literature review. The four broad dimensions are:

1. Banking structures and sustainability (BSS),
2. Borrowers' ability to meet financial obligations (BAMFO),
3. Green products and services (GPS), and,
4. Sustainability of banks service channels (SBSC).

A structured questionnaire was developed based on these dimensions of sustainable banking and responses were recorded from the top-level managers of banks in India. Exploratory factor analysis was used to explore the dimensions. Subsequently, confirmatory factor analysis was performed to confirm the structure of the questionnaire. Thereafter, validity and reliability of the questionnaire was tested by using Cronbach's alpha, composite reliability and average variance extracted.

8.2 Sustainable Banking and Dimensions—Literature Review

Sustainability as a concept extends beyond the effective utilization of natural resources and lowering of carbon emission levels. The banking sector, as regards to sustainability, is concerned with the formulation, construction and delivery of banking services based on six C's of sustainable banking which are: clients, culture, compliance, compensation, costs and capital (Straw 2013). It has been reported that the banking sector in India is increasingly adopting the green banking approach by taking various initiatives (Yadav and Pathak 2013). Also, public sector banks are more responsive to the call for sustainable banking practices as compared to private sector banks. A comparison of sustainable banks with Global Systemically Important Financial Institutions (GSIFIs) on several key parameters has concluded that the banks working on the principles of sustainable banking offer a more stable route towards sustainable banking as compared to banks with conventional working structures (Korslund 2013). A study on European banks found that the banks are moving towards the creation of a socially responsible industry and can improve upon this approach by adopting corporate social responsibility through focusing on the triple bottom line (Birindelli et al. 2015). The study further reported that there is scope for a lot of improvement in case of international agreements, certifications and indices as many international standards and principles are not yet adhered to by banks. Vaithilingam et al. (2006) concluded with the help of empirical evidence the impact of key factors such as infrastructure, intellectual capital, institutions, integrity, interaction and innovation (6I's) on the soundness of the banking industry in developed, developing and under-developed nations. The domain of sustainability has gained attention in the last few decades with the adoption of sustainability by the banking industry a more recent development since banking was earlier considered as an environment-friendly industry (Hoijtink 2005). Some banks in developed nations have been early-movers in the adoption of sustainability principles and started with the implementation of an Environmental Management System (EMS) which led to the elimination of projects not conforming to the accepted principles of sustainability. Many other banks also started offering Socially Responsible Investment (SRI) opportunities, environmental damage or recycling insurances, green credit cards, micro credit to help people out of financial and social exclusion, and trading in Renewable Energy Certificates and emissions.

8.2.1 *Brief Description of the Dimensions*

These are the dimensions of sustainable banking which are identified based on extensive literature review.

Banking Structures and Sustainability (BSS)
Banks which follow the principles of sustainability are required to have formal and well-designed operating structures in accordance with the said principles. The business should be structured to promote environment-friendly operations. For instance, lending decisions should also consider environmental implications (Thompson and Cowton, 2004). The processes should promote innovation and look towards improvement of stakeholder relations.

Borrower's Ability to Meet Financial Obligations (BAMFO)
Proper assessment of borrowers' needs and their ability to pay should be evaluated before sanctioning of loans. Otherwise, it may lead to default and have a negative impact on the lender. This may also affect the sustainability initiatives of the bank. Borrowers should therefore ensure the proper repayment of loans according to predetermined timelines (IISD 2019). A healthy credit rating helps both parties in their respective objectives. Most banks in China have adopted environmental and social risk management practices which has led to the distribution of green credit (Rao et al. 2017).

Green Products and Services (GPS)
With the help of innovative practices in new product development, banks are increasingly introducing products and services which are compliant with international standards on sustainability. These 'green' products and services are developed with a focus on the social and environmental aspects of banking (Zimmermann and Mayer 2000).

Sustainability of Banks Service Channels (SBSC)
As part of the efforts for sustainability in the banking sector, delivery of core and allied banking services are also being evolved to ensure that they are less impactful on the environment. New techniques centred on information and communication technology are being employed so that the delivery of products and services takes place in an efficient and sustainable manner. As part of green banking initiatives, banks are encouraging the use of cleaner service delivery mechanisms like branchless banking, internet banking etc. The reliance on self-service technology is also evident with the increasing use of ATMs (Prendergast and Marr 1994).

8.3 Objectives

- To identify the dimensions of sustainable banking by conducting an in-depth literature review.

- To develop and validate an attitudinal scale of sustainable banking.

8.4 Methodology

The dimensions of sustainable banking are identified through literature survey and a structured questionnaire is developed based on those dimensions to check the attitude of bank employees towards sustainable banking in India. All the necessary steps are considered to give a final shape to this measurement scale. These steps are performed as per Churchill's (1979) work of scale development. The first step is to identify the dimensions to be measured with the help of available literature. Secondly, to establish the face validity of the questionnaire with a group of academic experts and finally to conduct the pilot study. The pilot study was conducted on a sample of 25 responses to check for discrepancies in the research instrument and modify the content wherever necessary. This pilot study collected responses from academicians, researchers and other industry experts besides the target population of top-level managers of banks. The top-level managers of banks include bank personnel assigned as General Managers, Deputy General Managers, Assistant General Managers, Principal Officers and other higher order employees of the banks.

The rationale of selecting top level employees of the bank was that, since most banks in India do not have separate departments or functional areas dedicated to sustainability, it was presumed that employees higher up in the hierarchical order would be better equipped to comment on sustainability issues on the basis of their larger experience in the industry. Thus, this study undertook a purposive sampling technique. This technique of sampling is used where particular settings, persons or events are to be selected deliberately to obtain the important information which cannot be obtained through other choices (Maxwell 1997). Finally, data is collected from a total of 410 bank employees.

The initial questionnaire consisted of 19 items under 5 dimensions which described the main determinants of sustainable banking. A 5-point Likert scale was used to measure responses on these items. The scale ranged from points 1 to 5 to record responses from 'strongly disagree' to 'strongly agree' respectively. The questionnaire was developed on the Google docs platform and data was collected by sending the online link of the questionnaire through mails to the respondents.

The structure of questionnaire was explored through Exploratory Factor Analysis (EFA) and to confirm the structure Confirmatory factor analysis (CFA) was used. Cronbach's alpha, Composite reliability (CR) and average variance extracted (AVE) were used to test the validity and reliability of the questionnaire. Statistical packages used for data analysis were IBM SPSS 22 and AMOS 24.

Table 8.1 Nature of banks

Type banks	Frequency	Percentage
Public sector banks	174	42.40
Private sector banks	148	36.10
Foreign private Banks	65	15.90
Regional rural banks	23	5.60
Total	410	100

Source Authors

Table 8.2 Designation of respondents

Sector of banks	Frequency	Percentage
General manager	121	29.50
Deputy general manager	144	35.10
Assistant general Manager	62	15.10
Principal officer	54	13.20
Others	29	7.10
Total	410	100

Source Authors

8.5 Analysis and Interpretation

8.5.1 Demographics of the Respondents

Demographic break down of the respondents are shown in Tables 8.1 and 8.2 as regards the type of bank and the designation of the respondents respectively. Data is collected from managerial level employees of different banks based on convenience sampling method from different parts of India. For the purpose of the survey, public sector banks comprise 42.40%, while private sector banks make up 36.10%. Foreign private banks constitute 15.90% and regional rural banks constitute 5.60% from which a total of 410 responses were collected. In the same manner, out of the total number of 410 respondents, 121 were General Managers, 144 were Deputy General Managers, 62 were Assistant General Managers, 54 were Principal Officers and 29 were from other top positions in the banks.

8.5.2 Exploratory Factor Analysis

KMO and Bartlett's Test

The questionnaire used in the study was developed on the basis of available literature since there was no standard questionnaire for this specific kind of research. The scale so developed was then checked for reliability and validity in order to draw valid

Table 8.3 KMO and Bartlett's test

Kaiser–Meyer–Olkin Measure of Sampling Adequacy	0.747
Bartlett's Test of Sphericity Approx. Chi-Square	5555.882
Df	136
Sig	0.000

Source Authors

outputs from the study. The validity and reliability of the instrument was determined with the help of SPSS 22 and AMOS 24.

For extraction of the factors, Exploratory Factor Analysis (EFA) was performed to check the factor loading of all the items. To determine if data gathered is likely to factor well, before proceeding with EFA, Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's Tests of Sphericity were performed. If KMO is found to be greater than 0.50 then one can proceed with the factor analysis (Kaiser 1974). The KMO value determined in the present study was 0.747, showing that the value is good (Hutcheson and Sofroniu 1999) and thus the data is suitable for factor analysis.

Initially research commenced with five dimensions, but the rotated component matrix was able to extract the results in four variables, namely: BSS, BAMFO, GPS and SBSC. The KMO value on these dimensions was found to be 0.424 which was lower than the acceptable limit of 0.5 and hence two items from the instrument were removed because of multiple factor loading (Ahmad and Khan 2017; Büyüköztürk et al. 2004; Kline 2014 and Metin et al. 2012). Finally, after removing these two items, the value of KMO came out to be 0.747 which lies in between middling and meritorious on the scale suggested by Kaiser (1974). This improved figure of 0.747 (Table 8.3) of KMO is finally accepted and used for further analysis. Now the number of items is reduced to 17 from the initial figure of 19 items. The Rotated component matrix with the value of factor loadings of these 17 items are shown in Table 8.4.

Table 8.4 Rotated component matrix

Items	Factor loadings	Items	Factor loadings
S1D1	0.77	S4D2	0.72
S2D1	0.70	S1D3	0.75
S3D1	0.80	S2D3	0.86
S4D	0.69	S3D3	0.87
S5D1	0.81	S4D3	0.74
S6D1	0.88	S1D4	0.64
S1D2	0.80	S2D4	0.82
S2D2	0.75	S3D4	0.79
S3D2	0.84		

Source Authors

Extraction method: Principal component analysis

Bartlett's Test of Sphericity measures the presence of correlations among the variables. It provides the statistical probability that the correlation matrix has significant correlation among at least some of variables. Thus, a significant Bartlett's Test of Sphericity is required (Field 2009). Since $p = 0.000$ (its associative probability is less than 0.05) for the scale, factor analysis was performed. The statistics related to KMO and Bartlett's test are shown in Table 8.3. These four dimensions of sustainable banking in India explained 75.12% of the total variance in the model. The values of Total Variance explained are shown in Table 8.5.

Reliability

To validate a questionnaire, it is necessary to check the reliability of the scale. Reliability means that the questionnaire used should consistently reflect the construct which it is measuring (Field 2009). Cronbach's Alpha (α) is the most common measure of scale reliability. The common accepted value of α is from 0.7 to 0.8 (Kline 2014). The value of Cronbach's Alpha in case of overall reliability of the questionnaire was 0.876, which shows that the scale is reliable (Hair et al. 2006; Kerlinger and Lee 2000; Khan and Adil 2013). Separate values of Cronbach's alpha is also calculated for each dimension which is shown in Table 8.6.

Table 8.5 Total variance explained

Component	Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	5.92	34.82	34.82	3.84	22.56	22.56
2	3.15	18.53	53.34	3.62	21.30	43.86
3	2.48	14.57	67.91	3.28	19.30	63.16
4	1.22	7.20	75.12	2.03	11.96	75.12
Extraction Method: Principal Component Analysis						

Source Authors

Table 8.6 Reliability

S.No.	Dimensions	Cronbach's Alpha
1	BSS	0.879
2	BAMFO	0.830
3	GPS	0.855
4	SBSC	0.821
Overall		0.876

Source Authors

8.5.3 *Confirmatory Factor Analysis (CFA)*

EFA has certain limitations such as the items which show multiple factor loadings remain unexplained. These items might correlate with each other statistically (Ahire et al. 1996; Khan and Adil 2013). To overcome these underlying limitations of EFA, generally CFA is recommended (Lee, 2008; Khan and Adil 2013). Therefore, in this study also CFA was performed on the four dimensions (BSS, BAMFO, GPS and SBSC) of sustainable banking in India on the AMOS 24 platform. The factor loadings of each item were stated, and the hypothesized measurement model was developed and tested. The factor loadings of all the items of these four dimensions are mentioned in Fig. 8.1 and Table 8.7.

All the items of the scale are loaded on their respective dimensions and all the factor loadings are within the recommended range of more than 0.4 (Ryu et al. 2010) as shown in Table 8.7. The methodology suggested by Gerbing and Anderson (1988) was used to assess the measurement model. The obtained values of fit indices are shown in Table 8.8. All the values of fit indices were found to be within the acceptable range except the value of AGFI which slightly falls short of the recommended value.

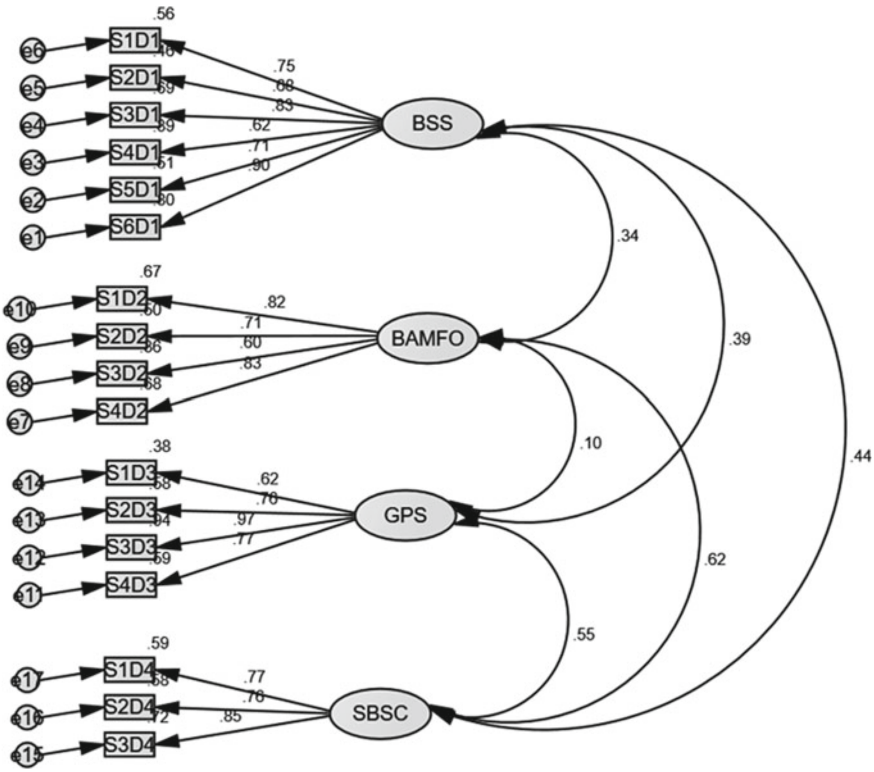

Fig. 8.1 Measurement Model. *Source* Authors

Table 8.7 Standardised regression weights (CFA)

	Estimate
S6D1 ß BSS	0.896
S5D1 ß BSS	0.714
S4D1 ß BSS	0.623
S3D1 ß BSS	0.830
S2D1 ß BSS	0.676
S1D1 ß BSS	0.746
S4D2 ß BAMFO	0.827
S3D2 ß BAMFO	0.599
S2D2 ß BAMFO	0.708
S1D2 ß BAMFO	0.816
S4D3 ß GPS	0.770
S3D3 ß GPS	0.970
S2D3 ß GPS	0.759
S1D3 ß GPS	0.619
S3D4 ß SBSC	0.848
S2D4 ß SBSC	0.763
S1D4 ß SBSC	0.767

Source Authors

Table 8.8 fit indices of measurement model (CFA)

Fit Index	Recommended values[a]	Observed values
CMIN/DF	< 3.0	2.536
GFI	0.90	0.902
AGFI	0.90	0.865
NFI	0.90	0.913
CFI	0.90	0.935
RMSEA	<0.070	0.064

[a]*Source* Hair et al. (2010), Hooper et al. (2008); Hu and Bentler (1998); Malhotra and Dash (2011)

The Values of GFI, NFI and CFI were found to be 0.902, 0.913 and 0.935 respectively. All these three values are more than the required value of 0.9. Similarly, the values of CMIN/DF and RMSEA were 2.536 and 0.064 respectively which were also with in the acceptable range. The value of AGFI was 0.865 which is slightly lower than the acceptable value of 0.9. The value of Chi-square measure was 192.736 with 76 degrees of freedom (df) and $p < 0.05$. These values were also found to be in the acceptable range.

The validity of the scale is measured with the help of Average Variance Extracted (AVE) which has been suggested as a healthy measure of validity by many researchers

Table 8.9 Reliability and validity

	CR	AVE	BSS	BAMFO	GPS	SBSC
BSS	0.866	0.623	**0.789**			
BAMFO	0.890	0.576	0.380	**0.759**		
GPS	0.829	0.552	0.094	0.344	**0.743**	
SBSC	0.836	0.629	0.547	0.428	0.619	**0.793**

(Fornell and Larcker 1981; Hair et al. 2010). In this study also, the convergent and discriminant validity of the scale are calculated with the help of AVE. all the values of AVE were found to be more than the threshold limit of 0.5 which indicates sufficient convergent validity (Fornell and Larcker 1981; Hair et al. 2010; Khan and Adil 2013; O'Leary-Kelly and Vokurka 1998). The values of AVE (Table 8.9) were 0.623, 0.576, 0.552 and 0.629 for BSS, BAMFO, GPS and SBSC respectively.

Similarly, the result of scale validity, which is calculated by taking square root of AVE, also shows sufficient discriminant validity as the value of each dimension was more than its inter-dimensional correlation (Fornell and Larcker 1981; Hair et al. 2010; O'Leary-Kelly and Vokurka 1998) and is presented in Table 8.9. The values of discriminant validity were found to be 0.789, 0.759, 0.743 and 0.793 for BSS, BAMFO, GPS and SBSC respectively.

The values of composite reliability (CR) of each dimension were also higher than the suggested limit of 0.70 which is a good indicator of sufficient scale reliability (Fornell and Larcker 1981; Hair et al. 2010; Malhotra and Dash 2011). The values of CR were 0.866, 0.890, 0.829 and 0.836 for BSS, BAMFO, GPS and SBSC respectively.

8.6 Discussion

Sustainable banking is among the newly developed and fastest growing concepts which is aimed at achieving sustainable development with the help of the banking sector. The Indian banking sector is lagging far behind in utilizing the concept of sustainability in their daily operations. There is an urgent need to develop a comprehensive framework of sustainable banking in India. This framework will guide the banking organisations towards the path of sustainable development (Shamshad et al. 2018). Banking sector is the only sector which can help in achieving all the three aspects of sustainable development i.e. The Environmental Sustainability, Social Sustainability and Economic Sustainability (Hoijtink 2005).

In the Indian context, since sustainability integration in the banking sector is almost unheard of, there arises a need to develop a comprehensive scale for sustainable banking. The researchers tried to fill this gap by developing a scale on the most important dimensions of sustainable banking in the Indian context. This scale will help the future researchers to further enhance their research in this area. This scale will also contribute in further refining and developing the aforesaid area by providing them a path to work upon and guide them towards a sustainable banking approach.

8.7 Conclusion and Recommendations

Researchers working in the area of banking and sustainability must be aware of these dimensions of sustainable banking which influence the working of banks towards achieving the goal of sustainable development. Banks should develop themselves more strategically by analysing and prioritizing their daily operations towards the achievement of overall sustainable growth. There is a long journey ahead for Indian banks to develop themselves as sustainable banks. Some of the renowned Indian banks have already started their journey towards sustainability but most of them are yet tread this path.

This scale of four dimensions will help the banks to develop themselves in the path of achieving sustainable development. The first dimension of this scale i.e. BSS will help the Indian banks to redesign their structures (including products and services) towards achieving sustainable development. In the same manner, the second dimension, BAMFO, enables banks to focus on their lending and borrowing practices in a sustainable manner. The third dimension of GPS relates to the development of environment friendly products and services as one of the most important ways to achieve sustainability. The fourth dimension of SBSC talks about the sustainability aspects of bank's service channels. If the service channels of a bank are following sustainability procedures, then it becomes easier for any bank to develop itself overall as a sustainable bank.

Besides these, the results of this study also provide important insights to those academicians and experts who are exploring this area of sustainable banking. This study will give them a way forward for better understanding and conceptualising the outcomes of further research in this area.

8.8 Limitations and Future Research Directions

Although not much literature is available on sustainable banking in India, this research tries to contribute to that existing body of knowledge. Like many other studies, this study also has some limitations which can be addressed by researchers in further studies.

One of the most important limitations of this study is the number of dimensions. This study revolves around only four dimensions of sustainable banking. It becomes very difficult to identify a greater number of dimensions because of the availability of limited amount of literature. This presents a direction to researchers to identify and add more dimensions of sustainable banking which may enhance the quality of the scale for sustainable banking.

In this research, an attempt is made to have representation from the different types of banks in the Indian banking sector. However, the sample size of 410 respondents is quite small considering it is drawn from the large pool of Indian banks. Since the study required responses from top management employees in banks, the task of data collection was quite difficult due to their busy schedules. This sample size of 410 respondents from the Indian banking sector can be increased by future researchers so as to achieve more generalised findings.

This study adopts the convenience sampling method which restricts the reach to respondents all over the country. This is also one of the limitations of this study which can be overcome by future researchers by targeting the whole country with the help of any probabilistic method of sampling. In probability-based method of sampling, the banks from all over the country will get equal chance to participate in such important researches.

One of the limitations may be attributed to the fact that Indian banks do not have any specific department or authority designated for sustainability aspects. This is the reason why it was difficult to identify suitable respondents to answer questions on sustainability aspects of banking. This limitation can be overcome in future if banks come up with some specific departments or authorities to cater to the need of sustainable development in the banking industry.

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Chapter 9
Sustainable City Planning and Management Strategies in Vernacular Settlement Patterns in Sri Lanka

K. K. Kamani Sylva and K. K. L. Aruna Sylva

Abstract Sri Lankan vernacular settlement patterns are mainly based on nature's circular metabolism. It is observed that most of the output discharged by one subsystem becomes an input for another, contributing to the sustainability of the entire ecosystem. These patterns were well-adapted to the ecology of a context with no recorded human-made disasters. But, with the increasing population and adoption of transferred alien practices in the recent past, this equilibrium has been adversely affected. Imbalances of new settlement patterns are triggering many natural, and human-made detrimental events, affecting the three pillars of sustainability: environment, society and economy of the country. This study focuses on examining the vernacular settlement patterns and architecture of Sri Lanka, aiming at identifying special features that could be adopted to the city planning in future. The qualitative study is based on interviews with people in villages where specific examples of sustainable practices prevail in settlements. Internal validity of data is met with observations. External validity is met by comparing the results with secondary information on vernacular settlements in Sri Lanka. The analysis was done by transcribing, coding and categorising data. Categories such as village planning and management, site selection, water efficiency, architecture and settlements, green material usage, and co-existence with nature and culture are developed during the analysis. Recommendations are made for future city planning in similar contexts as a result of this research. The output of this research would benefit the society, environment and economy, by adopting sustainable practices in future planning for highly biodiverse contexed nation such as Sri Lanka.

Keywords Sustainable city planning and management · Vernacular settlements · Water efficiency · Sustainable architecture · Co-existence with nature · Sri Lanka

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9.1 Introduction

With the increasing population, recent trends in unplanned settlement patterns are leading to detrimental effects, especially among developing nations. Problems such as filling of wetlands for settlements, mismanagement and dumping waste into wetlands are becoming common, making the wetlands less effective in natural pollution control. Flooding in cities has become a frequent disaster in Sri Lanka due to unauthorised as well as authorised fillings for settlements. Landslides are another unfavourable effect of settlements in highlands due to improper land-use patterns; cutting and filling of slopes. Use of advanced technology for cutting areas with slopes destroy the ecosystem in biodiverse contexts. Land-use patterns go through significant transformations, unplanned and inadequate for the increasing population, leading to human-made disasters and triggering natural disasters. In identifying the failures of sprawl development, although models such as Transit-Oriented Development (TOD) for settlements are being proposed in Sri Lanka (Udapitiya et al. 2020), these are mostly transferred concepts from foreign environments and may not harmonise with the context as expected or may be suitable for limited urbanised landscapes. These models do not address the concept of the whole system for sustainability. Most of the modern applications of sustainable practices in Sri Lanka are limited to technological concepts that are transferred, and poor attention is given to traditional and context-specific practices. The transferred technology may not adjust to the context. However, in most of the local settings, rich history of context-specific sustainable practises has been dominant in the past, which is rarely reconsidered in planning for the future.

Indigenous settlement practices have sustained communities for centuries, although modern measuring standards have not recognised the value of these sustainable practices. Such practices are regarded as undeveloped and backward (Dayaratne 2018). With the increasing concerns of sustainability, at present, there is a trend to reinvestigate the ancient practices for their sustainable properties (Dayaratne 2018; Sudha and Nishanth 2016). ‘Traditional vernacular settlements are those formed by the people living and working in them by employing the wisdom, knowledge and practices handed down from generation to generation’ (Dayaratne 2018, 334). There is an argument that ‘sustainability should be generated holistically from within rather than from the outside’ (Dayaratne 2018, 334). Sustainable practices from vernacular settlements include site selection, space utilisation, and usage of locally available material (Sudha and Nishanth 2016). Water efficiency, sustainable architecture and co-existence with nature have been identified as the main features of vernacular settlements that leads to sustainability.

Adopting alien practices introduces ecosystem conflict in agricultural-based societies in Sri Lanka as well as in many developing nations. For example, eco-strategies in farming systems responding to nature can be of three types, namely, the domination of nature, active adaptation to nature and passive adaptation to nature (Mendis 2003). Sri Lanka is moving forward with changes in irrigation practices towards the domination of nature. This movement is away from traditional practices, which were an adaptation to nature. Experts implementing these plans see very little intrinsic worth in ancient irrigation systems (Mendis 2003). It is timely for the Sri Lankan decision-makers to reconsider the context-specific ancient practices which were not damaging the ecosystem. According to Mendis (2003), Western strategies in agriculture may only suit the seasonal summer–winter variation approaches and might not be good for wet and dry climatic changes.

This qualitative research study examines the vernacular settlement patterns and the architecture of Sri Lanka to identify the special features to investigate concepts that could be reused for future sustainable city planning and management of agricultural-based environments. The study is based on interviews and observations as primary data. Secondary information was used for external validity. The concept of vernacular settlement patterns in Sri Lanka has been based on a dictum, 'Gamai, Pansalai, Wewai, Dagabai', meaning, 'village, temple, lake, and dagoba'. This has been a highly sustainable concept where the villages have been provided with spiritual help by the village temple. Cultivation has been secured with water efficiency and sustainability through the creation of a small lake at every village. Food security and economic stability have been met simultaneously. All other activities have been revolving around the agricultural practices, and no detrimental effects on the ecosystem have been recorded. Some of the practices that are used in these societies such as village planning, sustainable site selection, water efficiency and features of the sustainable architecture are discussed in this paper. The scientific trigger of the ancient practices and the possibility of using such practices in present-day sustainability considerations are discussed. Concepts extracted from vernacular practices that are reusable for sustainable city models are recommended as a result of the findings of this study.

