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Findings from householder survey in Laggere housing colony, Bangalore

Case study report

Rajat Gupta, Sanjoli Tuteja,
Pratibha Ruth Caleb, Megha Behal,
Jesus Salcedo.

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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 155 social housing residents of the Laggere area. The Laggere slum rehabilitation project was developed to improve the living conditions of slum dwellers in the area. The project designed and executed by BMTPC, demonstrates the use of alternate cost-effective building materials and systems for constructing low-cost housing in India. 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.

Although the building materials used in this social housing development were low cost and environment friendly, the householder survey revealed that indoor comfort was perceived to be (just) bearable during summer and winter. Despite moderate external temperatures throughout the year, these naturally ventilated dwellings were unable to provide adequate indoor thermal comfort during both summer and winter. Nearly one third (49 out of 155) of the surveyed households perceived indoor temperature to be *unsatisfactory* in winters. In summers this number was even higher (66 out of 155). Although, nearly two third of the residents perceived their dwellings to be well-ventilated during summer and winter, their perception of indoor air quality remained largely bearable. The building materials used may have proven cost effective but did not seem to be appropriate for the climatic conditions of the location. The residents living on the upper floors complained of water seepage from the roof and walls during the monsoon season. This could also be indicative of poor workmanship during construction. 'Nail-ability' of the walls also emerged as a major concern for the residents, since the wall materials did not allow residents flexibility of making basic alterations to the interiors. The development also lacked in maintenance and cleanliness of the buildings and common areas, as well as open areas and streets. Negligence of the local authorities regarding such developments could also be seen from the fact that, nearly 59 % (89 out of 151) households did not have electricity meters installed in them and were therefore not paying any electricity bill. A few households were illegally occupied.

1. Introduction

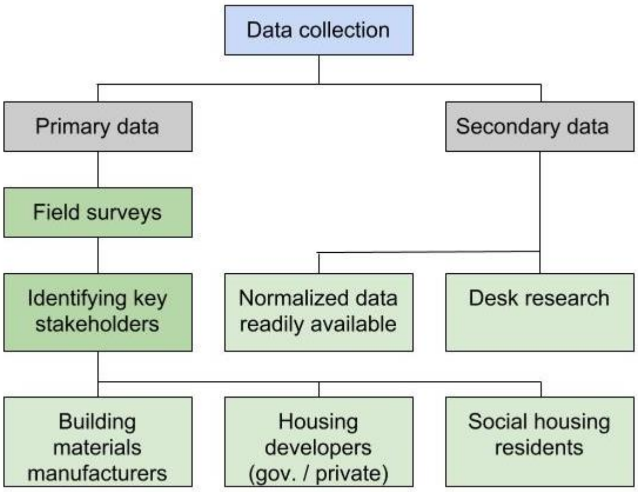
The urban housing shortage in India is currently estimated at 10 million, more than 95% of which pertains to low-income groups. Through its “Housing for All by 2022” mission, the Government of India intends to close this gap by aiming to construct 12 million housing units over the programme duration 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.

“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 – providing a methodology 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).

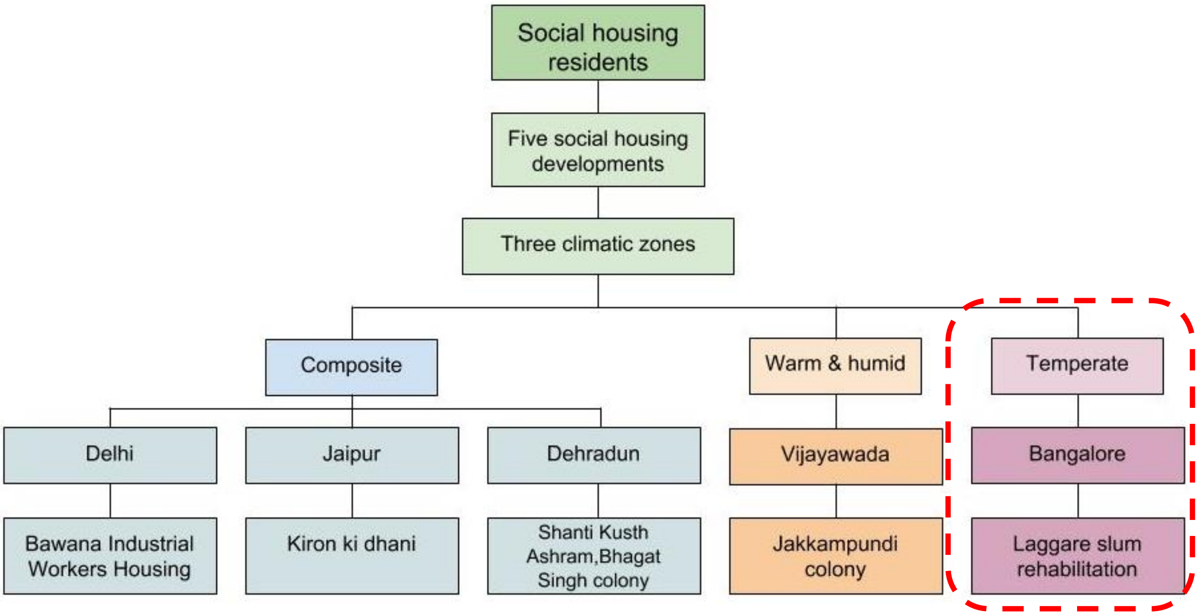
Figure 1: MaS-SHIP data collection methodology



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 Bangalore, representing the temperate 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 Laggere housing development 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 is summarised in this sections and critical aspects that need to be addressed are highlighted.

2. Case study overview

The first model demonstration housing, constructed under the Valmiki Ambedkar Awas Yojana (VAMBAY), is located at Laggere, in the North-west outer rim of Bangalore. The housing project is one of the many social housing developments by the Karnataka Slum Development Board, constructed with an aim to upgrade the dwelling units and improve living conditions for the slum dwellers of the Laggere area. Designed and constructed by Building Materials and System Promotion Council (BMTPC), the slum rehabilitation housing project at Laggare demonstrates the use of cost-effective materials and systems for use in social housing projects in India.

Table 1: Case study overview

Category	**Case study**
Location	Bangalore
Name of the development	Laggere slum rehabilitation
Government scheme	Valmiki Ambedkar Awas Yojana
Occupancy	10 years
Target group	Economically Weaker Section (slum dwellers)
Distance from city centre	13 km
Number of dwelling units	252
Built-up area of each dwelling (sq. ft.)	275
Cost of construction (INR per sq. ft.)	218

The development consists of G+2 storey structures housing 252 dwelling units. The 125 houses under VAMBAY and the 127 additional houses by the Karnataka Slum Clearance Board were designed to share maximum common walls. A typical floor layout comprises of four dwelling units accessed by a centrally located staircase and lobby provided at each level. With a built-up area of about 275 sq. ft. the dwelling units consists of two rooms, a kitchen, one WC and a separate shower area. Windows have been provided on the two longer façades, such that each unit has window openings only on one external wall; reducing the possibility of cross ventilation (Figure 3).

Figure 3: Typical unit layout

2.1 Building materials and system

The Laggere slum rehabilitation housing development was one of BMTPC's demonstration housing projects, developed with an aim to showcase and popularise the use of emerging sustainable and energy efficient building materials and systems for use in social housing projects in India. The building materials and construction systems used in the project (Table 2) allowed to limit the cost of construction to Rs. 220 per sq. ft. The householders paid on an average of about Rs. 60,000 at the time of possession.

