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MEASURING RESIDENTIAL SATISFACTION IN APARTMENTS IN EGYPT BY AN AHP-BASED SCALE

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ABSTRACT:

Residential satisfaction (RS) is an important characteristic of sustainable built environment and residential apartments. Yet, evaluating RS is complicated due to its interconnection with many influential criteria, and hence it is hard to formulate a single generic scale since it differs widely depending on location along with other variables. This paper presents a developed scale to measure RS in different residential apartments in Egypt; the novelty of the study is articulating a numerical scale with measurable criteria regarding different apartment cases within three scopes: apartment, building, and neighborhood RS. Criteria that influence RS were first compiled through different sources and within structured limitations. Through the Analytic Hierarchy Process (AHP), the outcomes of architectural evaluators were utilized to create the scale with different relative significance weights for the complied criteria (the proposed scale). For validation, the RS of sixty-six residents from different residential groups was surveyed; the results were compared to validate the scale. The comparison displayed a good correlation, thus implying the validity of the proposed RS scale; analysis of residents' responses shed light on other characteristics affecting RS, which have been analyzed and discussed through the paper.

Keywords: Residential Satisfaction; Perception; Measuring Scale; Relative weight; Correlations.

1. INTRODUCTION

1.1. The Concept of Residential Satisfaction (RS)

The concept of residential satisfaction (RS) has been introduced to literature since 1961 [1]; RS concerns quality of facilities located within a residence, and their ability to fulfil residents' needs [2]. A common definition of RS is *"the feeling of contentment when one has or achieves what one needs or desires in a house, is an important indicator and planners, architects, developers and policymakers use it in a number of ways"* [2,3].

Intertwined criteria contribute to RS which range from dwelling features to national policies [3]; hence, assessments of RS can be performed through miscellaneous approaches, of which personal perception plays an important role [1].

1.2. Previous Works

RS can depend on intangible parameters such as human behaviour [2,3] as residents adapt to their homes in different ways, hence have different RS priorities [4,5]; while some households experience differently in the same neighborhood [6].

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Furthermore,socio-demographic characteristics, specifically age, education and income are closely linked to RS [4], for example, higher-income families experience better RS due to their ability to locate in better neighborhoods [7]. Many studies developed location-sensitive RS scales and measurement tools, which have been surveyed, classified and compared as shown in Table 1 [6, 8-33]; the majority of them focused on one or two of the three scopes: apartment, building and location. In this study, all three scopes have been considered, through quantitative methods for more accuracy and viable outcomes.

Table 1: A comparison between the developed RS studies and the current study

Study/ Reference	**Area of Study**	**Scope**				**Inputs /Outputs type**		**Data collection method**		**Analytic tools and methods**			
		Apartment	Building	Neighborhood	City	Qualitative	Quantitative	Survey	Face-to-face Interview	Correlation	Likert Scale	Regression Analysis	Other
[6]	Netherlands	-	-	√	√	-	√	√	-	√	√	√	√
[8]	Thessaloniki, Greece and Oslo,	-	-	√	√	√	√	√	-	√	√	-	√
[9]	Santiago and Concepción, Chile	√	-	√	√	√	√	√	-	√	√	√	√
[10]	Pope Francis Village, France	-	√	-	√	√	√	√	-	√	√	√	√
[11]	Shenzhen, China	-	-	√	-	√	√	√	-	√	√	√	-
[12]	Eldoret, Kenya	-	-	√	-	-	√	√	-	√	√	√	√
[13]	Beijing, China	√	-	√	-	-	√	√	-	-	√	√	√
[14]	Yangon City, Myanmar	√	-	√	√	-	√	√	√	-	√	√	-
[15]	Terengganu, Malaysia	√	-	√	-	√	-	√	-	-	-	√	√
[16]	Besançon, French	-	√	√	√	-	√	√	-	√	√	-	√
[17]	Beijing, China	-	-	√	√	-	√	√	-	√	√	-	√
[18]	Ellembelle, Ghana	-	-	√	-	-	√	√	-	-	√	-	√
[19]	Greece	-	-	√	-	-	√	√	-	-	√	-	√
[20]	Ankara, Turkey	-	-	√	-	√	√	-	√	√	√	√	√
[21]	Oslo, Norway	√	-	√	-	√	-	√	-	√	√	-	√
[22]	Mumbai, India	√	√	√	-	√	√	√	√	√	√	√	√
[23]	Beijing, China	-	-	-	√	-	√	√	-	√	√	√	√
[24]	Chongqing, China	-	-	√	-	√	-	√	-	√	√	√	√
[25]	East Germany	√	√	√	-	√	√	√	√	√	√	√	√
[26]	USA	√	-	√	-	√	√	√	-	-	√	√	√
[27]	Beijing, China	-	-	√	√	-	√	√	-	√	√	√	√
[28]	Famagusta, North Cyprus	-	-	-	√	√	√	√	-	√	√	-	√
[29]	Hanoi, Vietnam	√	√	√	-	√	-	-	√	√	√	√	√
[30]	GonbadKavoos, Iran	√	√	√	-	√	√	√	√	√	-	-	√
[31]	Australia	-	√	√	-	-	√	√	-	√	-	√	-
[32]	Spain	√	√	√	-	√	√	√	-	√	√	-	√
[33]	Turkey	√	√	√	-	-	√	√	-	√	√	√	-
This study	Egypt	√	√	√	-	-	√	√	-	√	√	√	√

1.3. The Research Problem

The addressed problem is represented in: a) the complexity of measuring RS in different apartments and scopes due to the the forked relevant details and different relative weights of the architectural criteria; b) RS research must be conducted with the location in mind [4,5]. Table 1 shows that most RS studies focused on western countries with little attention to the Middle East; c) RS is a highly subjective matter, changes in circumstance and culture will result in different research outcomes, hence, personal perception plays an important role besides the architectural performance [1], for example, residents may react differently towards the same apartment based on thier personal characteristics.

1.4. Study Novelty and Contribution

The novelty of the study is articulating a numerical scale with measurable criteria pertaining to different apartments' cases. This scale should be capable of imitating residents' perception of RS in Egypt or similar contexts.

1.5. Methodology and Outcomes

To achieve the aim and contribution, many research stages and relevant methods have been structured: a) collecting and compiling RS-related criteria to RS; b) providing relative weights of criteria that influence RS; c) determining the most and least sensitive criteria that affect RS, d) determining the correlation between criteria and/or residents' classifications, and e) highlighting actual significant issues that affect RS. The previous methodology stages also represent the study's outcomes.

1.6. Scope and Limitations

The study focuses on three main scopes: a) apartment; b) building; and c) location (neighborhood). The present work focuses only on architecture-related criteria. Also, for simplification, the study focuses on RS that suits the majority of residents, excluding the specialized RS needs of specific groups of residents, such as the disabled or elderly residents; as this is a topic that better fits other studies. Furthermore, the article will focus on typical high-rise residential apartments only, the prevailing residential style of Egypt. The developed scale will also address apartments that achieve the minimum human needs and requirements of residences. For example, structural stability and electricity supply are essential; shortage in such basic amenities would result in a highly flawed evaluation which is unrepresentative of RS.

2. PROPOSED SCALE FOR MEASURING APARTMENTS' RS

The process of developing the proposed scale is carried out as follows:

2.1. Compiling Criteria

Many criteria have been collected along with proposing others as shown in Table 2 [2-6,11,13-15,21,24,31,34-87], in addition to categorizing them to three scopes: apartment, building and location criteria. Some criteria were considered subsidiary of others hence were integrated consequently. For example, the window properties are an important criterion; yet, it contributes to many other criteria such as thermal comfort, noise nuisance, zooning, and aesthetics; hence, it is unreasonable to evaluate it as a separate criterion, to avoid unnecessary duplication. A

total of twenty-one criteria were determined accordingly after compiling them.

