Civil Engineering and Architecture 13(3): 1538-1556, 2025 http://www.hrpub.org
DOI: 10.13189/cea.2025.130309

A Methodology to Enhance the Quality of Urban Life in New Urban Settlements Case Study: New Damietta City, Egypt

Raghda Abdelkader Mahmoud[1,*], Sherif Ahmed Ali Sheta[2], Esraa Mohamed Mohamed El-Azab[3], Ahmed Mohamed Thabet Alieldin[4]

[1]Ph.D Candidate of Architectural Engineering, Faculty of Engineering, Mansoura University, Egypt
[2]Associate Professor, Department of Architectural Engineering, Faculty of Engineering, Mansoura University, Egypt
[3]Assistant Professor, Department of Architectural Engineering, Faculty of Engineering, Mansoura University, Egypt
[4]Assistant Professor, Department of Architecture, Faculty of Fine Arts, Mansoura University, Egypt

Received November 28, 2024; Revised March 6, 2025; Accepted March 23, 2025

Cite This Paper in the Following Citation Styles

(a): *[1] Raghda Abdelkader Mahmoud, Sherif Ahmed Ali Sheta, Esraa Mohamed Mohamed El-Azab, Ahmed Mohamed Thabet Alieldin , "A Methodology to Enhance the Quality of Urban Life in New Urban Settlements Case Study: New Damietta City, Egypt," Civil Engineering and Architecture, Vol. 13, No. 3, pp. 1538 - 1556, 2025. DOI: 10.13189/cea.2025.130309.*

(b): *Raghda Abdelkader Mahmoud, Sherif Ahmed Ali Sheta, Esraa Mohamed Mohamed El-Azab, Ahmed Mohamed Thabet Alieldin (2025). A Methodology to Enhance the Quality of Urban Life in New Urban Settlements Case Study: New Damietta City, Egypt. Civil Engineering and Architecture, 13(3), 1538 - 1556. DOI: 10.13189/cea.2025.130309.*

Abstract The Egypt Vision 2050 aims to raise the quality of life standards to become one of the best 30 countries in the world instead of the current ranking 69th of the 100 countries in 2021: Increasing the area of green space, attempting to establish new urban communities and cities in the empty land, doubling the size of the residential areas, and increasing the commercial, industrial, educational, and recreational activities. Therefore, the research aims to measure the quality of urban life as a vital demand for human existence in one of the new cities in Egypt, New Damietta city, provided that it is one of the new residential areas that belongs to the new generations of Egyptian cities, and has a clearly completed strategic plan, which did not achieve the planned population objectives, with the appearance of some shortcomings in its urban environment. In this context, the researchers utilized a set of evaluation criteria to investigate the current state of New Damietta neighbourhoods. The criteria are based on an evaluation index proposed by the AARP Public Policy Institute in the United States. In this context, several tools have been used by the researchers to proceed with the evaluation process. These tools are the analytical hierarchy process, SPSS software, and fuzzy logic technique. The results obtained by this research showed that the QOUL in New Damietta City needs to initialize annual surveys to evaluate the level of residents' satisfaction with the city of New Damietta and take residents' suggestions to help achieve the quality of urban life from their point of view.

Keywords Human Needs, Quality of Urban Life, Sustainable Urban Settlements, City Livability Index (AARP), Fuzzy Logic Technique, New Damietta City

1. Introduction

The lives of citizens in the Egyptian urban communities face a lot of problems and challenges, making Egypt one of the countries with the lowest standards of quality of urban life [1]. The main reason of this is that the population of Egypt occupies only 6% of its total area. However, for some of these reasons, 59 new urban areas were established for development and construction [2]. These new urban communities emerged in the second half of the twentieth century and spread throughout the world. However, these new urban communities in Egypt face a number of challenges that affect the lives of their residents, such as a

lack of services and other non-urban issues, as well as a low population density because they fail to exceed 15% of their target population and meet residents' needs and desires [1]. Despite the state's interest in constructing new and integrated urban communities that are compatible with different groups and have all services available in a way that contributes to providing adequate housing worthy of the Egyptian citizen, restoring the civilized form of the state, and changing the form of life in Egypt, these communities lack the dimensions and standards of urban quality of life, which requires a clear strategy to measure the efficiency of the development of urban communities in performing their role and identifying the nature of the problems of the urban development department and the extent to which they achieve their goals to improve the quality of urban life in them [3]. In order to continue on the approach that achieves the standards of successfully new urban communities, quality of life indicators are crucial components. However, in order to assess the indicators' efficacy at any stage of development, they must be both quantifiable and organized into a systematic model [4, 5].

In our previous work [6], we justified using the UN dimensions and indicators QOL to derive seven fundamental standard criteria for achieving the quality of urban life—and they are social, psychological, economic, safety and security, physical, mobility, and environmental. In that work, we used a manual questionnaire-based method to assess the quality of urban life in New Damietta City based on residents' satisfaction. Although in this research, we adopted the AARP Livability Indicator and used a more objective method based on a fuzzy logic technique to build on those results with more management of uncertainty and ambiguity of subjective techniques. By addressing this gap, the research tries to justify the AARP Livability Indicator to derive eight fundamental standard criteria for achieving the quality of urban life, and they are housing, neighbourhood, accessibility, transportation, health, engagement, and opportunity. Furthermore, the study aims to process these eight criteria in an assessment model based on the fuzzy logic technique to obtain specific numerical results that can be compared with the results obtained from other traditional evaluation methods and thus be able to build the necessary conclusions that confirm the effectiveness of this model. The development of each urban community begins with understanding its issues, needs, and human requirements [7]. The quality of urban life indicators approach is regarded as a comprehensive approach because it reflects the local population's economic, social, cultural, psychological, physical, and health situations [8]. Evaluating urban quality of life is complicated, multidisciplinary, and multifaceted, emphasizing the significance of combining different disciplines when assessing a region's urban quality of life [9]. Furthermore, assessing socio-economic success in the context of sustainable urban development requires considering factors more than only economic values, such as the "quality of life" category. It is also necessary to apply a systemic-holistic approach, which considers subjective aspects in addition to objective ones and even the socio-cultural background [10]. Hence, each of these characteristics should be addressed when evaluating urban development initiatives; the index technique for assessing urban quality of life is required to guarantee the worldwide comparability of data on the growth of urban areas [11, 12]. It is conceivable to conclude that urban planning to promote sustainable development is associated with urban life quality [13].

The basic human requirements can be divided into physical and spiritual necessities, and their availability in an urban community helps to improve the standard of living and raise the quality of life, ultimately leading to member satisfaction. A large body of literature has examined human needs to address socioeconomic and ethical challenges from several perspectives, including philosophy, social studies [14], psychology [15], religion [16], and economics. This will allow data sets to be distinguished based on sub-groups, such as age, gender, occupation, and education, and the degree of vulnerability among various groups, such as lower-class men, women, children, while workers in the informal sector. Disaggregating assessments of quality of life into meaningful units will allow for deliberation regarding local investment planning and perhaps achieving sustainability of marginal groups [17].

Quality of life is an interdisciplinary concept; improving the quality of life in cities is no longer just about physical improvements [18], it is also about human satisfaction with various urban issues such as transportation, public space quality, recreational opportunities, land use patterns, population, building densities, ease of access to basic goods and services, public health, safety, education, social integration, promoting equality, and cultural identities [19]. In light of the analysis of the development movement of cities and new urban communities in Egypt, the human development of these communities did not go at the required rate and did not achieve its objectives because it did not achieve quality of life in economic, social, environmental, and urban areas [20].

2. Materials and Methods

2.1. Quality of Urban Life Indices

Many organizations worldwide are engaged in studying quality of life and citizen happiness, Table 1. A number of indices were proposed and used to score and rank cities and countries based on their quality of life standards. These organizations have different objectives and techniques [21]. The Quality of Living Index, created by Mercer consultants, is one of the most popular and frequently utilized. Another example is the Economist Intelligence Unit's (EIU) quality of urban living indicator, as well as the Organization for Economic Cooperation and Development's (OECD) better living indicator [22]. These many indexes focus on a

number of common qualities because they consider them the most important. These indices prioritize common factors key to determining quality of life [23]. These aspects include housing, money, jobs, community, education, the environment, governance, health, and life. Satisfaction, safety, and a work-life balance, are also included. Each index of those values considers several elements, including urban and social characteristics [21].

2.2. The Evaluation Process

The Livability Index (AARP) is a tool measuring the indicators of Livability within cities, counties, and towns. The AARP proves to be an effective and comprehensive tool because of its capability of assessing housing, urban spaces, healthcare, social, and environmental factors. At the same time, the research is concerned with studying the standards of the quality of urban life in New Damietta, a city that is distinguished by its strategic location on the Mediterranean Sea and that it is one of the most important Egyptian cities that combines residential and industrial services. In this context, the AARP will be the most appropriate among other indexes concerned with measuring the standards of quality of urban life in cities because it is the most appropriate in that it includes the most appropriate standards for measuring the extent of actual satisfaction of the city's residents, which is directly affected by the factors of housing, urban spaces, services, health, education, community engagement, accessibility, and environment.

The research method is based mainly on four basic stages: The formulation of the evaluation criteria, identifying the weights of criteria, questionnaire analysis, and utilizing the fuzzy logic technique. In the first stage, a set of evaluation criteria was utilized to investigate the current state of the urban neighbourhoods of New Damietta city, Egypt. The criteria are based on an evaluation index proposed by the AARP Public Policy Institute in the United States. This index is known as the AARP Livability Indicator, and it is a method for determining the extent to which the community's QOUL exists. In Table 2, these criteria are divided into seven major categories: housing, neighbourhood, transit, environment, health, engagement, and opportunity [21]. Sub-criteria were modified for the Egyptian case, interrogative descriptions representing the sub-criteria for population's opinion. To achieve quality of life, it is necessary to know the opinion of the population and their needs, through a questionnaire, and the questions varied according to the seven dimensions and their sub-indicators. From the analysis of the results of the questionnaire, the needs of the population can be known.

