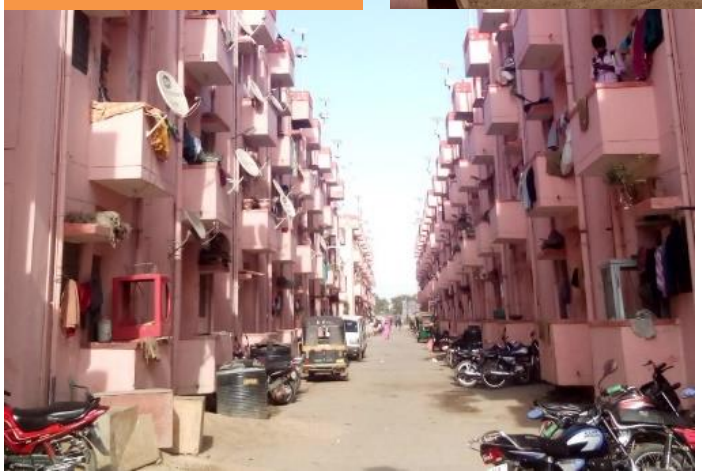
Findings from householder survey in Kiron ki Dhani colony, Jaipur



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 150 social housing residents of the Kiron Ki Dhani colony. The housing project developed under the Rajeev Awaas Yojana was constructed to rehabilitate the local workers and slum dwellers in the area. 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 occupants mostly feel *satisfied or bearable* with the overall indoor environmental conditions during winters but find the overall indoor environment only *bearable* during summer. Though during the survey, majority of the occupants reported not using artificial light during the day, the survey images reveal that the interiors of many dwellings lack adequate natural lighting. The dwelling units have been constructed using RCC structure and flyash brick walls. The householders' expressed the issue of Nail-ability as their primary concern regarding the use of these materials. Poor quality of materials and construction workmanship could be seen from the presence of dampness and the decrepit condition of the wall plaster and ground floor balconies/veranda. Like any other social housing in India, this development also lacks hygiene and maintenance. The occupants were found particularly unhappy about the location of the development. The locality lacks proper connectivity to basic facilities like hospitals etc. and access to public transport is also an issue; which adds on to the already challenging day to day life of the residents. As informed by some residents, by virtue of its location, the area is also becoming increasingly unsafe, especially for women and children.

1. Introduction

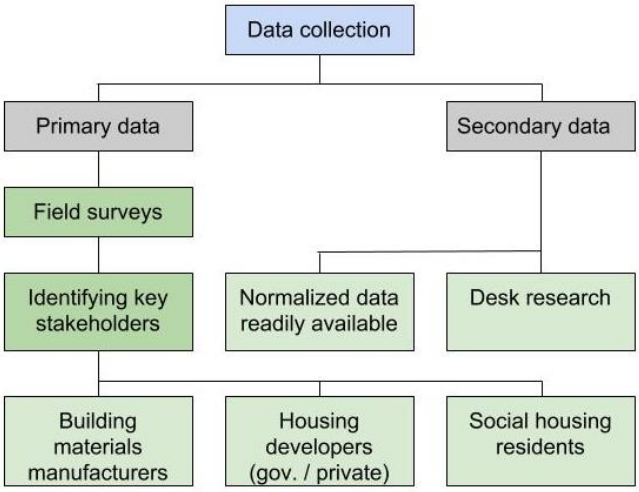
The urban housing shortage in India is currently estimated at 10 million, more than 95% of which pertains to low-income groups. Through its “Housing for All by 2022” mission, the Government of India intends to close this gap by aiming to construct 12 million housing units over the programme duration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

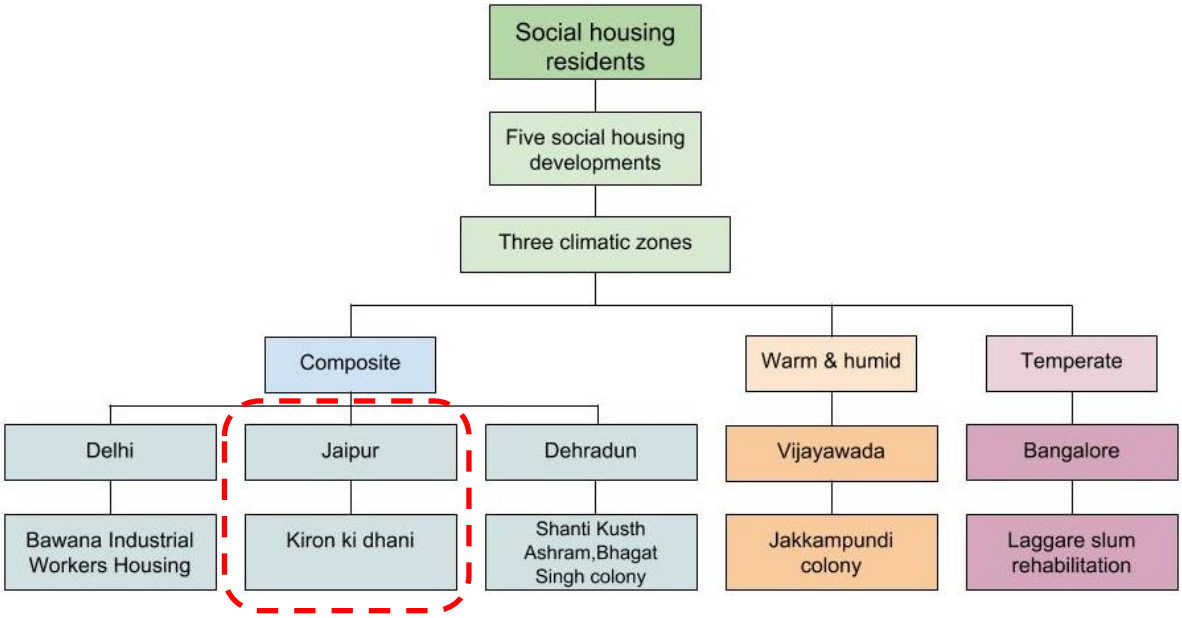
Figure 1: MaS-SHIP data collection methodology



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 Jaipur, representing the Composite 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 Kiron Ki Dhani 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 Kiron Ki Dhani housing project developed under the Rajeev Awaas Yojana was constructed to rehabilitate the local workers and slum dwellers in the area. It is situated near a wholesale vegetable market called Muhana mandi about 19km from the city center of Jaipur. The community comprises of daily wage earners, most of them working in Muhana mandi. The project was undertaken and constructed by the Jaipur Development authority (JDA) along with support from the union government and the Government of Rajasthan. The project was handed over in 2015. This housing project comprises of 1104 dwelling units with 100% EWS as the target group.

Table 1: Case study overview

Category	**Case study**
Location	Jaipur
Name of the development	Kiron Ki Dhani
Government scheme	Rajeev Awaas Yojana
Occupancy	4 years
Target group	Slum dwellers and Economically Weaker Section
Distance from city centre	19 km
Number of dwelling units	1104
Built-up area of each dwelling (sq. ft.)	328
Cost of construction (INR per sq. ft.)	1100-1200

The development consists of G+2 storey structures housing about 1104 dwelling units. A typical floor layout consists of four dwelling units laid out around a central service core on each floor. All units are identical and consist of two rooms, one separate kitchen, one WC and a separate shower area and a balcony (Figure 3). The central spaces provided in the development which were originally meant to be developed as green landscape areas, have been left barren and unfinished. The occupants have been known to use these as a dumping ground (Figure 4), severely impacting the health and hygiene of the area.