Table 2: Compiled criteria used to develop the proposed scale

Criteria			Nomination (References/ Design standards/ Proposed)		Compiled criteria to be used	
Apartment	Apartment Spaces	Area	Design criterion/standard	→	1	Area of Main Spaces
		Waste Area	Design criterion/standard			
		The Area of Bedrooms	[2]			
		Number of Bathrooms	[2]			
		Storage	Design criterion/standard			
		Zooning	Design criterion/standard	→	2	Zooning
		Privacy	[34]			
	Apartment Environmental Aspects	Temperatures	[35, 36]	→	3	Thermal Analyses
		Relative Humidity	[37, 38, 39]			
		Ventilation	[2,35, 40, 41]	→	4	Indoor Air Quality
		Indoor Air Quality	[36,42, 43, 44]			
		Light Glare /Orientation of Facades	[45, 46, 47]	→	5	Natural Lighting
		Natural Lighting	[48]			
	Apartment Architectural and Interior Design	Artificial Lighting	[37,48, 49, 50]	→	6	Interior Design
		Interior Aesthetics	[48, 49, 50, 51]			
		Visual Conditions	[50]			
		Interior Materials	[52,53]			
		Furnisher	[51]	→	7	Furniture
	Apartment Systems	HVAC Systems	[54, 55, 56, 57]	→	8	HVAC and Fundamental Systems
		Basic Indoor Amenities	Design criterion/standard			
		Number of Available Amenities	[3,4]			
		Smart Infrastructure	Design criterion/standard	→	9	Complementary Systems and Infrastructure
		Electric and Electronic Devices	Proposed			
Building	Building Features	Ownership	[34,58]	→	10	Residential Stability
		Sense of Stability in a Residence	[13]			
		Housing Policies	[59]			
		Involvement in Buildings' Management	[2,4,60,61]			
		Building Safety	[62,63]	→	11	Safety
		Facade Style	Proposed		12	Exterior Building Appearance
		Façade Materials	[52,53]			
		Building Height	Proposed		13	Elevators and Stairs Satisfaction
	Building Components	Elevators and Stairs Location	Proposed	→		
		Elevators and Stairs	Design standard, [64]			

		Utilities for the Physically Disabled	Proposed	→	14	**Utilities for the Physically Disabled**
		Private Layout	[65, 66]			
		The Quantity/Quality of Green Spaces	[67, 68, 69]	→	15	**Exterior Private Garden**
	Building Management	Maintenance	Proposed			
		Indoor Municipal Services	[70, 71, 72]			
		Management	[61,73, 74]	→	16	**Management and Security**
		Quality and Management Style of Amenities	[3,5,60]			
		Security	[75,76]			
Location	**Social Aspects**	Society	[11,15,24]			
		Location Safety and Crime Rate	[2,6,31,77]			
		Neighbors	[34,62]	→	17	**Society**
		Residents' Behavior	[2,4,60]			
		Ethnic Affiliations	[6]			
		Neighborhood	[2,3,4,21,78]			
		Availability of Appropriate Transport	[14,79]			
	Location Environment	Street Typology	[80,81,82]	→	18	**Neighborhood**
		Physical Properties	[24,77]			
		Walkability	[2,6,31, 77]			
		Location Perception	[31, 77]			
		Noise Nuisance	[83, 84]	→	19	**Noise Nuisance**
		Parking	[75,85,86,87]	→	20	**Parking**
	Aesthetic Aspects	Proximity to Landscape	Proposed			
		Exterior Aesthetics	[31,50,76, 77]	→	21	**Exterior Aesthetics**

Figure 1 shows an example of an architectural drawing (plans) where the compiled criteria are typically expected to be effective in different positions; facades and sections are also involved in that. Some of these criteria can be tested initially and directly from plans such as area of main spaces (criteria 1), zooning (criteria 2) and others, other criteria can be found clearly in sections such as interior design and furnisher (criteria 6 and 7). Layout and facades' drawings also demonstrate parking (criteria 20) and exterior aesthetics (criteria 21), respectively. In all design stages, also these criteria have their effect; these design stages include design concept, primilinary design and working drawings. For example, thermal analyses (criteria 3) extend to the insulation details, sections and how to install in the phase of working drawings.

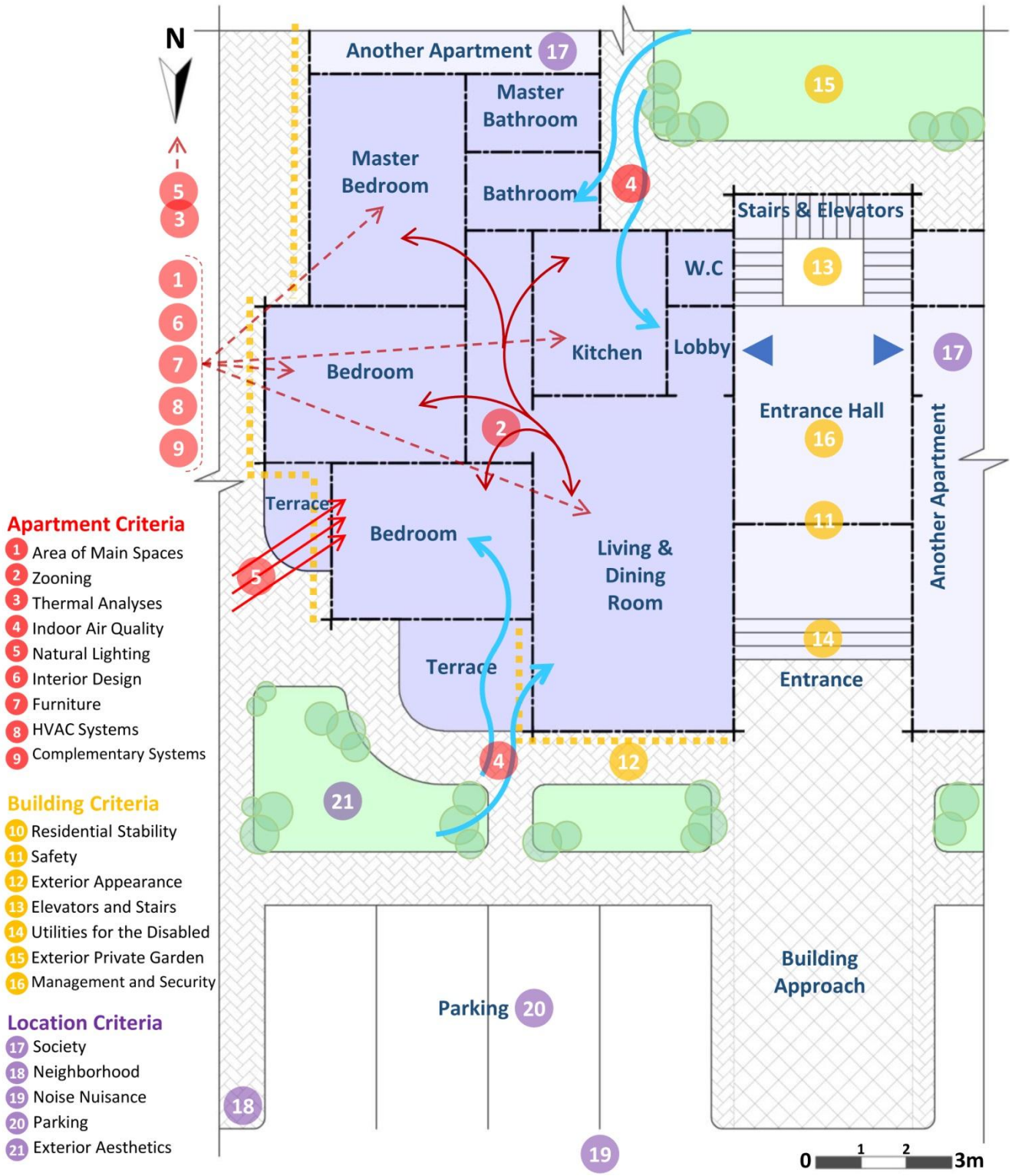


Figure 1: Positions where the complied criteria are effective in an apartment plan and layout

