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Findings from householder survey in Shanti Kusth Ashram, Dehradun

Case study report

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October 2018

MaS-SHIP

Mainstreaming Sustainable
Social Housing in India Project

OXFORD BROOKES UNIVERSITY
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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 120 social housing residents of the Shanti Kusth Ashram, located in the Bhagat Singh colony in Dehradun. The housing project was developed to rehabilitate and 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. Only 9 (out of 120) respondents rated their indoor conditions as 'satisfactory' in summer, whereas in winter this number was nearly four times (n: 37) of that in summer. Air inside dwellings was perceived to be still by nearly half of the surveyed households (n: 65) in summer, while in winter nearly similar number of households (n: 66) perceived their dwellings to be well-ventilated. The residents seemed to prefer well-ventilated indoors during winter. The survey also helped to reveal critical factors that determine the acceptability of building materials from the householders' perspective. The building materials used 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 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. The study revealed an urgent need to establish a maintenance mechanism to improve the health and hygiene of the residents.

1. Introduction

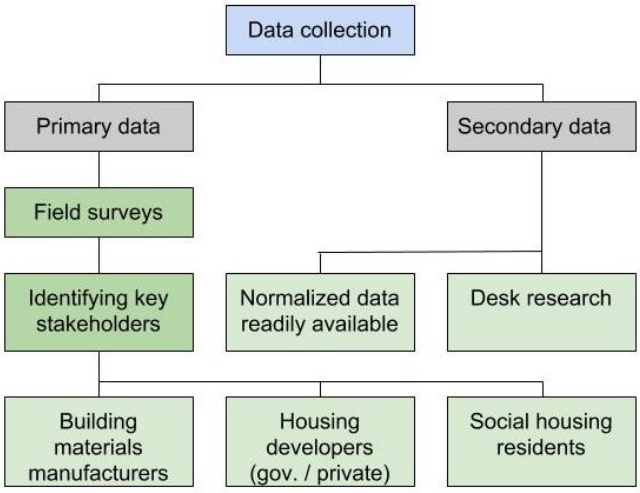
The urban housing shortage in India is currently estimated at 10 million, more than 95% of which pertains to low-income groups. Through its "Housing for All by 2022" mission, the Government of India intends to close this gap by aiming to construct 12 million housing units over the programme duration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

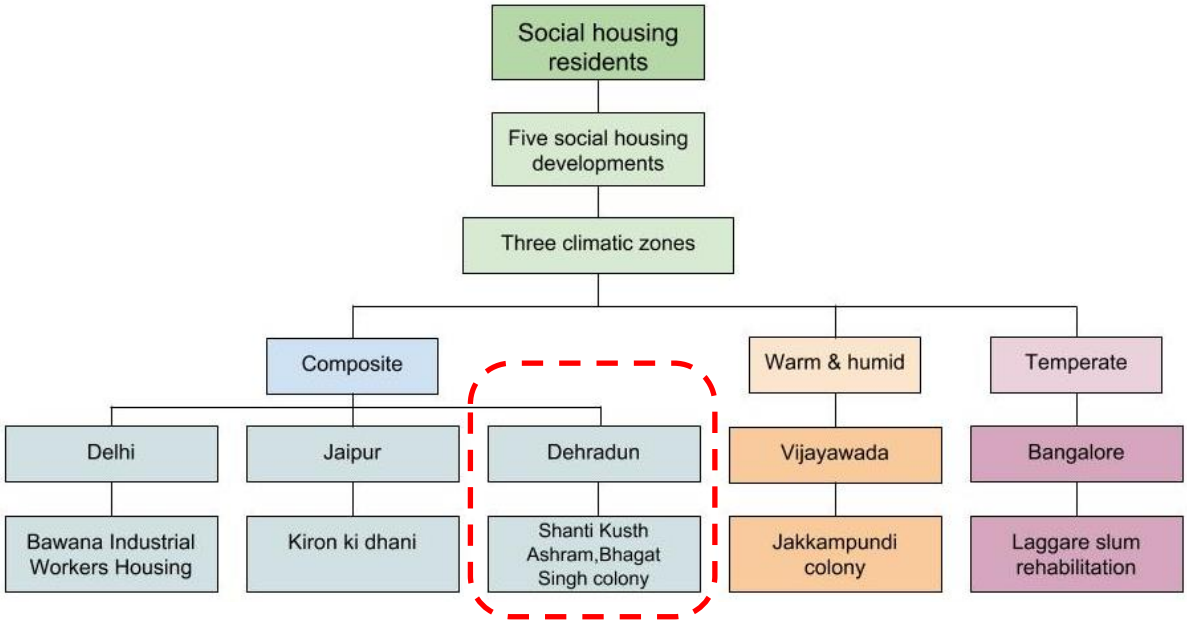
Figure 1: MaS-SHIP data collection methodology



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 Dehradun, 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**s, basic details of the Shanti Kusth Ashram housing 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

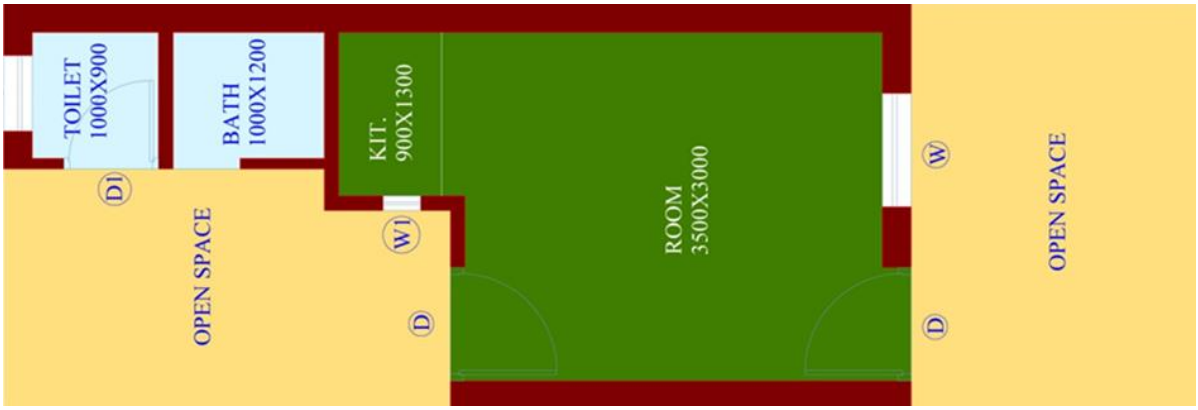
The Shanti Kusth Ashram housing project in Dehradun is a social housing project developed under the Valmiki Ambedkar Awas Yojana (VAMBAY) to provide affordable and improved housing for slum dwellers of Bhagat Singh colony. Designed and constructed by Building Materials and System Promotion Council (BMTPC), the slum rehabilitation housing project 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	Dehradun
Name of the development	Shanti Kusth Ashram, Bhagat Singh colony
Government scheme	Valmiki Ambedkar Awas Yojana (VAMBAY)
Occupancy	9years
Target group	Economically Weaker Section/Slum dwellers
Distance from city centre	1 km
Number of dwelling units	100
Built-up area of each dwelling (sq. ft.)	181
Cost of construction (INR per sq. ft.)	250

The development consists of ground floor structures housing about 100 dwelling units. All units are identical and consist of one room, kitchen space, one WC and separate shower area. The housing units being on the ground floor have access to plenty of open spaces. This area originally housed shanty constructions of these inhabitants that covered most of the space. After the construction was completed, green cover and community spaces were developed in these open areas (Figure 3).

