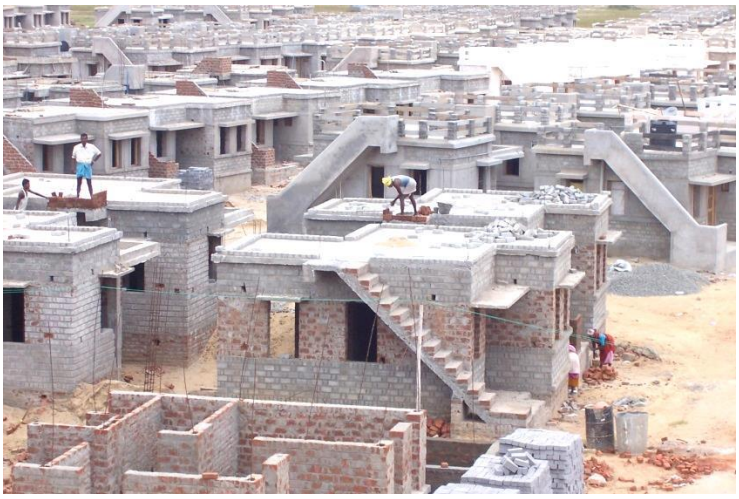
Sustainable Social Housing in India



Definition, Challenges and Opportunities

Technical Report

Gregor Herda, Sonia Rani,
Pratibha Ruth Caleb, Rajat Gupta,
Megha Behal, Matt Gregg, Srijani Hazra

May 2017

MaS-SHIP

Mainstreaming Sustainable
Social Housing in India Project

MaS-SHIP (Mainstreaming Sustainable Social Housing in India ***project***) is an initiative by the Low-Carbon Building Group at Oxford Brookes University, The Energy and Resources Institute (TERI), Development Alternatives and UN-Habitat, that seeks to promote sustainability in terms of environmental performance, affordability and social inclusion as an integrated part of social housing in India. MaS-SHIP is supported by the *Sustainable Buildings and Construction Programme* of the *10-Year Framework of Programmes on Sustainable Consumption and Production* (10-YFP).

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Technical peer reviewers:
Professor Amita Bhide, Tata Institute of Social Sciences
Dr Sameer Maithel, Greentech Knowledge Solutions
Professor B V Venkatarama Reddy, Indian Institute of Science

For more information on the MaS-SHIP project, please visit;
www.mainstreamingsustainablehousing.org
Or contact Professor Rajat Gupta: rgupta@brookes.ac.uk

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Images front and back cover: MaS-SHIP team

Research Team

Gregor Herda

Gregor Herda is an urban planner who has been coordinating the sustainable housing portfolio of UN-Habitat since 2014, including the activities of the Global Network for Sustainable Housing. His research interests include the socio-economic and financial sustainability of social housing programmes, integrated life-cycle energy analysis and application of building sustainability assessment tools in the Global South. He is currently based in New Delhi as a Regional Housing Advisor for India, Afghanistan and Sri Lanka.

Sonia Rani

Ms Sonia Rani is Fellow and Area Convenor at the Centre for Research on Sustainable Building Science (CRSBS) group under Sustainable Habitat Division (SHD) of The Energy & Resources Institute (TERI), New Delhi, India. - Her interest lies in the field of research and development, policy formulation through project implementation and incorporation of resource efficiency measures at building/campus level. She has almost 10 years of experience in different streams of sustainable development which primarily includes building materials, water & waste water management, solid waste management at both consultancy and policy levels. Under UNEP Funded project “Mas-SHIP”, she is involved in evaluating sustainability parameters to develop sustainability Index (SI) and to develop Design Support Tool (DST).

Pratibha Ruth Caleb

Pratibha is a deputy manager (Urban Research) at Development Alternatives. Her current areas of work are on policies related to resource efficiency, sustainable housing and sustainable cities. In the MaS-SHIP project she will be involved in assessing the housing projects based on social, economic and environmental parameters, as well as liasoning with the Government for greater buy-in for mainstreaming of such housing projects.

Rajat Gupta

Professor Rajat Gupta is Director of the Oxford Institute for Sustainable Development and Low Carbon Building Research Group at Oxford Brookes University (UK), where he also holds professorial chair in *sustainable architecture and climate change*. He is leading the UNEP funded MaS-SHIP project on mainstreaming sustainable social housing in India. Recently he won (with CEPT University) Newton Fund research award on *building performance evaluation for improved design and engineering* (Learn-BPE).

Megha Behal

Megha Behal is working as a Research Associate with The Energy and Resources Institute in the Centre for Research on Sustainable Building Science (CRSBS) group. Her interest lies in energy retrofits, building design optimization, performance evaluation & studies on visual comfort associated with integrated daylight systems, and sustainablebuildingmaterials and technologies. Megha is team member of

	the UNEP funded mainstreaming sustainable social housing in India project (MAS-SHIP).
Matt Gregg	Matt Gregg is a Research Fellow in Architecture and Climate Change, based in the Low Carbon Building Group of the Oxford Institute for Sustainable Development at the School of Architecture, Oxford Brookes University. Matt is currently involved with a 12-month project assessing the current and future overheating risk in four care homes in the UK; *Care provision fit for a future climate*.
Srijani Hazra	Srijani is a deputy manager (Habitat Solutions) at Development Alternatives. Currently she is leading the Habitat team and is involved in developing appropriate and affordable house designs for rural regions at various locations in India. Her primary focus lies in incorporating new construction technologies in housing schemes so that houses become accessible to large number of people.

Glossary of terms

Census (also called as population census) is the process of collecting, compiling, analyzing or otherwise disseminating demographic, economic and social data pertaining at a specific time, to all persons in a country or a well-defined part of a country. As such, the census provides a snapshot of the country's population and housing at a given point of time.

Census house is a building or part of a building used or recognized as a separate unit because of having a separate main entrance from the road or common courtyard or staircase etc. It may be occupied or vacant. It may be used for a residential or non-residential purpose or both. If a building has a number of Flats or Blocks/Wings, which are independent of one another having separate entrances of their own from the road or a common staircase or a common courtyard leading to a main gate, these will be considered as separate Census houses.

Census towns are places that satisfy the following criteria are termed as census towns: a) A minimum population of 5000 b) At least 75% the male main working population engaged in non-agricultural pursuits c) A density of population of at least 400 per sq.km.

Congestion factor refers to the percentage of households in which each married couple does not have a separate room to live. These are usually households with one or more married couples sharing room with a person aged 12 years or more.

Consumer price index is a comprehensive measure used for estimation of price changes in a basket of goods and services representative of consumption expenditure in an economy is called consumer price index.

Dwelling is defined as a set of living quarters. Two types of dwelling are identified in the Census:

Collective dwellings are institutional, communal or commercial in nature.

Private dwellings refer to a separate set of living quarters with a private entrance either from outside the building or from a common hall, lobby, vestibule or stairway inside the building.

Economically weaker section (EWS) households are defined as households having an annual income up to Rs 3,00,000 (Rupees Three Lakhs). States/UTs shall have the flexibility to redefine the annual income criteria as per local conditions in consultation with the Centre.

Floor area ratio (FAR) is the relationship between the total amount of usable floor area that a building has, or has been permitted for the building, and the total area of the lot on which the building stands. This ratio is determined by dividing the total, or gross, floor area of the building by the gross area of the lot. A higher ratio is more likely to indicate a dense or urban construction. Local governments use FAR for zoning codes.

Lower income group (LIG) households are defined as households having an annual income between Rs 3,00,001 (Rupees Three Lakhs and one) up to Rs.6,00,000 (Rupees Six Lakhs). States/UTs shall have the flexibility to redefine the annual income criteria as per local conditions in consultation with the Centre.

Habitat is a place or environment that is conducive to growth and provides controlled comfortable physical environment for the inhabitant.

Household is usually a group of persons who normally live together and take their meals from a common kitchen. The persons in a household may be related or unrelated or a mix of both. However, if a group of unrelated persons live in a Census house but do not take their meals from the common kitchen, then they will not collectively constitute a

household. Each such person should be treated as a separate household. The important link in finding out whether it is a household or not is a common kitchen. There may be one member households, two member households or multi-member households. There are three types of households namely:

Normal household is usually a group of persons who normally live together and take their meals from a common kitchen.

Institutional household comprises a group of unrelated persons who live in an institution and take their meals from a common kitchen. Examples of Institutional Households are boarding houses, messes, hostels, hotels, rescue homes, observation homes, beggars' homes, jails, ashrams, old age homes, children homes, orphanages, etc.

If in a building which is occupied by an Institutional Household, the families of the warden and peon are also living in separate Census houses and cooking for themselves separately, then each family will be treated as a separate household and the houses occupied by them will be treated as separate Census houses. In this situation there will be one building, three Census houses and three households, i.e., one Institutional Household and two Normal Households.

People staying in a *normal household* may be related or unrelated or a mix of both, whereas in an *institutional household* the persons are unrelated.

Houseless household do not live in buildings or census houses but live in the open or roadside, pavements, under fly-overs and staircases, or in the open in places of worship, mandaps, railway platforms, etc., are to be treated as Houseless households.

Housing demand is a market driven concept and relates to the type and number of houses that households will choose to occupy based on preference and ability to pay.

Housing need is an indicator of existing deficit. The number of households that do not have access to accommodation and are currently in homeless conditions, without a shelter /house are households that account for housing need.

Housing shortage is defined as the number of households in need of a shelter/ house and the households who need a livable house. Housing shortage includes households living in obsolescent houses, non-serviceable *katcha* house, congested houses needing new houses and households that are in homeless conditions.

Housing stock is the total number of dwelling units constructed in a defined area is defined as housing stock. This will include occupied and vacant houses

Migration rate is taken as the ratio of total migrants counted in the Census to its total population multiplied by 1000. While discussing the migration result, the term population mobility is taken as a synonym to migration rate.

Obsolescence Factor in housing is defined as the reduction in the usefulness or desirability of a house because of its outdated design feature or condition, usually one that cannot be easily changed. The first component of unacceptable housing is non serviceable units. The second component is obsolescent units which can be (a) all bad houses that are less than 40 years of age and (b) all houses aged 80 years or more

Out growth should be a viable unit such as a village or part of a village contiguous to a statutory town and possess the urban features in terms of infrastructure and amenities such as pucca roads, electricity, taps, drainage system, education institutions, post offices, medical facilities, banks etc. Examples of out growths are railway colonies, university campuses, port areas that may come up near a city or statutory towns outside its statutory limits but within the revenue limit of a village or villages contiguous to the town or city.

Pradhan Mantri Awaas Yojana (PMAY) was launched in June 2015 as a social welfare flagship program with an aim to provide affordable housing to urban poor. Under PMAY, it is proposed to build 2 crore houses for urban poor including EWS & LIG in urban areas by the year 2022 through a financial assistance of ₹2 trillion (US$30 billion) from central government.

This Mission has four components:

a) In-situ Slum Redevelopment with private sector participation using land as resource

b) Affordable Housing through Credit Linked Subsidy

c) Affordable Housing in Partnership with private and public sector

d) Beneficiary-led house construction /enhancement.

Rajiv Awas Yojana (RAY) was an Indian government program that attempted to help slum dwellers gain appropriate housing and address the processes by which slums are created and reproduced. It was introduced by the Indian government's Ministry of Housing and urban poverty Alleviation, which ran from 2013 to 2014. The scheme aimed to make India slum-free by 2022 by providing people with shelter or housing, free of cost.

Slum, for the purpose of Census, has been defined as residential areas where dwellings are unfit for human habitation by reasons of dilapidation, overcrowding, faulty arrangements and design of such buildings, narrowness or faulty arrangement of street, lack of ventilation, light, or sanitation facilities or any combination of these factors which are detrimental to the safety and health.

Urban agglomeration is a continuous urban spread constituting a town and its adjoining urban out growths or two or more physically contiguous towns together with or without urban out growths of such towns.

Urban area comprises statutory towns, Census towns, and outgrowths

List of abbreviations

10-YFP	10-Year Framework of Programmes
AAC	Autoclaved aerated concrete
AEGR	Average Annual Exponential Growth Rate
AHIP	Affordable Housing in Partnership
AHP	Affordable Housing in Partnership
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
AP	Andhra Pradesh
APHB	AP Housing Board
APL	Above poverty line
APRSCL	Andhra Pradesh Rajiv Swagruha Corporation Limited
APSHCL	Andhra Pradesh State Housing Corporation Limited
BCA	Building and Construction Authority
BDA	Bangalore Development Authority
BEES	Building for Environmental and Economic Sustainability
BIM	Building Information Modelling
BMRDA	Bangalore Metropolitan Regional Development Authority
BMTPC	Building Materials & Technology Promotion Council
BPL	Below Poverty Line
BREEAM	Building Research Establishment Environmental Assessment Method
BSUP	Basic Services for Urban Poor
C&D	Construction and Demolition
C&DMA	Commissioner and Director of Municipal Administration
CBRE	Commercial Real Estate Services
CEF	Connecting Europe Facility
CEPT	Centre for Environmental Planning and Technology
CPF	Central Provident Fund
CPWD	Central Public Works Department
CRSBS	Centre for Research on Sustainable Building Science
CSO	Central Statistics Office
DRI	Differential Rate of Interest
DST	Decision Support Tool
DU	Dwelling Unit
ECBC	Energy Conservation Building Code
ECBC	Energy Conservation Building Code
ECBC	Energy Conservation Building Code
EEFP	Energy Efficiency Financing Platform
EPI	Energy Performance Intensity
EPS	Expanded Polystyrene
ERG	Environmental Reference Guide
LCI	Life Cycle Inventory
EVALOC	Evaluating Low-Carbon Communities
EWS	Economically Weaker Section
FAQ	Frequently Asked Questions
FAR	Floor Area Ratio
FEEED	Framework for Energy Efficient Economic Development
FSI	Floor Space Index
FYP	Five Year Plan
GBCSA	Green Building Council South Africa
GDP	Gross domestic product
GERES	Groupe Energies Renouvelables, Environnement et Solidarites
GFRC	Glass fiber reinforced concrete
GHG	Greenhouse Gas
GIM	Green India Mission
GJ	Gigajoules
GRIHA	Green Rating for Integrated Habitat Assessment
GRIHA-NRS	GRIHA - the National Rating System
HAPI	Management of Housing Performance Information
HDB	Housing & Development Board
HFA	Housing for All Scheme
HIG	High Income Group
HK-BEAM	Hong Kong Building Environmental Assessment Method

HMDA	Hyderabad Metropolitan Development Authority
HRIDAY	National Heritage City Development and Augmentation Yojana
HUDCO	Housing and Urban Development Corporation
IAY	Indira Awaas Yojana
IGBC	Indian Green Building Council
IGBC-CII	Indian Green Building Council (IGBC), part of the Confederation of Indian Industry (CII)
IHSDP	Integrated Housing and Slum Development Programme
IIEC	International Institute for Energy Conservation
IITD	Indian Institute of Technology
INDC	Intended Nationally Determined Contribution
INR	Indian Rupee
IPE	International Panel of Experts
ISHUP	Interest Subsidy Scheme for Housing the Urban Poor
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
KHB	Karnataka Housing Board
KRNK	Karnataka Rajya Nirmana Kendra
KSCB	Karnataka Slum Clearance Board
KUIDC	Karnataka Urban Infrastructure Development & Finance Corporation
LCA	Life Cycle Assessment
LCCA	Life Cycle Cost Analysis
LEED	Leadership in Energy and Environmental Design
LIG	Lower income group
MaS-SHIP	Mainstreaming Sustainable Social Housing in India project
MEPMA	Mission for Elimination of Poverty in Municipal Areas
mha	Million Hectares
MND	Ministry of National Development
MNP	Minimum Needs Programme
MNRE	Ministry of New and Renewable Energy
MoEF&CC	Ministry of Environment Forests and Climate Change
MoHUPA / MHUPA	Ministry of Housing and Urban Poverty Alleviation
MSAHPUA	Model State Affordable Housing Policy for Urban Areas
MTEE	Market Transformation for Energy Efficiency
NAPCC	National Action Plan on Climate Change
NAPCC	National Action Plan on Climate Change
NCAER	National Council of Applied Economic Research
NGO	Non Government Organisation
NHB	National Housing Bank
NMEEE	National Mission for Enhanced Energy Efficiency
NMSH	National Mission on Sustainable Habitat
NSDP	National Slum Development Programme
NTFP	non-timber forest produces
NUHHP	National Urban Housing and Habitat Policy
NURHP	National Urban Rental Housing Policy
O&M	Operation & Maintenance
PAT	Perform, Achieve and Trade Scheme
PMAY	Pradhan Mantri Awaas Yojana
PMGAY	Pradhan Mantri Gramin Awaas Yojana
PNG	Papua New Guinea
PPP	Public-private partnership
PPPP	Public Private People Participation
PRI	Panchayati Raj Institutions
PVC	Poly Vinyl Chloride
R&D	Research & Development
RAY	Rajiv Awas Yojana
RCC	Reinforced Cement Concrete
RGRHC	Rajiv Gandhi Rural Housing Corporation
RICS	Royal Institution of Chartered Surveyors
RRY	Rajiv Rinn Yojana
SC/ST	Scheduled Castes and Scheduled Tribes
SCM	Smart Cities Mission

SDG	Sustainable Development Goals
SEPF	Slovenian Environmental Public Fund
SHD	Sustainable Habitat Division
SI	Sustainability Index
SIDBI	the Small Industries Development Bank of India
SPR	Singapore Permanent Resident
STBA	Sustainable Traditional Buildings Alliance
SVA-GRIHA	Small Versatile Affordable GRIHA
TERI	The Energy and Resources Institute
ULB	Urban Local Bodies
ULCRA	Urban Land Ceiling and Regulation Act

UNEP	United Nations Environment Programme
UN-Habitat	United Nations Habitat
UP	Uttar Pradesh
USAID	United States Agency for International Development
UT	Union Territory
VAMBAY	Valmiki Ambedkar Awas Yojana
ZEB	Zero Energy Building

Contents

Executive Summary

While more often than not, 'housing' is defined as a basic need which provides a family access to shelter and basic amenities, also enabling the creation of demand for resources, physical infrastructure, labour, technology, finance and land. Housing is a physical manifestation of social and cultural practices and forms an integral part of the assessment of the development and health of an economy. Thus housing refers not only to the physical structure of a house but its forward and backward linkages to job creation, resource requirements, institutional and regulatory systems, supporting infrastructure, services, and social cohesion.

The 10YFP-funded project "Mainstreaming Sustainable Social Housing in India (MaS-SHIP)" is designed to build upon the work previously undertaken in the field of sustainable social housing globally and India in particular while recognizing the priorities set by the Government of India, as well as their inherent constraints.

All consortium partners have been working in the field of construction supply chain, integration of sustainability principles in buildings, building rating systems, housing policy advice to governments with the goal of integrating sustainability principles in housing sectors the world over. The present study is constituted of an analysis of 'the problem' of social housing provision in India, the response with which India has met this challenge in the past, how it translated into state level responses, and what could be learned from national and international case studies to positively influence the Government of India's prerogative to provide housing for all. The study provides to the MaS-SHIP project, background evidence on and insights into policy drivers (and barriers) for integrating sustainability into low-income housing and the development of tools to help in making such decisions. The report is also developed to form a stand-alone output in its own right.

The report concludes that 'social housing' may be a more useful term than 'affordable housing' in the Indian context, and redefines the term for this purpose. A historical retrospective of urban development, and in particular housing-related policies and programmes in India over the last half century outlines recurring 'themes' in the national response to the housing challenge, while pointing out their substantial, yet still insufficient impact. In addition, the lack of development of urban development policies through the lens ofclimate resilience, or more specifically resource efficiency, this project aims to highlight such policies that call of a re-look through these approaches

Furthermore, the housing deficit and status of social housing at state level is examined, while five 'high priority' states are identified as suitable for further inclusion in the development of the project's Decision Support Tool (DST). Existing building sustainability assessment and benchmarking tools similar to the DST are reviewed in an effort understand common and unique approaches, and to identify a 'market gap' (if any can be found in India in particular) which the DST could potentially fill. Lastly, exemplary 'social' housing projects are profiled to highlight influencing factors contributing to project's perceived higher level of sustainability. The case of Singapore is used in particular to outline the interplay of policy measures, national legislation and regulation, as well as advocacy and training efforts to increase the housing sector's sustainability, while acknowledging the inherent differences between the Indian and Singaporean context.

The graph below illustrates the general outline of the report, leading to the recommendations provided in the conclusion section.

Throughout the report, a blue textbox is used to highlight particular notable observations.

Brief description of the main chapters can be seen in the table below.

The Aspiration	India's relevant commitments under the 2030 Agenda for Sustainable Development, the Paris Agreement and the New Urban Agenda are briefly outlined.
The Reality	The current state of the Indian housing sector is described, with a focus on Economically Weaker Sections (EWS) and Low-Income Groups (LIG).
National Response	National housing policies and programmes in India are summarised with a focus on those impacting social housing and resource efficiency in the last decade.
State-level Response	The housing deficit is disaggregated by state. Five states are selected for a more detailed analysis of their individual responses to the housing challenge.
Tools	Building sustainability assessment and benchmarking tools at the national and international level are outlined, including their discerning characteristics and uptake.
'Best Practices'	International and national project level 'best practices' are presented, including one example—Singapore—at national programme level.
Limitations	Limitations of the report are briefly outlined.
Take-home Lessons	Based on the study's findings, the main take-home lessons for both the present project and the provision of sustainable social housing in India are presented.
State Profiles	A housing data collection for five selected states is presented in the Annex.

1. The Aspiration: Commitments

On an international level, three major agendas have been supported by the Government of India which have a bearing on urban development in general as well as climate change mitigation and resource efficiency in particular: the 2030 Agenda for Sustainable Development, the Paris Agreement and the New Urban Agenda.

1.1 The 2030 Agenda for Sustainable Development

The 2030 Agenda for Sustainable Development, the implementation of which officially began on 1 January 2016, is a plan of action based on 17 Sustainable Development Goals, many of which relate to the objectives of this project. Below a list of Sustainable Development Goals and targets and how they relate to the present project (United Nations, 2016).

Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all

While the proportion of the population in Southern Asia with access to electricity has increased from 63% to 79% between 2000 and 2012, a substantial proportion is still being left out. In addition, 80% of those who gained access to electricity since 2010 were urban dwellers, highlighting at the same time the need for energy efficiency interventions in the urban domain. In addition, energy intensity, calculated by dividing total primary energy supply by GDP, has been falling in Southern Asia between 2000 and 2012 from 6.8 to 5.4 mega joules per 2011 US Dollars PPP[1]. This indicator is, however, not falling fast enough, with substantial impacts on the achievement of other SDG[2]'s.

Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Labour productivity (GDP per worker) in Southern Asia is growing but remains low with 3.5 constant US dollars, compared to 68.2 US dollars in developed regions. Considering the housing sector being India's third largest industry, the potential for local economic development in associated construction and service industries is substantial.

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

The construction market in India is forecast to become the world's third largest by 2022 (Global Construction Perspectives and Oxford Economics, 2013). The sector is expected to grow at a rate of 7013). The sector is expected to grow at a rate ofc demand (DMG Events, 2015) and enhanced proposed spending of USD 1 trillion in the 12th five-year plan period. Overall residential construction demand is expected to increase more than fourfold by 2030 from its 2005 level. In addition, switching to more energy efficient construction technologies, once identified, will contribute towards further reducing carbon dioxide emissions per unit of value added; a process which has already seen a 14% reduction between 2000 and 2013.

Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable

Goal 11 represents the biggest alignment with this project. Target 11.1 seeks to "By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums". While the Government of India has allocated tremendous resources to

[1] Purchasing power parity

[2] Sustainable development goals

achieving its share of this particular target, the delivery of less sustainable housing still represents a challenge to other sustainability dimensions, which is where this project will intervene. In addition, Target 11.c specifically calls to "Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials." What constitutes a 'sustainable and resilient building' and to what extent 'local materials' must be sustainable from a life-cycle perspective, will also be a direct contribution of this project to this particular goal and target.

Goal 12: Ensure sustainable consumption and production patterns

The increase of the material footprint of non-metallic minerals in developing regions between 2000 and 2010 from 5.3 to 6.9 kilograms per unit of GDP at constant 2005 US dollars is an indicator that the increasing development pressure marks the construction industry as one of the primary battlegrounds for this particular SDG.

Goal 13: Take urgent action to combat climate change and its impacts

Both Targets 13.2 "Integrate climate change measures into national policies, strategies and planning" and 13.3 "Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning" will be read in conjunction with the commitments of each country's Intended Nationally Determined Contribution (INDC), including India's, and will rely heavily on built environment actors for their realization.

1.2 The Paris Agreement

The Paris Agreement, which entered into force on November 4th, 2016, commits its ratifying member countries to, among others, "holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels".

India's INDC under the Paris Agreement targets a 33% to 35% reduction in emissions intensity per GDP compared to 2005 by 2030. Some of the building related policies highlighted in the INDC include the mandatory use of fly ash within a 100km radius of thermal power plants. The commercial building sector is highlighted by reference to the Energy Conservation Building Code (ECBC), while the housing sector's role is implied through reference to India's "Design Guidelines for Energy Efficient Multi-Storey Residential Buildings". The importance of the building sector as a whole furthermore features by reference to India's native building energy rating system GRIHA (Green Rating for Integrated Habitat Assessment), and the fact that, at the time, India had 2.68 billion sq. ft. of "registered green building space across 3,000 projects (second largest in the world), of which 600 are certified and fully functional". The important difference between "registration" and "certification" is discussed in section 5.2.2 of this document.

The World Bank notes that the political commitment for adoption and implementation of the INDC, as of November 2016, is still very low with no adoption at Head of State level, inter-ministerial level, parliamentary or Ministry level (World Bank Group, 2016). Nevertheless, sectorial approaches to (I)NDC implementation are receiving increased international attention,

most recently at COP22 in Marrakesh, and should be used as a leverage point for the present project.

1.3 The New Urban Agenda

The 2016 New Urban Agenda is the successor document to the 1996 Habitat Agenda and is intended as „an action-oriented document which will set global standards of achievement in sustainable urban development, rethinking the way we build, manage, and live in cities". It was adopted at the Third United Nations Conference on Housing and Sustainable Urban Development, Habitat III, held in Quito, Ecuador, in October of 2016. Other objectives of the Conference were to secure renewed political commitment for sustainable urban development, assess accomplishments to date, address poverty and identify and address new and emerging challenges.