2.2. Defining criteria relevant weights (RWs)

The Analytical Hierarchy Process (AHP) has been used to determine the varying significance (weights) of the compiled earlier criteria. Thomas L. Saaty created the AHP process in the 70s, which is a method that utilizes pair-wise comparisons to assess the magnitude of different individual criteria [88]. As shown in Table 3, evaluators should rate importance values to each criteria compared to another one, which starts from (1) that denotes equally important criteria to (9) that denotes overwhelmingly more important. The method simplifies the criteria into several inter-connected hierarchies and consequentially showing the effect each criterion has on the other [88,89]. The consistency of respondents' answers is evaluated through the Consistency Ratio; it should be lower than 0.1 to ensure the obtained weights accuracy [88].

Accordingly, an AHP-based questionnaire is developed to gather the collective visions of expert architects in terms of the relative weights (RWs); 19 evaluators participated, while only 8 evaluators presented an acceptable high consistency and were considered (Table 3 shows an example). The determined weights are presented in Figure 2 (more details are shown in Appendix (A)).

Table 3 : AHP method application to calculate relevant weights of the selected criteria (Evaluator 1 and location criteria as an example)

		Criteria (Pair-wise Comparison Matrix)					Criteria (Average and Criteria Weight) *							Criteria (Consistency Calculations) **						
		Society	Neighborhood	Noise nuisance	Parking	Exterior aesthetics	Society	Neighborhood	Noise nuisance	Parking	Exterior aesthetics	Average (Criteria Weight)	Relative Weight Percentage	Society	Neighborhood	Noise nuisance	Parking	Exterior aesthetics	Weight Sum Value	Weight Sum Value / Average (Criteria Weight)
Criteria	Society	1	1	7	3	5	0.37	0.37	0.33	0.39	0.35*	0.36	36.4%	0.36	0.36	0.31	0.44	0.41**	1.88	5.17
	Neighborhood	1	1	7	3	5	0.37	0.37	0.33	0.39	0.35	0.36	36.4%	0.36	0.36	0.31	0.44	0.41	1.88	5.17
	Noise nuisance	1/7	1/7	1	1/3	1/3	0.05	0.05	0.05	0.04	0.02	0.04	4.4%	0.05	0.05	0.04	0.05	0.03	0.22	5.07
	Parking	1/3	1/3	3	1	3	0.12	0.12	0.14	0.13	0.21	0.15	14.6%	0.12	0.12	0.13	0.15	0.24	0.77	5.23
	Exterior Aesthetics	1/5	1/5	3	1/3	1	0.07	0.07	0.14	0.04	0.07	0.08	8.1%	0.07	0.07	0.13	0.05	0.08	0.41	5.03
SUM		2.67	2.67	21	7.66	14.33	Average (Criteria Weight)							0.364	0.364	0.044	0.146	0.081	1.03	5.13

Notes (Consistency Calculations)[88]:

Number of Criteria = 5

Random Index (RI) = 0, 0, 0.58, 0.9 and 1.12 for implementations with 1,2,3,4 and 5 criteria, respectively.

RI = 1.12

ɔ max = 5.13 (the average of weight sum value)

Consistency Index (CI) = (ɔ max - Number of criteria) / (Number of criteria - 1) = 0.13 / 4 = 0.0325

Consistency Ratio (CR) = CI / RI = 0.0325 / 1.12 = 0.029 (Consistent inputs since it is less than 0.1)

***** This value (and all similar ones) = the relevant value in the pair-wise comparison matrix / the sum of values related to each criteria. For example, the indicated value = 5 / 14.33= 0.35.

****** This value (and all similar ones) = the relevant value in the pair-wise comparison matrix X the average criteria weight. For example, the indicated value = 5X 0.081= 0.41.

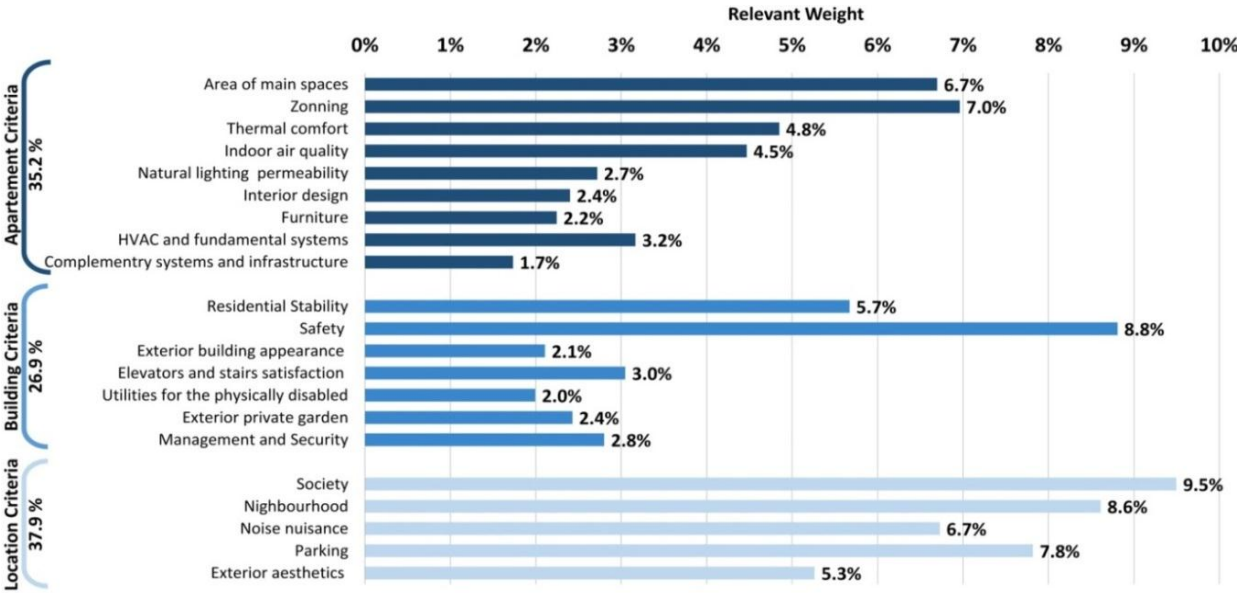


Figure 2: Relevant weights of selected criteriafor achieving RS

3. VALIDATION OF THE PROPOSED AHP-BASED SCALE

The concluded RWs of the studied criteria should be validated via real evaluators to highlight the attributes of applying these RWs, as well as illustrating any possible limitations. Evaluating the validity can be achieved via different methods, outlines and approaches as detailed below.

3.1. Validation Main Outlines

To evaluate the validity of the determined weights, a second questionnaire has been created to gather residents' evaluation (RE) of RS of their apartments; the same criteria mentioned in the AHP-based questionnaire are presented to sixty-six residents from miscellaneous social backgrounds, which assure that the responses are highly inclusive. Two distinct evaluation approaches can be applied to do so [2,76]: a) a "Standard-based Approach" through respondents' evaluating the application of design ideals/values in their apartments, and b) a "Perceptual Approach", which relies on respondents casually expressing their perceived satisfaction with certain aspects of their apartments. The first method is precise, but it is unpractical to implement this approach since it would require knowledge of which a typical apartment resident would be unaware. For example, evaluating thermal comfort, via measurements and using instruments, is accurate but requires expertise. Hence, the perceptual approach has been used for this validation.