Figure 3: Typical unit layout



2.1 Building materials and system

The Shanti Kusth Ashram 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 INR. 250 per sq. ft. The householders paid on an average of about INR. 45,000 at the time of possession.

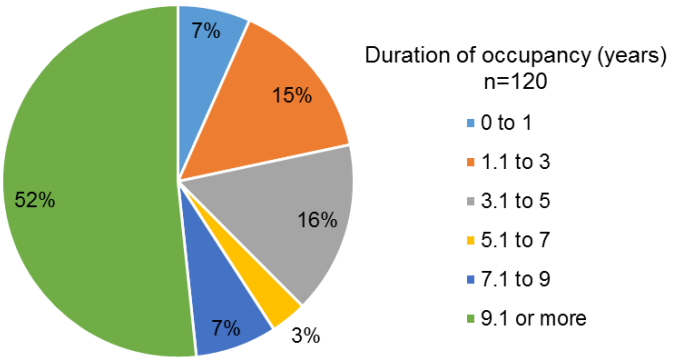
Table 2: Building materials

Foundation	• Step footing in solid concrete blocks
Walling	• Solid/Hollow Concrete Blocks • RCC plinth, lintel, roof level band, vertical reinforcement in corners for earthquake resistance
Roof / Floor	• RCC planks and joists with screed • IPS flooring
Doors and windows	• Pre-cast RCC door frames • Wood substitute door shutters • Cement jali in ventilators and windows
Others	• Internal and external pointing • White wash on walls • Precast Ferro cement chajjas

2.2 About the households

At the time of the survey the houses had been occupied for more than 9 years with most of the original residents still living there. Of the 120 surveyed households about 59% (52%+7%) had been occupied for 9 years or more. About 16% houses had been occupied in between 3.1 to 5 years and 15% of the households had been occupied as less as 1.1 to 3 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 inside these dwellings (Figure 6).

Figure 5: No. of residents in a household

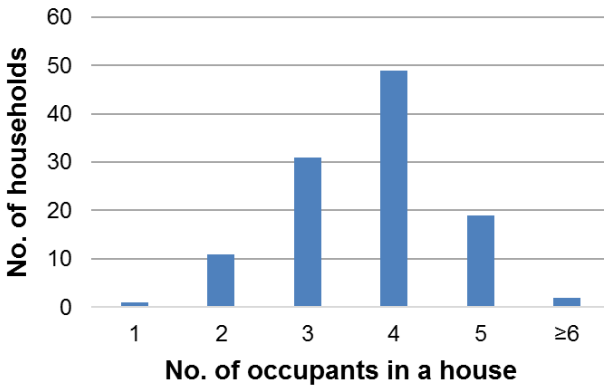


Figure 6: Interior of a dwelling

The surveyed households had 64% of residents aged between 19-59 years, and most of them would spend about 14-16 hours at home during the day. 27% 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. Though the percentage of elderly residents i.e. people above the age of 60 was found to be very less (4%), most of them would spend about 18-20 hours at home during a day (Figure 7). A considerable number of residents were also reluctant to disclose this information.

Figure 7: Age group of residents

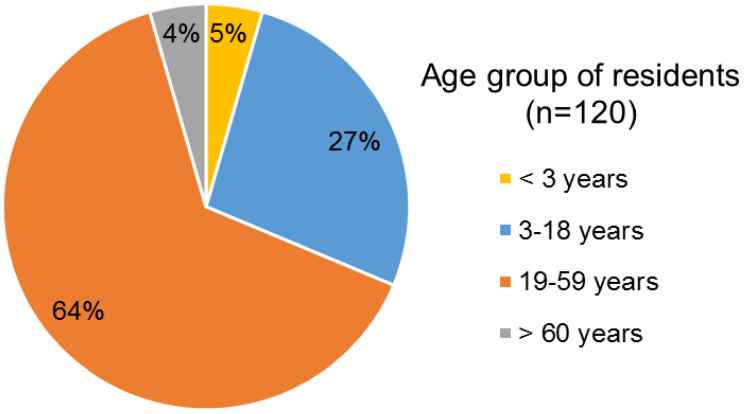
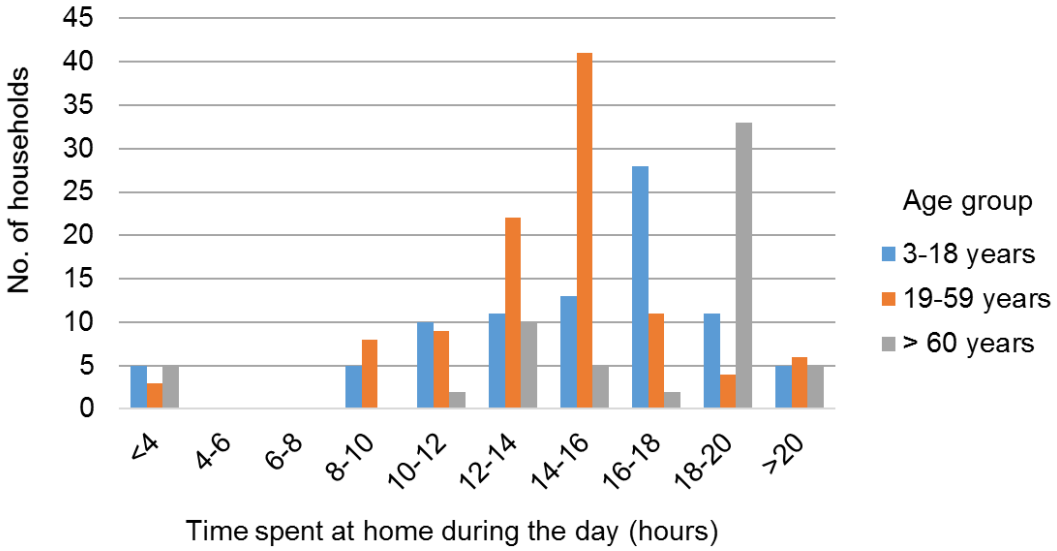


Figure 8: Time spent at home during the day



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 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 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 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	120
7	Air quality	stuffy	bearable	fresh	120
8	Air movement	draughty	still	well ventilated	120
9	Overall experience	unsatisfactory	bearable	satisfactory	120

