The critical review of Affordable Housing, the case of Light House Projects in India

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Abstract: Indian cities are projected to contribute to 70% of the total GDP by 2030. But rapid urbanisation and increase in urban migrants are exerting huge pressure on the environment. Despite the complexities of meeting the housing demand, sustainable affordable housing is a challenge. Indian Government has tried to boost the supply of housing stock from the first 5-year plans (1951) to the recent initiatives of "Housing for all". The six LightHouse Projects (LHPs) initiated under the Global Housing Technology Challenge in India, are a step closer to meeting the demand. As LHPs near completion, the paper attempts to critically analyse the projects by comparative analysis. The analysis is broadly divided into site/masterplan level, block level, and unit level. The study revealed that the LHP is innovative in terms of technological advancement, but lacks consideration in socio-cultural aspects and quality affordable housing which is required for diverse Indian households.

Keywords —Affordable Housing, Comparative Analysis, Light House Projects, Sustainable Development, Urbanisation.

I. INTODUCTION

Today, 4.4 billion people are in cities which accounts for 56% of the world's population. It is expected that the urban population will double by 2050 and 7 out of 10 people will be residing in cities [1]. Housing is a major component in cities which constitute 70% of urban land use, dictates urban growth, and density caters to the needs of diverse urban dwellers by providing employment opportunities and contributes to livability [2].

A. Housing & Affordability in Global Context

Despite different housing environments, various trends, patterns, and disputes exist across cities and countries. Housing affordability is worsened by increasing house prices, low income, and hindrances in supply. In spite of these existing distresses of poor housing conditions and increasing cost of living, affordability concerns have been uplifted by the worldwide crisis [3], [4], [5] characterised by passive supply in housing, scarcity of affordable housing, and the unplanned growth and tenacity of informal settlements in rapidly urbanising low and middle-income countries [6]. Cities across the globe bear significant repercussions due to such situations. On one hand, many major metropolitan areas in developed countries face severe housing challenges in providing the required quantity and thus making it harder to identify productive localities making the cities inefficient [7], [8]. However, the basic conviction of urbanisation in developing countries is that the prosperity by which urbanisation and better income will translate to better housing is not satisfied [9]. This is evident from urbanising regions with comparatively low or middle income, the rate of increase in informal settlements - a clear demonstration of non-affordability - is higher than the rate of the formal housing sector

B. Housing & Affordability in India

The vast history and diverse geographic, social and cultural setting of India have helped in evolving the housing transformation in the nation [10]. Indus Valley civilization is the most extensive one, among the three earliest civilizations in the world dating back to 2nd millennium BC. It is also the earliest known urban culture of the Indian subcontinent [12]. With the deterioration of the Indus Valley civilization and the rise of various empires and kingdoms across the country, the evolution of India's housing began to use stone construction and rock-cut architecture by 1000 BC. The community's ethics and heritage were manifested in the carved walls of the structures. Additionally, during 1000 A.D., India witnessed growth in supremacy by the Mughals, Rajputs, Marathas, and Sikhs. Succeeding the Mughals, various European countries including British, Dutch, Portuguese and the French conquered India and introduced their naive architectural style in the regions they ruled. However, a crucial transformation in

 DOI : 10.35291/2454-9150.2023.0041

India's housing progression is noticeable during British rule on account of an increase in trade and introduction to a new cultural context. Subsequently, as trade surged, infrastructure too developed; establishing significant ports in cities like Mumbai, Madras, and Calcutta leading to the onset of urban development [10], [11].

C. Policy Reforms Post-Independence

1. The Indian government encountered multiple challenges in housing and demand due to migration after Independence, particularly in urban areas. As a poverty mitigating tool, providing housing was considered which led to numerous schemes for diverse groups of the society during early stages [13]
2. In 1988, the initial National Housing Policy was devised and conceived by 1994. The National Housing and Habitat Policy(NHHP) in 1998 came after the 74th Constitutional Amendment Act of 1992.
3. The National Urban Housing and Habitat Policy (NUHHP) focussed 'Affordable housing for all' as the prime essential scope in 2007, focusing on issues hampering sustainable urban growth [13].
4. The Jawaharlal Nehru National Urban Renewal Mission (JNNURM) was established in 2005 with the objective to enforce reform-driven, strategic improvement of the city with the core duty of intensifying urban infrastructure, generating housing stock and facilitating urban poor with essential services, social participation and liability of Urban Local Bodies (ULBs). For the housing sector, the main objective during the missile period (2005–2012) was to build 1.5 million houses in 65 assigned cities [13].
5. In 2011, Rajiv Awas Yojana (RAY) was introduced with 'slum-free India' as the motto to be executed during 2013-2022, especially for urban poor and slum dwellers and is a Centrally Sponsored Scheme (CSS). It incites the crisis of informal settlements, and slums decisively throughout the country [13].
6. In June 2015, with an initiative to manage the limitations of the former programs, Pradhan Mantri Awas Yojana (PMAY) was evolved with an objective to construct 20 million houses for beneficiaries under EWS and LIG categories. It has four models to tackle the housing deficiency (1) Grant for individuals for the erection of their habitat (2) Affordable Housing in Partnership (AHP) (3) In-situ redevelopment of slums (4)Affordable Housing through Credit Linked Subsidy Scheme. Additionally, policy reforms for executing agencies have been recommended [15]
7. In order to execute the aims of NUHHP (2007) of supplying affordable housing for the urban poor, the AHP and the PMAY-Urban (PMAY-U) have been put into place. All programmes are currently covered by the PMAY-U to satisfy the habitat requirement for the urban poor of the nation [16]

The following table (Table 1) discusses various initiatives by the Indian government regarding housing in chronological order of the 5-year plans till date.