9.2 Sustainability and Vernacular Settlements

The trends in sustainability adopt concepts related to social indicators and environmental indicators to be prevalent to economic indicators as 'tracking only economic growth has been detrimental to social and environmental progress' (Hicks et al. 2016). Besides, policies and practices to address the challenges of shaping a sustainable future must draw on social sciences combined with natural science and engineering. In the natural step framework presented by Robert et al. (2002), four system conditions are identified for sustainability. According to them, in a sustainable society, nature is not subject to systematically increasing concentrations of substances extracted from the Earth's crust, increasing concentrations of substances produced by society and degradation by physical means (over-harvesting, introductions, mismanagement or displacement) while meeting human needs worldwide. As presented by Korhonen (2004, 810), 'harvest rates of renewable resources should not exceed regeneration rates', 'waste emissions should not exceed the relevant assimilative capacities of ecosystems' and 'non-renewable resources should be exploited in a quasi-sustainable manner by limiting their rate of depletion to the rate of creation of renewable substitutes' for sustainability. In complying with the sustainability of the whole system, the actions of sub-systems, in whatever the context, matters a lot. Traditional vernacular settlements have been highly successful as self-sufficient communities by adopting the whole system thinking while getting the contribution from its subsystems (Dayaratne 2018; Piyadasa 2009; Mendis 2003).

9.3 Methodology

A qualitative research study was conducted initiating with interviewing people in villages where traditional sustainable practices yet prevail from Kakirawa and Galgamuwa divisions of Anuradhapura and Kurunagala districts respectively, in Sri Lanka. Snowball sampling method was used in identifying villages who could explain the traditional practices and 12 successful interviews were completed during the research. Interview guide was started with one question 'could you explain the traditional planning of a village and the settlement patterns of your village?' and continued with probing questions (Annexure). The probing questions were identified for the interview guide with a thorough literature search on concepts on sustainable practices for city planning. Site selection, village planning, water efficiency, features of sustainable architecture were taken as main areas to be verified during the interviews. Allowance was made for verification of other sustainable practices during the interviews. The information gathered through interviews is transcribed, coded and categorised. Findings of the interviews were supported through recorded observations for internal validity (Yin 2013). The results were then compared with the available literature on vernacular practices for external validity. A general model for a sustainable village was created using the results obtained. Results and discussion are presented together in the following sections owing to the nature of the qualitative analysis. Planning and management practices that are replicable in the present context are recommended for future sustainable planning of similar contexts.

9.4 Analysis

Qualitative data were analysed by transcribing, coding and categorising data gathered through interviews. The coding procedure was according to grounded theories suggested by Flick et al. (2004) and Strauss and Corbin (1990). In-depth interviews were transcribed, and coding was done using open coding to conceptualise data to maintain the qualitative research standards. According to Strauss and Corbin (1990) conceptualising data is taking apart an observation which could be a sentence, a paragraph after transcribing and giving each discrete incident, idea or an event, a name that represents a phenomenon. The second step of the coding procedure is the discovering categories, which is grouping the concepts around phenomena identified. Categories allow reducing the number of units for further working. Then the categories developed were compared with observations and available literature on vernacular settlements as triangulation for the external validity of data.

9.5 Results and Discussion

Categories such as village planning and management, sustainable site selection, water efficiency, sustainable architecture and settlements, green material usage, and co-existence with nature and culture are developed for discussion. The categories developed are presented with a discussion in the following sections.

9.5.1 Village Planning and Management

Most of the people in rural settings yet live on agriculture as their main support for a living as indicated by many of the respondents. Planning of a village has been done considering the sustainability of the whole system, basically creating a lifestyle around water sources. Living styles with optimisation of water usage, while preserving hydrological systems and not damaging the ecosystems have been the goal of these settlements. Many such systems were observed during the research. The smallest unit of settlement is the village, and the entire system comprises of many such subsystems linking with each other through a larger hydraulic based network. This network is identified as the cascade system of tanks (Mendis 2003), which are functioning in many of these settings for decades. Planning of the village is around these small tanks, and the main source of livelihood is agriculture according to many of the respondents.

The village is planned in a manner that the essential items such as water storage for agriculture, vegetation cover, a temple for spiritual activities and settlements of people were within the reach of the community. The temples were made solid and are situated at a higher location in the terrain. People of the city gather at the temples for religious activities and also this space is used as evacuation centres for any natural disasters such as flooding during the monsoon season. Many other activities such as education, community meetings, and advisory services are linked to the temple of the village, and the priest is the main advisor for all religious activities.

The village houses are placed centrally to the village lake, paddy fields and the area that was used for Chena cultivation. This area is known as 'Gammedda', the centre of the village. The individual housing units are arranged in a cluster as observed, within an under-bushed common central courtyard known as the 'Meda-midula'. The spaces with few trees are used to locate each householder's grain stores known as 'Atuwa'. This common space is also used to dry paddy, etc. and the children use these areas as play space. The courtyard of houses is well protected with a fence around the housing units. This fence protected the harvest from wild animals such as elephants. Figure 9.1 illustrates the components of a 'Gammedda', the centre of a

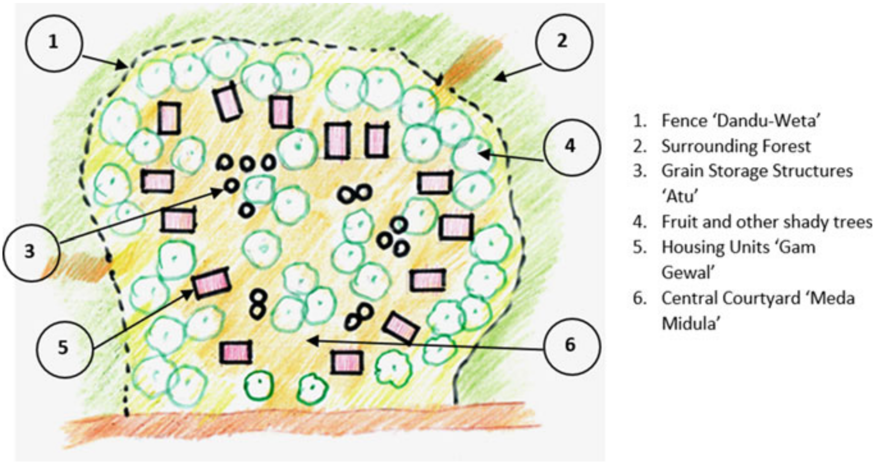

Fig. 9.1 Components of 'Gammedda', the Center of Village. *Source* Author K. K. L. A. Sylva

village. These concepts are supported by Dalupota (2003) where such clusters have been identified as 'Ihala Gammedda' (upper cluster), 'Meda Gammedda' (middle cluster) and 'Pahala Gammedda' (lover cluster) in relatively developed villages.

The 'Tisbambe' was a cleared area used for common gathering for the cultural activities and meetings of the villagers. It is located in the vicinity of the 'Gammedda' towards the forest. It also acts as a barrier between the forest and the 'Gammedda'. The traditional Sri Lankan village is always associated with a lake which is generally termed as 'Wewa'. In general, the name of the village is linked to the name of the lake, and this water source is the life-source of all activities of the village.

The village lake, 'Wewa', is protected by a forest patch surrounding the upper catchment area of the lake. This area was known as 'Ihaththawa', and no constructions or clearing of land was allowed except for the village temple. Lately, developments in these areas are observed in some of the villages considered for the research. The temple is usually located on a small hillock adjacent to the lake on firm ground. The most prominent structure of the temple is its stupa known as the 'Dagaba', Hence, the four main features: 'Gamai' (village), 'Pansalai' (temple), 'Wewai' (lake), 'Dagabai' (Stupa), are always linked in famous dictums associated with ancient Sri Lankan villages.

Apart from the temple, the 'Devalaya' (shrine) devoted to the Gods, believed to be protecting the lake, and the village is located near the lake bund sometimes adjacent to the temple. The lake bund is known as the 'We-kanda', and the shrine is known as the 'Sanhinda Devalaya'. This shrine is located under a large tree on the lake bund and may or may not have any prominent structures associated with it. With the village irrigation system, the whole network is known as an 'Elangawa' system. Figure 9.2 depicts a Model Village of a Vernacular Settlement which illustrates the 'Elangawa' system.

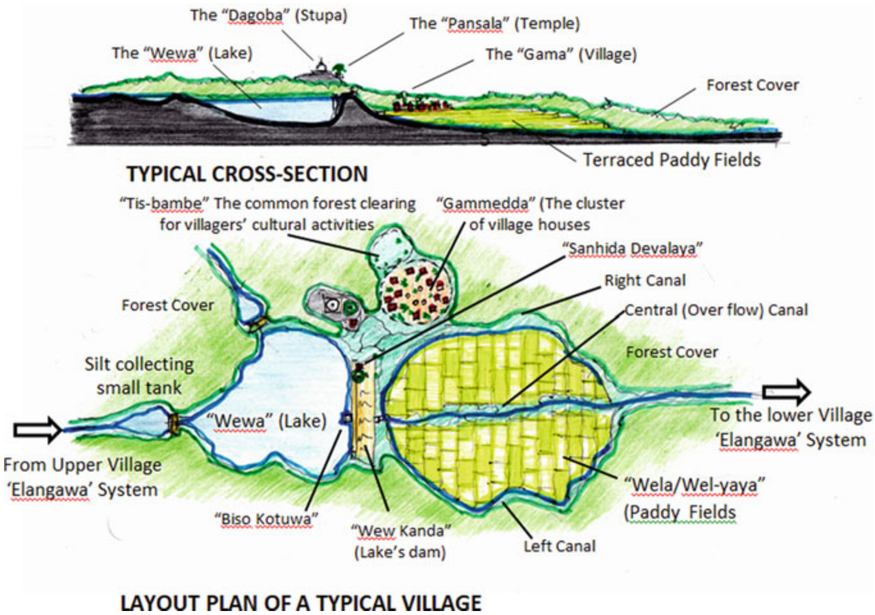

Fig. 9.2 A model village of a vernacular settlement. *Source* Author K. K. L. A. Sylva

According to many respondents, the main feature of a settlement was its lake as depicted in Fig. 9.2. The lake was designed and built in a way that it looks as a part of its natural eco-system with time. According to one respondent 'that is why after thousands of years, some lakes still exist even though no traces of the settlements supported by them are to be found'. Land sustainably in Chena cultivation has been maintained by the use of alternative plots and rotation of type of crops.

These findings are supported by many other authors who have reported the Sri Lankan indigenous communities to be conspicuously prosperous, and self-sufficient and have been an agricultural-based society mastering the art of managing water, land, vegetation, and settlements (Dayaratne 2018; Piyadasa 2009; Brohier 2000). The typical village, 'gama', 'consists of one large rice field, with its appurtenant high lands, used as Chena, and its group of small houses, for the most part, thatched huts of clay surrounded by gardens of various sizes' (Hayley 1923 cited in Mendis 2003, 211).

9.5.2 Sustainable Site Selection

Mostly the valleys were selected as villages near to water sources. The land selected was almost flat, avoiding any harm to the sloping grounds by cutting and filling of slopes. The bottom of the hills is taken as water collection tanks where the upstream has been secured with forest cover for the sustainability of water through water conservation. A forest cover would provide water conservation through rainfall interception, soil water storage and freshwater provision (Biao et al. 2010). The selection of the bottom of the hill with the upstream forest cover ensured clean water for the lake.

Agricultural land is just below the lake where gravity flow of water is used in supplying water for Chena cultivation and paddy lands. These patterns of agriculture are yet prevailing in the villages observed. The gravity flow system minimises the use of energy for the provision of water for the paddy lands. Wetlands for water purification were available in the downstream area, and any contamination was not flowing to another subsystem from one 'Elangawa' subsystem. No additional effort or energy has been used to clean water which flows out of the systems other than wetlands. Observation of the settlements around one or two small village tanks is supported by other authors (Mendis 2003).

As stated by Brohier (2000, 18) 'mastery over climate and terrain was chiefly achieved by the ingenuity of the ancient people, aided by bounteous care of their sovereigns'. This sustainable subsystem was not disturbing another subsystem downstream as nature's circular metabolism, where almost all the output discharges of one system becomes an input for another system, has been used at every possible level in planning. The smooth flow was ensuring the sustainability of the entire living ecosystem.

9.5.3 Water Efficiency and Hydraulic Structures

The stored water by blocking the streams with earth dam constructions and the rainwater collection during monsoons have been sufficient for the entire period of cultivation. Such storage is used for other human activities while allowing the wildlife and ecosystem to sustain. Conservation of water was secured by not damaging the upstream forest cover. Since, the circulation of water after using for agriculture was ensured, the downstream demand was not disturbed by one 'Elangawa' subsystem.

The distribution of the water in large lakes had been done through a unique invention of the traditional Sri Lankan irrigation design known as the 'Bisso-Kotuwa'. The role of the 'Bisso-Kotuwa', queen chamber, had been to reduce the water pressure applied to its main sluice (the king) known as the 'Sorowwa'. In many modern irrigation reservoirs, the water released by its sluice discharges the layer of water at its base. But in the traditional 'Keta-Sorowwa', where a series of short cylinders are stacked vertically on top of the other, the topmost layer of the lake is discharged first by removing the top cylinder. As the respondents explained, the topmost layer of water has more exposure to the sunlight and mixes with more oxygen in the air, and it is more nutritious for crops than the water at the deeper levels of the reservoir.

The water released from the lake is fed to the paddy fields through canals. There are either one or two such main canals, on each side of the lake. They are referred to as the 'Dakunu-Ela' (right canal) and 'Wam-Ela' (left canal). These canals have been constructed along the highest contours surrounding the paddy fields. The water has been tapped out of the canal system artificially and allowed to cascade down the paddy fields. Water flows through the terraced paddy fields and collected at the bottom to a central canal to diverted to the village below. Only one bank has been built in the left and right canals, allowing the outer bank of the water stream to flood and blend into the forest adjacent. The blending allows the surface water from the forest to enter the canal freely and allows the wild animals' safe and free access to drinking water.

The main livelihood of the historical Sri Lanka community is known to be agricultural and associated supporting industries. Water was stored in the village tank (lake) and used effectively for irrigation through canals before it was released back to the downstream. Series of such small tanks were distributed throughout the countryside finally collecting into large reservoirs in the dry zone. The large reservoirs are filled during heavy rainfalls and serve the paddy cultivation during drought. This principle has been adopted following water management practice introduced by the King Parakrama Bahu I '…let not a drop of the rain that falls on this fair land flow to the sea without having served the people' (Mendis 2003, xvii).

Many authors support the observations and findings of this research. As a typical agricultural society, the Sri Lankan settlers located the village or city concerning the availability of water and rich soil for agriculture (De Silva 1996). Landscaping the cities according to their ecology and availability of local resources has been observed in almost all the settlements (Madduma Bandara 2007). According to De Silva (1996), the nine months of dry spell demanded a system of water storage for agriculture and the topography of the island has been used effectively for water storage by constructing earth dams across rivers and seasonal streams. As Brohier (2000) points out, human-made tanks to guard against extraordinary emergencies of the season were made by building intricate systems of dams and dykes in the shallow valleys of the plains. Water 'was stored during the heavy rainfall and used to irrigate a thirsting land during the drought' (Brohier 2000, 18). The feeder canal to the larger tanks has been fed by perennial rivers which are flowing from the central mountains. The canals have been performing a dual role: keeping the tanks full supplied and supplying water for 'ribbon cultivation' (Brohier 2000, 19). River diversion structures are found to divert water into dry zones. Although the dams of the small tanks are made of the earth soil, the river diversion structures are found to be made of stone (Mendis 2003). As stated by Mendis (2003, 97) 'water was first diverted into the permeable soils on the valley sides for the cultivation of non-rice perennial and seasonal other field crops, and drainage water re-used for the cultivation of rice in the impermeable low humic gley soils in the valley bottoms'. According to them, this represents a water and soil conservation system for a wet-dry seasonal tropical environment, comparatively quite different to the summer–winter alternative of temperature agriculture what was directly transferred from the West by agri-business demands in the recent past in the country.

As reported by other authors, most of the large reservoirs have been built in dry valleys away from perennial rivers and interconnected with channels to maintain water supply throughout seasons for agriculture in dry zones (Mendis 2003). A chain of small village tanks which presently termed as ‘cascades’, were fed by the overflow from a relatively large tank higher up on each chain in the dry zone. Lately, the four-stage hypothesis of R. L. Brohier, which has been influenced by Kennedy’s concept of the less efficiency of small tanks, had led to submerging of the small village tanks for the evolution and development of irrigation systems replacing with large tanks or reservoirs (Mendis 2003). The traditional village life connected with these small village tanks has been ignored during this change. As stated by Mendis (2003, 100) ‘irrigation engineers, however, chose to ignore these other aspects of traditional village life in which the village tank had a central place, and focused their attention on the hydraulic and hydrologic aspects that they understood best’. The inefficient small tanks, as identified by the recent concepts, were replaced by more efficient large reservoirs in some parts of the country. The submerged small tank cascade system is a sustainable system that has survived political and social upheavals and in continuous operation for over 2000 years (Mendis 2003).

9.5.4 Sustainable Architecture and Features of Settlements

In the sustainability of vernacular settlements, architecture plays a major role. Moving from hunting to agriculture, the dwelling place of humans changed from cave to house. The very first shelter built is believed to be simply a supported roof at the entrance of the caves they already lived.

The first houses in villages are simple rectangular buildings with four or six timber posts and a two-way sloped roof which are yet visible in some locations. The plinth was made high to prevent creeping or crawling wild animals from entering the houses. The raised plinth around the house was known as the ‘Pila’ meaning a long narrow verandah and traditionally used for sitting and sleeping. The traditional people lived outdoors mostly as their living was based on farming. According to the respondents, they did not ‘live-in’ their houses, but, rather ‘lived-around’ their houses. This type of living didn’t need large spaces inside houses. Building a house was generally known as building a ‘Geyak-Dorak’ which means a house-door combination where the door included the outer space of the house. The inner house which was normally a dark space used only for the females and the children for sleeping purposes at night. Figure 9.3 illustrates the components of a village house.

9.5.5 Green Material Usage

All the materials used in village constructions were found from the vicinity of the village. As the need for such material was minimal due to the slow growth of the villages, and the simple, competition-less lifestyles of its people, the effect on the environment in using raw material was negligible. All the materials used are

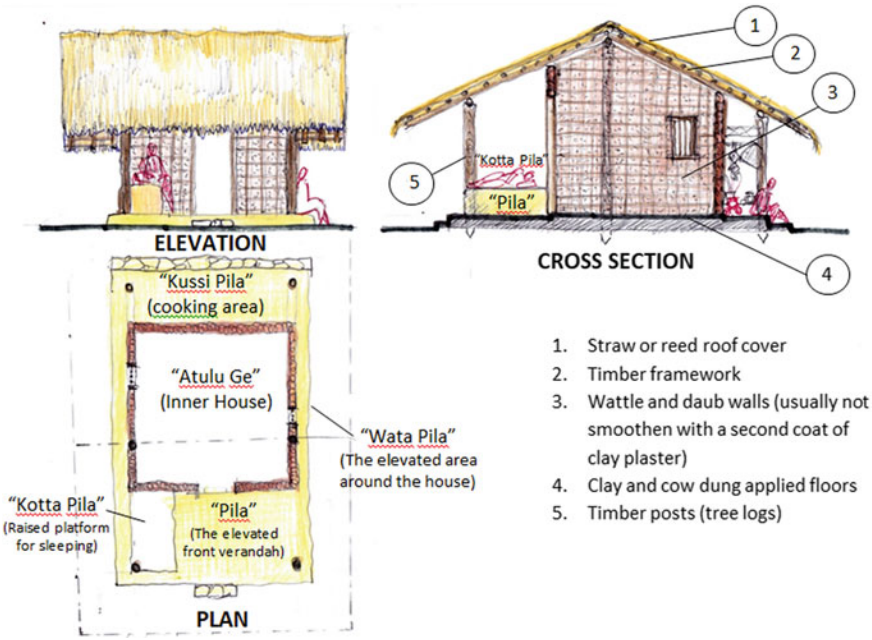

Fig. 9.3 Components of a village house. *Source* Author K. K. L. A. Sylva

biodegradable, and there is no environmental pollution associated with this lifestyle of people.

The walls are built with clay reinforced with bamboo. The common village house walls are not smoothened, exposing the bamboo sub-frame. Referring to the roughness of the walls, they are called 'Katu-Meti' walls. Rarely a second layer of mud plaster is applied on to the 'Katu-Meti' walls to make the walls smooth and even. According to many respondents, only religious buildings and houses of the elite are smoothened and whitewashed. The roofs of the houses are covered with straw or reed. Cadjan, woven coconut leaves, are also used to cover the roofs. Clay roof tiling was used only for public and religious buildings. The floors of the houses are finished by applying a mixture of clay and cow dung, which is found to be providing a healthy environment for the occupants (Ghamande et al. 2016). Seneviruwan (1998) supports the above observation of house building. As recorded by Seneviruwan (1998), the wooden posts to support the walls are selected from special types of timber to prevent any attacks from white ants and insects. According to Seneviruwan (1998), the timber is taken from trees cut on days where there is no moonlight to have the maximum strength of the tree. Different types of trees such as 'Hora' for waterlogged areas, 'Wal-del' for wooden members exposed to diverse weather conditions and Milla less damage from termites and decay are selected appropriately.

9.5.6 Co-existence with Nature and Culture

Similar to the architecture in the ancient lifestyle of the vernacular settlements, all other activities such as transportation, farming, etc. have been highly eco-friendly. The traditional farming practices have been co-existing with nature. While preventing any ill effects, the ecosystem has also been preserved to the fullest potential for the survival and sustainable lifestyles of people and wildlife. The village lake and associated irrigation system have been designed to function as a separate eco-system, that gradually blends to nature. It has its catchment area, ancillary tanks and canals that fed the main lake. Finally, allowing water to flow to another sub-system without contamination by cleaning water through wetlands. Water efficiency and life built around water systems are dominant in Sri Lankan settlements. Throughout history, many examples could be found on active and passive adaptation to nature although the initiating of activities to use resources effectively seems as the dominating nature.

In village planning, special attention has been given to preserve nature by allowing forest reservations for the conservation of water and wildlife habitats. Most of the maintenance work related to the irrigation system and water management has been done collectively, with the participation of all the villages. According to Dalupota (2003), the managing and diverting of water from stretches of paddy fields to another system has been monitored and administrated by the chief of the field 'Vidane'. To secure the harvest from invading flocks of birds, a special area of paddy fields has been reserved and collectively cultivated by all farmers know as then 'kurulu paluwa'(Dalupota 2003; Leach 1961), to be used by the birds. 'Kurulu' is birds and 'paluwa' means destruction; allowance for the destruction by birds. This area was generally located at the upper edge of the paddy fields, adjacent to the forest patch. The Vidane, after observing the migration patterns of the flocks of birds flying out of the forest, decides the location of the part for the birds. Although the villages mention reservations, the management practises are not very visible at present.

Another common paddy field that all the villagers worked together has been the 'pin kumbura', the paddy field for charity, of which the harvest was sent to the village temple. A part of the village chief's job was also to manage the water and land resources during the dry period. According to the availability of water stored in the lake, and the seasonal predictions of the monsoon rains, the Vidane decides on what type of paddy to be sewed, on what areas of the paddy field. Once renowned, the granary of the east (Lankanewpapers 2008), around 2000 varieties of paddy has been available in the past. Their time to harvest and the amount of water required during the process has been varying according to the types of paddy. The agricultural chief, Vidane, was responsible to preserve seeds of such paddy varieties and distribute them among farmers.

When the amount of water was not adequate to cultivate the whole filed, the Vidane is supposed to intervene and redistribute the paddy fields closest to the canal among all farmers proportionately to their original owned or cultivated land areas. When the lake went almost dry, the Vidane had even the right to demarcate and distribute the land within the dried-up lake among the farmers of the village. This type of cultivation done in the mud –plains of a dried-up lake is known as ‘Mada-Thaulu’ paddy cultivation. Anyway, considering the needs of water, for people and wild animals, the Vidane also had the right and responsibility to declare the deepest area of the dried-up lake as a protected area, prohibiting anyone from using that water for cultivation, or catch the last few fish trapped in the last puddle of water. This declaration of the prohibited area is made by erecting three posts with a particular type of twig tied to the upper end of these posts; the process is known as the ‘Ana-Bole’, restriction order (Dalupota 2003).

9.6 Recommendations

Many aspects of vernacular settlements discussed in this paper provide evidence for sustainable settlement patterns of the ancient people. Some concepts could be extracted and reconsidered for future planning and management of cities. The main feature of these settlements that could have ample benefits for future planning is the ‘whole-system-thinking’ rather than planning for isolated units. It is observed that the inputs and outputs of one subsystem relate with the predecessor and successor subsystems using the nature’s circular flow of metabolism. The collection of water at a later channel from one subsystem and cleaning through natural wetland systems before diverting to the next subsystem is a very important phenomenon that could be reframed in modern systems.

Green material usage, such as cow dung, observed in vernacular settlements, is supposed to have many health and environmental benefits. According to Ghamande et al. (2016), cow dung is found to help kill microbes and bacteria, and helps in keeping warm in winter and cool in summer, due to this antibacterial property it helps killing microorganisms, is heat resistant and considered antiseptic, purify the environment, protects from UV radiation, acts as a coolant in addition to its cost-effectiveness in using as paint. Using appropriate wood types for different climatic and contextual conditions without contaminating the environment by wood preservatives are noticed.

Future planning of cities could adopt co-existence with nature from vernacular settlements. Having streams around the villages would allow wildlife to access water sources and prevent them from entering the residential zones. Concepts such as ‘Kurulu Paluwa’ will prevent the birds from attacking the main harvest. Reserving a share of the harvest for wildlife at the boundary of villages or settlements will maintain the balance of the ecosystem while people have their share for survival. Protecting the wildlife would protect the biodiversity of the Asian region as well as contributing to the eco-balancing of the whole system. Maintaining the topography would preserve the ecosystem by not disturbing habitats living in the zones of rich biodiversity.

Many other features of vernacular settlements can be taken as a model for future city planning. The 3R concept (Reduce-Reuse-Recycle), Zero-waste concept, could be traced in vernacular systems. The respect for nature and natural resources have been the main feature in traditional systems. In modern days, worshipping the sun, trees and stones may be considered primitive. Worshipping the natural phenomena kept the human close to nature. Collective decision making, following social structure and order, obeying the experienced chief and teamwork are observed in these settlements. Setting examples for future generations, considering not only physical and economic development but spiritual development are a special feature to reconsider. Simplistic, minimal lifestyles, the wisdom of living with 'natures-laws' maintained the sustainability of the communities in traditional settings.