Table 1. Comparing factors of Quality of Life indexes, adopted from [21]

Mercer	OECD	City Livability index (AARP)	EIU	CPI (QOL)	QOL Survey	HCI
	Housing		Material well, being			
Economic environment	Income	Housing	Health care	Productivity	Economy	Work
Socio- cultural environment	Jobs	Neighbourhood	Political stability, freedom	Infrastructure development	culture	Health
Medical and health considerations	community	Access to life, work, and play/ proximity of destinations	security	Equality, social Inclusion	education	Education
Schools and education	education		Family life	Environmental sustainability	welfare	Place
Natural environment	Environment		Community life	QOL	safety	Housing
Public services and transport	Governance		Climates and geography	Public space	environment	Safety
Recreation	Health	Transportation safe and convenient options	Infrastructure	Community cohesion	City administration	transport
Consumer goals	Life satisfaction	Environment	Education	Material safety &security	Community life	Green space
Housing	safety	Health prevention access and quality				Community
Political and social environment	Work – life balance	Engagement civic and social involvement				Participation/such Isolation
		Opportunity				culture

Table 2. Suggested quality of urban life indicators according to AARP index, derived by authors from [24]

Criteria	Sub- criteria	Interrogative description
Housing	Housing & Buildings options/HOUSE 1	Are there several possibilities for housing? (Villas, apartments, public housing, and upscale housing)?
	Housing accessibility/ HOUSE 2	Are there any housing initiatives designed to help those with disabilities live freely?
	Housing affordability- HOUSE 3	Does a family's income cover the price of residential flats or units?
	Housing quality\ HOUSE 4	Do the city's inhabitants find the standard of housing and the amenities that go along with it acceptable?
Neighbourhood	Mixed use neighbourhoods\NEIB 1	Do different land uses (residential, commercial, cultural, and administrative) coexist in close proximity to one another?
	Neighbourhood facilities \NEIB 2	To what extent are the local amenities accessible?
	Responsive Design\NEIB 3	To what extent is the district's identity respected?
	Neighbourhood quality\NEIB 4	In most places, is it possible to consider neighbourhood quality and its constituent parts attained?
Transportation	Public transport\TRANS 1	Do passengers have a number of alternatives that make using public transit more flexible, safer, and quicker?
	Safe streets\TRANS 2	How are the city's public areas designed to provide room for bicyclists and pedestrians?
	Transportation affordability\TRANS 3	Are the prices of public transportation affordable for all groups?
	Pedestrian network\TRANS 4	Does it take enough time to walk to basic and secondary services?
Environment	Water quality\ENV 1	Is the provided water suitable for human use and consumption?
	Air quality\ENV 2	Does the city's air quality suffer from any pollutants?
	Energy efficiency\ENV 3	Are there any programs enhancing renewable energy that might contribute to the city's increased energy efficiency?
	Efficient waste disposal\ENV 4	Is a system in place for collecting and disposing of waste?
Health	Healthy behaviors\HEALTH 1	Are there any public health programs that include activities aimed at improving health behavior and awareness?
	Access to health care\HEALTH 2	Do healthcare services have 24/7 availability and are they simple to use?
	Quality of health care\HEALTH 3	Do medical facilities have the specific medical capabilities and cadres needed to provide the appropriate medical care?
	Health insurance\HEALTH 4	Does health insurance cover every medical service?
Engagement	Communication & Technology Services\ ENG 1	Do efforts like the internet of things exist? Can IOT give residents information about cars, houses, buildings, or any other service to make the city smarter than it was before?
	Civic engagement\ ENG 2	Are there programs for community involvement that allow locals to discuss and resolve their common issues as well as participate in planning processes?
	Social engagement\ ENG 3	Are there any programs that support the population's sense of community cohesiveness by offering a range of social and religious services and facilities?
	Social equity\ ENG 4	Does the whole population have fair access to housing, services, and facilities?
Opportunity	Economic opportunity\OP1	Does a city provide employment opportunities in both the public and private sectors?
	Education opportunity\OP2	Are there enough public and private schools in your neighbourhood that are accessible by foot?
	cultural opportunity\OP3	How much does the government fund creative endeavors?
	Recreational opportunity\OP4	To what extent are open places affordable and accessible?

In the second stage, the researchers performed a calculation process for each item of the criteria to make the criteria related to the case under assessment by a degree of correlation expressed by its weight value. This calculation process is known as Analytic Hierarchy Process (AHP), and it is a process to identify weights of criteria components; it is commonly used in the field of urban design and planning because of its convenience and inclusiveness related to the field experience concerning urban design and planning–based typology of this type of assessment [25, 26]. In this stage, stakeholders in New Damietta city were identified from different teams of experts. Officials from the city council, consultants, and academic specialists are invited through personal contacts to contribute to assigning the priority vectors concerning the seven criteria of the evaluation index. They have compared each pair of criteria and ranked them according to the scale described in Table 3, while: 2,4, and 6 are intermediate values.

Table 3. Pairwise criteria for prioritizing criteria elements [27]

1	Objects *x* and *y* are equal importance
3	Object *x* in weakly more important than y
5	Object *x* in strongly more important than y
7	Object *x* in very strongly more important than y
9	Object *x* in more important than y

Afterwards, the AHP model is going to practice some simple calculations to determine the overall weight that has been assigned to each criterion. The weight is a digit between 0 and 1 and the aggregation of all weights will be 1. This can be obtained by taking each normalized number for a criterion and dividing it by the sum of the column which is included in a matrix prepared for normalization process and calculation of weights. Table 4 shows the final result of calculating weights which can be obtained by calculating the average of the horizontal values for each row of the matrix. The values in Table 4 are calculated by using the mathematics of AHP, and adopted from methods and formulas performed in three steps as follows:

1. **Step1:** Comparing the elements of criteria according to their importance priorities indicated in table 3.
2. **Step2:** Normalization of cell values obtained from step 1 by dividing the rate score existing in each cell by its column summation in table 4.
3. **Step3:** Calculating consistency ratio as described in (Nowak, et al., 2008; Saaty, 2008) and shown below:

$$\mathbf{CI = (\lambda max - n) / n - 1}$$

where, λ**max** is the principal Eigen Value;
n is the number of elements of criteria;
and λ**max =** $\sum$ **of the products between each element of the priority vector and column totals**

$$\mathbf{CR = \frac{Consistency\ Index\ (CI)}{Random\ Consistency\ Index\ (RI)}}$$

Where **CI** obtained from $\mathbf{CI = (\lambda_{max} - n) / n - 1}$, and RI can be calculated from the following rule of Saaty (1980) by taking the (n) number of criteria into account to obtain its confronting value as listed below:

n-	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI-	**0**	**0**	**0.58**	**0.90**	**1.12**	**1.24**	**1.32**	**1.41**	**1.45**	**1.49**

After calculating the Consistency Ratio to be < 0.10, then the weights are accurately ranked and acceptable.

In the third stage, a questionnaire distributed to 200 inhabitants was developed to facilitate a general assessment of the population's opinions about the quality of urban life standards in their city, New Damietta, in Egypt. The questionnaire is based on the seven criteria derived from the AARP Livability Indicator described above, and its forms were distributed to a sample of various categories of the city's residents. The results of this questionnaire were then statistically analyzed using the SPSS software, and then the implications generated from these results were identified and formulated in the form of comprehensive graphic forms, listed below in the next section.

Table 4. Normalization of values and calculation of weights, created by authors

	Housing	**Neighborhood**	**Transportation**	**Environment**	**Health**	**Engagement**	**Opportunity**	**Sum (Σ)**	**Priority vector "Weight" Sum (Σ)/5**
Housing	0.17	0.22	0.16	0.23	0.18	0.11	0.23	1.3	**0.176**
Neighbourhood	0.08	0.11	0.08	0.15	0.18	0.11	0.11	0.82	**0.113**
Transportation	0.17	0.22	0.16	0.15	0.18	0.11	0.23	1.22	**0.170**
Environment	0.05	0.05	0.08	0.07	0.09	0.11	0.05	0.5	**0.079**
Health	0.08	0.05	0.08	0.07	0.09	0.11	0.11	0.59	**0.092**
Engagement	0.34	0.22	0.33	0.15	0.18	0.22	0.11	1.55	**0.239**
Opportunity	0.08	0.11	0.08	0.15	0.09	0.22	0.11	0.84	**0.131**

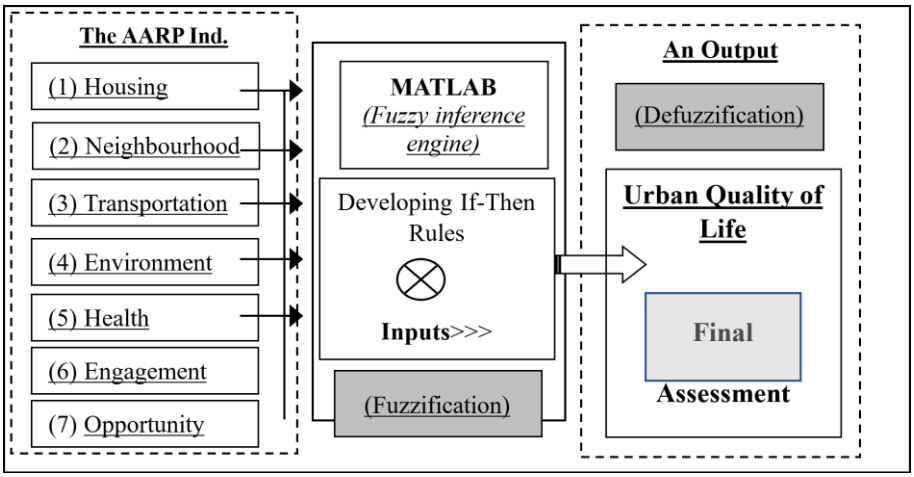

Figure 1. The process of fuzzy logic technique implemented in MATLAB for an assessment criterion, created by authors

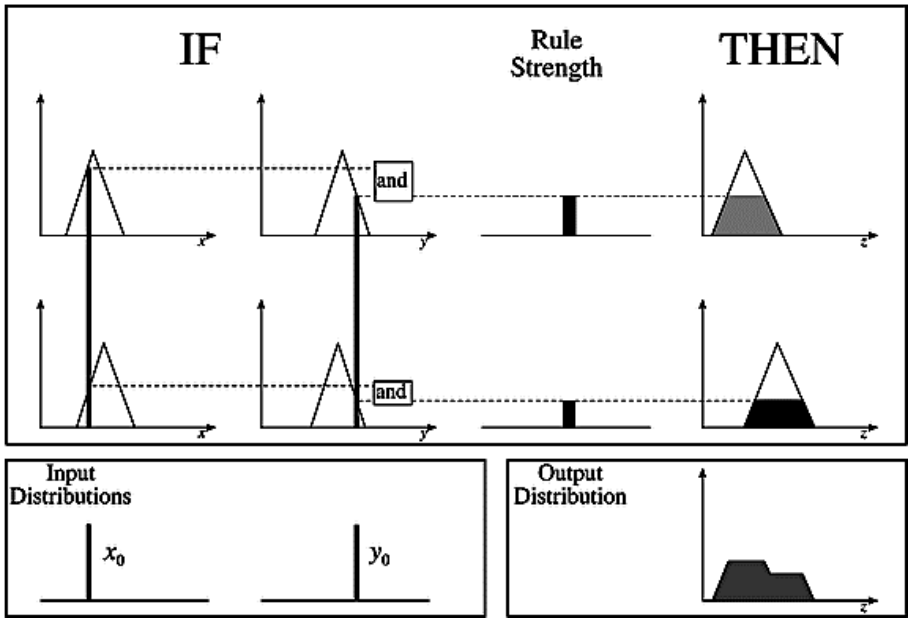

Figure 2. Input-Output processing in fuzzy logic technique [30]

Finally, in the fourth stage, the fuzzy logic technique was implemented by MATLAB software to transform the seven criteria of the AARP Livability Indicator to fuzzy sets and membership functions of the fuzzy sub-sets, in a process called fuzzification (see Figure 1) [28, 29]. Furthermore, a number of If-Then rules are constructed in order to link the information related to the evaluation process within the fuzzy logic technology model, as shown in Figure. 2 through which the input processes for the evaluation values will be run by the researchers' experience in the field of study, and then their digital outputs will be obtained.

