Findings from householder survey in Jakkampudi colony, Vijayawada

Case study report

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MaS-SHIP

Mainstreaming Sustainable
Social Housing in India Project

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Executive summary

The Government of India aims to construct 12 million social housing dwelling units through the Housing for All by 2022 programme. The UN Environment funded 'Mainstreaming Sustainable Social Housing in India project '(MaS-SHIP) seeks to identify what the impacts and benefits of housing production at such a massive scale could be, by promoting the use of sustainable building materials and systems in social housing developments. However this is not an easy task in an inherently data poor environment. To address this challenge, MaS-SHIP has adopted a field survey-based approach wherein primary data are gathered through interview-based questionnaire survey, from key stakeholders of social housing developments, including, developers, practitioners, building material manufacturers and social housing residents. Five social housing case study developments across three different climatic zones of the country were identified, and about 150 households were surveyed at each location to gain insights about the experiences of residents living in a social housing development.

This report describes the methodology and learnings from a field survey of 152 social housing residents in a housing colony at Jakkampudi in Vijayawada, which was developed under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) to provide affordable and improved housing for the Economically Weaker Sections (EWS) of the society living in the city. The purpose of the resident/householder survey was to gather subjective feedback from residents about their perception of the indoor environmental conditions (indoor temperature and air quality) in their homes during summer and winter, along with aspects of maintenance and upkeep of the development, familiarity with the building materials, and access to basic day to day necessities around the development. To undertake the householder survey, the MaS-SHIP team collaborated with a local architectural school to carry out these surveys. The gathered data were analysed and various aspects cross-related to better understand the existing indoor environmental conditions in these dwellings during summer and winter periods.

The householder survey of the development revealed that the residents mostly felt satisfied with the indoor environmental conditions during both summer and winter. However, the narrow distance between two building blocks did not allow enough daylight inside the dwelling units, especially on the ground floor. Inappropriate location of the window in the dwellings made them redundant, resulting in stuffy indoors during summer, and less daylight throughout the year. The development also lacked security, hygiene and a maintenance regime, element which are commonplace across social housing developments in India.

1. Introduction

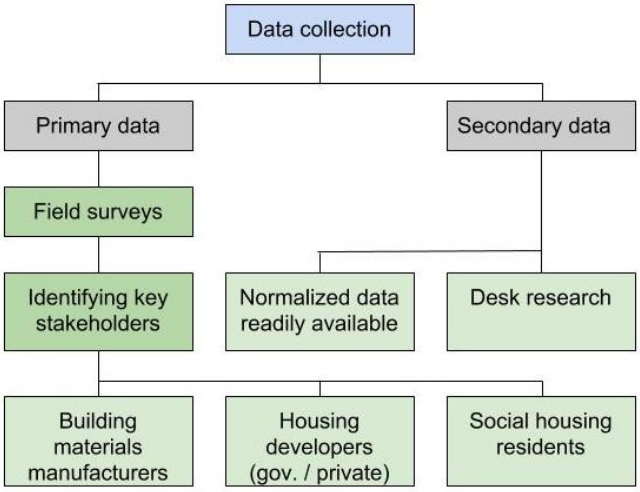
The urban housing shortage in India is currently estimated at 18.78 million, more than 95% of which pertains to low-income groups. Through its “Housing for All by 2022” mission, the Government of India intends to close this gap by aiming to construct 12 million housing units over the programme duration through a combination of slum upgrading projects in partnership with the private sector, direct government-led housing delivery, a credit-linked subsidy scheme as well as support to beneficiary-led construction. Since housing is, by definition, an energy and material intensive sector, this will require not only human and financial resources at an unprecedented scale, but natural ones, too. This represents both a grave danger in terms of environmental degradation, but also an opportunity for introducing life-cycle thinking into the building sector and promoting economic inclusion for millions. But first, a number of difficult questions require a scientific answer. This is no easy task in an inherently data poor environment.

“Mainstreaming Sustainable Social Housing in India project (MaS-SHIP)” is a UNEP funded two-year research project that aims to identify what the impacts and benefits of housing production at such a massive scale could be – for our environment, our economy, and our communities – and providing a method for identifying the most optimal solutions. To achieve this objective, the project is producing two major outputs.

- Sustainability Index (SI) to evaluate building systems based on a set of attributes (indicators) developed in close consultation with the Government’s System Sub-mission under Housing for All, led by the Building Materials and System Promotion Council (BMTPC), as well as India’s leading experts in the field.
- Decision Support Tool (DST) which will provide guidelines at the conceptual stage of housing projects to enable the adoption of sustainable building practices by housing providers such as government bodies, private developers, and individual households.

There is lack of data pertaining to the sustainability parameters and attributes for assessing the sustainability of social housing. Hence in this project both primary and secondary data was collected to develop an empirical data base not only for the project but to provide a base for future research as well (Figure 1).

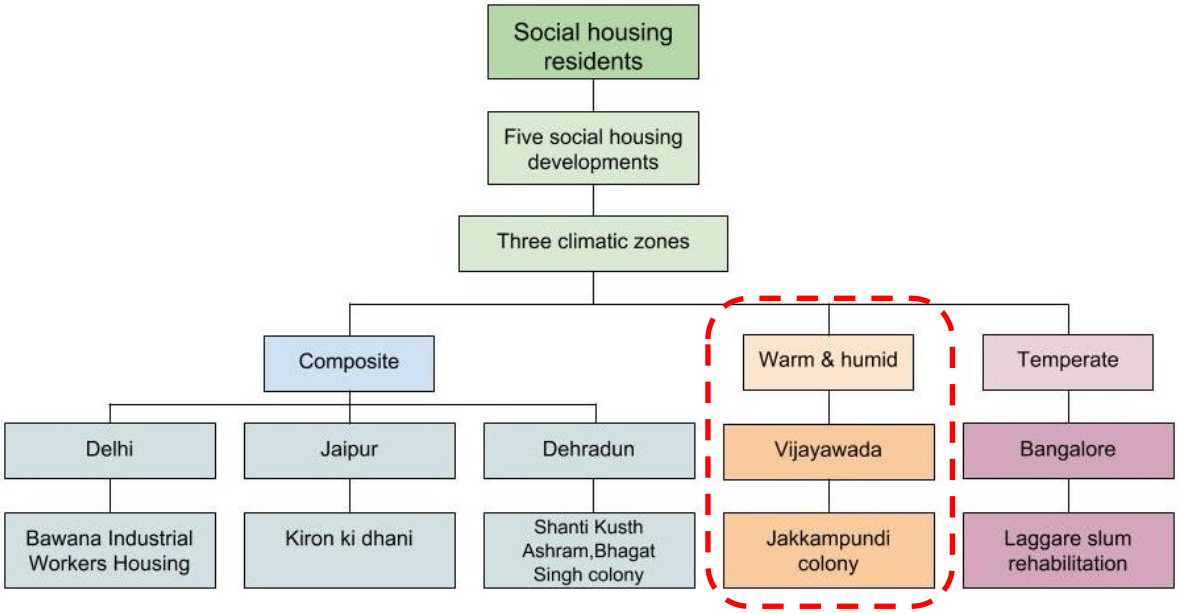
Figure 1: : MaS-SHIP data collection methodology



The primary data collection was done by conducting questionnaire surveys to gain first-hand insights from the key stakeholders of the social housing i.e. developers (both government and private), building material manufacturers and social housing residents.

For gathering data from the social housing residents, five social housing developments were selected on the basis of their geographical location (climatic zone); type and scale of the cities in which they are located; share of urban housing shortage and the Average Annual Exponential Growth Rate in the state; and also on the basis of their ranking base on the completed social housing projects under the most recent central government programme (WP3 report). Figure 2 shows the five selected social housing developments based on their location and climatic zone.

Figure 2: Social housing case studies



A questionnaire-based survey was conducted by visiting each of the selected developments with an aim to gather data to access the current state of social housing in India and gather first hand insights of the residents perceptive of the environmental, social and economic sustainability factors in these social housing developments. Nearly 150 households were surveyed at each location during the months of September-October 2017. This report presents the findings from the field survey conducted for a social housing development located in Vijayawada, representing the Warm and Humid climatic zone of India.

The report is structured as follows

1. **Introduction**- This section provides a brief background of the MaS-SHIP project, along with its aims and outputs. The overall data collection methodology adopted for the project and the rationale for conducting the case study of five social housing developments across three climatic zones of India is also provided.
2. **Case study overview**, basic details of the Jakkampudi colony at Vijayawada are highlighted in this section. The details about the location, type of dwellings, construction materials used, and demographics of the development are provided.
3. **Methodology** section explains in detail the process adopted for conducting the householder survey across the five different locations. A list of the survey questions covering the various aspects of a social housing development is also provided.
4. **Insights from the householder survey-** based on the methods defined in the previous section the gathered data is analysed individually and various aspects are cross related wherever required.
5. **Summary of findings**-The overall findings from the data analysis are summarised in this sections and critical aspects that need to be addressed are highlighted.

