Livable housing: representation of life in urban neighborhoods housing, Karaj Metropolis, Iran

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Abstract

In residential areas, livability entails high-quality life standards for citizens in all environment-related activities. As the smallest unit in an urban system, housing is a key variable of livability and a basic effective element in citizens' environment. Indeed, viewed as a basis for urban sustainability, livable housing relates to social, economic, physical and environmental aspects of life in an urban area. This study aims to evaluate housing livability at the level of neighborhoods and analyze the factors involved in it. The research population consists of 138 neighborhoods in the city of Karaj, Iran. The data analysis has been performed with a multi-criteria evaluation model and the geographic information system software along with weights and indices extracted from the classified maps of livable housing in the neighborhoods of the city. As the results of the study show, the neighborhoods in the city have different rates of livability and are thus heterogeneously aligned in this regard. Of all the neighborhoods, 51% are in good and very good conditions, 26% in average conditions and 22% in poor and very poor conditions, which shows the imbalanced distribution of livability factors through those neighborhoods. One of the applications of this study is to pay attention to the regeneration of neighborhoods with low levels of housing livability and to improve the physical and economic livability of housing in them, empowering neighborhoods with the aim of improving infrastructure facilities and services, benefiting from high per capita services and improving accesses to the center of neighborhoods.

1 Introduction

Having a long background in urban planning thoughts, livability has emerged after the 1990s following the rapid and unbridled development around cities. This approach became the center of attention of urban planning equations as a result of increasing environmental

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concerns and the expansion of competition between urban societies, the consequences of modernism with the guidance of researchers (Larice, 2005; Federal Highway Administration, 2011; Ahmed et al., 2019; Hovey, 2008). Because of the study of social factors along with economic and environmental factors, livability has a close and complementary relationship with sustainability. Basically, the focus of both is on meeting the needs of city residents (Drexhage & Murphy, 2012; Litman, 2011; Szibbo, 2016; Williams et al., 2004). In fact, livability with two aspects (livelihood and sustainability) expresses the values of the residents in the city. Viability is a complex and relative concept: complex because many factors are involved in improving the living conditions of the individual and society, and relative because these factors are interpreted differently in another society and place (Ruth & Franklin, 2014). Therefore, measuring livability based on the local conditions and culture of each environment is much more meaningful and relevant (Centre for Health Promotion, 2009; Portney, 2013).

Livable neighborhoods are communities with healthy environments for purposeful living at work, education, and recreation for residents and visitors (Palagi & Javernick-Will, 2020). Therefore, planners at all levels are interested in livability as a strategy for neighborhood revitalization (Larice, 2005). On the other hand, housing has become a key indicator in the livability of urban neighborhoods with the expansion of urban societies and the necessity of providing affordable housing (Mohit & Sule, 2015; Winston, 2007). In other words, housing is an important element at the macro-level of urban space and a micro-element in a person's life in interaction with the environment. Housing, not as a physical space, but in a broader context of place and neighborhood, is a space for cultivating societies along with improving the quality of life (Diener & Suh, 1997; Li et al., 2008; Moreland City Council, 2018; Sirgy & Cornwell, 2002; Van Kamp et al., 2003).

In addition to paying attention to the structure and internal shape of the house and its mental effects, the livability of housing requires the availability of resources and planning for the placement of housing-related equipment (Amerio et al., 2020; Nelson & Schneider, 2018). Improving the quality of housing and residential spaces is the most key solution to improve the quality of life (Fansuri & Zaina, 2020; Merriam-Webster, 2017; Okulicz-Kozaryn, 2011). Quality of life is also a subjective matter that is related to the general well-being and satisfaction of people (Berenger & Verdier-chouchane, 2007; Mohit & Sule, 2015; WHO, 2018). In return, livability is an objective condition in which social, economic, physical and environmental requirements, along with housing stability, lead to increased long-term comfort and well-being of local society members (Carlsson & Frederiksen, 2002; Kazana & Kazaklis, 2009; Mouratidis, 2020). The relationship is a complex and multidimensional relationship that biological, social, physical and environmental factors affect this relationship (Janahi et al., 2018; UN-Habitat, 2012). Comprehensive improvement of urban environments increases livability level, an experience that happened in the cities of New York and Bilbao (Patterson, 2020). In this method, the residents tend to interact with each other by increasing the urban facilities, and the livability of the housing also occurs by creating a sense of attachment and belonging to the housing and the residential environment (Marans, 2003; Mouratidis, 2018; Parker & Simpson, 2018; Zhan et al., 2018).