3. Results

3.1. Results from the Questionnaire

A Google Forms survey was conducted among the residents of New Damietta city to determine the level of citizens' satisfaction with the QOUL in the city, followed by a field visit to the city. A paper questionnaire was distributed to 200 inhabitants, with a consideration given to age groups as well as social and economic position. The criteria questions and their associated sub-criteria were listed in a table indicating the degree of approval of these items in a category ranging from highly not valid to strongly valid, derived from: the Linkert scale, and the results from the questionnaire were analyzed using SPSS software as follows:

Based on the findings of the questionnaire analysis which are presented in Figure 3, the percentage of residents' satisfaction with the housing QOUL in the city of New Damietta has been identified with the percentage of its validity, and Figure 3 indicates that there is need for improvement in housing accessibility, affordability, and quality based on the participants' responses. The highest valid percentage is for "Housing options (House1)" with a

valid percentage of 80.2%. On the other hand, the lowest valid percentage among the housing criteria is for "Housing affordability (House3)" with a valid percentage of 17.9%.

Based on the questionnaire results presented in Figure 4, it can be observed from the percentage of residents' satisfaction with the neighbourhood QOUL in the city of New Damietta, the highest sub criterion is "Neighbourhood facilities (Neib2)" with a valid rating of 81.5%. This indicates that a majority of respondents perceive the neighbourhood facilities to be valid or satisfactory. The lowest sub-criterion is "Responsive Design (Neib3)" with a valid rating of 62.3%. This suggests that a very small percentage of respondents consider the responsive design of the neighbourhood to be unsatisfactory.

In Figure 5, the questionnaire analysis presented that the percentage of residents' satisfaction with the transportation QOUL indicates that the highest sub-criterion is "Pedestrian Network (Trans4)" with a valid rating of 78.1%, the lowest sub-criterion is "Safe Street (Trans2)" with a valid rating of 21.9%. Overall, while there's a consensus on the need for development or validity across different transportation criteria, the level of endorsement is consequently varying. These findings highlight areas for improvement and suggest priorities for enhancing transportation infrastructure and services based on public perceptions and priorities.

In Figure 6, the questionnaire analysis shows that the percentage of residents' satisfaction with the environment QOUL indicates that the highest sub-criterion is "Water Quality (Env1)" with a valid rating of 79.5%, The lowest sub-criterion is "Energy Efficiency (Env3)" with a valid rating of 6.0%. This means that the analysis reveals a predominant tendency towards that water quality in the city can be considered "Very Good.

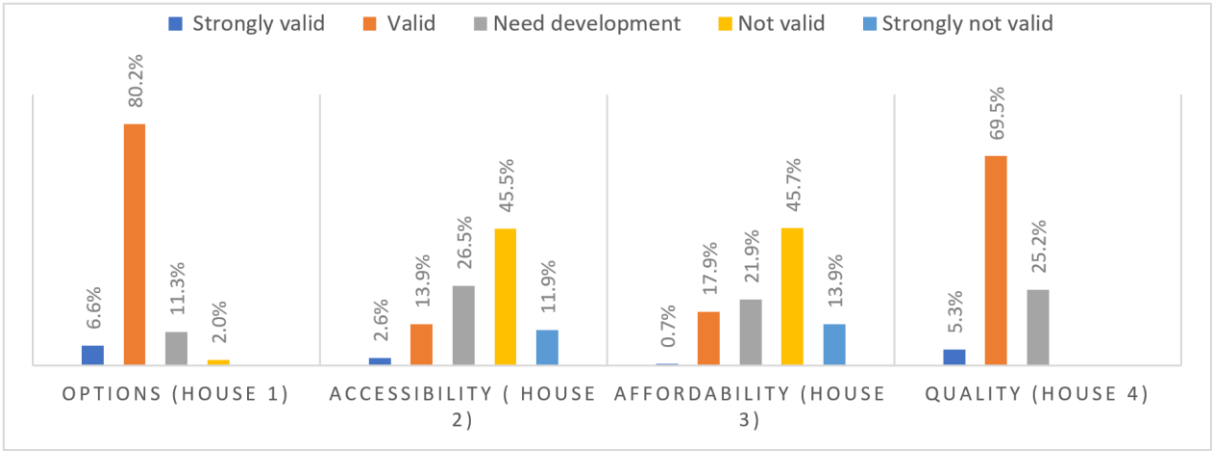

Figure 3. Statistical results questionnaire of the housing QOUL, data processed by authors from SPSS

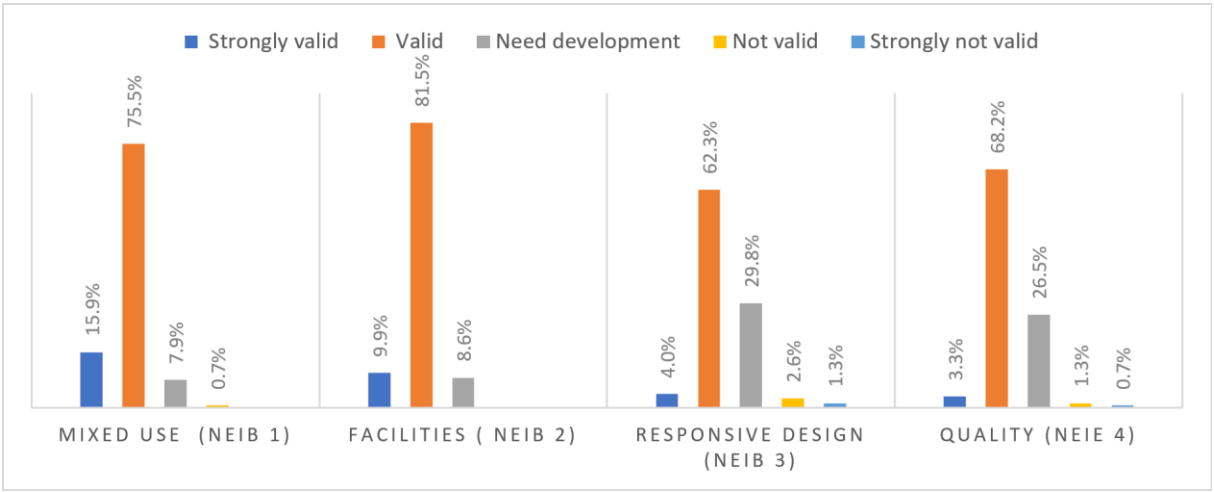

Figure 4. Statistical results questionnaire of the neighbourhood QOUL, data processed by authors from SPSS

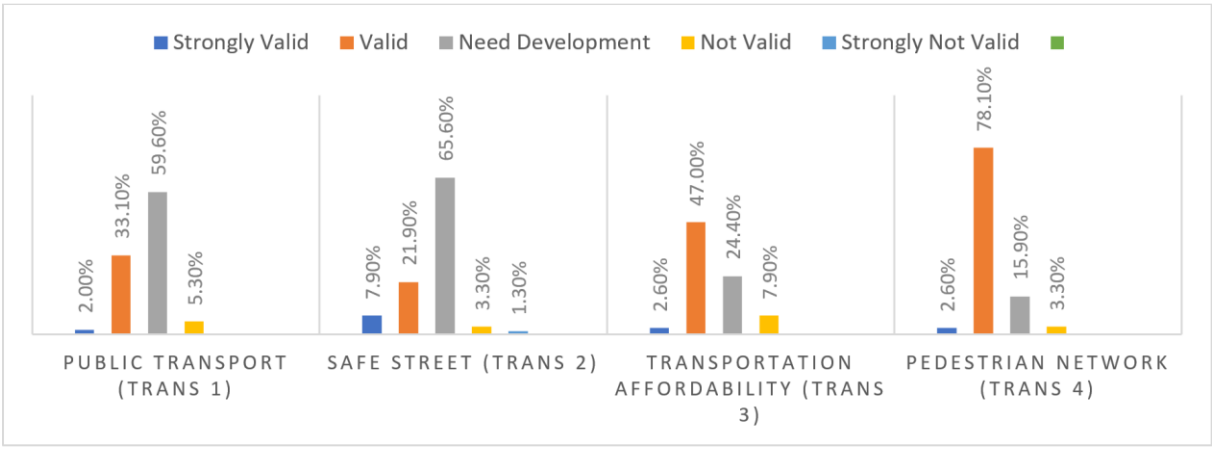

Figure 5. Statistical results questionnaire of the transportation QOUL, data processed by authors from SPSS

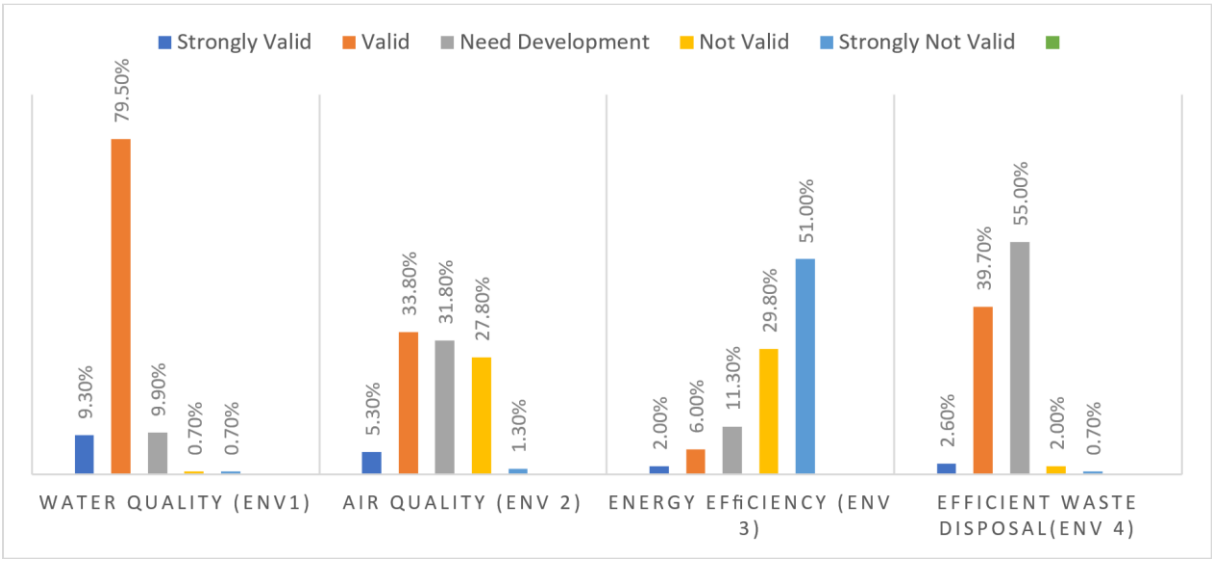

Figure 6. Statistical results questionnaire of the environment QOUL, data processed by authors from SPSS

Based on the results of the questionnaire presented in Figure 7, it can be observed that the percentage of residents' satisfaction with the health QOUL in the city of New Damietta city indicates that the highest sub-criterion is "Access to healthcare (health 2)" with a valid rating of 18.5%. This indicates that most respondents perceive the neighbourhood facilities to be valid or satisfactory. The lowest sub-criterion is "Health Insurance (health4)" with a valid rating of 3.3%. Overall, the percentages in Figure 7 suggest that there's a notable consensus among respondents regarding the need for improvement across various health criteria.

