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Building in Use Studies of Core Housing Unit in Ain Smara, Algeria: Residents' Satisfaction Perspective

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Abstarct

This study investigated residential satisfaction of randomly selected 154 household heads in the Core Housing of Hricha Ammar, Constantine, Algeria. Post-occupancy evaluation was conducted. Data were collected through Building Use Studies (BUS) survey and analysed using BUS benchmarking system, descriptive statistics, Principal Factor Analysis and residents' behavioural characteristics studied. Respondents were moderately satisfied with their housing conditions with a mean of 5.37 in a 7-point Likert scale for the overall comfort condition. They evaluated satisfaction based on four key dimensions of housing unit characteristics: Lighting, Dwelling design and neighbourhood, Overall thermal comfort in winter/summer and Noise. These residential components contributed the most to predicting residential satisfaction. Behavioural characteristics were also found to predict housing deficit and to explain housing adjustment and adaptation. A key implication of the findings is that comfort in Algerian core housing projects is suboptimal; however, it can provide a satisfactory living environment. This may only be enhanced by taking into consideration socio-cultural parameters and adopting a good housing design with natural lighting, and an adequate heating system to avoid sick building syndromes.

Keywords: Post-Occupancy Evaluation, Residential Satisfaction, Core housing, BUS methodology, Algeria.

INTRODUCTION

Housing is universally recognized as the second most fundamental human need after food and is viewed as a major economic asset in any country(Maslow 1943). In our quickly evolving needs in an ever changing world, housing does not only protect us from negative climate conditions but is vital in making our lives healthier and more productive(Ziama and Li 2018). Discrepancies between the spatial requirements of inhabitants and their actual accommodation can result in a lack of satisfaction with their living environment(Leaman, Stevenson, and Bordass 2010). Buildings are constructed based on norms and specifications established by public authorities, and experts who are supposed to have adequate knowledge of user needs and expectations(Gopikrishnan and Topkar 2017). These standards and specifications do not conform to the changing needs and expectations of users (David Jiboye 2012; Liu 1999). When significant levels of dissatisfaction persist the tenants might suffer from stress, poor health, maladjustment, pathological conditions and sick building syndromes (Ugochukwu and Chioma 2015). Indeed, studies have shown that not taking into account relevant inputs from occupants led to the failure of many housing projects in developing countries. This is particularly relevant for housing initiatives aimed at underdeveloped areas, such as core housing programs (Eziyi O. Ibem and Amole 2013), which many developing countries like Algeria have relied on to cope with low-income housing issues.

This is why residential satisfaction constitutes one of the most extensive approaches in the literature on housing environments andhas been studied by scholars from various disciplines (architecture, planning, geography, psychology, sociology, building, facility management as well as economy etc.). Residential satisfaction is a multidimensional concept measuring how happy occupants are with their housing environment as well as the gap between expected or aspired and actual housing conditions and situations(Eziyi O. Ibem et al. 2019; J. J. Maina 2021). Housing performance can be enhanced by regular performance evaluation, investigating and understanding occupant needs, and aspirations(Ziama and Li 2018). Post Occupancy Evaluation (POE) is considered to be the most commonly used term for the activity of evaluating buildings in use and assessing residential satisfaction (Jacob and Chander 2020; Leaman, Stevenson, and Bordass 2010; Preiser and Vischer 2005). Over the last few decades, POE has been used as a research framework to assess occupants' behaviour and adaptation, as well as the seasonal performance of various buildings. POE provides a good understanding of people's adaptive actions, with limited or no input from the investigator (Adekunle and Nikolopoulou 2020; Ilesanmi 2010; Nicol and Roaf 2005; F. Stevenson 2009; Fionn Stevenson and Rijal 2010).

However, few studies have attempted to evaluate post-occupancy satisfaction in core housing programs; even though this could help assess the success of these programs and highlight key issues faced by the end-users. This is particularly needed in a context such as Algeria, where such core housing programs were implemented to deal with the housing crisis but without ever surveying occupants, to understand their needs and evaluate their satisfaction.

Hence, this paper presents a POE of the appropriateness of the core-housing program in Algeria constructed in the rural areas of Ain Smara (Constantine).

Residential satisfaction

Satisfaction studies cut across a wide scope of disciplines in the management and social sciences as well as the built environment(Eziyi O. Ibem et al. 2019; Mustafa 2017). According to (Mohit and Al-Khanbashi Raja 2014) residential satisfaction, defined as the sensation of happiness when one has or accomplishes what one needs or wants in a house.

Most empirical studies on residential satisfaction rely on one, or a combination of, three main theories (Mohit and Al-Khanbashi Raja 2014). All of them consider that residential satisfaction measures the differences between household actual and desired housing and neighbourhood situations. The earliest one, the Housing Needs Theory (Rossi, 1955) introduced the notion of housing needs to conceptualize residential satisfaction/dissatisfaction. Among the key postulates, Rossi proposed that those needs change over one's lifetime and that the discrepancy between current and desired housing needs creates housing dissatisfaction. Households then respond by migrating or making adjustments to their housing needs. Adopting a broader societal perspective, Morris and Winter (1978) suggested in their Housing Deficit Theory that households evaluate the quality and condition of their housing according to some cultural or social norms. Incongruities between actual and individual norms will result in housing deficits and therefore in dissatisfaction. As in Rossi's (1995) theory, this deficit is addressed by making adjustments to reduce dissatisfaction, by remodelling and improvements, and/or by migrating to a more suitable house. Finally, the Psychological Construct Theory by Galster(1985), posits that individuals cognitively construct a reference condition for their residential satisfaction. Conflict between one's self-assessed needs and their actual situation produces a psychological state of dissatisfaction. In such cases, households are tempted to redefine their needs and lower their aspirations. If such "adaptation" is impossible, individuals will try to alter their current conditions, or move to a more adequate residential situation. However, some experimental studies have established that the housing deficit theory is most suitable in explaining residential satisfaction and behavioural mobility(Mohit and Al-Khanbashi Raja 2014).

Previous studies identified various factors influencing residential satisfaction. Based on existing work(Adekunle and Nikolopoulou 2020; David Jiboye 2012; Eziyi Offia Ibem et al. 2013; Liu 1999; J. J. Maina 2021; Mohit and Al-Khanbashi Raja 2014), we can identify 5 main categories of factors linked to residential satisfaction: sociodemographic factors (e.g., gender, age, marital status, household size, income level, location, time spent in the building), housing characteristics (e.g., length of residency, size, design, type of controls, quality of housing within a dwelling unit); physical characteristics (e.g., thermal/visual and overall comfort, windows' orientation, ventilation); neighbourhood characteristics (safety, distances and accessibility to services); and, finally, behavioural characteristics signalling dissatisfaction (modifications, remodelling attempts, adaptation, re-appropriation of the space, mobility or relocation). However, most studies on the topic focus on the third category—i.e., physical characteristics(Eziyi Offia Ibem et al. 2013; J. J. Maina 2021).