Buildings and housing construction feature strongly in the document. Paragraph 73 calls "to support sub-national and local governments, as appropriate, to develop sustainable, renewable, and affordable energy, energy efficient buildings and construction modes, and to promote energy conservation and efficiency." Similarly, Paragraph 74 acknowledges the need "to make sustainable use of natural resources and to focus on the resource-efficiency of raw and construction materials like concrete, metals, wood, minerals, and land, establish safe material recovery and recycling facilities, and promote development of sustainable and resilient buildings, prioritizing the usage of local, non-toxic and recycled materials, and lead-additive-free paints and coatings".

All the above instruments, while not legally binding, exert international pressure to put policies and tools in place for steering the Indian social housing sector towards greater sustainability.

2. The Reality: (Social) Housing in India

In contrast to these commitments at both the international and national level stands the current reality of adequate housing provision in India, which will be outlined in this chapter. This constitutes the problem statement based on which responses have been formulated and implemented in the past.

2.1 Defining 'Social Housing' in the Indian context

Before an analysis of the status of social housing can be undertaken, the term needs to be defined in a way which is In the Indian context, the term 'affordable housing' is more commonly used than 'social housing' by both government and external housing sector analysts. The most common understanding of what constitutes 'affordable housing' are listed in Table 1.

Semantically, housing can be 'affordable' at any income level. For this reason, this project will use the term 'social housing' 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.

Traditionally, social housing has been defined as housing that receives some form of public subsidy or social assistance, either on the supply or demand side (Europian Union, 2013). However, in the Indian context, it does not cover all forms of housing for the lower-income which do not receive public support. For this reason, the following definition of social housing in the Indian context is put forward.

Government Organisation **Pradhan Mantri Awaas Yojana** (Ministry of Housing and Urban Poverty Alleviation, Government of india)	• Size of DU for EWS: <30 sqm (Super Built-up area), for LIG: 30-60 sqm, for MIG: 60- 120 sqm • Repayment of home loans in monthly installments not exceeding 30% to 40% of the monthly income of the buyer
Research Institute **Making Urban Housing Work in India (RICS, LEVVEL, CBRE)**	• Provision of 'adequate shelter' on a sustained basis, ensuring security of tenure within the means of the common urban household • Affordable housing is that provided to those whose needs are not met by the open market
Private Sector **Affordable Housing – A Key Growth Driver in the Real Estate Sector by KPMG**	**Defined in terms of three main parameters** • **income level (independent variable)** • **the size of dwelling unit (independent variable)** • **affordability (dependent variable)**

Table 1 Definitions of affordable housing

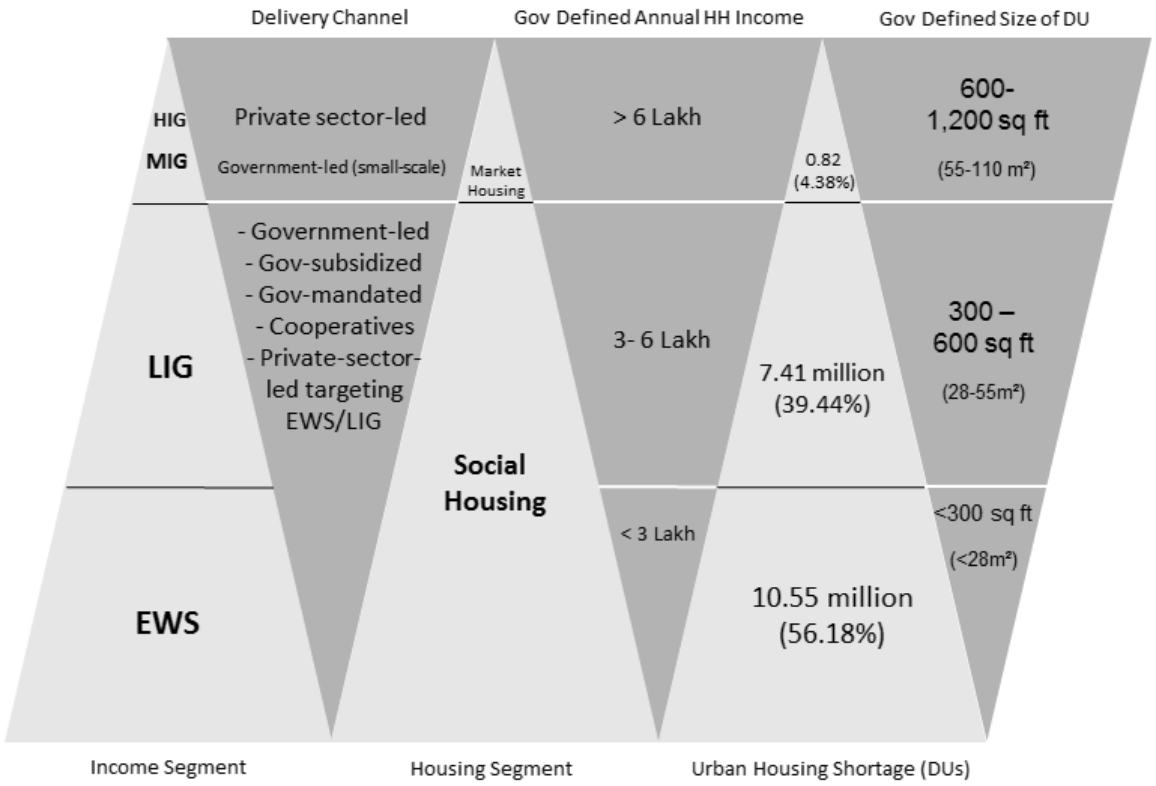


Figure 1 Definition of social housing as employed by the present project

As in most other parts of the world, in India the Government is primarily focused on housing provision for the lower-income, while the private sector caters to the middle-income and high-income strata. In addition, new forms of social housing, such as housing provided through cooperatives, community groups, non-profit private firms and political organizations other than state or national governments have emerged.

The definitions in Figure 1 can in addition be supplemented with average per unit costs. While the Royal Institution of Chartered Surveyors (2010) listed the average price of an EWS[3] housing unit (no floor area given) at the time at around INR 5 Lakh[4] (US$7,352), and that of an LIG[5] housing unit at up to INR 7 Lakhs (US$10,300), Deloitte (2013) states that low-income housing developers sell EWS/LIG houses at INR 1400-1700/ sq ft, or between US$6,650 and US$8,070 for a 30m² dwelling unit[6]. On the demand side, the affordability condition is met if the household expenditure for rent or mortgage servicing does not exceed a maximum threshold, usually given at 30% of monthly household income. Contrarily, the report of the high level task force on affordable housing for all (Deepak Parekh Committee, 2008) and the annual report by the Ministry of Housing and Urban Poverty Alleviation (Ministry of Housing and Urban Poverty Alleviation, Government of India, 2012) define affordability as a ratio of housing expenditure to *annual* household income,

[3] Economically Weaker Sections

[4] Indian numbering system equal to one hundred thousand (100,000)

[5] and Low-Income Groups

[6] It is noteworthy that, for the LIG segment, construction costs constitute 50-60% of the total sale price. compared to 18-20% in the HIG segment. Industry reports have noted an average annual price increase of 11.2% during 2008-2013.

with the former setting it at four times the annual income of EWS and LIG households.

2.2 Current Housing Shortage

The urban housing shortage (excluding the larger rural housing shortage) is officially estimated to be around 18.78 million dwelling units, aggregating households living in congested, obsolescent, and homeless conditions, or in non-serviceable kutccha (see Figure 2) (Government of India, Ministry of Housing and Urban Poverty Alleviation, 2012).

As Figure 1 shows, poor living conditions are heavily skewed towards the poor, with 96% of the housing shortage pertaining to the EWS LIG.

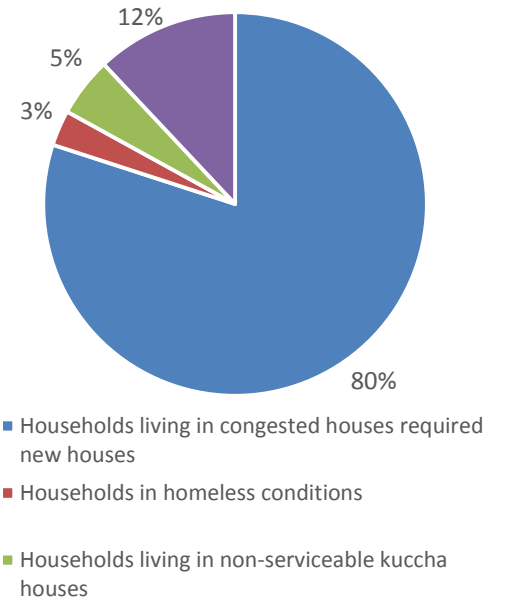


Figure 2 Distribution of urban housing shortage (2012)

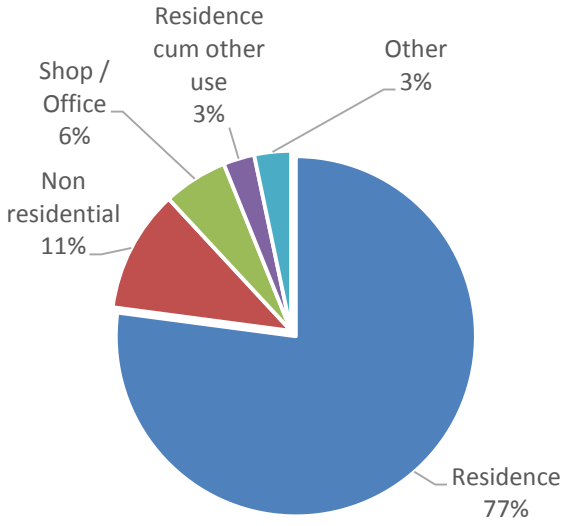


Figure 3: Use of census houses, India, 2011

The housing stock includes so-called 'census houses' in residential use, residential cum other use and non-residential census houses irrespective of whether occupied or vacant (see **Error! Reference source not found.**). According to a recent assessment by MoHUPA (2015), a total of 25% of houses constructed under the JNNURM scheme[7] are still to be occupied with the scheme having drawn to a close in March 2014. While some states have fared well in their occupancy ratio, namely Tripura, West Bengal, Assam and Odisha (99%), other States have performed very poorly namely Delhi (98% of houses *un*occupied), Punjab (78%) and Himachal Pradesh (63%) (Ministry of Housing and Urban Poverty Alleviation, Government of India, 2015).

Households living in congested conditions were found to be one of the main factors leading to these housing shortages. Among caste and ethnic groups, housing shortages were found to be higher for Scheduled Caste households than Scheduled Tribes and other households, mainly due to congestion.

[7] A city-modernization scheme launched by the Government of India

2.3 Housing as a Driver of Economic Growth and Resource Use in India

The construction sector is disaggregated into residential, non-residential and other construction sector. The residential construction sector refers to the housing sector which makes the fourth largest employment generating sector in India and accounts for (NCAER, 2014):

- 1.24% of the total output of the economy (total construction sector at 11.39%)
- 1.00% of GDP (total construction sector at 8.2%)
- 6.86% of employment (total construction sector at 11.52%)

The high percentage of construction-related jobs relative to the housing sector's smaller contribution to GDP signifies that productivity in the housing sector is relatively low, relying predominantly on informal, low value adding jobs which contribute 99.41% of the total job creation in this sector.

Investment in housing always results in inter-industry linkages and thus investment in housing creates strong multiplier effects by the generation of income and employment. A unit increase in final expenditure on the construction sector would help to create additional income for the economy as a whole, which is estimated to be five times the direct income generated by the public sector itself. Any further investment in the housing sector has an employment multiplier effect of 8 indicating that an additional unit of final expenditure in the housing sector induces an overall employment generation in the economy eight times the direct employment generated by the sector itself (NCAER, 2014).

As per the National Accounts prepared by the CSO for 2009-10, the contribution to GDP by real estate, ownership of dwellings and real estate related business services was 11.4 percent; thus construction and real estate contribute nearly one-fifth of India's GDP. In terms of employment during 2009-10, a little over 616 lakh workers were engaged in the construction sector and another 7.6 lakh in real estate[8].

The Indian construction industry is estimated to be one of the largest consumers by volume of raw materials/natural resources and construction materials/products manufactured. Reddy has estimated in his assessment of energy consumption of materials that the total energy expenditure on these materials is 3155×10^6 GJ per annum, which further is estimated to be 22% of the total GHG emission contribution in India (Reddy B. V., 2009). Table 2 indicates the transition that the construction sector has been through, from the use of zero-energy materials to high-energy materials. Table 3 indicates the annual consumption of construction materials and the energy expenditure from these materials.

[8] It may be noted that this employment does not mean that all the workers in these sectors had full time employment.

Prior to 4000 BC	4000 BC-1800 AD	1800 AD- to date
Soil, stones, reeds/thatch, Sun dried bricks, adobe, and unprocessed timber.	Burnt clay bricks, lime, cast iron products, lime-pozzolana cement	Aluminium, steel, glass, Portland cement, plastics, other smart materials, nano-materials, etc.
Zero-energy materials	Medium-energy materials	High-energy materials

Table 1: Energy consumption and developments in building materials, *Source: (Reddy B. V., 2009)*

Type of material	Annual consumption	Raw materials	Energy
Burnt clay bricks	150 x 10^9 nos.	Fertile soil (500 x 10^6 tonnes)	600 x 10^6 GJ
Cement	187 x 10^6 tonnes	Limestone, gypsum, oxides	650 x 10^6 GJ
Structural Steel	45 x 10^6 tonnes	Iron ore, limestone	1800 x 10^6 GJ
Coarse Aggregates	250 x 10^6 m^3	Granite/basalt rock	30 x 10^6 GJ
Fine Aggregates	350 x 10^6 m^3	River sand/rocks	75 x 10^6 GJ

Table 2: Construction materials produced in bulk quantities in India, *Source: (Reddy B. V., 2009)*

Energy resources used for production of materials include electricity, coal, oil, gas, and biomass. The energy consumption in the manufacturing and transportation of building materials is directly related to GHG emissions and related environmental consequences which range from land degradation, air and water pollution, loss of habitat, to global warming potential. In addition, apart from the energy demand of construction materials, their sustainable use is also a point for concern. It has been estimated that 300mm depth of fertile top soil of the entire country will be consumed for burnt clay brick production in about sixty years, assuming a compounded growth rate of 5% (Reddy B. V., 2009). In recent years, the increased demand of construction materials and the need to sustain construction activity, have ensured the exploration of alternative construction materials that are manufactured out of industrial/mining waste. Red-mud, coal ash, slag, and fly ash are by-products generated from large-scale mining, industries and thermal power plants. These waste products can be utilized for the manufacture of bricks, substitute for fine aggregates in concrete, partial replacement of cement in concrete, lime-pozzolana cements and others. Other construction techniques like stabilized mud blocks and rammed earth walls are also low-energy techniques which can reduce total embodied energy by up to 50%. Section 1.14.2.6 provides additional information on the different alternative and conventional construction materials and techniques used for low-cost housing projects in India.

3. National Response: Housing Policies and Programmes (1951-2017)

Housing demand in India is met by households themselves, community groups, private builders and government agencies. While the direct contribution of government agencies to building houses, in numeric terms, is limited, this segment of the housing stock, due to its potential for more effective oversight and inclusion of sustainability measures, shall be reviewed in this chapter.

Given the extent of the housing challenge in India, numerous policies and 'missions' have been enacted at the national level. Their limited impact has been attributed to some degree to their lack of interconnectedness and policy disincentives toward an urban economy (Tiwari & Rao, 2016). The major national housing policies, programmes and missions targeting EWS/LIG are outlined below, alongside more recent initiatives related to resource-efficiency and green growth.

3.1 Housing in India's Five Year Plans (1951-2017)

The proliferation of poor sections of society in 'mega cities' and metropolitan areas seeking employment are the primary factors causing the soaring demand for social housing. Ever since India's independence, trends of gradual industrialization and urbanization pushed the Government to consider housing as one of its main agenda points, which is reflected in its repeated mention in India's main policy document: the Five Year Plan.

The following section outlines the extent to which the housing sector was considered under the particular policy instrument of the Five Year Plan from 1951 to 2017 (Government of India). The intent behind this exercise is twofold: to provide a panorama of the policy levers deemed appropriate in the past, and to link the put current and future policy responses into context.

Five Year Plan (FYP)	Key features/coverage
First FYP (1951-1956)	- Housing for industrial workers; - **National Building Organization** (for cost reduction and improving building techniques) and **Housing Boards** (statutory autonomous bodies for implementation) (Tiwari & Rao, 2016); - Tax on vacant land (ibid.); - **Low Income Group Housing Scheme** (1954) led to addition of 1.3 million houses at year's end.
Second FYP (1956-1961)	- **Industrial Housing Scheme** extended to cater to EWS/LIG housing needs; - Construction of 1.9 million houses envisioned under **National Housing Programme** covering rural housing, 'sweeper's housing' and MIG housing (no figures on actual achievement) - Life Insurance Corporation of India provided housing finance to MIGs and to State Governments for undertaking rental housing for low paid state employees; - **State Housing Corporations (**1957) to furnish debt finance for projects with CG subsidies.

Third FYP (1961-1966)	- Research: building techniques, statistical housing data for effective programme planning; - Regional and urban development accorded recognition and development plans for 72 urban centres developed.
Fourth FYP (1969-1974)	- Town Planning legislation introduced in all states; - Emphasis on prevention of population growth or dispersal of population; - A special provision for water supply, sewerage and drainage was included; - **Housing and Urban Development Corporation (HUDCO**), 1970, to enhance housing conditions of EWS/LIG.
Fifth FYP (1974-1979)	- Financial/loan assistance for developing necessary infrastructure in Bombay, Madras, Calcutta and other cities; - Programmes directed towards construction of EWS 'housing colonies' by Housing Boards. - **Urban Land (Ceiling and Regulation) Act 1976** (ULCRA) to prevent land speculation and to ensure optimal allocation of land.
Sixth FYP (1980-1985)	- R&D grant to improve formulation of policy on urbanization and urban development.
Seventh FYP (1985-1990)	- Promotion of self-help housing, assistance to rural families - Promotion of low-cost housing techniques[9] and standards along with modifications in building bye-laws, land use control, minimum plot sizes and others in order to reduce costs. - **Minimum Needs Programme (MNP)** to tackle rural housing deficit; - **National Housing Bank (NHB)**, 1987; - **National Housing Policy,** 1988
Eighth FYP (1992-1997)	- Importance of urban sector for national economy recognized; - National Housing Policy replaced by **National Housing and Habitat Policy, 1998**, focussing on fiscal concessions, carry out legal and regulatory reforms and creating strong PPPs to resolve housing problem.
Ninth FYP (1997-2002)	- Affordable housing program for Below Poverty Line (BPL) category - Social schemes with credit assistance from HUDCO and other monetary institutions. - **Indira Awaas Yojana (IAY)** to deliver free housing units to BPL rural poor - ULCRA, 1976, deemed unsuccessful: **Urban Land (Ceiling and Regulation) Repeal Act**, 1999

[9] The Building Materials and Technology Promotion Council was established in 1990 to promote innovative and emerging building materials and technologies in the construction sector. Under the Technology Sub-Mission established for the mission on Housing for All (MHUPA), the BMTPC has been entrusted with the responsibility of providing the technical and knowledge support for promotion of such materials and technologies. The BMTPC has so far developed several compendiums of 'Prospective Emerging Technologies for Mass Housing', and 'Best Practices for Habitat Planning, Design & State Policies'. In addition, it has developed a multi-attribute evaluation methodology for emerging housing technologies and a virtual platform, i.e. a web-based knowledge network for technical information on building products, materials, technologies, systems, and processes encompassing sustainable habitat,.

Tenth FYP (2002-2007)	- **National Urban Housing and Habitat Policy, 2007**, to increase and strengthen housing stock in vulnerable regions for EWS/LIG; - Expansion of housing for weaker sections in rural areas; provisions for free of cost housing only to landless SC/ST families and shift to credit-cum subsidy system for other BPL families.
Eleventh FYP (2007-2012)	- Housing finance disbursals expected to increase along with growth in the volume of outstanding housing loans from commercial banks to households[10]. - Initiatives for **development of secondary mortgage** market to increase liquidity of housing finance for EWS, LIG and MIG highlighted by National Housing Bank (NHB). - BMTPC to provide financial support for **improving layout and design** of EWS/LIG housings. - Proposal: five-year 5% pa interest subsidy to commercial lenders for lending to EWS/LIG - 1.24 crore houses constructed under Indira Awaas Yojana (IAY)
Twelfth FYP (2012-2017)	- Availability of land to implement affordable housing plans recognized as major hurdle. - **Phase II of Rajiv Awaas Yojana (RAY)**, discontinued in 2015, subsumed under PMAY-HFA (U) - Suggestions: reorienting the role of SLBs, establishing an agency under Metropolitan Development Authorities for delivery of affordable housing, promotion of PPPs, increasing the Credit Risk Guarantee Fund and simplification of approval processes for affordable housing projects; - Need for greater financial support, smoother transfer of funds, abolition of APL-BPL distinction, enhanced land access for the poor, improving quality of IAY houses, developing rural building centres, emphasis on disaster risk reduction, training of masons and artisans, and partnerships with civil society and Panchayati Raj Institutions (PRIs). - Increased assistance for house construction under IAY to adjust for increasing costs; increase in Differential Rate of Interest (DRI) loans to IAY families.

Table 3 Housing and Urban Development in India's Five Year Plans

[10] Indeed, the volume of outstanding housing loans from commercial banks to households grew by 21% between 2006 and 2011 annually, even though loans to the cooperative sector shrank by 21.5% annually, though from much a much lower starting point (Singh, 2013).

In 2016, the Five Year Plans were abolished in favour of a 15-Year Development Agenda, containing a seven-year action plan with reviews every three years for 'course corrections'. It was felt that the previous Five Year plans lacked the 'long-term focus present in other countries' (The Economic Times, 2016).

If one were to crystallise broad themes or rationales emerging from this review of India's main policy instrument on housing and urban development, the following ten key points might emerge:

1. Repeatedly recognize the public sector's responsibility for housing the poor.
2. Establish both finance and implementing agencies at national and state level to fund and/or construct social housing.
3. Make affordable land available either through regulation or taxation; this remains a barrier.
4. Design housing programmes according to a) how much the target group earns (EWS, LIG, or MIG), and b) where they live (urban or rural).
5. Data is important to make actionable plans.
6. R&D into building technologies could still deliver a 'silver bullet' to reduce housing costs.
7. While slum clearance has been largely abandoned, slum upgrading or relocation to peripheral 'housing colonies' for the poor, are worth pursuing, with the more recent additions of assisted self-help, creating an enabling environment and full-scale public-private partnerships.
8. Housing policies should be updated regularly.
9. The housing finance ecosystem needs to be supported on both the demand and supply side.
10. The focus is on affordability and quantity rather than *sustainable* social housing.

While many of these 'rationales' can and should be questioned, the last point especially is essential for the present project which will argue that both housing and resource-efficiency objectives under both national and international agendas **should be pursued concurrently**.

3.1 Recent Housing and Urban Development Policies, Codes and Regulations

India has a long history of formulating housing policies. According to Tiwari and Rao (2016), their impact on ameliorating the shortage has been marginal due to limited resources allocated to their implementation, but also the obvious gap between the cost of housing construction and persistently low income levels. The two most recent housing policies are profiled below.

- **National Urban Housing and Habitat Policy (NUHHP), 2007:** The foremost objective of NUHHP is to promote and ensure sustainable development in the country with a focus on urban human settlements, duly served by ensuring equitable supply of land, shelter and services at affordable prices. NUHHP has critically analyzed the ways and means of providing 'Affordable Housing to All' with special emphasis on EWS and LIG sectors so that they are fully integrated into the mainstream of ecologically well-balanced urban development. The NUHHP aims at

urban planning, affordable housing by fostering fund generation, better management information system (MIS), employment generation, public private partnership (PPP), special incentives scheme (increase in FAR)[11] etc.

- **Model State Affordable Housing Policy for Urban Areas (MSAHPUA), 2014:** MSAHPUA is intended as a step towards implementing the NUHHP 2007. The policy empowers individual states to achieve housing policy objectives as listed under NUHHP 2007 by inclusion of legal and regulatory reforms, fiscal concessions, financial sector reforms and innovations. The Policy aims to provide "affordable housing for all" with special emphasis on EWS and LIG and other vulnerable sections of society such as Scheduled castes/Scheduled Tribes, Backward Classes, Minorities and senior citizens, physically challenged persons in the State and to ensure that no individual is left homeless. The policy further aims to promote Public Private People Participation (PPPP) for addressing the shortage of adequate and affordable housing.

- **National Urban Rental Housing Policy (NURHP), 2015:** NURHP focuses on promoting rental housing provided by the private sector, cooperatives, NGOs, industry (for workers' housing) and the services/institutional sector (for employee housing). It also encourages public-private partnerships in the rental sector.

  National Building Code of India, 2005: In 2013, a new Part 11 was added to the NBC entitled 'Approach to Sustainability'. This past covers the parameters required to be considered to be considered for planning, design, construction, operation & maintenance of building and those relating to land development from the point of view of sustainability. In 2016, revised and updated version of whole document is reprinted as NBC 2016.

- **Indian Standard IS 8888-1 (1993) – Requirements of Low Income Housing (Guide):** This standard provides guidelines for the planning and general building requirements of low income housing for houses having a maximum plinth area of 40m^2. It applies to low income 'housing colonies' by government bodies and private agencies.

3.2 Recent Housing and Urban Development Programmes and 'Missions'

Similarly, housing and urban development programmes have been plentiful over the years. The most recent ones are briefly profiled below, one of which, JNNURM, ended in 2014, and four others, with overlapping mandates, currently in implementation RAY, AMRUT, SMC, and PMAY:

- **Jawaharlal Nehru National Urban Renewal Mission (JNNURM), 2005-2014:**

- allocated Rs. 66,085 crores (US$9.732bn) over its nine year duration12;

[11] The NUHHP 2007 is not without its puzzling elements. Article 5.1 iv), for instance, states that "10 to 15 percent of land in every new public/private housing project *or 20 to 25 percent of FAR / Floor Space Index (FSI)* which is greater will be reserved for EWS/LIG housing through appropriate legal stipulations and spatial incentives". It is difficult to see how a percentage of a *ratio* (FAR) can be reserved for EWS/LIG housing.

