IOP Conference Series: Earth and Environmental Science

PAPER • OPEN ACCESS

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To cite this article: A. Ganga Warrier *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **294** 012092

IOP Conf. Series: Earth and Environmental Science **294** (2019) 012092 doi:10.1088/1755-1315/294/1/012092

Low-Cost Housing in India: A Review

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Abstract. The Government of India is on a mission to meet the housing needs of all in the society by 2022. This implies that about 27 million houses are expected to be constructed in the next 5 to 10 years. As of today, 5.1 million houses have been sanctioned under the Pradhan Mantri Awas Yojana. Houses for Economically Weaker Section (EWS) group and Low Income Group (LIG) represent a major portion of this initiative. Construction of millions of houses is expected to generate large demand for materials and energy at the national level. There is a need to evaluate alternate materials, construction methods and construction plans to conserve materials and energy use at the aggregate level. This study presents a review of various housing initiatives undertaken in India, housing technologies and evaluation criteria that are used to choose an appropriate technology. Further, a discussion on sustainability aspects of low cost house construction is presented.

1. Introduction

Housing sector caters to the basic needs of the society and provides shelter. Real estate sector is a major part of the Indian economy and contributed to about 6.3% of GDP during 2013-14 (CREDAI, 2013). The Government of India has launched many schemes to bridge the gap of demand and supply of housing in the Low Income Group (LIG) and Economically Weaker Section (EWS) group. The recent initiative is the Pradhan Mantri Awas Yojana (PMAY) by the Ministry of Housing and Urban Affairs. It was launched in June 2015 with the vision of meeting the demand of nearly 20 million house units by 2022. This project aims at building affordable houses with water facility, sanitation and electricity supply.

Housing is said to be affordable to people with median household income as rated by the Government by a recognized housing affordability index (Bhatta, 2010). That is, generally, affordability is measured as some comparison of income of the house and expenditure on housing. The definition accepted by the Government of India is “Affordable housing refers to any housing that meets some form of affordability criterion, which could be income level of the family, size of the dwelling unit or affordability in terms of EMI size or ratio of house price to annual income” (High level task force on Affordable Housing for All, 2008).

Affordability can also be defined in terms of rental affordability, purchase affordability, repayment affordability measure, housing + transportation or location affordability, affordable livability, total cost of housing affordability (Gopalan & Venkataraman, 2015).

Construction of houses consume significant amount of materials and resources such as electricity, fuel, water, sand, cement, steel, wood, bricks, plastics, aluminum and glass. Construction of a house is like any other construction and happens in stages like project initiation, planning, execution, monitoring and control and handing over. As far as energy consumption is concerned, there are many more stages in the service life of a building that are to be considered.

Energy consumption can be reduced majorly during the planning phase. Effective planning can make a building more sustainable and environment-friendly. To determine the energy expenditure, stages to be studied in detail are design, material selection, transport of material procurement, type of construction/installation/assembly, energy use during use, maintenance and repair, and finally demolition and transport of debris to landfill. Studies are being conducted around the world to reduce energy consumption in the construction sector. But, many a times, it is region specific. Resources that are found abundantly in the local areas are to be utilized to reduce the transportation cost. The Government also undertakes initiatives to promote the use of environmentally sustainable materials.

This study summarizes the initiatives undertaken by the Government of India for low cost housing construction. Various technologies used for low cost housing in India are discussed. Further, the criteria used for evaluating a low cost housing technology is presented. A comparison of sustainability aspect of low cost house construction is discussed using a case study of EWS type house constructed using cast-in situ concreting work.

2. Housing initiatives in India

Table 1 presents a classification of housing projects based on guidelines provided by the Ministry of Housing and Urban Poverty Alleviation (MoHUPA, 2011).