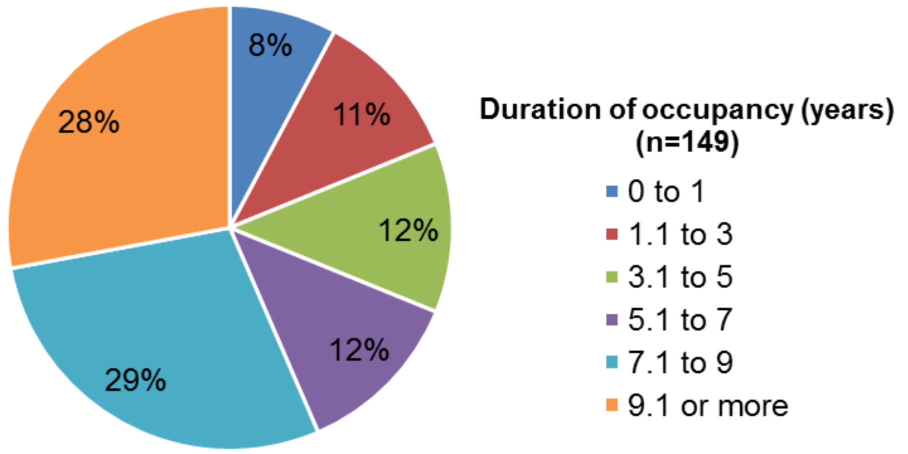
Table 2: Building materials used in Laggere

Foundation	• Random rubble stone masonry
Walling	• Solid concrete blocks for 200 mm thick walls • Clay bricks for partition walls • RCC plinth band for earthquake resistance
Roof / Floor	• RC filler slab using clay bricks as fillers in ground and first floors • RC slab for second floor • IPS flooring
Doors and windows	• Pre-cast RCC door frames • Coir polymer door shutters • Clay jalli in ventilators
Others	• External cement plaster • White wash on internal walls • Waterproof cement paint on external walls • Precast Ferro cement lofts, shelves, chajjas

2.2 About the households

At the time of the survey the houses had been occupied for more than 10 years with most of the original residents still living there. Of the 154 surveyed households about 28% had been occupied for more than 9 years. About the same percentage of houses (29%) had been occupied in between 7 to 9 years. An almost equal number of surveyed households had been occupied for a period of 3 to 7 years. Whereas less than one fourth of the surveyed dwellings were found to have been recently occupied within the past three years (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 five or more members which made the living congested.

Figure 5: Occupancy of the surveyed households

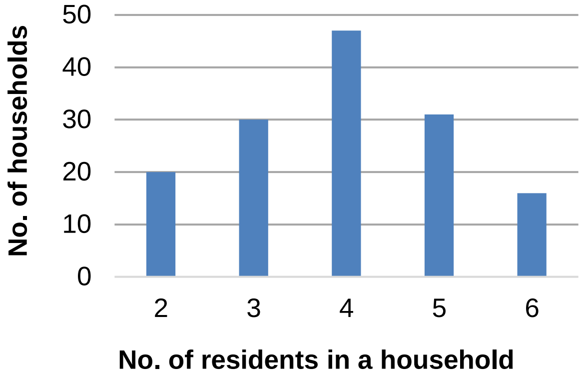


Figure 6: Interior of a DU at Laggere

The surveyed households had 61% of residents aged between 19-58 years (Figure 7), and most of them would spend about 14-16 hours at home during the day (Figure 8). 29% of the residents' aged between 3-18 years which would mean mostly children a majority of whom also spent similar amount 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. A considerable number of residents were also reluctant to disclose this information.

Figure 7: Age group of residents

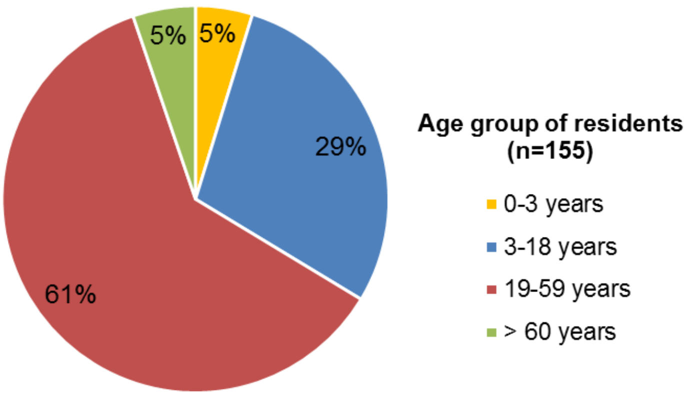
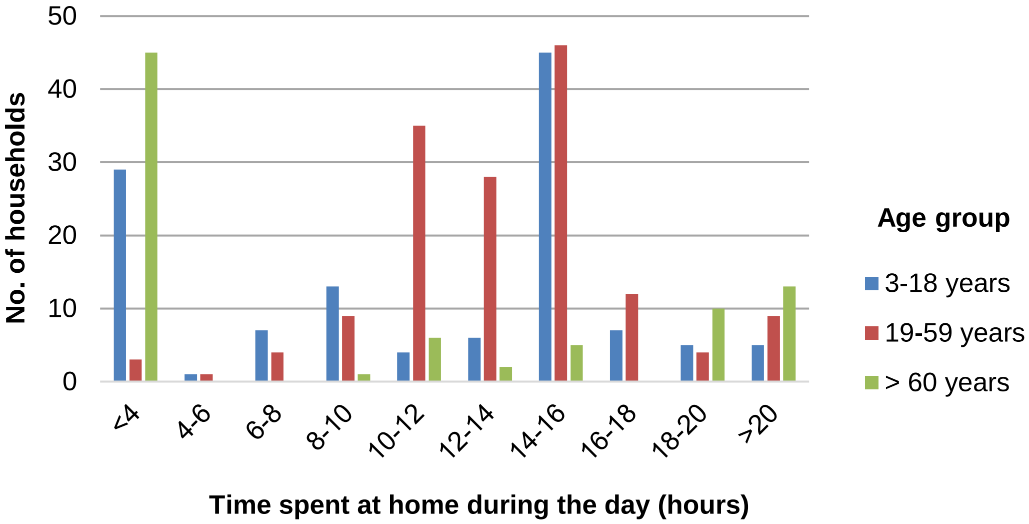


Figure 8: Time spent at home during the day



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 the 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	What is your experience with respect to 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 residents' survey, about their perception of the indoor environmental conditions (indoor temperature and air) inside their homes during winter and summer. Table 3 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.

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

Ques. no.	Aspects accessed	Rating scale			No. of response (N)
	Perceived indoor environment in Summer & Winter	**1**	**2**	**3**	
6	Indoor temperature	unsatisfactory	bearable	satisfactory	155
7	Air quality	stuffy	bearable	fresh	155
8	Air movement	draughty	still	well ventilated	155
9	Overall experience	unsatisfactory	bearable	satisfactory	155

The survey results, as shown in Figure 9, reveal that majority number of surveyed households (71 in summer and 81 in winter out of total 155) perceived *indoor temperature* to be *bearable* during both summer and winter. However, in comparison to summers, during winters the number of residents feeling completely *unsatisfied* with the *indoor temperatures* reduces and number of *satisfied* residents increases marginally. Similarly, indoor air quality was perceived as *bearable* by majority of the surveyed households (74 in summer & 96 in winter out of total 155) during both summers and winters (Figure 10). Though in summer, the number of households perceiving *indoor air quality* as *stuffy (n: 41)* was substantially higher as compared to winter (n: 26), interestingly the number of households perceiving *indoor air quality* as *fresh* was also found to be higher during summer (n: 40). In this study, *bearable air quality*, is assumed to correspond to a lesser stuffy house, an indoor condition which the residents have learnt to cope with.