Residential satisfaction is particularly important in housing initiatives aimed at underdeveloped area; as an evaluative measure for judging the success of housing developments and a key predictor of an individual's perceptions of general ''quality of life''(Galster 1985; Jacob and Chander 2020; J. Maina et al. 2021). It has been used to assess residents' perceptions of inadequacies in their current housing environment in different housing programs such as core housing (Eziyi O. Ibem and Amole 2013).

Core Housing

In 1964, Charles Abrams defined core housing as:

"*A major variant of the self-help technique. Introduced into the underdeveloped areas by United Nations missions, it has now become part of the housing vocabulary.... The one room core for small families in very poor countries; the two room core to be expanded horizontally for the growing family; the core that can be added to vertically; the row house core, the front and rear of which is expandable; and the core built as part of a compound"* (cited by (Napier 2002, 7).

Core housing is thus a highly managed and limited form of assisted self-help as developed by housing theorists like John Turner (1965) and Charles Abrams (1964). The housing areas that resulted, if they conformed to Abrams' vision, would eventually look much like other government built mass housing areas. It aims to provide an organized, cheap, and practical scheme for the urban and urbanizing areas of poorer countries. The development of core housing units was not similar to what the original theorists planned out for them, often to the dismay of city officials (Napier 2002).

Assisted self-help, especially in the form of core housing, was implemented in projects around the world, especially in South America and Africa (see Napier, 2002). Literature shows that much of the analysis of assisted self-help housing schemes, and core housing schemes in particular, has been limited to initial project evaluations undertaken immediately or soon after the completion of projects (Eziyi O. Ibem and Amole 2013; Napier 2002).Yet, while studies have analysed the formation process(Moussannef 2006) and/or the post-occupational consolidation process(Napier 2002) of core housing programs, none focused specifically on residential satisfaction within those programs. Conversely, studies on residential satisfaction have neglected core housing programs at the expense of other types of initiatives (e.g., (Adekunle and Nikolopoulou 2020; Jacob and Chander 2020); with one exception which did not however use POE as a systematic methodological approach (Eziyi O. Ibem and Amole 2013).Thus, there has been no attempt to evaluate post-occupancy satisfaction in core housing programs. We believe that filling this gap will further our understanding of residential satisfaction and bring out key issues that are especially relevant for core housing programs in developing countries, such as Algeria, that are dealing with an influx of low-income urban households.

The Present Study: Core Housing in Algeria

Algeria inherited the housing crisis from the colonial period (1962); this state continues to worsen daily, especially with the industrialization process, which accelerated the rural exodus. The real causes of the housing crisis are complex, deep and different (Safar Zitoun 2012a). State programs have failed to resolve this critical situation, due to a poor appreciation of the scale of this scourge. Because the Algerian housing policy was the object of late evaluation, therefore, most attempts to address the crisis failed or led to other issues(Safar Zitoun 2012b).

No longer able to escape these housing problems, and faced with high demand for housing, the Algerian State launched various collective, individual and private housing programs; including a "*core housing*" program aimed at providing decent housing to low-income people (Moussannef 2006). However, as the program targeted as many people as possible, even at the expense of quality, this national experience was short-lived and declined soon after launching.

This paper focuses on the core housing of Hricha Ammar, Ain Samara in the city of Constantine, Algeria. This program was launched in 1995, as part of Algeria's response to its housing crisis. It consists of 250-assisted housing, characterised by high density to make the most of lots (Figure 1), and the surface area of each lot is 120m ^{2}. Core housing was provided as identical minimum constructions with an extensible core; containing one or two rooms, kitchen, bathroom and toilet. The height of the constructions in the design specifications is limited to (R + 1) with an accessible roof plus laundry room; with the limitation that the beneficiary has to complete his accommodation in accordance with the building permit, within a period that cannot in any case exceed 10 years. The design was developed in five design offices; five variants were chosen (A, B, C, D, E), only three variants were actually realized (Figure 2) (source: Cahier de charge).

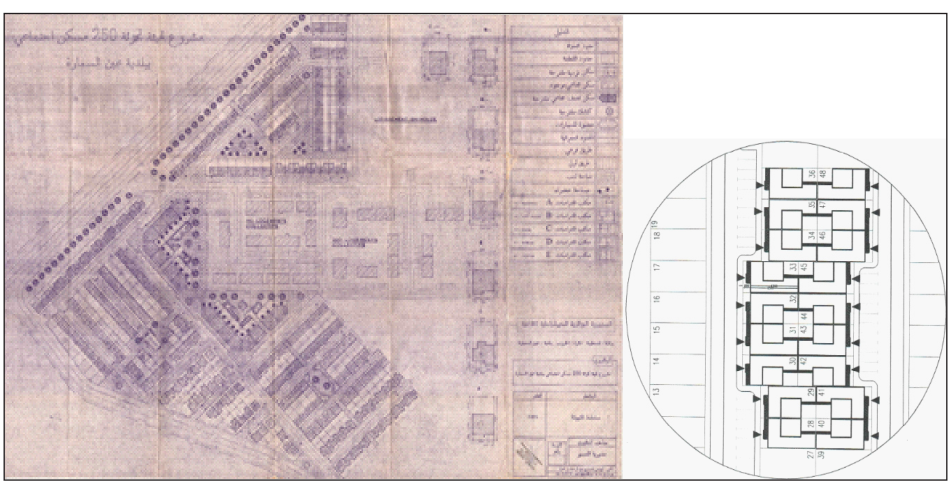

Figure 1. The ground plan of core housing In Hricha Amar, Algeria (source: the commune de Ain Smara)