Table 1: Classification of housing

Type	Size (sq.m.)	Income (INR 1,00,000)
Economically weaker section (EWS)	9-30	<= 3
Low income group (LIG)	<= 60	3-6
Mid income group-I (MIG –I)	<= 120	6-12
Mid income group -II (MIG –II)	<= 150	12-18

Affordability is defined based on a given context. To ascertain the affordable living, many countries came up with various programs and schemes. One such scheme is “Program Minha casa Minha Vida” of Brazil which was instituted in 2009 (Paulsen and Sposto, 2013). This scheme focused on developing over 7 million households (out of which 3.4 million are new) by providing financial assistance. Similarly, “Reconstruction and Development Program (RDP) houses” of South Africa is also an example of large-scale housing projects in the world. Various schemes started by the Government of India are presented in Table 2.

The initial steps by the Government of India were around late 1980’s (seventh five-year plan). By this time, the scarcity of housing in the country has increased exponentially since independence. Hence, the Government of India founded the Ministry of Housing and Urban Poverty Alleviation in 2004, to cater to the needs of housing as well as schemes for improving the quality of urban living. Since the inception, this ministry is working on variety of schemes and programmes related to housing, employment, transportation, health and cleanliness. This ministry has launched various programs such as the Rajiv Awas Yojana. Also, the program - Pradhan Mantri Awas Yojana (PMAY): Housing for All was launched. The ministry consists of Central Public Health and Environmental Engineering Organization (CPHEEO), Public Sector Undertakings, subordinate offices, attached offices and various statutory, autonomous organizations. The PMAY: Housing for All policy was drafted by the CPHEEO and was funded by the Housing and Urban Development Corporation Ltd. (HUDCO), supported by attached and subordinate bodies like Central Public Works Department (CPWD) and Town & Country Planning Organization. Other autonomous supporting organizations are Building Materials & Technology Promotion Council (BMTPC), Delhi Development Authority (DDA) and Central Government Employees Welfare Housing Organization (CGWHO).

Table 2. Housing schemes initiated by the Government of India

Scheme	**Started in**	**Target Users**	**Other details**
Indira Awas Yojana (IAY)	1996	EWS	Used locally available materials
EWS Housing scheme	1991 revised in 2007	EWS	INR 1,00,000 / house (160 sq.ft.)
National slum development programme	1996 (revised in 2004) till 2012	EWS	Annual funding of INR 300 crores. Started for 42.6 million slum dwellers
The National Housing and Habitat Policy (1998)	1998 - 2000	EWS and LIG	Planned for 2 million housing (0.7 million for urban and 1.3 million for rural areas). 1.64 million units completed.
Rajiv Awas Yojna	2009 - 2014	EWS and LIG	21 to 40 sq.m.
Valmiki Ambedkar Awas Yojana (VAMBAY)	2001	Urban slum dwellers below poverty line	Funded by Central and State Governments at 50:50 partnership
Jawaharlal Nehru National Urban Renewal Mission (Basic Services to Urban Poor and Integrated Housing and Slum Development Programme) (JNNURM – BSUP & IHSDP)	2005	Cities with minimum population of 5000	Flagship program for overall development of urban areas in India
Pradhan Mantri Awas Yojana – Gramin: Housing For All	2015	35% of project is for EWS in urban and rural areas and rest for LIG and MIG.	Construction plan for 20 million housing units in 404 towns and 500 cities.

3. Review of low cost housing technologies

There are various low cost construction technologies developed and applied around the world. Few technologies that are relevant in the Indian context are studied. Some technologies are well developed and are widely used as shown in Figure 1. Other technologies shown in Figure 2, are at the initial stages and feasibility studies are being done.

Apart from technology innovation, many new materials are experimented. Usage of filler slab by replacing conventional slab could cut the cost of construction by 25% (Srivastava and Kumar, 2018). Further, it is expected that building up of cooperatives to supply alternate raw materials can reduce the cost by 20-30%. Bricks made from cotton mill waste, recycled paper mill waste and rice husk ash have an extra edge on sustainability angle than burnt clay bricks or fly ash bricks when life cycle analysis was done (Joglekar et al, 2018). Sometimes, clay bricks are more sustainable than other options. For example, timber is the conventional construction material and it becomes scare due to deforestation and erosion in Ethiopia. Hence, sun-dried clay bricks or adobe technology using locally available materials becomes a sustainable option (Hjort and Widen, 2015). Use of bamboo reinforced prefabricated wall panels are 56% lighter in weight, 40% cheaper and have good strength in comparison to partition brick walls making it suitable for low-cost construction (Puri et al, 2017).