Figure 3: Typical unit layout

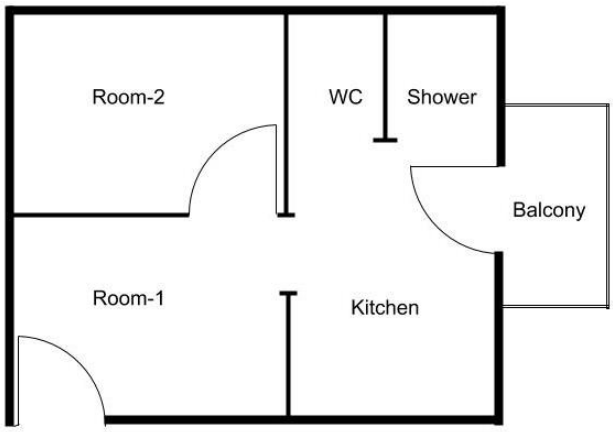


Figure 4: View of the central spaces left unfinished

2.1 Building materials and systems

Locally available building materials and construction systems were used in the development. Use of RCC framework with flyash brick masonry and marble flooring, could be seen in the dwellings (Table 2)

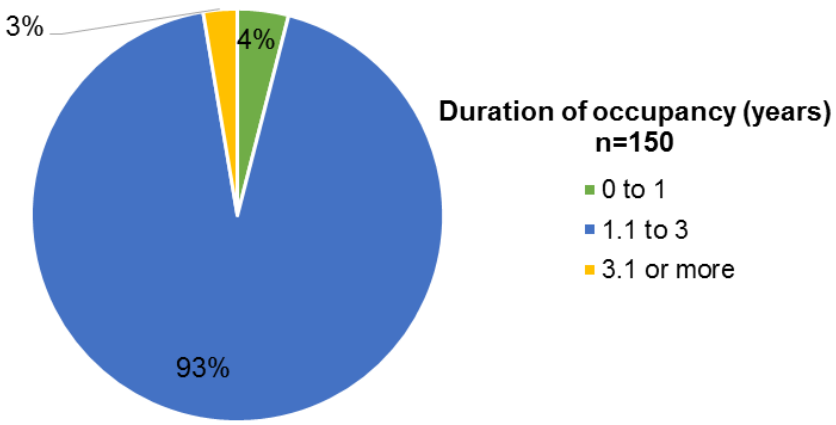
Table 2: Building materials used in the development

Foundation	• -
Walling	• Flyash brick • RCC plinth and roof level band
Roof / Floor	• RC slab and marble flooring
Doors and windows	• Timber
Others	• -

2.2 About the households

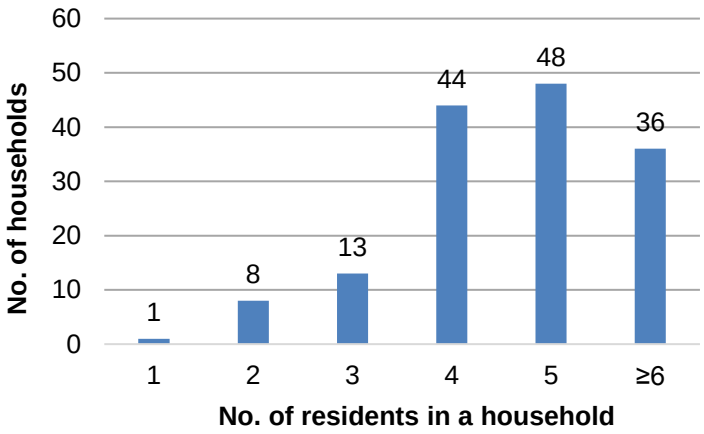
At the time of the survey the houses had been occupied for up to 4 years with most of the original occupants still living there. Of the 150 surveyed households about 93% had been occupied for up to 3 years. About the 4% had been occupied in between for less than 1 year and the remaining 3% of the households had been occupied for more than 3 years (Figure 5).

Figure 5: Duration of occupancy



In terms of number of residents, the survey revealed maximum households having about 4 to 5 members (Figure 6). A significant number of dwellings were also found having occupancy of more than 6 members which made the living congested.

Figure 6: Occupancy of the surveyed



The surveyed households had 51% of residents aged between 19-58 years (Figure 7), and most of them would spend about 12-18 hours at home during the day (Figure 8). 35% of the residents' aged between 3-18 years which would mean mostly children, a majority of who generally spent around 16-18 hours of time at home during a day. The percentage of elderly residents i.e. people above the age of 60 was found to be very less (6%), and they would spend most of their time at home during a day.

Figure 7: Age group of residents

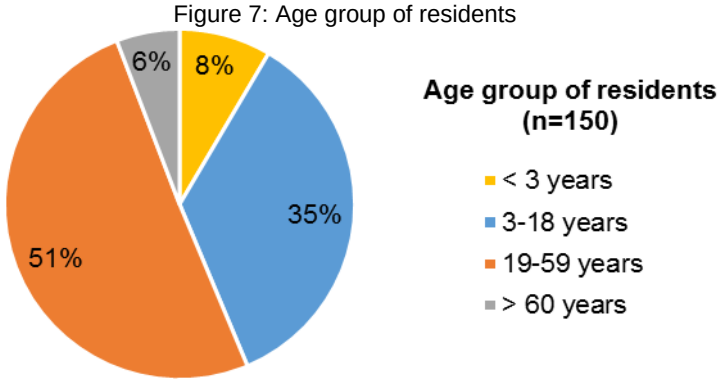
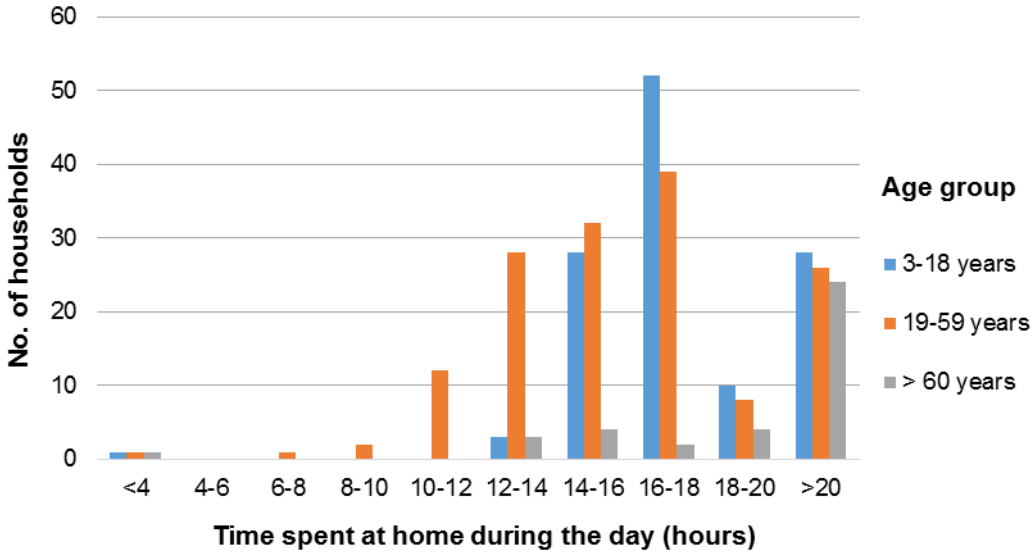


Figure 8: Time spent at home during the day



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 systems
- 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 or outside 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	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 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.