[12] A final evaluation report of the programme was produced in 2011 which, due to JNNURM's

- **Focussed** on providing basic infrastructure services, as well as heritage spaces on PPP basis and redevelopment of inner (old) city areas; shifting industrial/ commercial establishments to conforming areas;
- umbrella programme for thematic sub-schemes like **Basic Services for Urban Poor** (BSUP), **Integrated Housing and Slum Development Programme** (IHSDP), **Interest Subsidy Scheme for Housing the Urban Poor** (ISHUP) and **Affordable Housing in Partnership** (AHIP);
- **BSUP** to provide seven basic entitlements (security of tenure, affordable housing, water, sanitation, health, education and social security) to low-income segments in 65 cities;
- **IHSDP** to combine existing schemes of Valmiki Ambedkar Awas Yojana (VAMBAY) and National Slum Development Programme (NSDP);
- Envisioned to cover Delhi, Greater Mumbai, Hyderabad, Bangalore, Chennai, Kolkata and Ahmedabad, 28 million-plus cities and 34 cities with less than one million inhabitants;
- JNNURM's rules and guidelines did not contain requirements for the environmental sustainability of housing projects and associated supply chains.

- **Rajiv Awas Yojana (RAY), originally 2011-2022, subsumed under PMAY-HFA (U) in 2015:**
- Preparatory phase (2011-2013), implementation phase (2013-2022);
- The two-step implementation strategy: preparation of a 'Slum Free City Plan of Action' and preparation of projects for selected slums;
- Intends to improve housing, basic civic infrastructure and social amenities in targeted slums;
- Focuses on slum prevention by providing affordable housing stock to urban poor, for instance, through **Affordable Housing in Partnership** (AHP) scheme [13];
- Financial support including Operation and Maintenance (O&M) of scheme target assets provided to implementing agencies (states/UTs/Urban Local Bodies/National Agencies)
- Scheme extended to rental and transit housing
- Carries forward JNNURM's Interest Subsidy Scheme for Housing the Urban Poor (ISHUP), now renamed **Rajiv Rinn Yojana (RRY),** to provide 5% interest subsidy on 15-20 year loans with maximum loan amount of 5 lakh for EWS and 8 lakh for LIG.

(Ministry of Housing and Urban Poverty Alleviation, Government of India, 2016a)

- **Atal Mission for Rejuvenation and Urban Transformation (AMRUT), 2015-2035**:
- Focus on providing basic infrastructure, but also development of green spaces, parks and recreation centres, capacity building and reform implementation;
- 500 Cities to be covered (capital cities/towns, heritage cities as per HRIDAY Scheme, hill states/islands/tourist destinations and all cities/towns with populations of over one lakh with notified municipalities);
- Fund investment over twenty years estimated at 59.1 lakh crores

extension from 2012 to 2014, now constitutes a de-facto mid-term report (Grant Thornton, 2011).

[13] Central Government grant of INR 75,000 per EWS/LIG dwelling unit (DUs) of up to 40 m²; minimum project size of 250 DUs; DUs a mix of EWS/LIG-A/LIG-B/Higher Categories/ Commercial of which at least sixty percent of floor area to be used for DUs with carpet area of not more than 60 m²

(US$870.5bn), to be invested under different components in addition to Operation & Maintenance (O&M);

- **Smart Cities Mission (SCM), 2015-2020:**
- Aims to cover sustainability in broader terms with objective to promote cities that provide core infrastructure and decent quality of life, a clean and sustainable environment and application of 'smart' solutions;
- Focus on compact areas, spanning either more than 50 acres (city renewal), 250 acres (green field city extension), or 500 acres (city improvement through retrofitting), providing as replicable model for other aspiring cities;
- Apart from basic infrastructure, SCM covers affordable housing, robust IT connectivity and digitalization, good governance (especially e-Governance) and citizen participation, sustainable environment, safety and security of citizens (particularly women, children and the elderly), health and education;
- Will cover one hundred cities with continuation subject to evaluation;
- Includes so-called 'Pan-city Initiative' in which 'smart' solutions are applied to larger parts of city;
- Rs. 48,000 crores (US$7.081bn) over five years i.e. on an average Rs. 100 crore (US&14.75m) per city per year; equal amount to be contributed by the State/ULB, doubling the total amount available for Smart Cities development.

- **Pradhan Mantri Awas Yojana (PMAY) OR Housing for All Scheme (HFA), 2015-2022:**
- Envisions to provide housing for all by the end of 2022 through slum rehabilitation with participation of private developers using land as a resource, promotion of affordable housing for EWS through credit linked subsidy and in partnership with public and private sectors and subsidy for beneficiary-led individual house construction;
- Designed in three phases to cover 4041 statutory towns falling under 500 class-I cities
- States/UTs, either through their agencies or in partnership with the private sector 'encouraged to develop affordable housing projects'
- Central financial assistance of Rs.1.5 Lakh (US$2,211) per EWS house declared
- Rural scheme, Pradhan Mantri Awaas Yojana – Gramin (Housing For All – Rural) is also being implemented), with identical per unit subsidies as PMGAY (see below) (Prime Minister's Office, Government of India, 2016)

- **Indira Awaas Yojana (IAY), 1996 onwards, renamed Pradhan Mantri Gramin Awaas Yojana (PMGAY) in 2016:**
- Aims to provide housing for the rural poor (figures in parenthesis apply since 2016)
- financial assistance provided for new construction at Rs.70,000/- (Rs 1.20 lakh) per unit in 'plain areas' and Rs.75,000/- (Rs 1.30 lakh) for hilly areas; beneficiaries can avail of a top-up loan upto Rs 20,000/- (Rs 70,000/-) under the Differential Rate of Interest (DRI Scheme) from any Nationalized Bank at an interest rate of 4% pa.
- construction of the houses sole responsibility of beneficiary; engagement of contractors strictly prohibited, though technical assistance is provided

(Ministry of Urban Development, Government of India)

Despite the higher housing shortage, in absolute terms, in rural as opposed to urban areas (43.7m units in rural India vs 18.78m in urban areas) the government-led housing and infrastructure programmes have primarily focussed on urban areas (Tiwari & Rao, 2016; Government of India, Ministry of Rural Development, 2011), although specifically rural programmes do exist. In addition, it is evident that, at least at first glance, quite a bit of overlap exists between these separate schemes and sub-schemes, and it is unclear at present how these significant resources, should they in fact be made fully available, will be allocated to ensure their most effective use.

3.3 Recent 'Missions' on Climate Change Adaptation and Mitigation

Lastly, the recent focus on energy and general resource efficiency has spawned a number of national initiatives, mostly notably as a product of the National Action Plan on Climate Change (NAPCC), which could offer a number of synergies with the housing sector:

- **National Mission on Sustainable Habitat (NMSH), 2010:**
- promoting understanding of climate change, its adaptation and mitigation, energy efficiency and natural resource conservation;
- On adaptation, climate change impacts on human settlements and infrastructure 'addressed' in relation to water, sanitation, energy, transportation, health-care, fire services and other forms of emergency measures;
- On mitigation, covers extension of Energy Conservation Building Code (ECBC) into commercial and residential sector, better urban planning, modal shift towards public transport, recycling of materials, and urban waste management with focus on Waste-to-Energy;
- No information on the level to which NMSH is resourced.

- **National Mission for Enhanced Energy Efficiency (NMEEE**):
- Information on NMEEE is limited, with four main components listed:
- Perform, Achieve and Trade Scheme (PAT), a regulatory instrument to reduce specific energy consumption in energy intensive industries;
- Market Transformation for Energy Efficiency (MTEE), for accelerating the shift to energy efficient appliances;
- Energy Efficiency Financing Platform (EEFP), for creation of mechanisms that would help finance demand side management programmes in all sectors by capturing future energy savings;
- Framework for Energy Efficient Economic Development (FEEED), for development of fiscal instruments to promote energy efficiency.
- Building sector not mentioned despite potential for reductions in energy consumption.

- **Green India Mission (GIM):**
- To increase forest/tree cover to the extent of 5 million hectares (mha) and improve quality of forest/tree cover on another 5 mha of forest/non-forest lands;
- To improve/enhance eco-system services like carbon sequestration and storage (in forests and other ecosystems), hydrological services and biodiversity; along with provisioning services like fuel, fodder, and timber and non-timber forest produces (NTFPs); and

- To increase forest based livelihood income of about 3 million households14.

3.4 Conclusion

It is one thing to present what a policy or programme *says* the government will do, or in this case, an entire array of policies and programmes spanning a number of decades. It is another thing entirely to assess what has in fact materialized on the ground, an exercise which would arguably provide more insight into what should be done next.

While the latter would clearly exceed the scope of this project and report, the former allows us at least to draw a number of cautious conclusions based on the observations in the previous two sections:

1 Central government with experience in designing and implementing large-scale housing and urban development programmes.

2 Current set of programmes exists with some thematic, and most probably also geographic, overlap, in the housing sector especially between the RAY and PMAY programmes

3 It is important to sequence infrastructure provision, e.g. through AMRUT, to precede housing provision, e.g. through RAY or PMAY or state-led programmes (see following section).

4 There is little written reference connecting climate change and urban development agendas in the design of central government programmes.

Although there is increasing knowledge on sustainable development globally, one critical dimension of urban housing problems is that sustainable housing is yet to gain its widely acknowledged importance in a country like India. This is due to the lack of understanding of the social, economic, cultural and environmental components of sustainability in housing development. India's urban programmes and policies do not yet make a sufficient link with India's environmental commitments at the national and international level. The present project aims to address this particular shortcoming both through stakeholder engagement and eventually a series of policy briefs which will make the case for the social housing sector as the most cost-effective leverage point for achieving environmental and poverty reduction objectives of India's development agenda.

The next chapter is then aimed at understanding how these national programmes have been implemented at state level, in addition to separate state initiatives, which will be used to identify case studies to feed into the project's future outputs.

[14] A number of natural building materials, most notably timbers and certain species of bamboo, the latter particularly in the tropical belt, have a tremendous potential for achieving and supporting this Mission's stated goals. Bamboo's mechanical properties, for instance, are similar to wood, but it produces up to 6 times more biomass per hectare as many conventional timber plantations. In addition, a number of livelihood and biodiversity objectives can be simultaneously achieved by increasing this resource base. The excellent anti-seismic properties of engineered bahareque (vernacular/traditional construction system) housing could furthermore increase the disaster resilience of communities in earthquake prone areas of India (International Network for Bamboo and Rattan, 2016).

4. State-level Response: Housing Sector Review

Sustainability in social housing differs from place to place. In a country the size of India, this requires bespoke solutions depending on geography, climate, culture and economy. For this reason, the project intends to develop a Decision Support Tool which is adaptable to a variety of contexts. To ensure maximum representativeness, the five climatic zones of India are used as the first of five selection criteria for identifying states in which social housing projects will then be analysed to develop the Tool's core indicators. The multi-attribute evaluation methodology for emerging housing technologies developed by the Buildings Materials Technology Promotion Council under the Technology Sub-mission (MHUPA, 2015) will underpin the indicators adopted in this project.

4.1 Case Study Selection

These case studies, however, present only one of three levels of case studies examined during the course of this project. These are outlined in table 4.

In order to identify **Level 2** case studies, an assessment of the demand for social housing across all states and climatic zones is conducted. **Error! Reference source not found.**Figure 3 outlines the project's methodology for state selection.

Table 4 Case study levels

Levels	Purpose (What)	Need (Why)
Level 1	Study of national and international best practices, housing projects (see Section 6 and 1).	- Pros and cons of existing examples of social housing. - Detailing influencing factors for sustainable social housing. - Relevance and learning for Indian scenario.
Level 2	Housing projects from each of the selected states in different climatic zones. Selection criteria of states in different climatic zone is mention in Table 2. Selection criteria of case study is mentioned in figure 3.	- Assessment of Social Housing demand. - Establishing basis of parameters. - Data base building for development of SI.
Level 3	Housing projects which are in the initial stages of designing and thus can incorporate suggested changes after validation of the SI and DST.	Development, Testing, Validation and Refinement of the SI and DST.

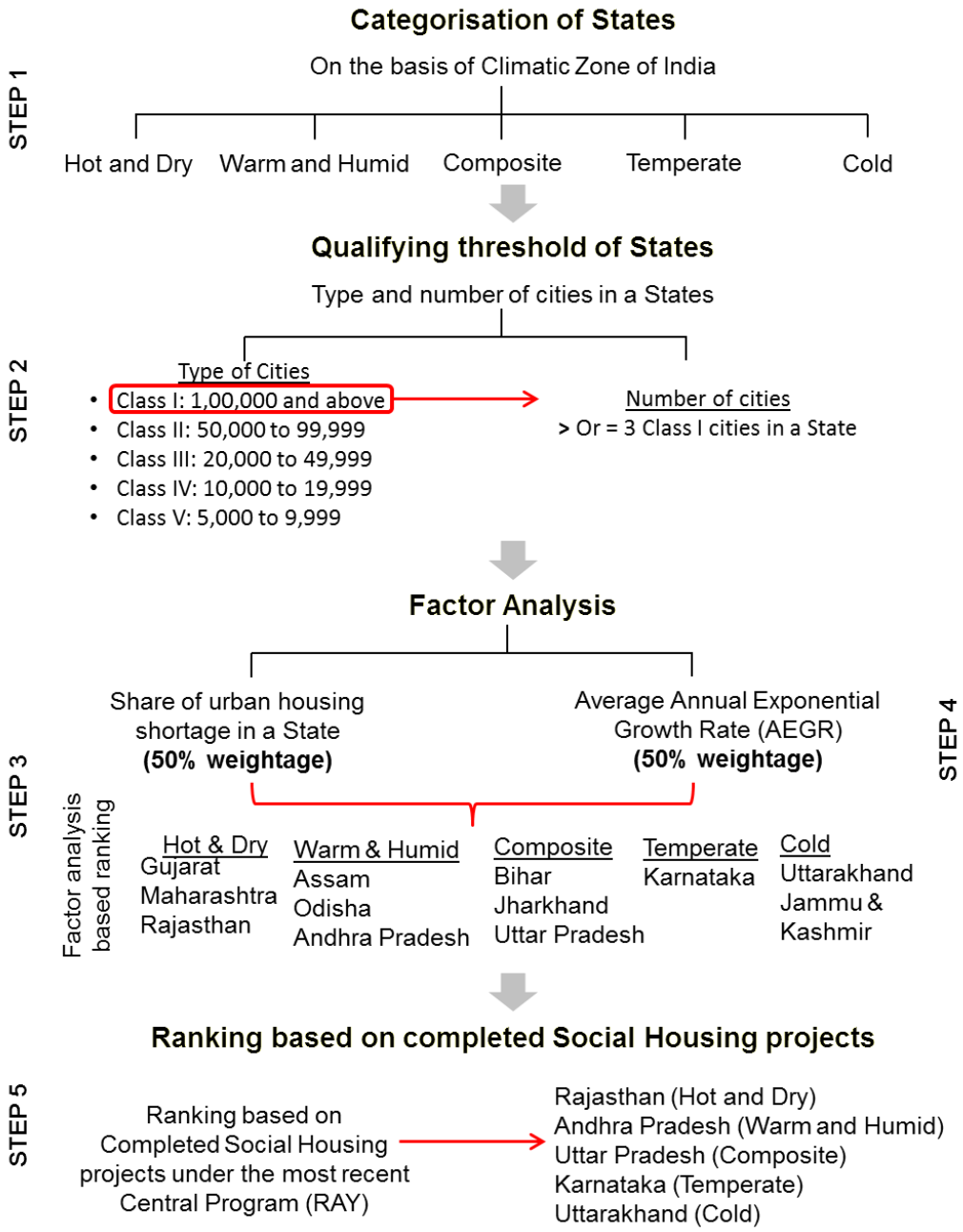


Figure 3: Detailed methodology for selection of State

	Criteria	Methodology	Assumptions taken	Rational
1	Climatic Zones (See Figure 8)	Categorisation of States	State boundaries do not necessary comply with that of climatic zones. A State whose area falls primarily within one climatic zone is designated as belonging to that climatic zone.	Housing typology is greatly dependent on climatic regions, reflected in the kind of building materials, construction techniques used, and the type of amenities required.
2	Size and number of cities (See Figure 9)	Qualifying threshold of States	A State with at least three* Class I cities (i.e. population of 100,000 and above) qualifies to be selected in the subsequent criteria. * for better statistical representation	Since in this study, and following the geographic focus of the GoI's urban development programmes, social housing is primarily aimed at urban areas, a state's number and size of urban areas is chosen as a qualifying criterion.
3	Share of urban housing shortage in a State (See Figure 10)	Factor Analysis-Representation of data according to importance (Criteria 3 and 4 are given equal weight).	The census definition for housing shortage is used and disaggregated at state level.	The need for social housing in a State with a greater housing shortage in relation to the number of urban households is considered to be more critical. Since the majority of the housing shortage affects EWS/LIG, the ratio given complies with the project's definition of social housing.
4	Average Annual Exponential Growth Rate (AEGR) (See table 6.	Factor Analysis-Representation of data according to importance (Criteria 3 and 4 are given equal weight)	State with high AEGR will indicate greater infrastructure requirements, a component of which will be providing housing.	States with high AEGR are relevant to the study since required infrastructure expansion will lead to an increasing demand for material resources.
5	Recently completed social housing projects	Ranking based on percentages of social housing projects completed in each State	States with a high percentage of completed projects are ranked in decreasing order. *An exemption has been made for the State of Rajasthan. Even though in factor analysis it scores very	In order to identify case studies from each State it is important to evaluate the status of States which have completed and delivered dwelling units under Central Government programmes such as RAY or PMAY.

	low, it has shown a remarkable completion rate of Central Government programmes.

Table 5 Rational for selection criteria of States for assessment of Social Housing Demand

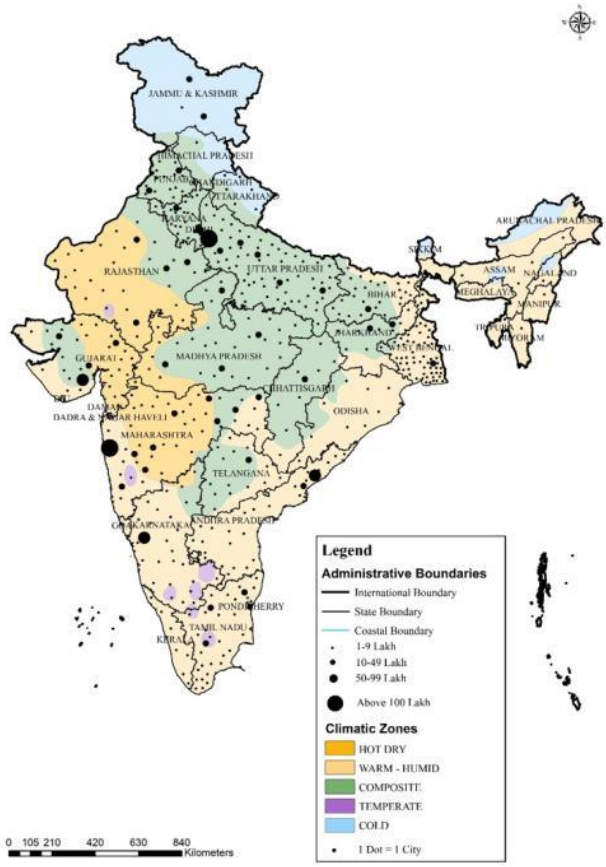


Figure 5 Class I cities of India and climatic zones

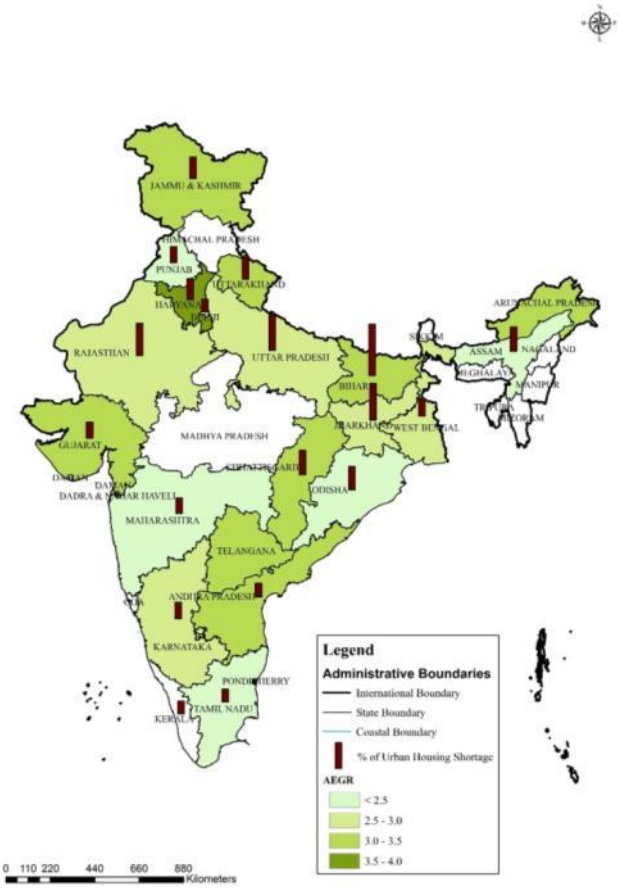


Figure 6 Urban housing shortage and AEGR by state

Climatic Zones	States	Urban Household	Housing shortage	Housing shortage %	AEGR (population) 2001-2011 %	Coloum 1 Housing shortage/ Urban household (%)	Coloumn 2 AEGR 2001-2011 %	Factor analysis based ranking	Completed projects under RAY	Ranking for State selection
Hot and Dry	Maharashtra	108.1	19.4	15.2	2.1	17.9	2.1	**16.0**	**33%**	2
	Rajasthan	30.9	11.5	27.1	2.6	37.2	2.6	**4.0**	**19%**	3
	Gujarat	54.2	10	15.6	3.1	18.5	3.1	**15.0**	**68%**	1
Warm and Humid	West Bengal	63.5	13.3	17.3	2.6	20.9	2.6	**12.0**	**58%**	Not applicable (a)
	Andhra Pradesh	77.8	12.7	14.0	3.1	16.3	3.1	**17.0**	**71%**	1
	Tamil Nadu	89.3	13.4	13.0	2.4	15.0	2.4	**18.0**	**57%**	3
	Orissa	15.1	4.1	21.4	2.4	27.2	2.4	**8.0**	**43%**	
	Kerala	36.2	5.4	13.0	6.6	14.9	6.6	**19.0**	**60%**	2
	Assam	9.9	2.8	22.0	4.0	28.3	2.4	**6.0**	**19%**	
Composite	Uttar Pradesh	74.5	30.7	29.2	2.5	41.2	2.5	**3.0**	**42%**	1
	Madhya Pradesh	38.4	11	22.3	2.3	28.6	2.3	**5.0**	**29%**	2
	Bihar	20.1	11.9	37.2	3.0	59.2	3.0	**1.0**	**6%**	3
	Haryana	17.5	4.2	19.4	3.7	24.0	3.7	**11.0**	**60%**	
	Punjab	20.9	3.9	15.7	2.3	18.7	2.3	**14.0**	**13%**	
	NCT of Delhi*	32.6	4.9	13.1	2.4	15.0	2.4	**20.0**	**22%**	
	Jharkhand	14.9	6.3	29.7	2.8	42.3	2.8	**2.0**	**6%**	
	Chhattisgarh	12.4	3.5	22.0	3.5	28.2	3.5	**7.0**	**35%**	
Temperate	Karnataka	53.2	10.2		2.7	19.2	2.7	**13.0**	**78%**	1
Cold	Uttarakhand	5.9	1.6		3.5	27.1	3.5	**9.0**	**20%**	1
	Jammu & Kashmir	5.2	1.3		3.1	25.0	3.1	**10.0**	**24%**	2(b)
(a) No data on Growth rate of GSDP)										
(b) Presently politically unconducive										

Table 6: Selection of States

4.2 Housing Sector Review of Selected States

In the following chapter, the housing sector in each of the selected states will be profiled. Apart from providing a general demographic overview, the profiles look at the institutions involved in the social housing field as well as some of the national and state-level housing programmes which have been undertaken, including their challenges of implementation. Given India's federal structure, states have a number of regulatory levers at their disposal to incentivize both low-income housing as well as resource-efficiency measures in the built environment. These levers, as far as they exist, are therefore also briefly outlined.

The review reveals a large spread both in terms of implementation rates of national as well as state-level housing programmes, with some states, like Andhra Pradesh, far outpacing other states in the implementation of national programmes, but faltering with state-level implementation. Information on sustainability indicators for government-led housing projects (occupancy rates, access to livelihoods, security, household energy consumption, health etc.) is yet to be gathered once the appropriate case studies have been identified.

The varying extent to which states offer incentives for GRIHA or IGBC registration of projects, once correlated with inter-state data on actual uptake, will then provide insights for policy recommendations during the course of the project.

The chapter closes with an overview of commonly used conventional as well as alternative building technologies in low-income housing provision.

4.2.1 Rajasthan

With an urban population of 17 million (24.87%) and a housing shortage of 1.15 million units (6.76%) (Census of India, 2011), Rajasthan demonstrated a high completion rate, especially under JNNURM of 75%, delivering 32,660 units, with a vacancy rate of only 11%. While a state-level programme was launched in 2015 (Mukhyamantri Jan Awas Yojana), it can be surmised that Rajasthan will continue to concentrate on implementing PMAY in the years to come. The main challenges encountered in the delivery of JNNURM were a lack of capacity of ULBs, lack of political support in some areas, and resistance from the state and local level to implement reforms. Rajasthan offers FAR increases and land use conversion fee waivers to the private sector when delivering units to the EWS/LIG segment.

4.2.2 Andhra Pradesh

Andhra Pradesh's housing shortage of 1.27 million units has been tackled with an aggressive implementation of the JNNURM programme, delivering 127,234 units or 70% of the target. With a vacancy rate of 38%, however, Andhra Pradesh clearly has room for improvement. With regards to challenges, BSUP and IHSDP, the two JNNURM sub-programmes primarily responsible for housing delivery, suffered from a lack of community engagement and long-term, integrated planning vision. Valmiki Ambedkar Yojana (VMBAY), which was subsumed under BSUP, had issues of identification of beneficiaries and convincing people to claim their dwelling units because of the lack of basic services.

The state level programme Rajeev Gruhakalpa which targeted the delivery of 200,000 units only delivered 332 units which in addition suffered from poor infrastructure provision. The programme in general is said to have

exhibited a lack of understanding of the need of the low income residents.