The questionnaire analysis presented in Figure 8 shows that the percentage of residents' satisfaction with the Engagement QOUL indicates that the highest sub-criterion is "Social Engagement (Eng3)" with a valid rating of 24.5%. The lowest sub-criterion is "Civic Engagement (Eng2)" with a valid rating of 4.0%.

As depicted in Figure 9, it can be observed that the questionnaire analysis addresses the percentage of residents who reported satisfaction with the Opportunity QOUL in the city to be highest valid in "Education Opportunity (OP2)" with a valid rating of 64.2%, while the lowest sub-criterion is "Cultural Opportunity (OP3)" with a valid rating of 4%.

Finally, as presented in Figure 10, the factor "Total Engagement" exhibits the lowest mean value (2.6717), representing approximately 53.40% of its possible range. This indicates that, on average, respondents expressed lower levels of engagement compared to the other dimensions, even below health-related aspects. On the other hand, the factor "Total Neighbourhood" has the highest mean value (3.8567), representing approximately 77.10% of its possible range. This indicates that respondents, on average, expressed higher satisfaction or agreement with the aspects related to the neighbourhood dimension. Considering Total Criteria "Validity" as the aggregate measures of satisfaction for the entire questionnaire, the obtained percentages indicate a positive association as they fall in between the lowest and highest mean values of the seven dimensions with approximately 23.7% – the difference between "Total Neighbourhood"

and "Total Engagement" – of its possible range. From all above results, the questionnaire proved to perform moderately well in meeting the criteria set, with a moderate and positive association between the variables "Total Engagement" and "Total Neighbourhood". However, there may still be a need for improvement, particularly in addressing the areas where satisfaction levels are comparatively lower, such as health-related aspects.

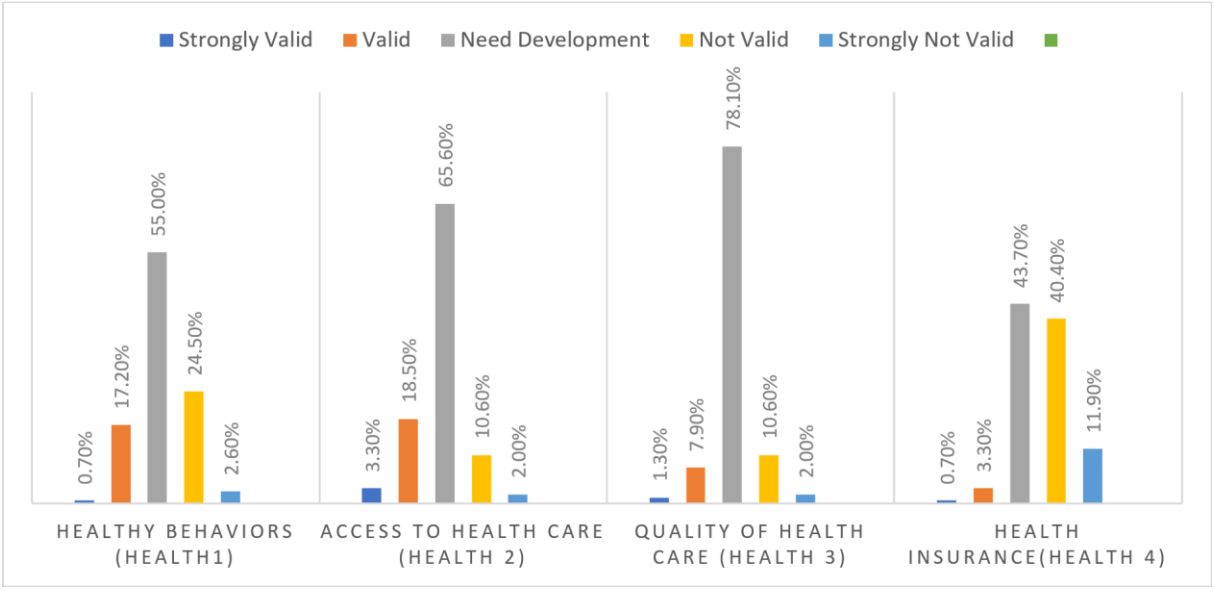

Figure 7. Statistical results questionnaire of the health QOUL, data processed by authors from SPSS

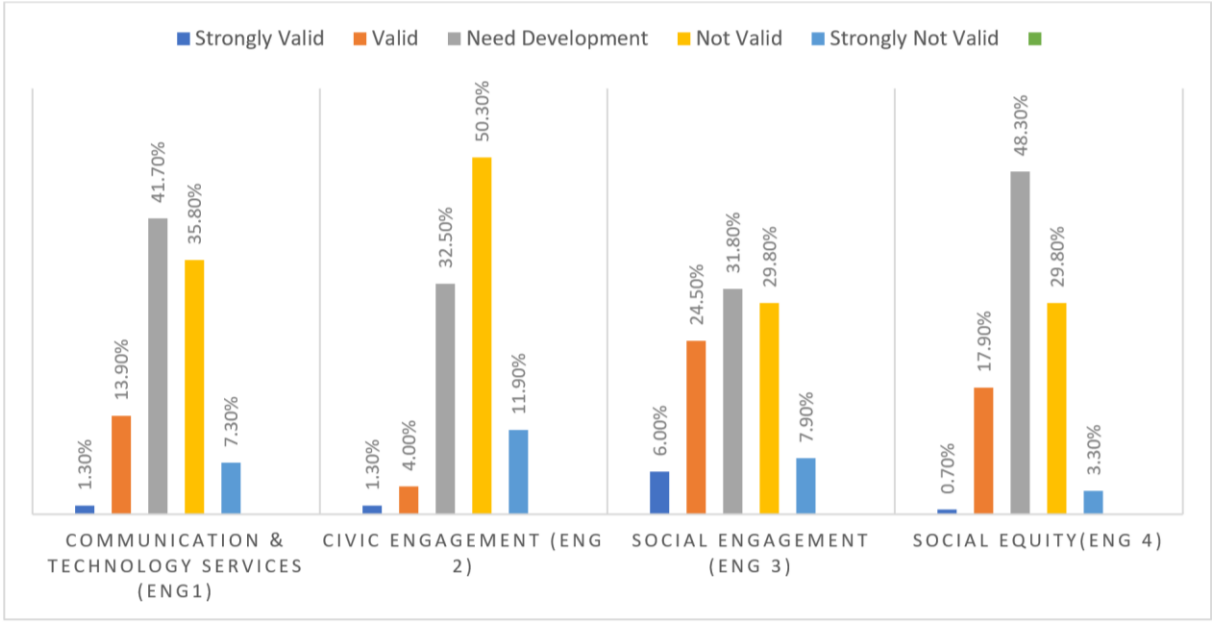

Figure 8. Statistical results questionnaire of the engagement QOUL, data processed by authors from SPSS

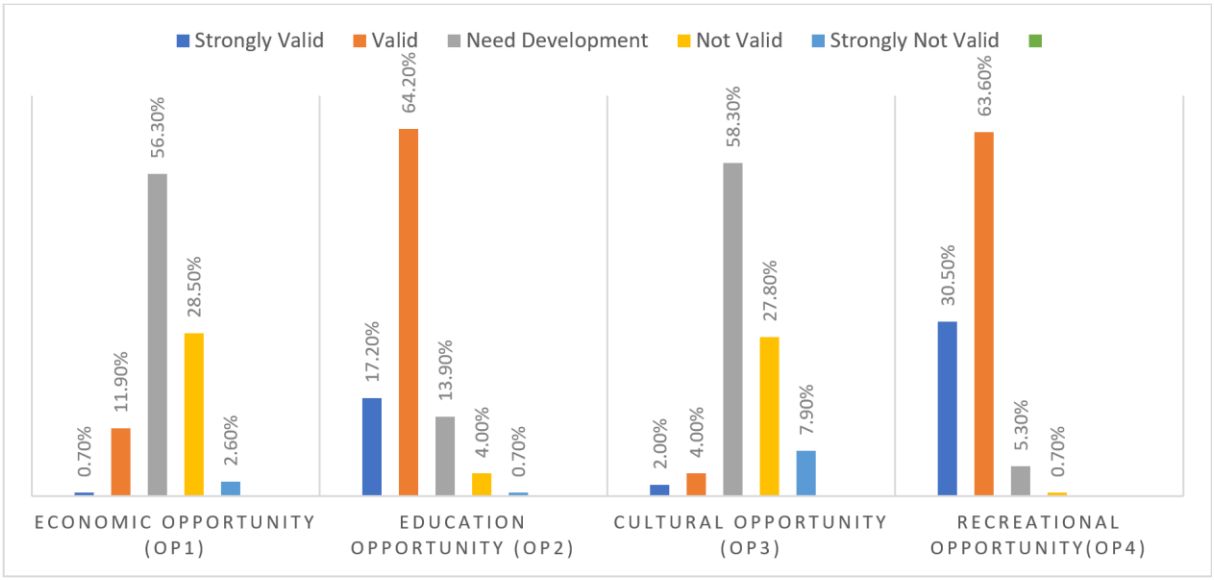

Figure 9. Statistical results questionnaire of the opportunity QOUL, data processed by authors from SPSS