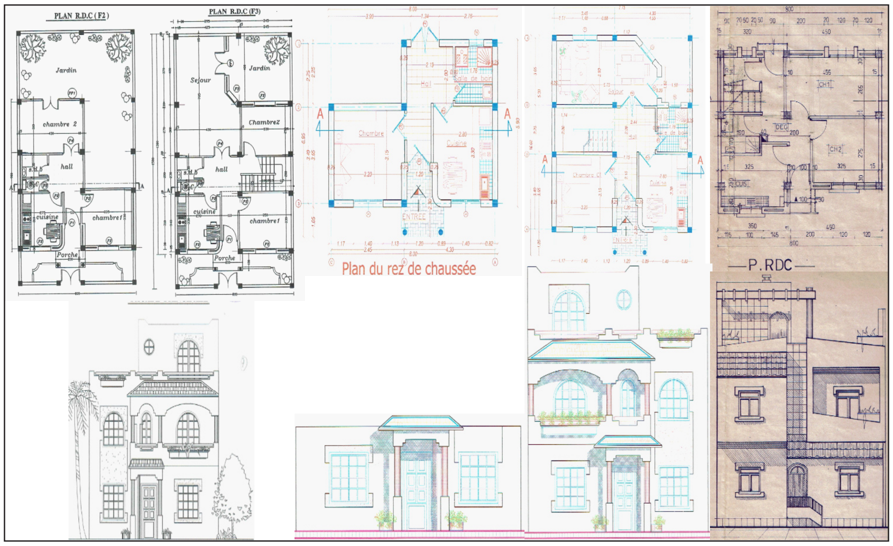

Figure 2. Three variations realized the in core housing program (source: the commune of Ain Smara)

Given the scarcity of urban land within the city perimeter, due to excessively high prices, authorities had to implement all sites on the cheaper edge of urban areas. Once the housing was operational, the government or researchers carried out no POE study to assess the degree of residential satisfaction. Yet, the modifications all deserve to be looked at and analysed, both in their objective presentation and in the light of the explanations provided by users (Figure 3).

Figure 3. Core housing of Hricha Amar district (2021)

Therefore, this study intends to analyse the perception and residents' satisfaction of core housing through POE. The result of this POE will serve as a tool for core housing future studies and deriving factors that can improve housing satisfaction.

METHODOLOGY

Strategy/Approach

The current study considered POE as the research framework while questionnaire was employed to collect data for analysis. The use of questionnaires as a data collection tool is common in the studies of POE and occupants' satisfaction (Albuainain et al. 2021). In order to understand residential satisfaction, it is important to adequately measure it. However, those measurements depend on studying the type of variables that are related to the different processes: cognitive, affective and behavioural resulting from the dynamic interaction between the individual and the residential environment (Mohit and Al-Khanbashi Raja 2014). Using a survey is suitable to obtain a generalised view of the phenomenon; i.e., occupants' perceived satisfaction of core housing.

Survey Design

We conducted the Building Use Studies (BUS) Domestic survey, 'Housing Evaluation'; which is based on the PROBE studies original survey ('BUS Methodology - About' 2021). According to (Gill et al. 2010), the BUS Domestic Questionnaire has a strong pedigree and implementation history, and provides a precise and repeatable evaluation of occupants' needs. The choice to use this survey was based on experience, availability, and the strength of the instrument. The core questions of the questionnaire have been used in a variety of POE in residential setting(Brown 2016; Carre, Williamson, and Soebarto 2019; Dykes and Baird 2013; Gill et al. 2010; Gupta, Gregg, and Joshi 2019; Woo 2017) and explore areas of thermal comfort, acoustics, lighting, design, health and general satisfaction.

Housing Evaluation questions tackle both quantitative and qualitative variables, including socio-demographic information (age, sex, time in the building, number of residents, and type of tenure); residents' satisfaction (location, space, layout, storage, appearance, perceived needs, winter and summer thermal comfort, ventilation, lighting, noise, perceived control); perceived health, context appropriate to the situation, circumstances, lifestyle and utilities costs. A comment section is also provided after each question for further feedback. The questions are mainly measured on a seven-point Semantic differential scale using two adjectives with a neutral point (e.g. '1=too cold and 7= too hot'). In order to assess behavioural characteristics signalling residential dissatisfaction, residents were asked whether they made modifications to make their life better, if so, which ones, and what modifications they hoped to make if they had the means.

Survey Administration

The buildings were studied during the winter season over a period of two months; December 2020 and January 2021. Respondents were randomly selected households and a sample size of 154 was determined using the following formula $n=N/(1+Ne^2)$ where N represents the total population (250) and e represents 0.05 margin of error (Bixley and Yamane 1965). Each household received a printed copy of the three-page long survey. Due to language barriers and illiteracy, the researcher administered the questionnaires as an interview during the field survey. Overall, 124 questionnaires (88% of the total sample size) were retrieved and found valid for analyses, which is above the minimum 30% acceptable return rate expected for construction related research(Oladapo 2006).

Dataset and Analyses

After the data collection phases ended, responses were entered into the standard BUS survey pro-formatted Excel file, using a standard file format with fixed variable names, and was emailed to BUS methodology for analysis. This allowed the results to be benchmarked against other BUS responses. The data were also independently analysed using Statistical Package for the Social Sciences (SPSS; version 20.0). Two types of analyses were conducted.

First, descriptive analyses, which generated frequencies and percentages of respondents' personal profiles for the socio-demographic section. Six indicators were used in this part of the analysis: The mean satisfaction score given by all respondents on each attribute (MSS), the actual satisfaction score on the 7-point Likert scale (ASS), the maximum possible satisfaction score that all respondents could give for each attribute on the 7-point scale (ASSmax = 868 for 124 questionnaires), and the relative performance index for each building attribute as a ratio of the sum of ASS and ASSmax (RPI). RPI is a measurement of relative importance of each building attribute towards satisfaction. Finally, we computed the Means and Standard Deviations for IEQ factors in terms of dwelling extension, dwelling position and heating system. The overall cut-off point was set at 4.00, midpoint of the 7-point Likert scale.

Second, a Principal Components Analysis (PCA) with Varimax rotation reduced 32 dwelling units into nine components. Kaiser-Meyer-Olkin measure of sampling adequacy was 0.760, which is above the minimum expected value of 0.6. Finally, we analysed the modifications made by residents and their behavioural characteristics in order to understand how occupants interact with conceptual issues.

RESULTS

Socio-Demographic Characteristics of Residents

The socio-demographic characteristics of respondents are presented in Table 1. The majority of respondents were female (76%)almost all (90 %) were over 30 years old. Most were owner-occupiers (94%) and very few were renters. The majority of them had extended or upgraded their core housing unit (86%) and few were still in their initial state.

In addition, half of the responses (52%) had their houses in the middle (one façade on the road), while the other half was located in the corner (two or three façades on the road). Respondents mostly used gas heaters (71%) and few used central heating. These statistics imply that respondents were familiar enough with their housing environment and were thus qualified to provide the required information.