As shown in Figure 3, the respondents have been asked to express: a) their evaluation of RS with each criterion in their apartments on a simple psychometric/ likert scale, so an average of residential evaluation to each criterion (AREC) can be calculated, and also; b) an overall residents' evaluation (ORE) of the apartment using a percentage, however, both values can be compared to the proposed AHP-applied evaluation (AHP-E) for validation; it is interpreted as a percentage using the weights conducted before. As ORE and AHP-E express RS with a specific apartment; they should demonstrate a strong correlation between them.

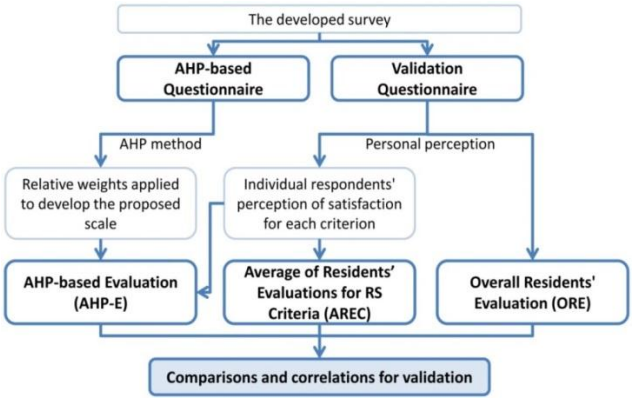


Figure 3: Validation processes and outlines

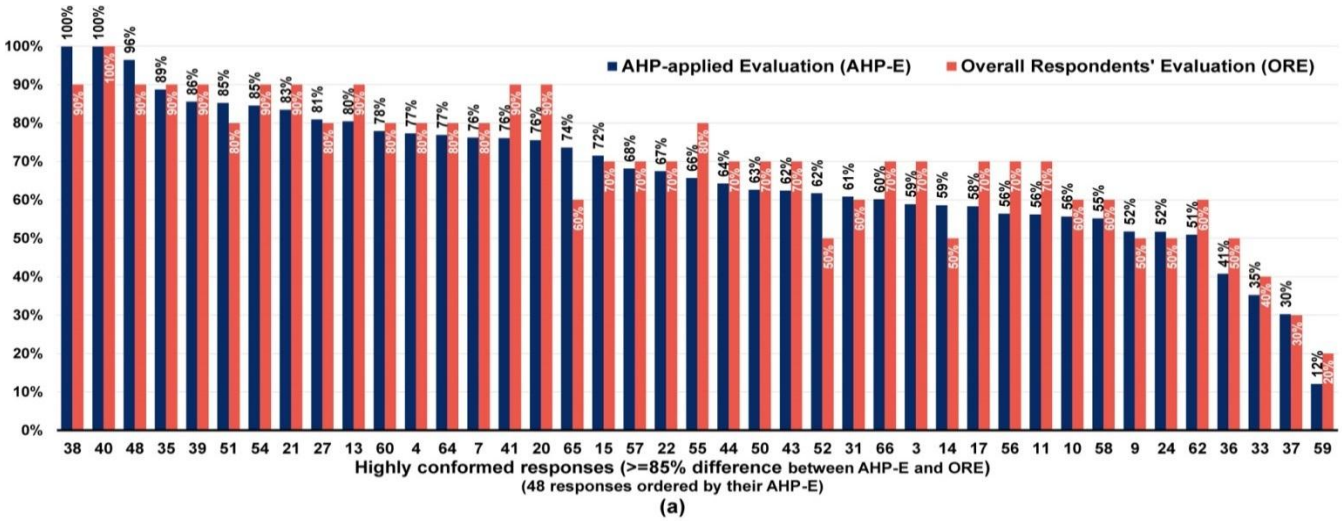
3.2. Validation Processes

Using the sixty-six inputs in the validation questionnaire detailed in Appendix (B), AREC and ORE have been compared with the developed AHP-E. The participants' responses were categorized accordingly into three groups as shown in Figure 4 and as follows:

1) Incoherent responses: these refer to responses in which the corresponding ORE and AREC differ within a margin of 20% or larger. The respondents, in this case, were not been able to provide an acceptable degree of consistency, as their individual answers contradict their overall evaluations. These answers (18 responses) have been considered as invalid ones, and have been eliminated from all following analyses.

2) Conformed responses: these refer to responses in which the ORE and AHP-E correlate within a margin of 15% or less. A total of 41of 48 respondents (85.4% of the sample), shown in Figure 4a, have been considered conformed, which indicates that the proposed AHP-scale is applicable with an acceptable degree of precision.

3) Non-conformed responses: these refer to responses in which the ORE and AHP-E differ within a margin larger than 15%, with a total of 7 of 48 responses (14.6% of the sample) as shown in Figure 4b.



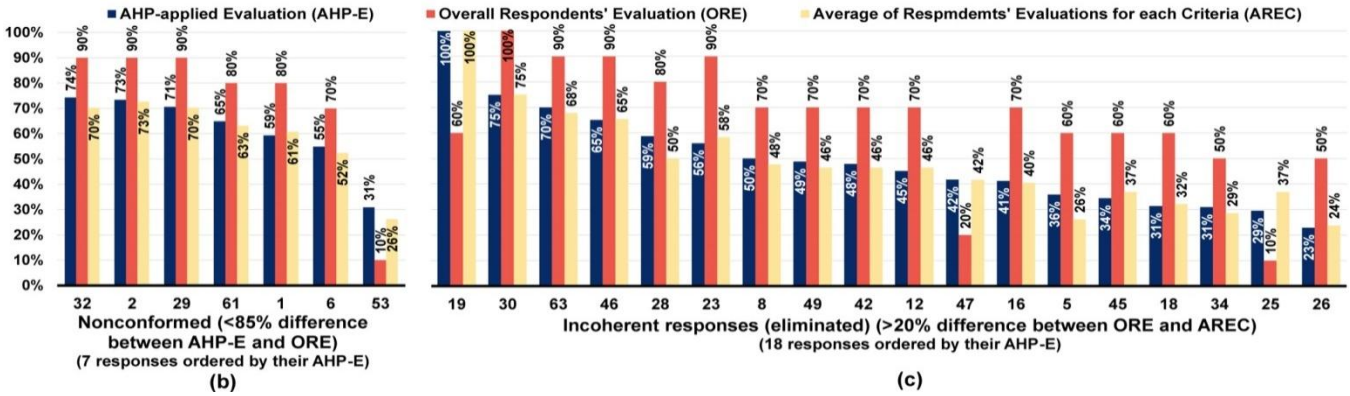


Figure 4: Responses evaluations and classifications: a) Highly conformed responses; b) Nonconformed responses; c) Incoherent responses

3.3. Validation Analyses

The previously discussed outlines and processes show that the proposed AHP-based scale is valid for assessing RS, since it applies to 85.4% of the sample. Regarding AHP-E, the developed weights are based on the objective views of architectural evaluators. Naturally, they do not consider the effect of social conformity, which may result in residents inadvertently being satisfied with lower living standards [90]. This difference in perception explains the gap between the ORE and the AHP-E. This also explains why most of the non-conformed responses are of low RS and vise versa, as such apartments encounter lower standards than apartments with higher RS; hence, the effect of social conformity is more visible. In other words, the most common feature in the conformed responses is the high ORE and AHP-E compared to other responses. Salient features of non-conformed responses cannot be outlined statistically since they are only 7 responses.

4. DISCUSSION

Further analyses of the proposed scale and its validation along with examining the findings/outcomes are detailed below.