4.2.3 Uttar Pradesh

India's most populous state is tackling a substantial housing shortage of over 3 million units. Under JNNURM, 64,130 units, or 77% of the target, were completed, 24% of which stood vacant as of December 2015. Samajwadi Awas Yojana, an ambitious state-level affordable housing scheme was to develop 300,000 MIG homes by 2016. However, as of January 2017, only allotment of plots have begun. Reduced land conversion fees are offered to developments serving EWS/LIG. In addition, a 5% FSI increase is offered to GRIHA certified projects exceeding 5,000 sqm.

4.2.4 Karnataka

Karnataka is tackling a housing shortage of currently 1.02 million dwelling units. Under JNNURM, of the 45,525 targeted dwelling units, 35,351 units (77%) were completed. Vacancy rates, as of December 2015, stood at around 17%. The main challenges revolved around delays in the selection of beneficiaries or inaccurate identification of beneficiaries. Drastic increases in the price of land and non-availability of Government lands in both rural and urban areas represented a major challenge in the reaching JNNURM targets. Interestingly, the state-level Vajpayee Housing Scheme (formerly called the Ashraya Scheme) delivered 165,614 units in urban areas between 2000 and 2015, a multiple of JNNURM's delivered units, though no vacancy figures were available at the time of this report.

4.2.5 Uttarakhand

Uttarakhand's housing shortage currently stands at 160,000. Only 2,143 units were delivered under JNNURM, though these constitute 54% of the target. The main challenge in the state is geological. Due to the hilly terrain there is a problem of soil stability to hold the foundation of the structure. As Uttarakhand is an earthquake prone area, solid structures and innovative technologies are required. No data on state sponsored housing programmes could be obtained.

4.2.6 Common Building Materials and Typologies for Low-Income Housing

At the outset, the bulk of housing for the Low-income segment in India has employed conventional construction technologies to create the building stock. The structural design of these buildings is based on RCC framed construction. Consequently, cement, steel and masonry are the principal building materials used for the building envelope. LIH housing typology is predominantly low-rise up to G+6, with (up to) G+3 being the most common typology, wherein each floorplate has a cluster of four dwelling units with a common staircase-corridor access.

The following table shows the most common specifications of construction materials which have been used in low-income housing in most states in Indi.

Building Element	Specification options
Structure	Most common for more than G+1 structures - RCC frame structure as per codal provisions for seismic design, using M20 strength concrete Optional for up to G+1 – Load bearing construction with strip footing and RCC plinth beam
Building envelope	230/250mm thick burnt clay brick masonry in cement-sand mortar (1:6) 150-200 mm thick concrete block masonry in cement mortar (1:6) Fly ash bricks have become a feasible alternative to burnt clay bricks over the last few years in government projects, wherever the project is within about 100 km
Flooring	Ceramic/ vitrified tiles Locally available (pre polished) stone tiles 20-30mm thick Plain Cement Concrete floor
Openings	Pressed steel door-window frames (125mmx65mm double rebate or 100mmx50mm single rebate) Solid Core Flush doors 30mm thick or PVC shutter for internal door 6mm thick float glass for glazed parts, 450mm wide RCC sunshades for windows
Finishes	Cement-Sand Plaster 20mm thick (external), 15mm thick (internal) White cement based putty Cement Paint external and internal or White wash internal

It should be acknowledged that the majority of construction materials in India are sourced from the informal sector. Any attempt to design a tool for material selection must consider this scenario, and its impact on material quality, price and environmental performance.

Construction cost is a significant component of the total cost of low-income housing projects especially, accounting for about 60% of the total project cost. At a typical 20% labor component, construction materials account for at least 40% of the project cost. In this context, the choice of construction technology is an important means for achieving cost efficiency in low-income housing.

There are alternative construction technologies, mainly for walling and roofing, which can reduce construction costs by 15-20%. Some of these technologies can reduce embodied energy, CO2 emissions (resulting chiefly from material production) and, given appropriate architectural design, also enhance the thermal comfort of occupants. Till now,

their use has been mostly limited to demonstration projects with technical support from institutions like BMTPC and regional technical institutes. Each of the selected states (for the project) have at least one such demonstration project. Although many of these technologies have been certified by BMTPC for their performance, they have not yet been absorbed into building codes and regulations.

Different forms of pre-fabricated building technologies are emerging for application in social housing and have mostly been demonstrated at small scale in Andhra Pradesh and Karnataka (among the selected states). These systems have a centralized eco-system for production, delivery and assembly at site. High strength for multi-story construction, seismic safety and rapid construction are their main advantages. However, the social aspect of sustainability is a challenge with these systems, because they are designed to provide uniform box-like structures, which curtails cultural expression and in-situ modifications which are commonly carried out by the households. Also, indoor thermal comfort of occupants may be compromised if their climate-compatibility is not carefully considered. Two prominent options in this category are Glass Fibre Reinforced Gypsum panels for wall and roof (certified by BMTPC) and monolithic concrete technology (shear walls) with plastic / aluminum composite formwork.

Alternative Building material/systems	Application in Low-income Housing (existing)				
	Rajasthan	AP	Karnataka	UP	Uttarakhand
Fly ash bricks					
Concrete blocks					
Stone filler blocks					
AAC blocks					
Rat-trap bond walls in burnt clay bricks					
Filler slab roof					
Precast brick panel roof					
Precast Plank Joist roof					
Jack Arch roof					
EPS panels for walling and roofing					
GFRC wall and roof					
Monolithic concrete technology					
Natural Fibre Composite door shutters					
Precast RCC door-window frames					

LIG housing in Uttar Pradesh - using Rat-trap bond walls and Precasat brick panel system

EWS housing in Dehradun, using Concrete Blocks, Precast RCC PLanks and Joists and RCC door-window frames

EWS housing in Jaipur, Rajasthan - RCC frame, brick

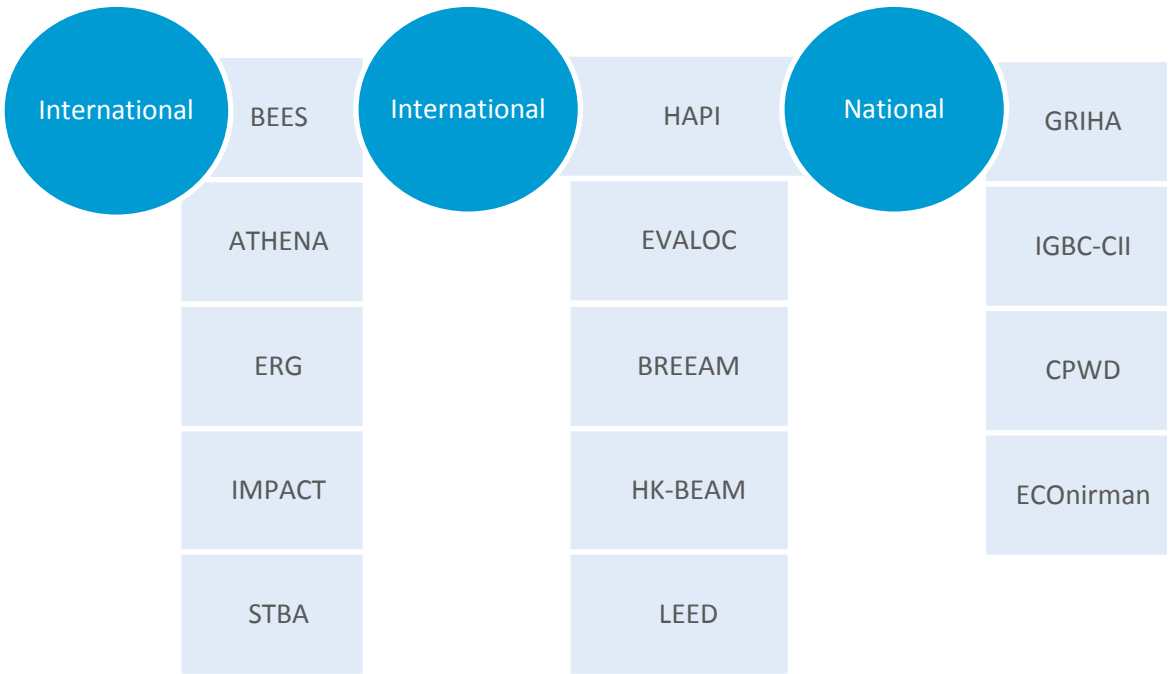
Monolithic Concrete Construction under JNNURM at Mysore, Karnataka

5. Building Sustainability Benchmarking and Assessment Systems

One of the present project's major outputs will be a **Decision Support Tool (DST)** based on a **Sustainability Index (SI)**. While the former will be the interface which "lays down the fundamentals and methodology for planning, implementation and operation practices, necessary for achieving sustainability in housing projects and developments", the latter represents "the comparative analysis of parameters related to materials, construction systems, socio-economic considerations based on case studies and best practices."

Since this particular output falls in the realm of building sustainability assessment and benchmarking, a field which has seen remarkable expansion since 1990 with now more than one hundred different systems, this section endeavours to only give a brief overview of some of the existing assessment and benchmarking schemes developed internationally and for the Indian context in particular. The intention is to identify the gap which the DST could be envisioned to fill while at the same time building on what has already been accomplished.

For the proven benchmarking of building sustainability various performance evaluation methods have been developed internationally and nationally. The due responsiveness towards climate change and environmental protection globally has given building sustainability benchmarking and assessment methods new urgency to ascertain the impact of buildings, finished building materials, and increasingly neighbourhoods, on the environment, economy and society. Distinct indicators, or benchmarks based on a single criterion, have been developed to assess, evaluate and monitor various aspects of building performance such as operational energy use, indoor air quality, comfort levels, or material resource use (Forsberg & Malmborg, 2003).



5.1 International Systems

5.1.1 Building for Environmental and Economic Sustainability (BEES)

Building for Environmental and Economic Sustainability (BEES) is a computerised tool for choosing environmentally preferable building materials (Lippiatt & Ahmad, 2005). The purpose of BEES has been to "develop and implement a systematic methodology for selecting building products that achieve the most appropriate balance between environmental and economic performance based on the decision makers values" (Lippiatt & Ahmad, 2005). The BEES environmental performance assessment is based on the Life Cycle Assessment (LCA) standard formalised in ISO standards 14040 and 14044. The processes include the manufacturing of materials; their installation and use in buildings; and their eventual reuse, recycling, or disposal at the time buildings are renovated or demolished, together in impact categories, normalised by dividing by the U.S. emissions per year per capita, and weighing by relative importance. The economic performance is based on Life Cycle Cost calculation, and normalised by dividing by the highest life cycle cost, thereby ranking the materials from 0 to 100. Finally, an overall evaluation involves the environmental score and the economic score being weighted together using relative importance decided by the user. BEES allow assessing products on a functional unit basis so that the comparisons made are true substitutes for one another. Trade-offs are important as a product may contain a negative impact constituent, but if that constituent is a small portion of an otherwise relatively benign product, its significance decreases dramatically (Lippat & Boyles, 2001).

5.1.2 ATHENA

ATHENA is an LCA tool whose foremost objective is to "encourage the selection of material mixes and other design options that will minimise a building's potential life-cycle environmental impact and foster sustainable development" (Trusty, Meil, & Norris, 1988). The results for the assessment can be presented in terms of:

- Absolute totals of selected measures of the complete design.
- Absolute values on a per unit area basis.
- Values normalized to a selected design that may be one of the alternatives designated as a base case or design of a similar building.

The user phase and demolition is excluded from the evaluation, as are economic aspects.

The functional units in ATHENA are specific designs of a building. With the background of an LCI (Life Cycle Inventory) database, the tool automatically breaks down the elements into products that are available in the database (Banani, 2011). From data in the LCI database, the program assesses the environmental properties of different design alternatives. ATHENA is for use at the conceptual design stage wherein a range of indicators without weighting are generated to show environmental effects of changes in shape, design, or material make-up of a building (Carmody & Trusty, 2002).

5.1.3 Environmental Reference Guide (ERG)

The **Environmental Reference Guide (ERG)** is a printed guide aimed at architects and designers (Demkin & The American Institute of Architects, 1988). Similar to BEES, its goal is to "help design professionals make environmentally informed choices when they select and specify building materials".

Generally, alternative materials are available for any given architectural application, and each alternative carries environmental burdens and may offer environmental benefits. The ERG addresses these issues along with other considerations relevant to functionality, interactions with adjacent materials, ease of installation, and life-cycle impact. The ERG analyses materials on a generic basis and does not advise which product or material to use. The ERG also points the user to other external information sources.

5.1.4 IMPACT

IMPACT is a specification and database for software developers to incorporate into their tools to enable consistent Life Cycle Analysis (LCA) and Life Cycle Cost Analysis (LCCA). IMPACT compliant tools works by allowing the user to attribute environmental and cost information to drawn or scheduled items in Building Information Modelling (BIM). Simply put, IMPACT multiplies building material quantities from a building information model with the environmental impact and/or life-cycle cost factors to produce an overall impact and cost for the whole (or a selected part) of the design. The results generated by IMPACT allow the user to:

- Analyse the design to optimise cost and environmental impacts.
- Compare whole-building results to a suitable benchmark to assess performance, which can be linked to building assessment schemes.

IMPACT is therefore an attempt to integrate LCA, LCCA and BIM. IMPACT works with a wide range of building types from the earliest stage of design onwards. Initially, the user selects a building template with predefined material information. As the design progresses the predefined material information is refined and expanded by selecting building elements (e.g. complete roofs, external walls, windows) from a library of alternatives. During the detailed design stages the user increases accuracy further by replacing library assemblies with building-specific components and material information thereby increasing the accuracy of environmental impact assessment.

5.1.5 Responsible Retrofit Guidance Wheel (Sustainable Traditional Buildings Alliance)

Accessibility is a necessary condition for a tool's uptake. The Sustainable Traditional Building Alliance's 'Responsible Retrotfit Guidance Wheel' deserves special mention in this regard. More than 50 retrofit measures are displayed around a wheel according to the building element or function they relate to. Each measure is analysed with regard to technical, heritage and energy concerns, listing both advantages, disadvantages and connections with other measures which are also visualised by means of color-coded arrows along the wheel.

Measures can be added to the list of interventions which can then be used to generate a report on the eventual effects of the retrofit (Sustainable Traditional Buildings Alliance, 2016). The Wheel is a clever tool to visualise the complex interdependencies between interventions, and allows for both a linear and non-linear exploration by the user.

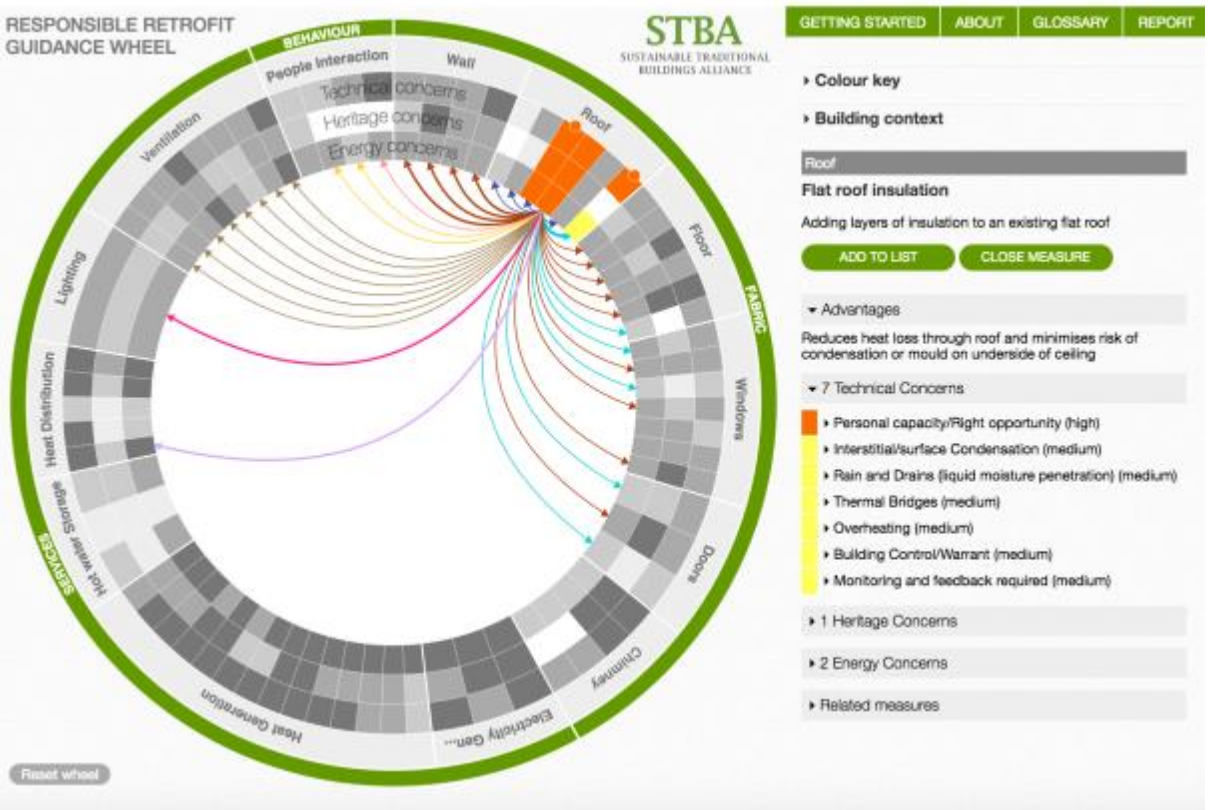


Figure 4 Sustainable Retrofit Guidance Wheel (Source: Sustainable Traditional Buildings Alliance)

5.1.6 Management of Housing Performance Information (HAPI)

Given the known possible discrepancy between predicted and actual performance, and the need for accountability in monitoring building performance, the Management of Housing Performance Information (HAPI) platform, currently at prototype stage, is noteworthy. It is developed by Oxford Brookes University and Oxford Brookes Enterprises in collaboration with the Joseph Rowntree Housing Trust under the Supply Chain Integration in Construction competition by the UK government. The platform aims to "provide designers, specifiers and housing providers with *hindsight* on actual performance of previous housing projects, *insight* on ongoing projects and *foresight* to improve future specification, design and performance" (Oxford Brookes University, 2016).

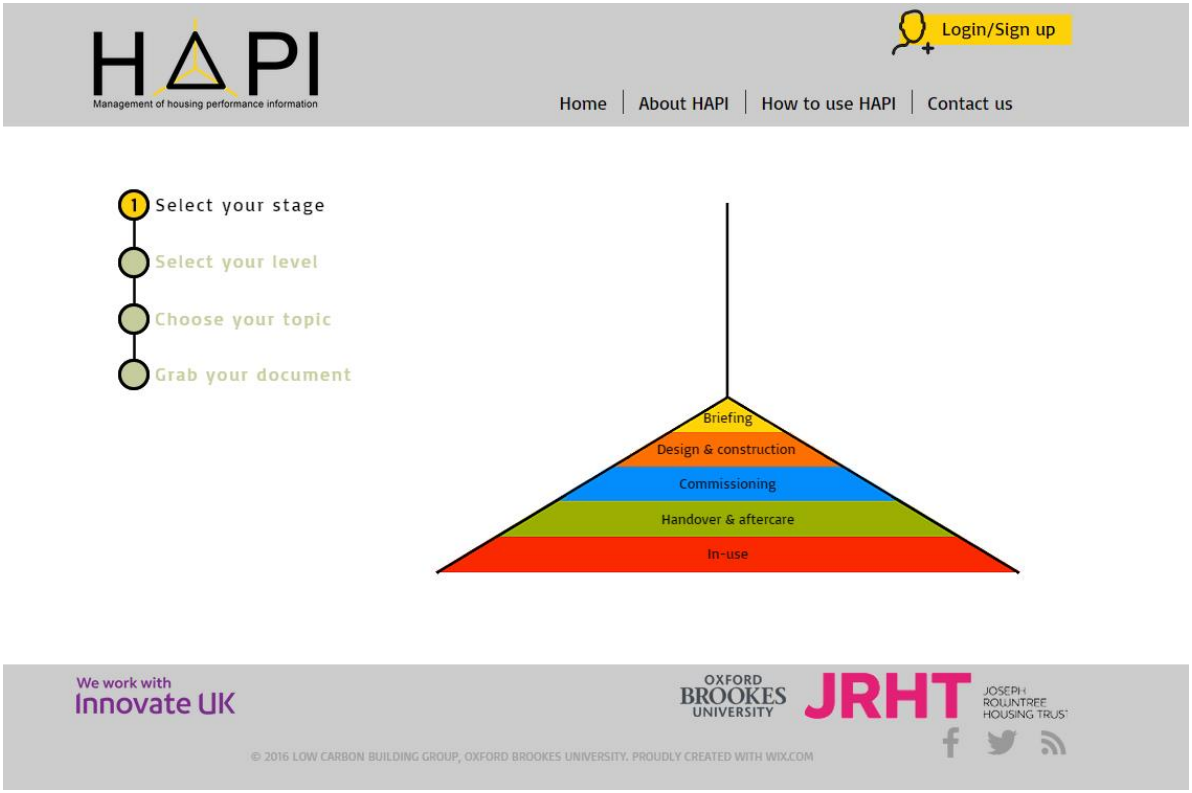


Figure 9 Management of housing performance information (HAPI)
(Source: HAPI research: http://lcbgroup.wixsite.com/hapi)

5.1.7 Evaluating Low-Carbon Communities (EVALOC)

Building on the DECoRuM methodology, the Evaluating Low-Carbon Communities project (EVALOC) pursues a broader community-level assessment of energy demand reduction measures. It aims to determine how community-based organisations can best monitor and communicate their own effectiveness at energy demand reduction, learn from their work, and identify limits and barriers, for instance, in the use of the DECoRuM tool. The project also attempts to answer sociological research questions such as determining the role of social networks in promoting or suppressing the communication and take-up of new energy technologies, and how far these interconnect with local community networks (EVALOC UK, 2016).

Given the focus on the community scale by, for instance, the Indian Green Building Council's Green Villages, rating scheme, possible linkages between the EVALOC project and the current research could be explored.

Figure 10 EVALOC energy and communities toolkit (ENACT)
(Source: EVALOC low carbon communities research: www.evaloc.org.uk)

5.1.8 Building Research Establishment Environmental Assessment Method (BREEAM)

Initially developed in 1990, **Building Research Establishment Environmental Assessment Method (BREEAM)** was the first environmental building assessment method and remains the most widely used. BREEAM evaluates the procurement, design, construction and operation of a development against performance benchmarks. Assessments are carried out by independent, licensed assessors, and developments rated and certified on a scale of Pass, Good, Very Good, Excellent and Outstanding.

BREEAM measures different sustainability dimensions, ranging from energy to ecology. Each of these categories addresses the most influential factors, including low impact design and carbon emissions reduction; design durability and resilience; adaptation to climate change; ecological value and biodiversity protection. Within each category, developments score points – called credits – for achieving targets, and their final total determines their rating. This system can be carried out as early as at the initial stages of a project and changes can be made accordingly to meet pre-designed criteria (BRE Global Ltd. , 2016).

Up until April 2016, more than 540,000 developments had been covered under BREEAM (roughly half of which are domestic) and over 2,230,000 buildings have been registered for assessment BREEAM has been adopted in about 77 countries till date, although the large majority (over 95%) of these were projects within Europe (BRE Global Ltd. , 2016). Canada, Australia, Hong Kong and other countries have developed their own environmental building assessment methods based on the BREEAM methodology. Noteworthy is BREEAM's limited uptake to date in the Global South (see Figure 11).

Figure 11 Certified BREEAM Assessments, 2008 schemes onwards (Source: Green Book Live, 2016)

5.1.9 Hong Kong Building Environmental Assessment Method (HK-BEAM)

Hong Kong Building Environmental Assessment Method (HK-BEAM) is a voluntary scheme launched 1996 as a significant private sector initiative in Hong Kong to promote environmentally friendly design and construction practice for air-conditioned office buildings only. The HK-BEAM assessment system has since undergone several revisions to adhere to the government policy to foster sustainable development in various building typologies (including residential) in Hong Kong. It covered a wide range of issues related to the impacts of buildings on the environment in the global, local and indoor scales (Lee, Yik, & Burnett, 2006). HK-BEAM seeks to measure, improve and label the performance of buildings over their life cycle through adoption of a set of best practice criteria. The intention is that HK-BEAM for new buildings merges with that for existing buildings, such that a building rated under HK-BEAM 'new' and suitably operated and maintained would achieve a similar rating under HK-BEAM 'existing' some years later. Both versions of HK-BEAM aim to reduce impacts of buildings using the best available techniques and within reasonable cost.

The comprehensive assessment framework encompasses exemplary environmental practices in planning, design, construction, commissioning, management and operation, and maintenance (Chu & Chan, 2005). Indeed, the assessment system is comprised of a mixture of 'performance specific' and 'feature specific' criteria. Performance specific criteria are those credits awarded once the desired performance level is achieved (Cole, Howard, Ikaga, & Nibel, 2005), while the feature specific criteria awards credits based on the presence or absence of desirable features or for compliance with a threshold value (as per codes)[15]. The total score awarded is the aggregation of the total number of credits obtained under the assessment scheme, then providing a 'label' for building quality in terms of *safety*, *health* and *comfort*, important considerations for building users (buyers, tenants, occupants), and levels of performance in respect of environmental and social dimensions (HK-BEAM Society, 2004).

Credits related to energy use and indoor environmental quality issues are comparatively more significant than the other environmental categories. It thus differs from the assessment framework of other major green building assessment systems. Credits for energy, water and IEQ-related aspects, weighted in alignment with the goals, indicate that the design-based assessment methodology for assessing the energy credits does not guarantee the energy saving for certified buildings (Leu, 2012). The correlation analysis for the relationship between post-occupancy energy use and energy credits earned indicates that the eventual rating does not reflect actual energy savings.

[15] The HK-BEAM structure comprises of two criteria namely-prescriptive (or feature-specific) and performance-based for covering a wide range of energy-efficient measures that can potentially be incorporated in the building design. Prescriptive criteria award credits based on the presence or absence of certain desirable feature. They do not necessarily mean achieving a certain performance target but are often established with reference to good practices. (Lee, Chau, Yik, Burnett, & Tse, 2002)

5.1.10 Leadership in Energy and Environmental Design (LEED)

Leadership in Energy and Environmental Design (LEED) is a voluntary, commercially marketed and performance-based tool for determining the environmental impact of a facility from the whole-building perspective (Kibert, 2013). It was designed by the U.S. Green Building Council (USGBC) in 1998 through a consensus process (Ding, 2004). It is a green building rating system for commercial, institutional and residential new builds, neighbourhoods, as well as retrofits covering seven areas of sustainability:

- Location and transportation,
- Sustainable sites,
- Water efficiency,
- Energy and atmosphere,
- Materials and resources,
- Indoor environmental quality, and
- Innovation (to test new strategies).

