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Investigating resident experiences of a sustainable social housing development in the composite climate of Delhi

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Abstract: The Government of India aims to construct 12 million social housing dwelling units through the *Housing for All by 2022* programme. It is vital to identify what the impacts and benefits of housing production at such a massive scale could be. This is no easy task in an inherently data poor environment. This paper describes the methodology and learnings from a field survey of 149 residents in a social housing development for local industry workers in Delhi, constructed using modular perforated bricks and flyash. The purpose of the resident 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 using a rating scale. The survey results showed that residents perceived indoor temperatures in summer to be much more unsatisfactory than in winter. Only 12% of respondents rated their indoor conditions as 'satisfactory' in summer, whereas the same proportion rated it as 'unsatisfactory' in the winter. 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 one-third of occupants, though still air was desirable in winters. The lack of cleanliness and absence of maintenance regime was also evident from garbage accumulation and water logging in the open areas and along the streets in, and around the development, resulting in unhygienic living conditions. The study is part of a United Nations funded research project on mainstreaming sustainable social housing in India.

Keywords: Economically Weaker Section (EWS), social housing, householders' survey,

Introduction

In recent times, housing shortage – particularly in the urban areas, has emerged as one of the most critical issues confronting India (KPMG and NAREDCO, 2012). Majority of this is attributed to the growing rate of rural to urban migration, which in turn has rendered stress on the existing basic amenities and infrastructure. According to an estimate by The Ministry of Housing and Urban Affairs (MoHUA) the total urban housing shortage at the end of 2017 was about 10 million, with more than 95% of this pertaining to the houses for the Economically Weaker Sections (EWS) and Low Income Groups (LIG) (Jones Lang Lasalle, 2018) Through its "Housing for All by 2022" mission , the Government of India intends to close this gap by aiming to construct 12 million social housing units over the programme duration (2015-2022) through a combination of slum upgradation 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 (MoHUA, Govt. of India, 2017).

The construction sector in India is energy and material intensive, contributing to about 22% of the total GHG emissions in the country (Reddy B.V., 2009). The future growth in this sector would therefore 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.

Several studies have revealed the need to use energy efficient materials and building techniques to achieve sustainable development and better thermal performance of low cost housing in India (Bardhan and Debnath, 2018). Research work on identifying the energy efficient features (Chandel et al., 2016) and thermal performance of vernacular dwellings (Singh et al. 2010) using extensive literature review, site monitoring and occupant surveys have revealed the satisfactory thermal performance of these dwellings. However, these come with issues of durability and require higher maintenance (Chandel et al., 2016). Nix et al. (2015) investigated the indoor temperature, relative humidity and residents' feedback in 13 self-build dwellings in an informal settlement outside Delhi in the winter period. The research found that the monitored dwellings were unable to provide adequate comfort temperatures during winter, and indoor temperature was significantly affected by the roofing material. Research on field studies of thermal comfort in middle class naturally ventilated dwellings (Indraganti, M. and Rao, K.D., 2010) have shown a weak effect of age group and gender on the residents' thermal comfort sensation. The impact of housing construction on social sustainability and well-being of the residents was studied in a study conducted by Karuppannan and Sivam (2011). Three different neighbourhoods with different urban forms were compared to establish the relation between urban form and social sustainability at a neighbourhood level, in Delhi India. However there is limited empirical evidence pertaining to the performance and sustainability of EWS or LIG housing from the residents' perceptive. It is this gap that this paper seeks to address.

This paper describes the methodology and learnings from a field survey of 149 social housing residents in a housing development for local industry workers in Delhi (Bawana housing development), constructed using modular perforated bricks and flyash. 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.

In India, the term 'social housing' has been more commonly referred to as 'affordable housing' (EWS and LIG) by the Government and housing experts alike. However, 'affordability' of housing can vary depending on the income level. In this study therefore, the term 'social housing' has been used instead, to signify housing which serves the housing needs of LIG and EWS with the provision of ensuring access to physical, social, environmental and financial well-being (Herda, G., et al., 2017). The present study is part of an ongoing UN Environment funded research project 'Mainstreaming Sustainable Social Housing in India Project' (MaS-SHIP) which seeks to integrate sustainability in social housing projects.