In relation to the subject of the research, there have been several studies (Table 1 of Appendix A in the supplementary material). The review of studies indicates that since the third United Nations conference in 2016 in the field of housing and sustainable development, urban livability has become a comprehensive indicator. Livability indicators are very vital for operationalizing the concept of sustainability in city planning and development; they also have a significant impact on the policies and growth path of

cities or megalopolises for the benefit of their societies (Balsas, 2004; Epley & Manon, 2008; Lihu et al., 2020; Rafee Majid et al., 2020; Stevens, 2009). The most important indicators used in the assessment of livability and especially housing livability are: natural, cultural and communication assets, safe neighborhood, suitable options for transportation and society support services, house price, economic development, institutionalizing people-oriented approaches in the government and civil society, number of bedrooms, power supply, quality of construction materials, Insulation, public and walkable spaces, mixed uses, employment, entertainment, cleanliness and security (AIA, 2010; Christy et al., 2021; Economist Intelligence Unit, 2012; Howley et al., 2009; Ling & Yuen, 2010; Mercer, 2014; Monocle, 2019; Owens, 2009; Statistics New Zealand, 2015).

Comparing the results of previous studies with the present article by summarizing the views of these studies and the gaps in them has led to the writing of this article. The most important distinguishing points of the present study with previous researches are the combination and integration of indicators of sustainable urban development, housing livability from the dimensions (social, economic, physical, environmental) at the scale of the neighborhood as the smallest part that can be planned at the city level for citizens, the housing evaluation of the neighborhoods in a range of 17 thousand hectares with 138 neighborhoods and special attention to housing, not only from the physical dimension as a house, but also as a whole with its surrounding environment from the dimension of livability.

The selection of the research sample "Iran" is due to the increasing growth of the population and at the same time, housing shortage and infrastructure along with the lack of attention to the quality of housing. The choice of Karaj metropolis is also due to its proximity to the country's capital (Tehran), the center of gravity of population and migration, the capital's population overflow, unplanned growth, physical expansion without providing infrastructure, etc., all of which have caused the explosive growth of population and housing. As a result of this, self-growing and marginal settlements have grown and have placed all kinds of residential tissues next to each other. In other words, many features of a large city can be seen in this city together, which has made it an exceptional city among Iran metropolises.

The evaluation of livability in terms of scales is mainly performed at three levels including a) the macro-level at which cities are compared and regional programming is discussed, b) the intermediate level which deals with the spatial units inside a city such as blocks and neighborhoods that truly represent the living places of a city, and c) the low level which mostly focuses on residences and even buildings by using micro-level indices (Zhu et al., 2020). In the present study, the intermediate and low levels are integrated to evaluate the housing livability in the neighborhoods of the city of Karaj. The initial data are collected from the low level of housing. After the data organization, the results are presented in the context of neighborhoods. The study seeks to present a methodological framework to deal with housing livability according to the definitions offered. The issue is explored in terms of the physical quality of housing, the quality of the environment as well as the social and economic qualities of housing. The research has the following major objectives:

- Identification and integration of the key indices of livability at the levels of housing and residential areas
- Modeling and mapping of livable housing in neighborhoods using macro-clusters (i.e., social, economic, physical and environmental clusters)
- Analysis of the clusters and the spectra of livable housing in the neighborhoods of the metropolis of Karaj

According to the proposed methodology, the livable housing zones in the neighborhoods are identified in terms of sustainable development and well-being. It is done through the integration of housing livability indices, evaluation of housing livability in urban neighborhoods, and detection of how livable housing is geographically distributed in the studied neighborhoods. This can provide valuable insights for decision makers and programmers in the field of urban and regional development.

2 Materials and methods

2.1 Study area

Iran is a country in West Asia and is located at the geographical coordinates of 25 to 40° north latitude and 44 to 63° east longitude. Karaj city, the central city of Alborz Province in Iran. It is located at the geographic coordinates of 35° 25′–36° 15′ N and 50° 30′–51° 5′ E. Figure 1 shows a view of Karaj and its geographical extent and neighborhoods.