4.1. Criteria RWs

The scale shows that society is the most influential criterion in terms of RS with a RW of 9.5%, followed by safety (8.8%) then neighbourhood (8.6%); which reflects the importance of social interactions over the other criteria since the sum weight of these three criteria solely exceeds 25% of the total RWs that controls RS in the studied scope. On the contrary, the AHP-based scale determined secondary systems as the least significant criterion (1.7%). Despite being important, they are complementary compared to other critical criteria; hence, this result is also reasonable. This is followed by furniture, exterior appearance, interior design and garden availability which have lowest RWs; this is rational since these items can be easily improved/ provided if purchased. On a larger scope, results pointed out that the criteria pertaining to the location then the apartment are of the most significance, followed by the building criteria.

4.2. RS with Surveyed Criteria

The average RS given by respondents to each individual criterion provides broad insight into their condition within the respondents' apartments. A plot of the

average RSs and AHP-E highlights no definitive correlation. For instance, society represents the highest gap between these values as shown in Figure 5, while complementary systems have the highest opposite gap. Respondents are mostly satisfied with their ownership status, while disabled amenities and landscape have scored the lowest RSs, which support the validity of the results as these are local problematic issues. However, this RS-RW discrepancy does not imply a fault in the proposed AHP-based scale; rather, it shows that building development processes do not take RS influencing criteria fully into consideration.

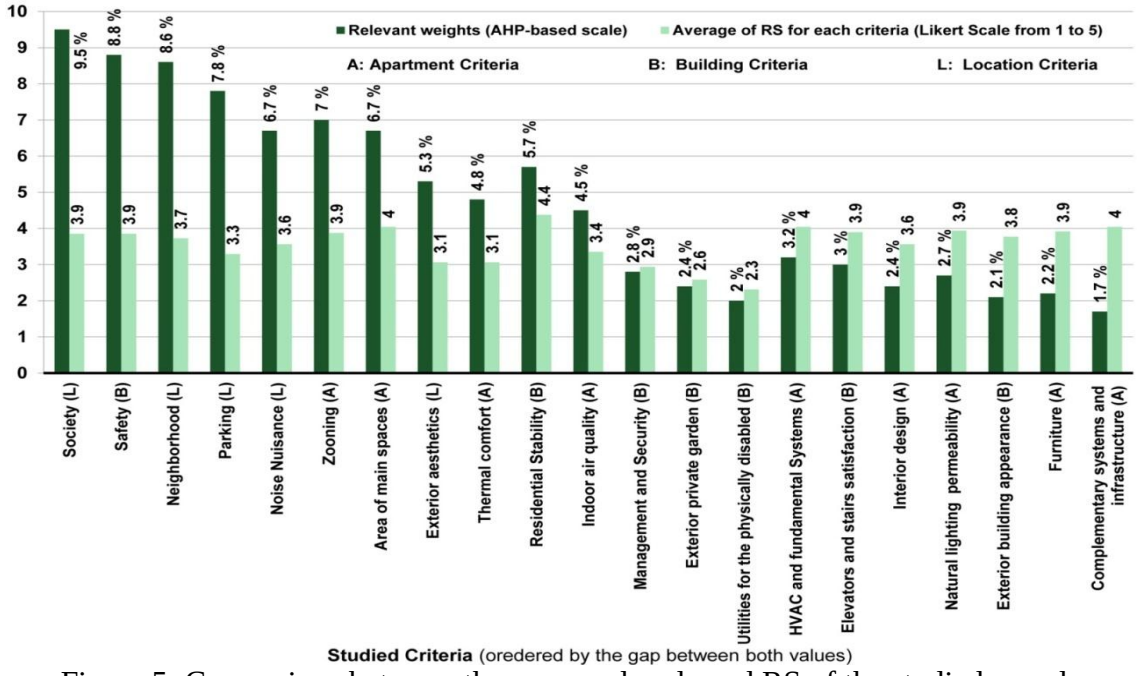


Figure 5: Comparison between the proposed scale and RS of the studied sample

4.3. Inter-correlation Analysis of REs

It is reasonable to assume that the investigated criteria are inter-linked, the Pearson Correlation Coefficient (PCC) has been calculated for every two sets of residents' responses to each criterion as shown in Table 4. This shed light on many characteristics, details and rationality as follows:

- PCC values are almost positive with few values between 0 to -0.05, implying a degree of correlation between the criteria; this indicates no conflicting criteria within the scope of this study.
- The highest PPC value is achieved between AHP-E and ORE as a reasonable correlation that confirms both evaluations' relations as detailed before.
- PCC values between AHP-E and the criteria are higher than those between ORE and these criteria; this is due to the AHP-scale's objectivity and the effect of social conformity indicated in section 3.3 above. This outcome further verifies the validity of the AHP-based scale compared with residents' expectation.

- Furniture and Interior design criteria share a strong correlation, which is reasonable as both affect the perception of an apartment's interior. This is also true for private garden, parking availability and noise nuisance, which affect the exterior state of a building. These logical values show the accuracy of residents' answers in the survey; as such criteria are intuitively linked.
- PCC values between the AHP-E and the building and location criteria show stronger correlation than the apartment criteria; building and location criteria have well defined standards, which facilitate their assessment in comparison with the apartment scope, resulting in higher accuracy.
- As described in other studies, higher-income families experience better RS due to their ability to locate in better neighborhoods [7]; this is reflected by the moderated PPC between neighborhood criteria and those criteria that directly reflect resident income such as residence stability, HVAC and fundamental systems.
- As presented in previous studies [4], some socio-demographic characteristics, specifically education level and culture, have been shown to be closely linked to RS; all PCCs between education level and all criteria are negative.

Table 4: Correlation coefficient of residents' responses to each criterion

		AHP-applied Evaluation (AHP-E)	Overall Respondents' evaluation (ORE)	Location: Exterior aesthetics	Parking	Noise Nuisance	Neighborhood	Society	Building: Management and Security	Exterior private garden	Utilities for the physically disabled	Elevators and stairs satisfaction	Exterior building appearance	Safety	Residential Stability	Apartment: Complementary systems/infrastructure	HVAC and fundamental Systems	Furniture	Interior design	Natural lighting permeability	Indoor air quality	Thermal comfort	Zooning	Area of main spaces
Apartment	Area of main spaces	0.5	0.54	0.38	0.19	0.15	-0.03	0.03	0.43	0.24	0.46	0.39	0.52	0.47	0.24	0.18	0.34	0.41	0.55	0.18	0.3	0.35	0.55	
	Zooning	0.6	0.56	0.6	0.35	0.43	0.03	-0.02	0.32	0.25	0.34	0.54	0.53	0.47	0.26	0.36	0.19	0.53	0.59	0.21	0.52	0.37		
	Thermal comfort	0.54	0.57	0.34	0.29	0.34	0.21	0.12	0.24	0.25	0.27	0.34	0.34	0.3	0.33	0.36	0.33	0.34	0.46	0.26	0.56			
	Indoor air quality	0.49	0.5	0.37	0.13	0.22	0.15	-0.04	0.17	0.21	0.16	0.3	0.38	0.38	0.33	0.22	0.22	0.34	0.55	0.61				
	Natural lighting	0.48	0.37	0.17	0.31	0.18	0.36	0.15	0.21	0.41	0.15	0.24	0.46	0.45	0.28	0.31	0.32	0.19	0.31					
	Interior design	0.54	0.55	0.40	0.2	0.19	0.25	-0.02	0.15	0.07	0.41	0.33	0.32	0.43	0.37	0.21	0.33	0.74						
	Furniture	0.54	0.57	0.48	0.34	0.28	0.35	0.01	0.27	0.12	0.4	0.31	0.39	0.31	0.42	0.32	0.41							
	HVAC and fundamental	0.63	0.49	0.33	0.31	0.29	0.73	0.45	0.47	0.24	0.31	0.43	0.41	0.49	0.45	0.49								
	Complementary systems/infrastructure	0.72	0.61	0.44	0.57	0.5	0.57	0.48	0.4	0.56	0.38	0.57	0.57	0.55	0.47									
Building	Residential Stability	0.64	0.6	0.34	0.35	0.37	0.49	0.32	0.28	0.28	0.35	0.44	0.46	0.58										
	Safety	0.75	0.73	0.39	0.4	0.4	0.3	0.37	0.51	0.35	0.33	0.65	0.71											
	Exterior building appearance	0.79	0.72	0.57	0.49	0.61	0.28	0.33	0.60	0.53	0.52	0.72												
	Elevators and stairs	0.75	0.68	0.55	0.47	0.61	0.33	0.39	0.52	0.4	0.53													
	Utilities for the physically	0.61	0.54	0.53	0.3	0.48	0.38	0.37	0.45	0.38														
	Exterior private garden	0.63	0.46	0.56	0.71	0.58	0.19	0.37	0.59															
	Management and Security	0.63	0.55	0.58	0.37	0.57	0.22	0.29																
Location	Society	0.56	0.49	0.30	0.43	0.5	0.52																	
	Neighborhood	0.56	0.4	0.24	0.35	0.27																		
	Noise Nuisance	0.74	0.58	0.72	0.55																			
	Parking	0.70	0.57	0.49																				
	Exterior aesthetics	0.74	0.68																					
Overall Respondents' evaluation		0.89																						
AHP-applied Evaluation (AHP-E)																								