Methods and case study

To gather empirical data on the perception of householders of the selected social housing development, the following methods were adopted (1) *Interview based questionnaire survey* (2) *Observations of researchers* (3) *Photographic survey* of the dwellings and surroundings to capture the existing conditions.

The survey questionnaire was designed based on Likert scale and consisted of questions (Table 1) on the following aspects: Indoor environmental conditions; Daylight and ventilation; Experience with the building materials and technology; Affordability; Maintenance and up-keep of the common areas; Accessibility to basic public facilities. While designing the questionnaire, careful consideration was given to the sociological and educational background of the respondents. To assess householder perception of indoor environment, easy-to-understand questions on the perception of 'indoor temperature and indoor air' were included, and the rating scale was also therefore limited to a scale of three (Table 1, Perceived indoor environment in summer and winter). Likewise, questions on adaptive measures adopted by the respondents were included to further understand and correlate factors that influence their experience of the indoor environment. The quality of building materials used and the general comfort conditions and well-being of the residents living in the development were assessed by inquiring about the physical condition of the building (presence of dampness) and the maintenance and cleanliness regime of the surroundings.

Table 1: Selected questions from the householder questionnaire survey

No.	Variables	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)	-
	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	-	-
11	Adaptive strategy during summer	Natural ventilation	Evaporative cooling	Ceiling fan	AC	-
12	Adaptive strategy during winter	yes	no	-	-	-
13	Artificial lighting required during the day	yes	no	-	-	-
14	Dampness in the house	yes	no	-	-	-
16	Causes of dampness	Leaking of pipes	Building material not water resistant	Improper construction workmanship	Poor design	-
	Maintenance and repair					
17	Regular maintenance of the common areas	yes	no			
19	Experience with respect to the building materials used	Satisfactory experience	Aesthetics/ material finish	Nail-ability	Adding/hanging electrical points	Inability to access pipes for repair

For easy comprehension the questionnaire was translated into the local language (Hindi) and the householder responses were later translated back to English for analysis. The survey was conducted by students (researchers) trained by the MaS-SHIP team, from a local educational institution. The students were trained through training workshop and mock surveys conducted by the MaS-SHIP team. A batch of 10 students took 4 days to complete the survey of 150 households.

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. While conducting the surveys, the responses were gathered from the available adult at home, and the feedback is assumed to be the general perception for that household. So each survey response represents a single dwelling unit.

Photographic survey

The researchers conducting the survey took digital pictures of the interiors of the dwellings and the surrounding areas (after seeking permission from the resident/s) to provide contextual data about the physical environment.

Researcher observations

The researchers also recorded their experience of conducting the survey and observations about the development, by completing two personal logs - one at the end of day one of the survey, and the second after completing the survey for the development. The information derived from the student logs generally helped to triangulate 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 study were also derived from the students' observations.

Overview of the case study

Following the Supreme Court's order to relocate both polluted and non-polluted industries from the city of Delhi, over 16,000 industries shifted to the 760-hectare complex set up at Bawana Industrial area in North-West Delhi. The Bawana housing, developed by DSIIDC (Delhi State Industrial and Infrastructure Development Corporation Ltd.) was constructed as a part of the Rajiv Gandhi Housing scheme primarily to provide shelter for the industrial workers and other Economically Weaker Sections (EWS). Located at around 30km from the city centre, the development is a typical example of habitat relocation of residents living in informal settlements in the heart of the city to the outskirts.

The housing development is spread across 37 acres (~15 hectares) having a high density- about 300 dwelling units per hectare. A total of 4384 dwelling units are housed in a mix of 2, 3 and 4 storey exposed brick buildings with 4 dwelling units on each floor. Cluster planning was adopted, to provide organised open spaces and green areas in the form of courtyards. The carpet area of the dwelling units ranges between 263 sqft. to 311 sqft, with each DU comprising of two rooms, a separate WC and bathing space, and a covered balcony. In terms of household size, the survey revealed that majority of households had four members, although a significant number of dwellings had five or more members, making the living congested.

The housing complex was intended to be developed as an economical, environment friendly and energy efficient housing. It is one of the first social housing developments in India which was built using alternative materials and technologies. Table 2 provides details of building materials used in the project.