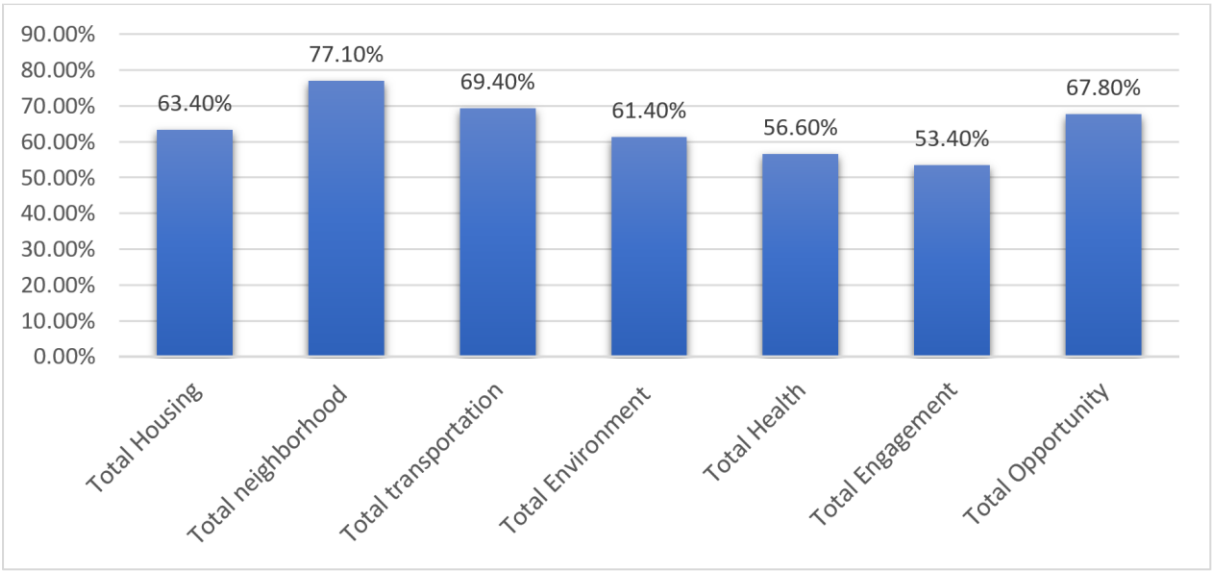

Figure 10. The aggregate measures of satisfaction for the entire questionnaire factor, data processed by authors from SPSS

3.2. Results from Fuzzy Logic Technique

The fuzzy logic technique used in this study relies primarily on the seven criteria of the Livability Index (AARP). While the fuzzification process depends on logical rules known as "If-Then rules," which are formulated by the researchers' experience and based on the quality of urban life criteria described in the Livability Index (AARP), and they imply correlated linguistic variables with the association of criteria to each other in certain consequence of quality, Table 5. For example, of a fuzzy If-Then rule: If (Housing_Options is Weak Achievement) or (Housing_Accessibility is Achieved Moderatley) or (Housing_Affordability is Achieved Moderatley) or (Housing_Quality is Achieved Moderately) then (Housing is Poor). Furthermore, this fuzzy logic technique relies on the researchers' experiences. In this context, the researchers' conducted a manual assessment for the study area based on the quality of urban life criteria described above, and its results have been processed as inputs to the fuzzy logic technique by applying the fuzzy inference system in MATLAB software for the seven criteria in the same way illustrated in Figure 11. This process was carried out on each criterion and sub-criterion of the Livability Index (AARP) mentioned above and its fuzzy results were obtained **as follows:**

Table 5. Sample If-Then rules processing, processed by authors from MATLAB.

If	Sub-Criterion (1) is...	And/Or	Sub-Criterion (2) is...	And/Or	Sub-Criterion (3) is...	And/Or	Sub-Criterion (4) is...	Then	Conclusion
If	Not Achieved	And	Weak Achievement	And	Achieved	And	Achieved Moderately	Then	(Poor)
If	Weak Achievement	Or	Not Achieved	Or	Achieved Moderately	Or	Weak Achievement	Then	(Poor)
If	Achieved Moderately	And	Achieved	And	Achieved	And	Achieved	Then	(Good)
If	Achieved	Or	Achieved Moderately	Or	Weak Achievement	Or	Not Achieved	Then	(Average)

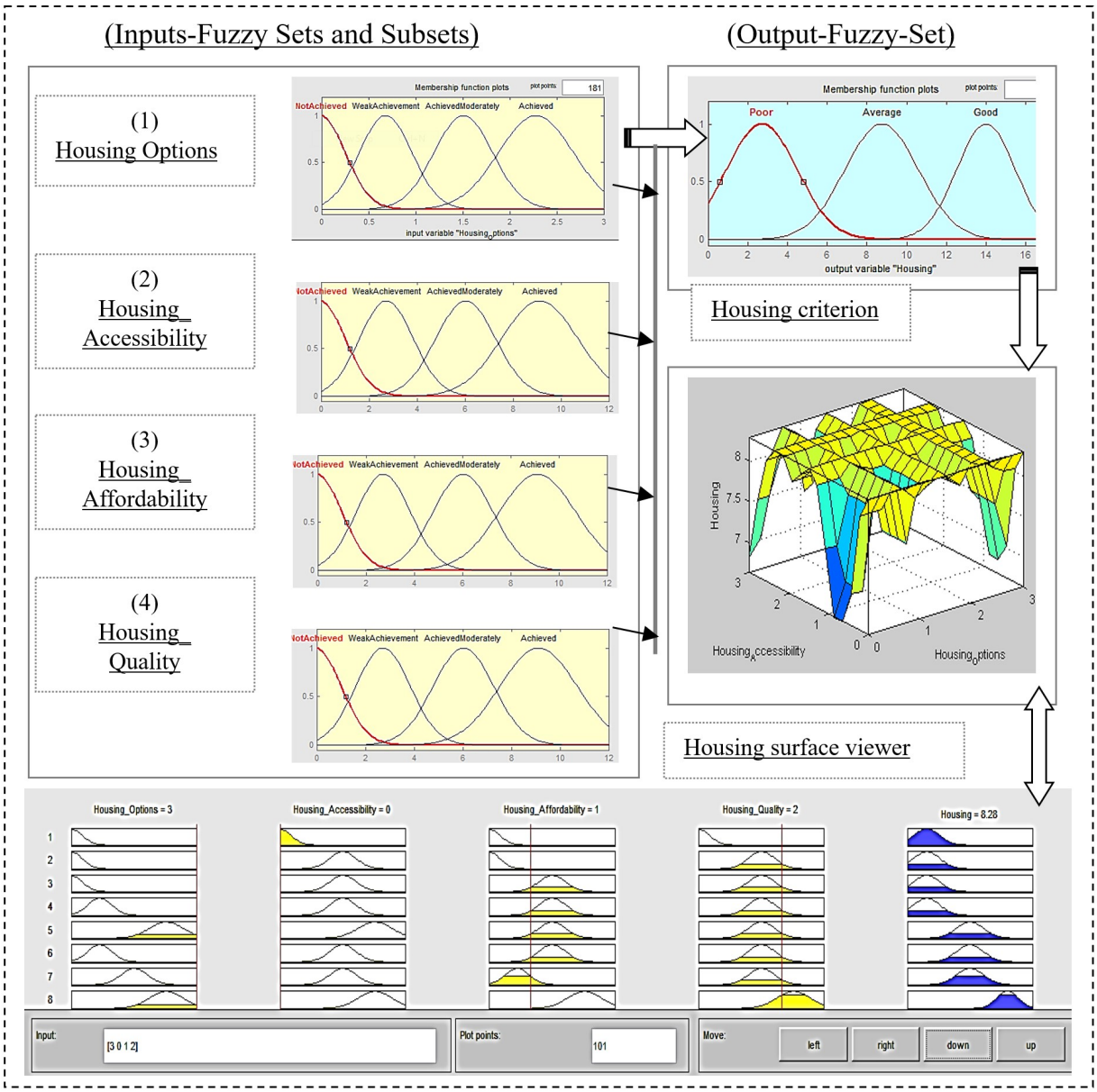

Figure 11. The fuzzy logic results for the criterion "Housing", processed by MATLAB software – The same way for the other 6 criteria of the Livability Index (AARP). processed by authors from MATLAB

For the "housing" criterion: The inputs are housing options, housing accessibility, housing affordability, and housing quality, and each one of them contains four membership functions that are equal in weight to each other and in the form of a Gaussian curve representing the assessment categories: Not achieved, weak achievement, achieved moderately, and achieved. The four membership functions are distributed orderly along the range [0–3]. The fuzzy inference system for this criterion takes the experts' values of {3, 0, 1, 2} coming from their manual assessment for the four inputs described above to be processed in parallel by using the fuzzy reasoning operator. On the other hand, the output "Housing" is a fuzzy set containing three Gaussian membership functions distributed orderly along the range [0–17], representing the assessment categories: poor, average, and good. The results coming from the operator are combined and defuzzified to get a crisp, nonfuzzy number representing the final assessment result of the criterion, which is 8.28%.

For the "neighbourhood" criterion: The inputs are mixed-use neighbourhoods, neighbourhood facilities, responsive design, and neighbourhood quality, and each one of them contains four membership functions that are equal in weight to each other and represent the assessment categories: Not achieved with a trapezoidal curve type, weak achievement with a trapezoidal curve type, achieved moderately with a triangle curve type, and achieved with a trapezoidal curve type; they were selected in this way to meet the requirements of the Quality of Urban Life Index. The four membership functions are distributed orderly along the range [0–3]. The fuzzy inference system for this criterion takes the experts' values of {3, 3, 2, 2} coming from their manual assessment for the four inputs to be processed in parallel by using the fuzzy reasoning operator. On the other hand, the output "neighbourhood" is a fuzzy set containing three membership functions distributed orderly along the range [0-12], representing the assessment categories: poor with a trapezoidal type, average with a triangle type, and good with a trapezoidal type. The results coming from the operator are combined and defuzzified to get a crisp, nonfuzzy number representing the final assessment result of the criterion, which is 9.04%, Figure 12.

For the "Transportation" criterion: The inputs are public transport, safe streets and transportation options, accessible system design, and pedestrian network, and each one of them contains four membership functions that are equal in weight and represent the assessment categories: Not achieved with a trapezoidal curve type, weak achievement with a trapezoidal curve type, achieved moderately with a triangle curve type, and achieved with a trapezoidal curve type; they were selected in this way to meet the requirements of the Quality of Urban Life Index. The four membership functions are distributed orderly along the range [0–3]. The fuzzy inference system for this criterion takes the experts' values of {2, 2, 3, 3} coming from their manual assessment for the four inputs to be processed in parallel by using the fuzzy reasoning operator. On the other hand, the output "transportation" is a fuzzy set containing three membership functions distributed orderly along the range [0–17], representing the assessment categories: poor with a trapezoidal type, average with a triangle type, and good with a trapezoidal type. The results coming from the operator are combined and defuzzified to get a crisp, nonfuzzy number representing the final assessment result of the criterion, which is 13.6%, Figure 13.