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	150
7	Air quality	stuffy	bearable	fresh	150
8	Air movement	draughty	still	well ventilated	150
9	Overall experience	unsatisfactory	bearable	satisfactory	150

The survey results as shown in Figure 9 reveal that *indoor temperature* was perceived to be *bearable* by nearly equal number of households during both summer and winter (58 in summer and 59 in winter out of total 150). However in summer the number of households perceiving *unsatisfactory indoor temperatures* (n: 59) was nearly three times of that in winter (n: 20). Consequntly, the tolerance of *indoor temperatures* is observed to be higher in winters with nearly twice the number of residents reporting feeling *satisfied* as compared to that during summer. Thus indicating the poor thermal performance of the building envelope during summers. *Indoor air quality* was perceived to be *bearable* by majoity of the surveyed households during both summer and winter (85 in summer & 111 in winter out of total 150). As compared to summer, the perception of *indoor air quality* was found relatively better during winter, as the number of households perceivng *stuffy* indoors during winter (n: 18) is nearly half of that during summer (n :37). Despite this, the number of households perceving *fresh indoor air* was found to be marginaly higher in summer as compared to that in winter (Figure 10). In this study, *bearable indoor air quality*, is assumed to correspond to a lesser stuffy house, an indoor condition which the residents have learned to cope with.

Figure 9: Perceived indoor temperature

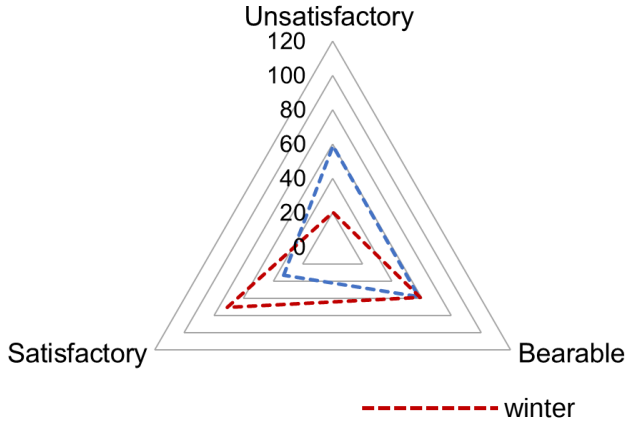
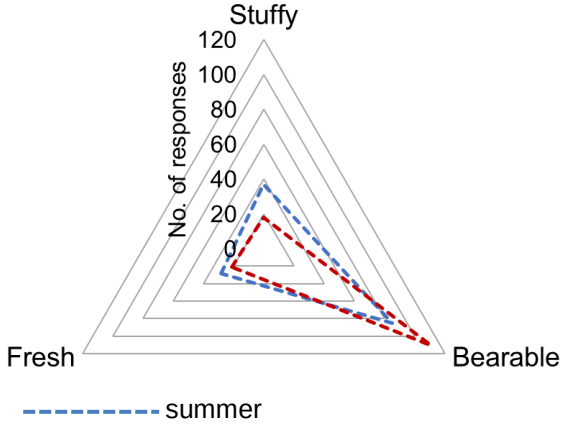


Figure 10: Perceived indoor air quality



On inquiring about the quality of *indoor air movement* majority and nearly similar number of the surveyed households perceived their dwellings to be *well-ventilated* during both summer and winter

(71 in summer & 78 in winter out of 150). While in summer *still* indoor air was perceived by one third of the surveyed households, during winter this number increases and nearly half (n: 70) of the surveyed households reported *still* indoor air. Interestingly, substantial number of households perceived draughty doors and windows in summer (n: 29), whereas in winter this number was found to be negligible (n: 2) (Figure 11). Overall, during summers nearly 50% (71 out of 150) of the surveyed households reported *bearable overall experience* of the indoor environment. Whereas, during winters the same number of households reported *overall experience as satisfactory*. Nearly equal number of households perceived *overall experience* as *satisfactory* (39 out of 150) or *unsatisfactory* (40 out of 150) during summer. The number of households perceiving *unsatisfactory overall experience* during winter was nearly one third of that during summer (Figure 12).

Figure 11: Perceived indoor air movement

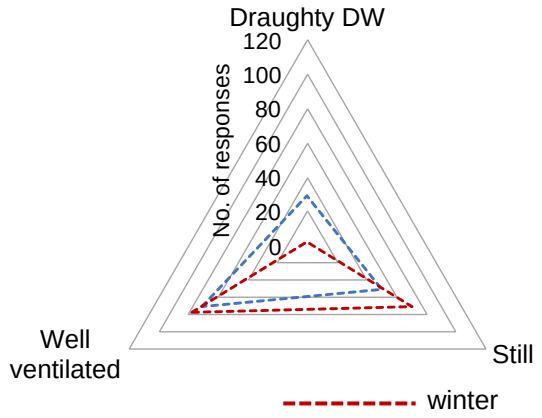
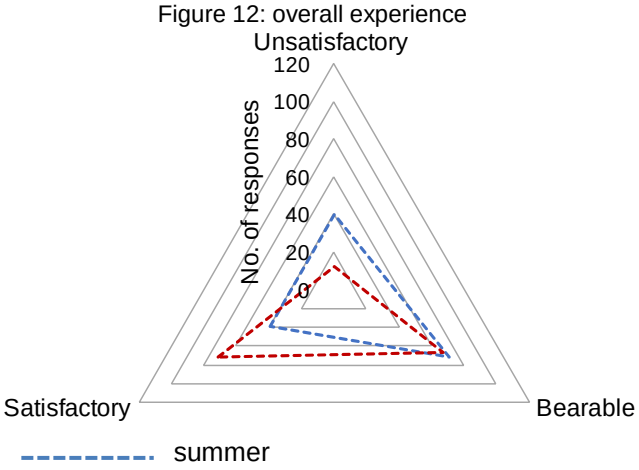


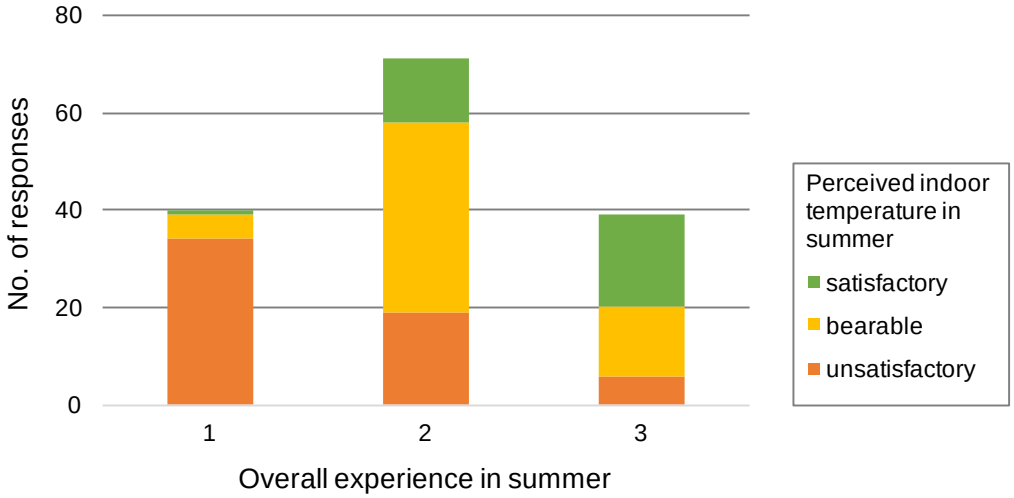
Figure 12: overall experience



Deeper analysis of the survey responses for indoor environmental conditions was performed in order to assess the influence of the perception of indoor temperature and air on the residents' overall experience during summer and winter. For this, the householders' responses about their perception of 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