Table 2: Building materials used in the case study development.

Foundation	• Under-reamed pile foundation
Superstructure	• Single brick load bearing wall using combination of modular Fal-G brick work & mechanised modular perforated bricks. flyash with cement mortars • Precast Ferro cement in stairs, kitchen shelves • Precast R.C. lintel & sunshade
Roof / Floor slab	• Precast RC Plank and Joists and cast in-situ waist slab in RCC
Doors and windows	• Second class Teak wood door window frames and flush door • Grill in ventilators and windows

Analysis and results

Perceived indoor environmental conditions

The survey revealed interesting findings about householder perception of their indoor environmental conditions (indoor temperature and air quality) in their homes during winter and summer. The number of householders perceiving *indoor temperature* as *unsatisfactory* during summer (n: 56) is about three times of that during winters (n: 20) (Figure 1). The tolerance of *indoor temperatures* is observed to be higher in winters with more number of residents reporting feeling *satisfied* (n: 32) as compared to that during summer (n: 19). A similar trend is observed in terms of perceived *indoor air quality* wherein 68 out of the 148 surveyed households, find their homes *stuffy* during summers, whereas in winters this number is reduced (25 out of 146), and majority of the residents (112 out of 146) perceived *indoor air quality* to be *bearable*, with a small number perceiving it as *fresh* during both summer and winter. In this study, *bearable indoor air quality* is assumed to correspond to a lesser stuffy house, an indoor condition which the residents have learnt to cope up with.

Despite the *indoor air quality* being perceived as poor, on inquiring about the *indoor air movement*, nearly 59% (87 out of 148) residents felt their homes were *well-ventilated* during summers. Owing to the relatively better indoor conditions experienced during winters, nearly 89% of the residents rated the *overall experience as satisfactory* (21%) or *bearable* (68%) during winter, as compared to the 67% residents who found the overall experience as *satisfactory (*12%) or *bearable* (55%) during summers. Consequently, the number of householders *unsatisfied* with the *overall experience* in winter, was nearly a third of that during the summer.