The survey results, as shown in Figure 9 reveal that of the 120 surveyed households, nearly equal number of households perceived *indoor temperatures* to be either *unsatisfactory* (n: 54) or *bearable* (n: 52) during summer. Whereas in winter nearly 50% of the surveyed households (59 out of 120) perceived *indoor temperature* to be *bearable*. The tolerance of indoor temperatures is observed to be higher in winter with the number of households perceving *satisfactory indoor temperature* being nearly twice of that during summer (36 in winter & 14 in summer out of total 120). Consequantly, in winter the number of households completely *unsatisfied* with the *indoor temperatures* was found to be nearly half of that during summer (25 in winter & 54 in summer out of total 120). Similar trend is observed for the householder survey responses for *indoor air quality* (Figure 10). During summer, of the 120 surveyed households, majority households perceived their dwellings to be *stuffy* (52 out of total 120) and nearly one third (42 out of 120) perceived *indoor air quality* to be 'just' *bearable*. While only 26 households perceived *air quality* in their dwellings as *fresh* during summer, nearly similar number of households (n: 25) perceived *stuffy* indoors during winter. Unlike summer, in winter nearly half (57 out of 120) of the surveyed households perceived *indoor air quality* to be *bearable* and about one third (38 out of 120) perceived it as *fresh*. 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

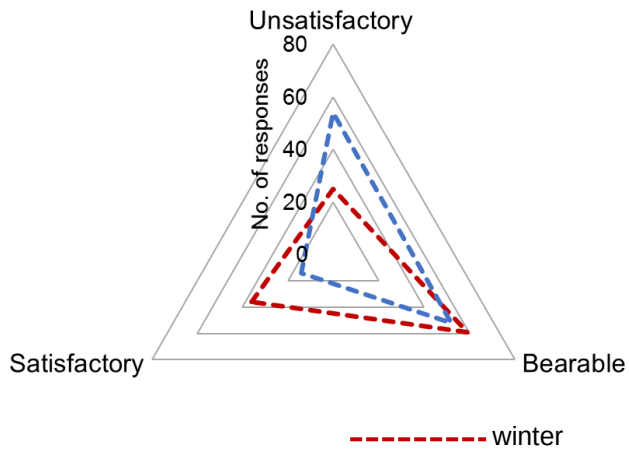
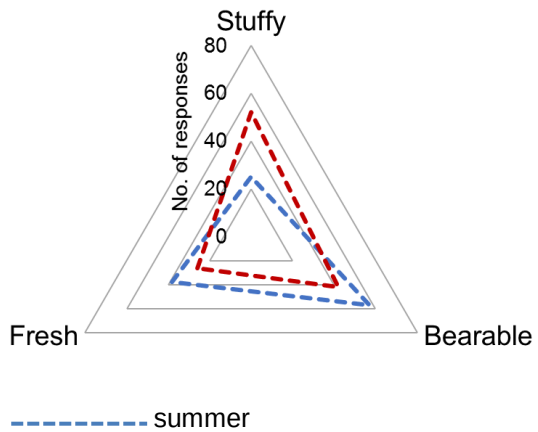


Figure 10: Perceived indoor air quality



On inquiring about the quality of *air movement* in their dwellings nearly 54% (65 out of 120) of households felt their homes were *stuffy* during summers. Whereas nearly similar number of households (66 out of 120) perceived their dwellings to be *well-ventilated* during winters. Likewise, in winter *still indoor air* was perceived by 50 households and nearly similar number of households (46 out of 120) perceived their dwellings to be *well-ventilated* in summer. Though *Draughty doors and windows* were reported by negligible number of households during both summer and winter, the number was found to be higher in summer (Figure 11). Owing to the better indoor environmental conditions perceived during winter, overall the number of households *unsatisfied* with their *overall experience* in winter (n: 15) was nearly one third of that during summer (n: 43). Consequently the number of households reporting *overall satisfactory experience* in winter (n: 37) was nearly four times of that during summer (n: 9). Interestingly, overall equal number of households (68 out of 120) reported *bearable overall experience* during both summer and winters (Figure 12).

Figure 11: Perceived indoor air movement

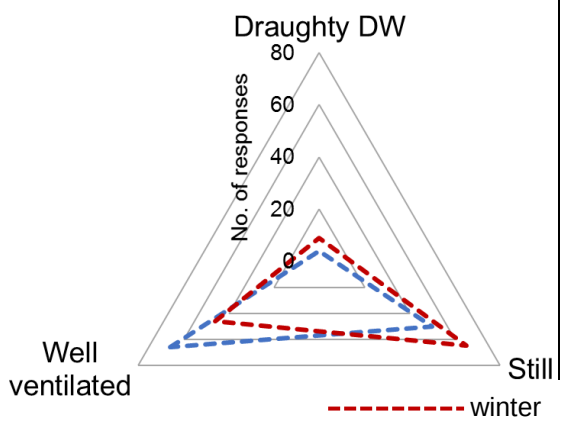
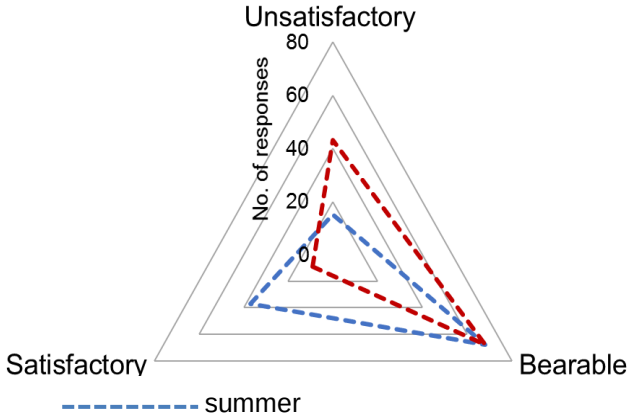


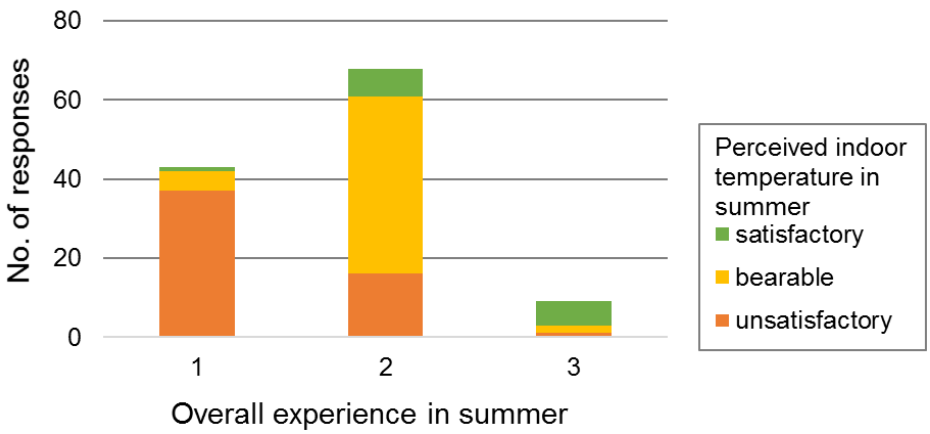
Figure 12: Overall experience



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 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