Schemes	Initiatives
First Five Year Plan 1951-56	Housing for industrial workers
	Subsidised Housing Scheme EWS and Industrial Workers (1952)
	The Low Income Housing Scheme (1954): 1.3 million houses within a year
	National Building Organization (NBO) to reduce the construction price and to enhance construction method and Housing Boards (Independent statutory bodies to execute) [14]
Second Five Year Plan 1956-61	The Slum Clearance and Improvement programme (1956)
	Industrial Housing Scheme expanded to the housing need of EWS and LIG sector
	National Housing Programme: Construction of 1.9 million houses constructed with rural, 'sweeper's and MIG housing
	Life Insurance Corporation of India : The low-paid State Government employees for rental housing and MIG sectors received Finance assistance for housing
	State Housing Corporations (1957): Projects with CG subsidies were granted debt finance
Third Five Year Plan 1961-66	Research: building techniques, housing statistics for efficient programme planning

 DOI : 10.35291/2454-9150.2023.0041

Fourth- Five Year Plan 1969-74	Special provision: Water supply, sewerage and drainage
	Formation of Housing and Urban Development Corporation (HUDCO) in 1970 to improve the quality of housing for EWS and LIG.
	The Environmental Improvement of Urban Slums (EIUS) was created in 1972
Fifth Five Year Plan 1974-79	Housing Boards directed programmes to build 'housing colonies' particularly for EWS
	Urban Land Ceiling and Regulation Act (ULCRA) in 1976 (ULCRA): Directed to assure optimum allocation of land and avoid land speculation.
Sixth Five Year Plan 1980-85	R&D funding to enhance policies formulation related to urbanisation and development
Seventh Five Year Plan 1985-90	Self-help housing advocacy and support for rural families
	Indira Gandhi Awas Yojana (IAY) 1985
	The Urban Basic Services (UBS) Scheme 1986
	Advancement of techniques that are less expensive and standards with further alterations in regulations in land use, building norms & byelaws, minimal size of the plot and furthermore reduce cost.
	Minimum Needs Programme (MNP): For handling the housing deficiency in rural areas.
	National Housing Bank (NHB), 1987
	NHP in 1988
	The Nehru Rozgar Yojana (NRY) 1989
Eighth Five Year Plan 1992-97	In 1998, NHP was replaced by NHHP: Emphasis regarding financial accommodations, legislative and administrative transformation and the creation of robust PPPs to solve housing issue
	The National Slum Development Programme (NSDP)
Ninth Five Year Plan 1997 – 2002	Agenda mainly for the sector of Below Poverty Line (BPL) regarding Affordable housing
	HUDCO and several other financial groups are to provide Social initiatives and credit support.
	IAY: Give rural BPL free homes
	ULCRA Revision, 1999
Tenth Five Year Plan 2002-2007	NUHHP in 2007: Raise and improve the home availability in EWS/LIG-vulnerable areas
	Increasing housing in rural areas for weaker sections. Facilitate free housing provisions for Scheduled Caste and Scheduled Tribe families who lack land, and move other BPL households to a credit-cumulative subsidy system
	JNNURM in 2005

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	The Urban Basic Services for the Poor (UBSP) 2005
Eleventh Five Year Plan 2007-12	Housing finance payments are anticipated to increase, as well as the total outstanding residential loans from commercial banks to households.
	Housing finance development actions for EWS, LIG, and MIG increase liquidity and are accented by NHB.
	Building Materials and Technology Promotion Council (BMTPC): Economic support for LIG and EWS housing design
	Proposal: Corporate groups providing loans for the LIG and EWS will receive a 5% per annum interest subsidy for 5 years
	IAY: 1.24 crore houses constructed
	RAY in 2009
Twelfth Five Year Plan	Land availability is acknowledged as a significant barrier for affordable housing.
	In 2015 Phase II of RAY was halted and bound with PMAY-HFA (U)
	Improving the access to land for the poor, increasing the quality standard IAY houses, providing rural construction centres, laying focus disaster mitigation, training artisans and masons, collaboration with the activist group and eliminating the APL, BPL distinction are all necessary (PRIs)
	Raised assistance for house construction through IAY to reflect rising cost and raise in Differential Rate of Interest (DRI) loans
Atal Mission for Rejuvenation & Urban Transformation (AMRUT) 2015	Establish infrastructure in cities and supply of fundamental services like provision for water, sewerage and urban transportation
Smart Cities Mission (2015)	Smarter ways to manage complexities, increase efficiencies with expanding urban population and urban areas and improve quality of life.
PMAY 2015	Addresses urban housing shortage (especially EWS/LIG, MIG sector, and slum dwellers) by assuring pucca houses to eligible beneficiaries (failed to achieve within 2022)
Affordable Rental Housing Complex (ARHCs) for Urban Poor and Migrants (2020)	Ensure that urban migrants and urban poor/migrants working in the industrial sector and informal urban economy have access to decent, reasonably priced rental accommodation.
LHPs (2021)	Innovative technologies that suit the climatic zones and geographical condition of the zone

Table 1: Policy reforms post-independence (Compiled by the authors)

In order to better understand the challenges and opportunities of affordable housing(AH), it is important to define the term Affordable Housing (AH). Defining AH is also important in order to critically analyze various AH projects by GOI. Multiple organizations & government bodies have varying definitions of affordability in housing. Some of the definitions by these agencies include:

1. UN-HABITAT

Affordable housing is defined as "housing which is adequate in quality and location and does not cost so much that it prohibits its occupants from meeting other basic living costs or threatens their enjoyment of basic human rights" [17].