Figure 9: Perceived indoor temperature

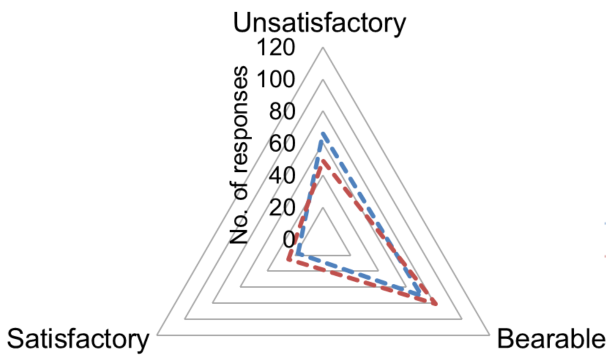
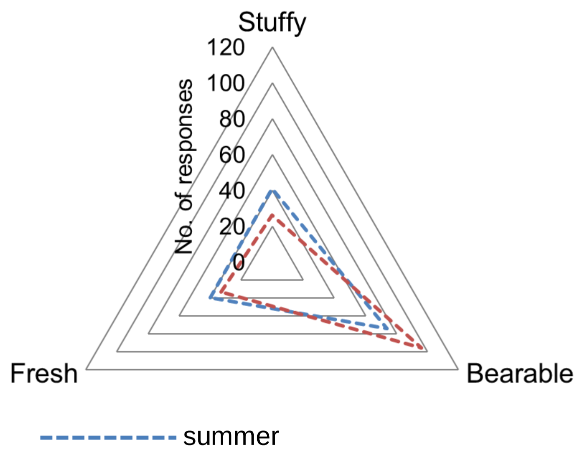


Figure 10: Perceived indoor air quality



On inquiring about the *air movement* in their dwellings, 68% (105 out of 155) residents felt their homes were *well-ventilated* during summers and 75% (116 out of 155) households perceived *well-ventilated indoor air movement* during winter. The percentage of households perceiving *indoor air movement* as *still* was less (46 in summer & 36 in winter out of total 155) and that of *draughty dw (doors and windows)* was negligible (4 in summer & 3 in winter out of total 155) during both summer and winter (Figure 11). Overall, majority number of households reported *overall experience* as *bearable* during both summer and winter. However, the number of households *unsatisfied* with their *overall experience* was higher in summer (n: 47) as compared to that in winter (n: 32). Likewise, though the number of households with *satisfactory overall experience* of the indoor environmental conditions was found to be higher during winter (n: 43) as compared to that during summer (n: 36) the difference in the numbers is only marginal (Figure 12). This is plausible, as the temperate climate of Bangalore, is characterised by moderate external temperatures during both summer and winter with less variation in temperature throughout the year. The residents' perception of the indoor environment is also therefore found to be similar for the two seasons.

Figure 11: Perceived indoor air quality

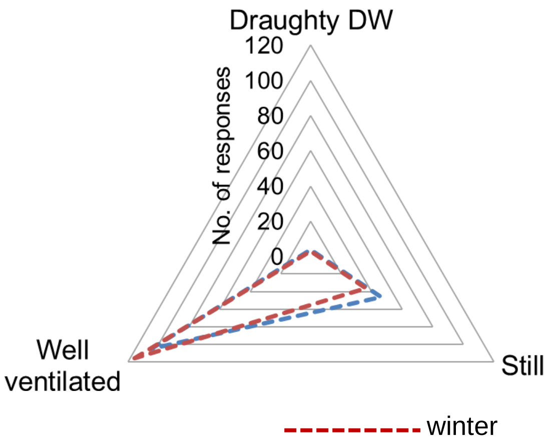
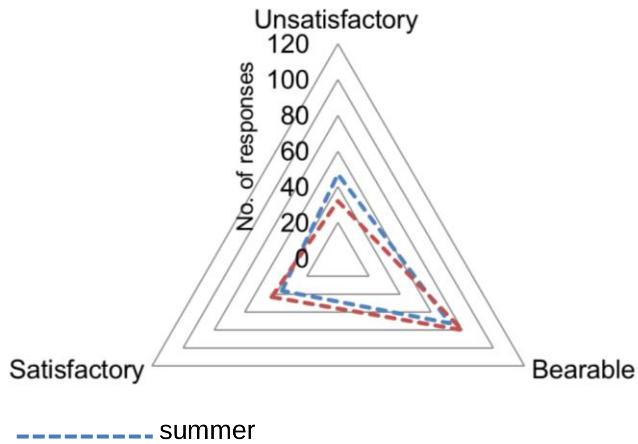


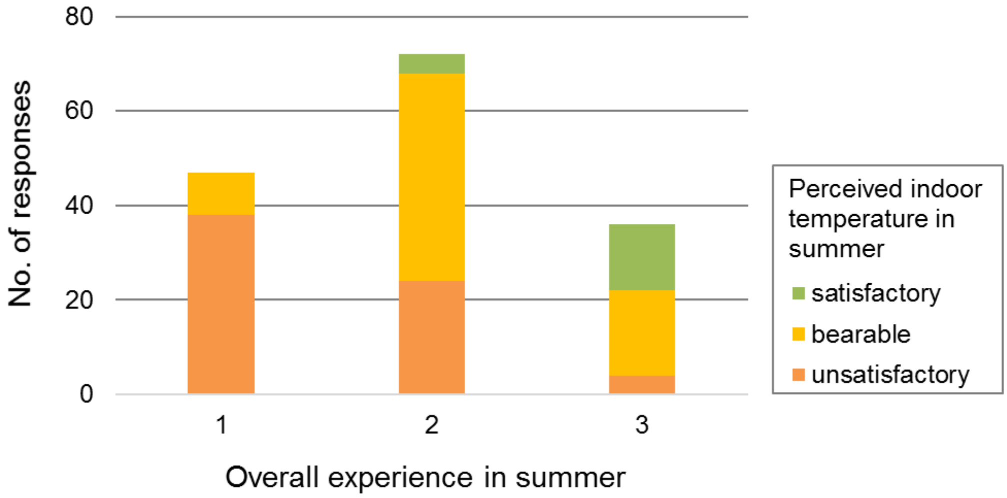
Figure 12: Overall experience



Deeper analysis of the survey responses for indoor environmental conditions was performed in order to assess the influence of the 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

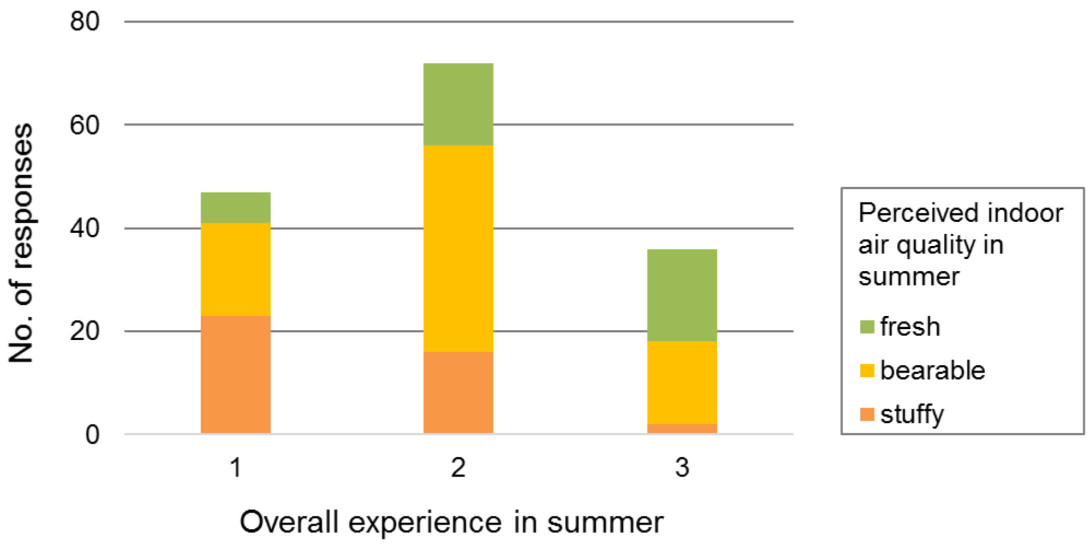
Table 5: Cross tabulation- overall experience vs perceived indoor temperature in summer