2. Case study overview

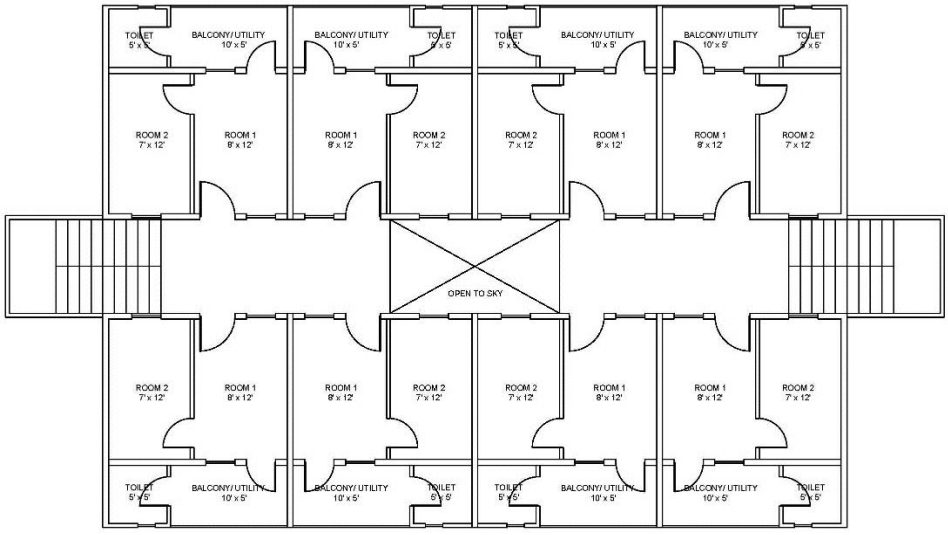
The Jakkampudi colony in Vijayawada is a social housing project developed under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) to provide affordable and improved housing for the Economically Weaker Sections (EWS) of the society living in the city. The project located around 11km from the city centre, was made on land pooling basis with 60% land from the inhabitants and 40% from the government. A screening process was established to identify the beneficiaries of the scheme. Through an online application system and physical visits, households were selected based on their original house location, number of family members and annual income. About 1000 units were left midway of construction due to funding issues from the government, 7104 have been completed and are occupied.

Table 1: Case study overview

Category	**Case study**
Location	Vijayawada
Name of the development	Jakkampudi colony
Government scheme	Jawaharlal Nehru National Urban Renewal Mission (JNNURM)
Occupancy	8 years
Target group	Economically Weaker Section
Distance from city centre	11 km
Number of dwelling units	7104
Built-up area of each dwelling (sq. ft.)	275
Cost of construction (INR per sq. ft.)	-

The development consists of G+3 storey structures housing about 7104 dwelling units. A typical floor layout consists of eight dwelling units and a central corridor with two staircases located at either ends of the corridor. With four dwelling units on either side the long central corridor is interrupted midway by a cut out equal to the length of a dwelling unit, to allow for daylight and natural ventilation into the building. All units are identical and consist of two rooms, one combined WC and shower area and a balcony. Except for the windows and ventilators provided in the balcony area, all the other windows of any dwelling unit open onto to the central corridor and/or the staircases, making them redundant to use due to privacy issues (Figure 3).

Figure 3: Typical layout of a building block at Jakkampudi colony



2.1 Building materials and system

The building materials and construction systems used were RCC framework with flyash brick masonry which is the most commonly used building material in Vijayawada.

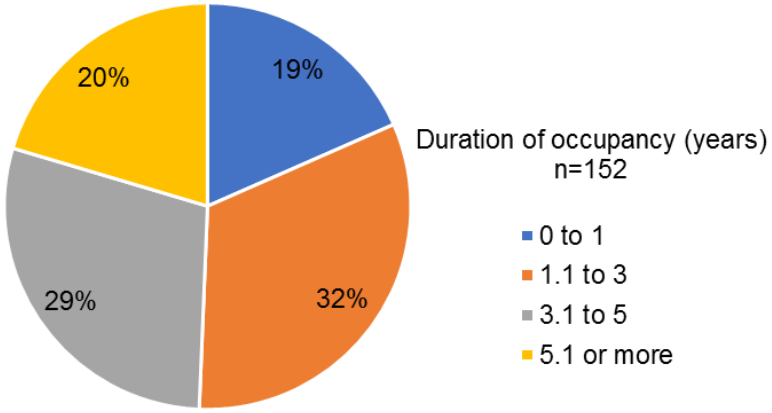
Table 2: Building materials used in Jakkampudi colony

Foundation	• Not known
Walling	• Flyash brick
Roof / Floor	• RC slab
Doors and windows	• Not known
Others	• Not known

2.2 About the households

At the time of the survey the houses had been occupied for more than 5 years. Of the 152 surveyed households about 32% had been occupied for upto 3 years. About the same percentage of houses (29%) had been occupied in between 3.1 to 5 years. Only 20% of the households had been occupied for 5 years or more (Figure 4).

Figure 4: Duration of occupancy



In terms of number of residents, the survey revealed maximum households having about four members (Figure 5). However, a significant number of dwellings were also found having occupancy of two and three members. The number of households with occupancy more than five or six was found to be less (Figure 6).

Figure 5: Occupancy of the surveyed households

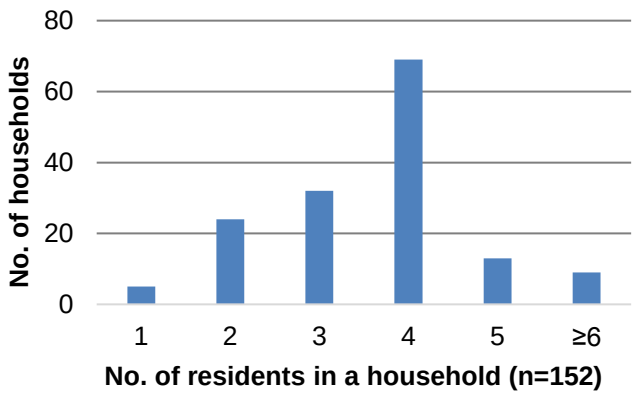


Figure 6: Interior of a DU at Jakkampudi colony

The surveyed households had 60% of residents aged between 19-58 years (Figure 7), and most of them would spend about 10-14 hours at home during the day. 29% of the residents' aged between 3-18 years which would mean mostly children, a majority of who generally spent around 14-16 hours of time at home during a day. Though the percentage of elderly residents' i.e people above the age of 60 was found to be very less (5%), oddly they seem to be spending less than 4 hours at home during a day (Figure 8). A considerable number of residents were also reluctant to disclose this information.

Figure 7: Age group of residents

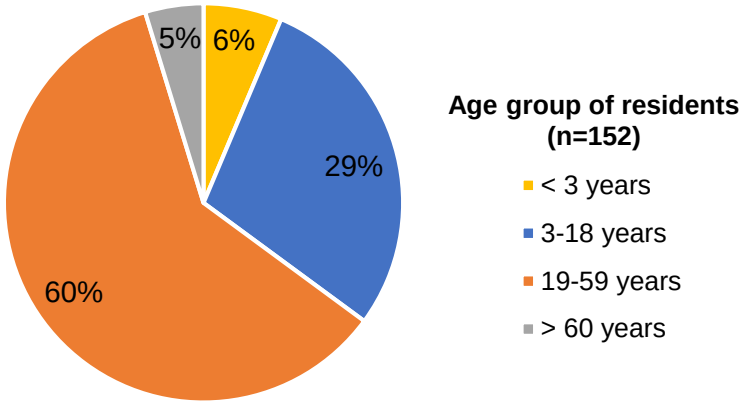
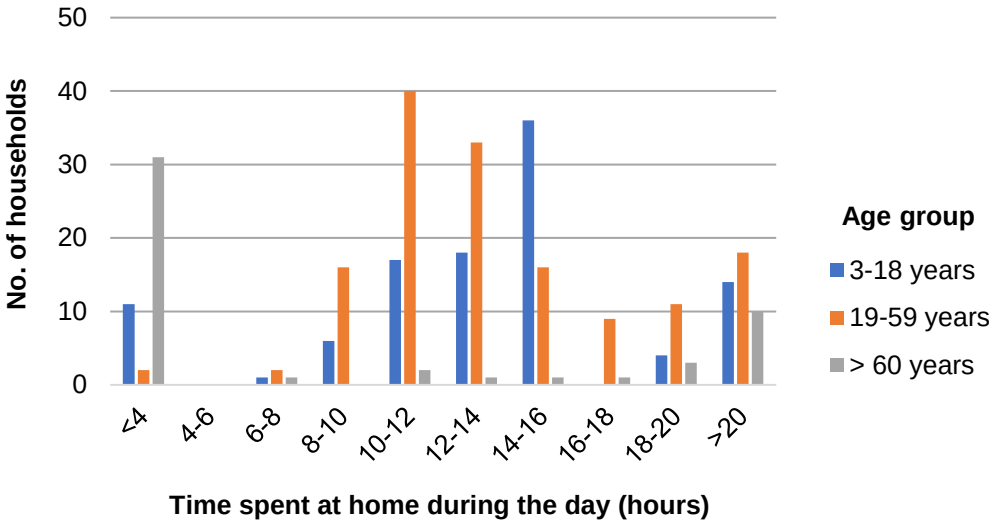


Figure 8: Time spent at home during the day



3. Methodology

3.1 Questionnaire survey

In order to collect a mix of quantitative and qualitative data, interview-based questionnaires were conducted based on structured questionnaires designed specifically for gathering feedback from the householders of the social housing developments at the five selected locations in India. The questionnaires went through several rounds of iterations which included review by the technical reviewers of the project and industry experts.