>= 0.7
< 0.3 - < 0.7
<= 0.3

5. CONCLUSION

An AHP-based scale has been developed to determine the significance of different RS criteria for Egyptian typical apartments; it considers the apartment, building and location scopes. A pool of relevant criteria have been compiled from different sources, and then refined to 21 main criteria. An AHP-based survey has been prepared and completed by 8 consistent evaluators; accordingly, relevant weights (the developed scale) were calculated – the aim of the study. Moreover, the scale was validated via another survey; 66 respondents have been asked to express their evaluation of RS for each criterion in their apartments, so an average (AREC) can be calculated in addition to an overall residents' evaluation (ORE) of the apartment. The results highlight the validity of the scale, as 41 of 48 responses show little difference between the scale and residents' self-evaluation. Hence, the proposed scale can be utilized to assess the RS of apartments. Some considerations must be sustained when utilizing the proposed scale, such as the presence of minimum human needs in the evaluated residence.

The scale, as a main outcome, places society as the most influential criterion in terms of RS (9.5%), and secondary systems the least (1.7%). The developed RWs point out that the location criteria pertaining are most significant, followed by the apartment criteria then the building criteria; the sum of RWs of society, safety and neighborhood criteria exceed 25% of the total weight. Location criteria presented the highest gap between RWs and RSs compared to others; this suggests the presence of problematic urban planning issues in studied cases such as parking, neighborhood services and others. Also, it is evident that all of the investigated criteria contribute positively to RS, with certain criteria affecting others. Inter-correlations between different evaluations and criteria satisfactions provided appeared reasonable outcomes, along with the further validating the AHP-based scale when compared with residents' expectation. For example, correlations between AHP-E and the building and location criteria satisfactions show stronger correlation than the apartment criteria (same as outlined in the RWs).

Many recommendations can be articulated as a result. Highlighted planning issues (e.g. neighborhood, transportation, etc) should be studied for improving RS of apartment residents. Such issues may be specific to apartmernt-style buildings only and may not be present in other housing types. The survey shows that the current approach of building development does not appreciate RS; it should be enhanced towards promoting RS. In other words, the findings promote RS integration into building development efforts, especially sensitive criteria that have high RWs with low RS such as parking. Also, the criteria weights form a guide that highlights the importance of several factors which should be applied in the context of residential design, and possibly influencing design approaches and architectural learning; RWs should also be consodered in all design stages of residential buildings. The study can be extended to different scopes and/or directions. First, perception exploration methods can be updated to be accurate measurement-based or standard-based to better fit to different residents groups. Accordingly, an apartment RS can be evaluated before occupation to aid residents, designers and the commercial sector to produce highly satisfactory apartments. Also, wider scopes can be studied such as villas, compounds and other housing types; this requires as well adding other criteria such as the design of the garden area, view

approaching, spaces' orientation and others. Likewise, specialized evaluations are required to address specific problems, such as elderly and disabled residents. Finally, many non-architectural aspects, such as the income, age and social level effects and others, can be integrated to enrich the study as a multi-disciplinary research.

6. DECLARATION OF INTEREST STATEMENT

The authors report there are no competing interests to declare.

7. LIST OF ABBREVIATIONS:

RS	Residential Satisfaction
AHP	Analytical Hierarchy Process
RW/s	Relevant Weight/s
AHP-E	AHP-applied evaluation
AREC	Average of respondents evaluations for each criteria
ORE	Overall Respondents' Evaluations to their residents
PCC	Pearson Correlation Coefficient

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Appendix (A)

Relative weights of the selected criteria based on evaluators' inputs (conducted by AHP method)

		Evaluator								
		Evaluator 1	Evaluator 2	Evaluator 3	Evaluator 4	Evaluator 5	Evaluator 6	Evaluator 7	Evaluator 8	Average
Apartment Criteria	Area of main spaces	36%	25%	17%	22%	3%	30%	12%	22%	6.7%
	Zooning	11%	21%	31%	33%	5%	21%	6%	32%	7.0%
	Thermal comfort	21%	4%	10%	7%	22%	12%	17%	5%	4.8%
	Indoor air quality	9%	4%	10%	9%	12%	16%	17%	5%	4.5%
	Natural lighting permeability	2%	4%	5%	8%	10%	4%	12%	9%	2.7%
	Interior design	6%	12%	11%	6%	13%	5%	3%	2%	2.4%
	Furniture	6%	11%	8%	8%	6%	8%	5%	2%	2.2%
	HVAC and fundamental Systems	6%	10%	6%	4%	23%	2%	19%	11%	3.2%
	Complementary systems and infrastructure	2%	9%	2%	4%	7%	2%	8%	11%	1.7%

Building Criteria	Residential Stability	30%	23%	15%	35%	26%	31%	25%	20%	5.7%
	Safety	30%	32%	41%	35%	42%	29%	34%	49%	8.8%
	Exterior building appearance	4%	7%	18%	5%	7%	9%	4%	5%	2.1%
	Elevators and stairs satisfaction	11%	19%	9%	7%	5%	13%	7%	9%	3.0%
	Utilities for the physically disabled	6%	3%	4%	8%	2%	3%	6%	5%	2.0%
	Exterior private garden	6%	3%	7%	5%	10%	11%	12%	3%	2.4%
	Management and Security	14%	13%	6%	4%	6%	5%	11%	10%	2.8%
Location Criteria	Society	36%	26%	27%	52%	9%	26%	22%	10%	9.5%
	Neighborhood	36%	26%	15%	23%	9%	47%	25%	53%	8.6%
	Noise nuisance	4%	6%	23%	11%	53%	16%	5%	5%	6.7%
	Parking	15%	28%	8%	8%	25%	4%	37%	22%	7.8%
	Exterior aesthetics	8%	13%	27%	6%	5%	7%	12%	10%	5.3%
Consistency Ratio		0.07	0.07	0.03	0.095	0.07	0.09	0.09	0.098	0.076

Appendix (B)