Table 1. Socio-demographic characteristics of respondents

Variables	Groups	Frequencies (n=123)	Percentage
Age	Under 30 30 or over	12 111	9 90
Gender	Male female	29 94	23 76
Length of Stay	Less than one year One year or more	12 111	9 90
Household size (average)	Over 18 years old 18 years old or under	3.8 1.4	/ /
Time spent at home	Most of the time Evenings and week-ends only	122 1	99 1
Dwelling tenancy	Tenancy Owner-occupied	7 115	5 94
Dwelling extension	Initial state Transformed	14 110	11 89
Dwelling position	Corner Middle	64 60	52 48
Heating system	Gas heater Central heating	88 31	71 25

Table 2. Summary results of BUS benchmark

Green square	Amber circle	Red diamond
• Noise overall • Air quality in summer • Temperature variation in summer • Ventilation in summer • Air quality in winter • Temperature variation in winter • Ventilation in winter • Personal control over cooling • Personal control over noise • Personal control over ventilation	• Building design overall • Conditions in summer overall • Conditions in winter overall • Effect on building on perceived health • Lighting overall • Overall comfort within the building environment • Thermal comfort in summer • Thermal comfort in winter • Amount of storage • Appearance • Enough space overall • Location overall • Suitability of layout • Air movement in summer • Air movement in winter • Humidity in winter • Personal control over heating • Personal control over lighting	• Humidity in summer • Temperature in summer • Temperature in winter • Amount of artificial light • Amount of natural light • Noise from neighbour • Noise from outside • Noise from people between rooms • Electricity cost relative to previous accommodation • Heating cost relative to previous accommodation

Note: Scale midpoint: lower, mean and upper limit. Lower and upper are the mean +/- 1.9 x standard error. Standard error (SE) the standard deviation divided by the square root of the sample size (https://en.wikipedia.org/wiki/Standard_error)

Housing Characteristics

Benchmarked survey responses

The BUS benchmarking results were grouped in the following categories:

- Red diamond: represents mean values that are rare and scoring worse than Benchmark and scale midpoint.
- Amber circle: are mean values no different from Benchmark and scale midpoint
- Green square: represents mean values scoring better or higher than Benchmark and scale midpoint.

The summary of 46 BUS variables presented in Table 2 indicate that the majority of the variables were ranked with an average benchmark (amber circles), the values of these variables are no different from the benchmark and the scale midpoint. The rest of the variables were evenly distributed, with ten of them scoring higher than the benchmark (green squares; e.g., overall noise, air quality in summer/winter, temperature variations, control) and ten scoring lower than the benchmark (red diamonds; e.g., humidity in summer, temperature in summer/ winter, amount of artificial/natural light, noise from neighbours/ outside and from people between rooms, electricity/heating cost relative to previous accommodation).

But also computed the BUS Comfort Index (Figure 4) which is the mean of the standard scores for 7 main variables (Temperature in winter: overall, Temperature in summer: overall, Conditions in winter: overall, Conditions in summer: overall, Lighting: overall, Noise: overall, Comfort overall). It showed that occupants' responses were under the comfort edge (-0).

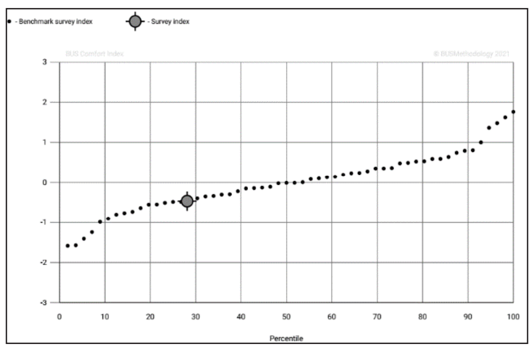

Figure 4. BUS Comfort Index

Descriptive analysis

The MSS, ASS and RPI for the dwellings' attributes appear in Table 3. Of the ten dwellings' attributes, respondents were satisfied with five of them; in particular, the overall space, the overall lighting, the location, the neighbourhood, and the condition in summer, but they were least satisfied with the storage in the core housings. The performance of the building as measured by RPI (Table 3) also shows that the overall space in the dwellings had the highest RPI value (0.75), while storage in the dwellings had the lowest RPI value (0.6). This suggests that these attributes contributed most and least, respectively, to the performance of the core housings sampled.

Table 3. Building attributes mean satisfaction scores (MSS), relative performance indices (RPI)

Building attributes		MSS	ASS	RPI
Residence Overall	Storage	4.23	525	0.60
	Appearance	4.50	558	0.64
	Space	5.25	651	0.75
	Location	5.15	639	0.74
	Layout	4.98	617	0.71
Comfort	Thermal comfort in summer	4.80	595	0.69
	Thermal comfort in winter	4.52	560	0.65
	Condition in summer	5.07	629	0.72
	Condition in winter	4.90	607	0.70
	Lighting overall	5.16	640	0.74
	Noise overall	6.04	749	0.86

Table 4 shows the means and standard deviations for the satisfaction levels with IEQ factors in terms of dwelling position, dwelling extension and heating system in the core housing of Hricha Amar. We found that temperature in summer/winter, condition in summer/winter had the lowest mean scores in the Initial state compared to complete satisfaction (7.00), while transformed dwellings scored better on all attributes (e.g. 6.60 in overall noise). The table also shows the mean scores for heating systems: The lowest mean was for temperature in winter using a gas heater system, while the highest mean was the temperature in winter using a central heating system. Given that, gas heaters were the default system in those core houses while central heating had to be installedby residents after occupation, these results highlight that residents who did not change their heating system were not satisfied in the winter season.

Table 4. Means and Standard Deviations (SD) for IEQ factors in terms of dwelling position, dwelling extension and heating system

	Dwelling extension				**Dwelling position**				**Heating system**			
	Transformed		Initial state		Middle		Corner		Gas heater		Central heating	
IEQ factors	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
T° in summer	5.02	1.88	3.36	2.02	4.72	1.96	4.88	2.01	4.47	2.01	5.74	1.59
T° in winter	4.47	2.05	3.29	2.05	4.81	2.02	4.23	2.18	3.94	2.04	6.10	1.39
Condition in Summer	5.30	1.34	3.50	2.10	5.18	1.45	5.02	1.69	4.90	1.62	5.65	1.30
Condition in winter	5.11	1.56	3.57	1.74	5.21	1.52	4.63	1.77	4.51	1.64	6.03	1.19
Noise overall	6.60	1.62	5.79	1.84	6.09	1.56	5.88	1.77	6.05	1.54	5.81	2.00
Lighting overall	5.30	1.74	4.29	2.09	4.75	1.88	5.57	1.64	4.98	1.87	5.71	1.46
Comfort overall	5.51	1.68	4.29	2.05	5.39	1.84	5.33	1.69	5.23	1.76	5.71	1.75

Principal Component Analysis (PCA):

The PCA extracted nine factors with Eigenvalues greater than 1, which together accounted for 71.916 % of the total variance across 32 items (Table 5).