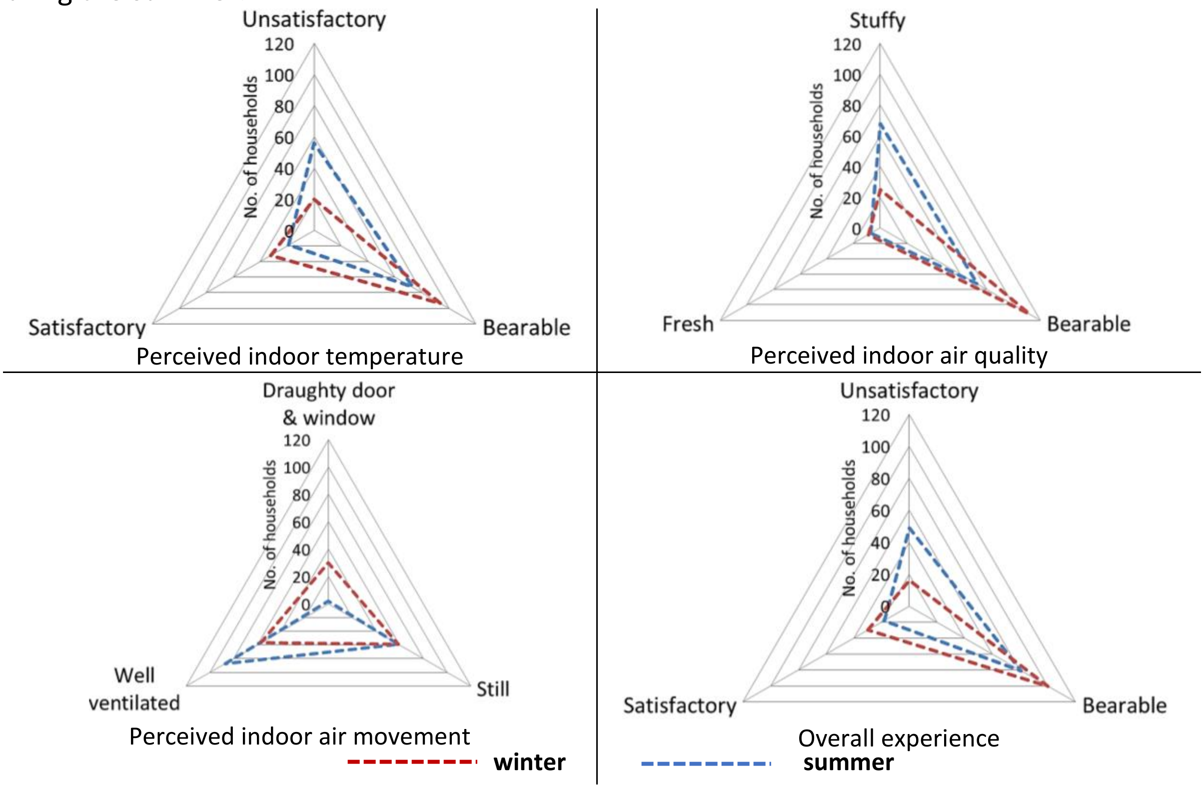

Figure 1: Householder survey results for perceived indoor environmental conditions in summer and winter

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 indoor air on the residents' overall experience during summer and winter. For this, both crosstabular and nonparametric statistical analysis were used to correlate the householders' response for perceived indoor temperature, air quality and movement with their overall experience during summer and winter. Table 3 shows the cross tabulation of householders' responses for perceived indoor temperature, air quality and air movement with their overall experience during summer.

Table 3: Cross tabulation of householder responses on perception of indoor temperature, air quality and air movement with their corresponding response for overall experience during summer

	Overall experience in summer			
Perceived indoor temperature in summer	**Unsatisfactory**	**Bearable**	**Satisfactory**	**Row total**
Unsatisfactory	**45**	11	0	**56**
Bearable	4	**64**	5	**73**
Satisfactory	0	6	13	19
Column total	**49**	**81**	**18**	**148**
Perceived indoor air quality in summer				
Stuffy	**43**	24	1	**68**
Bearable	6	**54**	13	**73**
Fresh	0	3	4	7
Column total	**49**	**81**	**18**	**148**
Perceived indoor air movement in summer				
Draughty dw (door & window)	1	1	0	2
Still	**24**	31	4	**59**
Well-ventilated	**24**	**49**	14	**87**
Column total	**49**	**81**	**18**	**148**

Cross relating the householders' responses about their perception of the indoor environmental conditions during summer (Table 3) revealed that an *unsatisfactory* perception of the *indoor temperature* and *air quality* had a direct impact on the residents' *overall experience* of the indoor environment and resulted in an *unsatisfactory overall experience*. Of the 49 households reporting *unsatisfactory overall experience* 45 were also *unsatisfied* with the *indoor temperatures* and 43 perceived *indoor air quality* as *stuffy*. Similarly a *bearable* perception of the *indoor temperature* and *indoor air quality* lead to an *overall bearable experience* and is indicated by the fact that of the 81 households with *bearable overall experience* 64 perceived *indoor temperature* also as *bearable* and *54 perceived indoor air quality* as *bearable* during summer. Interestingly for households with *satisfactory overall experience* during summer (n: 18) the number of households with perceived *indoor air quality* as *bearable* remained highest (n: 13), indicating towards the poor air quality of the interiors during summer.

The perception of *indoor air movement* seemed to have a slightly mixed effect on the residents' *overall experience* of the indoor environment during summer. It was observed that of the 49 households reporting *unsatisfactory overall experience* equal number of households (n: 24) perceived *indoor air movement* as *still* and *well-ventilated*. Similarly, for the 81 households with *bearable overall experience*, though the number of residents perceiving *well-ventilated* indoors was highest (n: 49), as substantial number of households also perceived indoor air as *still*. Well ventilated indoors however seem to result in a *satisfactory overall experience* for some householders (14 out of 18) during summer.