For the "environment" criterion: The inputs are water quality, air quality, energy efficiency, and efficient waste disposal, and each one of them contains four membership functions that are equal in weight to each other and represent the assessment categories: Not achieved with a trapezoidal curve type, weak achievement with a trapezoidal curve type, achieved moderately with a triangle curve type, and achieved with a trapezoidal curve type; they were selected in this way to meet the requirements of the Quality of Urban Life Index. The four membership functions are distributed orderly along the range [0–3]. The fuzzy inference system for this criterion takes the experts' values of {3, 1, 0, 2} coming from their manual assessment for the four inputs to be processed in parallel by using the fuzzy reasoning operator. On the other hand, the output "Environment" is a fuzzy set containing three membership functions distributed orderly along the range [0-11], representing the assessment categories: poor with a trapezoidal type, average with a triangle type, and good with a trapezoidal type. The results coming from the operator are combined and defuzzified to get a crisp, nonfuzzy number representing the final assessment result of the criterion, which is 3.32%, Figure 14.

For the "health" criterion: The inputs are healthy behaviors, access to healthcare, quality of healthcare, and health insurance, and each one of them contains four membership functions that are equal in weight to each other and represent the assessment categories: Not achieved with a trapezoidal curve type, weak achievement with a trapezoidal curve type, achieved moderately with a triangle curve type, and achieved with a trapezoidal curve type; they were selected in this way to meet the requirements of the Quality of Urban Life Index. The four membership functions are distributed orderly along the range [0–3]. The fuzzy inference system for this criterion takes the experts' values of {3, 2, 2, 1} coming from their manual assessment for the four inputs to be processed in parallel by using the fuzzy reasoning operator. On the other hand, the output "Health" is a fuzzy set containing three membership functions distributed orderly along the range [0-11], representing the assessment categories: poor with a trapezoidal type, average with a triangle type, and good with a trapezoidal type. The results coming from the operator are combined and defuzzified to get a crisp, nonfuzzy number representing the final assessment result of the criterion, which is 6.2%, Figure 15.

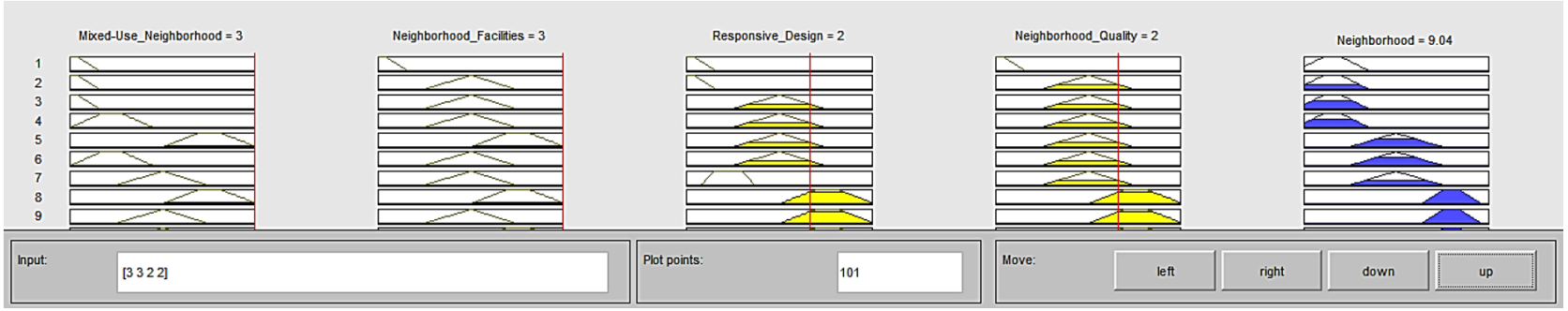

Figure 12. The fuzzy logic results for the criterion "neighbourhood", defuzzified by authors in MATLAB software

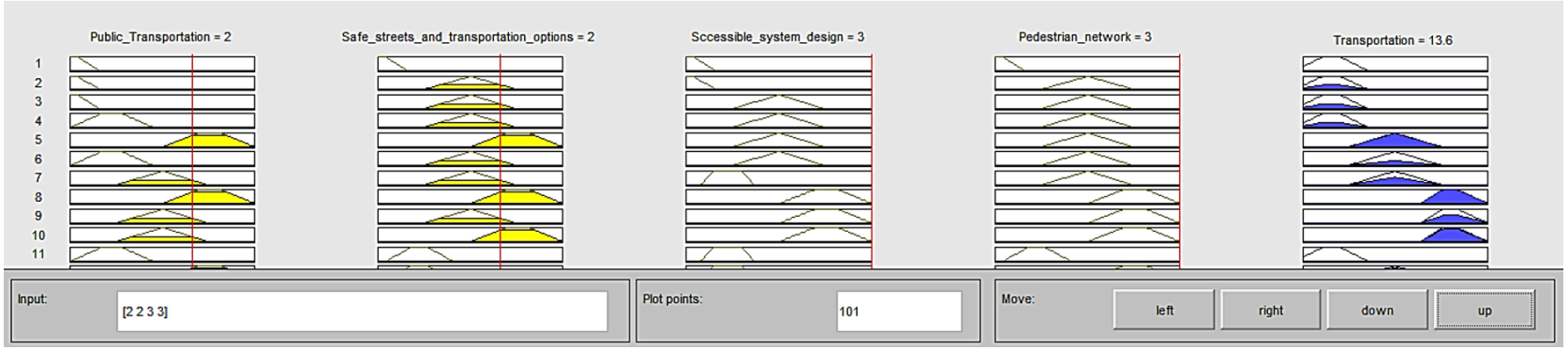

Figure 13. The fuzzy logic results for the criterion "Transportation", defuzzified by authors in MATLAB software

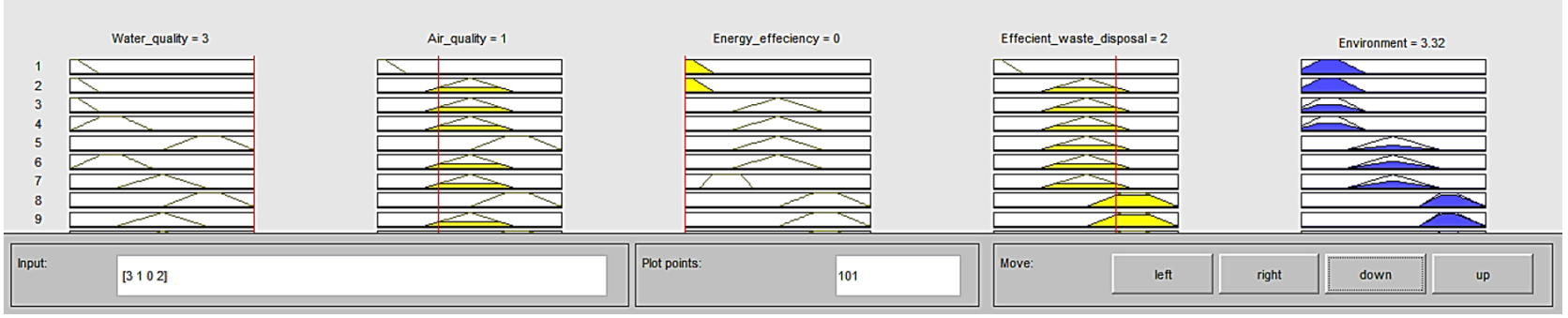

Figure 14. The fuzzy logic results for the criterion "environment", defuzzified by authors in MATLAB software

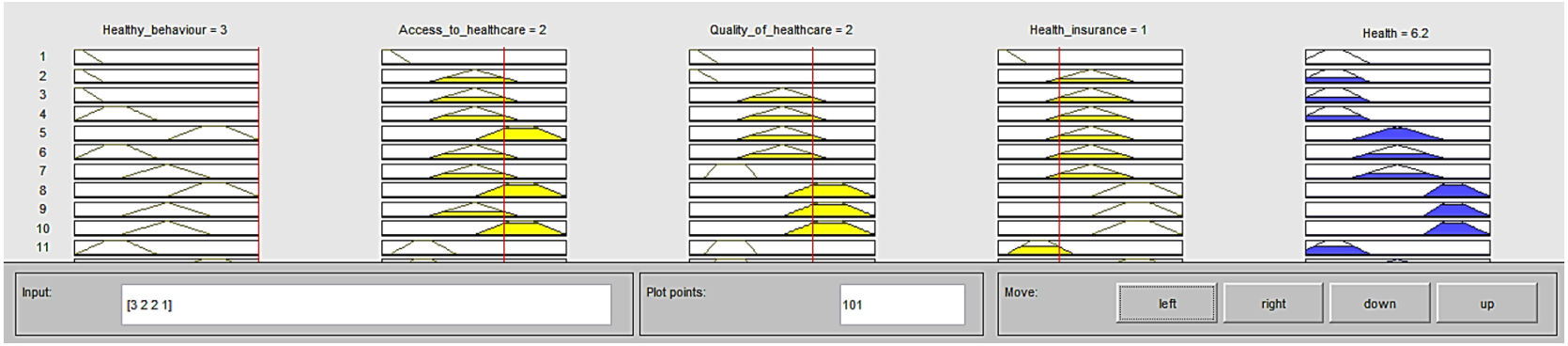

Figure 15. The fuzzy logic results for the criterion "health", defuzzified by authors in MATLAB software

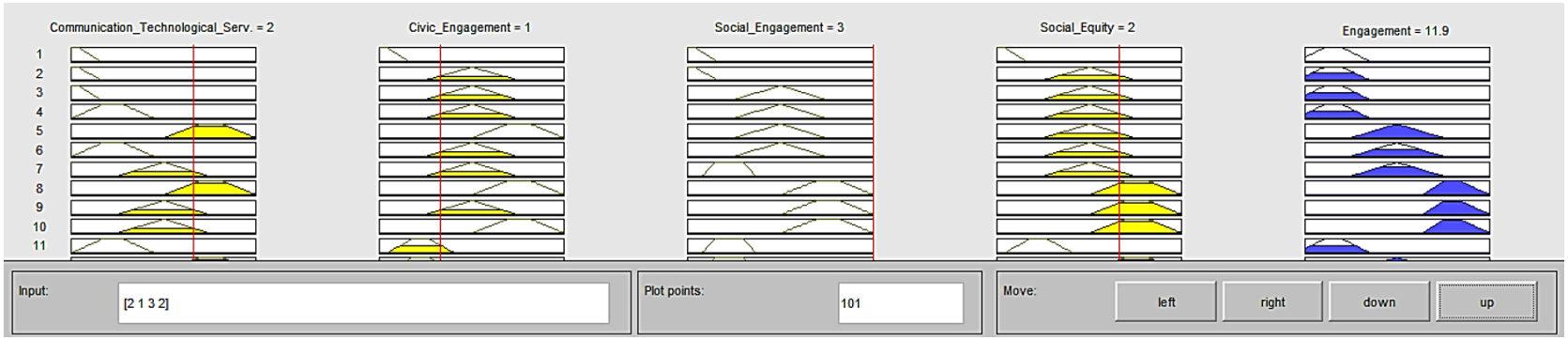

Figure 16. The fuzzy logic results for the criterion "engagement", defuzzified by authors in MATLAB software