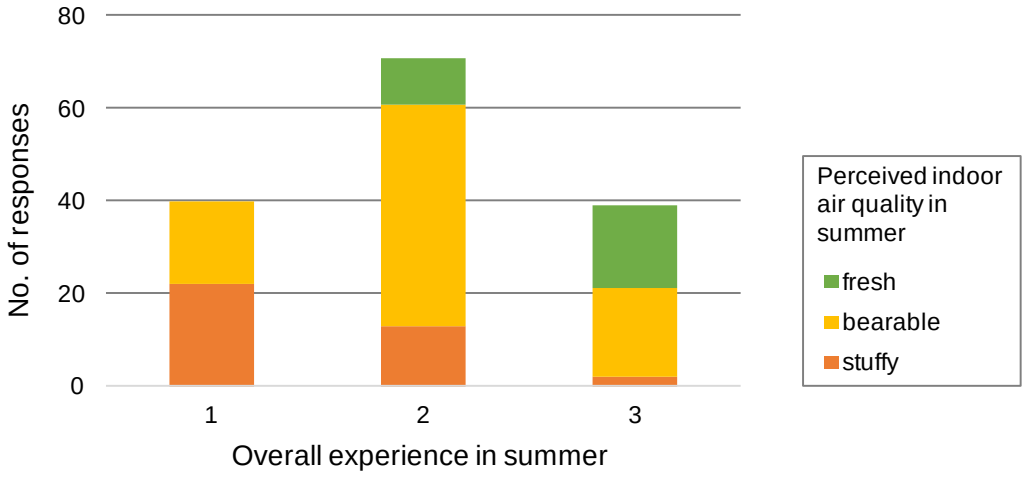
Table 5: Cross tabulation - overall experience vs perceived indoor air quality in summer

		Overall experience in summer			Total
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived Indoor temperature in summer	unsatisfactory	**34**	19	6	**59**
	bearable	5	**39**	**14**	**58**
	satisfactory	1	13	**19**	33
	Total	**40**	**71**	**39**	**150**

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 40 households reporting *unsatisfactory overall experience* 85% (34 out of 40) households perceived *indoor temperature* also as *unsatisfactory*. Similarly, for the 71 households reporting *bearable overall experience* the number of households perceiving *indoor temperatures* also as *bearable* was found to be highest (n: 39). However, of the 39 households reporting *overall satisfactory experience* nearly similar number of households perceived *indoor temperature* as *satisfactory* (n: 19) or *bearable* (n: 14). Overall, the residents were mostly seen *unsatisfied* or feeling just *bearable* with the *indoor temperature* during summer, but largely found their *overall experience* to be *bearable.* The high number of households, perceiving *unsatisfactory* and/or bearable indoor temperature in summer indicates the relatively poor thermal performance of the dwellings. Given the extreme external temperatures experienced in the composite climate of Jaipur during summer, the perception of indoor temperature alone did not seem to have a significant impact on the residents' overall experience of the indoor environment.

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

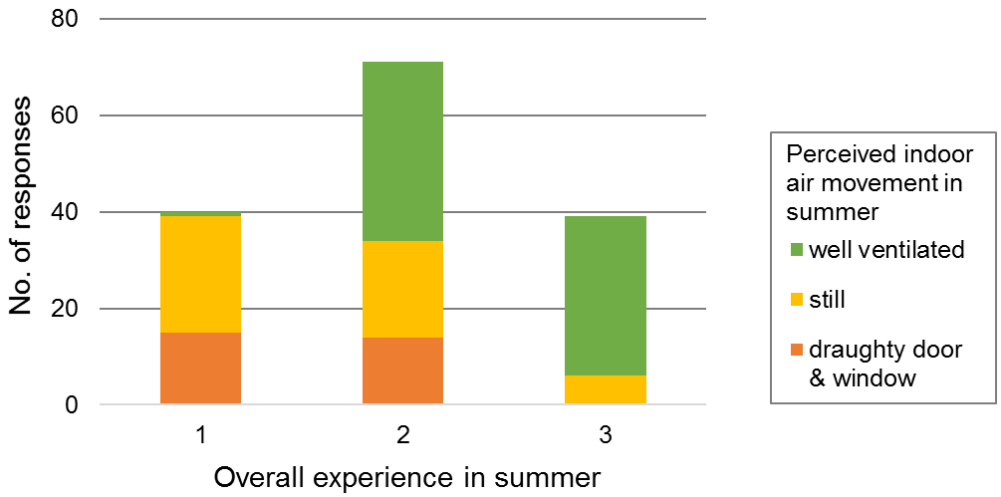
		Overall experience in summer			Total
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived Indoor air quality in summer	Stuffy	**22**	13	2	**37**
	Bearable	**18**	**48**	**19**	**85**
	Fresh	0	10	**18**	**28**
	Total	**40**	**71**	**39**	150

The survey found that the householders of Kiron ki dhani 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 40 households reporting *overall experience* as

unsatisfactory nearly 55% (22 out of 40) perceived *indoor air quality* as *stuffy* and the remaining 45% (18 out of 40) perceived it as *bearable*. Likewise, of the 71 households reporting *overall experience* as *bearable,* 48 households (68%) perceived *indoor air quality* also to be *bearable* during summers. Nearly similar number of households perceived *indoor air quality* as *stuffy* (n: 13) and *fresh* (n: 10), but found their *overall experience* to be 'just' *bearable.* For the 39 households reporting *satisfactory overall experience*, nearly equal number of households perceived *indoor air quality* as *fresh* (n: 18) and *bearable (n: 19)*. This indicates a relatively weak influence of the perception of *indoor air quality* 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

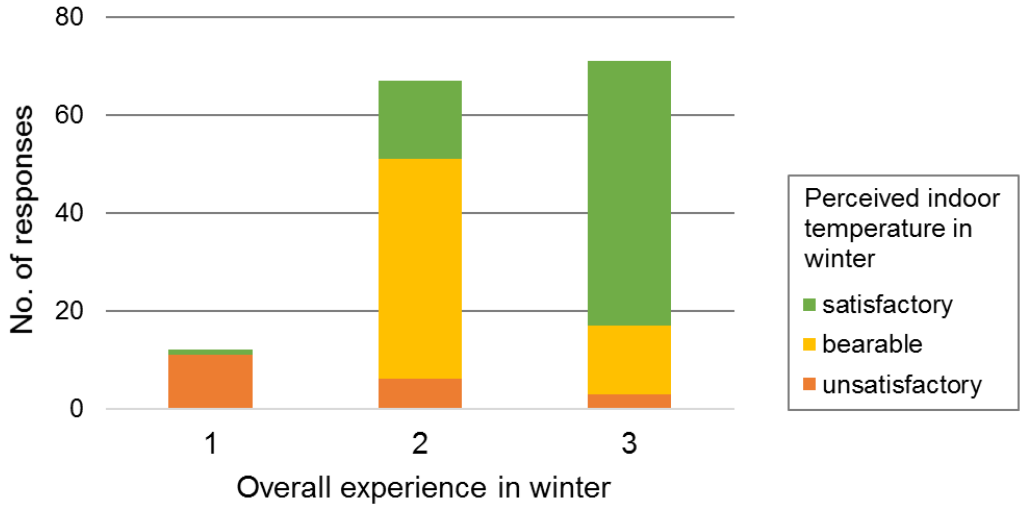
Table 7: Cross tabulation - overall experience vs perceived indoor air movement in summer

		Overall experience in summer			**Total**
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived Indoor air movement in summer	Draughty door & window	**15**	**14**	0	**29**
	Still	**24**	**20**	6	**50**
	Well-ventilated	1	**37**	**33**	**71**
	Total	**40**	**71**	**39**	**150**

Though majority of the surveyed households (71 out of 150) perceived their dwellings to be *well-ventilated* during summer, this seemed to have a relatively mixed effect on their *overall experience* of the indoor environment. This is indicated by the fact that, of the 71 households perceiving *well-ventilated* interiors during summer, majority of them (n: 37) reported overall experience as *bearable* (Table 7). For some residents however, *well-ventilated* indoors did lead to a *satisfactory overall experience* as- of the 39 households reporting *satisfactory overall experience*, majority (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 50 households perceiving *indoor air* as *still*, 24 households reported *unsatisfactory* and 20 households reported *bearable overall experience* during summer. Despite the high external temperatures in summer in Jaipur, the householders seemed to prefer well-ventilated dwellings.