Table 4: Cross tabulation of householders' responses for their perception of indoor temperature, air quality and air movement with their corresponding response for overall experience during winter

	Overall experience in winter			
Perceived indoor temperature in winter	**Unsatisfactory**	**Bearable**	**Satisfactory**	**Row total**
Unsatisfactory	**12**	7	1	20

Bearable	4	**85**	5	**94**
Satisfactory	0	8	**24**	32
Column total	**16**	**100**	**30**	**146**
Perceived indoor air quality in winter				
Stuffy	9	15	1	25
Bearable	6	**84**	**22**	**112**
Fresh	1	1	7	9
Column total	**16**	**100**	**30**	**146**
Perceived indoor air movement in winter				
Draughty dw (door & window)	6	24	0	30
Still	6	**43**	10	**59**
Well-ventilated	4	33	**20**	**57**
Column total	**16**	**100**	**30**	**146**

The cross-tabulation analysis of the householders' responses for indoor environmental conditions during winter (Table 4) revealed a higher and nearly equal number of households with *bearable* perception of both *indoor temperature* (n: 85) and *air quality* (n: 84) and this resulted in majority (n: 100) of households reporting *bearable overall experience*. Consequently, the number of households *unsatisfied* with their *overall experience* was found to be very less and for these residents, perception of *indoor temperature* seemed to have a relatively stronger effect. Of the 16 households reporting *overall experience* as *unsatisfactory* 12 perceived *indoor temperatures* also as *unsatisfactory* and only 9 perceived *indoor air quality* as *stuffy*. Similar to summer during winter too, of the 30 households reporting *overall experience* as *satisfactory*, 24 perceived *indoor temperatures* also as *satisfactory* and 22 households perceived *indoor air quality* as *bearable*. Indicating that the *indoor air quality* remains 'just' *bearable* inside these dwelling during both summer and winter. Unlike summer, in winter of the 100 households with *bearable overall experience*, the number of households with *still indoor air* was found to be highest (n: 43). Indicating residents' preference of still indoor air during winter. Of the 30 households with *satisfactory overall experience* during winters two third (n: 20) households perceived *indoor air movement* to be *well-ventilated*.

The residents of the surveyed dwellings were found to rely more on active cooling measures in summer as compared to more passive adaptive methods in winters. The survey revealed that apart from making use of natural ventilation, 130 out of the 149 surveyed households used ceiling fans, and a substantial number of these households combined the use of ceiling fans with evaporative cooling measures such as use of desert coolers to enhance indoor comfort conditions during summer. The relatively poor perception of the indoor environmental conditions during summer however indicates the inability of the dwelling units to provide comfortable indoor environment in the summer (in absence of air-conditioning). In winter, majority residents reported resorting to warm clothing and blankets and use of fire (in the form of bon-fire outside the house). Electric heaters were used in a very few households, due to the high electricity bills associated with their use.

Furthermore, statistical tests were applied to assess the strength of association among 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 0.803 and 0.712 (Table 5) for *overall experience* vs perceived *indoor temperatures* in summer and winter respectively, reveal *indoor temperature* as a noteworthy factor in influencing the householders' perception of the overall indoor environment during both summer and winter. Whereas the r_s values of overall experience vs perceived *indoor air quality* shows strong correlation between the two variables in summer, but shows weak correlation in winter. Correlation coefficient values for *overall experience vs* perceived *indoor air movement* indicate weak correlation between the two variables, during summer and winter.

Table 5: Spearman's correlation coefficient values for householder survey responses for perceived indoor environment

		Spearman's correlation coefficient
Overall experience in summer vs	Indoor temperature	**0.803**
	Air quality	**0.616**
	Air movement	0.175
Overall experience in winter vs	Indoor temperature	**0.712**
	Air quality	0.406
	Air movement	0.322

Daylighting

The quality of indoor lighting was accessed by asking the residents if they needed to use artificial lighting during the day. Nearly one third (57 out of 149) of the surveyed households reported that they need to use artificial lighting during the day. Though the survey did not prompt the residents to provide reasons for their response, a few observations made by the researchers reveal either the absence of residents at home during the day; or availability of adequate diffused light to carry out their tasks. It was also observed that flats on the upper floors generally do not require artificial lighting during the day (Figure 2&3).