It adopts a whole-building approach that encourages and guides a collaborative, integrated design and construction process. Due to its prominence and popularity in the community of building owners, designers and managers, the LEED system has received a higher level scrutiny than other benchmarking schemes, resulting in several critical reviews pointing out its unintended consequences in encouraging 'perverse behaviour' (Humbert S. , Abeck, Bali, & Horvath, 2007).

Similar to BREEAM and other tools, uptake in the Global South has been limited (see Figure 12).

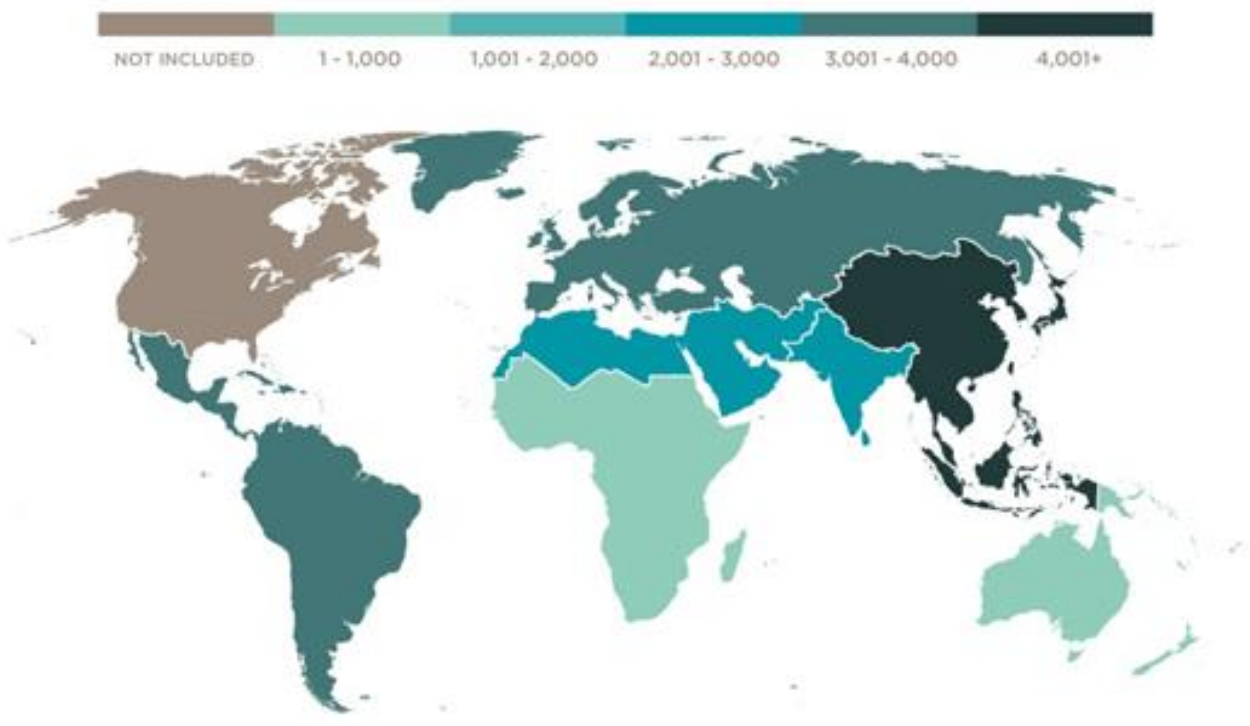


Figure 12 Distribution of LEED projects globally (Source: USGBC 2016)

5.2 National Systems

Below four national or India specific sustainability assessments tools are being profiled: GRIHA, IGBC-CII, CPWD Sustainability Tool and ECOnirman Prescriptive. While they pursue similar objectives, and follow a similar approach and structure to rate a building's performance, their rating methodology varies considerably (Kshirsagar, Mane, Saharkar, & Salunke, 2015).

5.2.1 Green Rating for Integrated Habitat Assessment (GRIHA)

Green Rating for Integrated Habitat Assessment (GRIHA) evaluates the environmental performance of a building holistically over its entire life cycle. It is based on accepted energy and environmental principles, seeks to strike a balance between the established practices and emerging concepts, both national and international. It covers commercial, institutional, and residential new builds, and, in the case of schools, existing buildings.

The projects can be registered under GRIHA, GRIHA-LD, SVA-GRIHA or GRIHA-Prakriti depending on the building use and scale. SVAGRIHA (Small Versatile Affordable GRIHA) is applicable only for projects which are less than 2500 m^2 of built-up area, and applies to all building uses, except industrial buildings. A need was felt to create a framework to assess the environmental performance of larger developments with a site area greater than or equal to 50 hectares. Hence, a rating system for large developments, GRIHA LD (Large Developments), was developed. The GRIHA-Prakriti rating system was developed with the intent to assist schools to reduce their environmental footprint. This is the first rating system for existing buildings under the GRIHA rating system (GRIHA Council).

Under GRIHA, buildings are assessed on their *predicted* performance from inception through operation. This rating system is divided into (importance in parentheses): sustainable site planning (21.2%), health and well-being (9.6%), building planning and construction (7.7%), energy: end use (36.5%), renewable energy (7.7%), recycle, recharge and reuse of water (6.7%), and waste management (4.8%), building operation and maintenance (1.9%), and innovation points (3.9%) (Sande & Phadtare, November 2014-October 2015).

In India, GRIHA as a nationally adopted rating system is increasingly linked to state and municipal governments' promotional policies for green buildings: five state governments offer increased FARs for GRIHA *registered* projects, while four municipal governments have similarly followed the Ministry of Urban Development's notification to the same effect. In addition, the Ministry of Environment and Forestry promotes fast-track project approval for GRIHA *registered* or *pre-certified* projects[16], while the Small Industries Development Bank of India (SIDBI) is offering concessional rates of 50 basis points (0.5%) at present. The Pimpri Chinchwad Municipal Corporation has announced incentives for developers and owners who voluntarily comply with GRIHA.

The MNRE granted the following incentives to various stakeholders under its 'Energy-efficient solar/green buildings' scheme to GRIHA-NRS projects for implementation during 2013-14 under the 11th Five Year Plan and the remainder of the 12th Five Year Plan.

- **Incentives for Capacity Building and Awareness Activities**: A financial support

[16] However, pre-certification is only a commitment. There is no legal provision requiring the project to actually achieve the level of rating promised in the pre-certification application.

of up to Rs. 2.00 lakh (US$2,950) for one to two day and Rs. 3.0 lakhs (USD$4,421) for three day training programmes, workshops, conferences, seminars, publications, awareness campaigns, and orientation programmes will be awarded to implementing agencies.

- **Awards to ULBs:** Every year, a onetime cash award of Rs.10 lakh (US$14739)will be given to the top three ULBs per year selected through competition for adopting and promoting Energy Efficient Solar/Green Buildings to be rated under the rating systems GRIHA, LEED India or ECBC.
- **Awards to individual buildings for renewable energy use**: cash award of Rs.15 lakh (US$22,109) , 10 lakh (US$14,739) and 5 lakh (US$7,370) along will be given to the three top-ranked buildings per year.
- **Incentive to architects / design consultants**: Cash awards of Rs. 5 lakh (US$7,370), 3 lakh (US$4,422) and 2 lakh (US$2,948) are given to the three top-ranked architects /design consultants for the three top-ranked buildings in any of the recognized green building rating systems.
- **Other activities:** Funds will be provided for other activities to promote Energy Efficient Solar/Green Buildings in the country. These activities may include: development of web based tools, short films on best practices, literature on green buildings, FAQs on MNRE website, course contents as part of curriculum, training modules, e-learning modules, organizing specific groups to initiate changes in the National Building Code, support to architectural magazines to bring out special features on green buildings, evaluation studies, R&D activities, lecture series orientation programmes and related activities.
- (Ministry of New and Renewable Energy, Government of India, 2009)

Despite the broad institutional support, there are currently only 800 registered GRIHA projects in the country, covering 32 million m^2. Considering that 650,000 m^2 of office space alone were added in the two month period of April to June 2016 alone (India Brand Equity Foundation, 2016), the relative impact of India's most successful green building rating system can still be considered marginal.

The project will benefit from a **critical analysis of the barriers** which may have prevented GRIHA's wider uptake to-date. Considering the wide-ranging institutional support granted to GRIHA, the present project needs to consider what would encourage project designers and owners to use the to-be-developed Decision Support Tool and thus possibly forego tangible incentives either in terms of faster approval processes, direct grants or higher FARs. Otherwise, the **added value of the DST** as an addition to GRIHA must be clarified.

5.2.2 IGBC-CII Rating tool

The Indian Green Building Council (IGBC) was formed in 2001 with a vision, "To enable a sustainable built environment for all and facilitate India to be one of the global leaders in the sustainable built environment by 2025". Indian Green Building Council (IGBC) has licensed the LEED Green Building Standard from the USGBC for local adaptation.

It works on a national level with a whole-building approach to sustainability by recognizing performance in the seven key areas listed above, and covers both homes (through the separate IGBC Green Homes system), townships, Special Economic Zones, green factory buildings and green landscapes. The rating is a point-based system labelling

buildings as “LEED Certified”, “LEED Certified Silver”, “LEED Certified Gold”, and “LEED Certified Platinum”.

The Ministry of Environment and Forests’ (MoEF) notification on green buildings states faster environmental clearances to projects applying for IGBC or GRIHA certification. However, as the Centre for Science and Environment (Centre for Science and Environment, 2012) rightfully points out, MoEF is offering these incentives “with the faith that the green rating agencies have carried out the due-diligence of these project designs and will be accountable for the environmental performance of such projects. However, pre-certification is **only a pledge** and there is no legal provision for requiring the project proponents to achieve the level of rating promised in the pre-certification application.”

Nevertheless, also in Maharashtra the Environment Department is developing green building guidelines along with the IGBC. The NOIDA Development Authority allows an FSI increase of 5% above the maximum to projects with plot size above 5,000 m^2 that achieve a minimum IGBC gold rating. The Hyderabad Metropolitan Development Authority's (HMDA) ‘green channel’ initiative provides faster clearances for IGBC compliant residential, commercial and industrial buildings, and a 50% reduction of the approval fee. NOIDA Development Authority has gone one step further to award a 5 per cent maximum FSI increase to projects which commit to achieving a LEED gold rating (Centre for Science and Environment, 2012). As of yet, there does not seem to be any data on whether these relatively minor FSI increases (say from an FSI of 150 to 155) have had any impact on (pre-) certification levels.

In general, it should be noted that there does not seem to be consistency as to which green building rating systems, i.e. GRIHA or LEED India, receive support from which national, regional or local authority, and whether *registration* for certification is sufficient, as opposed to certification itself. This may point to an already beginning level of fragmentation in the interplay between green building agencies and government policies which could limit the overall impact of these initiatives. A more unified approach, as was done in Singapore, may be more effective.

In India all three ratings systems are primarily whole building rating systems and are not limited to only building material and technologies only. **They do not, as such, provide a comparative assessment of trade-offs between different green building materials and construction technologies available.**

5.2.3 CPWD Sustainability Tool

The Sustainability tool, issued by the Central Public Works Department in 2014, is a set of guidelines for a sustainable habitat. The guidelines have been divided into four parts: 1) architectural design and layout, 2) **CPWD Sustainability Index** and guidelines for materials, 3) selection of equipment for electrical and mechanical services, and 4) guidelines on reuse and recycling of construction and demolition waste.

Part Two the sustainability index, consists of a set of parameters based upon which a relative evaluation can be made between two materials of the same product category, covering walling, partitioning, roofing, fenestrations and other building elements. The evaluation parameters include recycled

content, embodied energy, rapidly renewable, locally available material, functional life period, capital cost, maintenance cost, construction waste management, fly ash content, reduced weight, reduced time of construction and toxicity/indoor air quality/safety. It is unclear how these parameters were selected and whether all of them are equally applicable to the functional unit of 'building material', as maintenance costs, for instance, also strongly depend on site location, weather effects, and building design.

Similarly, weightages of either 5 or 10 points out of a total of 100, have been assigned to each parameter based on CPWD's working experience. While every weighting system is an exercise in subjectivity (even assigning no weighting at all is, in effect, a weighting implying equivalence), this particularly 'symmetric' system could be considered open to criticism (Central Public Works Department, March, 2014).

The Guidelines on Architectural Design and Layout broadly cover the parameters required to be considered for planning and design of buildings and relate to energy efficient design and process, site design, building orientation and shading; design strategies for day lighting, building envelope, reduction in overall embodied energy of building materials and an integrated approach to water supply, water waste and solid waste management. It also gives design guidelines for different climatic zones namely: cold, composite, warm and humid, hot and dry and moderate climate.

The obvious similarities between the CPWD's Sustainability Index to the present project's proposed output (in addition to being an already developed, government-sanctioned, home-grown solution) strongly suggest that the reasons for its possibly limited degree of uptake should be examined thoroughly before an additional methodology is developed independently.

5.2.4 ECOnirman

ECOnirman Tool is energy simulation software provided by BEE to assist architects and engineers in assessing the conformance of buildings with the ECBC (USAID ECO-III Project, 2011). The tool is mainly used to check conformity with the ECBC. A building complies with the whole building performance method when the estimated annual energy use of the proposed design is less than the standard design, even though it may not comply with the specific requirements of the prescriptive requirements as per the ECBC. It is a web-based compliance tool, which has been made available to users over the Internet with minimal software requirements and building science or simulation expertise (International Institute for Energy Conservation (IIEC) & the United States Agency for International Development (USAID, 2007).

The ECOnirman tool virtually assists decision making while altering certain parameters like window to wall ratio, U-values, vertical and horizontal shading to minimize the energy requirement of the building to make it more energy efficient. The tool compares the baseline parameters from ECBC prescriptive requirements to the proposed design to compare the Energy Performance Intensity (EPI).

5.3 Conclusion

Most building assessment and benchmarking tools and the results they produce need to be put into the context of their limitations. Their relatively limited uptake globally (in relation to the total number of new builds and the existing stock) can be broadly attributed to three major factors.

1) **Skill requirement**: If benchmarking or assessment is undertaken on an open-source basis, i.e. without payment of certification fees to cover the cost of professional assessors as well as 'labelling rights', an example being the popular SB tool, the skill required to correct gather and assess data may lie beyond the current expertise of many built environment professionals.
2) **Cost:** In a fragmented building sector where the certification is fee based, incentives for the payment of certification fees are limited. Also, the building designers, owners and occupants here, are often separate entities, and resource efficiency measures implemented at the design stage will not benefit all stakeholders in equal measure unless positive externalities are internalised through higher sales or rental value. If certification is fee based, then the fragmentation of the building sector where building designers, owners and occupants are often separate entities and where resource efficiency measures implemented at the design stage will not benefit all stakeholders in equal measure (unless positive externalities are internalised through higher sales or rental values), incentives for payment of certification fees are limited.
3) **Low demand:** Especially in many countries of the Global South, in particular in temperate climates with low operating costs, sustainability concerns take second place behind affordability concerns, limiting the demand for green building certification.

In addition, and as mentioned previously, some building assessment and benchmarking tools have attracted significant critical scrutiny for a number of reasons, including:

1) Lack of adaptability to local climate, culture and resources.
2) Lack of life-cycle inventory databases which make judgement calls about the life-cycle impacts of materials difficult to ascertain and call results into question.
3) Attention primarily to the operational phase of building and insufficient attention to life-cycle energy requirements of adjoining infrastructure, transport requirements of occupants, as well as process-based vs. input-outcome based calculation of materials' embodied energy.
4) Relative subjectivity of indicator weightings.
5) Discrepancy between projected and actual performance of buildings, mainly due to the user of the building as the unknown variable.

Nevertheless, the institutional incentivisation of, for instance, the GRIHA scheme demonstrates the vast potential for building assessment and benchmarking both as a requirement for building permits, fiscal incentives or direct grants and awards, but also as educational tools which utilise a common sustainability language.

The point made earlier, however, should be highlighted again: there does not seem to be consistency as to which green building rating systems, i.e. GRIHA, LEED India, the CPWD tool, or the ECBC, receive support from which national, regional or local authority, and

whether *registration* for certification is a sufficient condition to qualify for government support, as opposed to certification itself. The already apparent fragmentation of the green building certification 'market' could limit the overall impact of these initiatives. A more unified approach, as was done in Singapore, may be more effective.

It is agreed that comparing different tools is not an easy task as it results from a wide range of assessment criteria, application and building life-cycles which are covered by building assessment methods (Giama & Papadopoulos, October 2012) (Giama (2009) , Poston et al. (2010)).

Despite the rapid growth of building assessment schemes over the last fifteen years, the construction industry is still undergoing a cultural shift towards the widespread use of such tools. These tools must continue to evolve in order to maintain the momentum developed, at the same time expanding to include construction sectors and markets not currently undergoing assessment.

Significantly divergent from current philosophies, future assessment tools should:

- Establish a scoring system that accepts both quantitative and qualitative data.
- Establish a structure that can be used at various levels of detail, from broad-brush assessments to detailed ones.
- Implement the assessment in a software system that will facilitate the work of making regional modifications and also simplify the tasks of input and assessment of building data.
- Recognise the cumulative impacts that buildings have at local and regional scales.
- Address global environmental issues.
- Incorporate the effect of building users' actions on a building's performance.

6. Case Studies

In the following a number of Level 1 case studies are presented, primarily highlighting exemplary social housing projects, in the broadest sense of the word, identified by the Building and Social Housing Foundation as well as UN-Habitat. Each profile highlights how each project approach may be relevant to the Indian context and is followed by a summary of 'influencing factors' which contribute to making the respective housing project more sustainable.

6.1 Building Restoration for Social Housing Purposes - Celso Garcia, 787

Unification of Tenement-Housing Struggles (ULC) and Integra

São Paulo, Brazil

Context

Despite advances in public policies for housing in the last two decades, Brazil's housing deficit stands at 5.6 million housing units, 63 per cent of which is accounted for by families with a monthly income below US$250. In São Paulo, Brazil's largest city, an estimated one fifth of the population of 17.5 million is currently living in inadequate housing conditions, in favelas (squatter settlements), cortiços (overcrowded tenement housing) or clandestine land subdivisions. In recent years government offices, businesses and financial institutions have left the city centre, leaving 30 per cent of buildings disused or under-utilized. The city centre of São Paulo is filled with empty buildings while, paradoxically, millions of people live in inadequate conditions elsewhere.

This Building Restoration for Social Housing Purposes project works toward the reversal of the process of exodus from the central area, proposing housing alternatives in city areas that have lost part of their population in the last several years yet remain rich in urban infrastructure.

Solution

In 1999, the ULC popular movement for housing (Unification of Tenement-Housing Struggles) occupied a derelict building, in the centre of São Paulo. Feasibility studies were carried out, as well as negotiations with the owner and the public authorities for the purchase of the property to enable the conversion of the empty building into apartments for 84 member families living in inadequate housing conditions. Housing units range from 26m² to 33m².

The project was approved by the public authorities and received funding from Brazil's

federal savings bank, through the PAR Housing Lease Programme. The $600,000 package covered the costs of purchasing the building, renovating and converting the space into residential units, architectural design and engineering, and social/community development work. The project involved the creation of 84 dwelling units at an average cost of US$ 7,140 per unit (World Habitat Awards, 2004).

Potential relevance for India

The issue of vacant buildings and their reuse has been raised in India before, especially as an option for housing the homeless (Times of India, 2016). High vacancy rates also affect government-delivered social housing. Recent government figures show that 23% of houses built under JNNURM, RAY and PMAY-HFA, totaling 238,448 houses, are yet to be occupied (Ministry of Housing and Urban Poverty Alleviation, Government of India, 2016b; Dubbudu, 2016). Reasons cited include "reluctance of slum dwellers / beneficiaries to shift in cases of relocation projects" and "lack of / incomplete basic infrastructure and livelihood sources".

It should be acknowledged therefore that excess housing stock is often poor housing stock, locationally and structurally deficient or used purely for speculation. In such cases, takeover of vacancies to address homelessness and the general housing shortage may not be feasible or sensible.

Influencing factors

Environmental	**Climate change mitigation**	• Reduction of urban expansion protecting unused land. • Reduced transportation emissions . • Careful steps taken to ensure adequate natural ventilation and lighting to each housing unit in the deep-plan, formerly air-conditioned and electrically lit building.
	Climate change adaptation / resilience	• First project within a national housing programme to involve change of use (commercial to residential).
	Resource efficiency	• Building reuse: recycling of derelict buildings in the city centre into affordable housing for social purposes, making use of existing buildings and urban infrastructure.
Economic	**Affordability**	• The costs of project, funded by the CEF, repaid by residents in affordable monthly instalments over fifteen years. Average monthly payments of US$50 are cheaper than the rents charged in cortiços (overcrowded tenement-style housing), which typically range from US$83 to US$100 per month. Residents responsible for ongoing service and maintenance costs of approximately US$23.50 per month. At the end of the process, resident families lease the housing units from the bank for a period of 15 years, after which time they become owners of their apartments.
	Job creation and job access	• Urban location increases employment opportunities of occupants.
	Maintenance	• Workshops with future residents and extensive follow-up support.

Cultural & Social	**Well-being and comfort**	• Improved housing conditions and increased opportunities for an excluded segment of the population. • Improved health conditions, particularly among children.
	Respect of cultural heritage / local building culture	• Revitalization of city centre, increasing its asset base.
	Safety	• Reduced vulnerability of residents due to strict building codes.
	Conducive to community cohesion, inclusion and diversity	• Participatory workshops and extensive follow-up support • Residents as primary decision takers in design, planning and on-going management; involved in general weekly meetings, meetings with the co-ordination committee, work group activities and discussions on project design, building codes, conflict resolution and community development. The objective was to promote the integration and active participation of future residents, to consolidate public spaces for talks and deliberations and to provide ongoing support without creating a relationship of dependence between the group of residents and the Technical Advisory team.

6.2 Low energy and passive housing in Ljubljana

The Public Housing Fund of the Municipality of Ljubljana

Ljubljana, Slovenia

Context

Projects have been undertaken to reduce housing and maintenance costs and enhance the quality of living conditions in municipally-owned non-profit rented dwellings in degraded parts of the city. The main activities of the project are to refurbish the existing housing stock and to construct new stock that is energy efficient.

Solution

The first project carried out was the refurbishment of an existing block of 57 apartments with high levels of energy efficiency. The work included putting insulation on the external walls, basement floor and attic ceilings, and replacing windows and doors with energy efficient versions with external thermal shutters. Other projects followed with added benefits such as mechanical ventilation systems with 75 per cent heat recovery. As a result of all the retrofit work, energy consumption fell by nearly 40 per cent. Other projects followed including four new-build developments providing a total of 234 new apartments built to the PassivHaus standard in 2011. This standard uses high levels of insulation, careful design and mechanical ventilation to ensure that the total energy demand for space heating and cooling is less than 15 kWh/m^2/yr

treated floor area, and that the total primary energy use for all appliances, domestic hot water and space heating and cooling is less than 120 kWh/m^2/yr. A range of resources have been deployed by the municipality to carry out the refurbishment work to date. These include the municipalities' own resources (20%) and loans from the Slovenian Environmental Public Fund (SEPF) (80%) (World Habitat Awards, 2010).

Influencing factors

Potential Relevance for India

Data on heating and cooling requirements for the residential sector in India are currently hard to come by. The National Sample Surveys on Household Expenditure currently only track household expenditure for cooking and lighting (the last time this data was collected was during the 68th round in 2011/2012). Nevertheless given the aging housing stock in urban areas, in conjunction with the gradually growing need and ability to pay for active heating and cooling in many of India's climatic zones, the role of retrofitting should not be underestimated (Tiwari & Rao, 2016).

Environmental	**Climate change mitigation**	• Wherever possible materials used with low embodied energy. • Reduction in energy usage and carbon emissions. • Heat recovery ventilation units, pre-cooling and pre-heating of air with liquid earth heat exchangers, solar thermal and PV systems. • Urban land reuse: reduced the need for private transportation and other negative aspects of urban sprawl. • Greater awareness of the need to save energy developed, in both the private and social housing sectors. Schools and kindergartens are also being built to low energy standards. • Energy monitored, including online monitoring in the newest flats.
	Resource efficiency	• Brownfield site development
Economic	**Affordability**	• Significant reductions in energy bills.
	Job creation and job access	• Temporary jobs created through construction programmes. • Urban location increases employment opportunities of occupants.
	Maintenance	• Tenants instructed in management of their apartments' energy. • Residents contacted twice a year during periods of maintenance and interviewed to monitor occupant satisfaction.
Cultural & Social	**Well-being and comfort**	• Improved quality of social rental housing improves status of social housing tenants; helps to increase self-esteem
	Conducive to community cohesion, inclusion and diversity	• These projects are carried out in degraded parts of the city and have had positive socio-economic impacts on surrounding areas.

6.3 Technical team planning for self-help housing in the Kambi Moto Community

Kambi Moto community, Nairobi, Kenya

Context

60 per cent of the inhabitants of Nairobi live in informal settlements. In Kenya, the professional services of architects and engineers are not affordable for a majority of the population. Although the urban poor show impressive improvisation skills and innovation to better their housing situation, there is a need for value that can be added by the technical and design professions.

Solution

The Technical Team, working in conjunction with a local NGO, Nairobi City Planning Department and two universities, engaged with the residents of Kambi Moto. The Technical Team is an informal network of professionals (architects, planners and surveyors) working alongside communities to enable them to build their own homes and gain security of land tenure. Further, by training the community on procurement procedures and management of the projects, these tasks can be adopted by community members, minimising future long-term reliance on professional input.

The original informal plot was transferred to the community as a whole, and each household receives a sectional title, meaning that if a family wishes to sell up then their title is sold back to the community. All construction-related costs , 80 hours of labour and a 10 per cent down payment were provided by households, covered by savings, paid into the community savings scheme during the preparation stage, while 90 per cent of the construction cost is given as a loan, although a follow-up in 2015 with the project owners has revealed that repayment of the loan has stopped due to the absence of the threat of eviction. Despite this, the project points to a possible model for combining pro-bono professional expertise with community-driven construction. The construction has been carried out incrementally and in-situ so that the households did not have to move out of the community. During each construction phase between 20 and 30 homes are built. Therefore only a small number of the community are affected and can be

accommodated by their fellow community members (World Habitat Awards, 2009).