		Overall experience in summer			Total
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived Indoor temperature in summer	unsatisfactory	**38**	**24**	4	**66**
	bearable	9	**44**	**18**	**71**
	satisfactory	0	4	14	18
	Total	**47**	**72**	**36**	**155**

Cross relating the householder survey responses revealed that an *unsatisfactory* perception of the *indoor temperature* likely had a direct impact on the residents' *overall experience* of the indoor environmental conditions and lead to an *overall unsatisfactory experience*. Of the 47 households reporting *unsatisfactory overall experience* 81% (38 out of 47) households perceived *indoor temperature* also as *unsatisfactory*. Similarly, for the 72 households reporting *bearable overall experience* the number of households perceiving *indoor temperatures* also as *bearable* was found to be highest (n: 44). Interestingly, the number of households with *bearable* perception of the *indoor temperatures* was also highest (n: 18) for the 36 households with *satisfactory overall experience.* A few of households (n: 24) however, despite their *unsatisfactory* experience of the *indoor temperatures* reported their overall experience as *bearable*. This mixed influence of the perception of indoor temperatures on the residents' overall experience of the indoor environment during summer, can be attributed to the moderate external temperatures experienced in Bangalore throughout the year. However, despite this, the higher number of households, with *bearable* and/or *unsatisfactory* perception of the indoor temperature indicates towards the relatively poor thermal performance of the dwellings.

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

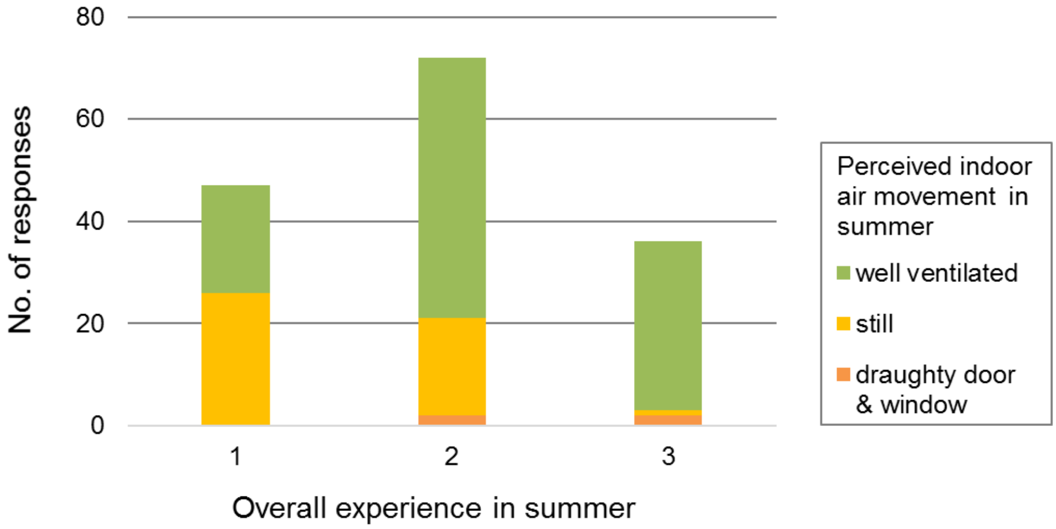
Table 6: Cross tabulation - overall experience vs perceived indoor air quality in summer

		Overall experience in summer			Total
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived Indoor air quality in summer	stuffy	**23**	16	2	**41**
	bearable	**18**	**40**	**16**	**74**
	fresh	6	**16**	**18**	**40**
	Total	**47**	**72**	**36**	**155**

The survey found that the householders of Laggere colony had a relatively mixed perception of *indoor air quality* during summer, which did not seem have any significant effect on their *overall experience* of the indoor environment. Of the 47 households reporting *overall experience* as *unsatisfactory* nearly 50% (23 out of 47) perceived *indoor air quality* as *stuffy* and a substantial percentage (38% (18 out of 47)) also perceived it as *bearable*. Likewise, of the 72 households reporting *overall experience* as *bearable,* 40 households (55%) also perceived *indoor air quality* to be *bearable* during summers. Equal number of households (n: 16) perceived *indoor air quality* as both *stuffy* and *fresh* but found their *overall experience* to be ‘just’ *bearable.* For the 36 households reporting *satisfactory overall experience*, only 50% (18 out of 36) households perceived *indoor air quality* as *fresh* and majority (n: 16) of the remaining households perceived it as *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.

Further, 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

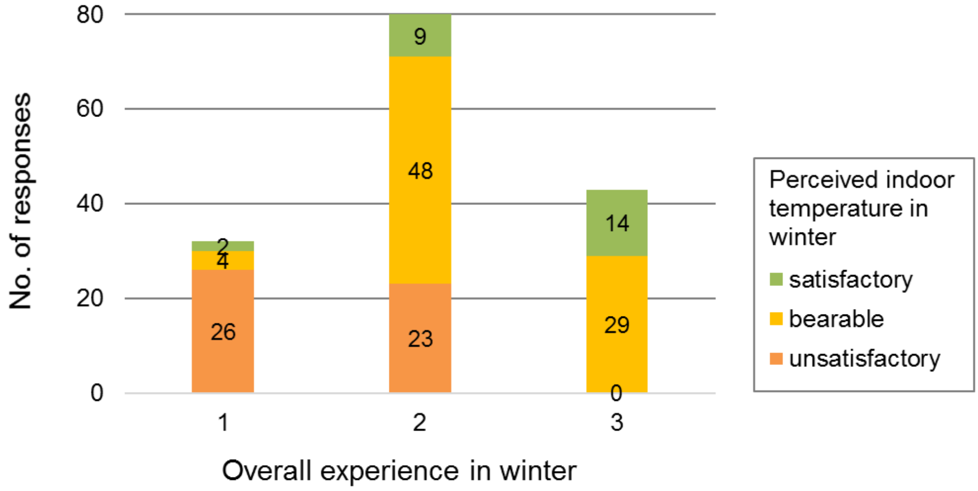
		Overall experience in summer			**Total**
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived Indoor air movement in summer	Draughty door & window	0	2	2	4
	Still	**26**	**19**	1	**46**
	Well-ventilated	**21**	**51**	**33**	**105**
	Total	**47**	**72**	**36**	**155**

Though majority of the surveyed households (105 out of 155) perceived their dwellings to be *well-ventilated* during summer, this seemingly had a mixed influence on their *overall experience* of the indoor environment. This is indicated by the fact that, for the 51 households perceiving *well-ventilated* interiors during summer, their overall experience remained only *bearable* (Table 7). Similarly, 21 households perceived their dwellings to be *well-ventilated* during summer but reported *unsatisfactory overall experience*. For some residents however, *well-ventilated* indoors did lead to a *satisfactory overall experience* as- of the 36 households reporting *satisfactory overall experience*, nearly all (n: 33) households perceived their dwellings to be *well-ventilated*. Likewise, the perception of indoor air being *still* resulted in poor overall experience. As of the total 46 households perceiving *indoor air* as *still*, 26 households reported *unsatisfactory* and 19 households reported *bearable overall experience* during summer. Given that these dwellings are naturally ventilated, and high wind speed experienced in Bangalore during summer, the weak influence of perception of *indoor air movement* in improving the residents' overall experience could be attributed to the location of windows in these dwellings. As seen in Figure 3, windows have been provided for each space (room) in the dwelling; however, these are located only on one external wall of the building, thus restricting the possibility of cross ventilation.