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One of the major challenges for any sustainable low-cost housing scheme is to identify land near work place of the residents. Travelling long distances to work place increases carbon footprint (Goebel, 2007). Larasati et al. (2017) came up with a method to reduce embodied energy of materials used in construction in Indonesia. Negative correlation was observed between the building area and the embodied energy. This study suggests that socialization of embodied energy values to stakeholders can have a huge impact on reducing the embodied energy.

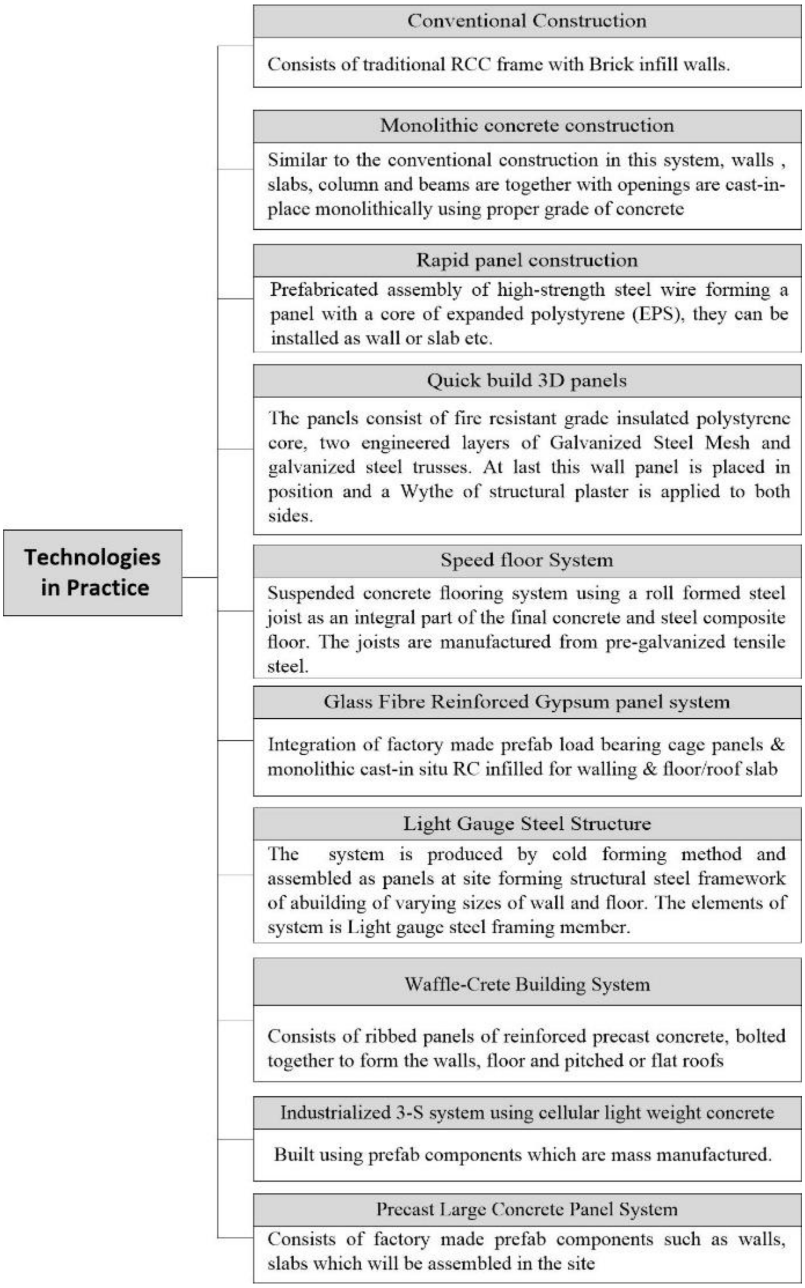

Figure 1. Low-cost housing technologies used in practice (adapted from BMTPC, 2015)