2. Urban and Regional Development Plans Formulation and Implementation (URDPFI)

"Affordable housing implies that the cost of the housing should be affordable to the disposable income of LIG, EWS, and the poor" [18]

3. PMAY

Size of Dwelling Unit (DU) for each category:

EWS: Super Built- up area, less than 30 sq.m; LIG: 30- 60 sq.m; MIG: 60- 120 sq.m

The paying back loans should be with the cost within 30-40% of the beneficiary's monthly income [19].

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II. OBJECTIVES

These are the research paper's objectives

- To analyse the LHPs based on various identified parameters
- To identify the strengths, weaknesses, and opportunities of LHP
- To provide suggestions, feedback, and way forward for the existing models

III. METHODOLOGY

Detailed study of the identified LHP which are only six, is done based on available data from central & state government sources. Comparative analysis of all the projects is tabulated based on identified parameters

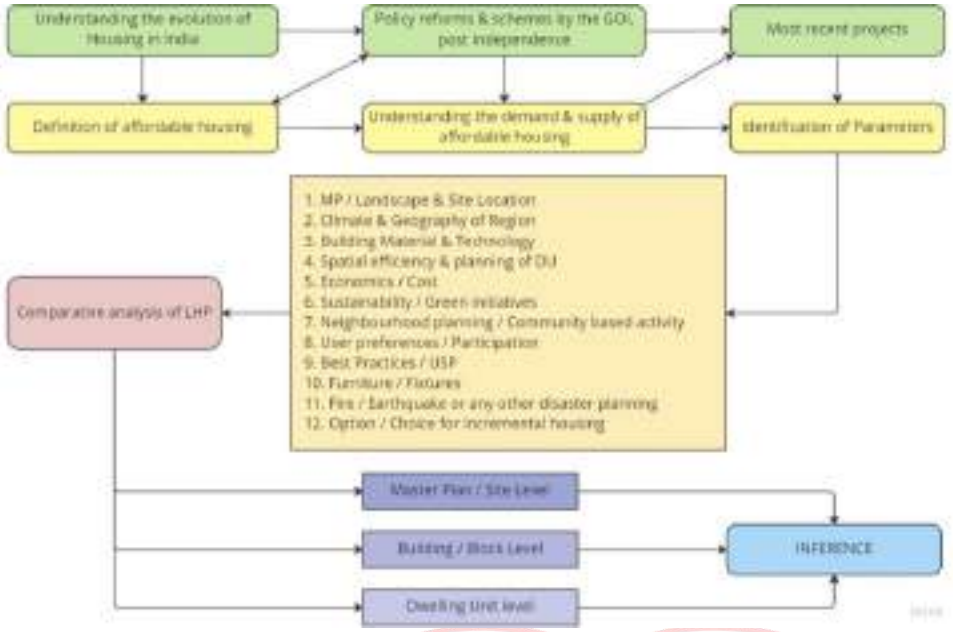

Figure 1 - Methodology Flow chart

IV. HOUSING DEMAND & SHORTAGE

A. *Overall Housing Demand In India*

Figure 2 - Distribution of Urban Housing Shortage (2012) [20]

The official estimate of the housing scarcity in urban areas (eliminating the shortage in rural areas), constituting homes in overcrowded, outdated, and situation with no home, or in kutcha houses without services is nearly 18.78 million residential units (see Figure 2) [20].

B. *Overall Housing Progress in India*

Only 8.5% of the scheduled houses are completed by January 2018. However, by June 2019, there is an increased completion rate to 31% due to the elevated government's focus on the execution of sanctioned houses. The validated affordable housing demand by 2020 was 1.12 crore [13]. Even though the number of sanctioned projects have increased, the number of completed houses failed to meet the same rates of progress (Fig 3)

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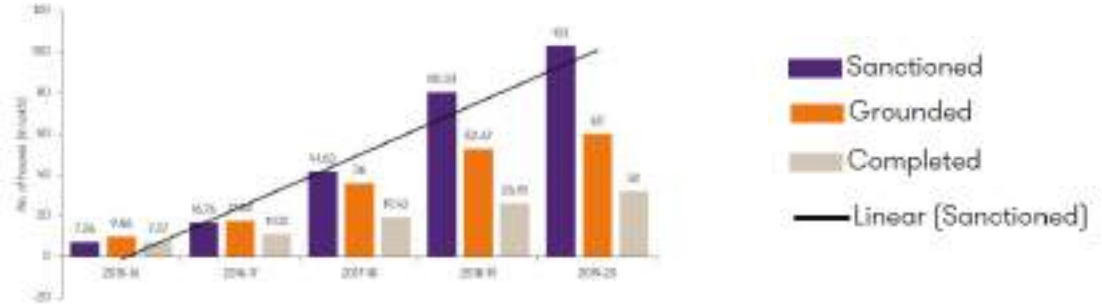
i.

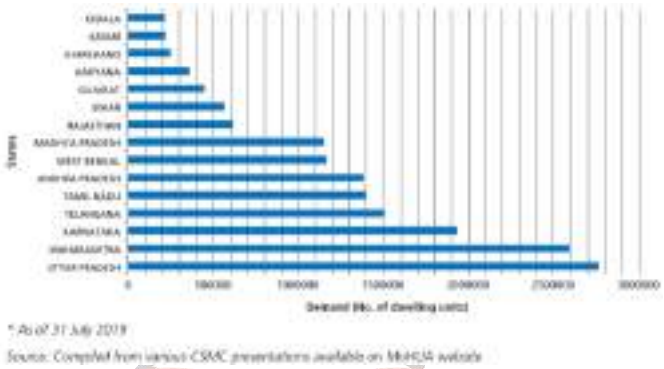


ii.**Figure 3 - Overall housing progress in India [12]**

C. State-Wise Demand

As per Cental Sanctioning and Monitoring Committee (CSMC) reports, the recent demand surveys show demand of 17.67 million dwelling units in 15 states (see figure 4 & figure 5) The national estimate by the Technical Group in 2012 also showed a nearly similar estimate [21].

b.



i.**Figure 4 - State wise Housing Demand [17]**

ii.