A similar comparison of the various factors affecting the residents' overall experience of the indoor environment was done for the winter months. Owing to less variation in external temperatures during summer and winter in Bangalore, the crosstabulation analysis of the survey responses for overall experience vs perceived indoor temperature; air quality and movement (Figure 16, 17 and 18 respectively) for winter, revealed results similar to that during summer.

In winter too, the perception of *indoor temperature* seemingly had a mixed effect on the residents' *overall experience* of the indoor environment. Due to relatively reduced external temperatures in winter, the number of households *unsatisfied* with both *indoor temperature* and *overall experience* reduces, but only marginally (Figure 16). Though the number of households with *overall satisfactory experience* increases in winter (n: 43), the cross-tabulation analysis shows that among these households the number of households with perceived *indoor temperature* as *bearable* remains highest (29 out of 43). Interestingly, for the 80 households with *bearable overall experience* the distribution of householders perceiving *indoor temperature* as *bearable* (n: 48) and/or *unsatisfactory* (n: 23) remains nearly same as that during summer (Table 5). Likewise, for householders with *unsatisfactory overall experience* (n: 32) the number of households perceiving *indoor temperature* also as *unsatisfactory* was found to be highest. This indicates towards the poor thermal performance of the dwellings even in winters.

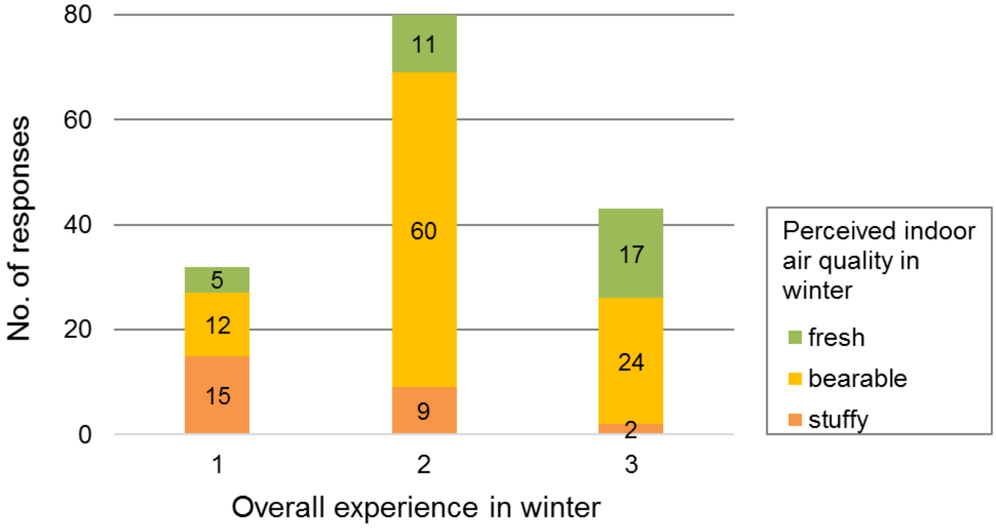
Figure 16: Overall experience vs perceived indoor temperature in winter



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

The perception of *indoor air quality* did not seem to have any significant influence on the householders' *overall experience* of the indoor environment even during winter (Figure 17). Of the 80 households reporting *overall experience* as *bearable*, 60 households perceived *indoor air quality* also as *bearable*. However, the number of households perceiving *indoor air quality* as *bearable* was also found to be highest (n: 24) for the 43 households reporting *overall satisfactory experience*. For the 32 households reporting *overall experience* as *unsatisfactory*, nearly equal number of households perceived *indoor air quality* as either *stuffy* (n: 15) or *bearable* (n: 12).

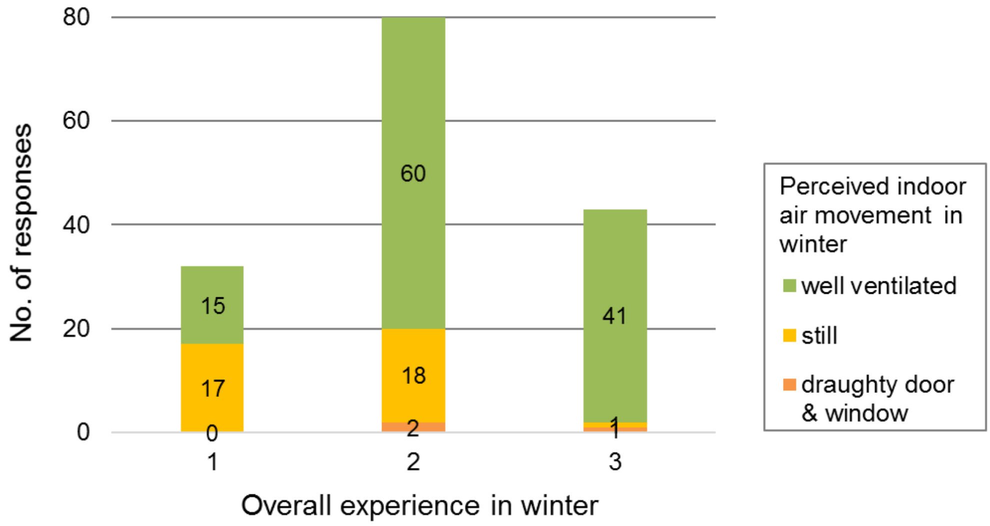
Figure 17: Overall experience vs perceived indoor air quality in winter



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

Majority of the householders of Laggere colony perceived their dwellings to be *well-ventilated* during winters as well, and this seemed to have a mixed impact on their *overall experience* of the indoor environment (Figure 18). Of the 116 households perceiving *well-ventilated* indoors, majority households (n: 60) reported *bearable*, 41 reported *satisfactory* and 15 households reported *unsatisfactory overall experience* during winter. In winters, though relatively lesser number of households perceived indoor air as still (n: 36), nearly equal number of these households reported *overall experience* as *bearable* (n: 18) or *unsatisfactory* (n: 17), thus indicating the poor effect of *still indoor air* on the residents' *overall experience* of the indoor environment during winter. In Bangalore's temperate climate, however, the residents seemed to prefer well-ventilated dwellings.

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



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

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 temperate climate of Bangalore which is characterised by moderate temperatures and humidity during both summer and winter; air movement plays an important role in determining indoor comfort conditions in naturally ventilated buildings. The above analysis of the survey data reiterates this aspect. Though less in numbers (36 in summer and 43 in winter out of 155) the number of households *satisfied* with their *overall experience* of the indoor environment is highest for residents perceiving their homes to be *well-ventilated*, both in summer and winter. The existing design and layout of these dwelling units does not encourage cross ventilation through window openings. Providing passive cooling design measures and improving cross ventilation can significantly improve the indoor comfort conditions in these dwellings.

According to ECBC's classification of the different climatic zones of India, the summer midday (high) temperature in Bangalore ranges between 30 to 34 deg. C, summer night (low) temperature ranges between 17 to 24 deg. C and winter midday (high) temperature ranges between 27 to 33 deg. C and winter night (low) temperature ranges between 16 to 18 deg. C. Due to this marginal difference in external temperatures in the two seasons, the householders' perception of indoor environment largely remains similar for both summer and winter months. The survey revealed that the residents generally perceived *indoor temperature* to be 'just' *bearable* or *unsatisfactory* during both summer and winter. Similarly, despite nearly two--third of the residents perceiving *well-ventilated* interiors during summer and winter, the large number of households perceiving *indoor air quality* as bearable reveals the poor indoor air quality in these dwellings throughout the year.

Further, statistical correlation methods were also applied in order to understand the correlation between the factors influencing residents' perception of indoor conditions. Spearman's correlation coefficient (r_s), also called Spearman's rho, is used to establish the correlation between the rankings of two variables. The value of r_s ranges from -1 to +1, the closer r_s is to ±1 the stronger the monotonic relation between the two variables. Kendall's Tau-b (τ_b) correlation coefficient, also considered as an alternate to the Spearman's correlation is a nonparametric measure of the strength and direction of association that exists between two ordinal variables. Both statistical tests when applied to the householder survey responses for indoor environmental conditions show similar results.