Details of respondents' answers

Resident ID	Residents' Categories								Criteria																	Evaluations		
									Apartment								Building							Location						
	Age (years)	Gender (M/F)	Educational level	Total number of residents (>18 years old)	Total number of residents(>=18 years old)	Apartment Area Range (m^2)	Apartment Story	Car ownership	Area of main spaces	Zooning	Thermal comfort	Indoor air quality	Natural lighting permeability	Interior design	Furniture	HVAC and fundamental Systems	Complementary systems / infrastructure	Residential Stability	Safety	Exterior building appearance	Elevators and stairs satisfaction	Utilities for the physically disabled	Exterior private garden	Management and Security	Society	Neighborhood	Noise Nuisance	Parking	Exterior aesthetics	Average of Responses' Evaluations for each Criteria (AREC)	Overall Respondents' Evaluation (ORE)	AHP-applied Evaluations (AHP-E)
1	>55	F	P.hD	3	3	150-200	>9	Yes	4	3	4	4	4	4	4	4	4	3	4	4	3	2	2	4	4	2	2	3	3.4	80%	59%
2	>55	F	B.Sc	2	2	100-150	1-4	Yes	5	4	3	3	3	4	5	5	5	5	5	5	5	2	2	4	4	4	2	4	3	3.9	90%	73%
3	36-45	M	P.hD	2	3	50-100	1-4	Yes	3	4	1	3	4	3	4	4	4	4	5	3	4	1	1	2	4	4	2	4	2	3.1	70%	59%
4	36-45	M	B.Sc	2	2	100-150	1-4	Yes	4	5	4	4	3	5	5	5	5	4	3	3	5	2	2	3	4	5	5	4	4	4.0	80%	77%
5	36-45	M	M.Sc	2	1	50-100	5-8	No	3	4	1	1	1	1	2	2	3	4	2	2	1	1	1	1	5	5	1	1	1	2.0	60%	36%
6	26-35	F	B.Sc	3	0	100-150	1-4	No	4	3	3	3	3	4	4	4	3	4	3	3	3	1	2	2	3	4	3	3	3	3.1	70%	55%
7	18-25	F	B.Sc	4	0	100-150	1-4	No	5	5	4	5	5	5	5	4	4	5	3	5	5	4	2	3	2	4	5	3	5	4.2	80%	76%
8	26-35	M	B.Sc	2	1	150-200	1-4	Yes	4	4	2	3	3	3	4	4	2	4	4	4	4	1	1	2	3	2	4	2	1	2.9	70%	50%
9	36-45	M	B.Sc	2	2	100-150	1-4	Yes	3	3	2	2	2	2	3	4	3	5	3	3	4	2	2	3	4	3	4	2	3	3.0	50%	52%
10	26-35	M	B.Sc	2	3	150-200	5-8	Yes	5	3	4	4	3	3	3	4	4	3	4	3	4	2	2	3	4	2	3	2	2	3.2	60%	56%
11	36-45	M	B.Sc	2	1	100-150	1-4	Yes	4	4	3	4	4	5	5	5	3	5	3	2	3	2	1	2	3	4	2	2	2	3.2	70%	56%
12	26-35	F	B.Sc	1	2	50-100	1-4	Yes	2	3	3	3	3	3	3	3	5	5	3	3	3	3	2	2	3	5	1	1	1	2.9	70%	45%
13	>55	M	P.hD	2	0	50-100	1-4	Yes	5	4	2	3	4	4	4	4	4	5	4	5	5	5	3	5	5	4	5	4	4	4.2	90%	80%
14	26-35	F	M.Sc	4	0	150-200	0	Yes	5	5	3	5	5	5	5	5	2	4	4	4	4	1	1	4	1	3	3	1	3	3.5	50%	59%
15	26-35	F	P.hD	2	2	100-150	1-4	Yes	3	3	4	4	4	5	5	5	4	5	4	3	3	2	2	3	4	5	4	4	3	3.8	70%	72%
16	26-35	F	B.Sc	2	1	50-100	1-4	Yes	4	4	2	2	2	4	4	4	4	2	1	1	3	1	1	2	3	4	3	1	3	2.6	70%	41%
17	36-45	M	B.Sc	2	2	100-150	1-4	Yes	4	4	4	4	4	4	4	3	4	4	4	4	3	2	2	3	4	2	4	2	1	3.3	70%	58%
18	26-35	M	B.Sc	1	1	100-150	1-4	No	2	3	2	2	1	4	4	4	4	4	1	2	2	1	1	1	3	4	1	1	1	2.3	60%	31%
19	36-45	M	M.Sc	1	5	>200	-	Yes	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5.0	60%	100%
20	>55	M	P.hD	4	0	>200	5-8	Yes	4	4	3	4	4	4	4	4	4	5	5	4	4	3	3	3	4	4	4	4	4	3.9	90%	76%
21	46-55	M	B.Sc	2	2	150-200	1-4	Yes	5	5	5	4	5	4	4	5	5	4	5	5	5	1	5	5	3	3	4	5	5	4.4	90%	83%
22	26-35	M	B.Sc	2	0	50-100	1-4	No	4	4	1	3	5	2	4	4	4	4	3	4	4	2	4	3	5	4	4	5	2	3.6	70%	67%
23	26-35	M	M.Sc	2	2	100-150	5-8	Yes	5	5	2	1	5	5	5	5	5	5	1	5	5	1	1	1	5	5	1	1	1	3.3	90%	56%
24	26-35	M	P.hD	2	2	100-150	1-4	Yes	5	5	3	2	2	4	4	3	4	5	3	2	3	2	2	2	2	3	2	3	2	3.0	50%	52%
25	26-35	F	B.Sc	7	0	100-150	1-4	Yes	1	2	3	3	3	4	3	5	5	4	4	3	3	2	1	1	1	1	1	1	1	2.5	10%	29%
26	26-35	M	B.Sc	2	0	-	-	-	3	2	1	1	1	3	5	3	1	2	1	3	3	1	1	1	2	4	1	1	1	2.0	50%	23%
27	26-35	M	Student	5	0	150-200	1-4	No	5	5	4	5	5	5	4	4	5	5	5	5	5	1	4	1	4	3	4	5	3	4.1	80%	81%
28	36-45	M	Student	2	3	-	5-8	No	3	4	2	2	3	2	2	2	4	4	3	3	2	2	2	2	4	5	5	4	3	3.0	80%	59%
29	>55	M	P.hD	1	1	150-200	>9	Yes	5	4	5	5	5	4	4	4	4	5	5	5	5	3	1	2	4	4	3	1	2	3.8	90%	71%
30	26-35	M	B.Sc	2	2	-	-	-	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4.0	100%	75%
31	26-35	M	B.Sc	5	0	50-100	1-4	No	1	3	4	4	4	1	4	3	5	5	1	3	3	1	5	2	4	4	5	5	4	3.4	60%	61%
32	26-35	F	B.Sc	2	1	150-200	1-4	Yes	4	4	3	5	5	4	3	3	4	5	5	3	3	1	4	4	5	3	5	2	5	3.8	90%	74%
33	26-35	M	B.Sc	2	2	50-100	1-4	Yes	3	4	3	4	4	2	2	2	2	1	2	2	3	1	2	2	2	1	3	3	2	2.4	40%	35%