D. State Wise Progress

According to the statistics by MoHUA, under PMAY-U only 2.6 million units were completed out of the 8.3 million sanctioned residential units by 2019. As per these numbers 26% of units are required to be approved and by 2022, 77% of units should have been done to achieve the mission "Housing for All" but this is not yet done. The PMAY-U assessment of the process state-wise discovered that some states such as Jharkhand, Andhra Pradesh, Gujarat, and Odisha have progressed approval rates nearing the residential demand which is higher than other states. State with more housing shortage such as Uttar Pradesh, Maharashtra, West Bengal, Tamil Nadu, Telangana, and Karnataka, more than half of the demand are yet to be granted [21].

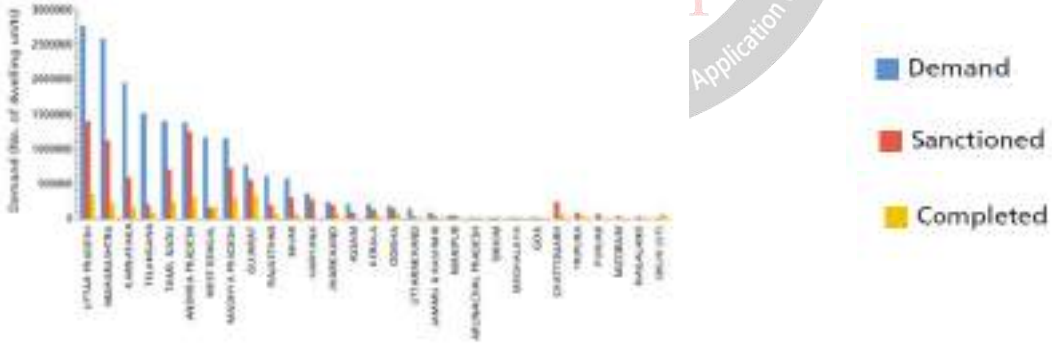


Figure 5 - State wise PMAY-U progress as of 1 July 2019

V. GLOBAL HOUSING TECHNOLOGY CHALLENGE, INDIA (GHTC-I)

The MoHUA has conceptualized LHP under the GHTC, India with its key foundation stone laid by Prime Minister of India, Narendra Modi on January 1, 2021. Various innovative, disaster-resilient, and sustainable technologies around the world have been identified for the project. More than 50 innovative technology-focused companies have participated in it and they are working on innovative technologies. Lucknow, Rajkot, Agartala, Indore, Chennai, and Ranchi are chosen for project demonstration with more than 1000 homes in every location with added auxiliary infrastructure [22].

The goal of GHTC-I is to acquire the most innovative global technology through a challenging process. The primary aim of GHTC-I is to demonstrate superior construction standards in ready-to-occupy residential units with less time and at a minimum expense in a sustainable manner. Through incubation support and accelerator workshops, the challenge intends to promote potential futuristic technologies to nurture the setting for exploration and development in India. The projects are built as a part

 DOI : 10.35291/2454-9150.2023.0041

of GHTC-India where the ecosystem embraces creative technologies in an integrated way for a holistic approach to residential construction. [13]

VI. EVALUATION OF CASE STUDIES AND COMPARATIVE ANALYSIS

LHP Case Studies and locations. (Fig 6)

1. Rajkot, Gujarat.
2. Indore, Madya Pradesh.
3. Lucknow, Uttar Pradesh.
4. Ranchi, Jharkhand.
5. Agartala, Tripura.
6. Chennai, Tamil Nadu.

Figure 6 - LHP site on India map [22]

All the 6 LHP are analysed on the basis of following parameters.

1. Master Plan / Landscape & Site Location.
2. Climate & Geography of Region.
3. Building Material & Technology.
4. Spatial efficiency & planning of units and building blocks.
5. Economics / Cost.
6. Sustainability / Green initiatives.
7. Neighbourhood planning / Community-based activity.
8. User preferences / Participation.
9. Best Practices / USP.
10. Furniture / Fixtures.
11. Fire / Earthquake or any other disaster planning.
12. Option / Choice for incremental housing.

c.

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A. Location And Context

	1.Rajkot	2.Indore	3.Lucknow	4.Ranchi	5.Agartala	6.Chennai
Location of city in State						
			Capital city			
Location of site in the city						
	In city's fringe region			Near central area	In city's fringe region	
Climate	Hot & Dry	Composite	Composite	Composite	Warm & humid subtropical	Warm & Humid
Geography & Region	Zone IV	Zone II	Zone III	Zone II	Zone V	Zone III

i.Table 2: Location and context [22], [23]

Most of the cities selected for the projects are the capital city of the chosen state. Due to the urban land constraint, the sites selected for the projects are located in the fringe areas as seen in table 2.