Table 5. Principal Component Analyses of resident satisfaction with core housing attributes

Building attributes	Factors loading	Eigen value	% Variance	%Cumul
1. Lighting		3.198	9.994	9.994
Lighting overall	,865			
Amount of natural light	,833			
Amount of Artificial light	-,786			
2. Dwelling design		3.149	9.841	19.835
Building design overall	,866			
Suitability of layout	,862			
Enough space overall	,636			
Amount of storage	,635			
3. Overall thermal comfort in winter and air quality		2.980	9.313	29.148
Temperature in winter	-,778			
Thermal comfort in winter	,744			
Condition in winter	,604			
Air quality in winter	-,559			
4. Overall thermal comfort in summer		2.978	9.307	38.455
Temperature in summer	,907			

Thermal comfort in summer	,822			
Condition in summer	,800			
5. Noise		2.800	8.749	47.204
Noise overall	-,874			
Noise outside	,802			
Noise from people between rooms	,687			
Noise from neighbours	,686			
6. Air quality, ventilation in summer and perceived health		2.612	8.162	55.366
Air quality in summer	,749			
Effect of building on perceived health	-,649			
Ventilation in summer	,616			
7. Residence overall		1.810	5.657	61.023
Appearance	,712			
Needs being met by facilities	,589			
Location overall	,530			
8. Variation in temperature summer/winter		1.784	5.575	66.598
Summer	,807			
Winter	,769			
9. Air movement in summer/winter		1.702	5.319	71.916
Summer	,874			
Winter	,823			

Note: Rotation method: Varimax with Kaise normalization

The first and most important dimension of housing was Lighting explaining 9.994 % of the total variance. Higher loading items on this factor were related to resident satisfaction with overall lighting and amount of natural and artificial light. In the BUS benchmark results (Figure 5), both artificial and natural lighting are in the red zone (rarer and worse than benchmark). When asked to comment about their lighting conditions, respondents with housing on the corner (three facades) offered praise, while respondents with housing on the middle (one façade) offered criticism. Comments include:

- "With three facades it is well lit".
- "The house is well oriented, the sun remains until evening".
- "Due to having two facades, the middle of the house does not receive any natural light".
- "It is not lit! In summer, we choke at home, we spend our day outside".
- "One facade, there is no natural light".
- "I do not just like the fact that the house is in the middle, the back of the house is dark because of the neighbour who is very close. I do not like how the house is oriented; I would have liked it to be facing the sun".

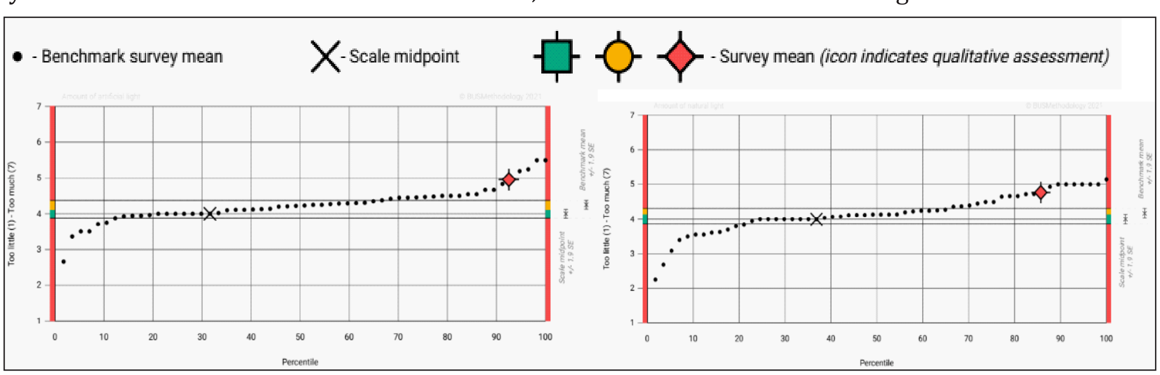

Figure 5. a) Amount of artificial lighting. b) Amount of natural lighting

The second most important dimension was the Dwelling design, which related to satisfaction with the design, suitability of the layout, having enough space overall, and the amount of storage. In BUS benchmarking results (Table 2), all of these attributes were in the amber zone; this supports the findings in the descriptive analyses in the previous section. Comments include:

- "We have a lot of bedroom space but the kitchen is too small".
- "Raw state without extension is too small".
- "The surface is good but it is deep, it would have been much better, if they reduced the length and added it in the width. Difficult to design".
- "It is small for five people, you cannot separate the living room from the guest bedroom, you have to combine the two unless you are building in the space reserved for the garden, and there you will have no light".
- "After making changes to the core of the state, it is much better".
- "For the layout, you can make two rooms that face the outside only and four rooms on the length with no opening, it is crazy! Normally the facade with more bedrooms overlooks the outside and not the opposite. I had to make small windows that overlook the corridor to ventilate (bedroom, bathroom). I also opted for a large window in the living room (all along the wall) to remedy the problem with the back façade".
- "The houses are too close to each other, and we have only one façade".

The third and fourth most important dimensions were Overall thermal comfort in winter and air quality, and Overall thermal comfort in summer, respectively explaining 9.313% and 9.307% of the variance. Attributes under these dimensions were related to the adequacy of temperature, satisfaction with thermal comfort and condition both in winter and in summer, in addition to air quality in winter. In the BUS benchmark results (Table 2, Figure 6), both thermal comfort and condition in winter/summer were in the amber zone, while temperature in winter/summer were in the red zone (rare and worse than benchmark; "too hot"in summer and "too cold" in winter). These results support the finding in the previous section about MSS and RPI (Table 3), the lowest value was for gas heating systems, which represented 71% of heating systems in the core housing sample for this study. During the interview, residents with a gas heater offered criticism while residents with central heating offered praise. Comments include:

- "Central heating. A very good ambient temperature, walking without socks, with little clothing. We are not cold, and we have no humidity".
- "Gas heater, we would have preferred a central heating".
- "Gas heater, I wear a jacket inside with the heater on".
- "Two gas heaters, that is not enough, it is too cold, humid and wet especially on the ground floor".
- "One gas heater, which is not enough at all, I cannot even use my living room, we all have to sleep in the same room and there is a lot of humidity, the strong pressure of the indoor air suffocates us".
- "Gas heating, everything is black because of the humidity".
- "A single gas heater, it is very cold, I am planning a central heater. When you put your feet on the ground, you feel it is too cold and damp, the walls damp even with the heating. I have to close everything (the other rooms) so that the room we are in warms up".