34	26-35	M	B.Sc	2	2	100-150	1-4	No	3	3	1	2	4	3	2	1	2	3	3	2	2	1	1	3	2	4	1	1	1	2.1	50%	31%
35	18-25	M	Student	4	0	>200	0	Yes	5	4	2	3	5	5	5	5	5	5	5	5	5	5	5	3	5	4	5	5	5	4.6	90%	89%
36	26-35	M	B.Sc	3	0	50-100	1-4	No	4	4	2	2	3	3	3	3	3	2	2	3	2	1	1	1	4	3	1	3	2	2.5	50%	41%
37	18-25	M	B.Sc	6	0	100-150	1-4	No	3	3	2	2	3	2	3	3	3	2	2	3	2	2	2	2	2	3	2	1	1	2.3	30%	30%
38	26-35	M	B.Sc	2	2	100-150	>9	No	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5.0	90%	100%
39	26-35	M	B.Sc	2	1	50-100	1-4	No	4	5	5	4	3	5	5	5	5	5	4	4	4	2	2	2	5	5	5	5	4	4.2	90%	86%
40	18-25	M	Student	4	2	100-150	1-4	No	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5.0	100%	100%
41	18-25	M	Student	4	0	>200	0	No	5	4	4	4	5	3	4	4	4	5	5	5	4	3	4	4	3	3	3	5	4	4.0	90%	76%
42	26-35	M	B.Sc	2	1	100-150	5-8	Yes	4	4	3	2	4	2	4	4	3	2	4	4	3	2	1	3	4	4	1	1	1	2.9	70%	48%
43	26-35	M	B.Sc	1	0	50-100	1-4	Yes	4	4	2	2	3	3	4	3	4	2	3	4	4	2	3	4	4	3	5	4	5	3.4	70%	62%
44	26-35	M	B.Sc	2	0	100-150	5-8	Yes	4	3	3	2	4	4	5	4	3	5	4	4	3	2	2	2	4	4	4	4	2	3.4	70%	64%
45	>55	M	P.hD	4	0	100-150	5-8	Yes	4	3	3	2	3	3	3	3	4	3	2	2	3	2	1	3	3	2	1	1	1	2.5	60%	34%
46	36-45	M	P.hD	3	0	150-200	>9	Yes	4	3	3	3	4	4	4	5	5	5	5	4	5	1	1	5	3	5	2	2	3	3.6	90%	65%
47	36-45	M	P.hD	2	2	150-200	>9	Yes	5	5	1	1	3	4	4	3	3	3	3	3	3	2	1	3	3	3	1	1	1	2.7	20%	42%
48	26-35	M	B.Sc	5	2	>200	1-4	Yes	5	5	4	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4.9	90%	96%
49	36-45	M	B.Sc	2	2	50-100	1-4	Yes	4	4	2	3	3	4	4	3	3	4	2	4	3	1	1	1	3	3	3	4	1	2.9	70%	49%
50	36-45	M	P.hD	2	3	50-100	1-4	Yes	4	4	3	3	3	3	3	4	4	4	3	4	5	4	2	3	5	4	4	1	3	3.5	70%	63%
51	36-45	M	P.hD	2	3	100-150	1-4	Yes	5	5	3	4	5	5	4	4	4	5	5	5	4	3	4	3	5	3	5	5	4	4.3	80%	85%
52	26-35	M	P.hD	2	1	50-100	1-4	No	3	5	1	5	5	4	4	3	5	5	5	5	4	2	2	2	2	4	3	2	3	3.5	50%	62%
53	26-35	M	P.hD	3	0	100-150	1-4	Yes	3	1	1	1	4	1	2	5	3	3	1	1	1	1	1	1	5	5	1	1	1	2.0	10%	31%
54	26-35	F	B.Sc	2	3	50-100	1-4	No	4	4	2	4	5	3	5	5	5	5	5	5	5	2	3	5	5	5	5	4	4	4.3	90%	85%
55	>55	F	B.Sc	3	0	100-150	1-4	No	5	4	4	4	4	3	4	5	5	5	4	4	2	2	2	4	3	4	3	2	3	3.6	80%	66%
56	26-35	F	B.Sc	2	0	50-100	1-4	No	4	4	3	1	2	2	4	3	3	5	4	4	4	1	1	3	4	2	4	3	3	3.0	70%	56%
57	26-35	M	B.Sc	2	0	50-100	1-4	No	3	4	2	1	2	3	4	5	5	4	5	4	5	3	2	4	5	4	5	2	4	3.6	70%	68%
58	26-35	F	B.Sc	3	0	50-100	1-4	Yes	4	4	2	4	3	2	2	4	3	5	4	3	4	1	2	2	4	3	2	2	3	3.0	60%	55%
59	26-35	M	P.hD	5	0	100-150	5-8	Yes	3	2	1	1	2	3	3	1	2	3	1	1	2	1	1	1	1	1	1	1	1	1.6	20%	12%
60	18-25	F	Student	5	1	>200	1-4	No	5	4	3	2	2	3	4	4	5	5	4	4	5	5	4	4	4	4	5	5	4	4.0	80%	78%
61	18-25	M	Student	4	2	100-150	0	No	4	3	3	4	4	4	4	4	3	5	4	4	3	3	2	3	4	4	3	3	3	3.5	80%	65%
62	18-25	M	Student	4	0	150-200	1-4	Yes	4	3	2	2	5	3	4	4	5	4	4	3	3	1	3	2	3	4	1	3	1	3.0	60%	51%
63	18-25	F	Student	4	1	100-150	1-4	Yes	5	5	4	4	5	4	4	5	5	4	2	3	4	1	1	3	4	4	4	4	3	3.7	90%	70%
64	18-25	M	Student	5	2	150-200	0	No	3	4	4	3	5	3	3	4	5	5	5	4	5	3	1	1	5	5	5	4	3	3.8	80%	77%
65	18-25	F	Student	5	3	-	0	No	3	2	3	2	5	1	1	5	5	5	5	5	5	1	5	5	5	5	5	5	1	3.8	60%	74%
66	18-25	M	Student	4	1	100-150	1-4	Yes	3	3	4	4	5	5	4	4	4	5	4	2	4	2	1	2	4	5	1	3	1	3.3	70%	60%
Average (with excluding incoherent responses)									4	3.9	3.1	3.4	3.9	3.6	3.9	4	4	4.4	3.9	3.8	3.9	2.3	2.6	2.9	3.9	3.7	3.6	3.3	3.1	3.6	71%	65.9%

Conformed Responses Non-conformed Responses Incoherent Responses

ملخص باللغة العربية:

قياس الرضا السكني في الشقق في مصر من خلال مقياس معتمد على عملية التسلسل الهرمي التحليلي

الرضا السكني هو سمة هامة من سمات استدامة البيئة المبنية والشقق السكنية. وعليه، فإن تقييم الرضا السكني أمر معقد بسبب ارتباطه بالعديد من المعايير، وبالتالي يصعب صياغة مقياس واحد عام لأنه يختلف ويتأثر بشكل كبير حسب الموقع ومتغيرات أخرى. تقدم هذه الورقة مقياسًا تم تطويره لقياس الرضا السكني في الشقق السكنية المختلفة في مصر، واسهام الدراسة يتمثل في وضع مقياس رقمي - بمعايير قابلة للقياس - للرضا السكني في حالات الشقق المختلفة وذلك في ثلاثة نطاقات: الشقة والمبنى والحي. وعليه، تم أولاً تجميع واختيار المعايير التي تؤثر على الرضا السكني من مصادر مختلفة وضمن محددات مناسبة. ومن خلال عملية التسلسل الهرمي التحليلي (AHP) ، تم استنتاج الأوزان النسبية المختلفة للمعايير المختارة بناءً على نتائج المقيّمين المعماريين (المقياس المقترح). تم إعداد دراسة مسحية من خلال استبيان على ستة وستين ساكنًا من مجموعات سكنية مختلفة للتحقق من أداء المقياس؛ وبمقارنة النتائج أظهرت المقارنة ارتباطًا جيدًا يدل على صحة المقياس. وتلقى نتائج الدراسية المسحية الضوء على خصائص أخرى تؤثر على الرضا السكني، والتي تم تحليلها ومناقشتها خلال الورقة البحثية.