B. Project Brief

Parameters	1.Rajkot	2.Indore	3.Lucknow	4.Ranchi	5.Agartala	6.Chennai	Inference
Year of initiation	January, 2021						The main advantage of the technology was timely construction which it failed to achieve.
Completion year	Oct, 2022	In progress	In progress	In progress	In progress	May, 2022	
Project budget	Project on progress					116 Crore [24]	Economically it is ineffective as subsidy is more from both the government.
Cost/ dwelling unit	Total: INR 12.59 Lakh [25] Central Subsidy: INR 7.83 Lakhs State Subsidy: INR 4.76 Lakhs						

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Site Area in Acre	9.780953	8.466172	4.948892	5.327543	5.969496	7.217834	Rajkot has a maximum site and built-up area
Total built up area (sq.mt)	62369	44798	48702	47860	45273	43439.76	
No. of Floors	S+13	S+8	S+13	G+8	G+6	G+5	All the buildings have lifts & fire stair
No. of Dwelling units	1144	1024	1040	1008	1000	1152	All projects have 1000+ DU
Carpet area/DU (sq.mt)	39.77	29.92	34.51	30.27	30.03	26.78	Minimum of 26.78 sq.m and a maximum of 39.77 sq.m is provided
Source	Compiled by the authors with available information[22]						
Open Area (sq.mt)	31874	28408	15366	14465	17054	21672	Indore has utilised minimum ground coverage
Ground Coverage %	20%	17%	23%	32%	30%	26%	
Source	Compiled & calculated by the authors with available information[22]						
Other Provisions	Community Centre, Health Centre	Community Centre/Hall	Community Centre, Shops	Anganwadi, Health Centre, Community Centre	Anganwadi, Health Centre, Community Centre	Anganwad, milk booth, library and ration shop	Required public amenities are provided in the site

ii.Table 3: Project Brief

iii.

The overall project brief have been compiled and evaluated by the authors as seen in table 3. Having 1000+ dwelling units in all the projects helps in optimizing the cost of construction and provides a standard bench mark for comparative analysis.

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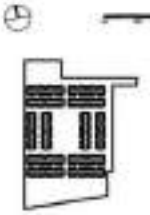
	1.Rajkot	2.Indore	3.Lucknow	4.Ranchi	5.Agartala	6.Chennai
Site Planning & Layout	 	 	 	 	 	 

iv.Table 4: Site Planning and Layout [22]

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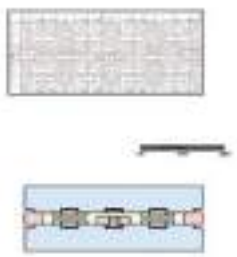
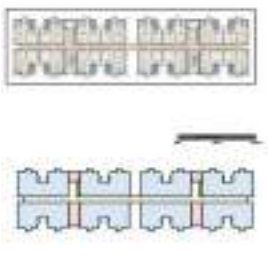
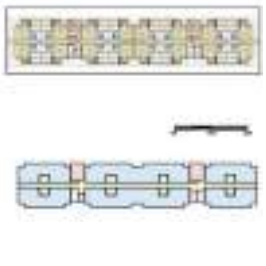
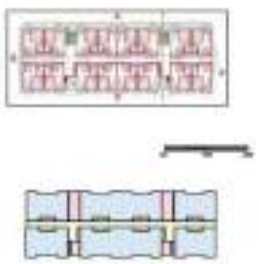
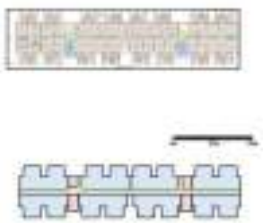
Even though the sites are unique in terms of location, Geometry and area, all the projects had identical approach of juxtapositioning building blocks that creates concrete jungles as seen in table 4. Most of the open space gets utilised as parking areas, leading to lack of quality outdoor space and minimal community interactions

	1.Rajkot	2.Indore	3.Lucknow	4.Ranchi	5.Agartala	6.Chennai
Block Layout						
MP / Site Plan / Landscape	A huge open space is left for parking, and then the buildings are located as per the shape of the site	Linear block arrangement as per the site context. Recreational spaces are split and provided	Open spaces are placed surrounded by buildings	The buildings are the open space are linearly arranged	The road dives the site into two. The buildings and open spaces are provided on both sides	Centrally located public amenities are surrounded by buildings and recreational spaces at the end

v.Table 5: Block Level Planning

d.

C. Dwelling Unit Space Planning

1.Rajkot **2.Indore** **3.Lucknow** **4.Ranchi** **5.Agartala** **6.Chennai**

Fig 7: Dwelling Unit Space Planning

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D. Dwelling unit Space Planning

Parameters	1.Rajkot (Sq.m)	2.Indore (Sq.m)	3.Lucknow (Sq.m)	4.Ranchi (Sq.m)	5.Agartala (Sq.m)	6.Chennai (Sq.m)	Inference
Living (sq.mt)	11.67	9.61	11.96	11.35	11.96	9.6	Most active space
Bedroom(sqmt)	16.53	9.33	10.97	9.82	10.97	7.7	Only Rajkot has a double - bedroom
Toilet (sq.mt)	3.55	2.52	3.23	2.64	3.23	2.8	Required space is allotted for the toilet and kitchen.
Kitchen (sq.mt)	4.58	3.8	3.91	3.61	3.91	5	
Utility / Balcony (sq.m)	2.6	2.23	1.57	1.61	1.57	0	Except for the LHP in Chennai, the other projects have a utility/ balcony space.
Passage/Foyer	0	1.85	2.9	1	2.9	1.2	Rajkot and Agartala lack foyer space
Total Area	39.77	29.92	34.51	30.27	34.51	26.78	
Source	Compiled & calculated by the authors with available information[22]						