A similar comparison of the various factors affecting the residents' overall experience of the indoor environment was done for the winter months.

Figure 16: Overall experience vs perceived indoor temperature during winter



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

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

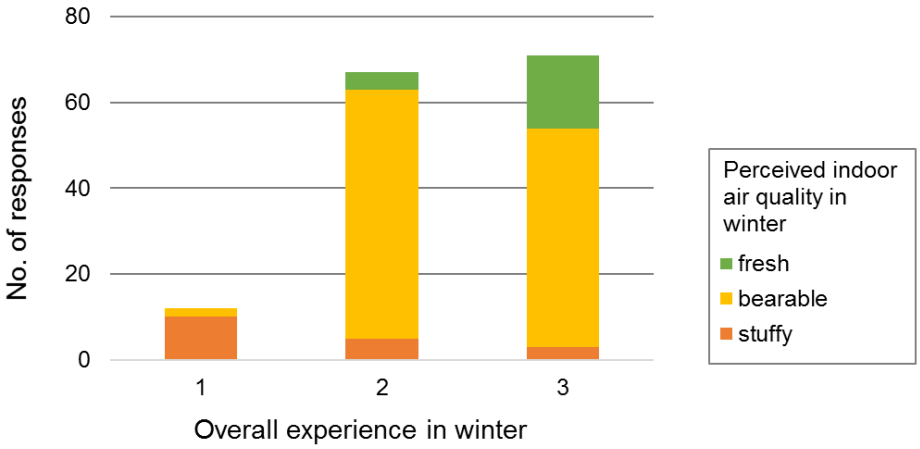
		Overall experience in winter			**Total**
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived Indoor temperature in winter	unsatisfactory	**11**	6	3	**20**
	bearable	0	**45**	14	**59**
	satisfactory	1	16	**54**	**71**
	Total	**12**	**67**	**71**	**150**

During winter, of the 150 surveyed households, equal number (n: 71) perceived both *indoor temperatures* and *overall experience* as *satisfactory*. Cross-relating the householder survey responses for *overall experience* with their response for perceived *indoor temperature* in winter (Figure 16 and Table 8) revealed a relatively stronger influence of the perception of *indoor temperature* on the householders' *overall experience* of the indoor environment during winter. This is indicated by the fact that, of the 71 households reporting *overall experience as satisfactory*, 76% (54 out of 71) perceived *indoor temperatures* also as *satisfactory*. Likewise, for the 67 households reporting *bearable overall experience*, the number of households perceiving *indoor temperatures* also as *bearable* was found to be highest (n: 45). Though less than one tenth of the total surveyed households (12 out of 150) reported feeling *unsatisfied* with their *overall experience* during winter, of these nearly all (11 out of 12) the households were also perceived *indoor temperature* as *unsatisfactory*.

Despite the extreme external temperatures experienced in Jaipur during both summer and winter, the relatively poor perception of *indoor temperature* and *overall experience* in summer, indicates the inability of these dwellings (building envelope) to keep the heat out when it is most required.

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

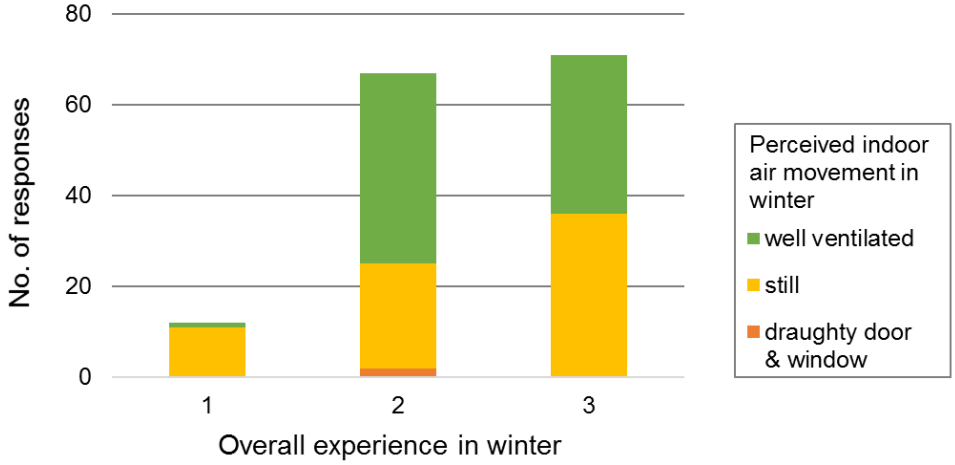
Table 9: Cross tabulation - overall experience vs perceived indoor air quality in winter

		Overall experience in winter			Total
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived Indoor air quality in winter	Stuffy	**10**	5	3	**18**
	Bearable	2	**58**	**51**	**111**
	Fresh	0	4	17	**21**
	Total	**12**	**67**	**71**	150

The survey revealed that though as compared to summer, *indoor air quality* was perceived to be *bearable* by more number of residents in winter; this did not seem to have any significant effect on their *overall experience* of the indoor environment. Of the 111 households perceiving *bearable indoor air quality*, nearly 52% (58 out of 111) households reported *bearable* and 46% (51 out of 111) reported *satisfactory overall experience.* However, unlike summer, in winter, *stuffy indoor air quality* did lead to a poor perception of the overall indoor environment, as for the 12 households reporting *unsatisfactory overall experience*, 10 perceived their dwellings to be *stuffy*. Likewise, perceiving the *indoor air* quality as *fresh*, resulted in a *satisfactory overall experience* for majority of the households, as of the 21 households perceiving fresh indoor air, 17 reported *satisfactory* and 4 households reported *bearable overall experience*.

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 summer	Draughty door & window	0	2	0	**2**
	Still	**11**	**23**	**36**	**70**
	Well-ventilated	1	**42**	**35**	**78**
	Total	**12**	**67**	**71**	**150**

The residents of Kiron ki dhani colony seemed to have a mixed perception of *indoor air movement* in winter. Though majority of them perceived their dwellings to be *well-ventilated* (78 out of 150), nearly similar number of households also perceived *still indoor air* (70 out of 150) in winter. The overall experience of the indoor environment did not seem to be directly influenced by the residents' perception of the *indoor air movement* as- of the 71 households reporting *satisfactory overall experience*, nearly equal number of households perceived *indoor air* in their dwellings to be either *still* (n: 36) or *well-ventilated* (n: 35) during winter. Likewise, though 42 (out of 67) households perceived their dwellings to be *well-ventilated* during winter, their overall experience remained 'just' *bearable.* Though less in number, for the 12 households with *unsatisfactory* experience of the overall indoor environment in winter, nearly all (n: 11) households perceived *indoor air* to be *still.* The perception of *indoor air movement* did not seem to have any direct and significant impact on the residents' *overall experience* of the indoor environment.