9.7 Conclusions

Sustainable vernacular settlements with a rich history of civilisations could provide context-specific examples for future development. However, at present, with the application of transferred practices and technology in these contexts, many detrimental effects have been noticed. Most of these technologically advanced applications are not verified for context-specific factors for appropriateness. This research study reinvestigates sustainability concepts in city planning such as village planning and management, sustainable site selection, water efficiency, sustainable architecture and settlements, green material usage, and co-existence with nature and culture in vernacular settlements. The most eminent features in vernacular settlements, such as whole system thinking, using circular metabolism of nature for resource reduction and pollution prevention, green material usage and coexistence with nature, could be highlighted for future planning of cities.

Annexure: Interview Guide

Interviews were started with one question for the qualitative study and then continued with probing questions as and when required.

Primary Question:

Could you explain to us the traditional planning of a village and the settlement patterns of your village?

Probing Questions:

1. How old do you think your village is?
2. Do you know why this particular site has been selected for the village?
3. How important is the village tank for your village's lifestyle?
4. Do you know who built the village tank?
5. Who is responsible for the water distribution and maintenance of the tank?
6. Are you aware of any external water management systems that affect you?
7. If yes, Are they functioning well yet & are you a part of its management?
8. How is the land divided and zoned in your village?

9. Could you explain how the houses of your village are constructed?
10. Are there any specific standards you follow in putting up these structures?
11. What are the materials commonly used in constructions?
12. Have these construction methods been the same during your past generations?
13. Is there any specific person leading the common activities of the village?
14. What is the purpose of having a village temple?
15. Is there any connection between the village tank and the Dageba of the temple?

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Chapter 10
Sociability—A Precursor to Social Sustainability

Aparna Sathish and Tina Pujara

Abstract Humans tend to seek out pleasant social relationships, to build kinship and to establish a sense of belonging to a social group. Sociability, as a quality, is based on the need of people to affiliate and interact with others. As suggested by a vast body of literature, fulfilling the requirements of sociability is one of the key functions of the public realm. This study builds upon research into the design of public spaces by addressing the tangible parameters of Sociability. A multi-faceted concept, Sociability is a result of a combination of factors, tangible and intangible, that brings the community together by creating spaces we move through and linger within. Sociable public spaces play host to a variety of related activities that encourages people to come together and interact, irrespective of age, ethnicity, cultural or economic disparity; thus, resonating with one of the three pillars of sustainable development, Social Sustainability. The pillar that holds the community together, Social Sustainability has associations with wide-ranging, multi-dimensional concepts, tied together by the common thread of social network. While there is a wide array of research attempting to clearly define Social Sustainability, investigations into tangible urban design parameters that would aid in realizing the aspects of Social Sustainability are still in its nascent stages. This paper draws parallels between the tangible parameters of Sociability of the public realm and the sub-themes of Social Sustainability, hence establishing that achieving Sociability takes us one step closer towards enabling Social Sustainability.

Keywords Sociability · Social sustainability · Public realm

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10.1 Introduction

The process of socialization, one of the simplest elements of human life, is crucially important by establishing communication and social interaction between the users of any reachable architectural public and common spaces (Fergas 2000). The ability to participate effectively in interaction with others both in private life and in public and professional life enriches the sense of belonging to the community and creating social cohesion within a community.

A socially sustainable society constitutes empowered citizens, enjoying a stable social structure, with equitable access to all resources that would support the desired quality of life, while maintaining the cultural identity evolved over hundreds and thousands of years to enable a sense of belonging and pride of citizenship among its citizens; as elaborated by the Brundtland Commission Report. Therefore, social sustainability is about people's quality of life, individual and collective well-being, now and in the future.

The quality of the public realm brings the community together by creating space irrespective of age, ethnicity, cultural or economic disparity. Sociability is the primary role of public space and public space is an essential arena which provides opportunities for individuals and communities to develop and enrich their lives (Mehta 2014). Intimately linked to the ideas of equitable and universal access, the common ground, and shared amenities; this role of the public realm, of being sociable, is directly connected to the requirements of a socially sustainable society.

10.2 Social Sustainability

Sustainable development is the 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, Our Common Future 1987) The concept of Sustainable Development is itself viewed in three dimensions, Environmental, Economic and Social (Fig. 10.1).

The social component of sustainability, focusing on nurturing the community to ensure the sustained well-being of the residents, involves social cohesion, participation, equity, empowerment, cultural identity, institutional effectiveness, and the like. We can summarize that social sustainability is concerned with communities' quality of life, and their capacity to function effectively in future. These ideas are underpinned by social capital and social cohesion, positive social and psychosocial processes where residents are drawn to cooperate in networks, in spite of differences, and think and feel positively about the people among whom they reside, and the places where they live. "Development (and/or growth) that is compatible with harmonious evolution of civil society, fostering an environment conducive to the compatible cohabitation of culturally and socially diverse groups while at the same time encouraging social integration, with improvements in the quality of life for all

Fig. 10.1 Three dimensions of Sustainability. *Source* Elborombaly (2015)

segments of the population" (Polese and Stren 2000). "Social sustainability is about accessibility; intergenerational equity and continuation of culture; A life-enhancing condition within communities, and a process within communities that can achieve that condition, that incorporates equity of access to key services (including health, education, transport, housing and recreation), as well as equity between generations," (McKenzie 2004) "The concept of Urban Social Sustainability is also associated with the pursuit and realisation of Social Equity, Social Inclusion and Social Capital. Social networks are identified as the common thread between these concepts." (Bramley et al. 2009). "A process for creating sustainable, successful places that promote well-being, by understanding what people need from the places they live and work. Social sustainability combines the design of the physical realm with the design of the social world—infrastructure to support social and cultural life, social amenities, systems for citizen engagement and space for people and places to evolve" (Saffron Woodcraft 2012).

The definitions of Social Sustainability leads to the inference that understanding the unexpressed requirements and intangible facets of the social and cultural identity of the society, and integrating social amenities, infrastructure, and associated resources to enable a compatible cohabitation, interaction and successful integration of socially, economically, culturally and even racially diverse groups into a social whole, that can sustain itself, forms the crux of the solution. A wholesome solution would be the creation of spaces that would encourage the community to be brought together, and sustain its identity, culture, and social structure while addressing the requirements of the changing urban living conditions.

Taking this discourse forward, it was suggested that Social Sustainability comprises two main dimensions, (i) Social Equity and (ii) Sustainability of the Community. While the first dimension basically deals with the aspects of urban form focussing on access to services and opportunities such as local services, public transport and affordable housing; the second-dimension deals with the broader aspects that include social interaction, satisfaction with the home and neighbourhood, safety, and participation (Bramley et al. 2009; Tsouroufor, 2000).

This is further reinforced by the extensive studies done by the Berkeley Design Group wherein three major dimensions are derived for urban social sustainability, namely, social and cultural life; amenities and infrastructure; and voice and influence. Here too, in amenities and infrastructure, the components highlighted are community space, transport links, distinctive character, local integration, and adaptable space; further supplemented by the social and cultural life dimension focusing on local identity, facilities and links with neighbours.

Summarizing the research into Social Sustainability from architectural and urban design points of view, sound spatial configuration promotes the uses of public spaces and encourages strangers to interact, i.e., the existence of the public realm. These, in turn, foster the development of positive tolerance, social integration, sense of community and unity, and public trust among people in the neighbourhoods and throughout the city. This is the social capital for community rebuilding and a prelude to the building and rebuilding of a more socially sustainable city and community.

10.3 Public Realm

Public realm comprises streets, squares, parks, green spaces and other outdoor places that require no key to access them and are available, without charge for everyone to use. A good public realm consists of spaces that enable neighbours to meet, spaces that can be adapted and used by various local groups, spaces for children, teenagers, youth, older people and families, and, attractive public spaces: green spaces and plays areas.

A more thorough understanding is required to get clarity regarding the variety and quality of spaces and the scale it encompasses.

- **Streets**: The project for public spaces, New York, states that streets should not be just arteries for vehicles, but a hierarchy of different street types, from quiet neighbourhood lanes to major boulevards—all of which will become the places of the city's future.
- **Squares and Plazas**: These are multi-use destinations and a great square is a focal point of civic pride and helps to make citizens feel connected to their cultural and

political institutions. These are places where citizens can find common ground—where ethnic and economic tensions can be overlooked and disparate sectors of society can come together peacefully.

- **Parks and Green Spaces**: A great urban park is a safety valve for the city, where people living in high density can find breathing room.

The Public Realm fulfils a variety of roles in keeping the community together, such as reflecting the community's local character and personality; fostering social interaction and creating a sense of community and neighbourliness; providing a sense of comfort or safety to people gathering and using the space; and, encouraging use and interaction among a diverse cross-section public.

According to the United Nations Habitat Report, urban population is set to increase by 72% between 2000 and 2030. Urbanization being a powerful driver for economic, social, political, and cultural transformation; the need for bringing people together and forming a cohesive, equitable, inclusive and sustainable society is of prime importance. Social opportunities in cities are enabled by dynamic relationships between the space, the built-form, and the functional roles played, and at times, unexpected factors, both tangible and intangible. The importance of public spaces in fostering these relationships is further witnessed by the fact that under Sustainable Development Goals 11: Sustainable Cities and Communities, one of the targets is to provide safe, inclusive & accessible, green & public areas.

10.4 Sociability and the Public Realm

The simplest element of social life of human is social interaction. Individuals have an innate tendency towards initiating social relations and due to the same fact, they provide situations to experience their social relations (Talebi 2005). But what is being observed in today's societies is the decrease in individuals' level of relations with each other. An increase in the size and realm of cities, speed, and density, civility, citizenship and social relations, as basic urban principles, are weakened. Accordingly, the collective sense of local communities and emotional attachment on one location are disappearing (Huffman, n.d.).

It is widely assumed that the intensity of social interaction is very much related to design elements, proposed activities and layout patterns (Talen and Ellis 2002). Generally, it is seen that a common area for passive and active recreation at the residential level and pedestrian-oriented neighborhoods increase interaction within the community and provides opportunities for people to interact with society. Design is a key to create sustainable development by improving or enabling social equity, economic vitality and environmental responsibility (Chan 2008).

A sociable place is one where people meet each other and take people when they come to visit. Sociability is a difficult quality for a place to achieve, but once attained it becomes an unmistakable feature. When people see friends, meet and greet their neighbors, and feel comfortable interacting with strangers, they tend to feel a stronger sense of place or attachment to their community—and to the place that fosters these types of social activities. (PPS, n.d.).

Sociability, as a quality, is based on the need of people to affiliate and interact with others. A multi-faceted concept, sociability is a result of a combination of factors, tangible and intangible, that brings the community together by creating spaces we move through and linger within. Sociable public spaces play host to a variety of related activities that encourages people to come together and interact, irrespective of age, ethnicity, cultural or economic disparity. Sociability is also stated to be a difficult but unmistakable quality for a place to achieve, when people see friends, meet and greet their neighbors, and feel comfortable interacting with strangers, they tend to feel a stronger sense of place or attachment to their community—and to the place that fosters these types of social activities (PPS, n.d).

While sociability has been discussed as a crucial quality of successful public spaces, it has been brought to the forefront as an essential component of place-making with Whyte's (1980) work on social life of small urban spaces and by the continuing project for public spaces. The public realm and the roles it fulfils need to be understood and analysed in detail before attempting to identify how the design of the public realm can promote sociability. PPS further lists the sub-themes that fall under sociability: diverse, neighbourly, cooperative, pride, friendly, interactive, welcoming, social networks, evening use, used by women, children and elderly.

Thus, we can see that the major themes associated with social interactions such as such as social cohesion, social networking, community connectivity, participation, adaptability, diversity and inclusion, etc., are included within the umbrella of the quality called sociability.

A selected literature study was undertaken to better understand the concept of sociability and how it occurs in the public realm. The literature study, predominantly from the works of Nestor Hernandez, Vikas Mehta, Jan Gehl, Lyn Lofland and William Whyte, aids in understanding the different perspectives under which investigation into how the public realm encourages sociability, and the different factors that enable social interactions and community connections in said space. These factors further guide the study into the various categories of interactions, networking, and participatory activities that make up the creation of a vibrant, sociable space.

According to Jan Gehl, as stated in life between buildings (Gehl 2011), spaces will encourage social activities only if they offer:

- Protection against traffic and accidents, crime and violence, and unpleasant sensory experiences
- Opportunities to walk, stand/stay, sit, see, talk and listen, play and exercise
- Enjoyment in terms of scale, positive aspects of climate, and positive sensory experience.

Gehl further elaborates that fulfilment of these requirements ensure that three types of activities happen in public spaces, namely.

- Necessary activities including those that are more or less compulsory, everyday tasks and pastimes.

- Optional activities are those pursuits that people can participate in if there is a wish to do so and if time and place make it possible. These activities take place only when exterior conditions are favourable, when weather and place invite them; and
- Social activities that are all activities that depend on the presence of others in public spaces and evolve from activities linked to the other two activity categories. Social activities include children at play, greetings and conversations, communal activities of various kinds, and finally—as the most widespread social activity—passive contacts, that is, simply seeing and hearing other people. Social activities are indirectly supported whenever necessary and optional activities are given better conditions in public spaces.

Lofland (1998), states that that the kind of possible interactions that people can experience in an urban environment is related to the way in which they perceive the public space. Looking at the way in which the space structures human interactions, Lofland determines three progressive steps:

- How interactions occur;
- Who interacts with whom;
- The content of interaction.

For example, while in the plaza, the interactions among people are formal; in a market, the same interactions occur in a more informal way. She further elaborates that, the control on the different human interactions can be moved in a larger scale looking at what Lofland call the “monitoring behaviour.” Its purpose can be described as a way to guarantee “controlled interactions” among people which is achieved by the design of the said spaces.

Whyte (1980) has conducted the most important studies of sociability of urban open spaces using observations and including them in his findings in ‘The Social Life of Small Urban Spaces’. He stated that people need open spaces so they can accomplish their social activities. Whyte concluded that people come together in an urban space not to escape the city, but to partake of it. There is a need for some people to spend their leisure time in urban spaces, and in the majority of the cases, this happens in plazas. Whyte added several factors of a successful plaza:

- The plaza should have spaces for people to gather.
- The plaza should provide spaces where an accumulation of people exists and lets them see others and imitate their actions.
- The existence of enough open spaces in big and small cities.
- The plaza can bring a sense of community to these cities.
- The plaza whenever successful, it is more likely to attract people.
- The people tend to imitate others.

Project for Public Spaces—New York, that carries forward work on urban public spaces based on the principles proposed by Whyte, state that sociability occurs if the public spaces allow for:

- Choice & chance meetings
- Group interactions

- Personal recognition & visual interactions
- Sense of pride
- Frequency of use
- Variety & diversity of users
- Sense of belonging & responsibility.

Vikas Mehta, in ‘Evaluating public space’, states that sociability is the primary role of a public space. He highlights the social role of public space and suggests “that public space is an essential arena which provides opportunities for individuals and communities to develop and enrich their lives”. Four social roles are identified for public space:

- An arena for public life;
- A meeting place for different social groups;
- A space for the display of symbols and images in society;
- A part of the communication system between urban activities.

Having effectively brought in the concepts of diversity, inclusivity, imageability, community identity, and community connectivity through these four roles, a further three aspects of neighbourhood public spaces are also discussed by Mehta. He suggests that it is the engagement between the places that has special meanings for the community, the elements of the behavioural environment (land uses and their management), and the elements of the physical setting (form and space characteristics) that creates a comfortable, pleasurable, meaningful and therefore desirable environment for people.

10.5 Sociability and Social Sustainability

Sociability represents the everyday connections, interactions, bonds, memories and associations within a community. Urban sociability exists as a total of interactions in a space people identify with and has a sense of belonging to, and that makes the community exist in perpetuity. This means urban sociability is a combination of robust communities, good places—neighbourhoods, districts, suburbs, free-standing towns—and forms of social life that occur in public places. In turn, this means where urban sociability exists, we can posit, community life and the sense of place and local identity will tend to be stronger.

Sociable public spaces play host to a variety of related activities that encourages people to come together and interact, irrespective of age, ethnicity, cultural or economic disparity. Sociability is also stated to be a difficult but unmistakable quality for a place to achieve, when people see friends, meet and greet their neighbours, and feel comfortable interacting with strangers, they tend to feel a stronger sense of place or attachment to their community—and to the place that fosters these types of social activities (PPS, n.d). The functions of creating identity in the space, generating a sense of place and belonging to the space, flexibility and enhancing environmental quality can be effective in enabling sustainability of the space.

Referring to one of the earliest theories of Urban Social Sustainability, Chiu (2003) states a people-oriented interpretation of the same, which focuses on maintaining levels of social cohesion. A socially cohesive society would be one in which the citizens are able to enjoy a vibrant social life. Social life can be elaborated as a result of a variety of factors starting from how people co-exist, their quality of life, relations between different parts of the neighbourhood, sense of belonging, identity, and safety. This theory resonates deeply with the qualities of community living that are enabled by sociable spaces.

This paper attempts to draw parallels between the tangible parameters of Sociability of the public realm and the sub-themes of social sustainability. In order to identify the tangible parameters of sociability, this paper refers to the literature review undertaken on sociability and attempts to study it within the established framework of a study done by Nestor Hernandez.

Hernandez (Hernandez 1986) stated eleven hypotheses synthesized from the research conducted by William Whyte, Suzanne and Henry Lennard, and Jane Jacobs to analyse the sociability of two plazas in Bogota, Colombia. He defined each hypothesis in relationship with the three levels in which the plaza is described. The three levels are level of surroundings, level of edge, and level of stage.

- Level of surroundings elaborates the need for having a sufficiently dense concentration of people in the surrounding area; a mixture of activities in the surrounding neighbourhood or district; high perceptual visibility; and heavy pedestrian flows along the bordering streets and the intersection of those streets.
- Level of edge states the importance of a good location on an active street corner or near shopping centres and restaurants; the need for a gradual transition between street and plaza; and the importance of providing the users with a sense of enclosure.
- Level of stage, the venue of social interactions, that is, the public space itself should have adequate sitting places; be a centre for festivals, celebrations, street entertainment, markets, and selling food; have a focal point in an established centre stage with fountains, statues, or other physical elements, which entice people into the life of a plaza; and utilize, via appropriate design interventions, the natural elements namely; Sun, wind, trees, and water, provide human comfort, which in turn strengthens the plaza's sociability.

Based on the understanding of sociability from the literature reviewed, the parameters it involves and the conditions to be satisfied by public spaces to enable sociability, a further investigation was made into the urban design and built component design elements, which would be the tangible interventions that can be made to enable conditions conducive to the fulfilment of said conditions. This process was done after consideration of the requirements of sociability as understood from the broader terms it encompasses, namely social interactions, social cohesion, social networking, community connectivity, participation, adaptability, diversity and inclusion, as summarized from the study.

Urban public spaces that are adaptable, resilient, and inclusive, can accommodate the requirements of different users and user groups, allows for personalization, offers a variety of sub-spaces, and allows for temporal and temporary transformations; become hubs of social activity that brings together all sections of the community, exposing them to differences, and allowing acceptance and awareness, thus becoming a key design solution towards making a socially sustainable space. Looking into the broad literature research carried out to understand the qualities of successful public spaces as identified by various experts, ranging from Jane Jacobs (1961) to Melissa Currie (2016), in the field of urban design over the years (Sathish and Pujara 2018), a consolidated list of parameters could be arrived at, which in turn could be classified under a framework consisting of both physical and social components. These parameters of the public realm that make it a successful, sociable, space was correlated against the indicators of social sustainability to establish which aspects account for the achievement of requirements of social sustainability.

The physical components are grouped under the framework of the three levels of surrounding, edge and stage adapted from the work of Nestor Hernandez. Physical components of sociable spaces that contribute to the social sustainability of the community, and thus the city can be summarized as below:

Level of Surroundings: The level of surroundings is the one that relates to the buildings, activities, and elements that create the district, neighbourhood, or part of the city that surround the space. It is important to understand that these surroundings are what gives proportion, character, identity and life to the space; by the people who use it and by the environments that enclose the space.

- **Context and activities in the neighbourhood**: Introducing design elements that would address the requirements of users of not only the space, but of the larger context and the activities supported within the socio-cultural infrastructure present in the neighbourhood are crucial in integrating the space to the community.
- **Permeability and Visibility**: Permeability or connectivity describes the extent to which urban forms permit (or restrict) movement of people or vehicles in different directions. Physical and visual permeability increases the chances of people coming to the space and increased knowledge about the space by potential users. It is also important that landmark elements be introduced as a part of the design that allows for imageability as well as visual permeability and recording the space in collective community memory.
- **Connections—magnets and generators**: The ‘Project for Public Spaces’, that takes forward the work of Whyte, emphasises the importance of ‘The Inner Square & The Outer Square’ (streets and sidewalks around a space and the buildings that surround it) and ‘Reaching Out Like An Octopus’ (extending into the surrounding neighbourhood, activities that entice people towards the space) when it comes to the connections between a space and its surroundings. The more the connections, the more vibrant and sociable the space becomes, also due to the visibility this affords.
- **Streets and pedestrian flow**: Streets that surround the space, as well as the intersection of those streets, must have heavy pedestrian flow. This way the space can

become an effective space for people to socialize. The number of people, who are walking next to the space, influences the sociability of the space. The mixture of activities that take place in the surroundings of the plaza and the location of these activities determine the number of people walking. The routes and schedules of the people who go from place to place determine the walking paths.

Level of edge: The level of edge is the one that relates the space to the immediate surroundings. The boundaries created by streets, sidewalks, and the intersection between the surroundings and the space create an environment that invites people to go to the space or provoke people not to get close to the space. The immediate surroundings also set the stage for a variety of extended activities that link the space to its context, and letting it become a part of the community memory.

- **Location of the Space**: The location of the space is very important and there are two key factors for a space to have a high number of users including its location on a busy corner and its proximity to commercial and eating areas. The assumption here being that the space will act as an extended area for the shopping and dining activities undertaken, and that this would attract more people into using the space as a transitory halt as well, and not just as a destination space.
- **Transition from the street and access**: Claire Cooper (Marcus and Francis 1997) asserts that the transition between the space and the street should be subtle. The gentle transition from the surrounding spaces allows for activities to merge and spill over, as well as the ease of access for all segments of the users will allow it to be utilized to the maximum.
- **Interactions with edge spaces, built environment and activities**: These aspects have evolved as one of the most crucial elements in ensuring sociability and social sustainability of a place. No open space can exist and sustain as a stand-alone piece of property. Inter-connections with spaces around it, especially spaces that also serve the collective recreational, and socio-cultural needs of the community, is essential in enabling the space to integrate itself within the fabric of the community. This will allow mutual spill-over of activities, and thus strengthen the role of the public space in enabling interactions and community connections.

Level of Stage: The level of stage is the one that relates to the public realm itself and its elements that form the stage of the space. In this case, the people create the social environment that causes the space to be alive, while the physical setting including the design elements set the stage for the social activities to occur.

- **Sitting Spaces**: Sitting places are very important elements in a successful urban public space, and they should be adequate and comfortable. Whyte has elaborated in his study of small urban spaces the importance of seating and considers the following as some of the parameters that has to be addressed when it comes to seating: amount of seating, size and design of the seating, arrangement of green areas for informal seating, usage of comers as seating, density of people that the seating arrangement can support, moveable chairs, arrangement of the loud and quiet areas, provision of shaded areas for seating, food vendors, usage of lighting.

- **Activities within the space**: Different activities are very important for a lively public space. Those activities, which include festivals, celebrations, streets entertainments, shopping, and eating places, are an important factor for bringing people together. Hence, it is important that the infrastructure and the design of the spaces be conducive to host a variety of events and activities in the space.
- **Central feature, pauses and focal points**: The central feature of the space is a crucial factor for its success. This feature, which may be a fountain, a statue, or any other physical element, helps the user to identify with the space and also becomes the identity of the space, which remains in collective memory, and gets referred to when the space is described to people unfamiliar with the space. It helps develop a sense of belonging to the space as well. In most ways, the central element is similar to the landmark element within the park, some.
- **Variety of sub-spaces**: Variety of sub-spaces within any urban public space allows for various activities to happen at the same time, thus increasing the liveliness of the space, and promoting different social groups and age groups to visit and enjoy the space, thus promoting the sociability, and social interactions in the space.
- **Flexibility and robustness**: Flexibility of the spaces to accommodate any type and size of gathering is critical to its success. Also, to be considered is its ability to address the changing needs of the society and keep updating itself, organically or in a planned manner to accommodate requirements of the younger generation in order to maintain linkages between the community and the future stakeholders, thus becoming an enabler for social sustainability.
- **Elements of Nature: Wind, Sun, Trees, Water**: Two of these elements (wind and sun) relate to the manipulation of the climatic conditions; while the other two (trees and water) are natural elements of design. These elements put together through creative design can give human comfort and strengthen the space's sociability.
- **Amenities, Maintenance, Safety and Security**: The infrastructure provided, their upkeep and maintenance, as well as the assurance of safe and secure use of the space is of utmost importance in terms of making the space inviting to all age groups, social groups, and genders.

The social component, as derived from the literature reviewed on focuses on the activities that happen in the public realm, as elaborated by Gehl, as well as the understandings from the parameters summarized from the research by Mehta and Lofland into sociable, successful public spaces. The social components are:

- **Optional and social activities**: Jan Gehl states that optional activities are those pursuits that are participated in if there is a wish to do so and if time and place make it possible, when exterior conditions are favourable, when weather and place invite them. It is particularly important for a vibrant neighbourhood since almost all recreational activities fall in this category. Social activities are all activities that depend on the presence of others in public spaces, evolve from necessary and optional activities. These include children at play, greetings and conversations, communal activities of various kinds, and finally, as the most widespread social activity—passive contacts, that is, simply seeing and hearing other people. And to support this, the space has to be a pleasant place in every respect with the maximum number of advantages and a minimum of disadvantages offered physically, psychologically, and socially. The space should offer protection from crime, protection from vehicular traffic, protection from unpleasant weather, climate and outdoor activity patterns year-round, aesthetic quality, sense of place, lively streets.

- **Variety and diversity**: Many leisure activities take place in public spaces where people are co-present with strangers and, although encounters between strangers have been characterized as brief and functional (Lofland 1998), these interactions can be meaningful. Through these encounters, people are confronted with differences that can lead to contrast or even conflicts, as well as new social ties or ways of looking at things. It can lead to social cohesion and stimulate feelings of comfort. This is one of the core factors contributing to the aspect of adaptability, as to how diverse facilities are accommodated in the space, and the variety of activities that encourage them to visit the space.
- **Inclusivity**: According to Vikas Mehta, inclusivity of a space can be measured according to the presence of people of diverse ages, different genders, diverse classes, diverse races, diverse physical abilities; range of activities & behaviours; opening hours; perceived openness and accessibility; and perceived ability to conduct and in most rating participate in activities and some events in space.

10.6 Conclusion

Our society is an ever-evolving entity. Architects and urban designers design spaces where life happens, sets the stage for human interactions to happen, at all scale and between all varieties of stakeholders. Hence it becomes a matter of extreme importance that the spaces we design take into consideration the ever-changing needs of the society, keeping in mind the historic, cultural and social identity while addressing the anticipated necessities of the future generation. This is the crux of the concept called Social Sustainability.