The householder survey provided a snapshot record of the perception of social housing dwelling units from the residents' perspective. The survey questionnaire consisted of 24 questions (Table 3) to record feedback on the following aspects:

- Indoor environmental conditions
- Daylight and ventilation
- Experience with the building materials and system
- Affordability
- Maintenance and up-keep of the common areas
- Accessibility to the basic public facilities.

The responses for the various questions were a mix of objective answers, rating scale and multiple-choice questions.

Since the three selected climatic zones vary in their seasonal temperature variations, in order to access the residents' perception of the indoor environment in these naturally ventilated dwellings, the survey posed questions only for hot and cold seasons (summer and winter). This also allowed for a universally applicable questionnaire survey across all the selected locations. Even though the duration and intensity of these seasons vary for each climatic zone, there are transition periods where outdoor conditions are more comfortable. The survey therefore, focused on gaining feedback on a general perception during the hottest and coldest periods during the two seasons. For this the respondents were asked to rate their experience on a rating scale.

Table 3: Householder survey questionnaire

Ques. No.	Aspects accessed	Response								
	About the household									
1	Duration of occupancy	Survey was done for households that had been occupied for a minimum of 5-6 months.								
2	Number of residents in the house	Infants (< 3 years)		Children (< 18 years)		Adults (19-59 years)		Elderly (> 60 years)		-
3	Average number of hours spent at home on a daily basis	<4	4-6	6-8	10-12	12-14	14-16	16-18	18 - 20	>20
4	Percentage of monthly income spent on rent	Less than half		About half		More than half				
5	Monthly average electricity bill	Residents were asked to share a copy of their latest electricity bill if feasible.								
	Perceived indoor environment in summer & winter									
6	Indoor temperature	unsatisfactory		bearable		satisfactory		-		-

7	Air quality	stuffy	bearable	fresh	-	-
8	Air movement	draughty	still	well ventilated	-	-
9	Overall experience	unsatisfactory	bearable	satisfactory	-	-
10	Window shading during summer	None	Curtains/blanket/screen/ cloth/netting/ inside blinds	News paper	Cardboard	Plywood
11	Cooling strategies adopted during summer	Natural ventilation (opening windows at night)	Evaporation cooling (sprinkling water on the floor, using coolers)	Ceiling fan	Air conditioner	-
12	Adaptive strategy during winters	yes	no	-	-	-
13	Artificial lighting required during the day	yes	no	-	-	-
14	Dampness in the house	yes	no	-	-	-
15	Room in which there is dampness					
16	Causes of dampness	Leaking of pipes	Building material is not water resistant	Improper construction workmanship	Poor design	-
	Maintenance and repair					
17	Regular maintenance of common areas	yes	no			
18	Is payment made to the residential welfare association to cover the maintenance of common areas, service connections and the building itself?	yes	no			
19	Experience w.r.t. the building materials used? Any issues with options mentioned?	Satisfactory experience	Aesthetics/material finish	Nail-ability	Adding/changing electrical points	Inability to access pipe for plumbing repair works
20	Convenient access to essential facilities	yes	no	-	-	-
21	Travel time to work (minutes)	0-20	20-40	40 -60	60 min & above	-
22	Travel time to school (minutes)	0-20	20-40	40 -60	60 min & above	-
23	Mode of travel to work; hospitals and other essential services	Own vehicle	Access to public transport	Walking distance	Availability of conveyance is an issue	-
24	Mode of travel to school	Own vehicle	Access to public transport	Walking distance	School bus	No school going children in the house

With approximately 750 households to be surveyed across the five locations of social housing developments, the MaS-SHIP project team engaged with local architecture education institutions for assistance in conducting household surveys. Each of the local institutions selected 10 architecture students (3rd and 4th year students) to assist the MaS-SHIP team in conducting these surveys. As part of capacity building the students attended half a day orientation workshop, conducted by members of the MaS-SHIP team, post which another half of the day was spent on-site, assessing the progress made by the students in conducting the surveys. On an average each batch of 10 students took 4 days to complete the survey of a total of around 150 households at each site. Households were selected through random sampling and were generally suggestive of the availability of the members in the house as well as their eagerness to participate in the survey.

3.2 Photographic survey

The students conducting the survey also took pictures of the interiors of the dwellings and the surround areas (after seeking permission from the resident/s) to support the responses gathered from the householders.

3.3 Researcher observations

Apart from gathering information through the survey questionnaire and photographs, the students were also asked to provide their feedback regarding their experience with respect to conducting the survey and their observations about the development. This was done by completing two personal logs - one at the end of Day-1 of the survey and the second after completing the survey for that particular social housing development. The questions provided for the two personal logs are as below:

Personal log-Day 1

1. Were the home-owners responsive to the questions asked to them?
2. What worked or didn't work in your favour while conducting the surveys?
3. Do you feel the questions were relevant or irrelevant? Give reasons.
4. What was your overall experience in conducting the surveys?

Personal log report

1. What is your overall experience in conducting the surveys?
2. What is your understanding of social housing?
3. Is it different from other residential projects? Describe your observations.
4. Are there any concerns that you think need to be addressed with respect to social housing projects?
5. What are your recommendations for addressing these concerns?
6. Reflect on the building materials and systems used in the housing project and your assessment of these, against economic, social and environmental parameters.

The information derived from the student logs generally reaffirmed the findings from the questionnaire survey and also at places provided additional feedback regarding various aspects of any particular surveyed development. Some of the conclusions made in this report were also derived from the students' observations.

4. Insights from the householder survey

4.1 Perceived indoor conditions

This section highlights the findings from the householders' survey, about their perception of the indoor environmental conditions (indoor temperature and air) inside their homes during winter and summer.

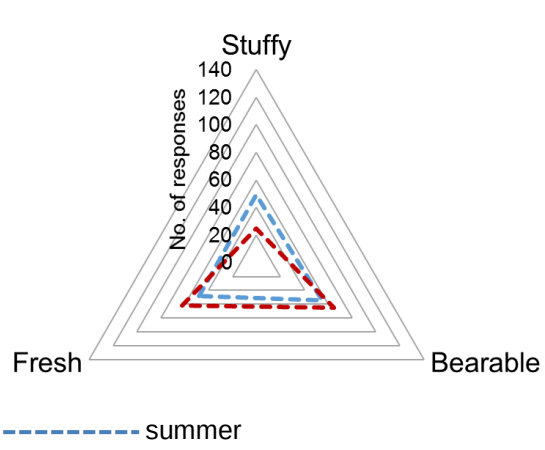
Table 4: Survey questions and householder responses for perceived indoor environment in summer and winter

Ques. no.	Aspects accessed	Response rating scale			No. of response (N)
	Perceived indoor environment in Summer & Winter	**1**	**2**	**3**	
6	Indoor temperature	unsatisfactory	bearable	satisfactory	152
7	Air quality	stuffy	bearable	fresh	152
8	Air movement	draughty	still	well ventilated	152
9	Overall experience	unsatisfactory	bearable	satisfactory	152

Table 4 shows the questions (as shown in Table 3) asked to the responders regrding their perception of the indoor environment, the response rating scale and the total number of responses received during the survey. The survey results, as shown in Figure 9 reveal that majority of the residents (81 in summer & 74 in winter out of total 152) perceive *indoor temperature* to be *bearable* during both summer and winter. However, in comparison to summers, during winters the number of residents perceving *unsatisfactory indoor temperatures* reduces to nearly half and number of residents with *satisfactory* perception is almost doubled. This can be ascribed to moderate external temperatures during winters in the warm-humid climate of Vijayawada. During summers, nearly one third of the surveyed households (55 out of total 152) perceived *indoor air quality* to be *bearable*. And of the remaining surveyed households *stuffy* or *fresh* indoor air quality was perceived by nearly equal numbers (*stuffy*- n: 49; *fresh*- n: 48). On the other hand, in winters almost equal number of households perceived *indoor air quality* to be either *bearable* (65 out of total 152) or *fresh* (62 out of total 152). In winter, the number of households perceiving *stuffy indoor air quality* was nearly half (25) of that during summer (Figure 10). For the purpose of this analysis, *bearable air quality*, is assumed to correspond to a lesser stuffy house, an indoor condition which possibly the residents have learned to cope with.

Figure 9: Perceived indoor temperature

Figure 10: Perceived indoor air quality



On inquiring about *air movement* in their dwellings, nearly 66% (100 out of 152) residents felt their homes were *well-ventilated* during summers. During winters 84% (128 out of 152) of the households perceived *well-ventilated indoor air movement*. The remaining households, during both summer and winter, perceived *indoor air movement* as *still.* None of the surveyed households perceived *Draughty*

dw (doors and windows) (Figure 11). Overall, during winters about 62% (94 out of 152) of the surveyed households reported *satisfactory overall experience* of the indoor environment; while during summer this number dropped to 47% (71 out of 152). Consequently, the percentage of households with *bearable overall experience* was higher in summer (44% (67 out of 152)) as compared to that in winter (32% (49 out of 152)). Similarly, the number of households unsatisfied with their overall experience of the indoor environment was 3% higher in summer as compared to that in winter (Figure 12).