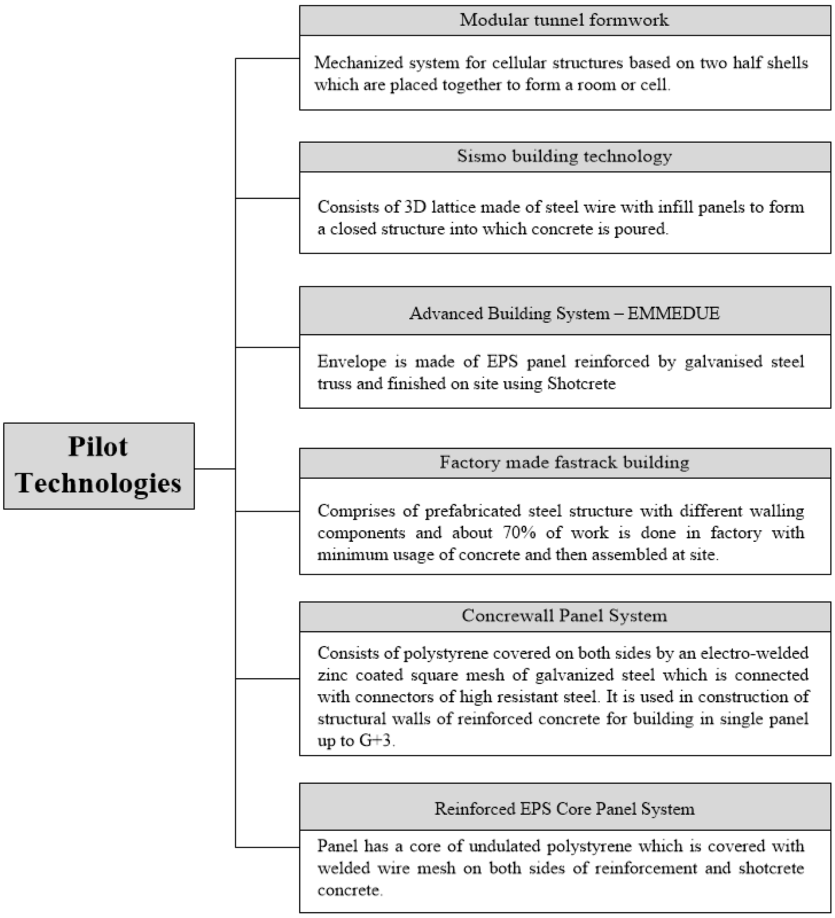

Figure 2: Pilot technologies for Low-cost Housing (adapted from BMTPC, 2015)

4. Criteria for evaluation of low cost housing technologies

The target for the PMAY – 'Housing for All' cannot be achieved by the conventional housing construction technology. Alternative technologies are needed to achieve this ambitious vision. During the past decade, many technologies came into picture and some of them remains quite innovative too. These technologies can ensure the product and the quality, but that doesn't qualify itself to become the best alternate for low cost housing. For example, in the last decade, precast technology was brought into market. But, because of its cost as well as plant establishment implications, it was limited to few large scale projects in India. Low cost housing needs to consider several aspects like economic viability, speed of delivery, maintenance and life time performance. Also, these technologies must be suitable for large scale mass production. Thus, a set of criteria were established for low-cost housing based on literature and studies carried out by the Building Materials and Technology Promotion Council (BMTPC, 2015).

These criteria can be classified as mandatory and preferred attributes as it was established in the literature (BMPTC, 2015). The focus of this paper is to identify sustainable low-cost housing solution for the PMAY scheme. So, other attributes are acquired which are necessary such as embodied energy and integration of smart technologies. Eight broad criteria are identified and are shown in Figure 3 for evaluating a housing construction technology namely cost, time, structural characteristics, envelope characteristics, maintenance and repair, operation, sustainability and user preferences.

5. Discussion on sustainability aspects

Embodied energy and embodied carbon are widely used as sustainability indicators. Since the current focus is on low-cost housing, operational energy is assumed to be lesser in comparison with other types of houses. The selection of a sustainable construction technology is case specific based on location, climate, construction practices, occupant preferences and culture. The embodied energy and embodied carbon vary depending upon the context.