Figure 2: Interior view of a room in a DU

Figure 3: Interior view of kitchen space

Experience with the building materials and technology

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 responses from the given options (Table 1, no. 16), as to what they perceived the cause for it. Since the

[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"

housing development was intended to be low-cost and energy efficient, the selection of building materials and technologies was primarily based on their cost effectiveness and also environmental friendly factors. The use of modular Fal-G brick work and mechanised modular perforated bricks for external walls resulted in cost saving by eliminating the need for external plaster. The current state of the dwellings however revealed the poor quality of construction workmanship and materials in the form of dampness inside many surveyed households. Of the 149 surveyed households, about 86 households reported the presence of dampness inside their dwelling, in the wet areas (kitchen and/or toilet walls), and hence attributed it to the leaking of pipes (poor quality of plumbing works) and/or building materials not being water resistant (Figure 4).

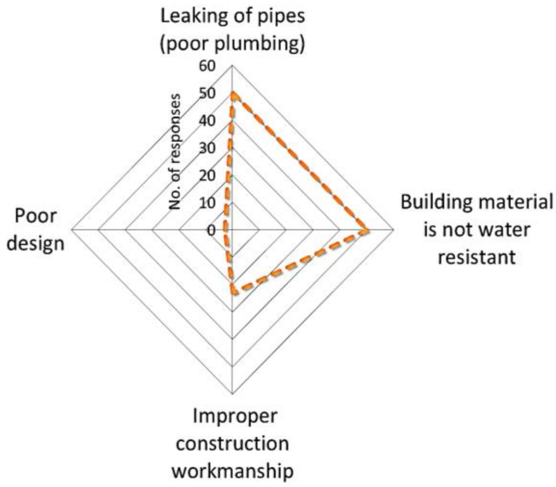

Figure 4: Perceived causes of dampness

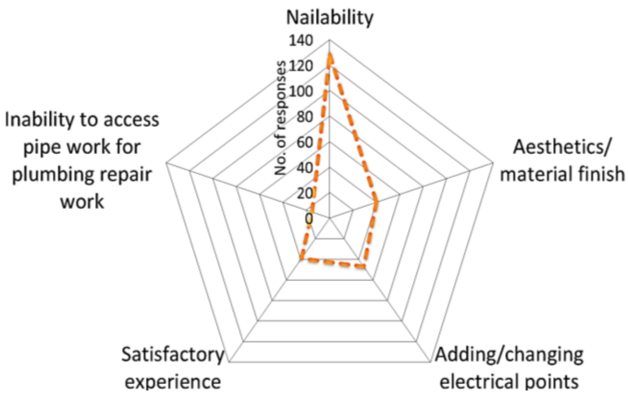

Figure 5: Householders' experience with the building materials

As shown in previous research that physical characteristics of low cost housing (such as quality of the interiors and the surroundings, cleanliness, maintenance and location) significantly affect residents' perception (Mulliner et al., 2013), similar findings were revealed regarding householder experience with the building materials used in the dwellings. The flexibility of being able to adapt their dwelling as per one's own day to day needs and aspirations is an elementary need of every human. The survey revealed 'Nail-ability 'i.e. the suitability [of a wall] for being nailed, as a main concern among majority of the residents (Figure 5). The choice of materials and the quality of construction of these houses, did not allow residents to make basic alterations to the interiors, like hanging a piece of art or a shelf to the walls, or adding or changing an electrical point. Residents also expressed their concern regarding the access to the plumbing pipes which poses limitations in carrying out any repair works. Some of the residents also voiced their concern on the aesthetics of the buildings related to architectural design and/or external/internal finishes.

Maintenance and up-keep

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. Majority of the householders expressed their dissatisfaction regarding the lack of maintenance and cleanliness of the development and were unaware of any committee that might have been setup or of a requirement of a regular maintenance fee. The open courtyards meant to promote community interaction were seen filled with garbage and stagnant water in the open drains. A few residents reported cleaning the immediate surroundings of their dwellings, but the development at large lacks cleanliness and hygiene (Figure 6 & 7).

Figure 6: Garbage accumulation along a street in Bawana housing

Figure 7: Water logging seen on streets of Bawana housing

Location and accessibility to the basic public facilities

The Bawana housing development is located on the outskirts of Delhi, approximately 30 km away from the city centre. 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 149 surveyed households, 119 houses were occupied on rent. A majority of them paid a monthly rent less than half of their monthly income. An almost similar number of households also reported spending half of their income in house rent every month.