Figure 11: Perceived indoor air movement

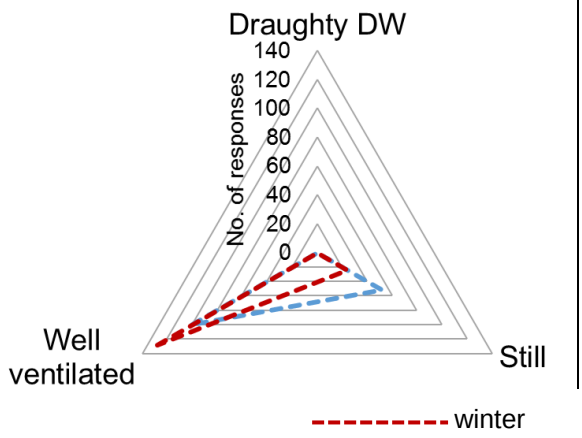
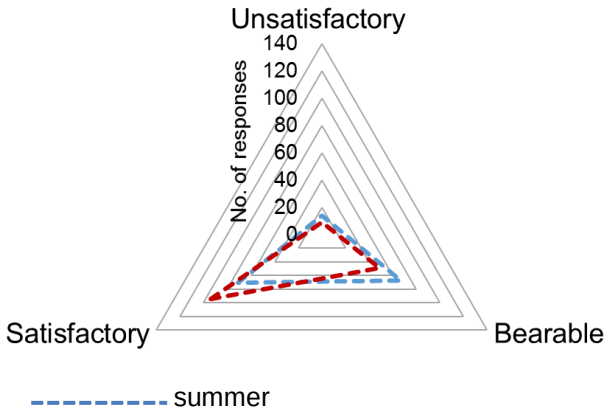


Figure 12: Overall experience

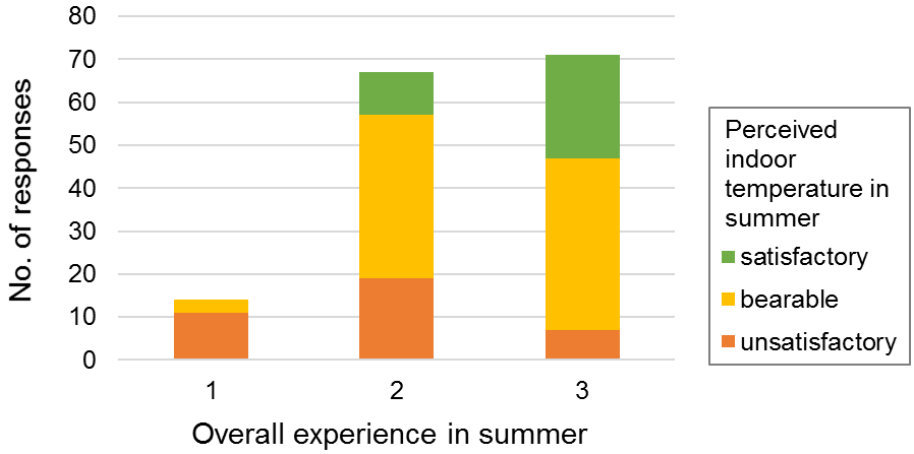


winter summer

Deeper analysis of the survey responses for indoor environmental conditions was performed in order to access the influence of the perception of indoor temperature and air on the residents' overall experience during summer and winter. For this, the householders' responses for their perceived indoor temperature, air quality and air movement were cross related with their corresponding response for the overall experience during summer and winter.

The householders' responses for *overall experience* in summer were compared with their response for perceived *indoor summer temperatures* (as shown in graph in Figure 13 and cross-tabulation in Table 5).

Figure 13: Overall experience vs perceived indoor temperature in summer



Overall experience: 1= Unsatisfactory; 2= Bearable; 3= Satisfactory

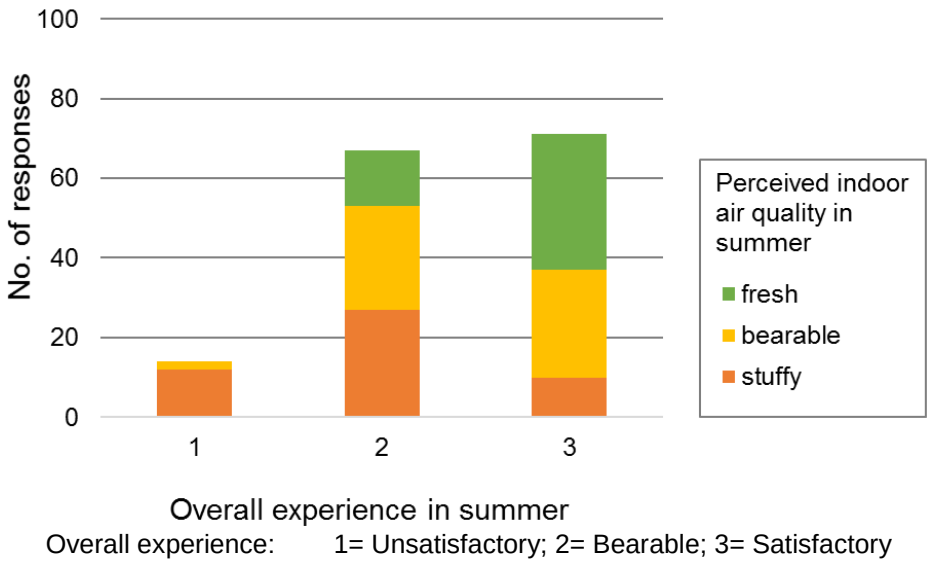
Table 5: Cross tabulation-overall experience vs perceived indoor temperature in summer

		Overall experience in summer			**Total**
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived Indoor temperature in summer	unsatisfactory	11	19	7	**37**
	bearable	3	**38**	**40**	**81**
	satisfactory	0	10	24	**34**
	Total	**14**	**67**	**71**	152

Cross relating the householder survey responses reveals a relatively weak influence of the perception of *indoor temperature* on the householders' *overall experience* of the indoor environment during summer. This is indicated by the fact that of the 71 households reporting *overall satisfactory experience*, majority (n: 40) households perceived indoor temperature to be 'just' *bearable*. The number of households perceiving *bearable indoor temperatures* remains nearly similar irrespective of whether their *overall experience* of the indoor environment is *bearable* or *satisfactory* (Figure 13). Overall, of the 152 surveyed households more number of households perceived *indoor temperature* to be *bearable* (81 out of 152) but for *overall experience* the number of households with *satisfactory* experience was highest (71 out of 152) during summer (Table 5). This indicates that though the residents perceived indoor temperatures in these dwellings mostly *bearable* during summer, it did not have a significant influence on their *overall experience* of the indoor environmental conditions.

The householders' responses for *overall experience* in summer were compared with their response for perceived *indoor air quality* (as shown in graph in Figure 14 and cross-tabulation in Table 6).

Figure 14: Overall experience vs perceived indoor air quality in summer



Overall experience: 1= Unsatisfactory; 2= Bearable; 3= Satisfactory

Table 6: Cross tabulation- overall experience vs perceived indoor air quality in summer

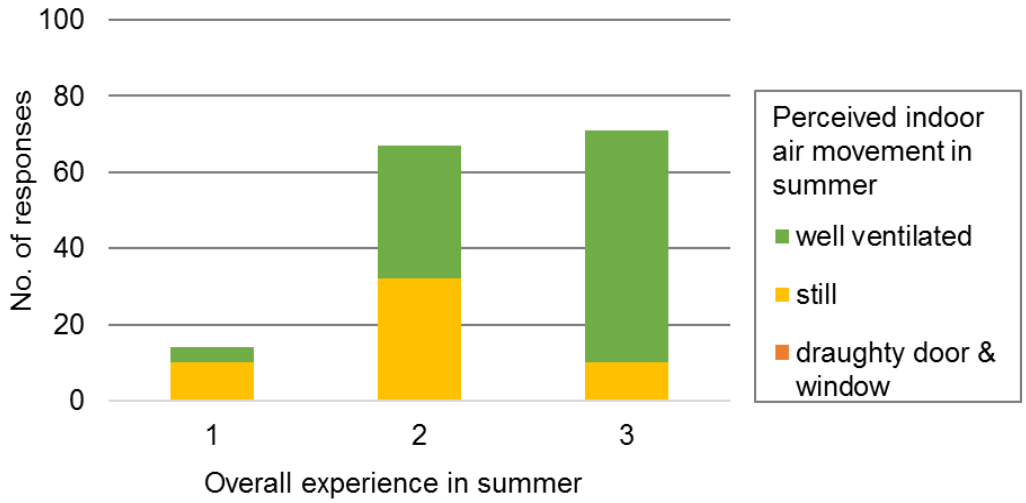
		Overall experience in summer			**Total**
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived Indoor air quality in summer	Stuffy	**12**	**27**	10	**49**
	Bearable	2	**26**	**27**	**55**
	Fresh	0	14	**34**	**48**
	Total	**14**	**67**	**71**	152

The residents' perception *of indoor air quality* in the surveyed dwellings seemed to be generally evenly distributed among *stuffy* (n: 49), *bearable* (n: 55) and *fresh* (n: 48). Consequently, it did not seem to have any significant effect on the residents *overall experience* of the indoor environment. The cross-tabulation analysis revealed that although for the 71 households reporting *overall satisfactory experience* the number of households perceiving *indoor air quality* in their dwellings as *fresh* remains highest (n: 34) a substantial number of these households (n: 27) also perceived *indoor air quality* as *bearable*. Interestingly nearly similar number of households perceived *indoor air quality as stuffy* (n: 27) or *bearable* (n: 26) but their overall experience remained only *bearable.* This shows *indoor air quality* being perceived as poor by most of the residents and indicates towards its weak influence on the residents' *overall experience* of the indoor environmental conditions during summer. While, this conclusion needs to be validated with actual measured data for indoor air quality, the mixed

responses could also be attributed to the design of the survey questionnaire; as perceiving the 'quality' of indoor air may not always be an easily palpable parameter for the householders.