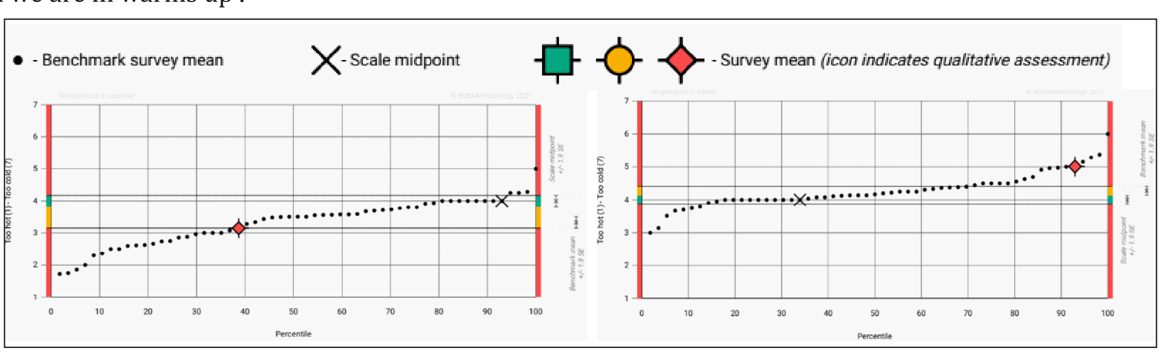

Figure 6. a) Temperature in summer. b) Temperature in winter

Another dimension was Noise, on which positively loaded items relating to satisfaction with overall noise, and negatively loaded items related to theoutsidenoise, noise from people adjacent rooms and noise from neighbours. In the BUS benchmark results (Figure 7), the three attributes of noise are in the red zone (rarer and worse than benchmark), while the overall noise was in the green zone (better than benchmark). When asked to comment about their acoustic conditions, the majority of respondents offered praise except for children' noise outside. Occasional criticism was mostly about construction noises and neighbours' noises. Comments include:

- "The calm is the only thing that kept us here".
- "Looks like we live with the neighbour, maybe the core of the state does not have a double wall. There are many children outside".
- "From time to time construction noise from neighbours".
- "Children playing outside".
- "As it is not a double wall, there is a lot of noise from the neighbours, as I am with them".

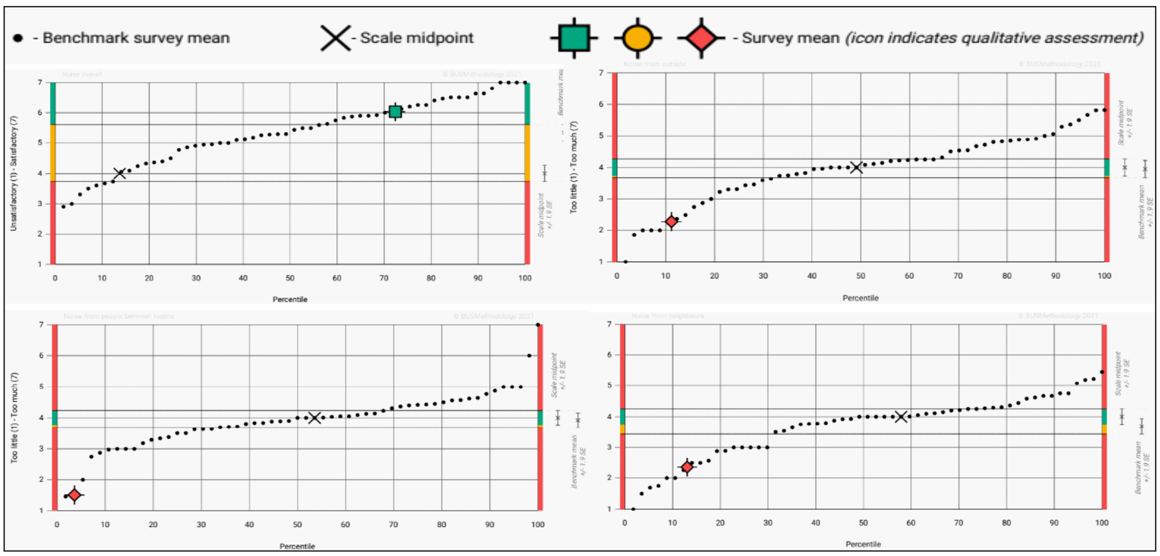

Figure 7. a) Overall noise. b) Outside noise. c) Noise from people between rooms. d) Noise from neighbours

Thesixth dimension was Air quality, ventilation in summer and perceived health. Attributes of this dimension were related to the adequacy of air quality in summer, the ventilation in summer and the effect of the building on perceived health, which was negatively related to the other two attributes. The seventh dimension was the residence overall, which included the adequacy of the appearance, the needs being met by facilities, and the location and neighbourhood. In the BUS benchmark results (Figure 8), appearance, location and neighbourhood (needs were not BUS-benchmarked) were in the amber zone (similar to benchmark). The majority of comments offered praise especially about the choice of site, very calm and far from the city, with a good neighbourhood and friendly neighbours. Others Offered criticism about the cleanliness, dirt, streets, safety issues, and the absence of playgrounds for children. Comments include:

- "I do not like the neighbours; there are thugs and drug addicts".
- "Isolated place, bad for business".
- "There are no play areas for children, there are cars right in front of the house, children cannot play, fortunately the school is not far but the others (stadiums ...) are far away".
- "Calm, individual, good neighbourhood shops and local services, everything is near me".
- "Neighbourhood full of dirt, waste, garbage cans, it is not built, the state does not do its job and neither do the inhabitants".
- "A house in the middle that I do not like at all. Besides, next to the farmland, there are a lot of rats and insects".
- "Calm, good neighbourhood, but it is not a place for commerce".

- "Compared to the Hricha Amar district, I give it 7/7 I am very satisfied. Regarding the location of the house in the neighbourhood (near the forest), but for safety, I give 5/7, there are thugs, drug addicts".
- "The place is calm, there are no problems but there are drug addicts, who come to the forest, and we are afraid for our safety, we spoke with the authorities but nothing to do about it".
- "The road is narrow and not built and has problems with the neighbours".