The quality of the public realm within our towns and villages can make a positive contribution to the lives of people who live and work in them. Most importantly, it brings the community together by creating spaces and related activities that encourage people to come together and interact, irrespective of age, ethnicity, cultural or economic disparity. There are many discussions ongoing in various sections of the academia on how the social connection that was the hallmark of the Indian society is fast disappearing in the highly individualized urban lifestyle, and how attempts can be made to capture it back. The significance of spaces where such interactions can happen which builds from chance and choice encounters to acquaintances to meaningful community connections are highlighted in such a scenario.

This paper was an attempt to capture the tangible and intangible criteria of such sociable spaces that have been an important tool in enabling social sustainability of the community it serves, and arrive at design guidelines for the development of further such spaces. The research has been able to identify the core parameters of the public realm that directly contributes to its Sociability. Further, the physical and social parameters of the said quality that needs to be satisfied during the design of the public realm have also been identified. The initial literature reviews having established relevant links between criteria of sociability as major contributors to social sustainability, the research further led to the development of guidelines for the design of sociable urban public spaces, taking us one step closer towards enabling social sustainability.

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Chapter 11
Assessment of Urban Quality of Life in Built Environment: A Case of Delhi

Shweta Shrivastava and Devendra Pratap Singh

Abstract Delhi is the capital city of India and among the largest urban agglomeration in the world. Due to rapid urbanization, the city possesses serious urban complications and challenges in managing urban growth and augmentation of city infrastructure which severely influences the quality of life. The quality of life in Delhi depends on its urban strategies and implementation towards the level of availability, accessibility and quality of built infrastructure. Quality of life is a complicated network of diversity and dynamism of multiple components. Hence it becomes imperative to study the assessment of quality of life indicator in the built environment as a tool for understanding and addressing the city level challenges. The purpose of this paper is to examine the various worldwide indicators used for assessing quality of life in built environment and to understand its various dimension as well as attributes (NIUA 2018). The paper develops comparative matrix of quality of life indicators of various organization and highlights indicators which are directly linked to the built environment. Further, this review paper investigates urban planning trends and strategies that altered and enhanced the quality of life in the built environment of Delhi. The investigation is done by exploring all three Master Plans of Delhi 1962, 2001, 2021. The study focused on macro-level issues in Delhi. Furthermore, the mapping of quality of life indicators has been done in the form of compiled matrix which comprehensively evaluates the adopted planning strategies in Delhi. The paper also suggests various planning strategies for sustainable development in Delhi. Finally, the paper calls for a need of regressive and robust strategies which are required to boost social, psychological and economic quality of life indicators in Delhi. The findings of the paper are directly applicable to planning strategies to improve the quality of life in the built environment of Delhi.

Keywords Quality of life · Built environment · Urban planning · Indexes and indicators of quality of life

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11.1 Introduction

Cities play a vital, inevitable role in human life and its history. The city's urban experience, neighborhood exuberance, and the environmental wholeness should be an integral part of the city. The city's diversity, density, design and dynamism contribute to joyous urban jumble. However, the escalating urbanization acts as a catalyst and inhibitor in the growth and development of city (Jacob 1961).

The unbridled urbanization in the country has led to genesis of five megacities in India i.e. Delhi, Kolkata, Mumbai, Chennai and Bengaluru. Delhi is the capital city of India and the residence of approximately 19.8 million (1.98 crore) people, which together formulate Delhi as one of the biggest urban agglomeration in the world. According to the UN report, Delhi will soon become the most populated city in world by 2028, the population will reach around 37 million (3.7 crore) in 2028 (United Nations 2018). Therefore, it provokes one of the most crucial interrogation of addressing different challenges and quality of life in Delhi.

Quality of life has been the focus of urban policy concern past several decades (Hitomi Nakanishi 2013). The term Quality of life in the built environment is not only used to describe physical feature but to emphasis upon interaction, networking, and the relationship of their diversity and dynamics. Thus, the Quality of life is a complicated network rather than based on simple basic components (Hamam Serag El Dina 2013).

The Quality of life in Delhi also depends on its urban strategies, approaches toward the level of availability, accessibility, and quality of built infrastructure. The rapid growth of population imposes serious urban complications and challenges in managing urban growth, regulating unauthorized colonies and augmentation of social and physical infrastructure. In response, urban planning of the city is constantly developing and assessing the strategies for managing its orderly growth and sustainable development. Hence, it became imperative to study the assessment of Quality of life indicators in the built environment as a tool for understanding and addressing the city level challenges.

Hence this paper reviews multiple worldwide indicators which are used to measure the Quality of life. The study aims to review the commonalities and difference among those indicators. The review study also attempts to understand various physical, social, mobility, environmental, economic and psychological dimensions. Further, the study filters out the list of indicators which are directly connected to the built environment. In addition to this, the focus of the study is to assess Urban Quality life in Delhi. The urban Quality of life in Delhi is assessed by mapping the Built-up Quality of life indicators to the urban strategies in Delhi. The trend of urban strategies has been studied by appraising MPD 62, MPD 2001 AND MPD 2021. The review paper suggests few planning strategies for sustainable development in Delhi. Moreover, the findings of the paper are directly applicable to planning strategies, which will improve the Quality of life in the built environment of Delhi.

11.2 Review on the Concept of Urbanization, Built Environment and Quality of Life

Urbanization is a global phenomenon. As per census of India 2011, definition of Urbanization varies from person to person and region to region, however, the true essence of urbanization is the rapid growth of population in the urban areas and economic activities which bring about more development of towns (India, Trends in Urbanization 2011a, b). Managing urbanization in India is a massive challenge as well as an immense opportunity. The rapid urbanization led to the development and evolution of built environment.

Built environment encompasses everything built by humans. It's a human-made surrounding that provides the setting for human activity, ranging in scale from park or green space to neighborhood and cities that can often include their supporting infrastructure such as water supply etc. (Streimikiene 2014). The built environment includes all buildings, spaces and products that are created or modified by people. It impacts indoor and outdoor physical environments (e.g., climatic conditions and indoor/outdoor air quality), as well as social environments (e.g., civic participation, community capacity and investment) and subsequently our health and Quality of life (Shobha Srinivasan 2003).

The Quality of life is a broader concept and the standard indication of the Quality of life that includes not only wealth and employment but also the natural and the built environment, physical and mental health, education, recreation and leisure time, social belonging, etc. (Barrington-Leigh 2010). Quality of life is a subjective notion. People differ in their notion with different incomes, influences and cultures governing their decisions. Nevertheless, the basic notion behind a good lifestyle must fulfil certain necessary though not enough conditions. For all residents, a city must offer basic amenities and infrastructure at a cost that makes living convenient and hassle free (CII Report).

Quality of life is often referred to different terminologies such as Livability, Living Quality, Standard of Living, Wellbeing, etc (Chidambar, Dudgikar 2017). Different researchers have proposed different indicators of Quality of life. At the global level, quantitative measurement of Quality of life is being done by using various indexes such as Human Development Index, Livability index, World Happiness Report, Physical Quality of life index, Gross National Happiness index, popsicle index, Healthy cities and so forth.

11.3 Cities—Quality of Life Indicators/Ranking

An indicator is "a measurement that reflects the status of some social, economic, or environmental system over time. Generally, an indicator focuses on a small, manageable, tangible, and telling piece of a system to give people a sense of the bigger picture (Competitiveness 2010). While ranking compares the given sets of data to each other periodically. However, ranking and indexing both encompasses tracking of consistently measured data. Indexing is a tool to observer change and the purpose of the index is to create a set of data for annual studies. The index strives to preserve the data integrity.

Quality of life has always been there from ancient times. Greek Philosophers like Plato and Aristotle were one of the first who discussed it. Plato had introduced the subjective parameter while Aristotle argued over objective parameter. Abraham Maslow also presented the contention of all basic need, psychological needs and self-actualization needs is the basis of Quality of life (Abdul 2013). In addition, Quality of life or liveability in turn needs to be sustained not only for present dwellers but also for future inhabitant, thus fulfilling the goals of sustainability or sustainable development.

Developing specific indicators for urban areas has achieved paramount popularity. There are number of worldwide recognized indicators initiatives. For research purpose, the review of following indicators has been done. Better Life Index—OECD, WHO QOL, CII-Liveability index, EIU Global liveability index, QOL index—mercer, most livable city index by Monocle. The rationale for selecting the above-mentioned indicators is to provide wide spectrum of indicators which have absolute national and global recognition. Although all the mentioned indicators concerned about the Quality of life and Liveability index

11.3.1 Better Life Index—OECD

The organization for economic cooperation and development (OECD) established its Better Life index of countries with best Quality of life (Kõrreveski 2011). It is essentially based on area of material living conditions and Quality of life. The indicators are based on 11 topics: housing, income, jobs, community, education, environment, civic engagement, health, life satisfaction, safety, work-life balance. Each of the 11 topics of the Index is currently based on one to three indicators. Within each topic, the indicators are averaged with equal weights. The indicators have been chosen based on a number of statistical criteria such as relevance (face-validity, depth, policy relevance) and data quality (predictive validity, coverage, timeliness, cross-country comparability etc.) and in consultation with OECD member countries (OECD 2019). The Better Life Index targets is to involve citizens in the debate on calculating the well-being of societies, and to allow them to become more educated and involved in the policy-making process that shapes all our lives.

11.3.2 World Health Organization—Quality of Life

World Health Organization defines Quality of life as an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns (Organization 1998b). WHOQOL primarily focuses on mental health. WHO assess the Quality of life by using WHOQOL 100 and WHOQOLBREF as an instrument to conduct the cross cultural studies. They look for multidimensional profile of scores and sub domain in Quality of life. The main attributes for the study are physical health, psychological state, personal belief, level of independence, social relationship, environment, spiritual/religious and personal belief. Since, the study investigates all the attributes which are associated with built environment. WHOQOL considers features which links to built environment: mobility, physical safety, accessibility to health infrastructure, availability to recreational activity, transport facility, physical environment (pollution, Noise, traffic and climate). The outcome of the study is used for research, public policy, medical practice etc. (Organization, Programme On Mental Health—WHOQOL User Manual 1998a).

11.3.3 Confederation of Indian Industry—Liveability Index

As per the Confederation of Indian Industry, the Quality of life index is a yearly study of key indicators to evaluate the degree of liveability in Indian cities. The agenda of the study is to measure imperative drivers of health and wealth in the community (Pandey 2010). The liveability index is based on social, environmental, economic and civics factors which ultimately helps in measuring different aspects of society. The liveability concept is supported by diamond model of Prof. Michael Porter of Harvard university who emphasized that the overall liveability index is determined by Demographics, Education, Health, Safety, Housing, Socio-cultural political environment, Economic environment, Natural Built and Planned Environment. The liveability index is an objective analysis of more than 300 indicators. The measurement of index process involves systematic steps for conduction of complete study that involves identification of parameters, collection of data, identify economic strength of the city, calculate the Quality of life index and the measure to enhance the potential of city, Identification and grouping indicators, calculating and interpreting the index. The outcome of Quality of life index provide incite about Quality of life to people and offers evidences on the future state of the city in terms of its liveability. The main indicators, which are linked to built environment are Safety, Housing, Natural and Planned Environment (Competitiveness 2010).

11.3.4 Economist Intelligent Unit (EIU)—The Global Liveability Index

Economist Intelligent unit has developed "The global liveability index" to investigate Quality of life across many global cities. The concept of liveability index is to assess the location which provides the best and worst living condition. The Global liveability index matrix is based on qualitative and quantitative attributes based on a given broad category: Stability, healthcare, culture, environment and infrastructure (Economist Intelligent Unit 2005). For qualitative indicators, assessment is based on in house analyst and in city contributor's judgement while quantitative indicators assessment is based on external performance of external data point. The results are then collated and weighed to provide a score range from 1 to 100, where 1 is intolerable while 100 is measured ideal. The Infrastructure component in Global Liveability index is directly linked to built environment, where they considered Quality of road Network, Quality of public transport, provision of good Quality housing, Quality of energy provision, Quality of water provision and Quality of telecommunications (Azila Ahmad Sarkawi 2017).

11.3.5 Quality of Living Index—MERCER

Mercer, Quality of living index which is developed by the global human resources consulting firm, is broadly classified into 10 groups which are further developed into 39 indicators. Mercer's ranking further categorizes cities into ideal, acceptable, tolerable, uncomfortable, undesirable and intolerable cities. The index is based on Political and social environment, Economic environment, Socio-cultural environment, Public services and transport, Recreation, Consumer goods, Housing, School and education, and Natural Environment and Medical and health consideration. Mercer provides tangible values for qualitative perception of different indicators of Quality of life. The objective of the quality of living index report is to compare in 498 worldwide cities and decide hardship allowance for international mobile workforce for various multinational companies (MERCER 2019).

11.3.6 Most Liveable City Index—MONOCLE

The lifestyle magazine "Monocle" has published, "The most livable city index" which explores world's best cities. Most Livable city index has 11 criteria with an addition of further 22 attributes. Important criteria in this survey are safety/crime, international connectivity, climate/sunshine, quality of architecture, public transport, tolerance, environmental issues and access to nature, urban design, business conditions, pro-active policy developments and medical care. In this index, "Quality of life" calculated is less concerned about the GDP, but rather focus on how one can easily travel to international destination. It emphasizes on high living standard and high Quality of life (MONOCLE 2019) (Table 11.1).

It has been found from studies held across various worldwide indicators, the common attributes for "Quality of life" are Housing, Environment, Natural

Table 11.1 Mapping of different quality of life indicators with defined dimension

S. No.	Dimension	OECD1	WHO2	CII3	EIU4	MERCER5	MONCOLE6
1	Physical (directly connected to built environment)	Housing Education Health		Built and planned environment Housing, health	Infrastructure Spatial characteristic, Healthcare Education	Housing, school and education, Medical and health	Quality of architecture, Medical care urban design
2	Social	Civic Engagement, Community	Social Relations	Socio-cultural political environment, Demographics,	Culture	Socio-cultural environment, Recreation, Consumer goods,	
3	Mobility (Directly connected to built environment)		Level of Independence	–	–	Public services and transport,	public transport, tolerance,
4	Environmental (Directly connected to built environment)	Environment	Environment	Environment.	Environment		Environmental issues and Access to nature
5	Economic	Income Jobs				Economic environment,	business conditions,
6	Psychological	Safety Life Satisfaction Work Life-Balance.	Psychological	Safety,			Safety/crime, international connectivity,
7	Others	–	Spirituality/ Religion/Personal beliefs		Stability,		Climate/sunshine pro-active policy developments

Source : 1. OECD 2019, 2.Organization WH (1998), 3. Competitiveness 2010, 4. Unit's 2005, 5. MERCER 2019, 6. MONOCLE 2019 Authors and Planned Environment, Infrastructure, Spatial characteristic, Safety, Quality of architecture, Public transport, access to urban design nature.

11.3.7 Urban Quality of Life: Delhi

The inception of Delhi started around more than 100 years ago. Historians traces the "Seven Older Cities of Delhi" (DUAC 2015) i.e. Qila Rai Pithora, Mehrauli, Siri Fort, Tughlaqabad, Firozabad, Shergarh and Shajahanabad, which developed around the fortresses of each dynasty that ruled Delhi from 1100 AD through 1947 AD. Delhi is evident of continuous inhabitation since olden times. The demographic evolution of Delhi during twentieth century is directly connected to the British Indian Empire in 1911, the population grew from 238,000 (2.38 Lakhs) to 669,000 (6.69 Lakhs) in 1947, however the spatial expansion of city occurred due to urbanization which led to dramatic decrease in residential density from 55 PPH to 18 PPH in 1921, followed by the gradual increase to 40 PPH in 1941. After 1911 Delhi became the focus of government activity when British shifted capital from Kolkata to Delhi (Véronique Dupont 2000).

In the year 1912, the city of New Delhi was planned by renowned town planner Edward Lutyens and Herbert Baker. The Nazul office was set up as Development authority in the year, which was further upgraded as an improvement Trust in 1937 for controlling the building regulation and regulating the land usage. In 1941–1951, Delhi witnesses the period of the highest demographic growth in its history, which expanded from almost 700,000 (7 Lakh) people to 1.7 million (17 lakh) people. This demographic growth followed with spatial expansion of the urban zone in all the direction. Improvement Trust and one municipal authority were unable to regulate the orderly growth of city and hence Government appointed committee. This committee recommended the single authority for Controlling and Planning authority for all urban areas in Delhi. Hence Delhi Development Authority was constituted in 1955, under DDA ACT.

Delhi Development Authority, played a vital role in orderly and swift development in Delhi. Delhi was the first city where Master Plan was formulated. In 1962 DDA promulgated the MPD 62. In India, Master Plan is the legal city level documents which governs the sustainable planned development of the city. The study focuses on macro level aspects of Delhi. Hence, MPD 62, MPD 2001, MPD 2021 has been selected to review the urban strategies of Delhi.

11.4 Overview—MPD 62, MPD 2001, MPD 2021

Master Plan of Delhi—1962 was planned for 5 million (50 lakh) people. The major recommendation of the plan was redevelopment of old area, zoning Regulation, decentralization of places, setting up urban village Authority (1957).

The comprehensive Master Plan of Delhi considered the complete Delhi Metropolitan area. It was planned as a compact orderly growth of Urban Delhi with six Ring Towns, self-contained in matters of work and residential places with strong economic, social and cultural ties with the central city (Authority, Master Plan of Delhi—1962, 1962).

The basic concept of modern urban planning was to keep traffic movement minimum and work to home relationship was considered as city started rising radially. The plan addressed multilevel issues of Delhi and it was deliberated for micro and macro levels of development. On further analysis of the strategies, it emphasized the need of multiple approaches taken in a unidirectional manner. It took care of the indicator of physical Quality of life by stressing on the decentralization measures, development of Ring Town, and further plan for zonal development plan also redevelopment of the old city area was suggested. Plan also envisaged for comprehensive planning for urban and rural areas. It separated land use appropriate built environment. MPD presented poly nodal hierarchical development, suitable transportation network. Also, extensive organized green spaces were intended. However, plan fails to integrate informal sector and due to exponential growth, it further failed at providing adequate infrastructure facilities.

Master Plan of Delhi 2001, was planned for a population of 12.8 million (128 lakhs). The city was undergoing several challenges such as rapid urban population, employment growth, land use permissibility, land use intensity, informal sector, incompatible use, development of unauthorized colonies, squatter settlement and so on. Hence, the Perspective Plan 2001 adopted approaches to ensure appropriate balance between the space allocation for different land uses and accommodation of different kinds of physical infrastructure and public utility system. Delhi was expanding at an exponential rate, hence it was imperative to consider the urban agglomeration for the purpose of planning and formulate plan National Capital Region which include the Union Territory of Delhi. It permitted the restricted mixed land use. It also guided the selective densification of urban area except Lutyens bungalow zone. To increase the urbanisable limit of Delhi, urban extension plan was worked out. Provision of shelter along with the supporting infrastructure was considered as the important aspect in economic and welfare term (Authority 1990).

The major characteristics of the plan was accommodating the surplus population in urban extension areas and increasing the holding capacity of areas through low-rise, high-density development. Further, the plan attributed the decentralization of city center area for the further development of district centers, freight complexes and directional terminals. The plan emphasized the need of transportation system to be multi modal MRTS, ring rail and road based public transportation system. Also, it highlighted the need of hierarchical urban development for essential facilities for example housing, neighborhood, commercial centers, and districts.

Master Plan of Delhi 2001 accomplished wider variety of housing typology. It integrates the development of new integration projects. However, MPD 2001 failed to address few important issues regarding land use permissibility, land use intensity, informal sector, incompatible use, informal settlements, role of agencies, allocation of resources in terms of land and finances. Dynamics of city is drifting every now and then, and due to increasing uncertainties of changing environment it is imperative for policy makers, planners to anticipate the transformation in planning process. Furthermore, it should be more procedure based rather than standard based. In 2001, the population of Delhi had risen by 8% as compared to projected population and thus it had serious implications on shelter and other infrastructure facilities.

MPD 2021, envisages different policies that includes review of the scheme of land policy, identification of alternative area for urbanization and provision of basic infrastructure and involvement of public private sector in the development of land. Regulating the growth of unauthorized colonies and squatter settlement and surprising growth in automobile has emerged as a major challenge for present and in upcoming growth and development (Authority 2017).

Keeping in view the road of challenges ahead, the MPD 2021 anticipated the critical areas and formulated the following focal points of the plan.

- The optimum utilization of land by public and private parties in land assembly, development and disposal.
- Effective public participation and focus on plan implementation and monitoring.
- Adopting decentralized local area planning by participatory approach.
- Redevelopment of planned and unplanned area. Planned area includes influence zone or transit-oriented development, underutilized area, commercial centers etc. Unplanned areas include villages, unauthorized colonies and J.J Cluster. Participation of private sector participation, conversion of plotted housing to group housing schemes and removal of unnecessary control on signature project has been adopted for optimal utilization of land. Reservation of 50–55% of housing for urban poor, in situ slum rehabilitation and categorization of housing types has been adopted for the provision of housing for poor.

The Upgrading of River Yamuna through several measures, conversation of Ridge and provision of additional lung spaces and green belt to be considered of improvement in environment. To attain work life balance flexible provision of mixed land development use in residential area is adopted. To maintain synergy between public transport and urban centers, major district and community centers are proposed to be developed as facility corridor. Additionally, the identification of Heritage zones and development of special conservation plan for listed buildings. Special focus on physical infrastructure and social infrastructure should be provided in MPD 2021.

Livability is a mutable, contest concept often applied to how a city might foster healthy environment and Quality of life for its residents. MPD 2021 purpose fully laid down multiple urban strategies to achieve aspiration to effective and efficient safety and security, world class infrastructure, a high level of services, cultural vibrancy, access to park and recreation, public participation, social equality and a growing economy. Quality of life in different settlements such as J.J Clusters, Slum Designated area, unauthorized colonies, resettlement colonies, Rural Village, regularized—unauthorized colonies, urban villages and planned colonies differs significantly. Several of them are striving for urban basic infrastructure like water, sewerage and electricity while rest is dealing with safety, security and social inclusiveness. MPD 2021 recognize the need of innovative strategy like spot zoning, special area plans, planning for special area and villages, regularization of unauthorized colonies, three tier system of plans that include master plan, zonal Plan and local area plan.

With the advent of transit oriented policy, urban city form of Delhi has been drifting from urban sprawl to compact city. Delhi has witnessed upcoming innovations and transformations like prominent mixed land use pattern with high residential and employment densities, walkable and livable communities with easy access to amenities and its centered around high quality mass transit station, the interconnected green spaces for walking and cycling. It also includes pedestrian and non-motorized transport friendly environment, high connectivity network, multimodal interchange, high density mixed use development.

As per WHO, New Delhi is one of the ten most polluted cities in the world. With the ongoing increase of motorization, air quality is a major concern with AQI reaching dangerous levels. In addition, number of traffic related fatalities are very high, private car ownership is rising. Furthermore, most of the working population who lives in the urban fringe and peripheries, travel the most because of the location of their work center and affordable, effective and efficient housing at urban periphery. As land use in the NCR is rapidly escalating, therefore there is a need that planner and policy maker should address to make city more sustainable (Table 11.2).

11.5 Results and Discussion

The paper reviews multiple indicators of Quality of life, while analysis of the EIU, MERECER and MONOCLE indicators reflect that, the focus of their study is commercial in nature. Their indicators and the interpretation of study derive the attention of investors, businessman, corporate companies, while WHOQOL is absolutely based on mental and psychological needs of individuals. While CII Liveability index is based on the sustainability Goals. OECD Better Life index goals is oriented toward well-being of society.

On analyzing the built environment Quality of life indicators with respect to Master Plan of Delhi 2021, it attempts to covers all the indicators used in Physical, Mobility, Environmental indicators. However, MPD 2021 shows concern in Social indicators, Economic and Psychological indicators. To improve the social Quality of life Delhi needs more regressive exercise on participatory approach. Also, laconic and explicit actions are required on economic from for better performance in Economic dimension of Quality of life indicators. Master Plan of Delhi should also have touched upon psychological needs of citizens. Strategy for maintaining work life balance, providing safe built environment will furnish the psychological satisfaction of citizen to another level.

Despite there being massive attempts for maintaining the Physical, Mobility and Environmental Quality of life, Delhi is currently dealing with mega challenges of accommodating the rapid growth in migratory population, disproportionate development in various part of the region, devolution of the activity which is not taking

Table 11.2 Mapping the quality of life indicators with respect to master plan of Delhi 2021

Housing	MPD 2021 is based on confirming "shelter for all" by harnessing the potential of the public, private/corporate and household sector. Provision for shelter has planned in the following ways 1. Restructuring and upgradation of the existing areas a. Planned area i. Plotted area ii. Employer Housing iii. Bungalow Area b. Traditional inner city and unplanned area i. Special area and Villages ii. Unauthorized/ Regularized Colonies 2. Housing for Urban Poor c. Rehabilitation/Relocation of Slum and J&J cluster d. Resettlement Colonies e. New Housing for Urban Poor 3. Night Shelter
Environment	Delhi is among top polluted cities in the world Master plan of Delhi 2021 envisages for the creation of a sustainable physical and social environment for improving Quality of life as the major objective of the plan. The following management strategy has been adopted for combating city environment 1. Natural resources which includes water, air and noise 2. Natural features which includes river Yamuna, regional park 3. Green/recreational areas which includes multipurpose ground, amusement park, green belt
Mobility	Delhi has witness phenomenal increase in the growth of vehicles and traffic in Delhi The broad aim is to ensure safe and economical commuting between trips, convenient and quick access. Following strategy has been adopted for smooth transport facility in Delhi 1. Integrated multimodal transport system 2. Expansion and restricting of existing network, metro rail network, Ring rail system, and sub urban rail system 3. Synergy between transport and land use 4. Planning for integrated fright complexes 5. Parking management system
Conservation of built heritage	Emphasis on conservation of built heritage strategy and conservation strategy. Heritage zones and archeological park is planned in MPD 2021
Urban design	City significant area of built environment for urban design has planned, which includes connaught place and extension, walled city extension, district centers and other areas
Social infrastructure	Health, education, sport facilities, communications, security police, safety, disaster management center, distributive facilities and socio cultural facilities and other community facilities, public and semipublic facilities are planned and provided
Physical infrastructure	Provision for existing and future requirement for water, sewerage, drainage, power and solid waste has given

Source Authority, Master Plan of Delhi, 2021

place in the region, non-development of counter magnet towns, shortage of funds and lack of development incentives.

Delhi needs to organize the alternative and innovative strategies to curb environmental degradation and manage the ecological assets to address environmental Quality of life. For Mobility Quality of life indicator, Delhi need to strategies their sustainable mobility plan that addresses local level mobility, green mobility, walkability plan to manage inter and intra city movement of goods and people. Approaches needed for regeneration of culturally significant urban fabric, revitalization of ageing buildings to build upon Psychological Quality of life. The thrust area for further planning should be extremely innovative and sustainable.