The householders' responses for *overall experience* in summer were compared with their response for perceived *indoor air movement* (as shown in graph in Figure 15 and cross-tabulation in Table 7).

Figure 15: Overall experience vs perceived indoor air movement in summer



Overall experience: 1= Unsatisfactory; 2= Bearable; 3= Satisfactory

Table 7: Cross tabulation- overall experience vs perceived indoor air movement in summer

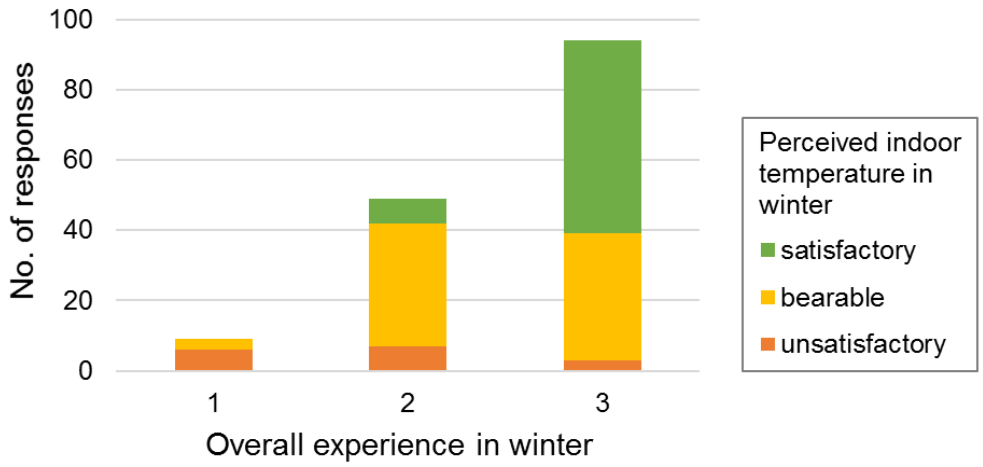
		Overall experience in summer			Total
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived indoor air movement in summer	Draughty door & window	0	0	0	**4**
	Still	**10**	**32**	10	**52**
	Well-ventilated	4	**35**	**61**	**100**
	Total	**14**	**67**	**71**	**152**

The survey revealed that majority of the surveyed households in Jakkampudi colony perceived their dwellings to be *well-ventilated* in summer, and this seemingly had a noteworthy impact on their *overall experience*. Of the 71 households feeling *satisfied* with their *overall experience* 61 households perceived *indoor air movement* to be *well-ventilated* and remaining 10 perceived *indoor air* to be *still.* For the 67 households reporting *overall experience* as *bearable,* nearly equal number of households perceived *indoor air* to be *still* (n: 32) or *well-ventilated* (n: 32) during summer. A perception of *still indoor air* seemed to lead to an *unsatisfactory overall experience*, as of the 14 households with *overall unsatisfactory experience* majority households (n: 10) perceived *indoor air* to be *still*. Given that these dwellings are naturally ventilated, air movement plays a significant role in determining residents' comfort levels in the warm and humid summers of Vijayawada.

A similar comparison of the various factors affecting the residents' overall experience of the indoor conditions was done for the survey responses for winter months. In the warm and humid climate of Vijayawada, the temperature variation between summers and winters is less. The winter months are characterised by moderate external temperature and humidity, which results in better outdoor conditions. Hence, cross relating householders' responses for winter months reveal results quite similar to those observed for summers.

The householders' responses for *overall experience* in winter were compared with their response for perceived *indoor temperature* (as shown in graph in Figure 16 and cross-tabulation in Table 8).

Figure 16: Overall experience vs perceived indoor temperature in winter



Overall experience: 1= Unsatisfactory; 2= Bearable; 3= Satisfactory

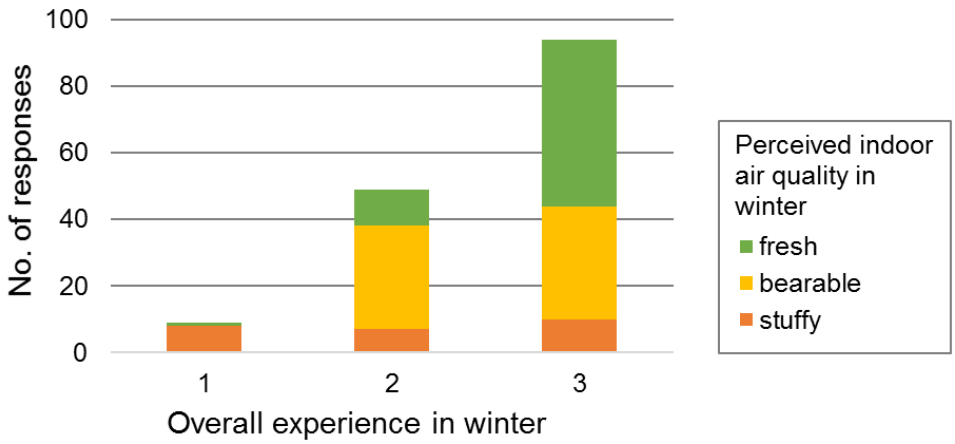
Table 8: Cross tabulation- overall experience vs perceived indoor temperature in winter

		Overall experience in winter			Total
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived indoor temperature in winter	Unsatisfactory	6	7	3	**16**
	Bearable	3	**35**	**36**	**74**
	Satisfactory	0	7	**55**	**62**
	Total	**9**	**49**	**94**	**152**

During winter, the number of households with *satisfactory* perception of *indoor temperature* increases, which seemed to influence the residents' *overall experience* of the indoor environment. Of the 62 households perceiving *satisfactory indoor temperature* in winter, majority (n: 55) households reported *overall experience* also as *satisfactory* and only 7 reported *bearable overall experience*. Similar to summer, in winter too, the number of households perceiving *bearable indoor temperature* remains nearly same irrespective of whether their *overall experience* of the indoor environment is *bearable* or *satisfactory* (Table 8). While this may be indicative of the relatively better thermal performance of the dwellings in winter; this could also be attributed to the moderate external temperatures and humidity during winters. The moderate climatic conditions likely improve the indoor environmental conditions in these dwellings and so does the residents' adaptability of the surroundings.

The householders' responses for *overall experience* in winter were compared with their response for perceived *indoor air quality* (as shown in graph in Figure 17 and cross-tabulation in Table 9).

Figure 17: overall experience vs perceived indoor air quality in winter



Overall experience: 1= Unsatisfactory; 2= Bearable; 3= Satisfactory

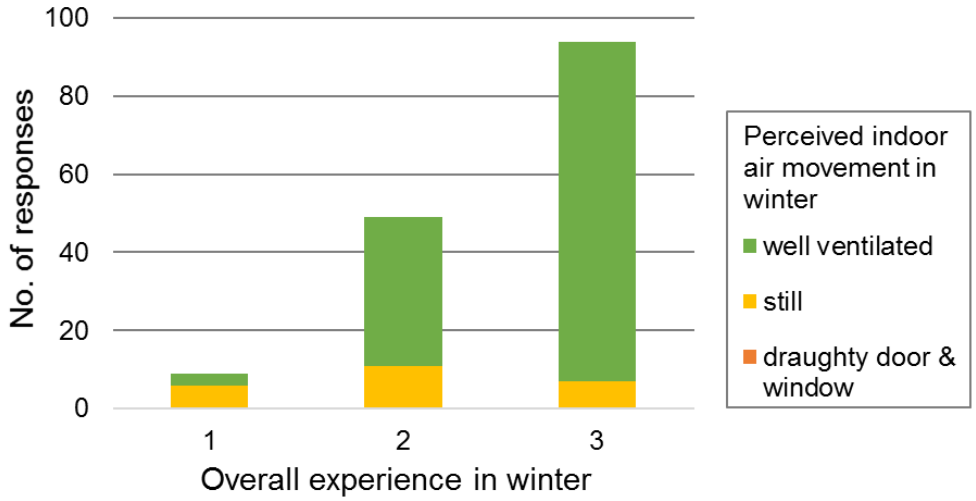
Table 9: Cross tabulation- overall experience vs perceived indoor air quality in winter

		Overall experience in winter			Total
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived Indoor air quality in winter	Stuffy	8	7	10	**25**
	Bearable	0	**31**	**34**	**65**
	Fresh	1	11	**50**	**62**
	Total	**9**	**49**	**94**	**152**

Unlike summer, in winter the residents' perception of *air quality* in their dwellings was found to be either *bearable* or *fresh* which seem to have a mixed effect on their perception of the indoor environment. Of the 94 households reporting *overall experience* as *satisfactory* majority (n: 50) households perceived *indoor air quality* to be *fresh* and 34 households perceived it as *bearable.* 49 households reported *bearable overall experience* during winters of which 31 households perceived *indoor air quality* also to be *bearable*. 11 households perceived *fresh indoor air quality* and only 7 households perceived *indoor air quality* to be *stuffy.* As seen in the case of perceived indoor temperature in winter, this relatively improved perception of *indoor air quality* can also be attributed to the moderate climatic conditions in winter.