Potential relevance for India

The importance of owner-driven, informal housing construction in India has been broadly recognized, as has been the need to improve construction quality and assist builders and artisans in accurate costing. One such initiative is the Budgeting and Planning Tool, in both Hindi and English, by the Indian think tank mHS City Lab (mHS City Lab, 2016).

Influencing factors

Environmental	**Climate change mitigation**	• Locally available stone and components fabricated on site reduced need for expensive, energy-intensive materials, with community members producing materials, providing skills and income.
	Climate change adaptation / resilience	• Planning of settlement took into account local knowledge of the site when considering storm-water run-off, path and road access.
	Resource efficiency	• Locally available lava stone blocks were used as building materials for the new homes, rather than cement blocks. • Floor slabs and roof terraces were built with pre-fabricated concrete mini-floor slabs that use a fraction of steel and cement compared to conventional concrete.
Economic	**Affordability**	• In order to reduce the labour costs, the households provide unskilled labour, developing skills for future tenants.
	Job creation and job access	• Due to the learned skills, community members applying and qualifying for formal construction work outside the settlement. • Catering group also formed and is developing its business. • Community-led process of negotiation on every issue from the design through to the conditions for loan repayment as a real and positive example for other communities and technical professionals in Huruma and across Nairobi.
	Respect of cultural heritage / local building culture	• The local professionals involved in this project received training and motivation to work locally and enhanced their skills by providing better service to the community-built housing process.
Cultural & Social	**Safety**	• Urban layout combining pedestrian settlement plan with access for emergency vehicles allowing all households to stay on site.
	Conducive to community cohesion, inclusion and diversity	• Community empowered to own and manage the whole process, developing skills and increasing capacity as they go. • Community developed skills and worked closely on all aspects of design, planning, saving, construction, project management and sharing experience through exchanges with other communities • The community members have become better leaders and are equipped to articulate their needs clearly to the city council. • The community of Kambi Moto is and will be assisting other urban poor communities in Nairobi and other towns in their struggle to enhance and secure their housing situation.

6.4 Cato Manor Green Street

Green Building Council of South Africa

Durban, KwaZulu Natal, South Africa

Context

The South African government has built an estimated 2.8 million low-cost homes since 1994 and a further 3 million are targeted by 2025. Cost-cutting has been common to maximize delivery, but unfortunately this has meant that these homes have generally been designed and constructed with no water heating system, and little regard for energy and water efficiency, adequate insulation or other 'green' design considerations. For this reason people living in these houses continue to spend significant amounts of their income on energy, while suffering disproportionate health burdens.

A few pilot projects like those in Joe Slovo, Kleinmond, Kuyasa and Witsands in the Western Cape, Cosmo City in Gauteng, and Zanemvula in the Eastern Cape have demonstrated the economic and societal benefits of more sustainable design in low-income housing. Not only do green interventions translate into energy, water and financial savings, but also reduce associated illness, safety risks, greenhouse gas emissions and environmental impact. The South African government has recognised the pressing need for more sustainable social housing programmes.

Solution

The project involved consultation with local government to provide support and equipment, e.g. LED streetlights, clean-up campaigns, environmental monitoring devices for monitoring stage, etc. Further consultation took place with the community to ensure co-operation and interest in the project. Among other upgrades, the retrofit involved installing insulation in the ceilings, electrical upgrade, and solar hot water systems along with the required plumbing. The project included a monitoring and analysis stage which focused on impact, notably electricity use, water use, comfort, cost-benefit and quality of life. Learning from the project has been used to make important policy recommendations for the construction of new homes, the retrofitting of existing houses, and the scaling up of key interventions (GBCSA , 2012).

Potential Relevance for India

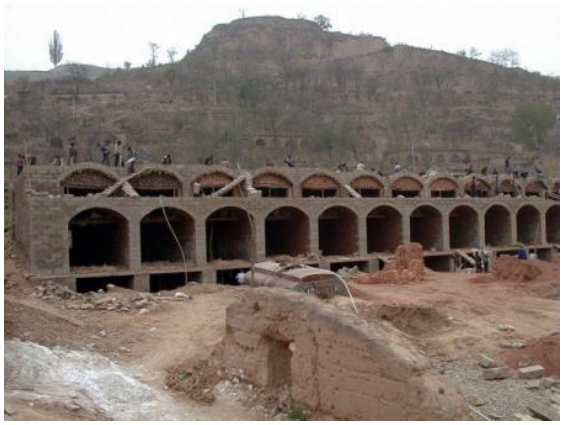
Similar to the Singapore case presented in Section 7, piloting sustainability measures before introduction into policy, law or regulations, may be an absolute imperative considering the scale of India's social housing programmes in the years to come and the possible danger of lock-in effects. A number of innovative projects can already be drawn upon for inspiration, and which will be

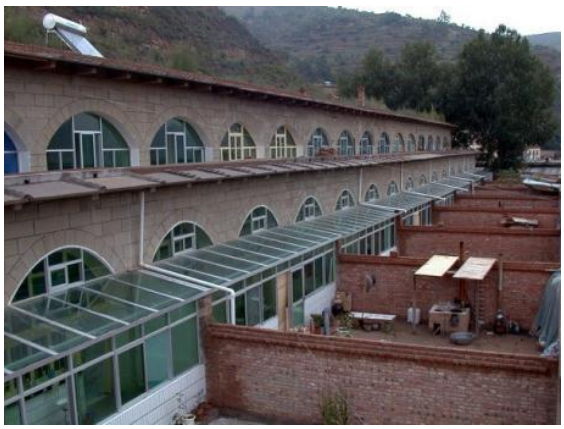
supplemented by the Level 3 case studies of the this project.

	Influencing factors	
Environmental	**Climate change mitigation**	• Solar hot water systems; Insulated ceilings and low albedo roof coating; Energy efficient lighting; Heat retention insulation cookers. • Energy reduced by 25%. 105 tonnes of carbon have been avoided, and the sale of carbon credits will generate funds to be invested back into this community.
	Climate change adaptation / resilience	• Rainwater harvesting systems for water security, especially in times of erratic rainfall or droughts, and will keep water costs down in periods of municipal water shortages. • Food gardens.
	Resource efficiency	• Rainwater harvesting systems. • Water efficient plumbing.
Economic	**Affordability**	• Sixty per cent of homes say that food costs decreased. • Home prices increased.
	Job creation and job access	• Onsite job training. • Training and work opportunities created: range of practical, on-the-job training sessions and community education workshops .
Cultural & Social	**Well-being and comfort**	• Permaculture and food gardening training. • Hot water on tap for first time through solar hot water systems, before many residents could not afford the energy to heat water. • Greater human comfort and aesthetics inside homes, and improved health and safety. Peak temperatures on summer days have dropped by 4-6°C with insulated ceilings. Less need for fuels like paraffin, coal and wood mean reduced health problems and fire safety risks for these homes. • Water and food security increased for residents.
	Respect of cultural heritage / local building culture	• Clean-up and rehabilitation of local stream. • Indigenous plants replace invasive plants.
	Safety	• Complete re-wiring of electrical for safety, Solid waste disposal. • The polluted stream in the area was cleaned up.
	Conducive to community cohesion, inclusion and diversity	• Community consultation. • Increased sense of community ownership.

6.5 The New Generation of Yaodong Cave Dwellings, Loess Plateau

Loess Plateau, People's Republic of China





Context

Located in north central China, the Loess plateau covers nearly 500,000 km^2, home to forty million people, 75 per cent of whom are farmers. Living conditions are amongst the lowest in China. Ninety per cent of the rural population lives in various types of yaodong (cave dwellings). The earliest types of these were dug into the hillsides and they have since evolved into masonry dwellings that are more disengaged from the mountainside (only 10% are still in the dug-out form, 70% have their rear wall abutting the mountainside and the remainder are entirely freestanding).

With the rapid growth of China's economy, most rural people want to live in new, modern housing and tend to be dissatisfied with the traditional yaodong dwelling, resulting in a large increase in energy usage and pollution. Valuable farm land is used, with impacts on the natural ecosystem.

Solution

Starting with a pilot project of 85 houses in Zaoyuan village (1996-2001), the project has now seen the development of over 1,000 dwellings by families using self-help construction in both rural and suburban areas. A real-estate developer has built a further 1,200 dwellings plus two large hotels.

The new housing design is based on the traditional design but increases the one-storey yaodong to two-stories and includes a sunspace at the front and earth-sheltered roofs, which serve to increase the indoor daylight levels, as well as improving natural ventilation and humidity. Although the houses are low-cost they are sufficiently modern to be attractive to the local people.

The sense of cultural continuity is very important. Surveys have shown that the residents feel that the new Yaodong is not something imposed on them from the outside, but is a continuity of their building tradition. Local people are involved throughout the design and construction process and friends and neighbours of the residents help build the houses, using traditional building skills. The resident's subjective opinion of the new dwelling and involvement in the design and construction process is considered to be an important aspect of the sustainability of the housing, of equal importance as the energy- and pollution-saving aspects (World Habitat Awards, 2006).

Potential Relevance for India

Cultural adequacy is one of the seven components of the Right to Adequate Housing which is included in the International Covenant on Economic, Social and Cultural Rights, ratified by India in 1979, where housing is not considered culturally adequate „if it does not respect and take into account the expression of cultural identity."

Influencing factors

Environmental	**Climate change mitigation**	• Zero consumption of energy for heating, ventilation and air conditioning due to the use of thermal mass, solar energy and natural ventilation systems. • Solar space provides heat and daylight - CO2 emission saving per property is 2,400 kg (2.4 tonnes) for a 100 m2 dwelling.
	Climate change adaptation / resilience	• Earth shelter thermal mass maintains even temperatures throughout the year.
	Resource efficiency	• Local topography provides housing structure, thereby reducing the need for roofing and wall materials. The building materials used are sourced locally and recycled building materials have been used wherever possible. • Use of two-storey construction rather than single-storey in order to increase the amount of functional space available.
Economic	**Affordability**	• The costs of the new dwellings are approximately half of that of the new flats being built using western methods and materials in the nearby towns. • Utility bills are lower as a result of reduced need for heating.
Cultural & Social	**Well-being and comfort**	• Environmental monitoring found that indoor temperatures are higher on average by five degrees in the new buildings (i.e. increasing from 10-15 °C at midday) and indoor daylight levels and ventilation are much improved in the new buildings.
	Respect of cultural heritage / local building culture	• Establishing a new typology for the rural population that is connected to local and traditional roots, but that meets changing social and economic circumstances and expectations. • The houses are cut into hill terraces on land that is infertile or hard to farm, thus maintaining the amount of land available for agriculture.
	Conducive to community cohesion, inclusion and diversity	• Retaining young people in the area with more modern and inexpensive housing helps boost the local economy and prevents rural depopulation. • People work together with their friends and neighbours to build their own homes. The design of the housing is more conducive to people meeting their neighbours than living in one of the new flats in the local towns.

6.6 Improved traditional housing in Papua New Guinea

Joint work between Community Based Building Program Ltd, SPK Projects, Niugini Works, and Assaí

Papua New Guinea

Context

Papua New Guinea (PNG) with a population of seven million has a population density of 10 people per km^2. The vast majority of housing in PNG is rural. In general, both housing finance and land are very difficult to obtain. Although PNG possesses a rich traditional building heritage suited to the local material base, climate, skills base, economy and way of life, this is increasingly being supplanted by an imported modern architecture that is unfamiliar to the local way of life, often very expensive and prone to rapid deterioration due to poor design and inappropriate materials choice.

Solution

The aim of the project was to develop a new and constantly evolving form of housing for PNG which maintains the inherent traditional architecture that is climatically, culturally, economically and ecologically appropriate and sustainable. Furthermore to meet the modern housing need the housing must be competitive with modern methods and easily taught, learned and replicated. Traditional building skills are retained and enhanced through the building process and through general confidence and capacity building. As an example, iron roofs replaced the traditional thatch roofing whilst retaining the original form and slope to provide shade, rain shedding and a cooling air volume for the interior. The iron roof allows for rainwater harvesting and is longer lasting than the thatch roofs (World Habitat Awards, 2003; UN-Habitat, 2012).

Potential Relevance for India

India's housing shortage is, in absolute terms, more pronounced in rural areas: 43.7m units in rural India compared to 18.78m units in urban areas (Tiwari & Rao, 2016; Government of India, Ministry of Rural Development, 2011). While the focus of India's housing programmes is decidedly urban, bespoke solutions for addressing the rural housing shortage will have to be found, taking account of both locally available materials, local building cultures, climate and culture.

Influencing factors

Environmental	**Climate change mitigation**	• Design of houses using traditional methods provide a naturally cool house, excluding the need for air conditioning; Solar power.
	Climate change adaptation	• Rain water harvesting.
	Resource efficiency	• Dry composting toilets; rain water harvesting. • Sustainably sourced timber, along with other locally sourced material, is used throughout the project with an emphasis on affordability, durability and local income generation opportunities.
Economic	**Affordability**	• Costs are reduced beyond half the price of non-traditional housing with imported materials and methods. • Costs reduced from labour (building and material supply) contribution from occupants. • Emphasis upon affordability, durability and buildability.
Cultural & Social	**Well-being and comfort**	• Single lined wall frames with a latticed infilling which allow an increased amount of light into the house. • Materials and designs used appropriate for climatic conditions and produce healthier living environment.
	Respect of cultural heritage / local building culture	• Residents play and active role in the planning and building process. • New approach is taken to culturally sensitive, traditional methods of construction for housing. • Use of traditional architecture as a prime driver for design and construction. • The Assai design philosophy is to preserve and adapt the traditional building culture in the face of modernisation and inappropriate western housing models. The approach used by Assai was to analyse traditional PNG architecture, to understand and maintain its value and change it only where it is necessary to respond to new demands.
	Safety	• Solutions to mosquito proofing, cleanliness, and sanitation.
	Conducive to community cohesion, inclusion and diversity	• Each housing project is designed with extensive end user consultation through a workshop process. Workshops were first held at the 'pattern' level, i.e. looking at what in general a house in this area should be like and secondly with the residents as part of the detailed design process. This approach has also been used for schools and other community buildings in the area. • In addition to housing for low-income earners, the project included high-income houses in an effort to increase the status of traditional design with lower income earners.

6.7 Passive Solar Housing in the Cold Desert of the Indian Himalayas

Groupe Energies Renouvelables, Environnement et Solidarites (GERES India)

Kargill District; Leh District, Western Indian Himalayas

Context

The Western Himalayas is a cold desert with 300,000 inhabitants living in high altitude villages. During the winter temperatures generally fall below -20°C. Traditional houses are built of wood and stone and are thermally inefficient, with room temperatures falling below -10°C in winter. Family members tend to live together in one room in winter which facilitates disease transmission and the use of stoves aggravates respiratory infections. Large intergenerational households are not uncommon, with 15 members sometimes living in one house.

The target population is individuals living with less than one dollar a day. Scarcity of local fuel and the high price of imported fossil fuels have resulted in a situation of energy vulnerability. Women and children spend almost two months a year gathering dung and bushes in pastureland. Very few activities are possible during winter, even indoors, due to the cold temperatures, however, the region benefits from strong sunlight for more than 300 days per year.

Solution

The passive solar housing technologies used in this programme of new housing construction and retrofitting include solar gain (direct gain, solar wall and attached greenhouse), thermal mass and insulation. In the passive solar houses, the average indoor temperature remains continuously above 5°C as opposed to -10°C in unimproved houses. Fuel consumption has reduced by 50 to 60 per cent. The average cost of installing energy efficiency features is US$955 and households provide approximately US$610 (64 per cent) of this in cash and kind through local materials, casual and part of the skilled labour. Benefits include improved comfort, more social visits, time saving, easier education and improved health. Local people have been trained in income generating skills which include local handicrafts (World Habitat Awards, 2011a).

Influencing factors

Environmental	**Climate change mitigation**	• Technical innovation in the use of energy efficiency techniques, which combine passive solar features, thermal mass and thermal insulation with local materials. • Fuel consumption has reduced by 50 to 60 per cent. • Greenhouse gas emissions reduction of 2.5 kgCO2 per household per year (1.3 tonnes of biomass per household per year saved). • Following the success of the project development of a first draft of the energy efficient building code has been submitted to the national Ministry for New and Renewable Energy as well as to the Local Authorities.
	Resource efficiency	• Locally available and renewable insulation materials: sawdust, straw and wild grass.
Economic	**Affordability**	• Cost savings from more efficient homes.
	Job creation and job access	• Trained and skilled artisans (in solar passive design, masonry and insulation) a product of the development, training local masons and carpenters in energy efficient construction techniques. • Less time spent collecting biomass for heating translated to more time for income generating activities.
Cultural & Social	**Well-being and comfort**	• Passive solar design to increase effortless warmth. • As a result of the project, people have the benefit of a warmer and healthier indoor environment and they are able to earn more money in the winter months. • The average indoor temperature remains continuously above 5°C as opposed to -10°C in unimproved houses.
	Respect of cultural heritage / local building culture	• Local materials and dwelling configurations made more efficient.
	Safety	• Reduced dependency on stoves – reduced respiratory infections.
	Conducive to community cohesion, inclusion and diversity	• Community buildings have been provided on site using the same techniques. • Twelve grassroots-level networks have been established to date consisting of village representatives, masons and carpenters who work together to promote passive solar housing. In addition to encouraging participation, the networks act as a pressure group to advocate for improved local government policy in respect of renewable energy. • Less time spent collecting biomass for heating translated to more time spent in community improvement and social activities. • Benefits include improved comfort, more social visits, time saving, easier education and improved health.

6.8 Jaunapur Slum Resettlement

Anangpu Building Center & Ashra

Southern Ridge area, Delhi, India

Context

In Delhi, one of the fastest growing metropolises in India, the slum population is growing also. Where 30% of the population live in degraded tenements, Delhi may soon have the fastest growing slum in the world. The major problems faced in Delhi, as in other Indian cities are lack of funds, non-availability of land and infrastructure. These are exacerbated by incorrect planning, the inadequacies of the government mechanism and the failure of past development approaches. Providing housing for the slum dwellers is an ongoing problem that seems to defy all plausible solutions and the problem continues to outpace the solutions.

In 1996 a Supreme Court directive stated that 3,600 illegal squatters from Delhi's ecologically sensitive Southern Ridge forest area were to be resettled on its outskirts.

Solution

52 dwelling units were built in 1997 as a pilot project for a scheme of re-housing the 3,600 former slum households of the Southern Ridge area of Delhi. The dwellings are designed in clusters of nine grouped in a 'through cluster' rather than an enclosed court. Each cluster is provided with two toilets, one bath, one washing area and one court in common. Each dwelling is 15.8m^2 and is capable of vertical extension to 31.6m^2. The overall density is 210 dwelling units per hectare.

The pilot scheme has been successfully built and at a cost of Rs.44,000 (US$ 1100)/ unit (nearly half of that the government department had estimated). The dwelling units have been provided as skeletal structures built with waste stone and other resource efficient technologies to be completed by the owners on a self-help basis reusing walling materials from their erstwhile homes. The project demonstrates the advantages of natural drainage and onsite waste disposal.

The cluster grouping responding to the socio-cultural needs, optimising length of service lines and roads and allowing provision of basic services at the cluster level. The rehabilitation scheme demonstrates that land classified as `unfit for development' is really to be utilised to create an environment responsive and sustainable human settlement that is also economical as opposed to the conventional system (Anangpur Building Centre, n.d.; Building and Social Housing Foundation, 2016).

Influencing factors

Environmental	**Climate change mitigation**	• Lower embodied carbon from local and reused material.
	Resource efficiency	• Residents encouraged to reuse materials from previous settlement. • Sewerage and wastewater are treated locally, treated water to be used to water fruit plantations. • Funicular shell roofing gives greater strength and uses less material than conventional roofing systems. • Roofs are built with waste stone quarried locally on the site and there is no need for steel reinforcement. • Project demonstrates that land classified as 'unfit for development' can be successfully used.
Economic	**Affordability**	• Shell structures are provided for residents to take to completion reusing materials from previous settlement.
	Job creation and job access	• Training will be provided by the local Building Centre to future residents in how to make hollow concrete blocks for the walls. • A range of income generating opportunities will be available to residents. These include the provision of small retail spaces in the communal areas of the final settlement and the provision of a local transport system.
Cultural & Social	**Well-being and comfort**	• The provision of clean water, sanitation and adequately ventilated dwellings will ensure that the living conditions are healthier than the slum areas of the city where the residents lived previously.
	Conducive to community cohesion, inclusion and diversity	• Community facilities are provided at the centre of each cluster of dwellings. • Careful planning and layout of the settlement to ensure social sustainability.

7. Singapore: Government-led Mainstreaming of Sustainability

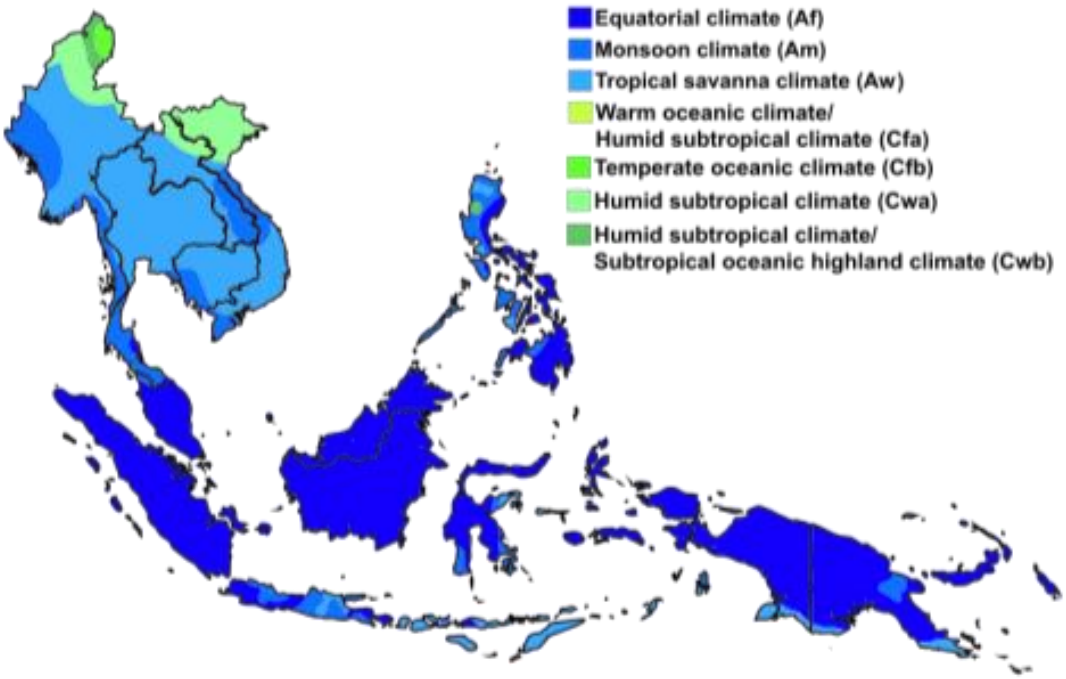


Figure 5 South East Asia Köppen Climate Classification and location of Singapore (University of Melbourne, 2007)

7.1 Background

The island city-state of **Singapore**, the technical and financial services hub of south-east Asia, differs from India in many respects. It is 100% urbanized with a total population of only 5.54 million. It is a high-income country with a per capita GNI of US$81,360 (2015 international US$, PPP), compared to India's US6,030 (World Bank Group, 2017). The political system also differs substantially. Contrary to India's multi-party system, Singapore's People's Action Party (PAP) has been the dominant executive and legislative force since 1959 and holds 93% of the seats in parliament as of the 2015 election.

Nevertheless, some lessons in the large-scale delivery of social housing, and how to make these units more sustainable, can possibly be drawn for the case of India as it embarks on the Prime Minister's Housing for All Mission.

Up until the 1960s, squatter settlements in Singapore were common. Only 9% of the population lived in social housing. Today, the national social housing program has delivered 1,200,000 units and makes up 80.4% of the total housing stock (Phang & Helble, 2016). Of these, 94% are owner occupied under a 99-year lease, while the remaining 6% are rental flats (Lee Kwan Yuu School of Public Policy, 2014).

Institutional Framework

The Housing & Development Board (HDB), established in 1960 under the Ministry of National Development (MND), finances and administers public housing and urban

development initiatives. The Building and Construction Authority (BCA), also under the MND, manages building inspections, administers building policies and a sustainability assessment program (BCA, n.d.).

The Public Housing Scheme (1968 – present)

Social housing in Singapore is, in comparison, a tightly controlled system. On the supply side, the main responsibility for delivery of units rests with the HDB which can resort to wide-ranging development rights within the legal framework. Beginning with the 1966 Land Acquisition Act, which allowed for the public appropriation of land for large-scale city planning and housing development. In 1968, Singapore's mandatory savings fund, the so-called Central Provident Fund (CPF), was expanded to include the Public Housing Scheme. This scheme, with the primary goal of home ownership for all (HDB, 2015a)[17], allowed 'Singaporeans to pay for the mortgages of their HDB flats using their CPF savings instead of having to use their take-home pay" (Central Provident Fund Board, 2016). The labour market's formal, rather than informal, character, which allows for the utilisation of a national mandatory savings scheme for the purpose of financing housing, is another fundamental difference to the Indian economy with its large informal sector.

Up until today, financial assistance is offered through first-time purchase subsidies, and grant schemes to eligible Singaporeans with a monthly income between $6,000-$18,000 (BCA, 2015). The HDB aims to keep monthly mortgage payments to **less than one-quarter of household income** (HDB, 2015a). After an occupancy period of five-years, tenants are allowed to sell their properties on the open market (Phang & Helble, 2016).

The country is a melting pot of different cultures with four official languages and diversified religions represented. Non-national citizens are integrated into HDB developments through the 1989 Ethnic Integration Policy and the 2010 Singapore Permanent Resident (SPR) quota which mandates a neighborhood ethnic mix mirroring that of the nation as a whole (Phang & Helble, 2016).

Aligning supply and demand of housing units, even in a tightly controlled market like Singapore's, has not always been easy. Following a housing *surplus* in the 1990s, the country switched to a Build-to-Order system in 2002, which has been attempting to manage demand with a small reserve supply as a buffer (Bow Tan, 2010). This change reduced output through to 2010, resulting in housing *shortages* by 2011 (Phang & Helble, 2016).