i.Table 6: Dwelling unit Space Planning

E. Natural lighting and ventilation, circulation

Parameters	1.Rajkot	2.Indore	3.Lucknow	4.Ranchi	5.Agartala	6.Chennai	Inference
Natural lighting and ventilation	Both bedroom has window opening towards the outside but the living area window opens to the interior corridor	The bedroom has a window facing the exterior and the living has window facing the duct	The bedroom and the living room has a window for ventilation. The living area near the stair does not have a window	The bedroom and the kitchen has window facing exterior	The bedroom has window facing the exterior and the living has window facing the duct	Bedroom, living, kitchen, and bath have a window. Duct are used for ventilating the Toilets	Only limited ventilation is available in some cases.
Circulation	Two bedrooms, kitchen, and toilet are accessed from the living. The living space is significant in connecting other spaces.	The bedroom and a foyer is connected by a living room. The foyer further connectsthe kitchen and toilet.	The living room connects the bedroom and a kitchen. The foyer connects the living with the toilet, bath, and balcony.	The living room is connected to the bedroom, kitchen & balcony.A foyer provides access to the toilet & wash.	The living acts as a common space connecting kitchen, bath and a toilet	The foyer is centrally connecting space between all the rooms	Living room is the central unit which connects all other rooms, yet has minimal cross ventilation & light. Should have the option to convert to a bedroom

ii.Table 7: Natural lighting and ventilation, circulation

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F. Block Planning

Parameters		1.Rajkot (Sq.m)	2.Indore (Sq.m)	3.Lucknow (Sq.m)	4.Ranchi (Sq.m)	5.Agartala (Sq.m)	6.Chennai (Sq.m)	Inference
BLOCK PLANNING	Dwelling Unit (sq.mt)	368.16	517.8	655.27	563.51	655.27	523.12	The building area varies correspondingly combining the area of the individual unit and circulation area
	Horizontal(H) - Circulation (sq.mt)	68.37	59	101.65	90.95	101.65	83.8	Necessary area is provided for circulation. Building level interaction happens in this space
	Vertical(V) - Circulation (sq.mt)	36.57	36.75	49.32	47.13	49.32	37.39	Optimum area is provided for vertical circulation
	Ducts / Shafts (sq.mt)	23.7	10.65	6.56	66.8	6.56	0	Except the LHP in Chennai, all the other projects have service ducts.
	Waste Duct (sq.mt)	0.75	0	3.55	5.15	0	0	Waste ducts are provided for three LHP
	Light Well (sq.mt)	0	42.1	0	0	0	0	Light well is provided for only the project in Indore.
	No of DU in each floor	8	16	16	16	16	16	The number of dwelling unit in five LHPs are similar. The number of dwelling units in Rajkot is only 8 as the apartments are double bedroom units
	Source	Compiled & calculated by the authors with available information[18]						

iii. Table 8: Block Planning

G. Details Of Technology Used In LHP

	1.Rajkot	2.Indore	3.Lucknow	4.Ranchi	5.Agartala	6.Chennai
Building Material & Technology	Monolithic Concrete Construction using Tunnel Formwork	System of prefabricated sandwich panels and pre-engineered steel structures	Stay In Place Formwork System with pre-engineered steel structural System	3D Volumetric Precast Concrete Construction	Light Gauge Steel Structural System with pre-engineered steel structural System	Precast Concrete Construction System - 3S System
Technology						

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	The technology consists of 2 half shelves made of steel placed together to form a room/cell. Multiple cells make an apartment with tunnel walls and slabs.	In this system the EPS cement fabrics are manufactured at the factory in controlled conditions. The cement motor and EPS granules bar together form the prefabricated sandwich panel system.	Prefabricated wall panels and hot rolled sections are transported to the site and erected as foundations by cranes and required connections. The floor is installed using decking sheets after which prefabricated wall panels with holes with services channel provision are placed above it and hollow braces are filled with concrete. Then ceiling and finishing work is executed.	Manufacturing of precast concrete structural module and foundation of the building takes place parallelly. Factory-finished rooms are installed by tower cranes in the site. The building's sides are terminated by cable-hung end walls. The flooring is then installed using prestressed slabs. The pieces are all connected with a ribbed mesh that was put for the structural stream. Likewise, consecutive floors are constructed.	The system use factory made galvanised steel components. The components of sections are produced by coal forming method and erected as panels on site forming buildings of structural steel framework with varied sized walls and floors.	The reinforcement cages are placed at the required positions in the boards. Concrete is poured and compaction of concrete is done by shutter, needle vibrator. The cast concrete is subsequently transported to stacking yards for the necessary curing period.
Best Practices / USP	Utilisation of custom engineered formwork in displacement of steel and shuttering formwork system	Panels having tongue and groove joined together Steel structure frame is used	PVC stay In Place Formwork System turn to be pre-finished walls without plastering and can be constructed with steel	Monolithic casting of Solid precast concrete structural modules in controlled condition in a plant or casting yard	Reduces foundation requirement. Hot rolled steel structures can make the system suitable for floors higher than G+3.	Precast concrete columns, beams and slabs in MS boards are transported,erected and installed by crane and united closely by grouting and jointing.
Salient features	Utilising industrial byproducts like Ground Granulated Blast Furnace Slag (GGBS), Micro silica, Fly Ash, etc. in the design of the concrete can improve its workability and durability while preserving natural resources.	Resource efficacy, improved thermal insulation, acoustics and energy efficiency is prompted as lightweight sandwich panels are the core material	Concrete's curing requirement is significantly reduced when used as a filling material, conserving precious water resources.	Workability and durability can be improved along with natural resource conservation when the design of the necessary concrete is done by utilising industrial by-products. Concrete is made with silica fume and granulated blast furnace slag.	High precision and accuracy are provided by a fully intertwined motorised system with Centrally Numerical Control (CNC) machines, which are originally used to manufacture LGSF sections. Steel used can be recycled multiple times	Conservation of natural resources with improved workability and durability by designing concrete with industrial by-products such as Fly Ash, GGBFS, Micro silica etc.
Disadvantage	-High investment [26] -More thermal radiation[26] -Difficult for maintenance[26] -Require cash flow required for speed construction [27] -Coordination and management is crucial for speed management [27]	-Advance planning and accurate measurements needs to be done in determining the size and positioning of openings [28] -Needs special protection as it can be damaged by moisture[29] -Requires pest protection [29]		-Transportation is difficult [29] -Possibly difficulty in connections [30] -Incapable for two-way structures [30] -Joints are complex and expensive [29], [30]. -Bulge in beams and slabs [30]	-Requires fire protection [31] Requires soundproofing [31]	-Initial investment is high [29] -Transportation is difficult [29] Possibly difficulty in connections [30] -Incapable for two-way structures [30] -Joints are complex and expensive [29], [30] -Bulge in beams and slabs [30]

Table 9: Details of Technology used in LHPs

The above table (Table 9) gives an overview of various features, pros and cons of the technology.