The total area of Iran is equal to 1,648,195 km², which according to the statistics of 2021 has a population of about 86,758,304. The population density is 48 people per square kilometer, and the average annual population growth is equal to 1.25%. In terms of country divisions, Iran has 31 provinces, 430 counties and 1242 cities. The capital of Iran is Tehran as the first metropolis in 2021 with a population of 9,039,000. Alborz province and its center, Karaj metropolis, as the fourth metropolis of Karaj, is located next to the capital. According to the latest maps of the country, the metropolis of Karaj consists of 12 districts
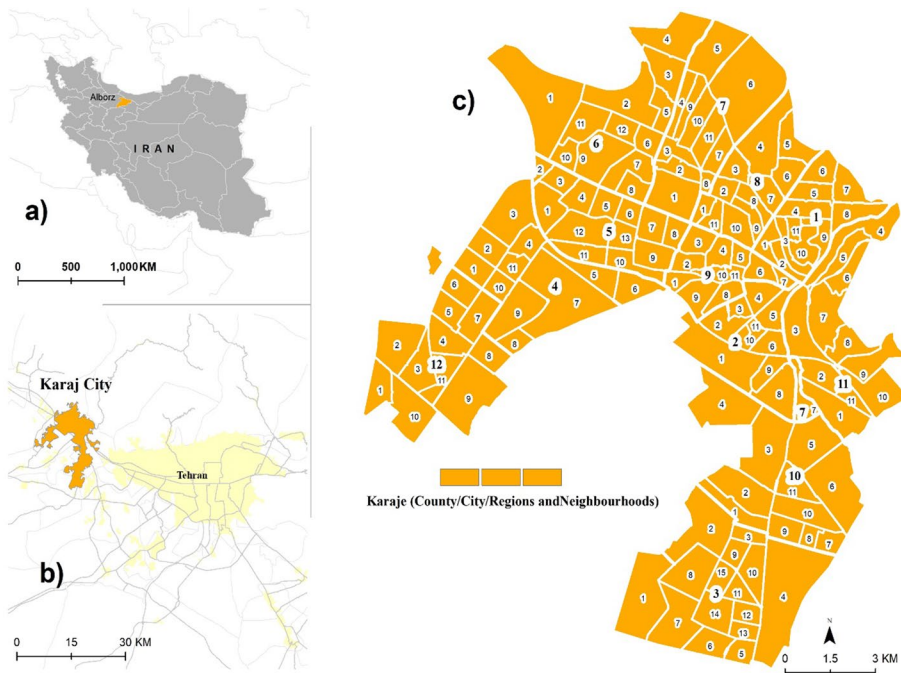
Fig. 1 Situation of the studied place **a** IRAN Country, **b** Karaj City, **c** Districts and neighborhoods Karaj

and 138 neighborhoods. In addition, based on the available official statistics, the minimum population of the city was 14,526 in 1956 growing to the medium of 537,281 in 1986 and the maximum of 1,760,414 in 2021. The largest share of the city population (13.5%) lives in District 6, 7.5% in District 1, and the minimum of 4.5% in District 11. There are 563,225 households living in the city. Of them, 99.3% live as single households per housing unit, 0.5% as double households and 0.09% as triple households. The average number of members in a household is 3.1. Compared to 2010, the annual rate of population growth in the city is currently 2.87%, but different districts have experienced different trends in this regard. The highest rate belongs to District 10 (Fig. 2).

The city of Karaj covers 17,000 hectares. It contains 7749 numbered blocks with 466,792 housing units. The relative population density is 100.7 persons per hectare (Appendix B in the supplementary material).

2.2 Data collection

In order to identify the main variables that contribute to livability (Table 1), the Delphi method was used to ask a number of experts for their opinions (Norouzian Maleki et al., 2014). In this regard, thirty experts who had backgrounds in urban planning and housing were selected in the hope of achieving convergent opinions or even a consensus. Those experts were interviewed in two rounds from September to October 2021. It is to be noted that, according to the Delphi method, two rounds of interviews are enough to detect the most effective variables (Skalickya & Cerpesb, 2019). The Likert scale was also used to determine the significance of the individual livability variables (5 as the most important down to 1 as the least important). Finally, the variables are obtained in three layers: first layer (Category), second layer (indicator), and third layer (Sub-indicator). The source of all the data under review is the census of the Statistics Center, the detailed plan and the municipality of the region in 2021.