Life cycle analysis (LCA) is conducted to evaluate low cost housing schemes. LCA of a single storey social house with 48 m^2 internal area under the scheme 'my house my life' in Brazil indicates 0.52 GJ/m^2/year for 50 years service life (Paulsen and Sposto, 2013). Earlier studies show that largest reduction in embodied energy can be achieved by replacing materials used for walls. The life cycle energy of a low cost house in India is found to be 0.46 GJ/m^2/year (Devi and Palaniappan, 2018). A study in Indonesia (Utama and Gheewala, 2008) shows life cycle energy as 0.25-0.26 GJ/m^2/year for 40 years of service life. LCA of a single family detached house in Spain shows 385 kg CO_2/m^2 of surface area (Torres et al, 2014).

This study considers a specific case of single storey low cost house in the coastline of Tamil Nadu in India. Figure 4 shows a typical plan of this EWS type house (Devi and Palaniappan, 2018). An attempt is made to compare different techniques such as precast, monolithic, GFRG panel and light gauge steel construction techniques. In the case of precast construction, in addition to the construction materials, concrete mix, plant establishment, transportation and skilled labors for erection requires additional budget. If there is no plant nearby (100-200 km), setting up a new plant is economical only if there is a need of 5000 dwelling units (BMPTC, 2017).

In the case of monolithic construction, it is economically beneficial if the formwork is repeated for 100 times. Large number of clients and contractors are willing adopt monolithic construction in the Indian market recently due to substantial reduction in floor cycle time. GFRG construction is considered economical, because it uses less quantity of primary construction materials. In a case study of demo housing project completed at Chennai, India, GFRG method is found to be 25% cheaper than cast-in-situ construction method (Cherian et al. 2017). In the case of Light Gauge Steel structure, there is potential to save cost since the structure is light weight.

Primary construction materials contribute to more than 90% of the overall embodied energy (Devi and Palaniappan, 2018). In a similar study using precast wall panels, it is noted that about 26.27% of total embodied energy reduction can be achieved compared to cast in-situ (Omar et al. 2014). In case of GFRG panel wall system, the primary material being gypsum, helps to reduce embodied energy as it is a by-product of fertilizer industry. The embodied energy will vary drastically depending upon the transport distance between the prefabrication/precast plant and the construction site.

Table 3 presents a comparison of energy use at various life cycle stages for two types of houses that belongs to Mid-Income Group (MIG) and Economically Weaker Section (EWS) group. Both the cases are based on cast-in-situ concrete construction. When it comes to flexibility and adaptability of the structure, cast-in situ and precast housing are preferred as they are framed structures. Cast-in situ and light gauge steel panels are better for thermal resistance because the thermal transmittance value (U-value) is low (BMTPC, 2015). Light gauge steel construction is not as fire resistant as other technologies (NBC, 2016).