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H. Analysis Of The Technology

	1.Rajkot	2.Indore	3.Lucknow	4.Ranchi	5.Agartala	6.Chennai
Low maintenance	No	Yes	Yes	Yes	Yes	Yes
High Investment	Yes	Yes	Yes	Yes	Yes	Yes
Units assembled at site	Yes	No	Yes	Yes	Yes	No
Similar components assembled at site	Yes	Yes	Yes	Yes	Yes	Yes
Required trained labors	Yes	Yes	Yes	Yes	Yes	Yes
Rapid construction	Yes	Yes	Yes	Yes	Yes	Yes
No plastering required	Yes	No	Yes	Yes	No	Yes
Reduces foundation size	Yes	Yes	No	No	Yes	No
Water conservation during construction	Yes	Yes	Yes	Yes	Yes	Yes
Fire / Earthquake or any other disaster planning	Yes	Yes	Yes	Yes	Yes	Yes
Limited Design flexibility	Yes	Yes	Yes	Yes	Yes	Yes
Inbuilt furniture	No	No	No	No	No	No
Option / choice for incremental housing	No	No	No	No	No	No

iv.Table 10: Analysis ocsmcf the Technology

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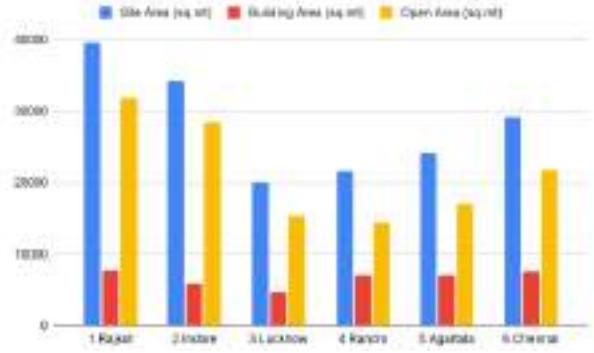
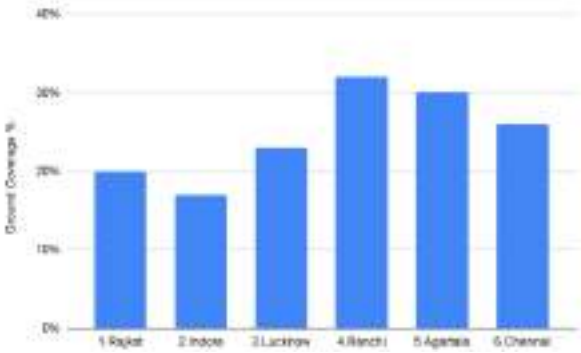
VII. COMPARATIVE ANALYSIS

A. *Site Wise Area Analysis*



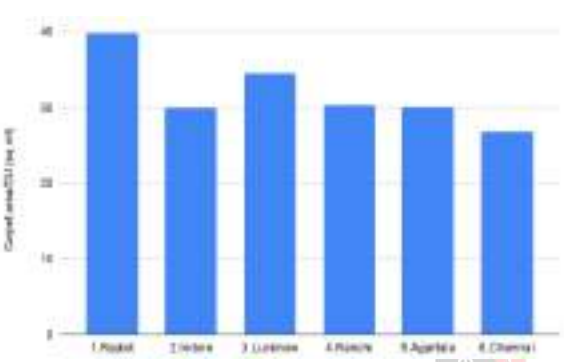
vi. **Figure 8: Site wise Area Analysis**



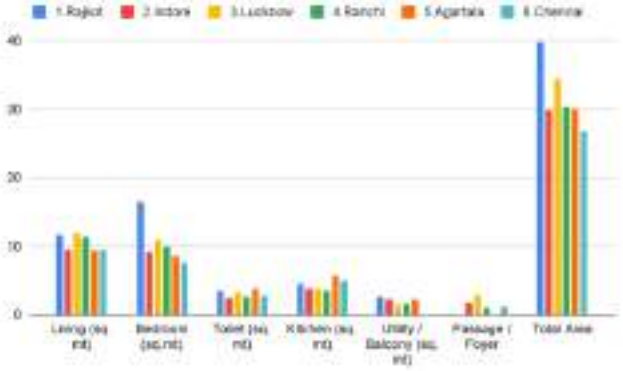
v. **Figure 9: Ground Coverage**

The site area is maximum for the LHP in Rajkot and minimum for Lucknow. The amount of open space varies within the site area. (Fig 8 & Fig 9)