7.2 Singapore's Green Building Masterplans and Programmes (2005 – present)

Singapore covers only 697km². For comparison, Mumbai covers 603km². While Singapore has managed to increase its land area by 20% in the last forty years, primarily through aggregate-based land reclamation, with neighboring countries now limiting their exports (UNEP, 2014), this **limited supply of land** and natural resources has not only resulted in waste disposal issues, but, on the positive side, made the efficient use of land and materials an absolute imperative.

In addition, **fossil fuel imports** supply 95% of the nation's electricity (CIA, 2016). This

[17] This is not to say the rental tenure models should not also be considered to cater to specific target groups' needs at certain stages in their lives, such as students, young couples, divorcees and tenants with a high requirement for job mobility (which may not apply as much in a context like Singapore's).

dependency has prompted the need to advance energy-efficiency measures and promote the use of renewables.

With the building sector a major leverage point, **building certification** was readily identified as one tool in reducing the country's overall resource use. In 2005, the BCA developed the **'Green Mark' sustainability certification and rating scheme** in response to the perceived unsuitability of existing tools for the country's tropical and sub-tropical climate (BCA, n.d.).

In the following a brief timeline of the Green Mark scheme and other initives is offered:

1982 – 'Support for prefab technology'[18]

- **Investment Allowance Scheme** encourages purchase of advanced construction equipment. used to support uptake of prefabrication technology; expenditure incurred by companies on new construction equipment eligible for investment allowance at a support level of 50% (BCA, 2014); 30% of the investment allowance can additionally be deducted from the company's taxable income (APEC, 2015).

2006 – 'Testing the waters'

- **first Green Building Masterplan** including public outreach campaigns, industry training programs, efforts to include Green Mark in national building code.
- **$20 million Green Mark Incentive Scheme** for certified projects The Masterplan included.

2007 – 'Research, dissemination and a first trial'

- **Centre for Building Research; $50 million MND Research Fund for the Built Environment.**
- **International Panel of Experts (IPE)** to review and modernize building standards.
- Information disseminated through **training and professional certification programs** and **guidelines**.
- **First Zero Energy Building (ZEB)** constructed to verify good practices (BCA, 2008).[19]

2008 – 'Making green mandatory…for some, not all, buildings'

- Green Mark certification now **mandatory**, minimum requirements **introduced into Building Control Act:** three-year energy audits and the conditions of review.
- **Building Control (Environmental Sustainability) Regulations** formulated: Green Mark scores by building type and size, penalties for deviations from initial scores with as-built ones.
- New buildings and major retrofits with floor area of over 2000 m² with minimum of 50 points: 30 in energy and 20 in water-efficiency, environmental protection, indoor-environmental quality, and selected other features (BCA, 2008).

2009- 'Expansion, more incentives, breaking down the resistance'

- Second **Green Building Masterplan** expands Green Mark certification to existing buildings; new public buildings over 5,000m² must reach a Platinum score; existing buildings over 10,000m²

[18] Since 1980 prefabricated housing has been "indispensable to [the] building programme" for its reduced onsite labor requirements and increased productivity" (HDB, 2015a).

[19] The ZEB contains a single coil twin-fan air system, advanced daylighting systems, personalized ventilation, makes use of passive design and rooftop greenery. Hot in-door air is removed from the building by solar chimneys utilizing the stack effect.Its aim is to reduce energy demand by 60-65%, while generating additional energy through photovoltaics. Hot in-door air is removed from the building by solar chimneys utilizing the stack effect.

must be retrofitted to Gold by 2020 (BCA, n.d.).
- $100million **Green Mark Incentive Scheme for Existing Buildings** to encourage purchase of energy-efficient equipment and energy audits.
- **Green Mark Gross Floor Incentive Scheme** with extra FARs for Gold and Platinum projects.
- Resistance to the implementation programs was resolved by intensive industry consultations.

2011 – 'More incentives, new financial partners'

- **Building Retrofit and Energy Efficiency Scheme** for large-scale energy audits for commercial building owners, management corporations, and energy service companies.
- BCA **lending schemes with financial institutions** to finance energy-efficiency purchases.

2012 – 'Into the neighbourhood, first results, updating legislation'

- **HDB Green Print programme** to retrofit thirty-eight neighborhood blocks (HDB, 2016b) extended to 40 more blocks, supports green, community driven 'test-bedding' solutions through the HDB Greenprint Fund with up to $100,000 per project (HDB, 2016c).
- **First results are in:** building retro-fits reducing operating expenses by up to 13.5%, increasing property value by up to 2.7%, payback period of around 6.3 years; monitoring since 2008.
- **Building Control Act was updated** to include minimum performance standards for existing buildings, reporting by utility companies, and regular energy-cooling audits by owners.

2013 – 'Inventives for bright ideas'

- **Energy Innovation Research Programme** with $20m for higher education institutes and enterprises to develop cost-effective retrofit solutions.
- **Green Mark Incentive Scheme for Design Prototypes** $5m for design workshops and simulation to optimize green building design.

2014 – 'Engaging everybody, consumers included'

- **Third Green Building Masterplan** large-scale training for 20,000 green building specialists by 2020 through BCA Academy; partnering with universities to develop Mechanical Engineering programs with environmental focus; **influence lifestyle-related consumption behavior** with software programs and advertising the business case for changes.

Green Mark certification scheme, now on its fifth iteration, continues to develop for both existing and new builds as the government advances its program, keeping **realistic targets for gradual program evolvement**[20]. Program advances are **piloted** before being introduced as the norm (BCA, 2016a). The results are evident in Figure 11.

[20] A full breakdown of all mandatory and optional metrics under the new program can be found at BCA (2016a).

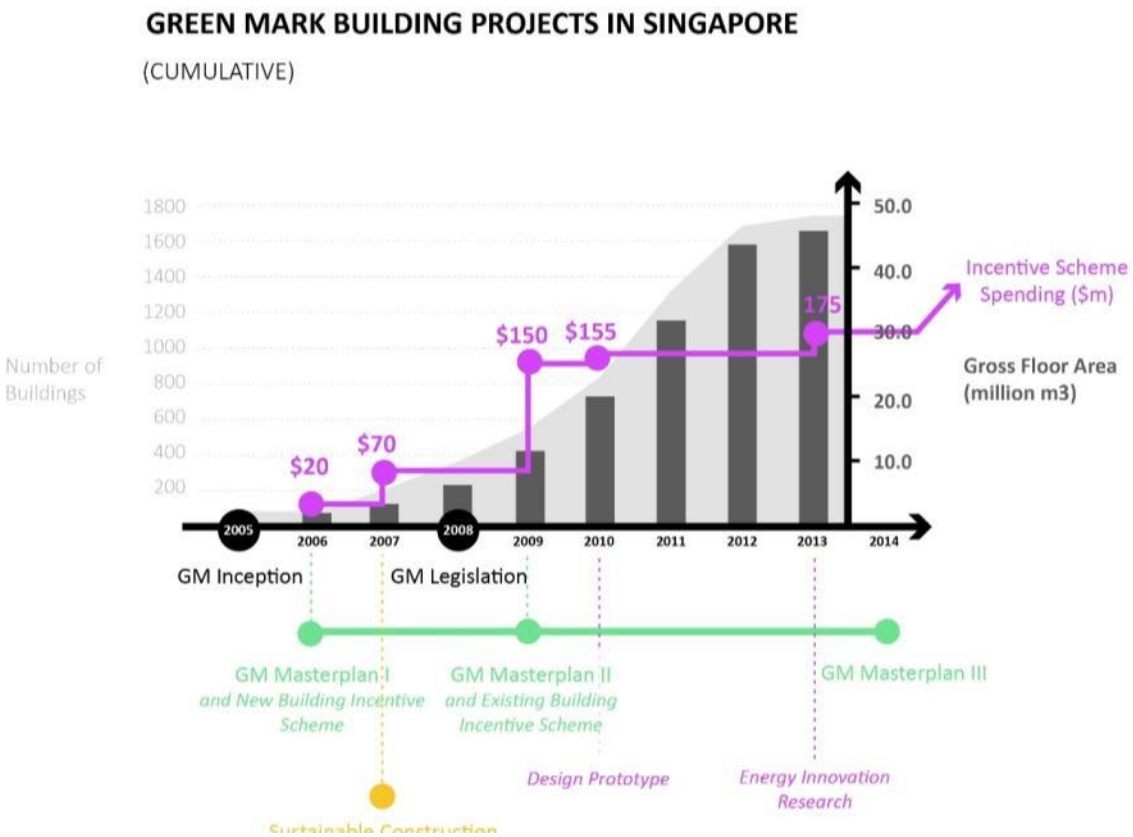


Figure 6 Green Mark certified projects and major regulatory changes (BCA, n.d., p. 15)

Eco-Precincts: Treelodge@Punggol

In the spirit of the public sector leading by example, the HDB began its first "**Eco-Precinct**" called Treelodge@Punggol, boasting numerous water, waste, and energy-efficiency measures beyond legislative requirements, in addition to green spaces, renewable energy integration, and prioritized pedestrian pathways. The goal is to test best practices before replication elsewhere and eventual adoption by law (HDB, 2015a; HDB, 2016d). The development can be seen below in Figure 11.

Figure 7 Treelodge@Punggol (Surbana Jurong Private Limited, 2016), (Tom, 2011)

7.3 Applicability to the Indian Context and Lessons Learned

The role of Singapore's particular geographical constraints in necessitating a reduction in the demand for raw materials, energy and land can certainly not be overstated. Similarly, its particular political system and manageable size certainly contribute to the way in which the challenge of building sustainability and social housing provision was handled.

Some parallels can, however, still be drawn. While Singapore mandates, for instance, the recycling and substitution of building materials, reduced concrete use in general (BCA, 2016e), as well as the use of concrete and sand from demolition and construction in pavement construction (BCA, 2007), some of these measures are already being implemented in India[21]. While the differences between Singapore and India surely outweigh the similarities, some broad brushstroke lessons can be drawn.

- Government-led social housing provides an ideal, controlled environment for interventions
- *One* national certification scheme gives clarity and certainty to industry stakeholders
- 'Try before you buy': piloting green building interventions before introduction into law is essential to both assure the industry and avoid negative lock-in effects; this requires government to lead by example
- Industry resistance needs to be tackled head-on through awareness raising, training programmes, incentives and hard evidence of the benefits
- Continuous programme refinement based on monitored results is essential to push improvements and capture additional market segments with particular requirements
- The 'city-state' mindset of striving towards increased independence could be a useful mental device to drive resource-efficiency in other localities

[21] The Indian Ministry of Environment recently published the 2016 Construction and Waste Demolition Rules which prohibit C&D waste dumping on roadsides and drains, proscribe the establishment of C&D waste plants in million-plus cities by September 2017, followed by smaller cities in the following years. In addition, submission of a waste management plan is made part of the development control process. Use of 10-20 percent recycled materials is also made mandatory for government contracts (Times of India, 2016).

8. Limitations of the Study

Due to time and resource constraints, several factors influencing the supply and delivery of social housing in India could not be addressed. First and foremost is a detailed analysis of the political economy around housing provision which would constitute a research project in itself. The reasons behind the poor connectivity of many social housing projects implemented under government schemes, which therefore contributes to the high vacancy rates in some states, in part go beyond high land prices alone. The study was also not able to examine the motivational barriers to private and public sector producers of housing's seeming reluctance to incorporate more sustainability measures in project designs.

While the study furthermore focused on the delivery of formal housing as part of, primarily, government-led and formal private sector-led initiatives, the importance of the informal sector for housing supply will not be left unacknowledged. Even if official figures for the current number of slum dwellers, for instance, may be questioned (Christ, 2016), conservative estimates alone of 24% (UN-Habitat, 2016) give an indication of the significant proportion of housing needs which are addressed informally. Given the focus of the project on formal sector stakeholders to eventually be the users of the Decision Support Tool, we feel this restriction of scope is somewhat justified.

Above all, it was deemed paramount to strike a manageable balance between compre-hensiveness and accessibility.

9. Main Findings and Recommendations

The primary findings of this report relate to both the project's strategy for influencing policy development, government instruments most likely to have an impact and their manner of delivery, as well as national and international best practices which could provide useful guidance going forward.

"Social Housing" rather than "Affordable Housing"

Even the most expensive housing will be 'affordable' to somebody. "Social housing" may thus be a more useful term to signify housing for lower income populations. Considering the large number of low-income housing providers acting independently of government support, Indian social housing would furthermore not be equivalent to "public housing" as in other countries.

Piecemeal solutions and untapped potential in linking housing and climate change agendas

Existing central government urban development programmes currently address environmental and socio-economic impacts of housing and/or infrastructure only in a piecemeal manner. In addition, there is potential for housing sector interventions to produce co-benefits for several missions under the NAPCC, whose relevance in the current policy ecosystem, however, appears to be uncertain. Both policy objectives offer opportunities for synergy and should be pursued concurrently.

2017 opportune year to highlight sustainable social housing for national development frameworks.

With the current review of the 2007 National Urban Housing and Habitat Policy and the formulation of National Development Agenda 2017-2032 replacing the Five Year Plans, 2017 offers a golden opportunity to highlight these synergies and integrate policy objectives from a number of sectors.

Fragmentation of green building certification market

There is no consistency as to which green building rating systems, i.e. GRIHA, LEED India, or the ECBC, receive support from which national, regional or local authority, leading to a fragmentation of the green building certification 'market' which could limit the overall impact of initiatives. The CPWD Sustainability Index, its development and the barriers to its wider uptake, may offer useful lessons for the development of the project's own Sustainability Index, though it must be acknowledged that there is a danger of the project's Decision Support Tool further fragmenting the market if mentioned 'selling points' do not materialise.

Policy incentives for registration rather than certification

Currently, in most cases, *registration* for certification with one of the main schemes is a sufficient condition to qualify for government support, as opposed to certification itself. This may be counterproductive and lead to a large-scale 'green washing' of projects.

Possibly limited impact of existing green incentives based on regulatory benefits and awards

Certification incentives are mainly of the 'regulatory' type offering marginally increased FSIs of 1-5% for projects *registered* as green. The Singapore case may point to possible leverage points despite the differing development context, e.g. focus on one national certification scheme with local adaptation, large-scale training of professionals, piloting of interventions before introduction into regulations, research and development support, and awareness raising campaigns.

International examples adaptable to Indian context

A number of international housing projects and programmes offer solutions to existing and emerging housing challenges in India, such as vacancies and homelessness, retrofitting and increase operational energy use, cultural adequacy, training for builders and professional support for self-construction, and rural housing solutions.

10. Annex – Selected State Profiles

Rajasthan

State Profile	
Urban Population (in lakh)	17,080,776 (24.90% of total population, census 2011)
Urban AEGR (%)	2.57
Urban Decadal Growth (%)	21.40%
Population of target group (in lakh)	85% in EWS/LIG category
Housing Shortage (in lakh)	11.5 lakhs
Housing Shortage %	37.2 %

Institutional Social Housing Stakeholders	
Government Owned	Urban Development Housing Department- Govt of Rajasthan, Rajasthan Housing Board.
Private owned	
Community owned	

Centrally-sponsored Housing Programmes/ Schemes/ Initiatives			
Programmes	**Jawaharlal Nehru National Urban Renewal Mission (JNNURM) 2006**	**Rajiv Awas Yojana (RAY) 2009**	**Pradhan Mantri AwasYojana 2015**
Delivery target (no. of units)	43,146	21,908	12,307
Achievement till date (no. of units)	32,660	7,264	Not applicable
Key initiatives	67 projects sanctioned under Integrated Housing & Slum Development Program, primarily slum improvement projects that included upgradation/ new construction of houses and	Affordable Housing in Partnership (AHP) as part of RAY approved in 2013.	Not applicable

	infrastructure facilities like water supply and sewerage.		
Challenges	Lack of capacity of the ULB's Lack of political support in some areas Resistance from state/ULB's to implement reforms	Community participation for the construction of the houses was not up to the mark, as only those families staying in the slums at the time of the survey were considered and not those who claimed ownership of the hutment. The Property Rights Bill had not been introduced to prevent eviction of slum dwellers.	Not applicable
Learnings	Need to build capacity before launching a programme of such scale Special emphasis needed for hand holding in states - financial incentives insufficient Sustained focus on reforms can be difficult - needs the right visionaries - political pressure on the investment	Need for provision of legislation that would provide property rights to slum dwellers. Greater community participation and awareness generation required. Preference for in-situ up-gradation or in-situ redevelopment versus relocation.	Not applicable

State sponsored housing programs/ schemes/ initiatives	
Programmes	**Mukhyamantri Jan Awas Yojana 2015** (Previously The Affordable Housing Policy – 2009)
Goal	**Affordable housing for all** and integrated habitat development in general and for EWS and LIG in particular.
Delivery target (no. of units)	2368
Achievement till date (no. of units)	1654
Key initiatives	Incentives for Green building technologies and installing rain water harvesting system. Use of alternate building construction materials encouraged.

Regulatory framework:

- Model Rajasthan Bhawan Viniyam 2013 for towns having population more than 1 lakh-except

Jaipur, Jodhpur and Bhiwandi
- Rajasthan State Industrial and Investment Corporation (RIICO) bye laws
- Jaipur Development Authority (Jaipur Region Building) Bye laws 2010
- Jodhpur Development Authority (Jodhpur Region Building) Bye Laws 2013

Rajasthan Urban Development and Housing Department- provisions under Jan Awa Yojana:

1. **Residential Regulations- % of project floor area to be allocated for EWS/LIG:**
   For private developers: 7.5%
   For ULB's / Development Authorities: 25%
   For RHB: 50%
   For Industrial schemes: 5 %

2. **Regular FAR**: 1.33

3. **Incentive for private developer on private land in partnership**
   If private developer constructs on private land in partnership in a scheme of 2 hectares, then minimum 50% area will be used to construct EWS/LIG housing.
   In this case land use conversion fee waiver will be given and an FAR of up to 2.25

4. **Incentive for private developer on entirety of private land (flatted development, Multi-storey format)**
   If private developer constructs 100% EWS/LIG housing on own land, then incentives like - additional height, land use conversion fee waiver, or FAR of up to 2.25, will be given

Andhra Pradesh

1	**State Profile**		
1.1	Urban Population (in lakh)	1.46 lakhs	
1.2	Urban AEGR (%)	3.09	
1.3	Urban Decadal Growth (%)	11.1%	
1.4	Population of target group (in lakh)	EWS	
		LIG	
1.5	Housing Shortage (in lakh)	12.7 lakhs (95% in EWS/LIG)	EWS: 7.1 lakhs (56.18% of total shortage)
			LIG: 5 lakhs (39.44%of total shortage)
1.6	Housing Shortage %	16.3%	
2	**Institutional Social Housing Stakeholders**		
2.1	Government Owned	1. **AP State Housing Corporation Limited** (APSHCL) is involved in the implementation of housing schemes like BSUP, IHSDP, Rajiv GruhaKalpa and INDIRAMMA (NTR Housing) for EWS. 2. **AP Housing Board** (APHB) caters to the housing requirements of LIG, MIG and HIG. 3. **AP Rajiv Swagruha Corporation Limited** (APRSCL) is a special purpose	

		vehicle for the implementation of Rajiv Swagruha Scheme for the urban middle class. 4. **Commissioner and Director of Municipal Administration** (C&DMA) administratively controls the municipalities and municipal corporations in the state. 5. **Directorate of Country and Town Planning** looks after the subject of planning and development in urban and rural areas. 6. **Mission for Elimination of Poverty in Municipal Areas (MEPMA)** is involved in the implementation of RAY in the state. Other notable housing stakeholders include the AP Weaker Section Housing Programs, AP Police Housing Corporation, AP Medical Health Housing Corporation, AP Housing Federation, private developers, banks and microfinance institutions.
2.2	Private owned	
2.3	Community owned	

3	**Centrally-sponsored Housing Programmes/ Schemes/ Initiatives**				
	Programmes	**Jawaharlal Nehru National Urban Renewal Mission (JNNURM)**		**Rajiv Awas Yojana (RAY)**	**Pradhan Mantri Awas Yojana**
		BSUP Basic Services to the Urban Poor	**IHSDP** Integrated Housing and Slum Development Programme		
3.2	Delivery target (no. of units)	139854	39914	2,850	1,93,147
3.3	Completed units	101685	25549	0	0
3.5	Challenges	BSUP and IHSDP suffered from a lack of community engagement and long-term, integrated planning vision. Valmiki Ambedkar Yojana (VMBAY), which was subsumed under BSUP, had issues of identification of beneficiaries and convincing people to claim their dwelling units because of the lack of basic services.			
3.6	Learnings	It should be the responsibility of the State Governments to ensure a separate provision for upkeep and maintenance of the public assets created under the scheme.			

4	**State sponsored housing programs/ schemes/ initiatives**
	Programmes	Rajeev Gruhakalpa Programme
	Goal	Construction of 2 lakh housing units in 2005-2006 for the EWS and LIG classes,
	Delivery target (no. of units)	2,00,000

	Challenges	Only 332 houses were completed in 2008-09, of which only 49 dwelling units have been occupied. Poor infrastructure provision and lack of understanding of the need of the low income residents

5	Regulatory framework:
	Andhra Pradesh Tenancy Laws (Amendment) Act, 2002 To protect tenants from unjust eviction. To regulate the fair rent payable by the tenant to the landlord. To prescribe the minimum period for agricultural leases. To provide for a right of first preference to tenant, in purchasing the land. **Andhra Pradesh Building Rules, 2012** **Andhra Pradesh Buildings (Lease, Rent & Eviction) Control (Amendment) Act, 2005** **The Andhra Pradesh Town Planning (Amendment) Act, 1996** **Master Plans of Cities in Andhra Pradesh & Telangana** **The Andhra Pradesh Town Planning (Amendment) Act, 1996** **The Andhra Pradesh Urban Areas (Development Amendment) Act, 1986** **Andhra Pradesh Slum (Identification, Redevelopment, Rehabilitation and Prevention)Act, 2010** **Andhra Pradesh Urban Areas (Development) Act, 1975**

Uttar Pradesh

1	State Profile	
1.1	Urban Population (in lakh)	44,495,063
1.2	Urban AEGR (%)	2.53
1.3	Urban Decadal Growth (%)	20.10
1.4	Population of target group (in lakh)	EWS: 30%
		LIG: 24%
1.5	Housing Shortage (in lakh)	30.7
1.6	Housing Shortage %	41.2%

2	Institutional Social Housing Stakeholders

2.1	Government Owned	Ministry of Housing & Urban Poverty Alleviation , Uttar Pradesh Housing & Development Board, Housing & Urban Planning Department
2.2	Private owned	Micro Housing Finance Corporation Ltd.
2.3	Community owned	

3	Centrally-sponsored Housing Programmes/ Schemes/ Initiatives			
3.1	Programmes	Jawaharlal Nehru National Urban Renewal Mission (JNNURM)	Rajiv Awas Yojana (RAY)	Pradhan Mantri Awas Yojana
3.2	Delivery target (no. of units)	82,327	8,409	Not Applicable
3.3	Achievement till date (no. of units)	64,130	2,039	Not Applicable
3.5	Challenges	Under Urban Statistics and HR Assessment (USHA) scheme headed by the National Building Organisation a comprehensive Slum Profile, Household Survey & Livelihood Survey was supposed to be initiated, that has not been done properly. Thus the Plan of Action (PoA) is being formulated without completing the survey.		

4	State sponsored housing programs/ schemes/ initiatives	
	Programmes	**Samajwadi Awas Yojana**
4.1	Goal	Samajwadi Awas Yojana is an ambitious affordable housing scheme of UP government in which UP aimed to develop about 3 Lakh MIG homes by 2016. As of January 2017, only allotment of plots had begun, however.
4.2	Challenges	--

5	Regulatory framework:
	The affordable housing policy allows maximum 2.5 FAR and a density of 450 housing units per hectare. Rebates are to be given to developers on external development fee and land conversion charges while converting agricultural land into residential land for EWS/LIG housing. In projects above 1 hectare, a builder has to pay land conversion charges on only 45% of the total land on which he would develop dwellings. The remaining 30% land will be allocated for building parks, green spaces, roads and other infrastructures while 25% will belong to the respective authority.

	Municipal Development Authorities formulate the building bye-laws.
6	**Incentives for green certification**
	If any, they include: a) conditions for incentives: Has to be approved by GRIHA. b) extent of incentives: The state government will allow 5% extra FSI for green developments exceeding 5,000 m².

Karnataka

1	**State Profile's**	
1.1	Urban Population (in lakh)	23.6 lakhs
1.2	Urban AEGR (%)	2.72
1.3	Urban Decadal Growth (%)	15.67%
1.4	Population of target group (in lakh)	EWS: 217.8 lakh
		LIG: 28.9 lakh
1.5	Housing Shortage (in lakh)	3.63 lakhs
1.6	Housing Shortage %	19.2%

2	**Institutional Social Housing Stakeholders**	
2.1	Government Owned	Karnataka Housing Board (**KHB**) Rajiv Gandhi Rural Housing Corporation (**RGRHC**) Bangalore Development Authority (**BDA**) Karnataka Slum Clearance Board (**KSCB**) Bangalore Metropolitan Regional Development Authority (**BMRDA**) Karnataka Rajya Nirmana Kendra (**KRNK**) Karnataka Urban Infrastructure Development & Finance Corporation (**KUIDC**) Urban Local Bodies Departmental Agencies and Government Departments.
2.2	Private owned	
2.3	Community owned	

3	**Centrally-sponsored Housing Programmes/ Schemes/ Initiatives**				
	Programmes	**Jawaharlal Nehru National Urban Renewal Mission (JNNURM)**		**Rajiv Awas Yojana (RAY)**	**Pradhan Mantri Awas Yojana**
		BSUP Basic Services to the Urban Poor	**IHSDP** Integrated Housing and Slum		

			Development *Programme*		
3.1	Delivery target (no. of units)	28288	17237	2272	16522
3.2	Completed units	20704	14647	78%	Not applicable
3.4	Challenges	• Delay in selection of beneficiaries, wrong identification of beneficiaries • In case of distribution of sites to site less families, due to drastic increase in the land cost and non-availability of Government lands in both rural and urban areas the Government could not able do much in this scheme as compared to the total demand.			