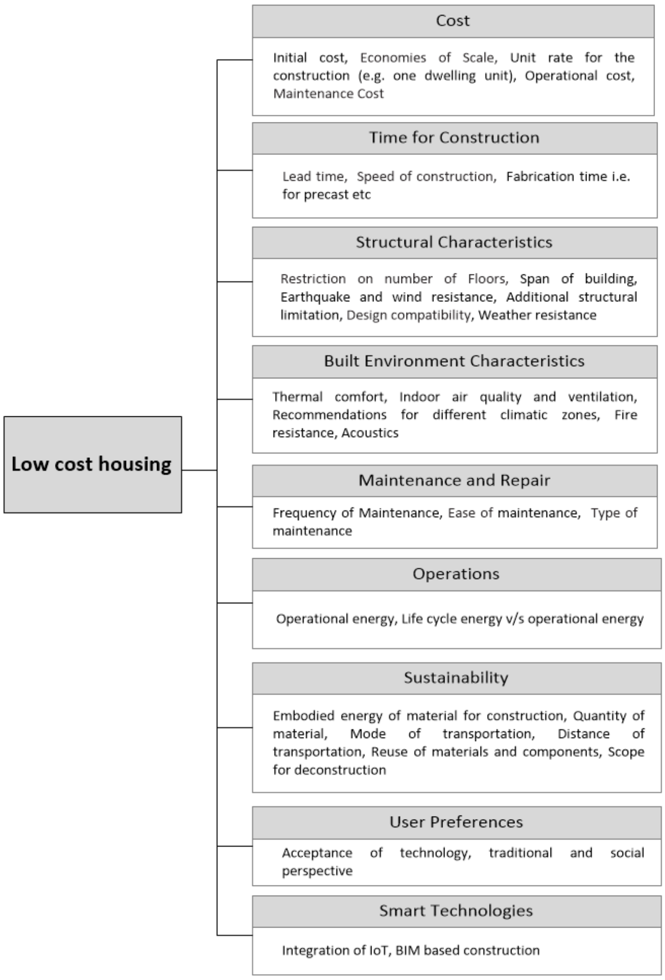

Figure 3. Criteria for evaluation of low-cost housing technologies

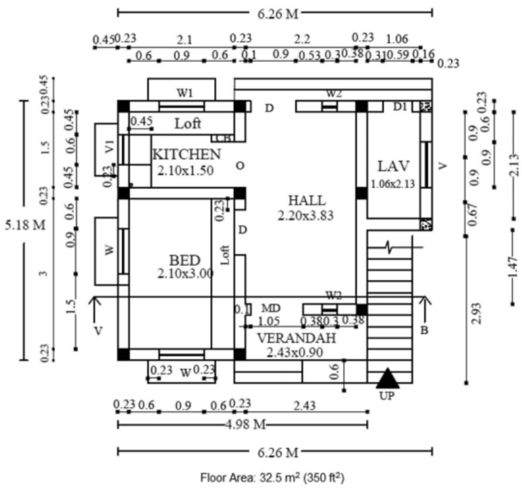

Figure 4. Floor plan of a typical EWS type dwelling unit (Devi and Palaniappan, 2018)

Table 3. Comparison of energy use in MIG and EWS type houses

	Floor area (m^2)	Service life (years)	Embodied of materials used (GJ/m^2)	Energy consumed during construction (GJ/m^2)	Operational energy ($GJ/m^2/year$)	Total life cycle energy ($GJ/m^2/year$)
MIG*	112.15	50-100	8.1-10.8	1.31	0.42	0.66 (50 years)
EWS**	32.5	50	4.9-5.9	0.8	0.33	0.46

* Devi and Palaniappan, 2014; ** Devi and Palaniappan, 2018

6. Conclusion and Way Forward

There are several technologies available for low cost housing. It is challenging to recommend one technology for a country-wide practice. Hence, a region-wise study should be done to choose an appropriate technology depending upon the context, location, climate, local requirements, locally available resources, occupant preferences, cultural issues, time, cost, sustainability and other factors. Trade-off analysis among various criteria shall be performed to choose the right technology and achieve sustainable development goals. At the global level, millions of houses are to be constructed to cater the housing requirement. In the housing initiatives stated, the aspect of technology and sustainability were not covered in detail. For a goal of magnanimous construction scale, these details can make a big difference. Every project should be taken as a different case and appropriate technology should be selected based on the project specific needs, by which the embodied energy can be reduced. For naturally ventilated and partially air-conditioned buildings, embodied energy plays a major role in the total life cycle energy. Also, in case of any housing, it is the thermal comfort aspect, that is directly related to energy, which binds the residents to the house. So, for the success of housing schemes, thermal comfort also play a major role. Methods like passive design might be effective to achieve the thermal comfort and reduction of operational energy in some cases in tropical climate, whereas, in other cases, passive design alone cannot give the necessary comfort to live. Hence, research direction should also point towards cooling and heating technologies that use minimum energy as well as that fits well in the budget. Hence, for the selection of technology, various criteria should be taken into account and in case of conflict, prioritizing the criteria will help in decision making. Sustainability in construction can be achieved only if these criteria are included in the planning stage.

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