B. *Building Level Area Analysis and Dwelling Unit Space Planning*



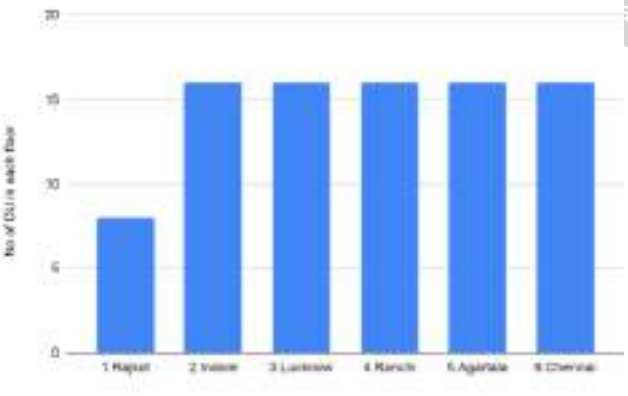
viii. **Figure 10: Carpet area of every unit (sq.m)**



vii. **Figure 11: Area distribution of spaces within each dwelling unit (sq.m)**

The carpet area of five LHP varies from 25sq.m to 35 sq.m and the LHP in Rajkot have a maximum area of 39.77sq.m. (Fig 10) Within the DU also, LHP in Rajkot takes proportionately more space (Fig 11)

C. *Typical Floor Planning*



ix. **Figure 12: No of dwelling unit on each floor**

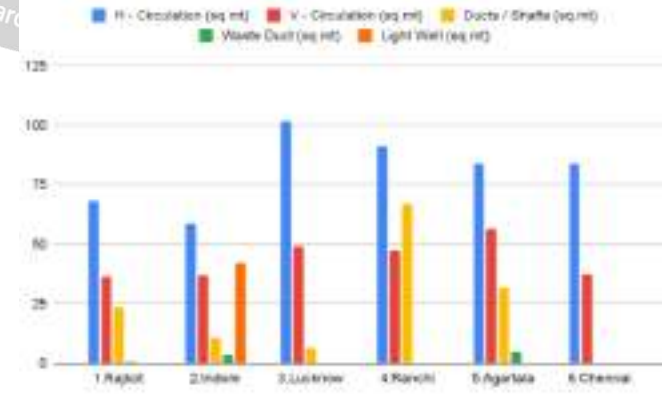


Figure 13: Typical floor Planning

All the projects other than Rajkot has twice the number of dwelling units (Fig 12) & it has proportionately lesser space for horizontal circulation (Fig 13). The project in Indore & Agarthala have ducts/shafts which is needed but missing from other projects. (Fig 13)

VIII. DISCUSSION

In regards to Site location, only the project in Ranchi, Jharkhand is identified closer to the urban core. The rest of the projects are situated in the urban fringes of the cities. (Table 2)

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The identified 6 technologies claim to be climate responsive and efficient in energy consumption. However, the effective difference is yet to be observed after post-occupancy evaluation (POE). All the technologies are earthquake and fire-resistant (Table 10). One of the main objectives of the identified technologies was the timely construction of the project, even so, only two of the projects are completed as of the study date and that by itself got delayed for over 8 months (Table 3).

The spatial efficiency and planning of the units tend to be restricted by the respective technology implemented. The construction technology allows the projects such as the one in Rajkot, Gujarat to go high rise as much as stilt + 13, which is unusual for affordable housing projects (Table 3). All the 1000+ units in the respective sites repeats a single plan which can make the masterplan homogeneous and repetitive. Only Rajkot and Lucknow sites went beyond the 30sqm restriction per dwelling unit (DU) even though none of the projects have an option for incremental housing. Only LHPs in Ranchi and Agartala have gone beyond 30% coverage even though Rajkot has a maximum site area(Fig 9). Most of the open areas will be further used for parking, hence reducing green areas and interaction spaces (Table 4). All the blocks are identical with doubly loaded corridors and limited cross ventilation. The Rajkot project has 8 units per floor and the rest of them have 16 units per floor. (Fig 13). Community amenities are provided on the site even though the location and planning of these are questionable (Table 3). Only the Rajkot project offers the beneficiary a two-bedroom apartment, the rest of them have only a 1BHK (Fig 7). The unit designs offers limited natural light and cross ventilation when placed adjacent to one another (Table 7).

IX. LIMITATIONS & FUTURE SCOPE

- The study is restricted to a literature review of the projects because only 2 projects have been recently completed on-site and the occupancy rate is low.
- Future assessment of livability factors & quality of life can be surveyed.
- Post Occupancy Evaluation (POE) of the technology also can be evaluated based on qualitative surveys once the project is handed over to the tenants.

X. CONCLUSION

LHP is technologically sound and offers a systematic way of approaching the required housing demand in the Indian context. However, the locations identified for the LHP itself are questionable due to their proximity to the urban center. The EWS & LIG sector depends on daily wages and their day-to-day life is often interconnected with the functioning of the city. In order to make affordable housing communities sustainable, future projects should be planned with the development of master plans of the city and integrated with transportation networks. The block-level plans of all the LHP evolved by placing concrete blocks one by one and the master plans of the projects eventually created concrete jungles. LHP can incorporate better designs from a user-centric point of view. There is only a single type of 30sqm unit, in each location for EWS and LIG categories respectively. India is a diverse country, and the provision of available housing choices to the end user goes a long way in affordability. Including multiple varieties of units ranging from 20 sqm - 60sqm can help to increase the success factor of the LHP. A wider range of users can benefit simply by improving the design and availability of choices. The economic sustainability of LHP should be revisited because providing 7-8 lakhs of subsidy per DU can be a huge concern for the government. Instead, considerations to decrease the entire project expense should be analyzed. The comparative analysis of LHP's gives us a critical outlook into all the projects as well as identify key strengths and weaknesses within each projects. These findings and observations can help to further refine the project briefs for affordable housing projects across the country.

While the initiatives of GoI are helping in achieving the required affordable housing stock, quality affordable housing is still a major concern. 'Housing for All' can also focus more on satisfying the needs of end users and the community and less on achieving statistical requirements. Affordable housing designs should reflect the government's vision of how its people should live. Creating sustainable housing which is both affordable and comfortable for the end user paves the way for sustainable cities and communities.

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