The householders' responses for *overall experience* in winter were compared with their response for perceived *indoor air movement* (as shown in graph in Figure 18 and cross-tabulation in Table 10).

Figure 18: overall experience vs perceived indoor air movement in winter



Overall experience: 1= Unsatisfactory; 2= Bearable; 3= Satisfactory

Table 10: Cross tabulation- overall experience vs perceived indoor air movement in winter

		Overall experience in winter			Total
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived Indoor air movement in winter	Draughty door & window	0	0	0	**0**
	still	6	11	7	**24**
	Well-ventilated	3	**38**	**87**	**128**
	Total	**9**	**49**	**94**	**152**

The perception of indoor air movement seemingly had a more significant influence on the residents' overall experience in winter as compared to that during summer. This is indicated by the fact that, of the 94 households reporting *satisfactory overall experience* during winters nearly 93% (87 out of 98) households perceived *indoor air movement* as *well-ventilated* and only 7 households perceived *indoor air movement* as *still.* Likewise, for the 49 households with *bearable overall experience* the number of households perceiving their dwellings to be well-ventilated was found to be highest (38 out of 49). Residents preferred well-ventilated homes during winters.

The above analysis of the survey data is based on purely correlating the householders' response of their *overall experience* of the indoor environment during summer and winter with their corresponding response for the perceived indoor temperature and air.

In the warm and humid climate of Vijayawada which is characterised by moderately high temperatures during summers, moderate temperatures during winters and high levels of humidity throughout the year; the residents find the indoor environmental conditions in these dwellings more comfortable in winters as compared to that during summers. For all the accessed parameters influencing the residents' *overall experience* of the indoor environmental conditions, the number of households perceiving better indoor conditions (temperature and air) was found higher during winters as compared to that during summers. Especially for perceived *indoor temperatures*, the number of *satisfied* households in winter is nearly twice the number of households in summers. This indicates poor thermal performance of the building envelope, especially during summers. Similarly, for *indoor air quality*, as compared to summers the number of households perceiving *stuffy indoor air quality* in winters is nearly half. Though a deeper level of monitoring and analysis is required to determine the actual factors influencing the air quality in these dwellings, from the current survey results this can be attributed to lesser number of households perceiving *still indoor air movement* during winters.

The survey results also revealed *Indoor air movement* (ventilation) as a significant factor influencing the residents' *overall experience* during both summer and winter months. Understandably because of high external humidity levels throughout the year and the dwellings being naturally ventilated, the residents rely on air movement to regulate comfort conditions inside their homes. Though the survey results for perceived *indoor air movement* show majority of the residents perceiving their dwellings to be *well-ventilated* both during winter and summer; providing passive cooling design measures and improving cross ventilation can significantly enhance the overall indoor comfort conditions in these dwellings during summer.

Further, statistical correlation methods were also applied in order to understand any dependencies among the factors influencing the residents' perception of indoor conditions. Kendall's Tau-b (τ_b) correlation coefficient is a nonparametric measure of the strength and direction of association that exists between two ordinal variables. Calculating Kendall's Tau-b correlation coefficient values for various factors influencing the indoor environmental conditions, reveals a moderate correlation value (τ_b = 0.497) between the *overall experience* and perceived *indoor temperature* during winters. Whereas during summers the value is less (τ_b = 0.387) indicating weak association between the two variables (Table 11). For *overall experience* vs *indoor air quality* and *air movement*, the correlation value of 0.417 and 0.406 respectively, reveals a moderate correlation between the variable during summer. In winter the lower correlation value for *overall experience* vs *indoor air quality* and *indoor air movement* show weak correlation between these two variables.

Table 11: Kendall's Tau-b correlation coefficient values

			Kendall's Tau-b (τ_b)
Overall experience in summer	vs	Indoor temperature	0.387
		Air quality	0.417
		Air movement	0.406
Overall experience in winter	vs	Indoor temperature	0.497
		Air quality	0.348
		Air movement	0.326

4.2 Comfort strategies adopted during summer and winter

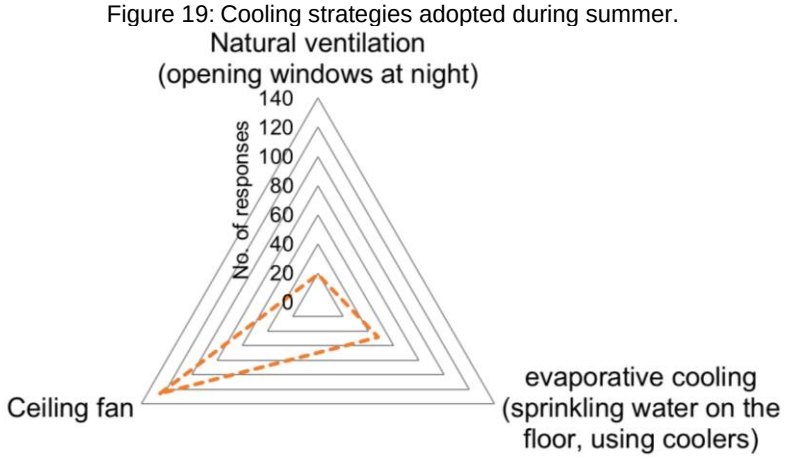
The researchers (students) also inquired from the residents about the adaptive measures used to improve indoor thermal comfort during summer and winter. Table 12 shows the survey questions asked to the responders (as shown in Table 3) their responses and the number of responses received, regarding the comfort strategies adopted during summer and winter. The householders were allowed to choose more than one of the options as their response.

Table 12: Survey questions and householder responses for comfort strategies adopted during summer and winter

Ques. no.	Aspects accessed	Response					
			N		N		N
11	**Cooling strategy adopted during summers**	Natural ventilation (opening windows at night)	19	Evaporation cooling (sprinkling water on the floor, using coolers)	48	Ceiling fan	125
12	**Adaptive strategy during winters**	yes	10	no			142

The survey showed the use of celling fans as a basic and most common measure adopted by the residents of Jakkampudi colony to provide cooling in summers. The householders combined the use of ceiling fans along with natural ventilation to enhance cooling of the indoor spaces. Despite the high external humidity levels throughout the year, use of evaporative cooling measures, such as sprinkling water on the floors, hanging wet cloth/curtains, use of desert coolers was also seen in substantial number of households (Figure 19).

Figure 19: Cooling strategies adopted during summer.



Given the moderate external temperature in winters nearly all the householders (142 out of 152) reported no use of any extra adaptive measures.

4.3 Daylighting

The quality of indoor lighting was accessed by asking the residents if they need to use electrical lighting during the day (question 13 in Table 3). Out of the 152 surveyed households, 88 reported the need to use artificial lighting during the day (Figure 20). The survey did not prompt the residents to provide reasons for their response; however, during the survey it was observed that though the dwelling units were provided with adequate windows and ventilators in each room, these either opened into the central access corridor or the staircase area, and hence had to be kept closed due to privacy and security issues. The only source of natural light in the house is from the balcony door and

window, which depending on the location and orientation of the building block, allowed diffused light into the house (Figure 21, 22 and 23).

Figure 20: Artificial lighting required during the day

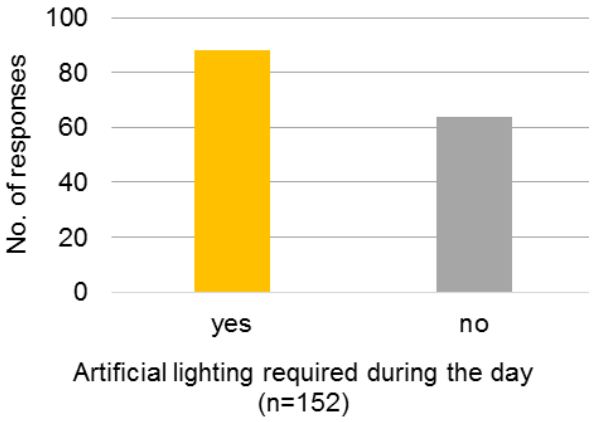


Figure 21: View of balcony door & window of a house

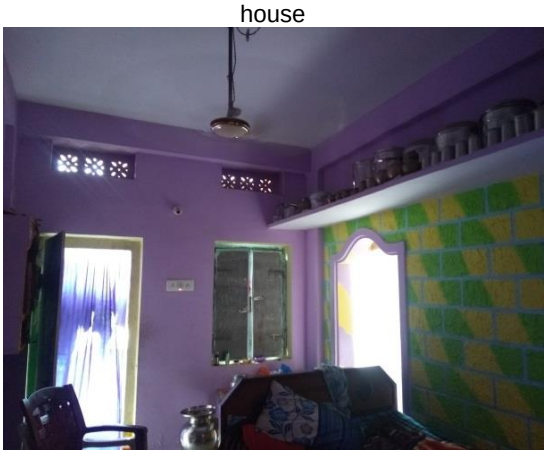


Figure 22: View of room window opening into the access staircase

Figure 23: View of entrance door & window opening into the access corridor.

The researchers conducting the survey also observed that due to the narrow distance between two building blocks, the dwelling units at ground floor did not receive any natural light thought out the day (Figure 24). The survey revealed that mostly the interiors of these dwellings were dark and lack adequate daylighting.

Figure 24: View of adjacent building blocks

4.4 Window shading during summer

Table 13 shows the question (as shown in Table 3) asked to the responders, their responses and the number of responses received about additional measures adopted for window shading during summers. As already highlighted in section 4.3 the dwelling units at Jakkampudi colony receive natural light only from the balcony door and window. When asked about shading the windows during summers, reasonably majority of the households reported not using any additional shading. However, yet a substantial number of households were found using either curtains or blankets or screens to shade their windows during summer.