During the survey however, majority of the residents' reported having convenient proximity to employment or other basic amenities like hospitals and schools. For most residents the place of work was up to 20 minutes' walking distance from their homes (Table 6). A substantial number of people also have vehicles of their own to commute to work and other places. Though a large number (n: 93) of residents reported having access to public transport to commute to hospitals there were substantial numbers (n: 38) of households reporting availability of conveyance as an issue for travelling to hospitals. Of the 149 surveyed households, 90 had school going children. Majority of them used school bus or had their schools at walking distance from the development.

Table 6: Householder responses related to location of the development

Survey questions pertaining to location of the development	**Number of responses**				
	Yes		**No**		**-**
Convenient proximity to employment (n=149)	113		36		-
Convenient proximity to school/ hospital (n=149)	128		21		-
Travel time (in minutes)	**>20**	**20 - 40**	**40-60**	**>60**	**-**
To work (n=149)	94	25	15	15	-
To school (n=90)	67	18	3	2	-
Availability of conveyance (respondents were allowed to choose multiple responses)	**Access to public transport**	**Walking distance**	**Own vehicle**	**Availability of conveyance is an issue**	**School bus**
To work (n=149)	39	71	47	7	-
To hospital (n=149)	93	24	23	38	-
To school (n=90)	11	26	12	0	41

Discussion

The Bawana housing development was constructed with the intention to rehabilitate the industry workers and people from EWS in a settlement with better living conditions. Although the building materials used in the project were low cost and environment friendly, the householder survey revealed that indoor comfort was perceived to be (just) 'bearable' during summer and winter. Only 12% of respondents rated their indoor conditions as 'satisfactory' in summer, whereas nearly the same proportion (11%) rated it as 'unsatisfactory' in the winter. This indicated 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 one-third of residents, though still air was desirable in winters. Through multiple statistical analyses, a greater correlation between the perceived indoor temperature and overall experience of the indoor environment during both winter and summers is observed. While this may differ in reality which will require a next level analysis of quantified indoor temperatures vs the comfort temperature, this could also be attributed to the design of the questionnaire survey. Considering the fact that the occupants were asked of their perception of indoor temperature, air quality, and air movement, temperature is often a more palpable parameter for the people to realise as a factor of comfort or discomfort.

The survey also revealed factors that determine the acceptability of building materials from the householders' perspective. The factory finished exposed brick work used for the walls 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 many 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 common areas. The survey revealed that unoccupied dwelling units had become dumping yards with garbage spill-over in the streets. An institutional system for regular maintenance must be put in place to ensure the health of the residents'. At the time of the survey, about 80% of the surveyed households were found to have tenants. The residents also expressed their dissatisfaction about the availability of job opportunities within accessible distances from the development. It was evident that due to the location of the development, most of the residents were forced to relocate back in order to retain their jobs in the city.

Conclusion

This study has revealed for the first time, resident perception and experiences of inhabiting a sustainable social housing development. The findings reveal that the quality of indoor environment, quality of the interiors, the maintenance and up-keep of the surroundings and availability of job opportunities at convenient vicinity are important factors in determining the level of 'satisfaction' of the residents.

With the Government of India's ambitious plan to construct 12 million such social housing units by the year 2022, there is an increasing stress on the use of alternative and sustainable building materials and technologies in order to reduce the environmental impact of housing construction at such a massive scale. This study provides important new evidence based on residents' perception of living in a 'sustainable' social housing development. It is evident that the use of sustainable materials alone is not sufficient for a social housing to be sustainable; construction quality of the building envelope is vital for achieving the expected performance. Moreover appropriate passive design strategies (based on the climatic zone) must be incorporated in the design in order to provide thermally comfortable indoor environment during both summer and winter. The ability to make changes in dwellings matters to residents and should be considered in the form of design for adaptation. Maintenance and cleanliness of the common areas and surroundings are important not only for the health and well-being of the residents, but also to ensure the appropriate use of passive design features such as opening of windows. Ideally a low cost but effective maintenance regime should be put in place. These factors need to be carefully considered in the planning, design, construction and operation stages, if these social housing developments are to be truly sustainable and liveable for the residents.

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