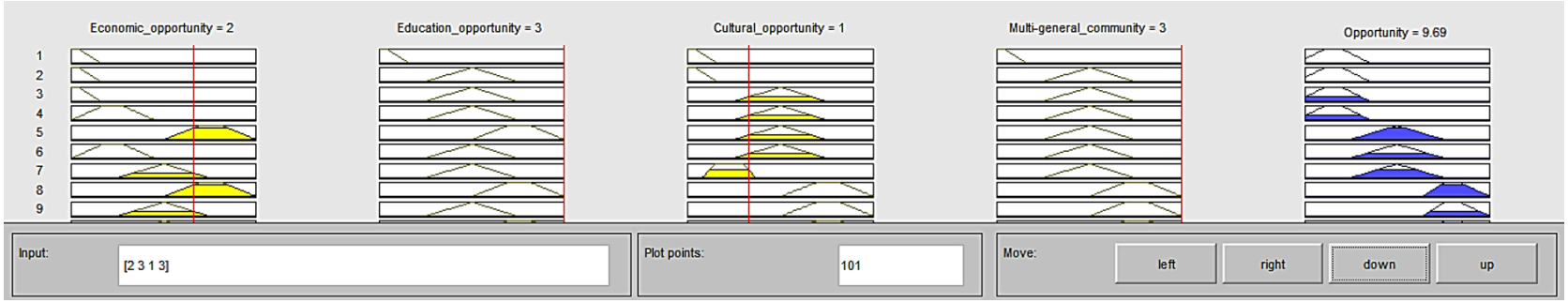

Figure 17. The fuzzy logic results for the criterion "opportunity", defuzzified by authors in MATLAB software

For the "engagement" criterion: The inputs are communication and community services, civic engagement, social engagement, and social equity, and each one of them contains four membership functions that are equal in weight to each other and represent the assessment categories: Not achieved with a trapezoidal curve type, weak achievement with a trapezoidal curve type, achieved moderately with a triangle curve type, and achieved with a trapezoidal curve type; they were selected in this way to meet the requirements of the Quality of Urban Life Index. The four membership functions are distributed orderly along the range [0–3]. The fuzzy inference system for this criterion takes the experts' values of {2, 1, 3, 2} coming from their manual assessment for the four inputs to be processed in parallel by using the fuzzy reasoning operator. On the other hand, the output "engagement" is a fuzzy set containing three membership functions distributed orderly along the range [0-25], representing the assessment categories: poor with a trapezoidal type, average with a triangle type, and good with a trapezoidal type. The results coming from the operator are combined and defuzzified to get a crisp, nonfuzzy number representing the final assessment result of the criterion, which is 11.9%, Figure 16.

For the "opportunity" criterion: The inputs are economic opportunity, education opportunity, cultural opportunity, and recreational opportunity, and each one of them contains four membership functions that are equal in weight to each other and represent the assessment categories: Not achieved with a trapezoidal curve type, weak achievement with a trapezoidal curve type, achieved moderately with a triangle curve type, and achieved with a trapezoidal curve type; they were selected in this way to meet the requirements of the Quality of Urban Life Index. The four membership functions are distributed orderly along the range [0–3]. The fuzzy inference system for this criterion takes the experts' values of {2, 3, 1, 3} coming from their manual assessment for the four inputs to be processed in parallel by using the fuzzy reasoning operator. On the other hand, the output "Opportunity" is a fuzzy set containing three membership functions distributed orderly along the range [0-12], representing the assessment categories: poor with a trapezoidal type, average with a triangle type, and good with a trapezoidal type. The results coming from the operator are combined and defuzzified to get a crisp, nonfuzzy number representing the final assessment result of the criterion, which is 9.69%, Figure 17.

4. Discussion

The research separately investigates the quality of urban life in New Damietta, Egypt. To this end, the criteria and sub-criteria of the Livability Index (AARP) were tested and analyzed by using both qualitative and quantitative techniques. A questionnaire has been distributed to a sample of 200 inhabitants from New Damietta, and its results have been statistically analyzed by using SPSS software. At the same time, the researchers used fuzzy logic techniques to assess the criteria of the QOUL index mentioned above by using a quantitative method like the Fuzzy Inference System of MATLAB software. Table 6 shows the results obtained from questionnaire analysis and the results of experts' assessment by using fuzzy logic technique, and by taking advantage of fuzzy logic capabilities, the research can reach quantitative benchmarks for each criterion of urban quality of life, and therefore, the majority of New Damietta can be redeveloped to reach a higher and acceptable level of urban quality of life.

According to the results obtained by this research, it can be remarked that the value of the "environment" criterion in the city is the lowest, with 4.85% according to city dwellers' questionnaire and with 3.2% by fuzzy logic technique. Then comes the criterion "health," which records a value of 5.20% by the city dwellers and 6.2% by fuzzy logic technique. Furthermore, the value of the "engagement" criterion is the highest, with 12.76% according to city dwellers' questionnaires, and the value of the "transportation" criterion is 13.6% by fuzzy logic technique. While the criterion "transportation" comes after "engagement," which records 11.9% by fuzzy logic technique, and the criterion "engagement" comes after "transportation" according to fuzzy logic technique with a value of 11.9%. This means that there has been a difference in the evaluation criteria in terms of their arrangement according to the results obtained from the two methods, as the first method—the population opinion poll—is a qualitative/objective method that depends on the opinions of users, and therefore it is likely to be true or false, while the second method—the fuzzy logic technique—is a quantitative-qualitative/subjective method that contains complex mathematical operations, and therefore its results will be the most correct and realistic. From this standpoint, researchers believe that it is better to adopt the numerical results issued by fuzzy logic technique, as they are the most comprehensive, systematic, and precise, especially since they are based primarily on setting logical rules that link the sub-criteria to each other for all assessment elements.

It is also clear from the final results of the research that there is a difference in the decrease in the result of the fuzzy logic technique by 1.34% compared to the result of the traditional method. Also, the two linear curves representing the results of the two methods, illustrated in Figure 18, show the great convergence between them, which appears in their behavior compatibility and their intersection in five graphical positions. This means that the adjacency of the results coming from the two methods emphasized that there is acute shortage of the quality of urban life standards in new Damietta city. This also supports the idea of the importance of taking the results of the fuzzy logic method into greater consideration, as this will give the study area the advantage of enjoying more general guidelines that

contribute to further raising the level of urban life quality. According to these results, the study area will most likely be in urgent need of immediate intervention to redevelop aspects related to "environmental" and "health" standards, medium intervention for aspects related to "housing" and "neighbourhood" standards, and finally long-term intervention to develop aspects related to "opportunity, engagement, and transportation" standards, respectively.

Table 6. Assessment results of the quality of urban life in New Damietta by using the questionnaire method versus the fuzzy logic technique. Data processed by authors

Criteria	Sub- Criteria	Assessment Processes		
	Sub-Criteria	Weights calculations by AHP	Questionnaire results by statistical analysis /SPSS software	Experts' assessment/ Fuzzy Technique by MATLAB software
Housing	Housing options	(17.6%)	11.16%	8.28%
	Housing accessibility			
	Housing affordability			
	Housing quality			
Neighbourhood	Mixed use neighbourhoods	(11.3%)	8.7%	9.04%
	Neighbourhood facilities			
	Responsive Design			
	Neighbourhood quality			
Transportation	Public transport	(17.0%)	11.8%	13.6%
	Safe streets & Transportation options			
	Accessible system design			
	Pedestrian network			
Environment	Water quality	(7.9%)	4.85%	3.32%
	Air quality			
	Energy efficiency			
	Efficient waste disposal			
Health	Healthy behaviors	(9.2%)	5.20%	6.2%
	Access to health care			
	Quality of health care			
	Health insurance			
Engagement	Communication & Technology Services	(23.9%)	12.76%	11.9%
	Civic engagement			
	Social engagement			
	Social equity			
Opportunity	Economic opportunity	(13.1%)	8.9%	9.69%
	Education opportunity			
	cultural opportunity			
	Recreational opportunity			
Summation of scores			***63.37%***	***62.03%***

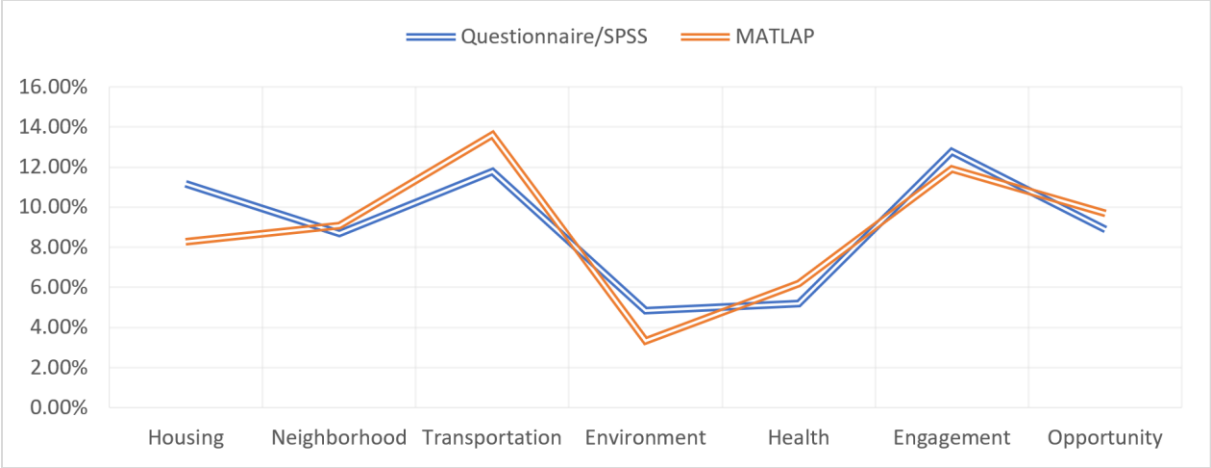

Figure 18. Fuzzy logic technique results versus questionnaire results of the quality of urban life in New Damietta, Egypt. Derived from SPSS and processed in Microsoft Excel by authors

5. Conclusions

Based on the findings of this study, New Damietta has achieved acceptable success in some indicators of the Livability Index (AARP); they are transportation, engagement, opportunity, and neighbourhood, as they recorded scores above 8% in both methods of assessment, traditional and fuzzy. This is because the city has implemented a visionary municipal urban strategy which was significantly reflected in the emergence of these standards in these mentioned indicators. While the health and environment indicators recorded the lowest value in the assessment ─ less than 8% ─ according to the results obtained from the two assessment methods, While the health and environment indicators recorded the lowest value in the assessment ─ less than 8%─according to what is obtained from the two assessment methods. The housing index in the central region remains among the other indicators, as it recorded assessment scores slightly higher than 8%. In general, it is preferable to rely primarily on the results of the fuzzy method because it is more comprehensive and accurate than the traditional method and thus provides more opportunities for the development of aspects related to indicators of urban quality of life in the study area. However, the results of the traditional method remain valid only as a general guiding model for the state of urban quality of life in the city, especially since it is based on the opinions of users, who are the primary target for establishing the city.