Lastly, to plan for largest mega polis Delhi, the thrust area should be sustainable mobility plan, innovative public participation at various level, effective and efficient regional strategy, revitalization and regeneration of culturally important building stocks and effective city governance.

11.6 Conclusion

The aim of the paper is to review worldwide indicators, deduce it to built environment - Quality of life indicators and further map the indicators with urban strategies of Delhi. After reviewing the worldwide literature on Quality of life in cities, it is evident that focus of each study is apparently unique in nature. However, all the studies are swathed in spectrum of dimension which ranges from Physical, Social, Mobility, Environmental, Economic and Psychological. On appraising and mapping the identified indicators against the trends and urban strategies of Delhi, the study divulges out the major segmental roadblocks in upholding the desired Quality of life in Delhi. Few of the major challenges are escalating population, unbalanced hierarchy of settlements and non-development of counter magnet. The study suggests that extremely innovative and sustainable solutions are obligatory to counteract with the parasite of inhibitors in the growth and development of Delhi.

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Chapter 12
Smart Cities in India: Linkages with Circular Economy

Almas Siddiqui and R. K. Pandit

Abstract The Sustainable Development Agenda 2030 proposed 17 Sustainable Development Goals (SDGs) in which the SDG 11 promotes inclusive, safe, resilient and sustainable cities and human settlements; SDG 7 encourages efforts to ensure access to affordable, reliable, sustainable and modern energy for all and SDG 12 ensures sustainable consumption and production patterns. For achieving these goals, various models have been experimented amongst which Circular Economy (CE) is one of the economic models facilitating key policy objectives for generating economic growth and reducing environmental impacts. In economies, cities are focal points of strengthening the transition of linear to a circular economy by smart practices towards a regenerative system. By consuming the assets at their highest utility, there will be an increase in economic resilience of the city and its citizens. The Smart Cities (SCs) and Smart Cities Mission (SCM) of India, Make in India, Digital India, and the Swachh Bharat Mission has potential to integrate CE principles in a pronounced way to pave the way towards a circular transition. To fulfill the SCs objectives, Indian cities have been integrating smart practices (like waste management, e-governance, and smart mobility) with circularity. For the challenges faced by the cities from the design until the implementation phase, circular economy calls for a refit in resource management. These would require policy-level reforms, institutional capacity building, uplifting infrastructure, and financing mechanisms. In India, there is already an existing repair and refurbish culture with strong local traditions integrating the 6Rs. The paper reviews the role of CE in Indian SCM for achieving SDGs by finding opportunities for circular economy and providing recommendations based on them. A matrix has been developed between the ReSOLVE framework and the opportunities of CE in cities. The SCM has increased the pace of transition, yet the recommendations are given to implement the CE principles efficiently.

Keywords Circular economy · Sustainable development · Smart cities

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12.1 Introduction

In the United Nations Conference on Sustainable Development in Rio de Janeiro in 2012, discussions on the importance of the Sustainable Development Goals (SDGs) recommenced to align our development towards a more sustainable path. It was a follow-up of the Millennium Development Goals (MDGs) which kick-started a global movement. The objective of SDGs are to produce a set of universal goals that meet the urgent environmental, political and economic challenges faced by the world. The achievable targets of SDGs are to reduce carbon emissions, manage the risks of climate change, and to build back better after a crisis, are also aligned with those of the COP21 Paris Climate Conference in 2015 and the Sendai Framework for Disaster Risk Reduction, Japan in March 2015.

SDGs are the best chance to improve life for future generations by involving all of humanity to build a safer and more prosperous environment. Many countries have started preparing their national and local development plans in line with the SDGs, developed indicator frameworks to review their progresses and added the data requirements for the SDG indicators to existing and new schemes. The aim is to identify sources, organize data producers, find out data gaps and instigate necessary capacity development activities.

The pressure on the existing infrastructure in the exploding urban areas due to rapid urbanization has adversely affected the living environment and public health. The urban areas are congested, lack basic services, a shortage of adequate housing, and declining infrastructure. As the population and the demand for cheap energy increase day-by-day, we need to move towards a circular economy which is less reliant on fossil fuels and more on renewable sources. By improving resource use and introducing circular economy into planning, the challenges faced by urban spaces can be overcome. In economies, cities are focal points of strengthening the transition of linear to a circular economy by smart practices towards a regenerative system. By consuming the assets at their highest utility, there will be an increase in economic resilience of the city and its citizens. Investing and improving the energy productivity of solar, wind and thermal power to ensure energy for all is vital to achieve SDG 7 by 2030. Cities have the potential to optimize efficiency by reducing energy consumption and adopting renewable energy sources. For example, in Rizhao (China) 99% of households use solar water heaters, making it a solar-powered city in the central districts.

To increase the prosperity of India, the dependency on primary materials and energy must be reduced. The proficient use and reuse of national capital by finding value of finished products throughout their life cycles is the motive of a circular economy. It is a restorative approach which doesn't work on today's linear model of production of take–make–use-dispose. Three major principles governing the circular economy are to balance the flow of renewable resources, enhance and preserve natural capital by controlling finite stock; to optimize resource yields by circulating components, products, and materials already in use at the highest possible levels at all times; and by eliminating negative externalities to make the system more effective

(Company 2016). In order to reach higher levels of circularity, substantial economic costs would incur. By 2030, India is expected to be home to six mega-cities with populations above 10 million. The transition of linear to a circular economy can offer an opportunity to India to decrease dependence on resources, increase their productivity, reduce waste, improve competitiveness and unleash innovation, raise employment and augment growth. India has been recycling, remanufacturing, and reusing materials through local vendors especially *kachrawalas* (local term for rag pickers/pickers of unwanted products and materials).

The Government of India's Smart Cities Mission, the Jawaharlal Nehru National Urban Renewal Mission, and the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) are working to address the challenge of improving urban spaces (Walter Leal Filho 2016). The Smart Cities Mission (SCM) of India and the Swachh Bharat Mission have integrated few of the CE principles in a pronounced way to pave the way towards a circular transition. To follow and achieve the SDGs 7, 11 and 12 and to fulfill the SCs objectives, Indian cities especially Indore, Coimbatore, and Surat have been integrating smart practices (like waste management, e-governance, smart mobility) with circularity. The paper reviews the role of CE in Indian SCM for achieving SDGs by finding opportunities for the circular economy. Various recommendations are given in governance, ethics, reuse, collaboration, and strong management to pace up the transition of a circular economy. CE has 6 actions, also called as ReSOLVE (regenerate, share, optimize, loop, virtualize, and exchange) framework which must be taken by government and companies. A matrix has been developed between ReSOLVE framework and the opportunities of the CE in cities. The SCM has increased the pace of transition, yet the recommendations are given to implement the CE principles efficiently.

12.2 Sustainable Development Goals and Circular Economy

12.2.1 Sustainable Development Goals

Four years of implementation of the UN 2030 Agenda for Sustainable Development, countries are trying to translate the shared vision of providing a global agenda for dignity, prosperity and peace to all, into their national development plans and strategies. In this paper, the circular economy is focused upon by studying the policies, schemes or development initiatives in achieving SDG 7, 11 and 12. To achieve SDG 7- affordable and clean energy, solar empowerment was done across 18 countries through a six-month "solar engineers" study program was possible because of a partnership between the Government of India (GoI) and the Small Grants Programme (SGP) which is supported by the Global Environment Fund (GEF) and UNDP. While ensuring access to energy for all, from 2000 to 2016, only one billion people were living without electricity and the access to electricity increased from 78 to 87%.

SDG 11 aims to intensify infrastructure and upgrade technology for producing clean and more efficient energy which will support growth and improve the environment. National priorities and policy ambitions need to be strengthened to put the world on track to meet the energy targets for 2030. In order to ensure sustainable consumptions and production patterns and achieve SDG 12, one of the most critical challenge is to decouple economic growth from resource use. This requires policies to create a conducive environment which will also improve the social and physical infrastructure and escalate the transformation of business practices in value chains around the globe. About 5 metric tons of per capita “material footprints” were increased during 2000–2017 which is mainly credited due to growth in construction and infrastructure as a result of a rise in the use of non-metallic minerals. Therefore, 108 countries made policies related to sustainable consumption and production by 2018. The SDGs for 2030 encourage nations to reflect on circularity and lead cities with innovative circular ideas and methods as pilot projects in all contexts of social, cultural, economic, technological or regulatory considerations (Schroeder 2018).

The key drivers to accelerate structural transformations approaches for sustainable development are inclusive and accountable governance, leveraging technological advances (like automation, digitalization, etc.), overcoming unsound practices of natural resource management and addressing deficient or obsolete infrastructure and services systematically. To address the challenges, governments require knowledge-sharing, access to high-quality technical advice, effective changes in policy, innovative development, finance solutions to leverage investments and greater capacities to promote innovation (UNDP 2017).

12.2.2 Circular Economy

Since the industrial revolution, a linear model of value creation and the make-use-dispose system has been followed by companies and consumers. As the resource prices have become more volatile and consumer demand increases, people and companies are ever more willing to pay for durable and reusable goods. To extend the lives of the items, they can be tracked and maintained by using digital technologies, novel designs and restrictions on pollution and waste imposed by governments. Redeploying the resources over and over is the organizing principle of circular economies. Research has revealed that by 2030, CE could generate a net economic gain of €1.8 trillion per year (Company 2016).

Breaking out the old models and discarding the traditional approaches are naturally challenging but it is outweighed by the efforts and the risk of gaining from the transition to the circular economy. The technical cycles use innovation to close the loop for materials and products and the biological cycles is the cycle of organic material and nutrients. CE is a model in which both the cycles are recognized from a systems perspective by emphasizing human society. Preference is always given to cycles which close on a local scale. Different enabling aspects of CE models are shown by the following nine principles:

1. **Waste is a resource**—Recycling and up-cycling to obtain the highest value of materials are required;
2. **Design is intentional**—Materials should be designed for easy recycling, up-cycling, and longevity making the systems with a service-based attitude;
3. **Social sustainability**—Sharing and collaboration can enhance social sustainability and stimulate economic development;
4. **Innovative business models**—By enabling tools, various innovative business models can become successful;
5. **Inspiration from ecology and living systems**—Inspiration should be taken from nature where both materials and nutrients exists in a cycle to restore and regenerate the ecological system on its own, making it economically viable;
6. **Recognition of both financial and natural capital**—Recycling and restoration of materials can generate new value making it financially viable;
7. **Reduction in energy usage**—Energy demands can be met by using renewable sources which cut off the usage of energy produced by conventional sources;
8. **Designing the system to be both resilient and adaptive**—The system can made adaptive and resilient through flexible design, mitigating risk and diversification; and
9. **Preservation of ecological system**—Ecological system can be preserved by supporting biodiversity and eliminating toxic materials (Lindner 2017)

12.2.3 ReSOLVE Framework

The authorities must undertake the following six actions of the ReSOLVE framework for easy transition from the linear to a circular economy.

- **Regenerate**—Regeneration of health of ecosystems to return the recovered resources to the biosphere can be done by shifting to renewable energy and renewable material.
- **Share**—Sharing of products (privately-owned or public sharing), reusing them to achieve the ends of technical lifespans and prolong them by durable designs, maintenance and repair can maximize the utilization of products reuse them throughout their technical life spans.
- **Optimize**—Eradicating waste from the supply chains or products and leverage technological advancements can improve their performance and efficiency.
- **Loop**—Keeping the components and materials in closed loops and prioritizing the inner ones can reduce waste generation at a big level.
- **Virtualize**—To reduce wastage of resources and manpower, production has to be minimized by delivering utilities virtually like e-books, autonomous vehicles, online shopping, remote sensing, etc.
- **Exchange**—The exchange of used old materials with the advanced renewable ones by attracting buyers and producers with the help of new technologies (like 3-D printing, electric engines) can improve overall economic development.

This framework increases the utilization of physical assets by shifting towards renewable resources, accelerate product performance, increase their cost competitiveness and lengthen their life spans. *CE is bringing sustainability to our urban environment* (Modak 2018).

Figure 12.1 depicts the profit potential (high, medium and low profit) of economic activities as per the ReSOLVE framework. 20 major sectors have been prioritized based on their economic impact of the six actions of ReSOLVE framework. Economic activities like manufacture of wood and paper products; water supply, waste and remediation; manufacture of food products; electricity, gas and air-conditioning supply

ECONOMIC ACTIVITIES	Regenerate	Share	Optimise	Loop	Virtualise	Exchange
Information & Communication services, media and telecommunications	Low	Middle	Middle	Low	High	Low
Scientific R&D, other professional, scientific & technical activities	Low	Middle	Middle	Low	High	Low
Education	Low	Middle	Middle	Low	High	Low
Human health and social work activities	Low	Middle	Middle	Low	High	Low
Administrative & support services	Low	Middle	Middle	Low	High	Low
Arts, entertainment and recreation	Low	Middle	Middle	Low	High	Low
Financial and insurance activities	Low	Middle	Middle	Low	High	Low
Legal & accounting head offices, consulting, architecture, TIC	Low	Middle	Middle	Low	High	Low
Distributive trades (incl. wholesale and retail trade)	High	High	Middle	Middle	High	Middle
Manufacture of wood and paper products, and printing	High	High	Middle	Low	High	Low
Public administration and defence; compulsory social security	Low	High	Middle	Middle	High	Middle
Real estate activities	Low	High	Middle	Low	Middle	Low
Manufacturing of textiles, apparel, leather and related products	High	High	Middle	Low	Middle	Middle
Construction	Low	High	Middle	High	Middle	Middle
Manufacturing of transport equipment	Low	High	Middle	High	High	Middle
Manufacturing of furniture	High	High	Middle	Middle	Low	Low
Water supply, waste & remediation	High	Middle	Middle	Low	Low	Middle
Manufacturing of elec. equipment, computer, electronic and optical products	Low	Middle	Middle	High	Middle	Middle
Manufacturing of machinery and equipment	Low	Middle	Middle	High	Middle	Middle
Manufacturing of rubber, plastics, basic and fabricated metal products	Middle	Middle	Middle	High	Low	High
Transportation and storage	Low	Middle	Middle	High	Low	High
Agriculture, forestry and fishing	High	Low	Middle	Low	Low	High
Manufacturing of food, beverages and tobacco products	High	Low	Middle	High	Low	High
Mining and quarrying	Low	Low	Middle	High	Low	High
Electricity, gas, steam and air-conditioning supply	High	Low	Middle	Middle	High	High
Manufacturing of coke, refined petroleum, chemicals products	Low	Low	Middle	Middle	Low	High
Manufacturing of pharmaceuticals, medicinal chemical, botanical	Middle	Low	Middle	Middle	Low	Middle
Accommodation and food service activities	Middle	High	Middle	Middle	Middle	Low

Fig. 12.1 Potential economic and resource impacts on Resolve Framework. *Source* Ellen MacArthur Foundation (2015) (The authors have used the figure for better understanding of the paper which has been unofficially translated and explained. This do not imply that the content has been endorsed or approved by the Ellen MacArthur Foundation. General website content: Copyright ©Ellen MacArthur Foundation (2015), www.ellenmacarthurfoundation.org. Publications: Copyright © Ellen MacArthur Foundation, *Growth Within: A Circular Economy Vision for a Competitive Europe*, page 27, (2015))

have immense high profit potential in regeneration of resources. Likewise, real estate activities, construction and food-service activities have high profit potential in sharing the products and services. All of the economic activities mentioned have medium-profit potential in optimization. Looping of construction activities; manufacture of transport equipment, electrical equipment and optical products; manufacture of rubber, plastics and machinery; manufacture of food; and transportation and storage can prove to be highly profitable. Virtualization of telecommunications, scientific and technical activities, R&D, education, human health records, social works, administrative services, entertainment, insurance activities, e-currency, wholesale trading, defense and social security can save lots of resources in terms of materials, time, money and man power. Similarly, exchange of used rubber, plastics, basic and fabricated metal products, agriculture waste, storage, etc. can be fruitful in long run (Foundation 2019).

Drivers of cities for their circular solutions include urbanization, supply and price risks, ecosystem degradation, environmental accountability, consumer behavior and advances in technology. Cities are the ideal testing grounds for CE models as they generate more than 80% of global GDP. It is easier to implement changes in policy due to the physical proximity in cities. The circular models and concepts can easily weigh down at a state and a national level due to their bureaucratic structures and legislative timelines. Therefore, cities can be more adaptive and responsive for implementing pilot projects to stimulate faster changes. Through the embedment of CE principles in urban services and infrastructure (energy, mobility, healthcare, etc.), efficiency and environment can be improved (Forum 2018). There is a need for a circular economy in cities as more than two-thirds of the world's energy is consumed in cities, accounting for over 70% of global CO_2 emissions. It is also predicted that by 2050, the material consumption of the cities will grow to about 90 billion tones. Also, the resource extraction is expected to be doubled by 2050 which had already increased 12-fold between 1900 and 2015 (Forum 2018). Figure 12.2 depicts the possibilities of practicing the circular economic aspects and principles in the departments of resources, geographies and value chain. This identification of pilot sectors is one of the four efforts suggested for a rapid transition to circular economy in Europe (Ellen MacArthur Foundation 2015). Cities have a huge potential to implement the aspects of circularity in smart water management, land management, and urban mobility.

12.3 Circular Economy in the Smart Cities Mission of India

Sustainable development can be linked with the circular economy through various dimensions of economy, environment, social responsibility of corporate, and business's entryway. The SDGs for 2030 encourage nations to act on principles of circularity in cities by experimenting with innovative circular ideas. The GoI launched the SCM with the aim to improve the governance and infrastructural deficiencies of Indian cities. It is an urban regeneration program in which the GoI utilized a competitive structure and selected 98 cities. The number of cities competing in the

Fig. 12.2 Possible circular economy pilot sectors. *Source* Ellen MacArthur Foundation (2015) (The authors have used the figure for better understanding of the paper which has been unofficially translated and explained. This do not imply that the content has been endorsed or approved by the Ellen MacArthur Foundation. General website content: Copyright ©Ellen MacArthur Foundation (2015), www.ellenmacarthurfoundation.org. Publications: Copyright © Ellen MacArthur Foundation, *Growth Within: A Circular Economy Vision for a Competitive Europe*, page 40, (2015))

Mission increased from 98 to 110 between 2015 and 2017 and 99 cities were chosen over 5 rounds (including fast track round) of selection. It took place in two stages: stage one was short listing of cities by states based on the conditions precedent (13 criteria) and the scoring was laid out, stage two includes the 'City Challenge' in which proposals were made based on some of the criteria like credibility of implementation, city vision and strategy, impact of proposal, innovation and scalability and its cost-effectiveness. Indian businesses are flourishing in the transition for new economic and innovative models to achieve SDGs. CE have paved ways to incorporate SDGs in the SCM of India. The technological innovation, research, and changes in policies for a plastic economy can provide practical solutions to the challenges being faced in the transition. Some of the opportunities for CE in cities are discussed below.

12.4 Opportunities for CE in Cities

The opportunities of circularity lie in key sectors like reuse of wastewater, organic waste and plastic; rain water harvesting; reduced energy usage; unused electronic waste; urban healthcare; unused demolished/broken building materials to build new building sites; and circular procurement. Awareness about CE and cooperation between role players like businessmen, policy makers, stakeholders and NGOs are the need of the hour in order to make the circular future a reality in cities. Table 12.1 depicts the generated matrix of opportunities for CE in cities and ReSOLVE framework. Channelizing used building materials for new construction can be shared and optimized through material passports, kept in closed loops and can be delivered virtually through online marketplaces and databases. For water harvesting and reuse, shifting to renewable energy for treatment of water can regenerate the ecosystem, and automation of collection of harvested rainwater in each building can optimize

Table 12.1 Matrix of opportunities for CE in cities and ReSOLVE framework

Opportunities for CE in cities	Regenerate	Share	Optimize	Loop	Virtualize	Exchange
Channelizing used building materials for new construction		■	■	■	■	
Water harvesting and reuse	■		■			
Circularity through reduced energy use	■	■	■			■
Electronic waste in cities		■	■	■	■	
Circular solutions to urban healthcare		■	■	■	■	■
Organic waste, including food	■	■	■			
Plastic waste	■	■	■	■	■	■
Circular procurement	■	■	■	■		

Source Authors

the wastage of water. Circularity through reduced energy use can be regenerated by compelling the utility companies to use only renewable sources. CE can be optimized by new models of decentralization of energy exchange between sellers and buyers and smart energy grids to improve efficiency. Pool sharing can maximize the utilization of products. Electronic waste in cities can be reduced by increasing the replacement cycles, refurbishing old phones, creating second markets for its optimization, and maximum utilization. Looping can be done by fast and easy collection process through a virtual platform.

Circular solutions to urban healthcare can be optimized on a shared platform virtually between the healthcare center, manufacturers and waste collectors for optimal use of surplus medical equipment. By incentivizing manufacturers, looping can be done by reusing the medical equipment. Organic waste (including food) can be collected and good food can be donated; treated and used for composting, thus regenerating, optimizing and maximizing utilization or organic waste. Plastic waste can be reclaimed before returning it into the ecosystem, reused throughout its life span through repair and maintenance, automation of the waste collected can help in optimizing waste to improve the performance and new technologies can be devised to increase the rates of collection and make the disposal methods efficient. Virtual platforms for buyers and sellers of recycled plastic wastes can boost the process in a circular economy. Based on the literature reviewed and understanding of the concept of circular economy with respect to smart cities in India, a matrix of opportunities for CE in cities and six actions of the ReSOLVE framework have been attempted in Table 12.1.

An approach of circular procurement provides better opportunities by sharing bonds between departments rather than buying new, reused, refurbished items, and providing service of leasing products (McLennan n. d.). For this, designing tenders technically and functionally, collaborating with industrial sector, closure of the loop of materials and energy, and deciding the purchase of goods or services can be done for the circular procurement.

There are four main types of barriers to successful implementation of circularity being financial, institutional, social and technical (Forum 2018). The financial barriers include lofty transition costs, an upfront investment which makes finding the investors difficult, and finding new economic viable solutions for recycling. The institutional barriers include the efforts to change the deep-rooted mindset of business models based on linear economy, the designed policies, rules and regulations for linear processes which hinder the potential of innovative models and partnerships and limited or unclear allocation of responsibilities to urban local bodies. The social barriers include the lack of awareness, sense of urgency to focus more on up-cycling and reuse, and the resistance to change the production processes from linear to circular. The technical barriers comprises of lesser efforts in designing the product-as-a-service models, greater incentives to develop high-end quality, stronger and maintainable products; planning obsolete products which leads to limited availability of spare parts and their disposal; separating technical and biological nutrients; lack of information exchange; and lack of standardized methodologies in cities to evaluate levels of circularity.

12.5 Circular Economy's Opportunities in India (Council 2019)

12.5.1 Cities and Construction

India has invested in the SCM in order to incorporate the principles of the CE into the design of the infrastructure and to improve citizens' quality of life. It is the responsibility of urban planners and managers to aim for targets like lower congestion, healthier environment, higher air quality, reduced urban sprawl and densification, preservation of biodiversity and low carbon footprints by planning the city spaces more systematically and smartly. Circularity can be easily incorporated in daily routines by flexible and easy to use urban spaces, buildings and infrastructures with the aids of digital applications (NETWORK 2018). With the help of renewable and recycled materials, collapsible structures, modular construction methods, waste and construction costs can be decreased effectively while constructing houses for urban poor. With the sudden changes in needs and ecosystem, buildings should be adaptable to climate change and affect it in the least way possible during their use phase.

12.5.2 Food and Agriculture

To meet India's growing food demand, a combination of traditional practices and modern technology (like precision farming, and digitally enabled asset and knowledge-sharing systems) can regenerate the agricultural system. In order to do so, a large-scale network of farmers can be formed to share their experiences and local knowledge, to interconnect their practices and to leverage the small-farm structure, decrease requirements of water, pesticides and fertilizers, and increase yield significantly. In order to reduce food waste and transportation requirements, solutions like digitizing food supply chains, urban farming, and optimizing production can bridge the gap between demand and supply effectively.

12.5.3 Mobility and Vehicle Manufacturing

In order to provide effective mobility systems and transportation facilities, the dependency on imported fossil fuels need to be reduced. Innovation in technology can provide faster and safer travel. Vehicles also need to be designed based on CE principles of reuse, remanufacturing and recycling of vehicles. Innovations like zero-emission propulsion, multi-modular, vehicle-sharing, door-to-door convenience, mobility system on demand, etc. need to be regularized.

GoI has undertaken substantial work towards policy interventions and formulation. Some of them are promotion of cleaner production processes; adapting BS-VI fuel standards by 1st April 2020; taxing polluting vehicles and incentivizing hybrid and electric vehicles. Some of the amendments were done in the waste management regulation; construction and demolition waste management regulation; and implementation of national river conservation plan. The main focus of India's National Manufacturing Policy is to promote and adopt greener technologies and green manufacturing. GoI has embarked upon an initiative of creating 100 smart cities across the country in which waste management and resource conservation are main agendas. GoI is in the process of finalizing national goals prioritised under UN's SDGs. One of them is the concept of Zero Defect Zero Effect which accelerates the process in achieving green economic growth by producing items with zero defects by the process having zero impact on the environment.

12.6 Recommendations for a Rapid Transition to a Circular Economy

12.6.1 Innovation

Solid waste management is one of the infrastructure services on which municipalities (especially in developing countries) have spent almost 20–50% of their budgets. This financial pressure can be relieved by introducing private sector into its planning and management, but this doesn't guarantee value recovery which discourages private sectors to invest into. Innovative ideas need to be incorporated in the planning process. The plastic economy is doomed because of its single use-disposal in landfills, costly packaging and huge environmental costs. It can be made as a circular system by finding ways to reduce the need for single use, improve reuse and recycling processes, improve resource productivity through innovations, and define shared goals and standards between various organizations. Innovative ideas like refilling systems, credit-based return systems, taxation on food waste to reduce its quantity on landfills, promote reusable good quality plastic containers can encourage producers and consumers to reduce single-use plastic waste. Technological innovations in collecting, segregating and processing plastic waste can increase the chances of materials being recycled with high quality. Digital innovations, like 3-D printing and nano-printing, in manufacturing and distributing the plastic can alter the needs of companies for plastic packaging. Costly innovations like bio-based plastics can replace the use of fuel-based plastics in packaging but their viability is yet to be proved. The handling and protection of products, simplicity in management, efficient logistics, and coordinated businesses transport goods can be achieved by fitting the plastic containers with radio-frequency-identification (RFID) tags.

12.6.2 Strong Management

To extract more value from technological investments, scale and volume should be justified. A strong management is required for integrating infrastructure and supply chains amongst widely dispersed consumer products. Developing countries are aiming for stronger performance-based management, better strategic decisions and an industrial approach in managing waste.

12.6.3 Economic Viability

For a thriving resource-recovery system, capacity building of recyclers with a strong balance sheet, reliable agreements, access to feedstock, assurance on consistency are the pre-requisites. Investors should know the commercial and operational processing for long-term efficiency which is being researched based on the socio-economic impact of plastics and their energy recovery.