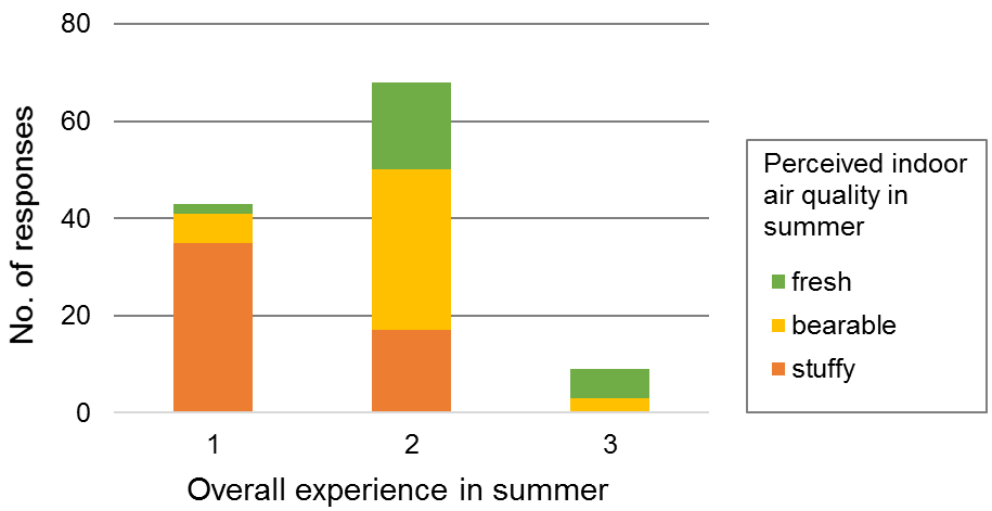
Table 5: Cross tabulation- overall experience vs perceived indoor temperature in summer

		Overall experience in summer			Total
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived Indoor temperature in summer	unsatisfactory	**37**	**16**	1	**54**
	bearable	5	**45**	2	**52**
	satisfactory	1	7	**6**	**14**
	Total	**43**	**68**	**9**	**120**

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 43 households reporting *unsatisfactory overall experience* 86% (37 out of 43) households perceived *indoor temperature* also as *unsatisfactory*. Similarly, for the 68 households reporting *bearable overall experience* the number of households perceiving *indoor temperatures* also as *bearable* was found to be highest (n: 45). A few of households (n: 16) however, despite their *unsatisfactory* experience of the *indoor temperatures* reported their overall experience as *bearable*. Though the number of households reporting *overall satisfactory experience* was nearly negligible (n: 9), of these, the number of households with *satisfactory perception of indoor temperature* was found to be highest (n: 6). Overall, the residents perception of indoor temperature in these dwellings was found to be mostly *unsatisfactory* or *bearable* during summer, indicating the poor thermal performance of the building envelope. In the composite climate of Dehradun, the perception of indoor temperature also seemed to have a relatively significant effect on the residents' overall experience of the indoor conditions.

Cross relating the survey responses for overall experience vs perceived indoor air quality in summer (as shown in graph in Figure 14 and cross-tabulation in Table 6), revealed that the householders largely perceived indoor air quality as either *stuffy* or *bearable* and this seemed to have a noteworthy effect on their *overall experience* of the indoor environment.

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



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

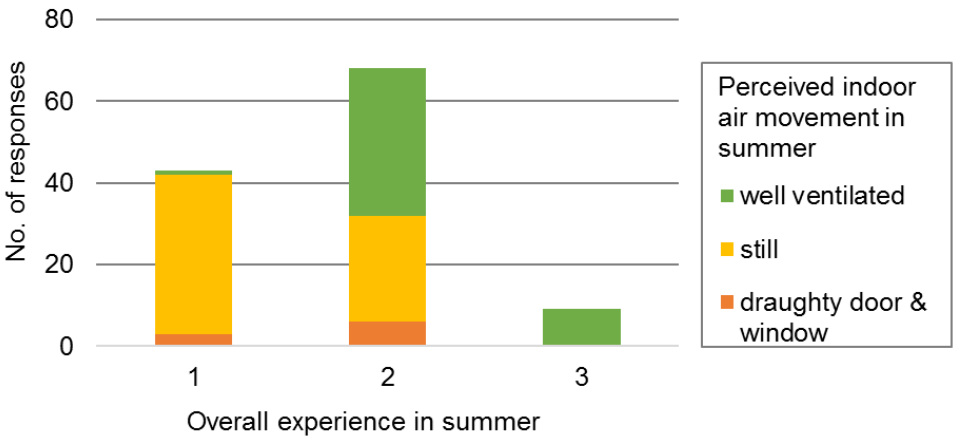
Table 6: Cross tabulation - overall experience vs perceived indoor air quality in summer

		Overall experience in summer			Total
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived indoor air quality in summer	stuffy	**35**	**17**	0	**52**
	bearable	6	**33**	3	**42**
	fresh	2	**18**	**6**	**26**
	Total	**43**	**68**	**9**	120

A *bearable* perception of *indoor air quality* did lead to a *bearable overall experience* for majority of the residents. Of the 42 households perceiving *air quality* in their dwellings as *bearable*, majority (n: 33) households reported *overall experience* also as *bearable*. Majority of the surveyed households perceived their dwellings to be *stuffy* (n: 52) during summer, of these the number of households with *overall unsatisfactory experience* was found to be highest; however a substantial number of these households also reported *bearable overall experience* (n: 17). Interestingly, perceiving *indoor air quality* as *fresh* did not seem to trigger a *satisfactory overall experience* for the residents. 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 quality in summer



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

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

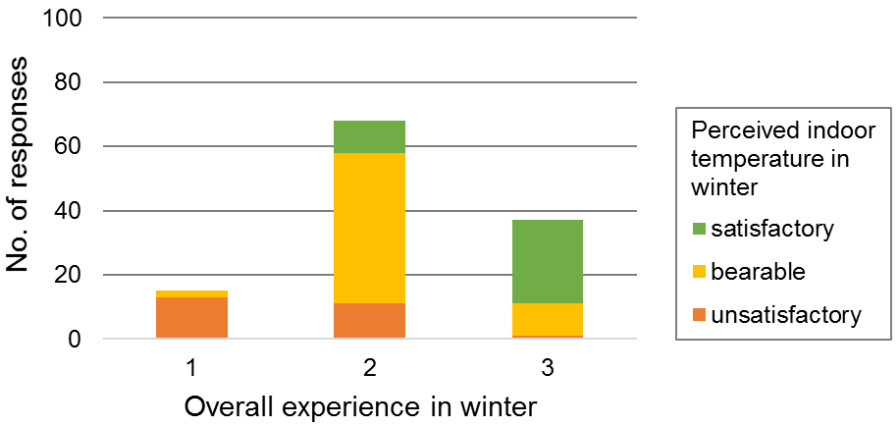
		Overall experience in summer			**Total**
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived indoor air movement in summer	Draughty door & window	3	6	0	**9**
	still	**39**	**26**	0	**65**
	Well-ventilated	1	**36**	**9**	**46**
	Total	**43**	**68**	**9**	**120**

The survey results showed that the householders largely perceived *air movement* in their dwellings to be either *still* (n: 65) or *well-ventilated* (n: 46) during summer. It was observed that the perception of *indoor air* being *still* lead to an *unsatisfactory overall experience* for majority of the households. Of the 65 households perceiving *still indoor air*, 60% (39 out of 65) households reported *overall unsatisfactory experience*. However, a substantial number of households despite perceiving *still indoor air* reported *overall experience* as 'just' *bearable*. Perceiving *well-ventilated* indoors in summer did not seem to significantly improve the residents overall experience of the indoor conditions but likely made the overall indoor environment only more *bearable* for them. Of the 46 households perceiving their dwellings to be *well-ventilated*, nearly 78% (36 out of 46) reported *overall experience* as *bearable*, while only 20% (9 out of 46) of these households reported *overall satisfactory experience*. This indicates that ventilation (air movement) did not have any significant cooling effect in summer. This is understandable as due to high external temperatures in summer, ventilation (air movement) without any passive cooling measures may not always provide cooling in these naturally ventilated dwellings.