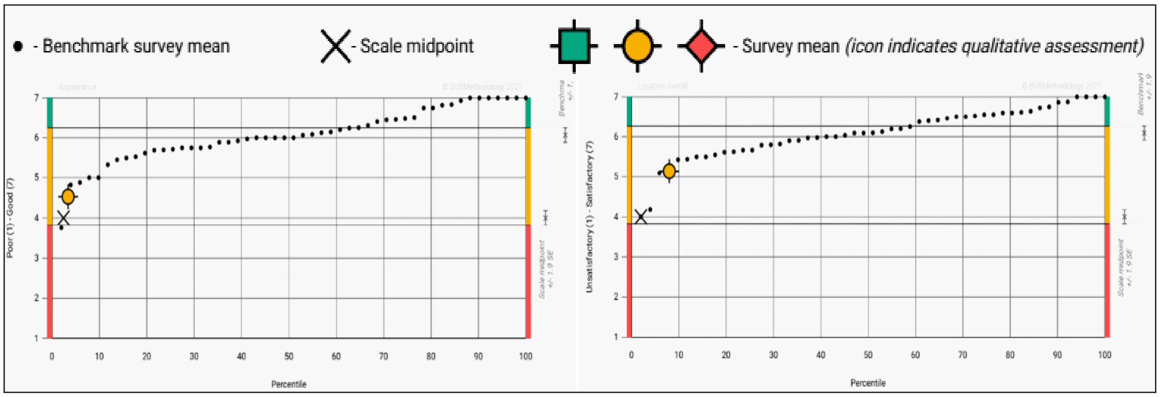

Figure 8. a) Appearance. b) Location overall

The eighth dimension was The Variation in temperature during the day in summer/winter. The least important dimension was the Air movement in summer/winter. The final two dimensions related to the dimensions of the overall thermal comfort.

In summary, when evaluating their satisfaction with residential conditions in the core housing estate, respondents highlighted four main dimensions: the adequacy of lighting, the overall building design and location, the overall thermal comfort, and the noise.

Notably, one variable, Humidity in summer/winter, did not load on any of the PCA factors. Though in the BUS benchmarking results (Figure 9), the humidity in summer was in the red zone (rarer and worse than benchmark), but was very far from the comfort zone and the scale midpoint. In winter, humidity was in the amber zone, which means it was similar to the benchmark but very close to the red zone. Respondents' comments about humidity in winter explain more about the living situation in core housing in Hricha Amar. It can cause health problems like allergies, respiratory problems, asthma… Comments include:

- "I had a start of asthma and my children had allergies because of the humidity".
- "In the extendable part of the house, the state did not make a double wall, and I for financial reasons did not make the extension from the start so I had a lot of humidity".
- "I have asthma and my children have become allergic to the humidity".
- "My son has been very allergic since he was born because of the humidity, and that is why I do not let him sleep in the living room anymore because it is the wettest place in the house".
- "My sister became asthmatic".
- "We all have asthma due to humidity".

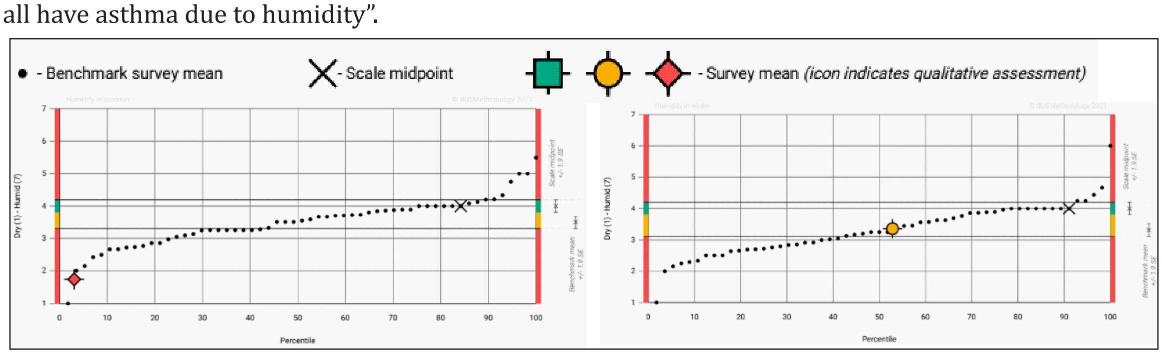

Figure 9. a) Humidity in summer. b) Humidity in winter

Behavioural Characteristics of Residents

Results show that 89% of core housing in Hricha Amar had been through some changes and modification. The core housing as a program was meant to be extended, i.e., to be transformed following, or not, a pre-established plan. This section focuses on modifications made by residents in an effort to make their housing better able to answer their needs and thereby improve their residential satisfaction, which demonstrate the housing deficit theory by Morris and Winter (1978).

Firstly, regarding natural lighting. In some cases, residence dissatisfaction led to *adaptation* by using artificial lighting 'day and night' (n=10). In other cases, it resulted in *adjustments and modifications* (n=17), manifested by enlarging windows to maximize natural lighting (because those of the initial plan were too small), large balcony doors, zenithal windows on the roof of the 3rd floor to light up the middle of the house, creating patios in the middle of the house (Figure10).

Figure 10. Enlargement of windows- Zenithally windows/ Patios in the middle of the house

Secondly, regarding dwelling design. The cases expressed *adaptation* came from low-income families, who could not afford big modifications. Residence dissatisfaction expressed through *adjustments and modifications* was for a large part about the kitchen size, manifested by adding the area of the front garden to the kitchen or adding the area of the toilet and bathroom. Another element that went through many modifications was the back garden, since residents had to leave a back garden for ventilation and lighting after extension. Moreover, due to the small size of the area, and socio-religious factors, residents tended to build those gardens, to gain more space and privacy (Figure 11).

Figure 11. Adjustment of the back gardens

Thirdly, regarding thermal comfort. Some cases expressed *adaptation*, especially in winter, by trying to move furniture far from walls to avoid humidity, or not using certain rooms during winter season, with many cleaning and repainting walls from humidity. Other households expressed *adjustments and modifications* by exchanging the default gas heater, which turned out to be dissatisfactory for central heating (for families who could afford it); other families added aluminium doors in the stairs because heat escaped through it (Figure 12).