12.6.4 Recycling Plastics by Private-System Operators

This needs to have a robust, cash-flow position and externally audited balance sheet. Private-system operators don't invest in the recycling business due to poor quality of plastics, lack of global standards, generation of lower-value applications, inadequate quality and quantity of packaging, old collection methods, inefficient processing systems, and lack of programs about collection and recycling of local waste.

12.6.5 Reuse

Reusing is a better alternative to recycling. This is due to the lesser requirements of material for plastics per-use. It needs to be adapted in the system to make it as a common practice by embracing new behaviors in producers and consumers.

12.6.6 Transparency

In order to assess and access track of improvement and important metrics, ease the monitoring of environment and social outcomes by authorities, to adjust the changes in the process of system management, to inform the regulatory authorities about everything legally, transparency needs to be maintained with priority.

12.6.7 Ethics

Manufacturers should take responsibility to dispose the products they sell. Voluntary pledges, legal documentation and policies should be framed to accelerate this process and to encourage recycling or reuse. Also, it should be the responsibility of the producers and consumers not to dump waste in their bins and ultimately on landfills after a certain extent.

12.6.8 Governance

Initiatives taken by government like banning plastic bags and CNG driven vehicles have boosted the transition to sustainable development. Similarly, refilling system of bottles instead of single-use plastics, drinking fountains in publicareas, restriction on manufacturing of polythene bags, public procurement and awareness about circular economy from the school levels should be incorporated into governance models at local, state and national levels. Pilot projects can help in improving the governance structure.

12.6.9 Collaboration

In order to incorporate innovative ideas into practice, much collaboration of government organizations with companies, industries and non-governmental organizations is the need of the hour. New technologies will be developed with improvement in research collaborations between researchers and businessmen.

12.6.10 Standardization

Innovative ideas need to be implemented with standardization of products being manufactured. Recycling can be made economical by setting standards for packaging materials, specifications of quality for easy sorting and collection of waste. This will assure the buyers of recycled materials and satisfy their goals. This will be helpful for uniform batches of production.

12.7 Conclusion

The main aims of the circular economy are to relieve pressures on municipal services and budgets, increase disposable income, reduce carbon emissions, increase livability, encourage an innovation-rich urban economy, and create employment opportunities in the city. The circular economy is a new way to extend the lifespan of products by improvement in service and design and creating value, complete the loop of products and waste generated for the reuse and recycling, utilize resources more efficiently and cautiously. The CE also offers employment and entrepreneurship opportunities especially in sectors of health, sanitation, waste management, recycling, and research in developing countries (Foundation 2017). This paper emphasizes the circular economic potential of cities and comes up with recommendations to pursue a sustainable growth trajectory with a focus on Indian SCM. The initiatives underpinning SCM by the Government of India have been analyzed in the paper to recognize the potential of circular economy. It is clear from the review that the capacity building activities and implementation of CE in urban local bodies and private sector will contribute to the sustainable development of the nation. Governance structures need to be strengthened for the purpose of incorporating circularity at all stages of development. Decentralization of the powers and policies can be done through pilot projects at the local levels.

The matrix generated between the opportunities of CE in cities and the ReSOLVE framework clearly mention the possibilities, ideas, and methods to implement the action plan of circular economy in cities. Some of the important conclusions include sharing and optimizing of channelized used building materials for new construction virtually through online marketplaces. For water harvesting and reuse, shifting to renewable energy for treatment of water can regenerate the ecosystem, and automation of collection of harvested rainwater in each building can optimize the wastage of water. Plastic waste can be reclaimed before returning it into the ecosystem, reused till its life span through repair and maintenance, automation of the waste collected can help in optimizing waste to improve the performance and new technologies can be devised to increase the rates of collection and make the disposal methods efficient. Virtual platforms should be created for buyers and sellers of recycled plastic wastes which will pace up the processes in a circular economy. Through decisions on purchasing works, goods or services, closing energy and material loops within supply chains, designing tender specifications using a technical or functional approach, collaboration with industries, etc. can be done for circular procurement. The barriers in the transition towards a circular economy are subsequently discussed. It can be concluded that Indian cities have significant potential for embracing a circular economy, provided that right policies, stakeholder interactions, innovations, and capacity building are put in place. A more holistic approach aimed at country-wide development would have been more equitable in the transition of circular economy nation-wise instead of few cities selected in SCM. Therefore, a more inclusionary approach and a new policy should be devised in order to implement the CE principles all over India. Incentives should be given to companies to encourage them in investing in a circular economic model of growth. This would also be more in line with the Sustainable Development Agenda 2030 to promote circularity.

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Chapter 13
Impact of Building Materials on Heating and Cooling Loads for Social Housing in India

Kiran K. Ghosh, Megha Behal, Sanjoli Tuteja, Sanjay Seth, and Rajat Gupta

Abstract To bridge the growing housing shortage, India plans to construct 10 million dwellings under the 'Housing for All by 2022' initiative. Since housing is responsible for 22% of the country's energy consumption (in 2014), it is integral to ensure that the new housing stock reduces the need for energy-intensive air conditioning. This paper assesses the impact of building materials and technologies on the electricity consumption for heating and cooling in case of social housing. The simulations were run for seventeen building materials and technologies across five Indian cities representing all climatic zones of India. The results demonstrate that the use of AAC block work instead of conventional brick masonry for walling helps reduce the electricity consumption due to cooling of households by 24.7–29.6% across all climatic zones. The use of ferro-cement roofing channels instead of conventional concrete roof slabs reduces electricity consumption due to cooling by 47.4%. The insights provided by this study can help policymakers, designers and construction professionals make informed choices of building materials and technologies to reduce the need for air conditioning.

Keywords Climate response · Sustainability · Social housing · Mass housing · Construction material · Construction material

13.1 Introduction

India's building energy consumption accounts for a third of the nation's energy use and is estimated to grow at a rate of 8% annually (Climate Works 2014). The residential building sector not only has the highest number of consumers but also accounts for 22% of the total 883 billion units of electricity consumed in India

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(Prayas 2016). Despite the current trends and the fact that residential buildings make up 75% of India's construction market, the residential buildings sector has not been a priority for framing energy efficiency policy (IESS 2012). Space conditioning technologies including air-conditioners, air-coolers and fans account for a third of the total energy consumption of the residential sector (Prayas 2016). Thus, optimizing energy consumption due to space conditioning in residences is essential to achieve an overall reduction in energy consumption of India.

India needs to build 700-900 million square meters of commercial and residential space every year to meet its growing demand. The new building stock will contribute to the growing energy consumption of buildings which stood at 14% of total delivered energy consumption in India in 2015. The Government of India through initiatives like Global Housing Technology Challenge (GHTC) aims to upscale the deployment of energy efficient construction technologies to ensure reduced energy consumption in buildings. This would entail reducing the growing energy demand due to space cooling and heating which is projected to double by 2027 (AEEE 2018). Within this context, the study assesses the potential of building materials and technologies to reduce electricity consumption due to heating and cooling in social housing.

The study was funded by and carried out as part of the United Nations One Planet Network's Sustainable Buildings and Construction Programme funded research Mainstreaming Sustainable Social housing in India project (MaS-SHIP).

13.2 Objective

The objective of the study is to use dynamic thermal simulation to assess the impact of various emerging and existing building materials and technologies on electricity consumption due to cooling and heating, vis-à-vis current conventional building materials in social housing projects. Given India's diverse climate conditions, adaptive thermal comfort, user behaviour and energy mixes, it is imperative to further research specific to its climatic context. Here, the comparative analysis of different building materials and technologies was carried out by assessing their performance across five cities representing the five climatic zones of India.

Electricity consumption due to cooling or heating is the total electricity required to maintain thermal comfort levels indoor and is dependent on the summation of its internal and external gains. The external gains can be minimized through appropriate selection of building materials and technologies. Since the need for heating and cooling is to provide comfortable temperature ranges indoor, the pre-requisite for this study was to ensure thermal comfort conditions for all occupied cooling/heating hours. The scope of the study was limited to the impact assessment of the U-values for both walling and roofing technologies on the energy consumption due to space conditioning.

13.3 Methodology

A survey was conducted on social housing with 725 households for 5 projects across three climatic zones. Amongst the five housing projects surveyed, the Bhawana Housing project was used as the typical building typology for this study. To signify housing which serves the housing needs of low-income groups with the provision of ensuring access to physical, social, environmental and financial well-being, the term social housing has been used.

To ascertain a benchmark for conventional practices, a base case was established using similar works (Alessio Mastrucci 2018; Shukla et al. 2014). Parameters such as user behaviour (activity schedule for occupancy, lighting, air-conditioning), conventional building materials, technologies and cooling/heating equipment details were defined. Simulations were run for these parameters to estimate the annual electricity consumption due to cooling and heating per unit carpet area across five different cities identified to represent the five climatic zones of India.

The results from the Mainstreaming Sustainable Social Housing in India (Gupta et al. 2018) have been used to identify 17 building materials and technologies. Parametric tests were carried out for each across all climatic zones. The results were then compared to the base case to assess the impact of these building materials and technologies on the annual cooling and heating electricity consumption per unit carpet area.

DesignBuilder, a world-wide known tool for energy intervention for both mechanically and naturally ventilated buildings, was used to run the simulations. The software is based on the DoE's BLAST engine and is a mature product which offers flexible modelling options for modelling different building typologies and HVAC systems with high accuracy.

13.4 Typical Building Typology

To model a typical social housing project in the context of India, the Cluster plans for Bhawana Housing project were used to run parametric simulations (Fig. 13.1). The building considered is a four-storey multi-family dwelling comprising of four independent 1-bhk (bedroom, hall, kitchen) apartments on each floor. A single dwelling unit has a carpet area of 22.35 m^2 and comprises of a multi-purpose living room, a bedroom, a toilet and a bath with a floor height of 3 m. The external heat gain of a structure is directly dependent on the surface area of the building envelope exposed to the outside. Therefore, dwelling located on the top floor, with south-west orientation was selected to account for the maximum possible solar exposure. The parametric tests were carried out for this particular unit to assess the impact of walling and roofing technologies for dwelling units with maximum exposed surfaces. Since the orientation of the unit would be specific to the site and context it is planned in, the orientation of the building was assumed to be North-South, which is considered to

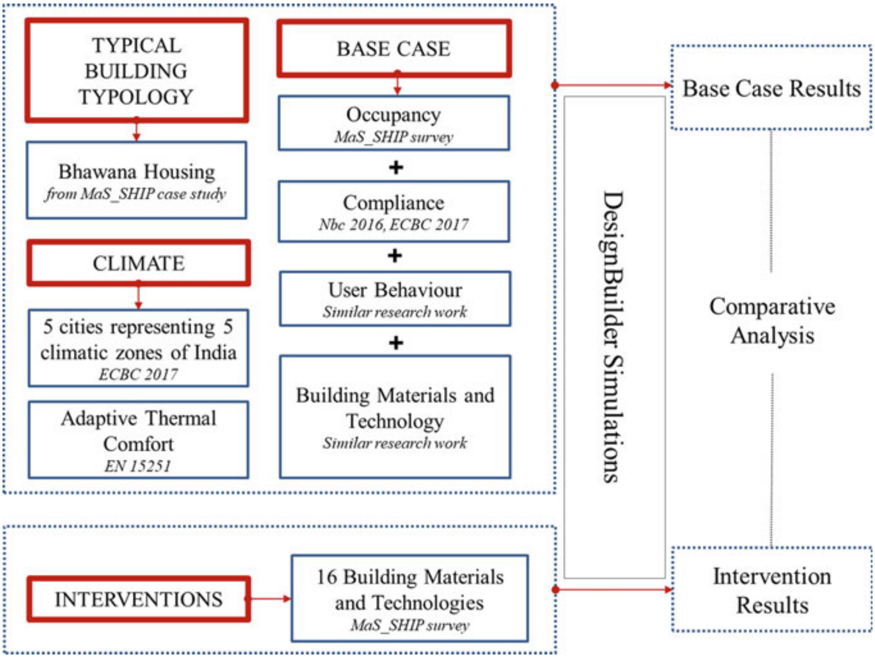

Fig. 13.1 Overview of the methodology. *Source* Authors

be the most efficient orientation in India overall (BIS 2007). The layout and sizes of openings considered were drawn from this typical building typology (Fig. 13.2).

13.5 Climatic Variations

A similar study—Analysis of weather conditions of Indian cities with respect to rating conditions for HVAC equipment (Kumar 2013) and ECBC 2017 were considered for identification of the cities which are the best representative of each climatic zone (BEE 2017). On the basis of geographical variations, weather profile (and availability weather data), and city type (class—1 cities), New Delhi, Chennai, Ahmedabad, Bengaluru and Sundernagar were selected (Fig. 13.3).

In India, the National Building Code (NBC) prescribes two narrow ranges of comfortable temperature, 23—26 °C and 21–23 °C for summer and winter, irrespective of variation in building type and climatic conditions (BIS 2005). However, India has a wide variation in geography, climate, culture and household income, all of which affect adaptation and thereby also the thermal comfort. An extensive study of occupant thermal comfort (Sanyogita Manu 2016) revealed that Indian occupants living in naturally ventilated dwellings have a wider range of comfortable temperatures. The EN 15251 (CEN 2007) which uses the mean outdoor temperature for a particular

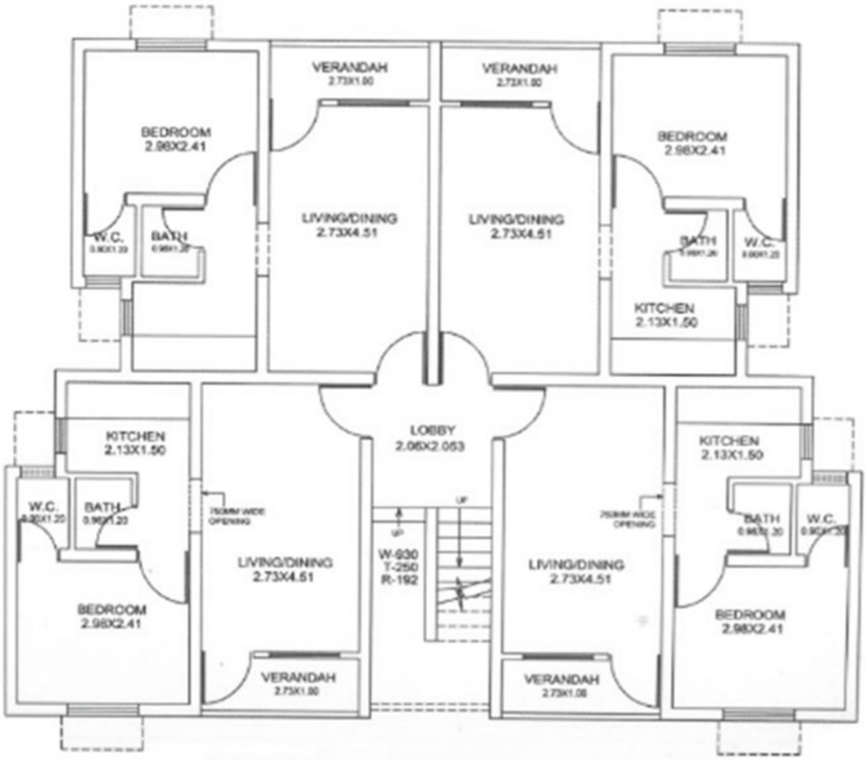

Fig. 13.2 Cluster plan for Bhawana housing project. *Source* Authors

location to conservatively estimate a site-specific adaptive thermal comfort range was used to define the setpoints for heating and cooling, as suggested by similar studies (Doris Hooi ChyeeToe 2013). The adaptive comfort equations underlying EN15251 standards are as follows:

$$T_{comfop} = 0.33T_{outrm} + 18.8,$$

where T_{comfop} is the comfortable operative temperature and

T_{outrm} is the mean outdoor temperature.

Weather data from the Indian Meteorological Department was used to calculate the range of comfortable temperatures. These ranges were used to define the heating and cooling set point for each city as shown in Table 13.1. Since the adaptive thermal comfort range considers relative humidity, no relative humidity set points were taken into consideration.

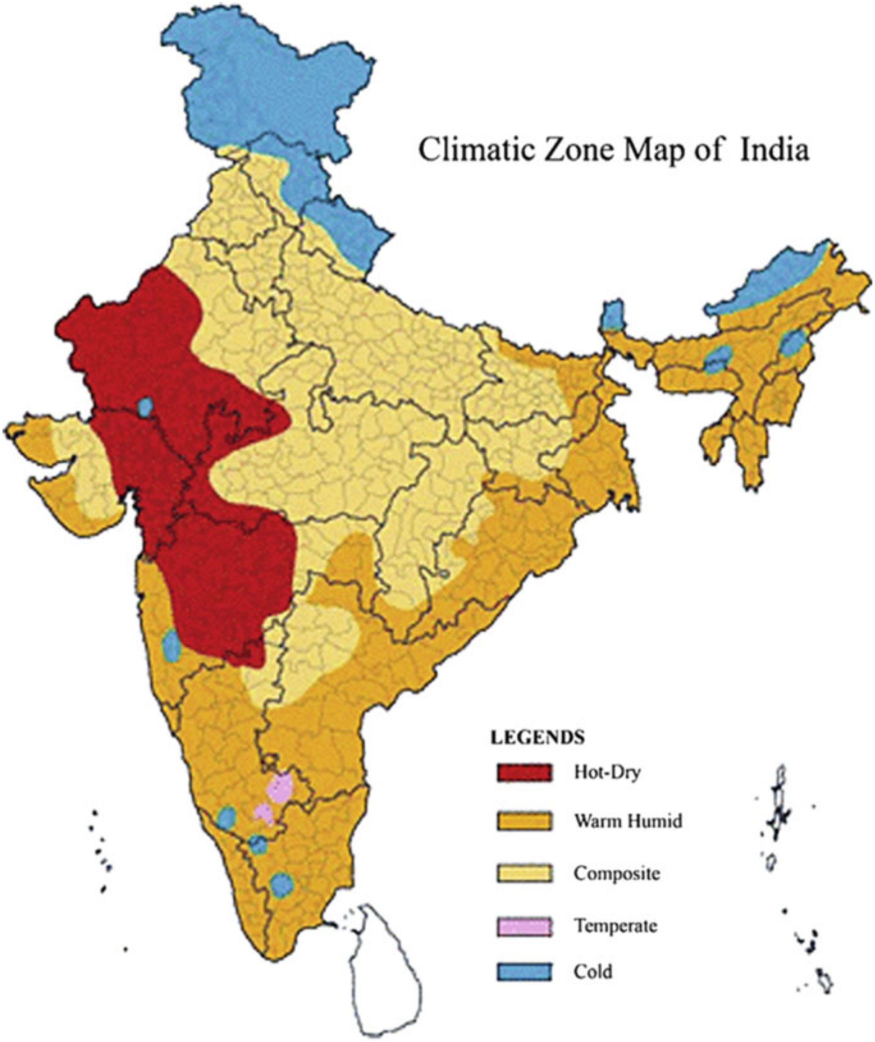

Fig. 13.3 Climatic zones of India. *Source* National Building Code 2005, Authors

13.6 Base Case Conditions

The base case was defined based on current construction practices in India, and according to relevant national codes (BEE 2017; NBC 2016). Occupancy of 5 for each dwelling unit of 22.35 m^2 was assumed as per the findings of the survey (Gupta et al. 2018). The amount of glazed surface, minimum thickness of structure and infill was sized in accordance with the minimum requirements for ventilation and lighting of the National Building Code of India. Using similar studies for reference (Alessio

Table 13.1 Climatic data and thermal comfort considerations

City	Climate	Mean temp		Setpoint	
		Annual min	Annual max	Min	Max
New Delhi	Composite	19	31.4	–	29
Chennai	Hot and humid	24.8	33.1	–	30
Ahmedabad	Hot and dry	21	34.4	–	30
Bengaluru	Temperate	19.2	29.6	–	29
Sundernagar	Cold	6.0	34.5	20	–

Source Authors

Table 13.2 Technology and material considerations for the base case

Building materials				
Component	Assembly	Total thickness (mm)	U-value (W/m^{2}k)	SHGC
External wall	12.5 mm cement plaster + 225 mm brick + 12.5 mm cement plaster	250	2.13	NA
Internal wall	12.5 mm cement plaster + 112.5 mm brick + 12.5 mm cement plaster	137.5	2.91	NA
Roof	100 mm RCC + 100 mm lime concrete	200	2.78	NA
Glazing	Single glass	6	4.8	0.819

Source Authors

Mastrucci 2018; Shukla et al. 2014) the construction technology for base case conditions was identified as masonry walls with an RCC framed structure as shown in Table 13.2 While these particular considerations might not be the most sustainable practice, it is a suitable representative for the most conventional construction practices across India. A lighting power density of 10.9 W/m^2 was assumed on the basis of ECBC for Residential Buildings (BEE 2017). In the Indian context, construction and maintenance quality for social housing is compromised under economic restraints. Hence, an air infiltration was assumed of 1 ACH (air change per hour), as per similar studies (Mastrucci 2018).

13.7 Cooling Systems

As per survey undertaken for a related work package for the same project, air-conditioners are used in less than 2% of the said households. The bulk of households rely on ceiling fans as the primary means for indoor comfort (Gupta et al. 2018). Apart from this, evaporative cooling through desert coolers is adopted for indoor space cooling, most commonly in hot and dry summers when it is most effective. Each of the cooling technologies was assessed to estimate its effectiveness in providing thermal comfort during all occupied cooling hours.

13.7.1 Natural Ventilation and Ceiling Fan

To emulate conditions of living in current social housing projects, the first phase of simulations was run to assess the feasibility of providing thermally comfortable spaces with the use of desert coolers and natural ventilation. A ceiling fan was also simulated for internal air circulation of 2 m/s. The results for the simulation have shown a large number of uncomfortable hours during occupancy due to the following reasons:

1. Ceiling fans regulate the fluid dynamics internally and do not directly bring down the indoor temperature.
2. Natural ventilation during the night can help reduce indoor temperature during summers but is subject to outdoor climatic conditions and is not desirable during summer days or winter months.
3. The results of the simulations show that while desert coolers can help achieve an indoor temperature reduction up to 7 °C during peak summer months of May and June, it fails to provide acceptable thermal comfort conditions according to CEN15251 Category II (CEN 2007) for the entire year.

While efficient and innovative building materials, passive design strategies and evaporative cooling could help reduce the uncomfortable hours during occupancy, it fails to provide thermal comfort for 38% of the occupied period (CEN 2007). This makes the social aspiration to graduate to air conditioning a physical need.

13.7.2 Air Conditioners

Since the previous two phases were unable to provide comfortable temperature during occupied hours, the third phase of simulation used an air conditioner with a COP (Coefficient of Performance) of 3.26 as per the schedule given in Table 13.3, as derived from similar studies (Mastrucci 2017). Air conditioning is usually run for seven months (Shukla et al. 2014), March to September. The contribution of electricity consumption due to heating to the overall operational energy cost in India is null or low for most climatic conditions apart from those in cold climates (Alessio Mastrucci 2018). Hence, heating was simulated only for the cold climate using an electric heater with a COP of 0.9 (Talakonukula Ramesh 2013). Electric heaters are the most commonly used equipment for space heating in residences across India and are usually operated for four months (Shukla et al. 2014), December to March as per the schedule given in Table 13.3. The results show that the use of air conditioning

Table 13.3 Activity schedules

Occupation	Space type		
	Living room	Bedroom	Washroom
	W: 8:00–18:00 (50%); 18:00–22:00 (100%) WE: 8:00–22:00 (100%)	22:00–08:00 (100%)	–
Lighting	18:00-06:00	18:00-06:00	–
Cooling (March to September)	W: 18:00–22:00 WE: 13:00–22:00	22:00–08:00	–
Heating (December to March)	–	22:00–08:00	

Source Authors
Note W(weekdays) WE(weekends)

can provide comfortable temperature for all occupied cooling hours. The operation schedule for both heating and cooling was drawn from similar studies (Mastrucci 2017).

13.8 Parametric Tests

To compare the impact of different building materials or systems on the electricity consumption due to cooling and heating of a unit, all input parameters were kept constant while the building materials for the external wall and roof were varied. The choice of materials was drawn from the MaS-SHIP project (Gupta et al. 2018) which has looked across a wide horizon of technology options, narrowed it to roof and wall materials and selected 16 for assessment, based on popular application and push by the government (as shown in Table 13.4).

13.9 Results

Results for the electricity consumption due to cooling for the base case for each climatic zone is given in Table 13.5 and falls within the range of 15.2–50.2 kWh/m^2-year. Electricity consumption due to heating for the base case in cold climates is estimated at 42.32 kWh/m^2-year. The results were compared to similar studies in literature (Alessio Mastrucci 2018) and were in good agreement.

Table 13.4 Building materials for parametric tests

Tests	Material		Thickness	Finish	U-value of assembly
			in mm	Cement Plaster	in W/m^2-K
Base case	External wall	Fire clay brick—English bond	225	12.5 mm on both sides	2.13
Parametric test 1	External wall	Fly ash brick	200	12.5 mm on both sides	1.90
Parametric test 2	External wall	AAC block	200	12.5 mm on both sides	0.70
Parametric test 3	External wall	Fire clay brick—rat-trap bond	225	12.5 mm on both sides	1.79
Parametric test 4	External wall	Hollow concrete block masonry	200	12.5 mm on both sides	1.89
Parametric test 5	External wall	Solid concrete block masonry	200	12.5 mm on both sides	2.70
Parametric test 6	External wall	Compressed stabilised earth block	200	12.5 mm on both sides	1.94
Parametric TEST 7	External wall	Stonecrete blocks	200	12.5 mm on both sides	3.40
Parametric test 8	External wall	Glass fibre reinforced gypsum (GFRG) panel		–	2.85
Parametric test 9	External wall	Precast Large concrete panel system		–	2.00
Parametric test 10	External wall	Reinforced EPS core panel system		–	0.58
Parametric test 11	External wall	Light gauge steel frame (LGSF)		–	3.87
Parametric test 12	External wall	Monolithic concrete construction using plastic/aluminium formwork		–	3.59
Parametric test 13	Roof	Reinforced brick panel roof		–	2.80
Parametric test 14	Roof	RCC filler slab		–	3.94
Parametric test 15	Roof	Plank and joist roof (60 mm tile above + 60 RC plank + 75 mm mud phuska)		–	2.00

(continued)

Table 13.4 (continued)

Tests	Material		Thickness	Finish	U-value of assembly
			in mm	Cement Plaster	in W/m^2-K
Parametric test 16	Roof	Ferrocement roof channel		–	2.56

Source Authors

Table 13.5 Annual electricity consumption due to cooling/heating

Climate	City	Annual electricity consumption due to cooling/heating (in kWh)	Cooling energy (in kWh/m^2-year)
Composite (cooling)	New Delhi	1121.79	50.2
Hot and humid (cooling)	Chennai	1002.37	44.8
Hot and dry (cooling)	Ahmedabad	1038.5	46.5
Temperate (cooling)	Bengaluru	340.65	15.2
Cold (heating)	Sundarnagar	945.83	42.32

Source Authors

13.9.1 Parametric Tests

Results for the impact of different building materials for external walls (parametric test 1–12) and roofs (parametric tests 13–16) on the annual electricity consumption due to cooling are shown in Table 13.6. For walling technologies, AAC blocks (parametric tests 2) perform the best by providing a reduction of 12.54–29.6% across all climatic zones. The energy consumption in the case of Stonecrete Blocks, Glass Fibre Reinforced Gypsum (GFRG) panels, Light Gauge Steel Frame (LGSF) and Monolithic Concrete Construction using Plastic/Aluminium Formwork is more than that of the base case. The use of Light Gauge Steel Frame (LGSF) in particular cases show a maximum increase in the electricity consumption due to cooling of 15% and heating of 80% over the base case. For roofing materials, pre-cast RCC Plank and Joist roofing provide a maximum reduction in electricity consumption while the use of RCC filler slabs can increase the electricity consumption from 7.19 to 25.77%. The trends show a consistent reduction in electricity consumption due to cooling with the decrease in the U-values of materials showing slight variations with different climatic zones. Roofing materials with comparable U-values to walling materials perform better due to the roof being a larger source for external heat gain.