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

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

Figure 16: Overall experience vs perceived indoor temperature during winter



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

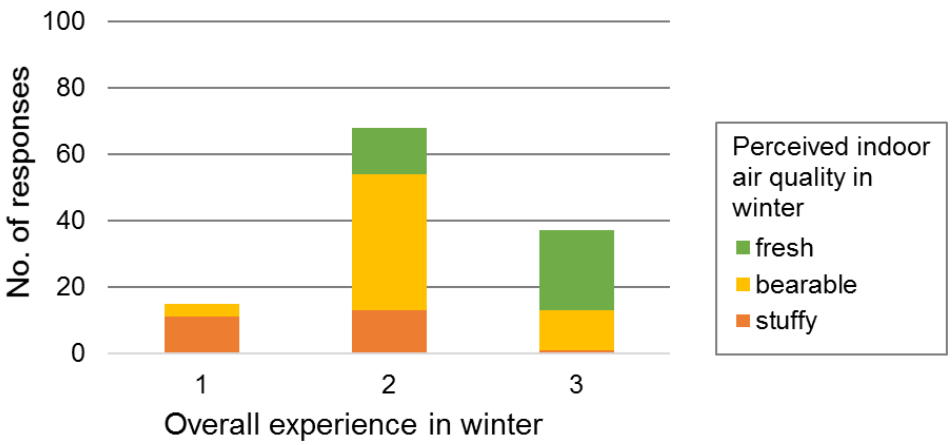
Table 8: Cross-tabulation- overall experience vs perceived indoor temperature in winter

		Overall experience in winter			Total
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived indoor temperature in winter	unsatisfactory	**13**	11	1	**25**
	bearable	2	**47**	10	**59**
	satisfactory	0	10	**26**	**36**
	Total	**15**	**68**	**37**	**120**

Similar to summer, in winter too the perception of *indoor temperature* seemed to have a significant influence on the householders' *overall experience* of the indoor environment. Of the 15 households reporting *overall unsatisfactory experience*, the number of households perceiving *indoor temperatures* also as *unsatisfactory* was found to be highest (n: 13). Similarly, 68 households reported *overall experience* as *bearable* during summer, of which majority (n: 47) households perceived *indoor temperatures* also to be *bearable*. Of the remaining, nearly equal number of households perceived *indoor temperature* as either *unsatisfactory* (n: 11) or *bearable* (n: 10), but their *overall experience* remained only *bearable*. For the households reporting *overall satisfactory experience* (n: 37) the number of households with *satisfactory* perception of *indoor temperatures* (26 out of 37) was found to be highest. Though the residents' perception of indoor temperatures in these dwellings was found to be relatively better in winter, this could be attributed to their greater adaptability of the indoor environment in winter.

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



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

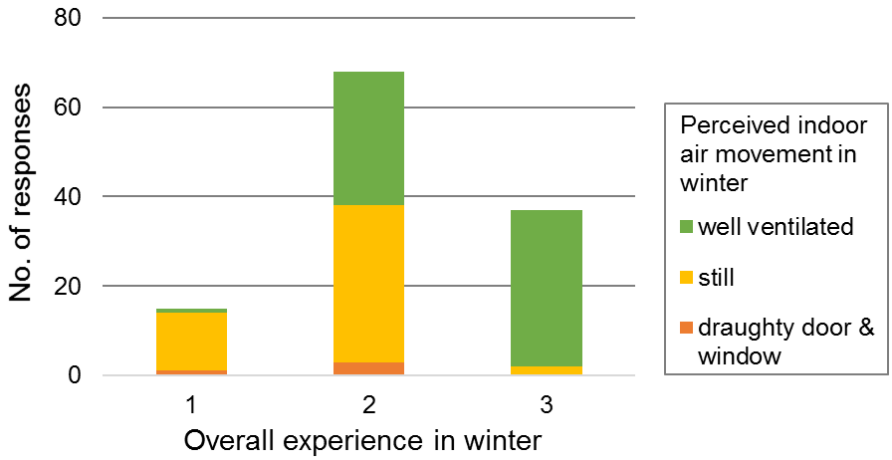
Table 9: Cross tabulation- overall experience vs perceived indoor air quality in winter

		Overall experience in winter			**Total**
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived indoor air quality in winter	stuffy	**11**	13	1	**25**
	bearable	4	**41**	12	**57**
	fresh	0	14	**24**	**38**
	Total	**15**	**68**	**37**	**120**

The residents of Shanti Kush Ashram colony seemingly had a relatively mixed perception of air quality in their dwellings, and this therefore did not seem to have any significant effect on their overall experience of the indoor environment. Of the 68 households reporting overall bearable experience, majority (n: 41) perceived air quality in their dwellings to be also bearable. Of these remaining households, nearly equal number of households perceived air quality as *stuffy* (n: 13) and *fresh* (n: 14) but their *overall experience* remained only *bearable*. For households with *overall satisfactory experience* in winter, though the number of households perceiving *fresh indoor air* was found to be highest, a substantial number of these households also perceived *indoor air quality* to be just *bearable*.

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

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



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

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

		Overall experience in winter			Total
		1=unsatisfactory	2=bearable	3=satisfactory	
Perceived indoor air movement in winter	Draughty door & window	1	3	0	**4**
	still	**13**	**35**	2	**50**
	well ventilated	1	**30**	**35**	**66**
	Total	**15**	**68**	**37**	**120**

Similar to summer, in winter too, the householders largely perceived *air movement* in their dwellings to be either *well-ventilated* (n: 66) or *still* (n: 50). It was observed that the perception of *indoor air* being *still* lead to an *unsatisfactory overall experience* for majority of the households. Of the 15 households perceiving *still indoor air*, nearly all (13 out of 15) households reported *overall unsatisfactory experience*. However, a substantial number of households despite perceiving *still indoor air* reported *overall experience* as 'just' *bearable*. Unlike summer, perceiving *well-ventilated* indoors did seem to have a noteworthy influence in improving the residents overall experience of the indoor conditions during winter. Of the 66 households perceiving their dwellings to be *well-ventilated*, nearly 53% (35 out of 666) reported *overall experience* as *satisfactory*, and 45% (30 out of 66) reported *overall bearable experience*. Well-ventilated homes seemed to be preferred by the residents during winters.