Table 8: Spearman's correlation coefficient

			Spearman's correlation coefficient
Overall experience in summer	vs	Indoor temperature	0.587
		Air quality	0.403
		Air movement	0.344
Overall experience in winter	vs	Indoor temperature	0.563
		Air quality	0.368
		Air movement	0.367

The Spearman's correlation coefficient (r_s[1]) values of 0.587 and 0.563 (Table 8) for *overall experience* vs perceived *indoor temperatures* in summer and winter respectively, reveal a moderate correlation between the two factors during both summer and winter. The r_s value of 0.403, for correlation between *overall experience* vs *perceived indoor air quality* during summer indicates air quality also as a notably influential factor in summer. While during winters this correlation value reduces (r_s = 0.368) indicating weak impact of perceived *air quality* on the residents' *overall experience* during winters.

[1] Guide to determine the strength of correlation for absolute value of rs
00-0.19 "very weak"; 0.20-.39 "weak"; 0.40-0.59 "moderate"; 0.60-0.79 "strong"; 0.80-1.0 "very strong"

The r_s values of *overall experience* vs perceived *indoor air movement* show weak correlation during both summer and winter.

Through multiple statistical analyses, a greater correlation between the perceived indoor temperature and overall experience of the indoor environment during both winter and summers is observed. While this may differ in reality which will require a next level analysis of quantified indoor temperatures vs the comfort temperature, this could also be attributed to the design of the questionnaire survey. Considering the fact that the residents were asked of their perception of *indoor temperature*, *air quality*, and *air movement,* temperature is often a more palpable parameter for the people to realise as a factor of comfort or discomfort.

4.2 Comfort strategies adopted during summer and winter

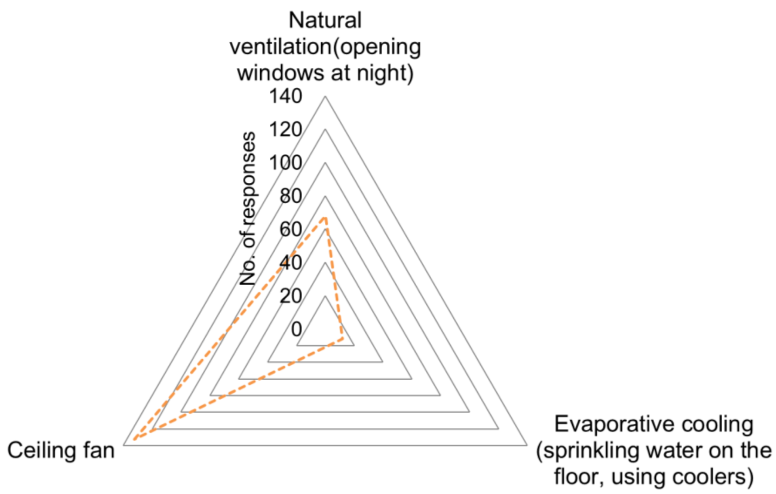
The researchers (students) also inquired from the residents about the adaptive measures used to improve indoor thermal comfort during summer and winter. Table 9 shows the survey questions asked to the responders (as shown in Table 3) their responses and the number of responses received, regarding the comfort strategies adopted during summer and winter. The householders were allowed to choose more than one of the options as their response.

Table 9: 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)	68	Evaporation cooling (sprinkling water on the floor, using coolers)	12	Ceiling fan	132
12	Adaptive strategy during winters	yes	5	no			150

The survey showed the use of ceiling fans as a basic and most common measure adopted by the residents of Laggere housing to provide cooling in summers. Out of the 132 residents using ceiling fans about 51 also reported opening windows to allow for night time ventilation cooling. Use of evaporative cooling measures was seen in almost negligible number of households; understandably because Bangalore experiences high humidity throughout the year and using evaporative cooling will increase the humidity resulting is more discomfort (Figure 19**)**

Figure 19: Cooling strategies adopted during summer



Given the moderate external temperature in winters nearly all the householders (150 out of 155) reported no use of any extra adaptive measures.

4.3 Daylighting

The quality of indoor lighting was assessed by asking the residents if they needed to use artificial/electrical lighting during the day (question 13 in Table 3). Out of the 151 survey responses received for this question, 79 households 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 many residents revealed the need to close the windows due to privacy issues. Some of the households were also forced to keep their windows closed to avoid mosquitoes from entering their homes. The survey images reveal that mostly the interiors of these dwellings were dark and lack adequate daylighting.

Figure 20: Electrical lighting requirement during the day

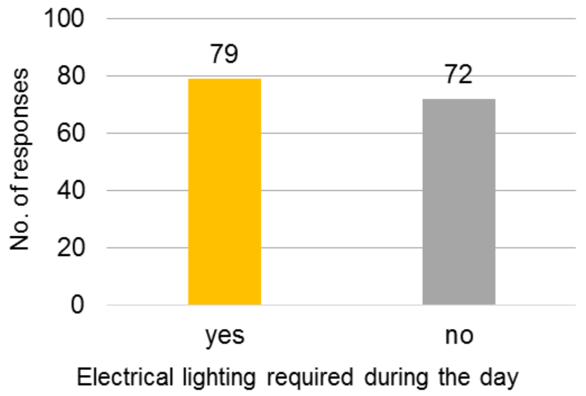


Figure 21: Interior of a DU at Laggere

4.4 Window shading during summer

Table 10 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. During the survey majority numbers of residents were found using either curtains or screens to shade their windows during summer. A few households did not use any additional window shading during summer.

Table 10: Survey question and householder responses for additional window shading used in summer

Ques. no.	Aspects accessed	Response			
			N		N
10	**Window shading during summer**	None	31	Curtains/screen/ cloth/netting/ inside blinds	124

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 the cause for it. Table 11 shows the survey questions (as shown in Table 3) and the householders responses in this regard.

Table 11: Survey questions and householder responses regarding presence of dampness in the dwellings.

Ques. no.	Aspects accessed	Response				No. of response
14	Dampness	yes	no	-	-	155
16	Causes of dampness	Leaking of pipes	Building material is not water resistant	Improper construction workmanship	Poor design	65

The poor quality of constriction and building materials was evident in the presence of dampness inside many surveyed dwellings. 65 out of the 155 surveyed households reported dampness in their homes (Figure 22). The materials and construction techniques used may have proven cost effective but did not consider the climatic conditions of the area. Bangalore experiences heavy rainfall during the monsoon season (May to Oct), many householders on the upper floors complained of dampness due to rain water seepage from the roof and external walls. Majority householders therefore perceived *improper construction workmanship* and *building materials not being water resistant* as the primary reason for dampness (Figure 23). Some of them also attributed the dampness to poor design of the dwelling.