Table 13.6 Savings (%) in electricity consumption due to cooling/heating from Base Case

Parametric test no	Savings (%) in electricity consumption due to cooling/heating from base case				
	New Delhi (cooling)	Chennai (cooling) (%)	Ahmedabad (cooling) (%)	Bengaluru (cooling) (%)	Sundarnagar (heating) (%)
1	4	3	4	5	4
2	28	29	30	26	13
3	5	5	6	7	5
4	4	3	4	5	4
5	−6	−5	−8	−11	−16
6	4	−7	−12	−7	3
7	−8	−4	−13	−19	−45
8	−7	−5	−9	−13	−22
9	2	2	2	3	2
10	39	35	30	38	15
11	−7	−1	−13	−19	−66
12	−8	−3	−13	−19	−54
13	2	14	−16	3	0
14	−7	−10	−26	−18	−12
15	7	9	8	16	8
16	5	−8	−10	14	11

Source Authors
Note Negative values denote increase while positive values denote reduction

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13.10 Conclusion

This paper estimates the impact of building materials on the electricity consumption due to cooling and heating while providing thermal comfort conditions in different climatic zones of India for a typical social housing project. Preliminary simulation results reveal the inadequacy of naturally ventilated buildings to provide thermal comfort to its occupants. While evaporative coolers can reduce indoor temperatures significantly, it cannot provide comfortable temperatures for all occupied hours. The trends seen in the case of each parametric test is subject to the climatic conditions. For example, a building material which can help reduce electricity consumption in hot and humid climates might fail to perform well in cold climates. The results of the simulations were used to inform a metrics to assess the sustainability of the building materials considered and arrive at a framework for future assessment.

The deployment and mainstreaming of energy efficient building materials in the case of social housing can help reduce electricity consumption in India. The parameters considered in the simulation assure thermal comfort for occupants throughout the year and exceeds the current living conditions of social housing in India. To ensure healthy living conditions in social housing while reducing energy consumptions of buildings, further research into energy-efficient and affordable cooling solutions, passive design strategies and sustainable building materials are imperative.

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Chapter 14
Strengthening Sustainability in Sri Lankan Construction Industry: Through Corporate Social Responsibility

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Abstract Corporate Social Responsibility (CSR) is an approach for any kind of business organization to brand themselves as sustainable. Construction is an interwoven industry in the sectors of economy, environment, and society. In addition, it is a growing business entity with many stakeholders. CSR activities performed by Sri Lankan Construction companies could be categorized under three main branches such as philanthropic, business environment (BE) related CSR practices and CSR in business processes (BP). Yet there are ample opportunities for the industry to utilize the concept of CSR in their business processes (BP) related activities. Furthermore, it has been identified that many organizations undertake CSR only to furnish the legal requirement and customs. Apart from that lack of awareness and misconception regarding CSR, there are key constraints of adopting CSR in Sri Lankan construction industry. Thus, this research has focused on developing a practical guideline for construction companies to cater for sustainable development of Sri Lanka. Qualitative research study based on grounded theory through transcribing, coding and categorizing has been utilized as the key research method for this study. Twenty in-depth interviews were carried out with client organizations, consultants, contractors and material manufacturers/suppliers to gather primary data and five focus groups to validate the data. Based on the analysis of primary data the final framework has been developed. This framework mainly focused on incorporating CSR to the business process, to its culture and strategies. Encouragement of green practices to construction organizations while inculcating a culture of greenery was the main determination behind this initiation.

Keywords Corporate social responsibility · Sustainability · Construction industry

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14.1 Introduction

Construction industry, which is considered as one of the focal industries in any nation, significantly affects triple bottom lines of sustainability: economy, environment and society. Construction industry metabolizes businesses involving clients, consultants, contractors, material producers, professional service suppliers, construction enterprises and many more. In a wide-spectrum, the construction industry is evident for an inferior ethical conduct due to unethical performances, health and safety tragedies and being insensitive towards the environment (Moodely et al. 2008). Thus, sustainability of the construction industry will depend on the sustainable practices in the construction businesses. This is where Corporate Social Responsibility (CSR) concept comes in, to encompass corporate sustainability expression with business operations. Corporate Social Responsibility (CSR) reveals the obligation of organizations for the impacts of its decisions and performances on society and the environment, through transparent and ethical behavior (ISO 2010).

Presently, construction industry activities are on the rise with the awakened development of Sri Lanka. Central Bank of Sri Lanka pointed out that contribution of Sri Lankan construction industry for GDP is 6% - 8% on average during the last decade whereas similar situation is observed for construction investment. On average, construction investments in Sri Lanka during the last decade accounted for 16% of the GDP (Ramachandra et al. 2013). Although many companies contribute positively to CSR activities, presently the construction industry has been frequently complaining for being inattentive for the environment (Tam et al. 2006; WBCSD 2009; Turk 2009); for being provoking with its clients and for being insensitive and hard-hearted toward the society (Jones et al. 2006a b; Qu 2007; Barthorpe 2010). *Economynext* article stated that, Sri Lanka has slipped 12 places to 95 among 177 countries that have been ranked on perceived corruption in the state sector in 2016, according to an index that measures transparency falling two years in a row (Economynext 2017). It has been pointed out that certain areas of the Sri Lankan construction industry are corruption prone (Perera 2014). Citing as an example illegal sand mining, where in certain instances even politicians too are involved. Perera (2014); further pointed out that there is no planning in the use of national natural resources and there should be proper monitoring of imported building materials. Perera (2014), further stated that; Sri Lanka's construction desperately needs a regulatory mechanism to manage and monitor this sector, which is threatened by widespread corruption. Thus, the need for realistic framework, which fits with the business environment of Sri Lankan construction industry leading for sustainable development, is becoming a critical issue since many activities of the construction industry are leading towards unsustainable practices harming the society and environment.

It has been revealed that the CSR activities among Sri Lankan construction business could be categorized under three main branches as; philanthropic, business environment (BE) related CSR practices and CSR in business processes (BP). Although the industry is focusing on philanthropic activities under the concept of CSR, yet there are ample opportunities for the industry to utilize the concept of CSR in their business processes (BP) and business environment related activities in a more effective manner. This research is focused on developing a CSR guideline for construction companies to cater for sustainable development of Sri Lanka while incorporating CSR to the business process and business environment.

14.2 Literature Review

Through the mounting rapidity of change in the business environment, technological advances and globalization, sustainability has become an important social and economic issue throughout the world. Sustainable development has been defined in many ways, but the most frequently quoted definition is from 'Our Common Future' (also known as the Brundtland Report), the report of the world commission on Environment and Development, published in 1987. It states that 'sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. In the commercial world most businesses approaching to create a long-term consumer and employee value by creating a "green" strategy aim towards the natural environment while considering the business operation within social, cultural, and economic environments. To achieve Corporate Sustainability, the concept of Corporate Social Responsibility (CSR) has been recognized as an evolving part, which incorporates Corporate Social Responsibility (CSR) manifestation with business operations. Elkington (1998) discussed more into detail when arguing that companies should not only focus on enhancing its value through maximizing profit and outcome but also concentrate on environmental and social issues equally. The notion of CSR originally started in the 1950s as the result of World War II (Murray and Dainty 2009) and as argued by Zhen et al (2012); the fundamental impression of CSR is to focus at how the corporate world integrates stakeholders' requirements and societal ethics, to enhance the relationships between organization and society. Murray and Dainty (2009) accepted that CSR as one of the most crucial term in present business subjects. ISO 26000 defined CSR as:

> The responsibility of an organization for the impacts of its decisions and activities on society and the environment, through transparent and ethical behavior.

CSR could be defined as an expression of corporate sustainability in terms of business case. Thus, there is a universal recognition as CSR is a crucial component to achieve Corporate Sustainability from a business viewpoint. CSR initiatives of businesses are mostly balancing the competing needs of shareholders and stakeholders (Bansal 2014). CSR Europe (2003) (cited in Kakabadse et al. 2005) stated that Corporate Social Responsibility is the way in which a company manages and improves its social and environmental impact to generate value for both its shareholders and its stakeholders by innovating its strategy, organization and operations.

With regard to construction businesses; sustainability refers to a beneficial outcome on a win-win basis by approaching towards an improved environment, developed society as well as achieving economic benefits for the construction business organization. Thus, pursuing corporate social responsibility (CSR) is significant to achieve sustainable construction (Shen et al. 2010).

It is a typical fact that the construction industry confronts many challenges and problems (De Silva et al. 2008). These problems range across developing countries as socio-economic stress, chronic resource shortages, institutional weaknesses and a general inability to deal with the key issues and changing government priorities due to various sociological, economic and political constraints (Chan et al. 2005). In Sri Lankan construction industry, fluctuating construction workload, unfair competition, skills drain and shortages as well as high cost of developing skills were the key acknowledged snags (De Silva et al. 2008).

Many stakeholders of the construction industry are directly influenced by construction activities in life, activities, asset values, jobs, friendships and long-term and short-term living plans. Thus, mismanagement of construction activities and its significant destructive impacts, jeopardizes the industry itself in long-term (Jones et al. 2006a, b). CSR acts as a tool to assist organizations in considering early rectification methods or strategies to minimize the negative effects on society and environment (Keyvanfar et al. 2018). In global context UK has shown considerable progress in CSR implementations whereas USA, China and Australia also working in this field (Duman et al. 2015). Accordingly, many researchers identified several potential CSR concerns as minimization of emissions, effluents and waste, improved biodiversity, energy efficiency, water efficiency and generate indirect economic effects (Lu et al. 2015). According to Zaho et al. (2012), protect the local environment, minimize safety hazards to the community, and establish good communication channels with neighbors are considered as possible CSR implementations. Ensuring harmonious relationships with local communities, employment from the local area (neighborhood) can also be utilized as CSR implementations (Hanyang Ma et al. 2017). Ensure transparent information disclosure, protect the local ecological environment, express concern over the community and public requirements, maintain social stability, protect local community environment are also considered as important in implementing CSR (Lin et al. 2017).

Through a study done on possible CSR practices that could be performed by client, consultant, contractor and material supplier organizations of the Sri Lankan construction industry, it was identified prevailing practices in CSR related to business environment and CSR related to business process could overcome some of the challenges related to social and environmental aspects in the industry (Somachandra et al. 2018a, b). It was found that cost-oriented nature of most client organizations, lower positive influence from government regulatory bodies, resource constraints, several unethical practices of construction professionals, client's values and client's apprehension for sustainability were suppressed by the client organizations from CSR initiatives (Somachandra et al. 2018a, b). It has further come to light that; in contractor organizations, there is a considerable gap in the prevailing practice and required practice in the areas of CSR related to business environment and CSR related to business process although CSR related to philanthropic activities in the industry was at a high level. When studying the consultant organizations CSR initiatives, it has revealed that most of consultants have misconception about CSR considering it is all about charitable donations.

In similar strain awareness on sustainable approaches, deprived professionalism and unethical professional activities, use of strategies and lack of organizational social capital have limited the CSR initiatives among consultant organizations. Apart from that, misconceptions on CSR concept as philanthropic approach, poor ethical conduct and lack in professionalism, poor focus towards to morally obliged business process practice, limited process innovations and improvements towards sustainable production has been evident in material supplier organizations (Somachandra et al. 2018a, b).

Nevertheless, since almost all the stakeholders involved in this industry are cost conscious, quite high unethical business operation has been evident overruling the CSR essential practices that could be adopted for sustainability (Somachandra et al. 2018a, b). Thus, a proper framework to guide stakeholders in CSR practices for better social and environmental accountability has emerged to achieve sustainability in the industry.

14.3 Methodology

A qualitative study was carried out to develop this CSR guideline. In-depth interviews were carried out among client, consultant, contractor and material supplier organizations to identify the present CSR practices and possible modifications to the guidelines to adopt a better CSR process for sustainability. The qualitative study was based on a judgmental sample with interviews selecting five companies from each cluster. Transcribing, coding and categorizing of qualitative data were done to build and finalize the conclusions and CSR framework to fulfill the identified gap of the study.

14.4 Discussion

During the qualitative data analysis carried out based on transcribing, coding and categorizing, several gaps of prevailing CSR practices of the industry practitioners were identified. In order to fulfill the identified gaps following guideline was developed for client, consultant, contractor and material supplier organizations in Sri Lankan construction industry. This guideline has been built mainly based on three categories namely business process, business environment and philanthropic.

14.4.1 Business Process

Since the construction industry is always having an interwoven nature among all stakeholders; influential power of one stakeholder for the business process decision making of another stakeholder lies at a high level. Among all the stakeholders in construction industry, the client has more influential power; as they are the owner and the investor of the project. Thus, ethical and responsible decision making of the client in every stage of the project is vital. In order to take wise decisions to enhance the environmental and social impacts from the project, client organizations' awareness on sustainability initiatives is significant. Further to that clients' purchasing power and investment decisions, matters largely for the business process CSR implementations among their organizations. Here, clients' understanding on life cycle costing in financial decision making is again important. Moreover, client can encourage the consultant to initiate innovative resource conservation techniques, to use green materials and to develop more environmentally friendly and minimalistic designs. Meantime, ethical conduct like maintaining transparency when working with project parties, settling all the payments according to the contract and revealing all the necessary information that support the development directly impact the CSR initiatives in business process. Apprehension of the client towards morally obliged sustainable practice, attitudes and values also significantly affects the client organizations' business process CSR implementations.

Turning towards consultant organizations business process, it is the responsibility of consultants to encourage the client to use green materials while convincing the client with realistic cost-benefit analysis. Ethical and responsible decision making at every stage of the project while promoting environmentally friendly minimalistic designs is expected from consultant organizations. Technically, influential power is available for the consultant party in a project. Hence, based on the decisions made by consultants it can encourage or discourage the business process decision making of other project parties like contractor or material supplier. Developing a morally obliged business operation and sense of responsibility to work beyond the legal requirement needs to be implemented within consultant organizations for an innovative future in the construction industry. Utilization of innovative resource conservation methods during the designing stage is indeed for the implementation of business process CSR and it will lead to a smooth business process implementation for contractor or material supplier. Professionalism and professional conduct are other essential factors, which directly decide the long-term survival of any business.

For contractor organizations business process CSR implementations; there is a substantial impact for awareness, knowledge and interest on sustainable initiations among contractor party. Ethical and responsible decision making in every stage of the project along with attention to long-term impacts and benefits in decision-making is essential. Developing a morally obliged business operation and sense of responsibility to work beyond the legal requirements and ensuring the development of innovative solutions for environmental and social impacts arise from the organization itself. Allocating a fixed budget for business process improvements and establish a department or unit for research and development to make sure that the organization operating based on an environmentally friendly and socially responsible framework will provide exclusive paybacks.

From material supplier standpoint, promoting environmentally friendly material manufacturing and supplying process (raw material extraction, manufacturing process, waste generation, etc.) is crucial. It is further necessary to carry out environmental impact assessment for all stages of the material (manufacturing, usage, and disposal). Considering quality of the material, durability and health and safety of material through the attainment of legal and safety requirements is having utmost importance since it directly affects the end user's satisfaction. Utilization of innovative resource conservation methods during the product designing and manufacturing stage will lead to an economized manufacturing process which increases the profitability of the organization. Meantime, fair competition and establishment of self-regulatory mechanisms to abide by the law is necessary to implement along with ethical decision making.

Maintain healthy relationship with project parties (effective communication, appropriate communication channel, corporate problem solving etc.), ethical and professional conduct of professionals is substantially important for all the stakeholders to maintain harmonious relationship. Furthermore, it is found that disappearance of business process CSR in consultant and contractor organizations, again lead the client in suppressing green initiatives (Somachandra et al. 2018a, b). This is due to the overwhelming factor and it further affirms the interwoven nature of construction industry through showing the impact of the practice of one organization or one party over other organizations or other parties' decision-making. Correspondingly, it needs to understand that there is a cyclic reaction in every action of every part of this industry. Thus, being genuinely and morally responsible is important to maintain the healthy relationships and to sustain in the industry as a whole (Table 14.1).

14.4.2 Business Environment

Concerning CSR related to business environment, focus directed to develop human capital of the organization is vigorous. Satisfied, loyal and skillful employees are a resource for an organization to achieve greater heights. Thus, educating the employees to enhance their skills is vital for human capital development. Recognizing employees is a further important factor. Development of top management commitment for ethical, environmentally friendly and socially responsible business environment is crucial for long-term survival of the business. Apart from that, adherence to organizational level policies to create a healthy working environment, ethical and fair treatment for all employees, provide all welfare facilities for all the employees, establish proper occupational health and safety procedures for employees and developing

Table 14.1 Business process CSR practices

Business process		
Environmental	Environmental friendly, ethical and responsible decisionmaking of stake holders	Environmental friendly high performance designs, use of sustainable materials, waste minimisation, consideration on energy efficiency in decision making
	Awareness on Environmental friendly concepts and positive impacts of those concepts	Awareness on concepts like sustainability, embodied energy, low energy building designs, zero waste concept, passive house concept and low carbon emission, understanding on life cycle costing
	Use of innovative resource conservation techniques	Solar power, bio-degradable materials, green insulations, building automation systems, low carbon processes, cool roof, sustainable resource sourcing, electrochromic smart glass, water efficiency technologies and appliances, energy efficiency technologies and appliances, sustainable indoor environment technologies
	Innovative solutions for environmental impacts	Waste management, re-use of waste, bio-gas generation, sell-waste accumulating in the site
	Develop and adherence to organizational level policies to minimize the environmental impact	Waste management policy, energy policy, quality policy
	Assess the impacts of the organization operation to the environment and minimise the impact	Environmental impact assessment, energy audits, environmental audits
Economic	Cost effective decision making considering long term impact	Minimalist designs, selection of cost effective durable materials, concern on life cycle cost impact in decision making
	Financial stability in decision making	Client's purchasing power in investing green initiations
	Long-term survival	Morally obliged sustainable business practices like ethical conduct and fair competition, developing term non adversarial partnership
	Invest on innovative solutions	Invest on possible research and development and process improvement approaches

(continued)

Table 14.1 (continued)

Business process		
Social	Socially responsible decision making	Use of local materials, recruit local employees, use of healthy and safe materials
	Healthy relationship among project parties	Transparency and accountability, timely settlement of payments respect all the project parties
	Professional conduct	Professionalism and professional ethical behavior, having a code of ethics for the organization
	Develop and adherence to organizational level policies to minimize the social impact	Develop employment opportunities (discourage automation in areas of high manual workforce population

Source Somachandra et al. (2019)

code of ethics from organizational level and adhering to it is vigorous to maintain healthy working environment (Table 14.2).

14.4.3 Philanthropic

Almost all the stakeholder organizations in construction industry are already contributing for the charitable donations in different ways. However, it is noted that these charitable donations are diffused and not aligned with organizational strategies. Thus, movement towards to a strategic philanthropic approach, which focuses their corresponding charitable and philanthropic activities around a specific issue or cause, which will in turn support their own business objectives will further nourish the organization to support longstanding survival. Potential strategic philanthropic activities could be stated as follows (Table 14.3).

14.5 Conclusions

Corporate Social Responsibility (CSR) has been identified as an effective tool to overcome the challenges and introduce sustainable practices among construction stakeholders on their business decisions. During the investigation of prevailing CSR practices in Sri Lankan construction industry, it has evident that there is a considerable gap in the sectors of business process, business environment and philanthropic. Thus, formulating a framework to guide stakeholders in CSR practices for better social

Table 14.2 Business environment CSR practices

Business environment		
Environmental	Create healthy working environment	Clean environment for employees
	Educate employees	Provide training programs on environmental aspects
	Legal adherence	Establishment and improvement of corporate environmental management system
Economic	Invest on employee recognition	Give rewards and incentives to top performers
	Invest on human capital development	Invest on education employees, training programs, workshops, team building and leadership programs
Social	Educate employees	Provide training programs, professional coaching and mentoring, on-site education, perform team building activities
	Recognise employees	Encourage positive employee recognition
	Organizational environment	Promote a friendly organizational culture
	Availability of welfare facilities	Medical insurance, rest areas, lunch rooms, washrooms, lockers
	Develop and adherence to organizational level policies to minimise the environmental impact	Health and safety policy, recruitment policy, employee development plans, legal compliance on payments and other benefits, transparent annual performance and appraisal procedures
	Fair treatment for all employees	Equal opportunities, human right, disability, treat all employees ethically

Source Somachandraet al. (2019)

and environmental accountability along with morally obliged business practices has emerged. To cater that requirement above, CSR guideline was developed to fulfill the gap of prevailing practice in three clusters namely; business process CSR, CSR in business environment and philanthropic. The stakeholders of the construction industry will reach a win-win situation by using this model being sensitive to society as well as environment and achieving their enduring economic goals.

Table 14.3 CSR practices related to strategic philanthropic

Strategic philanthropic	
Environment	Organize tree plantation campaigns with school children
	Organize waste collection/clean up projects with school children
	Preserve environment scared resources from by-products of waste generated from the ore business (coral rehabilitation using cube test samples)
Economic	Create job opportunities from waste generated from the core business and get some margin from tem
	Organize fund raising programs to do donations for under-privileged people
Social	Provide internship opportunities for university students
	Sponse for industry related research conferences, research projects
	Keep workshop or seminars for school children
	Work closely with non-profit organizations in tobacco and drugs controlling
	take the responsibility in fund raising and fulfill a timely requirements in hospitals

Source Somachandra et al. (2019)

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Chapter 15
How a Little Design Project Means a Lot to a Community: Lessons Learnt from the Power of Partnerships in the Design of Anganwadi in Ajjarkad, Karnataka, India

Susan Ang, Norwina Mohd Nawawi, and Nandineni Ramadevi

Abstract Social responsibility is an ethical ideology or theory that an entity, be it an organization or individual has an obligation to act to benefit society at large (ARCASIA 2012). Building a better world is a global imperative to achieve the vision and aspirations of the United Nations Charter, to be "architects of a better world" through effecting positive social change, cultural preservation and issues of inequalities related to access to basic needs, women's empowerment and children's education. Social responsibility in architecture is about designing spaces and environments that are accountable and accessible to the interests of stakeholders; engender trust, respect and ownership in accordance to the Rule of Law and Respect for Human Rights. In designing socially responsible architecture and built environment, it is argued that these concerns can only be successfully addressed through platforms of global intercultural education, with collaboration and partnership as well as stewardship of the local government including community resources. This paper explored Intercultural Dialogue through Design (iDiDe), an immersive learning, community stakeholder engagement and consultation methods in the design of an Anganwadi building in Ajjarkad, Karnataka, India as the case study. iDiDe, as architecture and built environment education platform, explores student learning experiences and measures qualitatively the value of the design outcomes that benefit the community. This paper reflects upon the lessons learnt from the experience of the power of partnerships and social engagement through the sense of responsibility the students had gained in learning how their little project meant a great deal to the community.

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15.1 Introduction

Social responsibility is an ethical ideology or theory that an entity, be it an organization or individual has an obligation to act to benefit society at large (ARCASIA 2012). Building a better world is a global imperative to achieve the vision and aspirations of the United Nations Charter, to be "architects of a better world" through effecting positive social change, cultural preservation and issues of inequalities related to access to basic needs, women's empowerment and children's education. Social responsibility in architecture is about designing spaces and environments that are accountable and accessible to the interests of stakeholders; engender trust, respect and ownership in accordance to the rule of law and respect for human rights. This paper explored Intercultural Dialogue through Design (iDiDe, pronounced "i-dee-dee"), an immersive collaborative learning program for architecture and built environment students, which involved community stakeholder engagement and co-design consultation methods in the design of a new purpose designed Anganwadi centre in Ajjarkad, Udupi, Karnataka, India. iDiDe, as an architecture and built environment education platform, explores student learning experiences and measures qualitatively the value of the design learning outcomes that sought to benefit the Anganwadi community at large. This paper reflects upon the lessons learnt from the experience of the power of partnerships and community engagement along with the sense of social responsibility the students gained in learning about how their little project meant a great deal to the community.

The organisation of Architects Regional Council Asia (ARCASIA) had established an ARCASIA Charter of Socially Responsible Architecture—ACSR 2015. In believing that good architecture is about people and their communities, the Charter defined social responsibility as an ethical ideology or theory that an entity, be it an organization or individual, has an obligation to act to benefit society at large. The Charter clarifies the policy of social responsibility as applied and observed by Governments, Institutes and Societies of Architects, architectural practices/firms and individual architects including Schools of Architecture and Universities across Asia. In adopting the social responsibility of the architectural institute and embedding it into schools of architecture coursework curricula as a code of conduct, the expected outcomes will be the better management of global resources, more efficient use of building materials, reduction in energy consumption, less pollution and a more sustainable world at the onset. In designing socially responsible designs in the built environment, it is argued that these concerns can only be successfully achieved through platforms of global intercultural education, with collaboration and partnership as well as responsible stewardship of resources by the local governments.

Research in social health fields, and education have shown increased interest in recent years in finding new ways to study and address complex social problems with increasing value in conducting community-based studies (Wright et al. 2011). This paper has drawn parallels from such studies and championed the need for inclusion of social responsibility in architecture and sustainable built environment education. Reflections shared have been through the lenses of the faculty academics who taught and led the educational program in the core elements that linked the partners together in responding and solving the community design challenges. The process was one of nurturing those ties such that community values and vision are placed at the forefront of the design education agenda. This paper puts forward iDiDe as an innovative pedagogical model that leverages off the power of partnership and collaboration for such an argument. The positive outcomes of the iDiDe programme have spurred other schools of architecture in other countries in Asia and professional institutes to adopt and adapt the programme as part of an international effort to enliven the social conscience of society in sustaining the world through the concept of architecture and environment for humanity.