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

In the composite climatic zone of Dehradun which is characterised by high temperatures in summers and cold in winters and high levels of humidity during the monsoons; the residents of Shanti Kush Ashram colony mostly found the indoor environmental conditions in their dwellings 'just' *bearable* during both summer and winter. For all the accessed parameters influencing the residents' *overall experience* of the indoor environmental conditions, the number of households perceiving better indoor conditions (temperature, air and overall experience) was found higher during winters as compared to that during summers. Especially for perceived *indoor temperatures*, the number of *satisfied* households in winter was found to be nearly twice of that in summers. Consequently, the number of households perceiving unsatisfactory indoor temperatures in winters was nearly half of that during summer. This indicates poor thermal performance of the building envelope, especially during summers. For *indoor air quality and air movement*, more number of households perceived fresh indoor air and well ventilated interiors in winters as compared to summers. Likewise, the number of households perceiving *stuffy indoor air quality* in winters was half of that in summer. A significantly lower number of occupants feeling unsatisfied with the indoor temperature and air quality in winters as compared to that in summers, indicates greater adaptability of the occupants during winters and also the need for adopting better passive cooling strategies in order to improve indoor comfort, during summers.

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.

The Spearman's correlation coefficient (r_s[1]) values of 0.624 and 0.665 (Table 11) for *overall experience* vs perceived *indoor temperatures* in summer and winter respectively, reveal *indoor temperatures* as a significant factor influencing the householders' perception of the overall indoor environment during both summer and winter. Likewise, the r_s values of overall experience vs perceived *indoor air quality* and *air movement* (Table 11) shows moderate correlation between these variables in both summer and winter.

Table 11: Spearman's correlation coefficient

		Spearman's correlation coefficient
Overall experience in summer vs	Indoor temperature	0.624
	Air quality	0.585
	Air movement	0.536
Overall experience in winter vs	Indoor temperature	0.665
	Air quality	0.575
	Air movement	0.578

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.

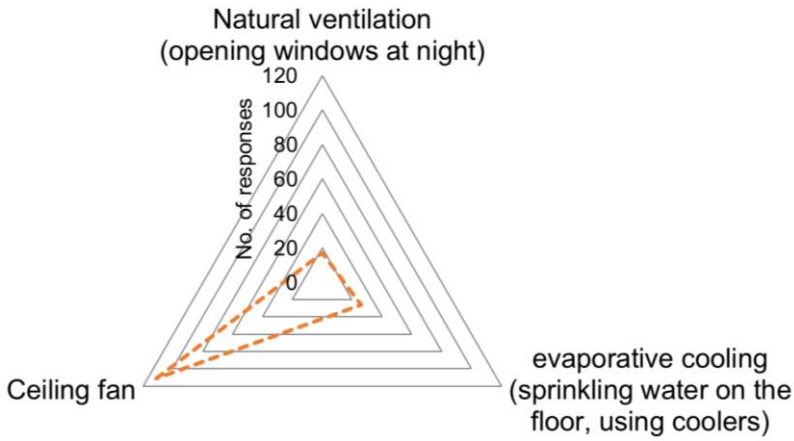
Table 12: Survey questions and householder responses for comfort strategies adopted during summer and winter

Ques. no.	**Aspects accessed**	**Response**					
			N		**N**		**N**
11	Cooling strategy adopted during summers	Natural ventilation (opening windows at night)	17	Evaporation cooling (sprinkling water on the floor, using coolers)	26	Ceiling fan	111
12	Adaptive strategy during winters	Blankets & shawls	13	Bon fire	30	Electric heater	16

The survey showed the use of celling fans as a basic and most common measure adopted by the residents to provide cooling in summers. Out of the 111 residents using ceiling fans about 17 also reported opening windows to allow for night time ventilation cooling. A substantial number of households could afford desert cooler which enhanced the indoor comfort through evaporative cooling. Sprinkling water on the floor also emerged as a way that the residents resorted to in order to reduce indoor temperature through evaporative cooling (Figure 19).

[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"

Figure 19: Cooling strategies adopted during summer



Despite the external temperatures dropping as low as 4 to 10 deg. C (Bureau of Energy Efficiency, 2011) during winters, maximum number of households (61 out of 120) reported using no extra measure to adapt to the reduced external temperatures. However, a substantial number of households (30 out of 120) reported using fire (in the form of bon-fire outside the house) to cope with the cold weather. Use of electric heaters/blowers was seen only in some households, presumably due to the relatively high electricity bills associated with their use.

4.3 Daylighting

The quality of indoor lighting was accessed by asking the residents if they needed to use artificial/electrical lighting during the day (question 13 in Table 3). Nearly one third (43 out of 120) of the surveyed households reported that they needed to use electrical lighting during the day (Figure 20). Though the survey did not prompt the residents to provide reasons for their response it was observed that poor quality of daylight inside these dwelling units can be attributed to the design and layout of the houses and dense cluster planning. The surveyors also observed this as a reason of inadequate air movement in these dwellings.

Figure 20: Electrical lighting requirement during the day

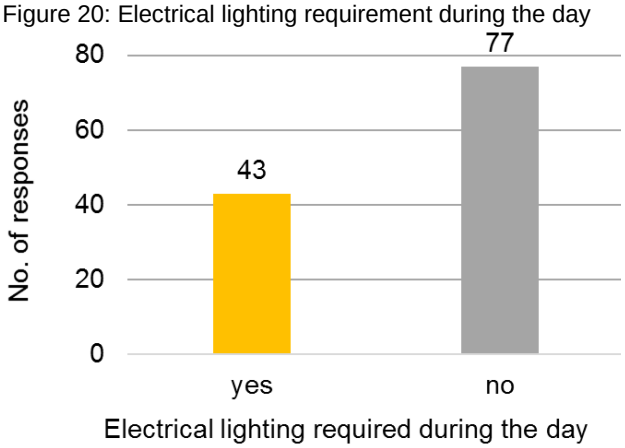
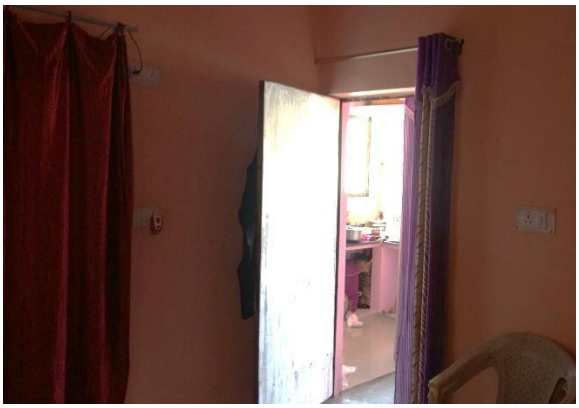


Figure 21: Interior view of a dwelling



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. Nearly all the residents reported using either curtains or screens to shade their windows during summer.