2.3 Research methods

Analytic Hierarchy Process or AHP (weighting to each layer and the importance of indicators and sub-indicators in the same layer and related group) to determine the most important variables of livable housing in three layers {first layer: economic, social, physical and environmental group, the second layer: indicators and the third layer: sub-indicators)} have been used. As an analytic, systematic and hierarchical process, AHP offers a combination of qualitative and quantitative methods to make hierarchical models (Subramanian &
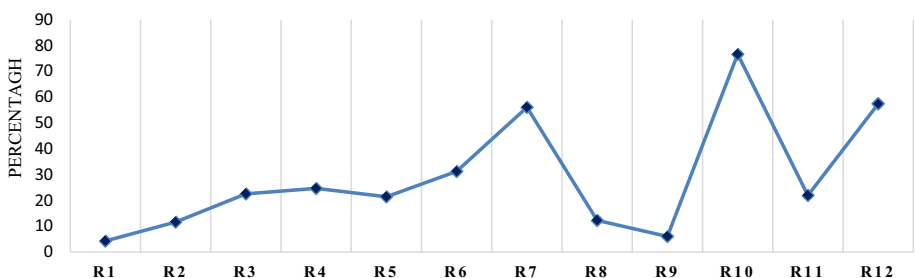
Fig. 2 The annual growth of population in the *d* area from 2010 to 2021 (*R* = Region)

Table 1 Indicators and sub-indicators of livable housing

Category layer	Indicator layer	Sub- indicator layer	Variables domain	Data source	Study source
Physical P	P1 Stability and durability of the building	P1-1 Building Materials	Brick and iron, cement blocks, stone and brick, brick and wood, all wood, clay and wood, clay and mud	Statistics Center	Jun & Yi, (2016); Newton, (2012), Pandey et al., (2013); Norouzian-Maleki, (2015); Lowe et al., (2015); Okulicz-Kozaryn, (2011); Li & Yao, (2013)
		P1-2 Building Skeleton	Metal, Reinforced concrete, Other	Statistics Center	
	P2 Per capita and density	P2-1 Number of rooms in a residential unit	6 rooms, 5 rooms, 4 rooms, 3 rooms, 2 rooms, 1 room	Statistics Center	Wang et al., (2011); Li & Yao, (2013); Safavi Sohi, (2014); Pandey et al., (2019); Bo et al., (2019); Saitluanga, (2013)
		P2-2 The amount of residential unit area	501 square meters and more, 500–301 square meters, 300–201, 200–151, 150–101, 100–81, 80–76, 75–51, less than 50 square meters	Statistics Center	Li et al., (2008); Norouzian-Maleki, (2015); Lowe et al., (2015); Paul & Sen, (2018); Luo et al., (2022)
	P3 Facilities	P3-1 Number of infrastructure facilities	Water, electricity, gas, toilet, kitchen, bathroom, heating, refrigeration, telephone	Statistics Center	Safavi Sohi, (2014); Ghasemi et al., (2018); Lingjun et al., (2009)
		P3-2 Number of superstructure facilities	Number of Parking Spaces, the amount of connection to the sewerage network, number of passages with lighting (electric poles), width of passages and sidewalks	Municipality of district	Balsas, (2004); Lingjun et al., (2009); Li & Yao, (2013); Liang et al., (2020); Safavi Sohi, (2014); Pampanga et al., (2015)
	P4 Durability and age	P4-1 The age of the building	Under 10 years, 10–20 years, 20–30 years, 30 years and above rates	Detailed Plan	Lingjun et al., (2009); Jun & Yi, (2016); Newton, (2012); Li & Yao, (2013); Norouzian-Maleki, (2015)

Table 1 (continued)