4	**State sponsored housing programs/ schemes/ initiatives**			
	Programmes	Delivery target (no. of units)	Achievement till date (no. of units)	Key initiatives
4.1	Vajapayee Housing Scheme (Ashraya-Urban)	300,000 urban units	165,614	This scheme will provide houses to houseless persons whose annual income is less than 11800/- in the below mentioned ratio. SC : 30% ST: 3% BCM: 15% Minorities : 4% Others: 48%
4.2	Special Housing Scheme	10,000	1000	Houses are reserved for persons with disabilities, leprosy cured persons, HIV-affected families, devadasis, nomadic tribes, safai karmacharies, people affected by communal riots, exploits, free bonded labourers, widows, houseless orphans, transgenders, and others.

5	**Regulatory Framework**
	Karnataka Housing Board Regulations, 1983 Karnataka Housing Board Act, 1962

Uttarakhand

1	**State Profile**	
1.1	Urban Population (in lakh)	30.91

1.2	Decennial AEGR (%)	3.5%
1.3	Urban Decadal growth	41.9%
1.4	Population of target group (in lakh)	36.5% Below Poverty Line (Urban)
1.5	Housing Shortage (in lakh)	1.6
1.6	Housing Shortage %	27.1%

2	**Institutional Social Housing Stakeholders**	
2.1	Government Owned	Uttarakhand Housing and Urban Development Authority, Mussoorie Dehradun Development Authority
2.2	Privately owned	-
2.3	Community owned	-

3	**Centrally-sponsored Housing Programmes/ Schemes/ Initiatives**			
	Programmes	**Jawaharlal Nehru National Urban Renewal Mission (JNNURM)**	**Rajiv Awas Yojana (RAY)**	**Pradhan Mantri Awas Yojana**
3.1	Target	491	302	-
3.2	Delivery target (no. of units)	3915	3130	2757
3.3	Achievement till date (no. of units)	2143	346	-
3.4	Challenges	Stability of soil: Due to hilly terrain there is a problem of soil stability to hold the foundation of the structure. As Uttarakhand is an earthquake prone area, solid structures and innovative technologies are required.		

4	**State sponsored housing programs/ schemes/ initiatives**
	No data on state sponsored housing programmes could be obtained

5	**Regulatory Framework**
	Uttarakhand Building Bye-laws and Regulations (Amendment, 2016) Town & Country Planning Department

References

Akadiri, O. P. (2011). Development of a multi-criteria approach for the selection of sustainable materials for building projects, Phd Thesis. Wolverhampton.

Anangpur Building Centre. (n.d.). *Jaunapur Slum Resettlement.* Retrieved from http://www.anangpur.org/

APEC. (2015). *Compendium of Energy Efficiency Policies of APEC Economies 2015.* Retrieved December 19, 2016, from Asia-Pacific Economic Cooperation: http://aperc.ieej.or.jp/file/2016/4/28/Singapore_Compendium_2015_-_Final.pdf

Banani, R. A. (2011). A sustainable assessment method for non-residential buildings in Saudi Arabia: Development of Criteria. Reading, UK.

BCA. (2007). *Sustainable Construction Materials for Buidlings.* Retrieved November 19, 2016, from Building and Construction Authority: https://www.bca.gov.sg/SustainableConstruction/others/sc_materials_book.pdf

BCA. (2008). *Annual Report 2007/2008.* Retrieved November 14, 2016, from Building and Construction Authority: https://www.bca.gov.sg/aboutus/others/ar08.pdf

BCA. (2014). *Investment Allowance Scheme for the Construction Industry*. Retrieved January 4, 2017, from https://www.bca.gov.sg/AssistanceSchemes/assistance_schemes_ias.html

BCA. (2015, November 17). *HDB Flat*. Retrieved December 19, 2016, from Housing & Development Board: http://www.hdb.gov.sg/cs/infoweb/residential/buying-a-flat/new/hdb-flat

BCA. (2016a). *BCA Green Mark for Residential Buildings for Pilot.* Retrieved November 14, 2016, from Green Mark: https://www.bca.gov.sg/GreenMark/others/GM_RB_2016_guide_pilot.pdf

BCA. (2016b, January). *Existing Building Certification Standard.* Retrieved 11 November, 2016, from Green Mark: https://www.bca.gov.sgg/GreenMark/others/GM_Existing_Building_Certification_Standard.pdf

BCA. (2016c). *Green Mark Score Calculator*. Retrieved November 15, 2016, from https://www.bca.gov.sg/GreenMarkScoreCalculator/FormLayer_v4_1/EP_RB_v4_1.aspx#

BCA. (2016e, June 29). *Sustainable Construction Masterplan*. Retrieved November 18, 2016, from https://www.bca.gov.sg/SustainableConstruction/sustainable_construction.html

BCA. (n.d.). *Singapore: Leading the Way for Green Buildings.* Retrieved November 15, 2016, from Green Mark: https://www.bca.gov.sg/greenmark/others/sg_green_buildings_tropics.pdf

Bow Tan, M. (2010, October 1). Housing Supply: Allocating Scarce Resources. *Reflections on Housing a Nation*, p. pB7.

BRE Global Ltd. . (2016, March 12). BREEAM International New Construction 2016 Technical Manual (SD233 1.0). Retrieved from www.breeam.com

Building and Social Housing Foundation. (2016). *Jaunapur Slum Resettlement Scheme.* Retrieved from https://www.bshf.org/world-habitat-awards/winners-and-finalists/jaunapur-slum-resettlement-scheme/

Building and Social Housing Foundation. (2016b). *Resilient Social Housing.* Retrieved from https://www.bshf.org/world-habitat-awards/winners-and-finalists/resilient-social-housing/

Carmody, J., & Trusty, W. (2002). Life Cycle Assessment Tools. *InformeDesign- Implications Volume 05 Issue 03*. University of Minnesota.

Census of India. (2011). *Urban Population.*

Central Provident Fund Board. (2016). Retrieved December 15, 2016, from https://www.cpf.gov.sg/Members/AboutUs/about-us-info/history-of-cpf

Central Public Works Department. (March, 2014). *CPWD Guidelines for Sustainable Habitat.* New Delhi.

Centre for Science and Environment. (n.d.). *Green-Building Rating: Overrated*. Retrieved December 16, 2016, from http://www.cseindia.org/userfiles/04%20Green%20Building.pdf

Chani, P. (2003). Comparative analysis of embodied energy rates for walling elements in India. *Journal of Architectural Engineering, 84*, 47-50.

Christ, K. (2016). Slums and informal housing in India: a critical look at official statistics with regard to water and sanitation. *Water International, 41*(2), 308-324.

Chu, C., & Chan, P. (2005). HK-BEAM (Hong Kong Building Environmental Assessment Method): Assessing Healthy Buildings.

CIA. (2016, November 10). *The World Factbook*. Retrieved November 26, 2016, from https://www.cia.gov/library/publications/the-world-factbook/geos/sn.html

City Mayors Foundation. (2007). *The largest cities in the world by*. Retrieved November 14, 2016, from http://www.citymayors.com/statistics/largest-cities-density-125.html

Cole, R. J., Howard, N., Ikaga, T., & Nibel, S. (2005). Building Environmental Assessment Tools: Current and Future Roles.

Community First! (n.d.). Retrieved April 1, 2014, from Community First!: http://mlf.org/community-first/

Construction Excellence in NI. (n.d.). *Lisnahull Terrace, Dungannon: Ireland's first certified social passive housing scheme.* Retrieved April 1, 2014, from http://ab4.beri.ulster.ac.uk/ceni/e107_files/public/case_study_-_lisnahull_terrace.pdf

Dakwale, V., Ralegaonkar, R., & Mandavgane, S. (2011). Improving environmental performance of building through increased energy efficiency: A review. *Sustainable Cities and Society, 1*, 211-218.

Deepak Parekh Committee. (2008). *Report of the High Level Task Force on Affordable Housing for All.*

Deloitte. (2013). *State of the Low-Income Housing Market: Encouraging Progress & Opportunity to Realize Dreams of Millions.*

Demkin, J. A., & The American Institute of Architects. (1988). Environmental Resource Guide. Washington, D.C.: John Wiley & Sons, Inc.

Ding, G. K. (2004). Sustainable Construction – The Role of Environmental Assessment Tools.

Dubbudu, R. (2016). Retrieved December 12, 2016, from Factly: https://factly.in/96-houses-constructed-urban-poor-vacant-delhi/

Eleventh Five Year Plan 2007-12. (n.d.).

Erlandsson, M., & Borg, M. (2003, February 18). Generic LCA-methodology applicable for buildings, constructions and operation services—today practice and development needs. *Building and Environment*. Sweden: Elsevier.

Europian Union. (2013). *Social Housing in the European Union by Directorate General For Internal Policies Policy Department A: Economic And Scientific Policy.*

EVALOC UK. (2016). *Core Research Questions*. Retrieved December 15, 2016, from Evaluating Low Carbon Communities (EVALOC): http://www.evaloc.org.uk/core-research-questions

Forsberg, A., & Malmborg, F. v. (2003, September 6). Tools for environmental assessment of the built environment. Sweden: Elsevier.

Gallagher. (n.d.). *Building Performance Evaluation programme. Technology Strategy Board.* Retrieved April 1, 2014, from http://www.nuigalway.ie/iruse/downloads/amandagallagher.pdf

GBCSA . (2012). *Improving lives by greening low-cost housing: Case study report of the Cato Manor Green Street retrofit.* Retrieved May 13, 2014, from Green Street retrofit. [Online]. Available at: http://www.gnshousing.org/

Giama, E., & Papadopoulos, A. M. (October 2012). Sustainable building management: overview of certification schemes and standards. *Advances in Building Energy Research, Vol. 6, No. 2*, 242–258.

Government of India. (n.d.). *Planning Commission, Planning Commission, Yojana Bhavan*. Retrieved from Five Year Plans: http://planningcommission.gov.in/plans/planrel/fiveyr/index1.html

Government of India, Ministry of Housing and Urban Poverty Alleviation. (2012). *Report of the Technical Group (TG-12) on Urban Housing Shortage.*

Government of India, Ministry of Rural Development. (2011). *Working Group on Rural Housing for XII Five Year Plan.* Delhi.

Grant Thornton. (2011). *Appraisal of Jawaharlal Nehru National Urban Renewal Mission (JnNURM), Final Report – Volume I.*

GRIHA Council. (n.d.). *Green Rating for Integrated Habitat Assessment*. Retrieved 2016, from http://grihaindia.org/

H & P Architects. (2013). *Blooming Bamboo Homes.* Retrieved from http://www.hpa.vn/blooming-bamboo-home_pr103.aspx

Hastings, R., & Wall, M. (2007). In J. J. Klemeš, *Assessing and Measuring Environmental Impact and Sustainability.* Butterworth-Heinemann, Elsevier.

HDB. (2015a, October 26). *Public Housing - A Singapore Icon*. Retrieved November 12, 2016, from http://www.hdb.gov.sg/cs/infoweb/about-us/our-role/public-housing--a-singapore-icon

HDB. (2016b, April 15). *HDB Greenprint*. Retrieved November 14, 2016, from http://www.hdb.gov.sg/cs/infoweb/about-us/our-role/smart-and-sustainable-living/hdb-greenprint

HDB. (2016c, October 13). *HDB Greenprint Fund*. Retrieved November 14, 2016, from http://www.hdb.gov.sg/cs/infoweb/about-us/our-role/smart-and-sustainable-living/hdb-greenprint/funding

HDB. (2016d). *Treelodge@Punggol*. Retrieved November 14, 2016, from http://www10.hdb.gov.sg/ebook/treelodge/punggol.html

Hingorani, P. (2011). Revisiting Low Income Housing: A Review of Policies and Perspectives. Mysore: Indian Institute for Human Settlements.

HK-BEAM Society. (2004). HK-BEAM—an environment assessment for air conditioned office premises. *Version 4/04: new buildings and version 5/04: existing buildings, Building Environment Council, Hong Kong*. Hong Kong.

Howard, N., Edwards, S., & Anderson, J. (1999). BRE. *The BRE Methodology For Environmental Profiles Of Construction Materials, Components And Buildings*.

Humbert, S., Abeck, H., Bali, N., & Horvath, A. (2007). Leadership in Energy and Environmental Design (LEED) - A critical evaluation by LCA and recommendations for improvement. *International Journal of Life Cycle Assessment, 12(Special Issue 1)*.

Humbert, S., Abeck, H., Ball, N., & Horvath, A. (n.d.). Leadership in Energy and Environmental Design (LEED) - A critical evaluation by LCA and recommendations for improvement. *International Journal of Life Cycle Assessment 12 (1)*, 46-57.

India Brand Equity Foundation. (2016). *Office space absorption up 46% in June quarter*. Retrieved December 19, 2016, from http://www.ibef.org/news/office-space-absorption-up-46-in-june-quarter

International Institute for Energy Conservation (IIEC) & the United States Agency for International Development (USAID. (2007). Energy Conservation Building Code (ECBC).

International Network for Bamboo and Rattan. (2016). *Design Guide for Engineered Bahareque Housing.* Beijing: INBAR.

Jawali, R., & Fernández-Solís, J. (June 25-28,2008). A building sustainability rating index (BSRI) for building construction. *8th International Post Graduate Research Conference, Prague, The Czech Republic,*.

Kibert, C. J. (2013). *Sustainable Construction: Green Building Design and Delivery.* New Jersey, Canada: John Wiley & Sons.

Kshirsagar, B., Mane, V., Saharkar, U., & Salunke, H. (2015). Comparative Analysis of Green Building Rating Systems. *International Journal of Engineering Technology, Management and Applied Sciences, Volume 3 Issue 2*.

Larsson, N. (1998). Green Building challenge '98: International Strategic Considerations. In *Building Research and Information* (pp. 118–121).

Lee Kwan Yuu School of Public Policy. (2014). *Public Housing in Singapore: Examining Fundamental Shifts*. Retrieved from National University of Singapore: https://lkyspp.nus.edu.sg/wp-content/uploads/2014/11/Public-Housing-in-Singapore.pdf

Lee, J., Yik, F. W., & Burnett, J. (2008). Benchmarking energy use assessment of HK-BEAM, BREEAM and LEED. *Building and Environment 43*, 1882–1891.

Lee, W. L., Yik, F. W., & Burnett, J. (2006, August 8). Assessing energy performance in the latest versions of Hong Kong Building Environmental Assessment Method (HK-BEAM). *Energy and Buildings*. Hong Kong: Elsevier.

Lee, W., Chau, C., Yik, F., Burnett, J., & Tse, M. (2002). On the study of the credit-weighting scale in a building environmental assessment scheme. *Building and Environment 37*, 1385 – 1396.

Leu, C. (2012). A critical analysis on the effectiveness of energy performance assessment for green building labelling scheme in Hong Kong. City University of Hong Kong.

Lippat, B. C., & Boyles, A. S. (2001, April). BUILDING FOR ENVIRONMENTAL AND ECONOMIC SUSTAINABILITY (BEES): SOFTWARE FOR SELECTING COST-EFFECTIVE GREEN BUILDING PRODUCTS. *CIB World Building Congres*. Wellington, New Zealand.

Lippiatt, B. C., & Ahmad, S. (2005, May 1). Measuring the Life-Cycle Environmental and Economic Performance of Concrete: The BEES Approach. *International Workshop on Sustainable Development and Concrete Technology*. USA.

Lundahl, E. (2014). *Tiny Houses for the Homeless: An Affordable Solution Catches On. Yes Magazine.* Retrieved April 1, 2014, from http://www.yesmagazine.org/new-economy/tiny-house-villages-for-the-homeless-an-affordable-solution-catches-on

mHS City Lab. (2016). *Access to the Budgeting and Planning Tool.* Retrieved July 22, 2016, from http://www.mhscitylab.org/estimate-access/

MHUPA. (2015). Housing for All (Urban): Technology Sub-mission. http://mhupa.gov.in/writereaddata/11_techsubmission.pdf.

Ministry of Housing and Urban Poverty Alleviation, Government of India. (2012). *Annual Report 2011-12.* Ministry of Housing & Urban Poverty Alleviation, Government of India.

Ministry of Housing and Urban Poverty Alleviation, Government of India. (2012). *Report of The Technical Group On Urban Housing Shortage (TG-12).*

Ministry of Housing and Urban Poverty Alleviation, Government of India. (2013). GOI.

Ministry of Housing and Urban Poverty Alleviation, Government of India. (2015). Retrieved from http://pib.nic.in/newsite/PrintRelease.aspx?relid=132398

Ministry of Housing and Urban Poverty Alleviation, Government of India. (2016a). *Schemes and Missions*. Retrieved from Ministry of Housing and Urban Poverty Alleviation, Schemes and Missions: http://mhupa.gov.in/User_Panel/UserView.aspx?TypeID=1267

Ministry of Housing and Urban Poverty Alleviation, Government of India. (2016b). *Vacant Houses - Lok Sabha Starred Question No. 256*. Retrieved December 15, 2016, from http://164.100.47.190/loksabhaquestions/annex/8/AS256.pdf

Ministry of Housing and Urban Poverty Alleviation, Government of india. (n.d.). *Schemes and Missions*. Retrieved from Ministry of Housing and Urban Poverty Alleviation, Schemes and Missions: http://mhupa.gov.in/User_Panel/UserView.aspx?TypeID=1267

Ministry of New and Renewable Energy, Government of India. (2009, February 5). Revised Scheme on “Energy Efficient Solar/ Green Buildings”. *Issued vide sanction No. 3 / 5 / 2008-UICA (SE) dated*.

Ministry of Urban Development, Government of India. (n.d.). *Policies*. Retrieved from Ministry of Urban Development, Policies: http://moud.gov.in/policies

Mok, K. (2013). *Affordable bamboo housing floats when it floods.* Retrieved from http://www.treehugger.com/green-architecture/affordable-disaster-resistant-bamboo-housing-floats-in-flood-hp-architects.html

NCAER. (2014). *Impact of Investments in the Housing Sector on GDP and Employment in the Indian Economy.* National Council of Applied Economic Research.

Occupy Madison Inc. (n.d.). *Occupy Madison, Inc. – Ending homelessness one tiny house at a time!* Retrieved April 1, 2014, from http://occupymadisoninc.com/

Opportunity Village Eugene. (2014). *Opportunity Village Eugene. Facebook.* Retrieved April 1, 2014, from https://www.facebook.com/OpportunityVillageEugene

Oxford Brookes University. (2016). *Management of Housing Performance Information (HAPI)*. Retrieved December 16, 2016, from http://lcbgroup.wixsite.com/hapi

Panditi, A. (2010, January 22). Vacant buildings spruced up. *Times of India*.

Phang, S.-Y., & Helble, M. (2016, March). *Housing Policies in Singapore.* Retrieved from Asian Development Bank Institute: https://www.adb.org/sites/default/files/publication/181599/adbi-wp559.pdf

Planning Commission. (2013). *Twelfth Five Year Plan- Economic Sectors Volume 2.* New Delhi: SAGE Publications India Pvt Ltd.

Prime Minister's Office, Government of India. (2016, March 23). *Implementation of the rural housing scheme of Pradhan Mantri Awaas Yojana — Gramin to achieve Housing for All by 2022.* Retrieved February 23, 2017, from http://www.pmindia.gov.in/en/news_updates/implementation-of-the-rural-housing-scheme-of-pradhan-mantri-awaas-yojana-gramin-to-achieve-housing-for-all-by-2022/

Professional Green Building Council. (2008). *A Report on the State of Sustainable Building in Hong Kong.* Hong Kong.

Rao, P. (2004). *Transformation of Housing Policy in India - the Trend Towards Market Mechanism.* Retrieved 12 14, 2016, from Hong Kong Housing Authority: https://www.housingauthority.gov.hk/hdw/ihc/pdf/rhk.pdf

Reddy, B. V. (2009). Sustainable materials for low carbon buildings. *International Journal of Low-Carbon Technologies, 4*, 175-181.

Reddy, B., & Jagadish, K. (2003). Embodied energy of common and alternative building materials and technologies. *Journal of Energy and Buildings, 42*, 129-137.

RICS, LEVVEL, CBRE. (n.d.). *Making Urban Housing Work in India.* Ministry of Housing and Urban Poverty Alleviation, GOI.

Royal Institution of Chartered Surveyors. (2010). *Making affordable housing work in India.*

Sande, I. I., & Phadtare, N. S. (November 2014-October 2015). Comparative Study of LEED and GRIHA rating system. *Journal of Information, Knowledge and Research in Civil Engineering, Volume 3, Issue 2*.

Singh, S. (2013). *Housing market in India: A Comparison with the US and Spain.* Bangalore: Indian Institute of Management.

Surbana Jurong Private Limited. (2016). *Surbana.* Retrieved December 19, 2016, from Treelodge: www.worldarchitecturefestival.com

Sustainable Traditional Buildings Alliance. (2016). *Sustainable Retrofit Guidance Wheel*. Retrieved December 15, 2016, from http://www.responsible-retrofit.org/wheel/

The Census of India. (2011). *Provisional Population Totals, Size Growth rate and distribution of population.*

The Economic Times. (2016, March 13). Retrieved 11 27, 2016, from http://economictimes.indiatimes.com/news/economy/policy/15-year-development-agenda-to-replace-five-year-plans-to-include-internal-security-defence/articleshow/52247186.cms

Times of India. (2016, March 9). Retrieved December 15, 2016, from http://timesofindia.indiatimes.com/city/delhi/Govt-frames-rules-to-manage-construction-demolition-waste/articleshow/51599447.cms

Tiwari, P., & Rao, J. (2016, April). Housing Markets and Housing Policies in India. *ADBI Working Paper Series*.

Tiwari, P., & Rao, J. (2016, April). Housing Markets and Housing Policies in Inia. *ADBI Working Paper Series*.

Tom. (2011, March 30). *Your Community Forum.* Retrieved December 19, 2016, from Punggol.Sg: http://www.punggol.sg/forum/community_issues/treelodgepunggol-t31811.36.html

Trusty, W. B., Meil, J. K., & Norris, G. A. (1988). ATHENA: A LCA Decision Support Tool for the Building Community. Canada.

UNEP. (2014, March). *Sand, rarer than one thinks.* Retrieved November 15, 2016, from GEAS: http://www.unep.org/pdf/UNEP_GEAS_March_2014.pdf

UN-Habitat. (2012). *Going Green: A handbook of sustainable housing practices.* Nairobi: United Nations Human Settlements Programme (UN-Habitat).

UN-Habitat. (2016). *World Cities Report 2016.* Nairobi: UN-Habitat.

United Nations. (2006). *Guidelines on Social Housing .* Geneva: Economic Commission for Europe.

United Nations. (2016). *The Sustainable Development Goals Report 2016.* Department of Social and Economic Affairs of the United Nations Secretariat, New York.

University of Melbourne. (2007). *File:World Koppen Classification (with authors).svg.* Retrieved November 11, 2016, from Wikimedia Commons.

Urban Land Institute. (n.d.). *Via Verde*. Retrieved from http://casestudies.uli.org/via-verde/

Urban News Digest. (n.d.). *NBC releases new chapter on sustainability.* Retrieved 02 23, 2017, from http://www.urbannewsdigest.in/?p=15984

USAID ECO-III Project. (2011, September). Econirman Whole Building performance User manual.

Viitaniemi, P., & Haapio, A. (2008). A critical review of building environmental assessment tools. *Environmental Impact Assessment Review 28*, 469–482.

Vilčeková, S., & Krídlová Burdová, E. (2012). Building Environmental Assessment of Construction and Building Materials. *Journal of Frontiers in Construction Engineering Dec. 2012, Vol. 1 Iss. 1*, PP. 1-7.

World Bank. (2016). *Age dependency ratio, old (% of working-age population)*. Retrieved 12 15, 2016, from http://data.worldbank.org/indicator/SP.POP.DPND.OL

World Bank Group. (2016). *(Intended) Nationally Determined Contribution - India.* Retrieved November 27, 2016, from World Bank NDC Platform: http://spappssecext.worldbank.org/sites/indc/PDF_Library/IN.pdf

World Bank Group. (2017). *GNI per capita, PPP (current international $)*. Retrieved January 4, 2017, from World Bank Data: http://data.worldbank.org/indicator/NY.GNP.PCAP.PP.CD

World Habitat Awards. (2003). *Improved Traditional Housing Systems.* Retrieved May 14, 2014, from http://www.worldhabitatawards.org/winners-and-finalists/project-details.cfm?lang=00&theProjectID=125

World Habitat Awards. (2004). *Building Restoration for Social Housing Purposes – Celso Garcia, 787.* Retrieved April 1, 2014, from http://www.worldhabitatawards.org/winners-and-finalists/project-details.cfm?lang=00&theProjectID=154

World Habitat Awards. (2006). *The New Generation of Yaodong Cave Dwellings.* Retrieved April 1, 2014, from http://www.worldhabitatawards.org/winners-and-finalists/project-details.cfm?lang=00&theProjectID=314

World Habitat Awards. (2009). *Technical Team Planning for Self-Help Housing in the Kambi Moto Community.* Retrieved April 1, 2014, from http://www.worldhabitatawards.org/winners-and-finalists/project-details.cfm?lang=00&theProjectID=18A60F52-15C5-F4C0-99C4EF674461D6A1

World Habitat Awards. (2010). *Low Energy and Passive Housing in Ljubljana.* Retrieved April 1, 2014, from http://www.worldhabitatawards.org/winners-and-finalists/project-details.cfm?lang=00&theProjectID=8F149F97-15C5-F4C0-9938D774165977B0

World Habitat Awards. (2011). *Sustainable Village – Post-earthquake Reconstruction and Rehabilitation in Da Ping Village.* Retrieved April 1, 2014, from http://www.worldhabitatawards.org/winners-and-finalists/project-details.cfm?lang=00&theProjectID=D7AB9365-15C5-F4C0-99C3FFDB19A5E678

World Habitat Awards. (2011a). *Dissemination of Passive Solar Housing in the Cold Desert of the Indian Himalayas.* Retrieved April 1, 2014, from http://www.worldhabitatawards.org/winners-and-finalists/project-details.cfm?lang=00&theProjectID=D8045D7F-15C5-F4C0-998DD42602A7C533

World Habitat Awards. (2012). Retrieved May 1, 2014, from World Habitat Awards: http://www.worldhabitatawards.org/

World Habitat Awards. (n.d.). *Green Mortgage.* Retrieved April 1, 2014, from http://www.worldhabitatawards.org/winners-and-finalists/project-details.cfm?lang=00&theProjectID=9DA03455-15C5-F4C0-99170E7D631F50E9

Yin, L. C. (2012). A critical analysis on the Effectiveness of energy performance assessment for Green building labelling scheme in Hong Kong, PhD thesis. Hong Kong.

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