Table 13: 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	0	Curtains/blanket/screen/ cloth/netting/ inside or outside blinds	120

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 researchers 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 responses
14	Dampness	yes		no		149
16	Causes of dampness	Leaking of pipes	Building material is not water resistant	Improper construction workmanship	Poor design	149

The poor quality of construction and building materials was evident in the presence of dampness inside majority of the surveyed homes. 96 out of the 120 surveyed households reported dampness in their homes (Figure 22). Nearly all these households reported dampness in the walls and ceiling of the entire house and hence majority residents attributed it to *building materials not being water resistant.* A substantial number of households also perceived the *leaking of pipes* (poor plumbing) and *improper construction workmanship* as a cause of dampness (Figure 23). Some of them also attributed the dampness to *poor design.*

Figure 22: Presence of dampness inside the dwelling

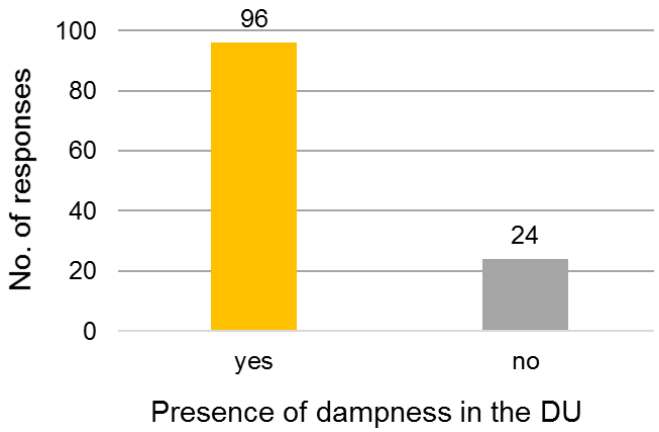
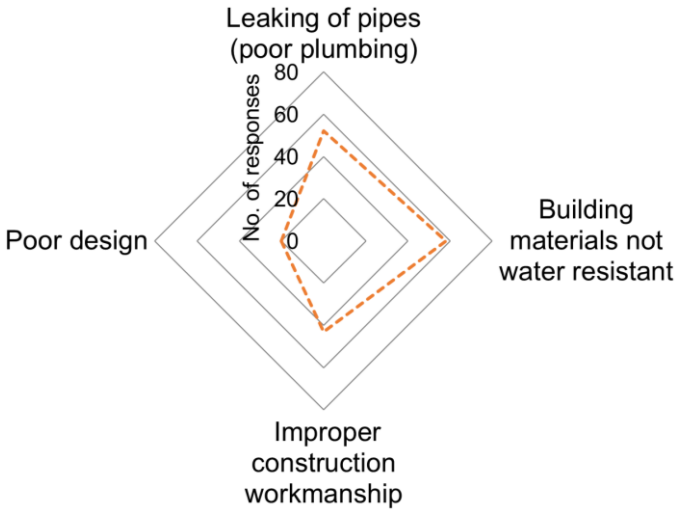


Figure 23: Perceived causes of dampness



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

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

Ques. No.	Maintenance and repair	Response			
			N		N
17	Is the maintenance of the common areas and building regularly done?	yes	7	no	113
18	Do you pay into a resident's welfare association to cover maintenance and repair costs for common areas and the building?	yes	0	no	120

The residents informed that there was no system in place for the up-keep and maintenance of the common areas of the colony. Evidently, the streets and the surroundings of the houses were not properly maintained. There was no system for garbage disposal, which had resulted in the accumulation of waste along the streets.

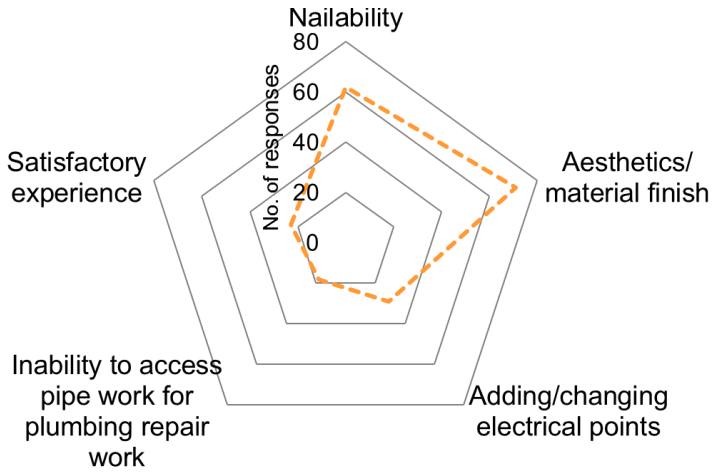
The householder survey questionnaire also focused on gathering feedback from the residents regarding their experience with the building materials used in the dwellings. Table 16 shows the survey question and responses of the householders' experience with the building materials of the dwellings. For this survey question the householders were allowed to choose more than one response.

Table 16: 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	Nail-ability	Adding/changing electrical points	Inability to access pipe for plumbing repair works	120

During the survey, majority number of residents (n: 71) voiced their opinion on the *aesthetics* of the buildings, which is subjective and pertains to the architectural design and/ or external/internal finishes of the building. The residents' dissatisfaction regarding the building materials was also evident from many of the households (n: 62) expressing concern regarding the *'Nail-ability'* 'i.e. the suitability [of a wall] for being nailed and facing difficulty in *adding/changing electrica*l *points.* Concerns regarding the *inability to access pipe work for plumbing repair works* were expressed only by 18 households (Figure 24).

Figure 24: 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. The housing development is located at the heart of the city approximately 1 km away from the city centre. During the survey it was found that for nearly two third of the households (80 out of 120) the place of work is at a convenient distance from their residence (Figure 25).

Table 17: Survey questions and householder responses regarding 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	-	-	-	120
21	Travel time to work (minutes)	0-20	20-40	40 -60	60 min & above		120
22	Travel time to school (minutes)	0-20	20-40	40 -60	60 min & above		120
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		120

24	Mode of travel to school	Own vehicle	Access to public transport	Walking distance	School bus	No school going children in the house	120

Majority residents (n: 57) would therefore would take about 20 minutes to reach to their work place and for the remaining others travel time to work varied between 20 minutes to an hour or more (Figure 26).