Figure 22: Presence of dampness inside the dwelling

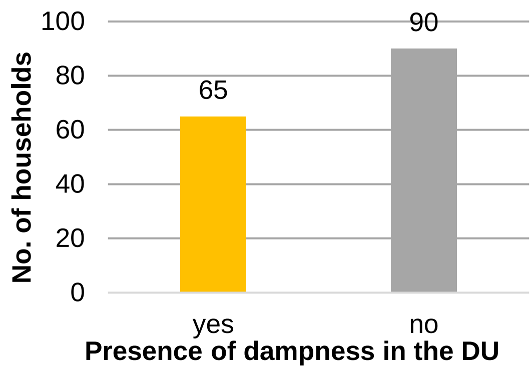
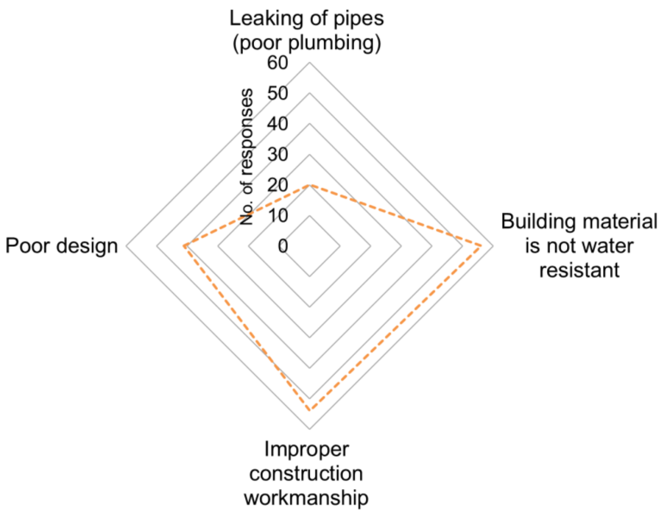


Figure 23: Perceived causes of dampness



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 12 shows the survey questions asked in this regard and the number of responses received.

Table 12: 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	52	no	103
18	Do you pay into a resident's welfare association to cover maintenance and repair costs for common areas and the building?	yes	4	no	151

Majority of the surveyed households expressed disappointment regarding the up-keep and maintenance of the common areas. Of the 155 surveyed households, 103 reported complete absence of any maintenance system for the housing development (Figure 24). The survey revealed the unhygienic condition of the areas around these dwellings. Open drains, water logging and garbage collected along the streets have become active breading grounds for mosquitoes rendering the development unhealthy to live in. The residents expressed their dissatisfaction about the incomplete roadworks in the development, which also contribute to water logging during monsoons.

Figure 24: Existence of mechanism for maintenance of common areas

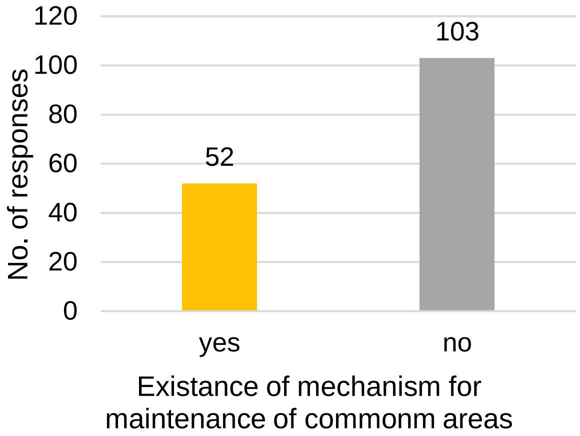


Figure 25: View of a street in Laggere colony

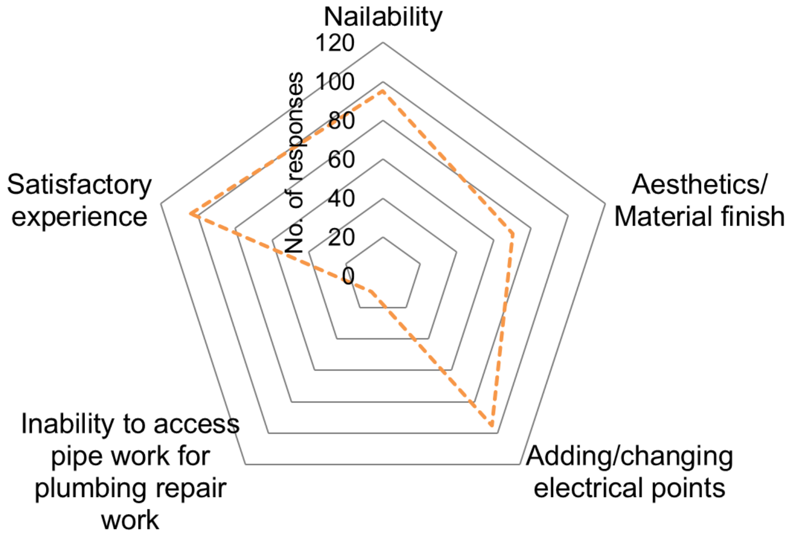
The householder survey questionnaire also focused on gathering feedback from the residents regarding their experience with the building materials used in the dwellings. Table 13 shows the survey question and responses of the householders' experience with the building materials of the dwellings. For this survey question the householders were allowed to choose more than one response.

Table 13: Survey question and householder responses regarding experience with the 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	Aesthetic s/material finish	Nail ability	Adding/ch anging electrical points	Inability to access pipe for plumbing repair works	155

During the survey though, majority number of residents (n: 104) expressed having a satisfactory experience with the building materials, a substantial number of them also expressed concern regarding the *'Nail ability'* 'i.e. the suitability [of a wall] for being nailed and the difficulty in *adding/changing electrical 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 26).

Figure 26: Householders experience with the building materials used



4.7 Location

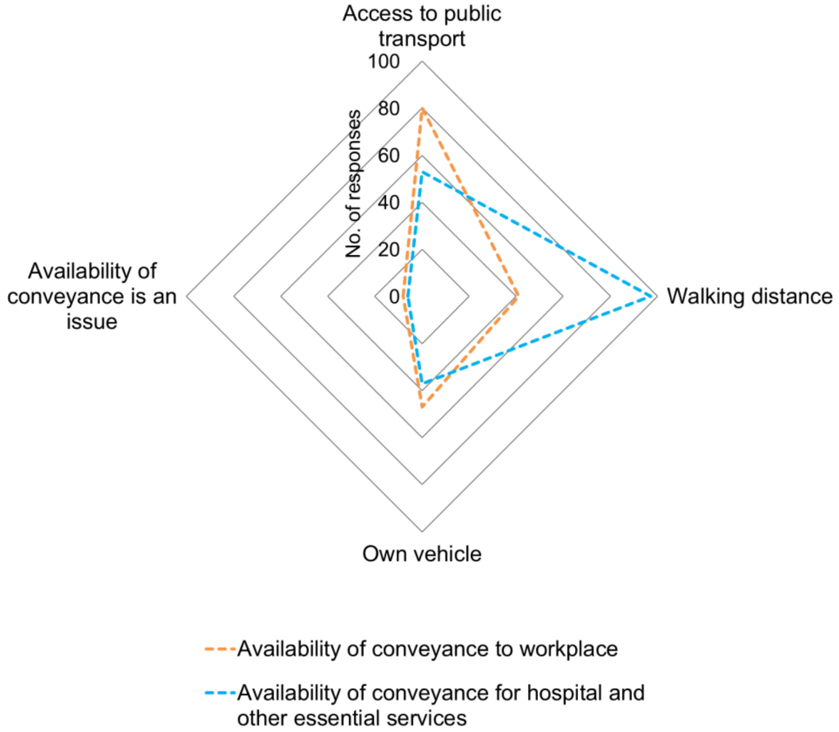
The survey questionnaire also covered aspects related to the location of the development. Table 14 shows the survey questions (as shown in Table 3) asked to the responders and their responses regarding accessibility to basic facilities.

Table 14: Survey questions and householder 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		
21	Travel time to work (minutes)	0-20	20-40	40 -60	60 min & above	-	156
22	Travel time to school (minutes)	0-20	20-40	40 -60	60 min & above	-	156
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	-	156
24	Mode of travel to school	Own vehicle	Access to public transport	Walking distance	School bus	No school going children in the house	111

The housing development is located approximately 13 km away from the city centre. During the survey it was observed that for most residents (104 out of 155) the place of work is at a convenient distance from their residence. Majority number of these residents (n: 80) informed of having access to public transport for commuting to their place of work (Figure 27) and would take approx. 20-40 minutes travel time.