The QOUL in Damietta city is considered low and needs to be developed to a large degree. In other words, the percentages described above are logically explained by the following characteristics of the city: The city has provided mixed-use neighbourhoods that are well distributed among residential districts, and these districts are designed to provide all the required services in all parts of the district, ensuring that all zones have their daily needs within walking distance of many destinations. The city has offered several tourist sites that reinforce the city's identity, such as beach areas and athletic areas, which draw people from both within and beyond the city. On the other hand, while the city has offered a variety of quality of life facilities, others are lacking, affecting the city's QOUL. The existing bus network does not serve the area; thus, inhabitants must walk or take private taxis, and the majority of city residents drive when they travel outside of the city. The roadways are built to allow for safe mobility; however, cycling trails were not considered in residential areas, resulting in conflict between bicycle and car traffic. The city's design consists mostly of a range of housing units of varying sizes, including apartment buildings and villas; however, it is not affordable to everyone, and there is a shortage of access to health care services within a 5- to 15-minute walking distance, and New Damietta has a lower per capita share of green areas than the national average. In addition, residents stated that energy efficiency is a big difficulty that must be addressed, as are difficulties related to solid waste management. The paper recommends issuing an annual survey to evaluate the level of residents' satisfaction with their city of new Damietta and taking residents' suggestions to help achieve the quality of urban life from their point of view. Furthermore, the fuzzy logic technique is justified and recommended because it can support the assessment processes of the quality of urban life, generally, in new urban communities because of its many advantages in obtaining specific numerical results for characteristics that are essentially qualitative values. Finally, quality of urban life indexes proved to be highly recommended for urban planners and decision makers because they are important to develop new urban communities and to improve life standards for their residents in the short, medium, and long terms. Quality of urban life indicators should extend extensively as a tool for assessing the condition of sustainable urban development as it is, the steps being taken to make it better, and the plans being made for the future to address its human needs. From an outcome-

oriented standpoint, indicators offer valuable insights into community challenges and requirements. It is also necessary that the problems identified through this research be a new research focus for future research on how to solve them using the methodology followed in this research and by formulating a strategic plan that adopts this methodology and the measurement tools it includes, especially fuzzy logic technique. Furthermore, the study recommends adopting a comprehensive index that is consistent with the nature of residential communities in general, both planned and slums, in future research that measures the gaps in the numbers of the results obtained from study areas that vary between planned and slum residential environments

Acknowledgements

The authors would like to thank their universities' higher studies affairs for allowing them to contribute to this transdisciplinary research.

REFERENCES

[1] Monira A., Asmaa N., and Nanees E., "A Methodology to Measure Urban Quality of Life in New Cities in Egypt (New Damietta Case Study)," Civil Engineering and Architecture, vol. 11, no. 5, pp. 2543-2558, 2023. DOI: 10.13189/cea.2023.110522

[2] Ibrahim H., "The quality of life between theory and implementation in Egypt: The case of Al-Rehab City, Egypt," Ain Shams Engineering Journal, vol. 12, no. 2, pp. 2285-2296, 2021. DOI: 10.1016/j.asej.2020.09.010.

[3] Hosam K. and Heidi A., "Eco and Green cities as new approaches for planning and developing cities in Egypt," Alexandria Engineering Journal, vol. 55, no. 1, pp. 495-503, 2016. DOI: 10.1016/j.aej.2015.12.018.

[4] Ali E., "Evaluation of the Egyptian Experiment in Establishment the new Towns in the Desert Areas," Journal of Engineering Sciences, Assiut University of Egypt, vol. 31, no. 1, pp. 231-244, 2003.

[5] Omar T., Mohamed F., and Ahmed R., "The Importance of Quality of Urban Life Indicators in Developing New Urban Communities in Cairo," MEJ-Mansoura Engineering Journal, vol. 46, no. 2, pp. 58-66, 2021. DOI: 10.21608/bfemu.2021.184361.

[6] Raghda M., Sherif S., Esraa M., and Ahmed A., "A Standardized Approach for Measuring the Quality of Urban Life in New Urban Communities Case Study: New Damietta City, Egypt," Journal of Engineering Research, vol. 8, no. 6, pp. 1-26, 2024. DOI: 10.70259/engJER.2024.861832.

[7] Jernej T., "Measuring urban quality of life: case study of Ljubljana," Acta geographica Slovenica, vol. 56, no. 1, pp. 57–73-57–73, 2016. DOI: 10.3986/AGS.828.

[8] Ahmed S., "Managerial Smart Governance Model and Indicators as an Evaluation Methodology to Promote Public-Private Partnership in Infrastructure Projects," Port-Said Engineering Research Journal, vol. 25, no. 2, pp. 13-25, 2021. DOI: 10.21608/pserj.2021.54652.1082.

[9] Michael P., "Urban environmental quality and human wellbeing—a social geographical perspective," Landscape and urban planning, vol. 65, no. 1-2, pp. 19-30, 2003. DOI: 10.1016/S0169-2046(02)00234-7.

[10] Adam P., Agnieszka K., and Piotr P., "Quest for a tool measuring urban quality of life: ISO 37120 standard sustainable development indicators," Energies, vol. 15, no. 8, p. 2841, 2022. DOI: 10.3390/en15082841.

[11] Hamam E., Ahmed S., Hend F., and Sarah A., "Principles of urban quality of life for a neighbourhood," HBRC Journal, vol. 9, no. 1, 2013. DOI: 10.1016/j.hbrcj.2013.02.007.

[12] Jakleen Z. and Jamal M., "Sustainable housing indicators and improving the quality of life: the case of two residential areas in Baghdad City," in *IOP Conference Series: Earth and Environmental Science*, 2021, vol. 754, no. 1: IOP Publishing, pp. 1-14, DOI: 10.1088/1755-1315/754/1/012002.

[13] Raghavendra N. and Paresh D., "Sustainable development and management of groundwater resources in mining affected areas: a review," Procedia Earth and Planetary Science, vol. 11, pp. 598-604, 2015. DOI: 10.1016/j.proeps.2015.06.061.

[14] Mohammad R., Hossain M., and Mohammad S., "Evaluating quality of life in urban areas (case study: Noorabad City, Iran)," Social indicators research, vol. 112, pp. 203-220, 2013. DOI: 10.1007/s11205-012-0048-2.

[15] Abraham M., "A theory of human motivation," Psychological review, vol. 50, no. 4, p. 370, 1943. DOI: 10.1037/h0054346.

[16] Handan T., "Sustainable development and quality of urban life," Procedia-Social and Behavioral Sciences, vol. 202, pp. 10-14, 2015. DOI: 10.1016/j.sbspro.2015.08.203.

[17] Emma P., "Sustainable development goals and quality of life targets: Insights from Metro Manila," Global Futures, vol. 63, no. 2, pp. 244–260, 2015. DOI: 0.1177/0011392114556586.

[18] Mojdeh N. and Abdollah M., "Assessment of quality of life in the urban environment; case study: Famagusta, N. Cyprus," Civil Engineering and Architecture, vol. 8, no. 5, pp. 860-872, 2020. DOI: 10.13189/cea.2020.080513

[19] Katarzyna W., "Quality of urban life in Poland," Journal of international studies, vol. 8, no. 2, pp. 155-163, 2015. DOI: 10.14254/2071-8330.2015/8-2/13.

[20] Dina D., Mohsen B., and Mohamed M., "Quality of Life to Achieve New Egyptian Cities," ARCHive-SR, vol. 3, no. 3, pp. 1-12, 2019. DOI: 10.21625/archive.v3i3.518.

[21] Elkhouly A., Attia S., and Zayed M., "Quality of Urban Life Indexes' Analysis to Initiate Socio-Urban Based Criteria," International Journal of Engineering Research and Technology, vol. 12, no. 12, pp. 2273-2283, 2019. [Online]. Available: http://www.irphouse.com

[22] Raghad A. and Fatin S., "Evaluating livability perceptions: Indicators to evaluate livability of a university campus," Sustainability, vol. 14, no. 19, p. 11872, 2022. DOI: 10.3390/su141911872.

[23] Ahmed S., Alias A., and Norimah D., "A critical review on the worldwide economist intelligence unit, mercer and monocle quality of life indicators," Journal of Business and Economics, vol. 8, no. 7, pp. 584-593, 2017. DOI: 10.15341/jbe(2155-7950)/07.08.2017/007

[24] AARP. "AARP Livability Index." AARP. https://livabilityindex.aarp.org/ (accessed March. 4, 2025).

[25] Thomas S., "Decision making with the analytic hierarchy process," International journal of services sciences, vol. 1, no. 1, pp. 83-98, 2008. DOI: 10.1504/IJSSCI.2008.017590.

[26] Arief S., Nitin M., Abdullah Y., and Perera B., "Using the Analytic Hierarchy Process to identify parameter weights for developing a water quality index," Ecological Indicators, vol. 75, pp. 220-233, 2017. DOI: 10.1016/j.ecolind.2016.12.043.

[27] Hamed T., "Decision making using the analytic hierarchy process (AHP); A step by step approach," International Journal of Economics and Management Systems, vol. 2, 2017. [Online]. Available: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3224206.

[28] Zainab A., "Traffic congestion evaluation of urban streets based on fuzzy inference system and GIS application," Ain Shams Engineering Journal, vol. 15, no. 6, pp. 1-9, 2024. DOI: 10.1016/j.asej.2024.102725.

[29] Ahmed A., Sherif S., and Ibrahim H., "Adoption of Fuzzy Logic to assess the Environmental Quality of Urban Development," MEJ-Mansoura Engineering Journal, vol. 41, no. 2, pp. 9-14, 2020. [Online]. Available: https://mej.researchcommons.org/cgi/viewcontent.cgi?article=2700&context=home.

[30] Prenciton University. "Fuzzy Inference Systems." Prenciton University https://www.cs.princeton.edu/courses/archive/fall07/cos436/HIDDEN/Knapp/fuzzy004.htm (accessed Aug. 25, 2024).