Figure 25: Convenient proximity to work

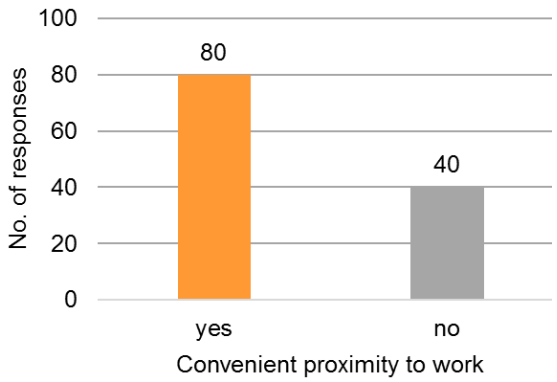
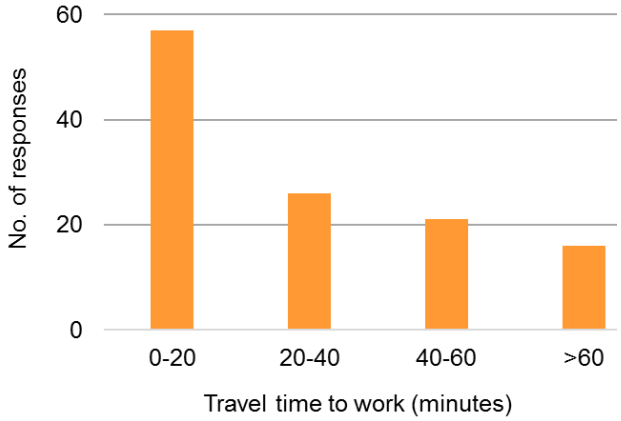
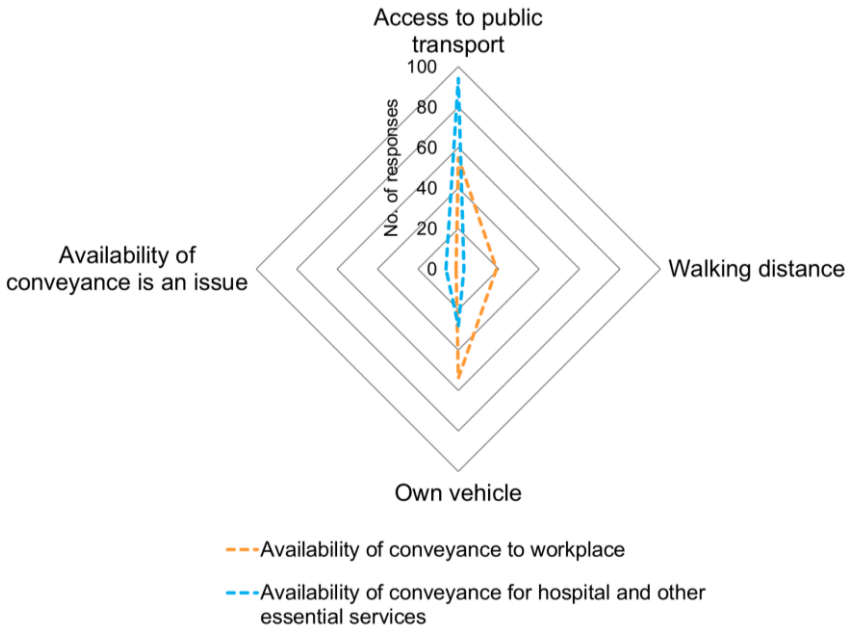


Figure 26: Travel time to work



None of the surveyed households expressed concern regarding the availability of conveyance to travel to their work place or other essential facilities like hospitals. Nearly equal number of households reported using their *own vehicles* (n: 54) or having *access to public transport* (n: 55) for commuting to their place of work. Likewise, majority residents (n: 94) reported having *access to public transport* to travel to hospitals or other places of utility. Some of them also used their *own vehicles* to commute to hospitals (Figure 27).

Figure 27: Mode of travel



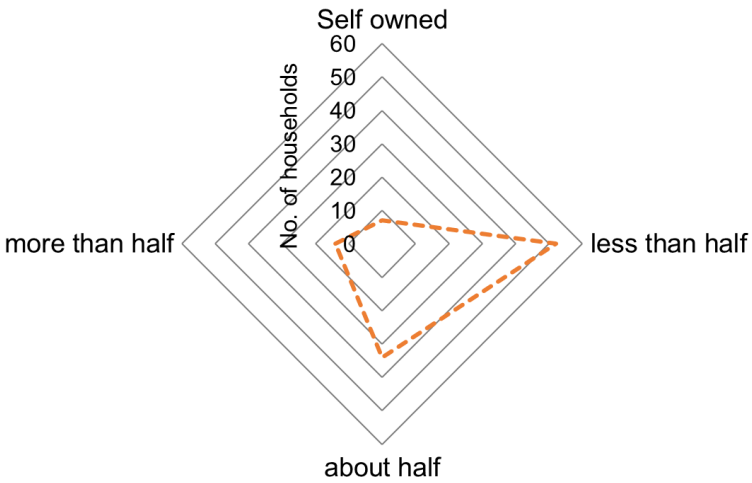
Of the 120 surveyed dwellings, 80 households had school going children. Majority of the children in the development had their schools at walking distance from their house. Nearly equal number of

households reported that the children use their own vehicles or have access to public transport for travelling to school. A few children also used *school bus* to commute to their schools (Figure 27). Majority children would take about 20 minutes to reach to their schools while some also took up to 40 minutes (Figure 28).

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, it was observed that most of the original owners of these dwellings had moved to a different location and rented out their houses in this development. Out of the 120 surveyed households, 100 houses were occupied on rent. Majority of these households (n: 52) paid monthly rent less than half of their monthly income. Some of them also reported paying about half of their monthly income into house rent, while a few paid rent more than half of their monthly earnings.

Figure 27: Proportion of monthly income spent on rent



When inquired about the monthly electricity bill, though the residents were mostly reluctant to share the copy of their electricity bill, it was found that majority of the surveyed households payed about INR 450 to 600, while some also paid around INR 150 to 300. A substantial number of households reported paying INR 750 or more monthly for electricity. Interestingly a few households informed that electricity was being provided for free by the government.

5. Conclusions

- The Shanti Kush Ashram housing, in Dehradun was developed by the BMTPC with the aim to improve the living conditions of the slum dwellers in the Bhagat Singh colony, 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/hollow concrete blocks, Pre-cast jail in ventilators and use of wood substitute for door shutters. 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. Only 9 (out of 120) respondents rated their indoor conditions as 'satisfactory' in summer, whereas in winter this number was nearly four times (n: 37) of that in summer. This indicates the inability of the dwelling units to provide comfortable indoor environment in the summer (in absence of air-conditioning). However in winter, higher levels of adaptation occurs wherein residents resort to warm clothing and blankets, along with a reduced heat loss due to small size/exposure of the dwelling units. Air inside dwellings was perceived to be 'still' by nearly half of the surveyed households (n: 65) in summer, while in winter nearly similar number of households (n: 66) perceived their dwellings to be well-ventilated. The residents seemed to prefer well-ventilated indoors during winter.
- 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 significant factor in influencing the householders' perception of the overall indoor environment during both summer and winter. While correlation factors between overall experience and indoor air quality and air movement revealed air quality and movement having moderate correlation with the residents overall experience 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 building materials used 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.
- It was also realised that poor quality of plumbing and workmanship was widespread in the development. Presence of dampness was found in 80% of the dwellings, with residents expressing dissatisfaction with the inaccessibility of the pipe work and poor water proofing. It is vital that construction quality is kept high in such projects to reduce maintenance costs in the future.
- There appears to be a lack of maintenance regime for the upkeep of the development. The survey revealed that there was no system in place for the up-keep and maintenance of the common areas of the colony. Evidently, the streets and the surroundings of the houses were not properly maintained. There was no system for garbage disposal, which had resulted in the accumulation of waste along the streets. An institutional system for regular maintenance must be put in place to ensure the health of the residents.
- By virtue of being located in the heart of the city, the development is well connected to the basic amenities like schools and hospitals. Majority of the residents reported having convenient proximity to their place of work and had access to public transport facilities to commute to palaces of day-to-day necessities.