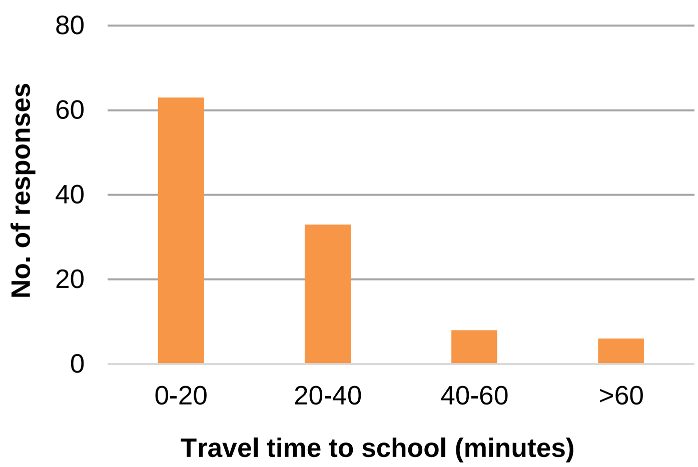
Figure 27: Mode of travel



A substantial number of people also have vehicles of their own to commute to work and other places. Basic facilities such as hospitals and market place were found to be at convenient proximity from the development. Overall the residents did not seem to have issues regarding the connectivity of the development. Some of the residents however expressed concern regarding safety in the area.

Of the 156 surveyed households, 110 had school going children. For a majority of the children the schools are at walking distance and it takes about 0-20 minutes to travel to school. A very few children take longer time to reach to their respective schools (Figure 28).

Figure 28: Travel time to school (minutes)



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 10 years with most of the original residents still living there. Of the 148 households, nearly 42% (n: 62) houses were owned by the residents themselves. They paid approximately 60,000 INR to gain the ownership. The remaining households (n: 81) where rented and spent less than half of their monthly salary on rent (Figure 29). Some interesting findings were made on inquiring from the residents about their expenses on the electricity bill. The survey revealed that of the 151 gathered responses nearly 59% (89 out of 151) dwellings did not have an electricity meter installed in them. Though these households were regularly using electricity for their day to day needs but did not pay any bills for it. The rest of the surveyed households paid about 150 to 500 INR for electricity every month (Figure 30).

Figure 29: Proportion of monthly income spent on rent

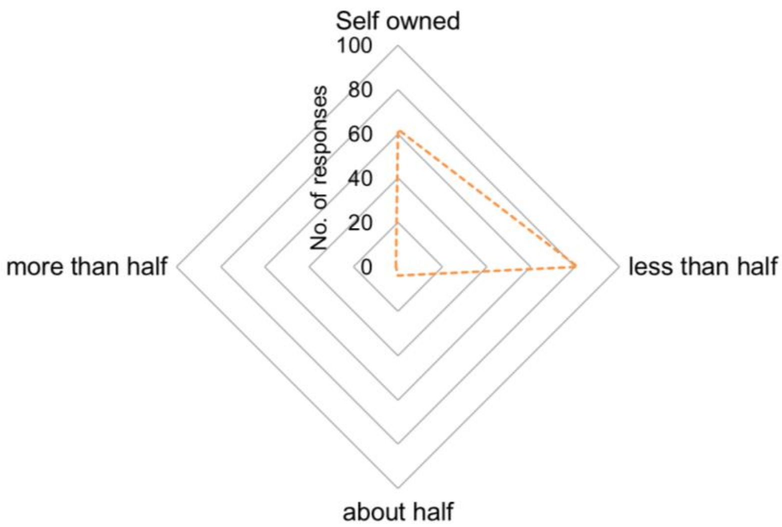
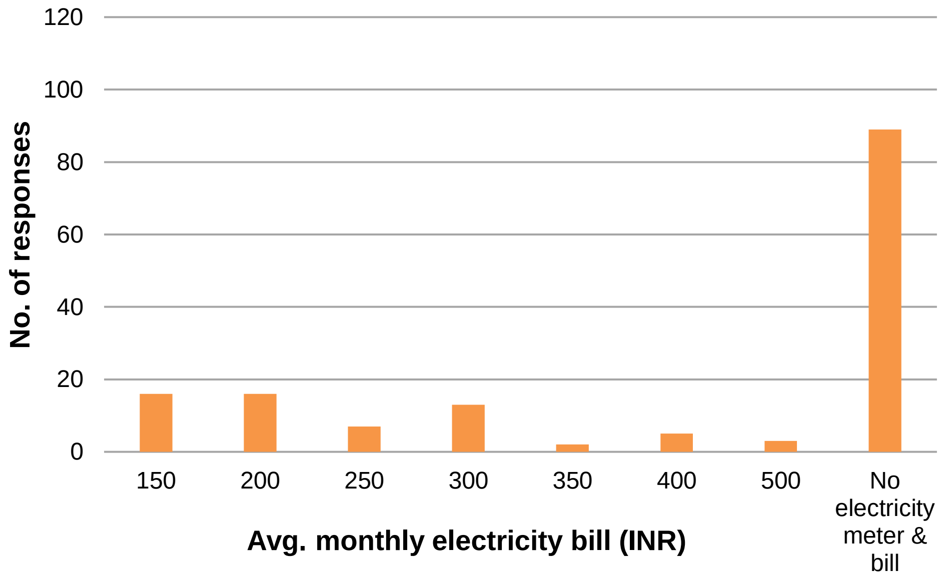


Figure 30: Average monthly electricity bill (INR)



5. Conclusions

- The Laggere slum rehabilitation project by the BMTPC was developed with the aim to improve the living conditions of the slum dwellers in the Laggere area, by providing low cost affordable dwellings. The project demonstrates the use of alternate and cost effective building materials and systems such as use of solid concrete blocks, clay bricks for internal partition walls, clay jail in ventilators and use of Ferro cement. Though the use of these materials made the dwelling units affordable for the residents, the householder survey revealed that indoor comfort was perceived to be (just) *bearable* during both summer and winter. Despite moderate external temperatures throughout the year, these naturally ventilated dwellings were unable to provide adequate indoor thermal comfort during both summer and winter. Nearly one third (49 out of 155) of the surveyed households perceived indoor temperature to be *unsatisfactory* in winters. In summers this number was even higher (66 out of 155). Thus indicating the poor thermal performance of the building envelope. Although, nearly two third of the residents perceived their dwellings to be well-ventilated during summer and winter, their perception of indoor air quality remained largely bearable. This is presumed to be likely due to the design of the dwelling units and window location. All the window openings in any typical DU have been provided only on one external wall of the building, thus restricting the scope of cross-ventilation. In Bangalore's temperate climate, where enhanced air movement can contribute in improving the indoor comfort conditions, careful design of fenestrations and passive cooling strategies should be adopted in order to enhance indoor comfort in these dwellings.
- Statistical analyses of the survey data showed correlation between overall experience and perceived indoor temperatures in summer and winter respectively, reveal indoor temperatures as a noteworthy factor in influencing the householders' perception of the overall indoor environment during both summer and winter.
- The survey also helped to reveal critical factors that determine the acceptability of building materials from the householders' perspective. The solid concrete blocks and clay bricks used as walling material may have helped to reduce the initial construction cost, but nail ability of the walls emerged as a major concern for the residents, since the wall materials did not allow residents the flexibility of making basic alterations to the interiors. The building materials used did not also seem to be appropriate for the climatic conditions of the location. The residents living on the upper floors complained of water seepage from the roof and walls during the monsoon season. This could also be indicative of poor workmanship during construction.
- The householders were found mostly satisfied regarding the connectivity of the development to the basic amenities but raised concern in terms if safety in and around the development. There appears to be a lack of maintenance regime for the upkeep of the common areas. The incomplete road works in the development result in water logging and become active breeding ground for mosquitoes especially during monsoons. Nearly 59 % (89 out of 151) of the surveyed households did not have electricity meters installed in them and were therefore not paying any electricity bill. A few households were also illegally occupied.