15.2 iDiDe (Intercultural Dialogue Through Design): A Platform of Global Education for Humanity and Premise of Social Responsibility Within the United Nation's Charter

ARCASIA stands for Architects Regional Council of Asia. It consists of all the Presidents of the National Institutes of Architects in 21 countries in Asia. Its objectives (https://www.arcasia.org/retrieved 24 May 2019) are:

- to unite National Institutes of Architects on a democratic basis throughout the Asian region, to foster friendly, intellectual, artistic, educational and scientific ties;
- to foster and maintain professional contacts, mutual co-operation and assistance among member institutes;
- to represent architects of the member institutes at national and international levels;
- to promote the recognition of the architect's role in society;
- to promote the development and education of architects and the architectural profession in their service to society;
- to promote research and technical advancement in the field of the built environment.

Despite a geographical location that could be argued to be within the Asian context, Australia is not part of ARCASIA and has never been invited to be a part. The ARCASIA charter that serves to advance the architecture profession in Asian nations precludes a non-Asian country to be a member. Yet the education links between Australia and several nations in Asia are long-standing and run deep. Moreover, historical links through shared commonwealth roots exist. Australian schools of architecture enjoy close relationships with Asian counterparts today, more than ever, in this climate of exchange, collaboration and partnerships, which are reflected in high international student enrolments as well as increasing faculty staff employed and the source countries of these students and staff from the Asia continents. Australia certainly realises the imperative for international understanding of human relations through education and learning of Asian cultures in the context of built environment education. Since 2010, the School of Architecture and Built Environment at Deakin University in Geelong, Australia, has led intercultural education and collaboration with partner universities in Asia, namely in Malaysia, India, Indonesia, Sri Lanka and Thailand. These collaborations have been initiated through the creation and development of the Intercultural Dialogue through Design (iDiDe) program (Ang 2018) to address the intercultural concerns and partnerships on ground amongst all global stakeholders (Refer Fig. 15.1). iDiDe is a platform for intercultural dialogue through design. It provides students with immersive learning environments that embrace community centred design and community stakeholder engagement and consultation methods in the design process. This paper has mentioned at the outset the case for social conscience and ethical considerations as core values and are desired graduate attributes for architecture and built environment students through experiential learning and engagement with authentic user contexts, in this case, the community within the built environment. Such platforms of global intercultural education, that look towards collaboration and partnership as well as stewardship of the local government including community resources can be of benefit when included as part of a sustainable architecture education. Margarita (2005) highlighted that experiential learning within a cross-cultural setting helps students in the development of a range of skills and competencies, including the ability to engage multiple voices in diverse partnerships.

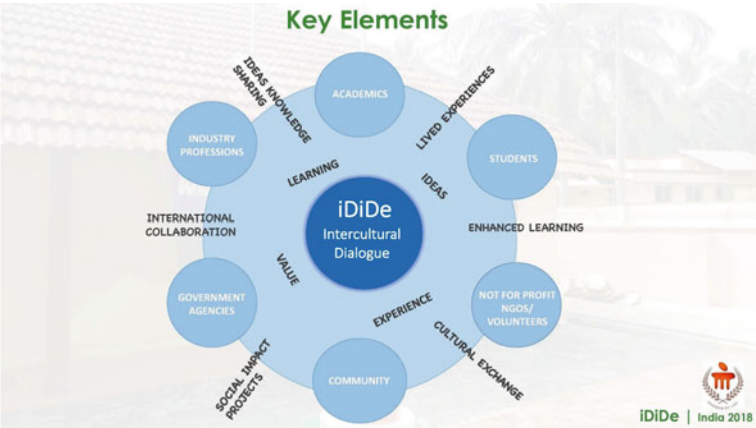

Fig. 15.1 The iDiDe model of collaborative design and education for sustainable built environments. *Source* Ang (2017a, b)

To support the above argument, iDiDe 2018 has been discussed as a case study for sustainable built environment with a focus on the social responsibility of architects in this paper. An iDiDe programme was conducted in India in January 2018 with 35 students from three universities from three countries—Australia, India and Malaysia. The Anganwadi centre in Ajjarkad, Udupi, Karnataka (rural mothers and child welfare centre) was chosen as a community empowerment philosophy and design building project, since there was a dire need to provide an improved facility for the community. This project served as the architecture and built environment design project.

15.3 Sustainable Built Environment Education Platform—The iDiDe Programme

The management of the iDiDe programme includes three key pedagogical phases comprising: pre-design research and fieldwork, design and fieldwork and post design reflection. The programme involved prior agreement between the host university of the chosen destination country (Faculty of Architecture, Manipal Academy of Higher Education and the lead university of the iDiDe programme (School of Architecture and Built Environment, Deakin University). Other participating universities from other nations were invited to participate (in iDiDe 2018, The Faculty of Architecture and Environmental Design, International Islamic University of Malaysia) came onboard as a third partner university to enrich the cross-cultural diversity and learning experience. Pre-design research and fieldwork stages included detailed pre-face to face collaboration briefing and preparation of the participants (both faculty members and students) at their respective home ground from the psychological, physiological perspectives as well as financial contexts. Students from all participating universities in the iDiDe program are required to engage virtually pre-face to face via online media platforms designed specifically for the programme to share their thoughts in relation to work ethics, learning preferences, learning styles, cultural values, and design skills and knowledge. Each university provided the profiles of their student participants to allow students to become familiar with one another before they were divided into teams of 5–6 members for the iDiDe studio. As an academic programme, students are also informed about the learning objectives and outcomes of the programme apart from the preparation to learn the culture of the host country and team members from other cultures and background. Country and culture familiarisation of host country includes exploring the climatic conditions, building construction techniques, availability of local building materials, geographical contexts, health status, economics as well as social traditions, cultural practices and religious beliefs.

Design and fieldwork stage commence with the actual embarkation to another country and experiencing the excitement and adjustment of travel from home country to host country. The reception and first impression experiences of the host country and host university can be of significant impact to a student learning experience, particularly in cases where this may be a student's first international travel experience and first intentioned cross-cultural educational experience. The overall academic programme offered unique cultural immersive activities relevant to the community design project as an intended "breather" and break away from intensive studio work. The final exhibition and publication of work are published in a project catalogue. The iDiDe design studio programme is interspersed with a more traditional version of a study tour which includes visits to architectural sites of value and interest before participants head home. The fieldwork stage is the experiential learning stage of many dimensions for all participating universities. The host university remains steadfast and prominent in the leadership of the flavour of the programme and requisitely remains open to changes at any point of time despite highly detailed logistics and careful prior planning, organising and scheduling. The needs of the participating cultures and religious beliefs were observed and accommodated wherever practicable and within reason throughout the programme. The engagement with other stakeholders were critical in the programme, and these were set in advance so that implementation could be executed smoothly. Dress codes, time management, ethics and moral values of respective participating universities/nation were given due attention and addressed. While students intensively design as a team in the studio, the accompanying faculty members contributed academic collegiate leadership to the lecture content as well as research seminar cum workshop associated with the programme as part of the holistic intercultural dialogue through design (iDiDe) experience.

Post-fieldwork, in particular post study tour reflection takes place after the design project is concluded. During this stage student participants are required to submit their individual journals and reflections of their experiences throughout the programme, from the outset of preparation, through the three stages of the programme. This outcome is included as creative formats and artefacts which include poster exhibition, a book, a video presentation in mixed use media formats. The relationship and fraternity of the participating students was begun on social media (online) platform continued long past the conclusion and physical departures of each participating team and historically in the iDiDe journey has continued to be maintained in the professional careers of the participants (Ang 2017a, b).

15.4 Partnerships and Stakeholders Involved in the Project

The academic partnerships between the three countries of India, Australia and Malaysia, represented by the three Schools of Architecture from the respective universities, work together under one umbrella and as a united collaboratiive studio, iDiDe has achieved user centric design proposals along with strong, structured engagement with the community and other stakeholders of the project. The co-participation between the community and academia (represented by the students and faculty staff who act as design leaders and mentors) is established through constant and frequent engagement and interactions initiated by academia with the community to build confidence and trust in the partnerships. This enabled the students to pursue

Fig. 15.2 Photo of iDiDe studio group comprising students from India, Australia and Malaysia engaging with the community parents and teachers at Ajjarkad, Udupi. *Source* Photo by Ang (2018)

and arrive at user friendly design proposals for the Anganwadi centre for Ajjarkad (Refer Fig. 15.2).

The participating Universities are represented by their respective students from the discipline of Architecture and Built Environment who are in their graduation program and possess the knowledge of design process, sustainable methods and concepts of design, materials and construction techniques. However, to ensure appropriate selection of the students for iDiDe with particular mindfulness of suitable individuals to work on social outreach projects for the rural communities, a thorough selection process is followed by all the participating partner Universities. Each university applies its own unique and rigorous process of recruiting and selecting suitable student candidates' to participate which included a combination of academic performance and student's interest and attitude for intercultural engagement and designing in diverse contexts. Before grouping them into the iDiDe studio teams, student participant profile and traits of design ability, technical and communication skills and interpersonal and teamwork skills are identified through web based psychomotor tests. Thus, the students were selected from all three participating Universities and regrouped into seven studio teams with diverse and equitable group composition comprising strengths of skills, team management and design communication in each group for best effective approach towards creating teams to work on the design proposals of context-based projects. The teams are mentored by a team of faculty academics representing each participating University. Each faculty member is qualified and experienced in design studio teaching in their respective Universities. The mentors collaborate, coordinate and contribute by giving relevant inputs individually and collectively to the teams throughout the programme and throughout the intensive design studio project. This not only results in students receiving a united teaching team's direction and also the opportunity to understand the same subject from different cultural perspectives and different universities teaching perspectives. This approach enables students to be well prepared to design in and for any context across the globe. The relationship between mentors and students of diverse cultures and amongst themselves created a healthy learning environment for decision making in the design project. This activity of iDiDe is a prime example of the power of partnership and cross university teaching and learning collaboration for achieving its goal.

It may be noted that iDiDe was founded with the vision to instil social responsibility in future architects. This vision included the prime objective of transformation into design by creating sustainable solutions for the under privileged, impoverished and remote located communities across the world, keeping in mind the local context, climate, availability of resources and the governing bodies, if found to be involved. With reference to the case study in consideration, Anganwadis are set up by the local governments in consideration with Integrated Child Development Service (ICDS), as stated earlier. Consequently, the Director of Women and Child welfare of the district is the concerned Government official authorized to set up Anganwadi in the district of Udupi. The Director has a hierarchical team consisting of Project Development officer (PDO), Supervisors (one in charge of 20–25 Anganwadi), teachers and workers to initiate, set up and manage. Thus, the officials mentioned above are the government stakeholders involved in the project. This implies that the students and mentors needed to establish early rapport and strong intercultural dialogues within the context of the Anganwadi project with the government stakeholders to incorporate their input and suggestions in the design to satisfy their needs and aspirations, at the same time meet the government policy and recommended guidelines for provisioning of Anganwadi without compromising on the community and end users needs and comfort. This constraint presented an unprecedented challenge to the students in this unique iDiDe learning process as its point of difference in authentic learning environments as that was never ever presented in a traditional classroom or design studio situation. It has been observed and respecfully understood that the local government will take the lead in the final decisions and hence the proposals have to fulfil the government needs whilst considering the requirements and preferences of the beneficiaries, community leaders, well-wishers and self-help organisations in the community, who form an important category of stakeholders in the project.

Intercultural dialogue through design revolves around academia and industry partnerships in mentoring the students to work intensively for putting forth the design proposals to the Government, Community and Anganwadi stakeholders. The challenge lies in achieving a design that is capable of meeting the policy driven Government requirements yet is capable at the same time of not only prioritizing the needs, safety and comfort of the children in Anganwadi but also capable of promoting their learning and the health and social development. Hence, it is very important to understand the hierarchies and perceptions of the government and community stakeholders and Anganwadi beneficiaries for a successful design.

15.5 The Context: The Typical Anganwadi

As mentioned in previous sections, a design studio of 35 students from three universities from three countries worked in mixed studio teams and were tasked with creating design proposals for an Anganwadi centre. “Anganwadi”, meaning “courtyard shelter”, is one of the largest public health initiatives created by the Indian Government, and was introduced in 1975 as a national public health service to combat child hunger and malnutrition. The Anganwadi or ‘courtyard house’ in the local dialect is a government initiative started in 1975 resulting in over 1 million Anganwadis throughout India. The Anganwadi Centre is part of the national initiative launched by the Government of India’s Integrated Child Development Scheme (ICDS) to improve health and nutrition of children. The aim was to combat child hunger and malnutrition, and maternal health care for rural communities in which they serve. It is best understood as a rural day care centre for early learning of children and health and education of lactating mothers.

Dwivedi and Nagda’s study in 2013 investigated the impacts of Anganwadi on the lives of the mothers and elder siblings of the children who attended the Anganwadi. Poignantly and of relevance to this paper, their findings identified that the involvement of the mothers in the community relied upon their use of the Anganwadi as an informal platform and social meeting point. This strongly suggested that the physical environment of the Anganwadi, namely the design of the centre played a crucial role in enabling this to take place. Dwivedi and Nagda (2013) noted during their surveys of Anganwadi centres, that it was evident the buildings were of varying standards, some had a lot of internal space for the children and others had very little. These physical spatial inadequacies were prevalent in buildings that were not purpose built but in makeshift or commandeered spaces in existing buildings such as our case study, located on shared premises of the existing Ajjarkad school (refer Fig. 15.3). Dwivedi and Nagda (2013) further found that existing Anganwadis were operating in under par physical conditions where the building roofs leaked during rainy seasons without basic sustainable building capacity and that internal dry spaces were used for the storage of fodder. Clearly, user safety, in particular, the lactating mothers and young children’s safety (typical age of infant children being 0–6 years) needed to be prioritised in these situations.

The design response was to be met with the typical professional constraints of budget, programme and scope faced in the built environment industry and academic requirements of benchmarked research and outcome. Up to 40 infant and pre-school children spend their day within the small Anganwadi building. Our case study visits showed that the entire duration of time spent in these premises were up to 8 h, all of this time, they were restricted to one central “all in one multi-purposed room, with an adjacent basic kitchen and wash area. Windows are barred for safety from animals, which evokes a prison like atmosphere. Outdoor play takes place within restrictive verandas that extend from the front of the building. There are no playground or outdoor equipment, and the site boundary is only partially secured with a basic perimeter timber

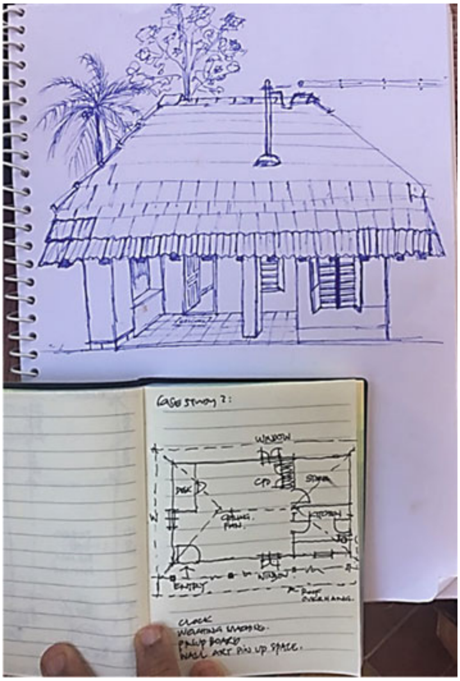

Fig. 15.3 Sketch of existing case study Anganwadi community in Ajjarkad, Udupi. *Source* Sketches by iDiDe participants. Photo by Ang (2018)

fence. Students were tasked with envisioning a potential new space for the Anganwadi children. How could the spaces be creative, explorative, and exciting, whilst still providing all the required practical and safety elements, within a low cost and tight budget? Could this humble structure be treated with the same seriousness and sincerity as a more expansive or prestigious one? During the design process, students were provided with the opportunity to visit and spend time with the children, workers, mothers and government officials. Connecting and collaborating with people who are invested in the outcome was an incredible and enlightening experience. Although, language barriers and cultural differences amongst many other challenges tested the students' capacity as budding globally aware and socially conscious architects, they also prompted them to explore innovative alternative options, and to question typical and obvious practices. Moving away from conceptual ideas within a typical studio, the project exposed students to the reality of the architecture and built environment for an under privileged community, and its potential impact of their inputs. The project actively inspired students to perceive and understand the environment through a different lens, and to push the boundaries of possibility and find a new familiarity beyond their normal comfort zones.

15.6 Engagement with Anganwadi Community Stakeholders in the Design Workshop

Engagement must include a two-way dialogue so that community members actively shape and inform not only the design outcome but the design process (refer Fig. 15.4). Professor Nishant Manapure, one of the academic leaders in the iDiDe program offered his insightful views towards the design challenge:

> Design gets its value from culture, acceptance through collaboration, and purpose through contribution. These three dimensions become the soul for architecture through the process of dialogue.

The importance of culture, collaboration and contribution was instrumental in designing for a rural context. The students worked with the children, parents, teachers, workers in the Anganwadi and health care providers in understanding their needs and adjusting the concept to suit, keeping in mind that stakeholders came from mostly rural backgrounds and spoke little to no English. The site allocated was 120sqm in Ajjarkad, which is located within an established government school. The mostly flat topography was overarched by an existing rain tree, containing extensive roots, on red laterite soil. Inclement weather was noted as an issue with tropical temperatures ranging from extremely hot to monsoon. A few rogue snakes and rodents joined us on the site analysis. The design needed to accommodate 20–30 children aged 0–6, 1 teacher and 2–3 caretakers allowing for future growth. Our brief sought to deliver

Fig. 15.4 Photo showing iDiDe participants facilitating a design workshop with Anganwadi community in the design of a new Anganwadi centre in Ajjarkad, Udupi. *Source* Photo by Ang (2018)

suitable spaces within 78 m^2 including a multi-purpose room for teaching, kitchen and rodent proof storage. External to the building required a sustainable vegetable garden and outdoor play. This was to be delivered within a proposed budget of 8 lakh Indian rupees or just under $16,000 Australian. The final designs were submitted for review and vetted by the stakeholders, an architecture panel and finally displayed at a public exhibition. The academic teams from Deakin, Malaysia and India are currently working towards funding requests to be submitted to the local district. These papers will include the seven designs completed by the students of iDiDe.

As the programme drew to a close, we returned to farewell the children and workers of the Anganwadi. Some members of Deakin University's School of Architecture and Built Environment may remember a chocolate drive that was run in the staff tea-room inviting donations. This fundraising effort raised a donation of just over $1000AUD and resulted in the purchase of a much-needed filtered water system and potted vegetable garden donated to the centre. Student reflection upon the learning experience demonstrated a strong evidence of emotional sense of the connection felt in the short period of engagement with the community:

> 'iDiDe has brought with it an emotional connection to the creation of architecture centering on the dimensions of collaboration, culture, and contribution,' she said. 'The need for 'sense' in design, 'an emotional connection to design', is required more than ever as we look to the future of built environment. I now know before we ask others to believe in our designs, we must first believe in them ourselves (Melissa Herron, Deakin University, Australian student participant in iDiDe 2018)

The iDiDe design workshop program was conducted over in nineteen days and included structured academic content as well as semi structured cultural immersion activities, field work, site visits and a public exhibition of student outcomes and experiences. To provide an overview of the program the following is the academic schedule as in Table 15.1.

15.7 Student Reflections Upon Learning Experiences

Students submitted a post study tour reflection report that allowed them to reflect upon their learning from the Anganwadi community design project. The following selected testimonials demonstrate how the students have reflected upon their engagement with the Anganwadi community design project. The recurrent themes are of:

- the opportunity to give back to society
- the impact of architecture design on the life of the Anganwadi
- the collaborative experience
- the engagement with community

> *iDiDe has made me realize how lucky I am to be a student of architecture and to be given the opportunity to give back to our society by helping those in need through design.* (Student 1 from FOA MAHE, iDiDe Student participant, 2018, Indian student participant)

Table 15.1 Academic schedule of iDiDe 2018 held at Manipal, India for designing Anganwadi at Ajjarkad, Udupi, Karnataka, India

Day	Activities	Details
01	Inauguration	To collaborate with partners for a common purpose
	Ice Breaking	Students to familiarize with their diverse team members
	Cultural Immersion	Folkdance/ beat boxing etc. by host students
02	Academic Seminars	Seminar on iDiDe intentions and process Seminar on basics of Anganwadis Seminar on current iDiDe program and process for design of Anganwadi, Ajjarkad, Udupi, India
	Site visit and existing Anganwadi study	To observe, collect data and interact with stakeholders
	Studio working session	Analysis of site data
03	Academic seminars	Seminar on site planning and sustainability
	Case study	Trip to Kidiyoor, Udupi
	Studio working session	Analysis of case study data
04	Cultural immersion	Visit to Manipal College of philosophy (eco-friendly) Visit to "Atriya" Architect's Residence, Manipal (construction, joinery and detailing in reclaimed wood) Visit to heritage village and Nirmithi Kendra
05	Studio working session	Program/concept/schematic plan of Anganwadi, Ajjarkad
06	Academic seminars	Seminar on children behaviour
	Social outreach	Workshop for the school children and Anganwadi kids (paper craft, painting, sketching etc.)
	Studio working session	Finalisation of program/concept/schematic plan
07	Academic seminar	Seminar on designing for diversity
	Studio working session	Review of earlier work and preliminary design development
	Cultural Immersion	Udupi City walk to experience Paryaya festival
08	Studio working session	Finalisation of design development Preparations for Stakeholder meeting-I (Design charrette)

(continued)

Table 15.1 (continued)

Day	Activities	Details
09	Academic seminars	Seminar on materials and construction techniques Seminar on project estimation and costing Seminar on design detailing
	Stake holder meeting	Part I—review meeting evaluation of proposals
10	Cultural immersion	St. Marys island and Stella Marys Church
11	Cultural immersion	Trip to Sringeri Vedic patashala and Sirimane falls
12	Studio working session	Finalization of design development
13	Stake holder meeting	Part- II presentation of refined proposals
14	Studio working session	Design detailing
15	Studio working session	Final presentation and Printing
16	Studio working session	Final review by academicians and practitioners
	Cultural evening	Celebration of australian day and republic Day of India
17	iDiDe exhibition	Public display of the work Program attended by University officials, local Government officials, Nirmithi Kendra, Non-profit organizations, stake holders, beneficiaries and community
18	Cultural immersion	Travel to Goa for post project study tour
19	Cultural immersion	Goa

Source Nandineni (2018)

> *iDiDe gave me a welcome departure from my usual curriculum. It made me realize how much of an impact architecture can bring to the daily life of the Anganwadi people when the right design principals are applied.* (Student 2 from FOA MAHE, iDiDe Student participant, 2018, Indian student participant)

> *iDiDe broke the circuit of an otherwise routine program of study. It helped me remind myself of the reason I chose architecture in the first place – to make a social contribution.*

(Student 3 from FOA MAHE, iDiDe Student participant, 2018, Indian student participant)

> *Studio and cultural immersion, with lots of fun and valuable learning. iDiDe provided a great opportunity to give back to the society.* (Student 4 from FOA MAHE, iDiDe Student participant, 2018, Indian student participant)

> *These centers play a vital role in the community, strengthening the fabric of neighborhoods and helping improve early learning skills, imagination, independence, and health outcomes for children. It was a privilege for me to contribute to such a noble social cause.* (Student 5 from School of Architecture and Built Environment, Deakin University, Australian student participant)

iDiDe accelerated my development of collaborative skills in a stimulating environment. The Anganwadi project was often challenging, having to overcome differences in culture, language and ways of thinking to deliver a design response with heavy time constraints. Completing the project developed my confidence in dealing with unexpected situations, my resilience and ability to work under pressure. Visiting the rural community where the Anganwadi was located and interacting with the residents really emphasized the magnitude of our work and how potentially beneficial it could be. The end result was a great sense of accomplishment and a heightened passion regarding the importance of design. Student 6 from School of Architecture and Built Environment, Deakin University, Australian student participant)

15.8 Reflection Upon Lessons Learnt

This paper reflects upon the lessons learnt from the experience of the power of partnerships and social engagement also through the sense of responsibility the students had gained in learning how their little project meant a great deal to the community. The iDiDe programme demonstrated the value upon the student learning when universities collaborated in teaching and learning in an authentic global context to create and sustain deep partnerships with communities worldwide. The different beliefs and opinions amongst the students were inherently both an obstacle as well as an advantage where students ultimately relied upon their shared language of design. As the programme ran its course, the students demonstrated through their reflections recorded in above sections how they became increasingly aware that the Anganwadi centers played a vital role in the community, strengthening the fabric of neighborhoods and helping improve early learning skills, imagination, independence, and health outcomes for children. Further evidence of impact towards raising awareness in community and government are demonstrated through multiple media articles that published the experience and the outcomes.

The evidence was published by Chandandeep of the Times Group in his article's titled "Anganwadi designs with holistic approach". Published on Monday July, 16, 2018 as part of the Education Supplement of the Times (www. Educationtimes.com) and an article titled "International design studio" was published in the Deccan Herald, by DH New Services, Mangaluru, India on January 13, 2018

https://www.deccanherald.com/content/653575/international-design-studio.html date retrieved 2 May 2019), Daijiworld.com news also reported an article titles "Udupi: iDiDe gets underway at MAHE, (https://www.daijiworld.com/news/newsDisplay.aspx?newsID=490437 date retrieved 23 May 2010). In Australia, the Australian media published this article, titled "Students 'design our future" dated July 12, 2018. (https://geelongindy.com.au/indy/12-07-2018/students-design-our-future/ Date retrieved 23 May 2019).

15.9 Discussion and Conclusion

This paper described the experience of the iDiDe community of university architecture students, and faculty teaching academics engaging with the Anganwadi community and with the local government. The research method was not the driving motive in this study. The primary objective was in creating and providing a learning environment and learning experience for the students. The sustainable development agendas are providing an opportunity to ask fundamental questions of design itself (Chick 2012). Design strategies, methodologies, tools and language are evolving, due to how design professionals and others are addressing an increasing range of social, cultural and environmental challenges (Chick 2012). This experience showed that the on-ground lived experiences and the powerful process of reflection upon learning and engagement are extremely helpful in creating knowledge for what works for specific contexts and a specific community. The significance of this on-ground lived experience and a somewhat organic approach is that there is intuitive learning at play. Future research might investigate the development of a teaching and learning framework or guidelines that help determine and establish working relationships among the partners in an intercultural collaboration setting so that all stakeholders feel ownership and investment in the educational framework and the collaborative research efforts as a community classroom. Partnerships related to co-design and community-engaged research remain complex and require immense pre-delivery planning and organising. The collaborative process presents many challenges and requires investment of time and commitment by all parties, community and university. Nurturing social responsibility as part of humanity in a challenging world where ethics are at stake at every level, takes collective effort. In the built environment world, there is no boundary. What affects one country affects its neighbours in a variety of ways. The iDiDe programme is a small but impactful effort by a group of academic communities from Australia, India and Malaysia with the hope that the effort will instil understanding of cultures and the needs of humanity in future generation of architects without borders.

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Correction to: Sustainable Banking—Scale Development and Validation

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In the original version of the book, the affiliation of authors in chapter 8 was inadvertently published with incorrect information. The corrected chapter and the book have been updated.

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