Figure 12. a) Furniture adjustment. b) Humidity issues. c) Aluminium door

Finally, in some cases, residence dissatisfaction manifested in an expressed desire to sell the house or move to another accommodation. Comments include:

- "I want to sell the house; it is very close to the other houses, dark, there is no view".
- "It is very far from services, I always have to go downtown, I want to sell and move to another place".
- "The neighbourhood is disgusting, there is no air and no ventilation, and the houses are too close from everywhere. I want to sell and move, it looks like "the neighbours' house", between my house and the opposite neighbour a distance of less than 2m".

DISCUSSION AND CONCLUDING REMARKS

This study explored residents' satisfaction with core housing units in Hricha Amar, as stated before such studies are rare in literature. Most of the core houses were extended; the remaining houses in the initial state were rental houses or houses without official administration papers. As pointed out by (Eziyi O. Ibem and Amole 2013) this seems to match the objectives of the core housing program, which is to provide habitable cores that can be extended over time as the residents' income improves. Moreover, since the ground plan did not take into consideration socio-cultural characteristics, such as *privacy*, and in order to have a "successful" core housing program after extension, residents need to leave a square garden unbuilt in the back of the house (Figure 1). This garden will provide natural ventilation, natural lighting and green space. However, privacy appears more important for occupants of this case study, than in(Eziyi O. Ibem and Amole 2013) findings. To fulfil this need for privacy, they either integrate the square garden in the area of the house (living room in the back) or build long walls, to cover the neighbour's windows. This results in a "garden well", preventing natural lighting into the back of the house or natural ventilation. These modifications in turn produce several problems that reduce satisfaction among residents, as our PCA results show. Indeed,*Lighting* emerges as the most important factor, supported by the BUS benchmark results and residents comments: Residents report dissatisfactory lighting conditions especially in the back of the house and on the ground floor. In response,occupants make adjustments to improve this situation; by creating patios and zenithal windows, modifying their openings, putting glaze walls in place, or in the worst scenario, using artificial lighting 24h, which creates in turn another issue with electricity costs.

The other element not taken into consideration in the ground plan is the orientation: The majority of the houses are oriented South-East/ North-East/ North-West or South-West. This element makes it worse for natural lighting. The results suggest that the core housing program was built by architects, who did not have knowledge about the lifestyle of the residents and the basic conceptual axes (e.g. orientation, *vis à vis*), which echoes(Moussannef 2006) findings that there is no prior study in the conception phase of core housing.

According to the original extended plan, the maximum extension should result in an 8*15m house, as consequence core housing with "length and without width". Accordingly, the second most important factor emphasized by respondents is*Dwelling design.* Though descriptive analyses suggest residential satisfaction on this dimension, the modifications made by residents imply otherwise (setting apart the expected extension). Modifications regarding the kitchen area are judged to be too small, sanitary spaces are without natural or mechanical ventilation, and rooms are too small for big families. They have to extend vertically, integrating the back and front garden to win more square meters. Since the houses are with "length and without width", the extended plan produces either windowless rooms in the middle (deprived of natural view, ventilation and lightning), or rectangular, deep rooms (deprived of natural lighting).

This finding supports (Napier 2002) assumption, that most core housing transformations worldwide are informally conducted and not formally supported by the ground plan.

Dissatisfaction with dwelling design is also linked to location and neighbourhood: Comments show that residents are frustrated by unclean, unbuilt roads, which we witnessed ourselves during our visits to the site. Moreover, because this core housing program is located in the cheaper rural areas outside the city, lack of transportation is an issue. Residents do not feel safe from drug dealers, rodents and insects coming from agricultural lands. They are also dissatisfied with the lack of green space, parks for children and adults. As (Eziyi O. Ibem and Amole 2013) show, there is a gap between residents' aspirations for their neighbourhood and their living conditions. This finding supports previous analyses (Moussannef 2006), indicating that site location can lead to urban failures and problems for residents.

Our results also highlight the importance of heating systems: gas heater's results are dissatisfactory compared to central heating. Accordingly,*Thermal comfort in winter/summer emerges as* the third most important factor. Indeed, gas heaters were the default installation in the initial plan and many families were unable to afford a change. Both our quantitative and qualitative (comments) results imply that gas heaters are insufficient in winter, resulting in issues such as allergies and osteoarthritis. This is compounded by high levels of humidity, which lead to other health problems (e.g., asthma) but also aesthetic problems (mold on walls, degradation of interior painting). In general, we find that residents of core housing in its initial state are dissatisfied with the IEQ factors, while residents in transformed core housing are moderately satisfied with those factors. Thus overall the core housing examined in this study does not seem to provide adequate and sustainable housing for all residents; as concluded by (Napier 2002) "*Most governments seem to be following the trend towards trying to provide less of a product for less money, with less direct responsibility, but trying to reach more people" (p. 256).*

In summary, this study assessed the adequacy of the core housing program in Hricha Amar, Ain Smara (Constantine, Algeria) in order to inform similar, future housing initiatives. Adopting a POE approach, we measured residents' satisfaction using the BUS methodology. Our findings highlight several noteworthy implications. First is the initial conception, which does not take into consideration the house orientation, streets width, the suitability of heating systems, deep houses and privacy issues. The second point is modifications made by the residents, which did not respect the conceptual specifications; vertically extending for more than two floors, building back gardens that block neighbours' view and deprive of ventilation and lighting. Moreover, despite the initial limitation, they did not finish construction after 10 years—as was found in other Algerian core housing estates (Moussannef 2006). After two decades, some constructions have stopped at an intermediate stage without care for the prejudices brought to the urban landscape (e.g., incomplete floors, reinforcement pending, plasterless masonry). Extension here has become an eternal building site; where densification of the neighbourhood and changing patterns of living occur completely outside of public control and urban regulations (Moussannef 2006).

Thus, this study shows that Algerian core housing programs suffer from many of the same limitations found in other parts of the world, such as extra time burdens on residents, poor location, low service and construction standards, overcrowding, lack of meaningful participation, and poor targeting(Napier 2002). Yet, core housing can provide satisfactory living environments, but this can only be enhanced by taking into consideration socio-cultural parameters and adopting suitable housing designs with natural lighting, adequate heating systems to avoid Sick Building Syndromes, and more flexible extensions. As (Napier 2002, 250) concludes: "*The design of houses and plot layouts should be done to maximise the opportunities for extension, not to suit a single predetermined plan".* Planners and designers should consider these factors as indicators of satisfaction and be more aware of their significance in carrying out planning and development of core housing programs.

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Competing of interests

The author(s) declare that they have no competing interests.

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