Table 13: Survey question and householder responses for window shading during summer

Ques. no.	Aspects accessed	Response			
			N		N
10	**Window shading during summer**	None	89	Curtains/blanket/screen/ cloth/netting/ inside or outside blinds	63

4.5 Dampness

The study also focused on visually analysing the quality of construction and building materials used and sought the residents' perception of it through the survey questionnaire. During the interview the researcher inquired about the presence of dampness in that particular dwelling, its specific location and then prompted the respondents to choose one or multiple response from the given options, as to what they perceived was the cause for it. Table 14 shows the survey questions (as shown in Table 3) and the householders responses in this regard.

Table 14: Survey questions and householder responses regarding dampness in the house

Ques. no.	Aspects accessed	Response							
			N		N		N		N
14	Dampness in the house	yes	66	no	86	-	-	-	-
16	Causes of dampness	Leaking of pipes	73	Building material is not water resistant	19	Improper construction workmanship	12	Poor design	21

The poor quality of construction and building materials was evident in the presence of dampness inside many surveyed homes. 43% (66 out of the 152) of the surveyed households reported dampness in their homes (Figure 25). Nearly all these households reported dampness in toilet and/or kitchen walls and hence attributed it to the *leaking of pipes* (poor plumbing). Many households also perceived *building materials not being water resistant* as a cause of dampness (Figure 26). Some of them also attributed the dampness to *improper construction workmanship and poor design.*

Figure 25: Presence of dampness inside the dwelling

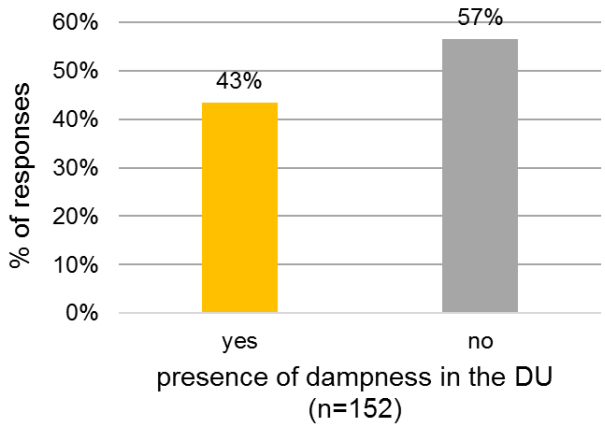
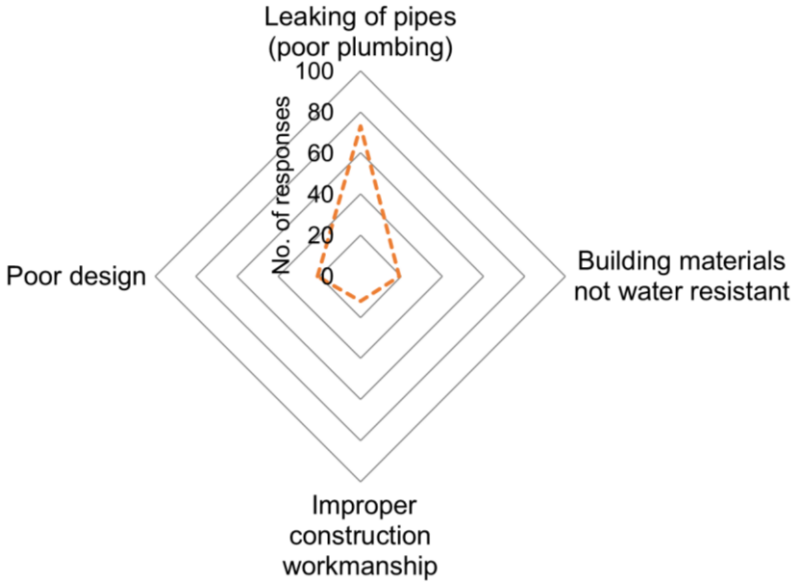


Figure 26: Perceived causes of dampness



4.6 Maintenance and repair

The researchers (students) also inquired from the householders about the maintenance and repair mechanisms in place for the development and if they paid any charges for maintaining the common areas of the building and its surroundings. Table 15 shows the survey questions asked in this regard and the number of responses received.

Table 15: Survey questions and householder responses regarding maintenance and repair of the development

Ques. No.	Maintenance and repair	Response			
			N		N
17	Is the maintenance of the common areas and building regularly done?	yes	134	no	18
18	Do you pay into a resident's welfare association to cover maintenance and repair costs for common areas and the building?	yes	124	no	28

The residents informed that the development has a Residents Welfare Association in place which carries out regular up-keep and maintenance of the common areas. Majority of the residents pay a monthly charge for the same. However, visits to the Jakkumpudi colony revealed that despite this, the

streets and the surroundings of the area are not properly maintained. The drainage and sewage system in the development is not properly planned and maintained, which has resulted in the accumulation of sewage water and garbage in the barren land around the colony (Figure 27, 28, 29 and 30). This has resulted in sever health issues for the residents.

Figure 27: View of site behind Jakkampudi colony

Figure 28: Garbage accumulated behind a dwelling

Figure 29: Sewage water accumulated behind the development

Figure 30:View of site behind Jakkampudi colony

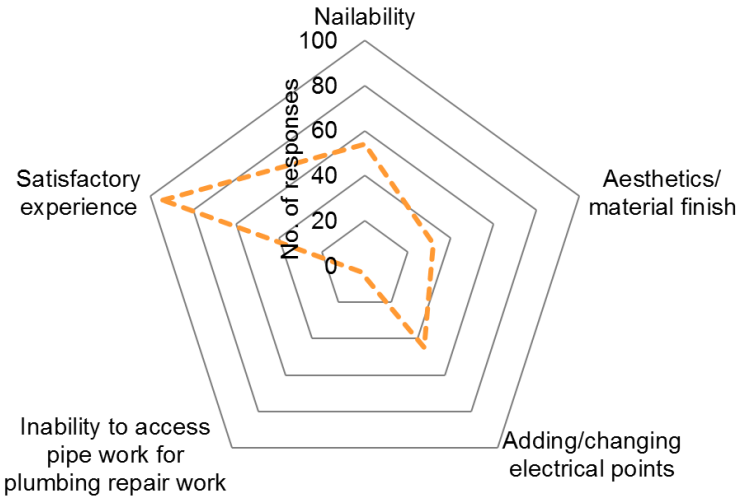
Table 16: Survey question and householder responses regarding acceptability of building materials

Ques. No.	**Aspects accessed**	**Response**					**No. of response (N)**
19	What is your experience with respect to the building materials used? Any issues with options mentioned?	Satisfactory experience	Aesthetics/material finish	Nailability	Adding/changing electrical points	Inability to access pipe for plumbing repair works	152

For this survey question the householders were allowed to choose more than one response. During the survey, majority number of residents (n: 94) expressed having a satisfactory experience with the building materials. However nearly 54 residents expressed concern regarding the *'Nailability'* 'i.e. the suitability [of a wall] for being nailed and about 45 households expressed facing difficulty in *adding/changing electrica*l *points.* Some of the residents also voiced their opinion on the aesthetics of

the buildings, which of course is subjective and pertains to the architectural design and/ or external/internal finishes of the building (Figure 31).

Figure 31: Householder experience with the building materials used



4.7 Location

The survey questionnaire also covered aspects related to the location of the development. Table 17 shows the survey questions (as shown in Table 3) asked to the householders and their responses regarding accessibility to basic facilities.

Table 17: Survey questions and householders' responses regarding the aspects related to the location of the development.

Ques. No.	Aspects accessed	Response					No. Of response (N)
20	Convenient access to essential facilities	yes	no	-	-	-	152
21	Travel time to work (minutes)	0-20	20-40	40 -60	60 min & above		152
22	Travel time to school (minutes)	0-20	20-40	40 -60	60 min & above		87
23	Mode of travel to work; hospitals and other essential services	Own vehicle	Access to public transport	Walking distance	Availability of conveyance is an issue		152
24	Mode of travel to school	Own vehicle	Access to public transport	Walking distance	School bus	No school going children in the house	87

The housing development is located approximately 11 km away from the city centre. During the survey it was found that for residents of most households (81 out of 152) the place of work is not at a convenient distance from their residence (Figure 32). The travel time to work varies across the surveyed households with majority (42 out of 152) taking more than an hour (>60 minutes) to reach to their work place (Figure 33). An almost equal number of households (40 out of 152) also reported

taking around 20 minutes, while remaining residents reported taking 20 to 60 minutes for traveling to work.