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 composite climate of Jaipur which is characterised by high temperatures in summers and cold in winters the residents of Kiron ki Dhani colony 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 occupants' *overall experience* of the indoor environmental conditions, the number of households perceiving better indoor conditions (temperature, air quality and air movement) was found higher during winters as compared to summers. Especially for *indoor temperatures*, the number of households perceiving *satisfactory indoor temperature* in winter is more than twice of that in summers. Similarly, for *indoor air quality*, as compared to summers the number of households perceiving *indoor air as stuffy* is nearly half in winters. Overall, the occupants in these dwellings generally reported *satisfactory or bearable overall experience* during winters, where as in summers majority reported feeling only *bearable* with the overall indoor conditions of their dwellings. Given the extreme external temperatures in Jaipur, during both summer and winter, while this may be indicative of the poor thermal performance of the building envelope during summers; better perception of the indoor conditions in winter can be attributed to both the greater adaptability of residents to the environmental conditions and also the compact size and less exposure of the dwelling units, resulting in lesser heat loss during winter.

Cross-relating the survey responses revealed that while the perception of indoor temperature had a relatively significant influence on the householders' overall experience in winter, during summer this influence was observed to be very weak. Similarly, though majority of the households perceived their dwellings be *well-ventilated* during both summer and winter, the influence of perception of *indoor air movement* on their overall experience was found to be relatively more in summer as compared to that in winter. Though in summer, the external temperatures are high, occupants tend to prefer and use air movement to improve comfort conditions in these naturally ventilated dwelling units. Providing passive cooling design measures and improving cross ventilation can therefore significantly enhance the overall indoor comfort conditions in these dwellings during summer.

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 11: Spearman's correlation coefficient

			Spearman's correlation coefficient
Overall experience in summer	vs	Indoor temperature	0.556
		Air quality	0.531
		Air movement	0.598
Overall experience in winter	vs	Indoor temperature	0.591
		Air quality	0.428
		Air movement	0.012

The Spearman's correlation coefficient (r_s[1]) values (Table 11) for *overall experience* vs perceived *indoor temperatures*, indoor air quality and indoor air movement in summer reveals a moderate correlation between the variables. During winter the r_s value of 0.591 for *overall experience* vs perceived *indoor temperature* and the r_s value of 0.428 for *overall experience* vs perceived *indoor air quality* show indoor temperature and air quality as noteworthy factors influencing the residents' overall experience. Similar to the findings in the previous section, r_s value of 0.012, for correlation between *overall experience* vs *perceived indoor air movement* indicates weak impact of perceived *air movement* on the residents' *overall experience* during winters.

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

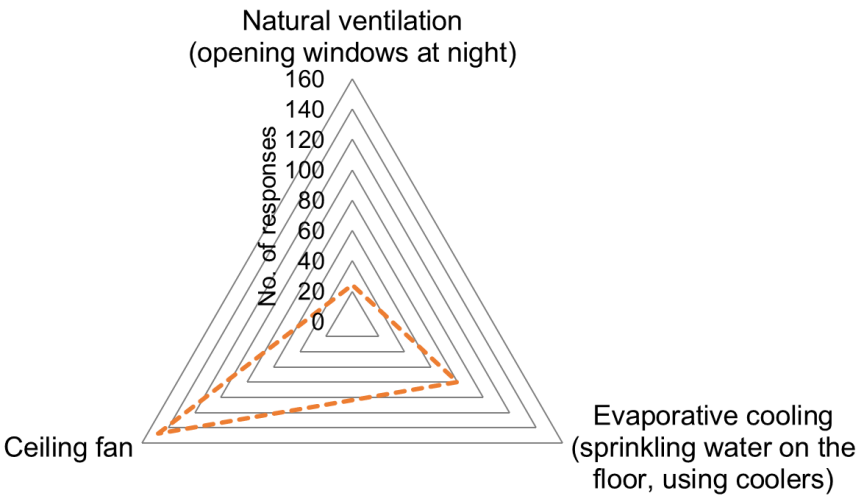
Ques. no.	**Aspects accessed**	**Response**					
			N		**N**		**N**
11	Cooling strategy adopted during summers	Natural ventilation (opening windows at night)	24	Evaporation cooling (sprinkling water on the floor, using coolers)	80	Ceiling fan	148
12	Adaptive strategy during winters	none	132	Blankets	11	Bon fire	7

The survey showed the use of celling fans as a basic and most common measure adopted by the residents to provide cooling in summers. The householders combined the use of ceiling fans along with natural ventilation to enhance cooling of the indoor spaces, especially at night. Use of evaporative cooling measures, such as sprinkling water on the floor and/or roof, use of desert coolers was also seen in substantial number of households (Figure 18). Use of Air conditioners is seen in

[1] Guide to determine the strength of correlation for absolute value of r_s
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"

negligible number of homes (2 out of 150), visibly because of the higher capital and operational costs associated with it.

Figure 19: Cooling strategies adopted during summer



Though, during winters in Jaipur, the external temperature is low during the day (10-25 deg. C), the survey revealed that majority of the residents (132 out of 150) do not generally use any extra adaptive measures. Some residents resorted to warm clothing, while a few also made use of bon fire at night as a way to cope with the cold. One of the households also remarked that they do not need to use any extra adaptive measure during winter since 'the house is already very warm'.

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 150 surveyed households, 138 reported not needing to use artificial lighting during the day (Figure 20). However, the survey images (Figure 21, 22 & 23) reveal that most of the dwelling units especially, on the ground floor lack adequate natural lighting during the day. The less use of artificial lighting during the day as reported by the residents can be attributed to them compromising and adapting to the sub-optimal lighting levels in the absence of any other alternatives.

Figure 20: Electrical lighting requirement during the day

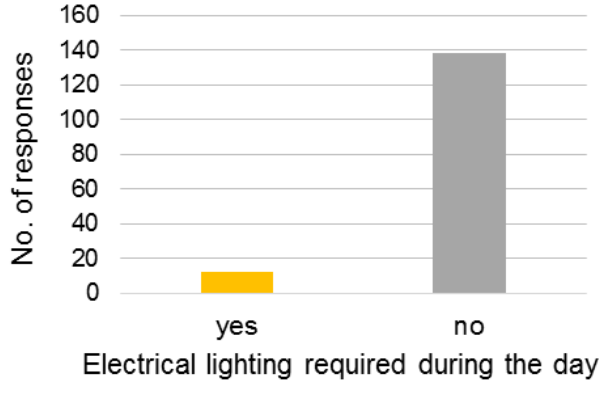


Figure 21: View of interior of a DU

Figure 22: Street view

Figure 23: View of room on ground floor

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. During the survey majority numbers of residents (107 out of 150) were found using either curtains or screens to shade their windows during summer. A substantial number of households were also seen not using any additional shading. A very small number of households had also covered their windows with newspapers.to protect from direct sunlight during summer

Table 13: Survey question and householder responses for additional window shading used in summer

Ques. no.	Aspects accessed	Response					
			N		N		N
10	Window shading during summer	None	43	Curtains/screen/ cloth/netting/ inside or outside blinds	107	News paper	11

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 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 presence of dampness in the dwellings.

Ques. no.	Aspects accessed	Response				No. of response
14	Dampness	yes	no	-	-	150
16	Causes of dampness	Leaking of pipes	Building material is not water resistant	Improper construction workmanship	Poor design	49

Figure 24: Presence of dampness inside the dwelling

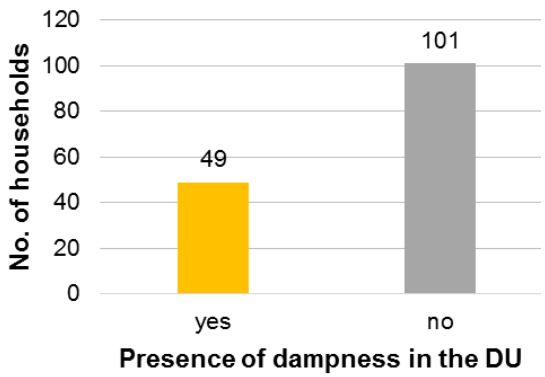
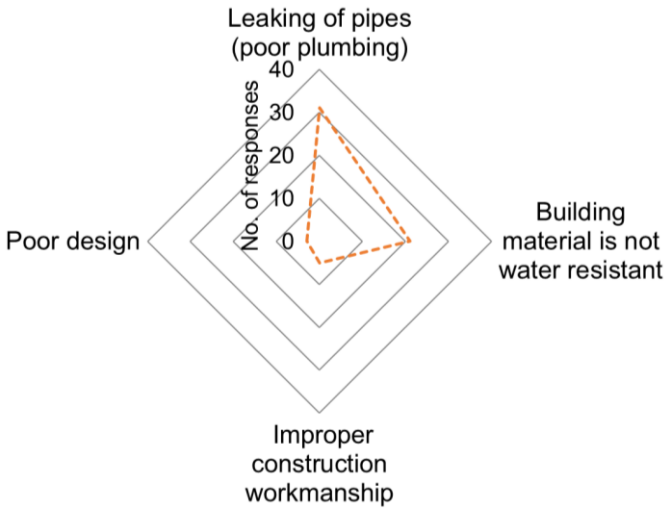


Figure 25: Perceived causes of dampness



The poor quality of constriction and building materials was evident in the presence of dampness inside many surveyed dwellings. Out of 150 surveyed households nearly one third (49) households reported the presence of dampness in their homes (Figure 24). Most of these houses had dampness on the toilet or kitchen walls and hence attributed it to the *leaking of pipes* (poor plumbing). In some houses dampness was also seen on the balcony walls. Many households also perceived *building materials not being water resistant* as a cause of dampness (Figure 25). Almost negligible number of householders attributed the dampness to *improper construction workmanship and/or poor design.*

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.

Ques. No.	Maintenance and repair	Response			
			N		N
17	Is the maintenance of the common areas and building regularly done?	yes	149	no	1
18	Do you pay into a resident's welfare association to cover maintenance and repair costs for common areas and the building?	yes	149	no	1

All the residents unanimously informed that the development has no maintenance system in place. Many householders clean the surroundings of their dwellings on their own or share duties with their neighbours. Visits to the Kiron Ki Dhani housing revealed the poor state of cleanliness and up-keep of the streets in the development. There was not system in place for disposing garbage and due to no proper drainage system water logging could be seen in nearly all the streets, resulting in unhealthy living conditions for the residents.

Figure 26: Garbage and water logging on the streets of the development.

Figure 27: View of garbage and water logging behind a dwelling.

Figure 28: View of a street in Kiron ki Dhani

Figure 29: Garbage and water logging under the ground floor balcony of a dwelling

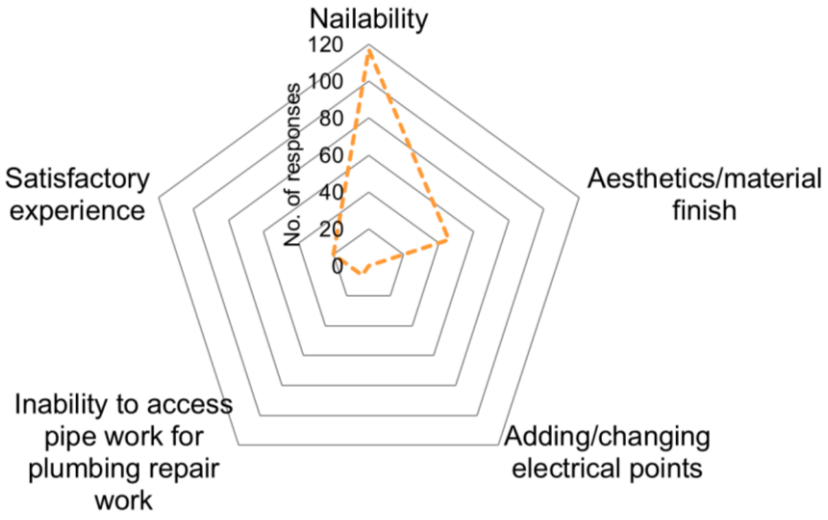
The survey also focused on obtaining feedback from the residents regarding their experience with the building materials used in the development (Table 16). For this survey question the householders were allowed to choose more than one response.

Table 15: 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	Aesthetics/material finish	Nailability	Adding/changing electrical points	Inability to access pipe for plumbing repair works	150

During the survey, majority of the surveyed households (117 out of 150) expressed concern regarding the *'Nail-ability'* 'i.e. the suitability [of a wall] for being nailed. While some residents had a *satisfactory experience* with the building materials, a substantial number of them 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 30: Householders 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 responders and their responses regarding accessibility to basic facilities.

Ques. No.	Aspects accessed	Response					No. Of response (N)
20	Convenient access to essential facilities	yes	no	-	-	-	150
21	Travel time to work (minutes)	0-20	20-40	40 -60	60 min & above		150
22	Travel time to school (minutes)	0-20	20-40	40 -60	60 min & above		113
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		150
24	Mode of travel to school	Own vehicle	Access to public transport	Walking distance	School bus	No school going children in the house	113

The cases study housing development is located approximately 19 km away from Jaipur city centre. During the survey the householders informed that for most residents (88 out of 150) the place of work is not at a convenient distance from the development (Figure 31). The travel time to work varied across the surveyed households with majority (55 out of 150) taking around 20-40 minutes to reach to their work place. A similar number of households (52 out of 150) also reported taking around 20 minutes, while remaining residents reported taking 40 to 60 minutes for traveling to work (Figure 32).

Figure 31: Convenient proximity to work

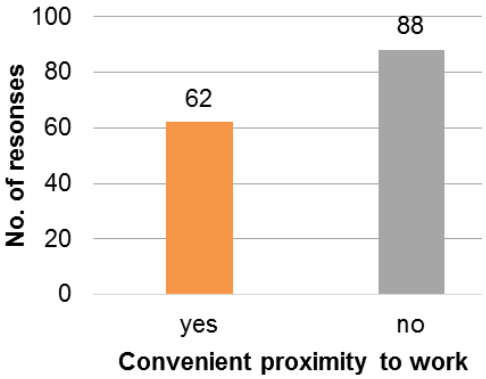
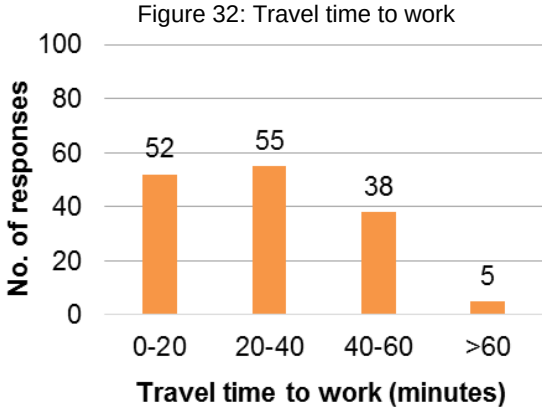
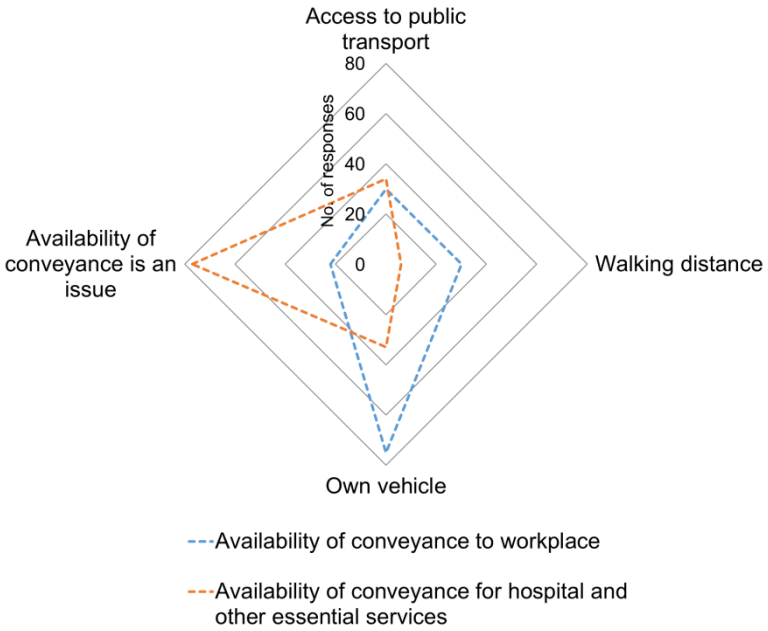