Figure 32: Householder responses for proximity to work place

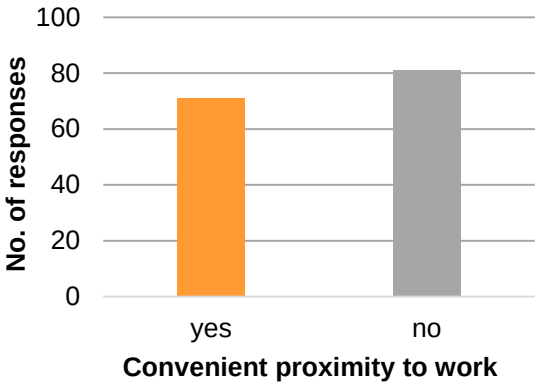


Figure 33: Householder responses for time required to travel to work

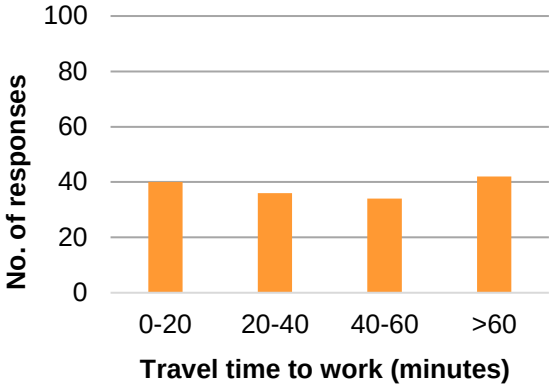
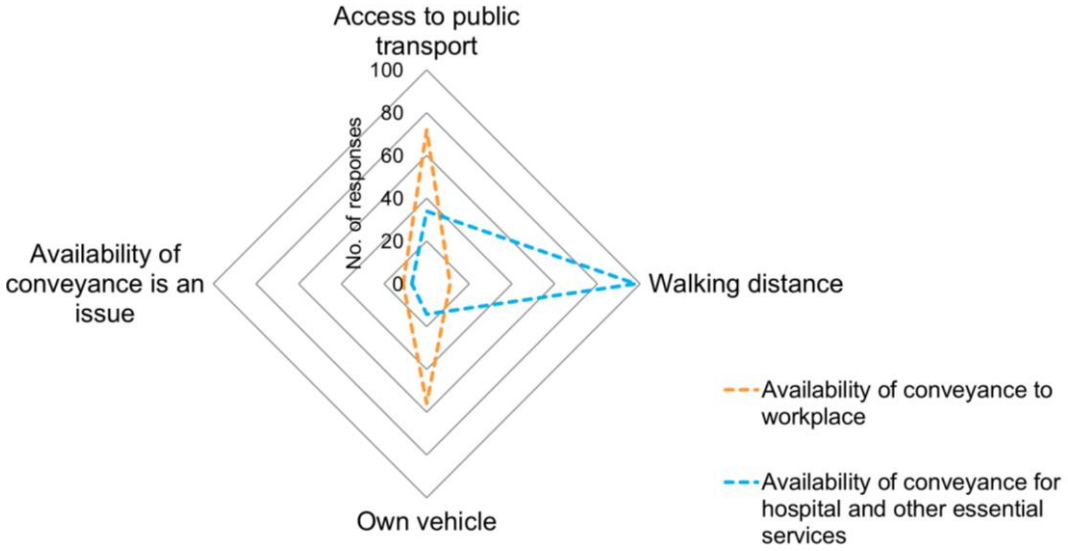


Figure 34: Mode of travel



Access to public transport for commuting to the work place was reported by 72 households, while 56 households have their *own vehicle* to commute to work and other places. Basic facilities such as hospitals and market place are at proximity from the development (Figure 34). Overall the residents did not seem to have issues regarding the connectivity of the development.

Of the 152 surveyed dwellings, 87 households had school going children. Majority of the children in the development use *school bus* to commute to their schools. Some have their schools at a walking distance while some others use public transport to travel to school (Figure 36). Mostly the children take about 20 minutes to reach to their schools while others take 20 minutes or more (Figure 35).

Figure 35: Travel time to

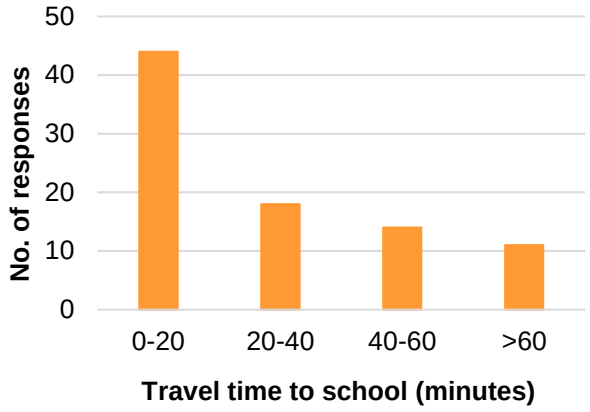
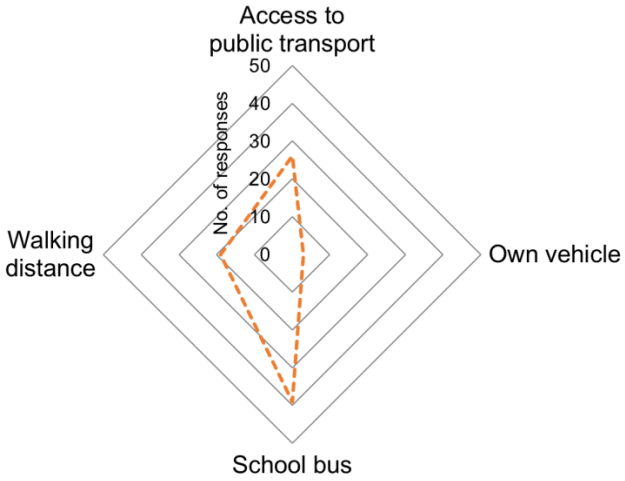


Figure 36: Mode of travel to school

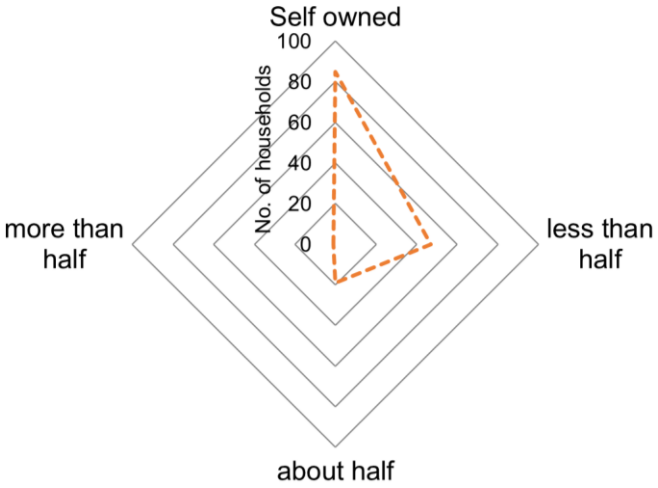


4.8 Affordability

The survey questionnaire also covered the aspect of affordability by inquiring from the residents about the household expenditure on monthly rent and electricity bills (question no. 4 and 5, Table 3). At the time of the survey the households had been occupied for more than 5 years. Of the 152 surveyed households, nearly 56% (85) houses were owned by the residents themselves. The remaining houses (66) were rented of which majority (47) households spent *less than half* of their monthly income on rent (Figure 28).

Majority (116 out of 152) of the surveyed households at Jakkampudi colony paid about 150 to 300 INR for electricity.

Figure 37: Proportion of monthly income spent on rent



5. Conclusions

- The *overall experience* of the householders with indoor environmental conditions in the surveyed dwellings remains mostly *satisfactory* during both summer and winter. However, for any given variable (temperature, indoor air movement, indoor air quality), the residents' perception generally lies between *bearable* and *satisfactory* during summer and winter. Given the higher number of householders experiencing *unsatisfactory indoor temperature* during summer, this indicates relatively poor thermal performance of the building envelope during hot weather.
- The materials used for construction is mainly RCC for the structure and flyash bricks for walls. Nearly 41% of the surveyed households reported to have a *satisfactory experience* with the building materials. Some residents reported facing issue of *'Nailability'* and difficulty in *adding/changing electrical points* inside their homes. The residents also complained of presence of dampness mainly on the toilet and/or kitchen walls and attributed this to the *leaking of pipes* (poor plumbing), indicating poor quality of workmanship.
- Though majority of surveyed householders perceived their homes to be *well-ventilated* in both summer and winter (100 in summer and 128 in winter out of 152), in summers the number of households perceiving *stuffy indoor air quality* is higher, which may be due the inappropriate locations of the window wherein most of the windows and ventilators open on to the central access corridor and/or the staircase (Figure 38 and 39). The residents are forced to keep these windows closed due to privacy issues, resulting in inadequate cross-ventilation, making the interiors feel *stuffy*, especially in summers.

Figure 38: Window opening onto the staircase

Figure 39: Windows opening into the central cut out space

- The inefficient design of the windows along with the planning and location of the building blocks has also resulted in poor quality of daylight in these dwellings. Due to the narrow distance between two building blocks, the ground floor units do not receive enough daylight for most of the year. The only source of natural light in these houses in the balcony door and window, which allows for diffused light inside the house.
- The small size of the dwelling units emerged as a concern in this and other case studies in MaS-SHIP. With majority of the households comprising four members, the household size added to the prevalence of discomfort in these dwellings.
- It was found that this development also lacked cleanliness and maintenance. Despite the presence of a Residents' Welfare Association, the streets in the development had garbage accumulated on the sides. The poor planning of drainage and inappropriate sewage disposal

from the houses has resulted in water logging and sewage water accumulation on a barren land behind the development, results a strong stench and posing health hazards to residents of the development.

- The residents seemed to have adapted to the location and their surroundings of the development. The householder survey revealed that while the distance of place of work from the development varied across the surveyed households and was majorly found inconvenient, access to basic facilities such as hospitals and schools was mostly convenient.