Figure 32: Travel time to work



During the survey 50% (75 out of 150) of the surveyed households reported using their *own vehicle* for commuting to work. For about 30 householders their place of work was at *walking distance* from the development and nearly equal number of households reported having *access to public transport* to travel to work. The residents also informed that basic facilities such as hospitals and market place were not at convenient proximity from the development and the *availability of conveyance is an issue* (Figure 33). Overall the residents seemed to be largely unsatisfied with the isolated location of the development. The housing is disconnected from the city, and there is no proper public transportation system easily accessible from the development. The residents have to walk for 1 to 2 km to access the nearest public transport. The nearest hospital is located at a distance of around 5-6 km from the development and an absence of proper public transportation system makes it even more difficult for them to access these facilities. The householders also voiced their concern regarding safety in and around the development.

Figure 33: Mode of travel

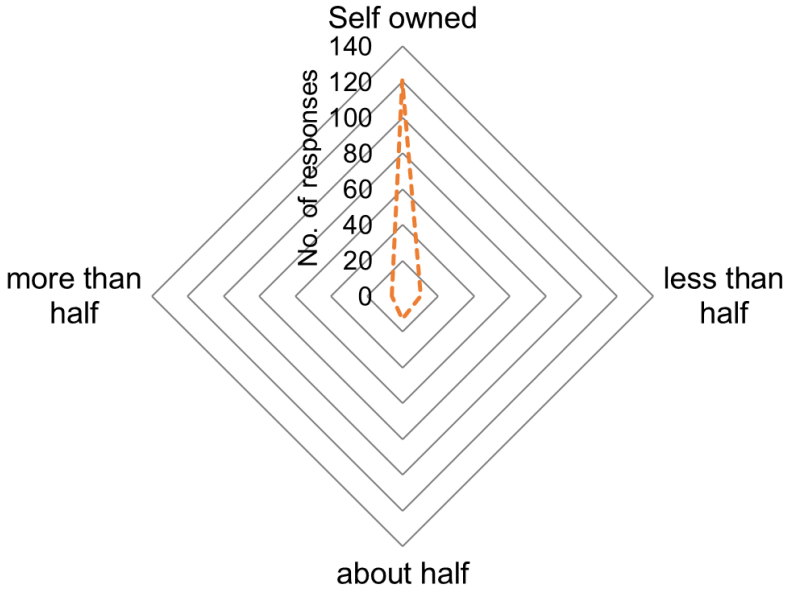


Of the 150 surveyed dwellings, 113 households had school going children. Majority of the children in the development use *school bus* to commute to their schools. Some also have their schools at walking distance. Mostly the children take about 20 minutes to reach to their schools while others take 20 minutes or more.

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 about 4 years. Of the 150 surveyed households, nearly all (n: 121) were owned by the residents themselves. The remaining houses (n: 29) were rented of which majority (n: 13) households spent *about half* of their monthly salary on rent (Figure 34). Majority (108 out of 150) of the surveyed households paid about up to 500 INR for electricity

Figure 34: Proportion of monthly income spent on rent



5. Conclusion

- The Kiron Ki Dhani housing development was constructed with an aim to improve the living conditions of the slum dwellers and daily wage workers, working in the Muhana Mandi area of Jaipur city. The housing project may have provided upgraded dwellings to the residents, but the survey revealed that the residents perceived the indoor comfort conditions in these dwellings to be 'just' bearable during summer. Nearly 50% (71 out of 150) of the surveyed households reported their *overall experience* of the indoor environmental conditions as bearable during summer, whereas during winter the same number of households found their overall indoor conditions satisfactory. The residents where seen particularly unsatisfied with the indoor temperatures during summer. Given the extreme external temperatures in Jaipur, during both summer and winter, while this may be indicative of the poor thermal performance of the building envelope during summers; better perception of the indoor conditions in winter can be attributed to both the greater adaptability of residents to the environmental conditions and also the compact size and less exposure of the dwelling units, resulting in lesser heat loss during winter.
- Cross relating the survey results for indoor environmental quality revealed that in winter the perception of indoor temperature had a relatively stronger influence on the householders' overall experience of the indoor environment as compared to that in summer. Whereas, the perception of indoor air movement was found to be more influential in governing the householders'' overall experience in summer, as compared to that in winter. Despite the high external temperatures in summer in Jaipur, the residents' seemed to prefer well-ventilated dwellings. Incorporating passive cooling measures in the design could enhance the indoor comfort in these dwellings during summers. The planning and design of the dwelling units and their orientation at site should be given better attention in order to promote better indoor environmental conditions.
- The small built-up area allotted for these houses emerges as a concern in all the surveyed social housing developments across the country. With majority of the households comprising of minimum 5 members, living conditions become congested, which can also be the cause of discomfort inside these homes.
- The materials used for construction is mainly RCC for the structure and flyash bricks for walls. Majority of the surveyed households reported facing issue of *'Nailability i.e* 'i.e. the suitability [of a wall] for being nailed as a prime concern w.r.t to the building materials. 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) or *building materials not being water resistant*. This reflects the poor workmanship in construction. Poor quality of materials used and lack of attention during construction could also be seen in the damaged conditions of ground floor balconies. Due to budget constraints in the project, these balconies where added after the completion of the building and were not structurally stable or of good quality. Many residents had to provide extra support to these ground floor balconies for stability. The quality of plaster used was also very poor.
- As is the case with most social housing developments in India, this locality also lacks cleanliness and maintenance. There is no garbage disposal or maintenance system in place for the development. The inappropriate planning of drainage resulted in water logging on the streets creating unhygienic conditions and posing health hazard to residents of the colony. The central spaces originally meant to be developed as landscaped areas, have been left incomplete and unattended, and as a result have become dumping grounds. The locality also

lacks clean drinking water facilities, as many householders informed of the presence of florid in the available water.

- The residents seemed largely unsatisfied with the location of the development. The survey revealed that for majority of the households the proximity to place of work and basic facilities like hospitals is not convenient and availability of conveyance is an issue. The residents have to walk for about 1-2 km to access the nearest bus stop. Due to the isolated location of the development residents also expressed concern regarding their safety, especially that of women and children. They also reported increasing number of thefts in the area over the years.