Category layer	Indicator layer	Sub- indicator layer	Variables domain	Data source	Study source
	P5 Type of residence	P5-1 Type of residential unit	Apartments, non-apartments, tents, huts, sheds, slums	Statistics Center	Wang et al., (2011); Lowe et al., (2015); Saitluanga, (2013);Pandey et al., (2013)
Social–Cultural S	S1 Population	S1-1 Population Density S1-2 Number of Households S1-3 Households Dimension	Low, medium, high population (household 1, 2, 3+) (low, medium, high household dimension)	Statistics Center	Balsas, (2004); Bao-zheng & Ding-wei, (2012); Onnom et al., (2018); Jun & Yi,(2016); Luo et al., (2022)
	S2 Education	S2-1 Access to Educational Spaces S2-2 Access to Library and Cultural Center	Kindergarten (220–250 meter), elementary 500 m, middle school (2000–1000 meter), high school (2000 meter) from the center of the neighborhood. Library 275–200 meter	Municipality of district	Newton,(2012); Wang et al., (2011); Marsal-Llacuna, (2015); Jones & Newsome, (2015); Huang et al. (2016); Onnom et al., (2018); Paul & Sen, (2018)
	S3 Leisure	S3-1 Access to cinemas and theaters S3-2 Access to coffee shops, restaurants and dining halls	Cinema and theater 1350–1250 m from the center of the region, 15–30 min away from the center of the neighborhood and the region (American and Iranian Urbanism Standard)	Detailed Plan	Pandey et al., (2013); Pampanga et al., (2015); Liu, (2017); Jun & Yi, (2016); Tan et al., (2018); Li et al., (2017)
	S4 Individual and Social Security	S4-1 Access to law enforcement and security centers	Access radius 650–750 m from the center of the area	Detailed Plan	Pampanga et al., (2015); Tan et al., (2014); Liu et al., (2017); Zhan et al., (2018); Chen et al., (2018); Paul & Sen, (2018); Liang et al., (2020)

Table 1 (continued)

Category layer	Indicator layer	Sub- indicator layer	Variables domain	Data source	Study source
Economic E	E1 Ownership	E1-1 Type of Ownership	Land and Building, Tenancy, Mortgage and Rent	Statistics Center	Balsas, (2004); Lingjun et al., (2009); Bao-zheng & Ding-wei, (2012); Jomehpour, (2015); Lowe et al., (2015); Huang et al. (2016); Tan et al., (2018);
	E2 Transportation and Access	E2-1 Access to bus and taxi stations, train stations and terminals E2-2 Access to offices and banks E2-3 Access to shops and squares E2-4 Access to the fire station	Wholesale and fire department 1250–1350 m from the center of the district, offices and banks 750–650 m from the center of the district, bus station 375–300 m from the neighborhood (American and Iranian Urbanism Standard)	Municipality of district	Balsas, (2004); Lingjun et al., (2009); Okulicz-Kozaryn, (2011); Pandey et al., (2013); Saitluanga, (2013); Lowe et al., (2015); Fan et al., (2021); Saituanga, (2013); Pampanga et al., (2015); Marsal-Llacuna, (2015); Antognelli & Vizzari, (2016); Zhan et al., (2018); Onnom et al. (2018)
Environmental	e1 Energy	e1-1 Types of fuel for residential units	Electricity, natural gas, liquefied petroleum gas, oil, diesel, waste	Statistics Center	Lingjun et al., (2009); Huang et al., (2016); Tan et al., (2016);Wang et al., (2011); Chiang & Ling, (2013)
	e2 Sanitation and Health	e2-1 Access to health centers (clinics) e2-2 Access to health centers (hospitals)	Clinic access radius to residential areas 650–750 m from the center of the district, hospital access 1–1.5 km from the center of the district (American and Iranian Urbanism Standard)	Detailed Plan	Li et al. (2017); Wang et al., (2011); Li & Yao, (2013); Safavi Sohi, (2014); Jones & Newsome, (2015); Lowe et al., (2015); Bo et al., (2019); Liu et al., (2017); Tan et al., (2018); Zhan et al., (2018); Paul & sen, (2018); Fan et al., (2021)

Table 1 (continued)

Category layer	Indicator layer	Sub- indicator layer	Variables domain	Data source	Study source
	e3 Open and Public Space	e3-1 Access to sports venues e3-2 Access to parks and green spaces	Sports clubs 750–650 m from the center of the district. Green space and local park 375–300 m from the center of the neighborhood (American and Iranian Urbanism Standard)	Municipality of district	Bao-zheng & Ding-wei., (2012); Fan et al., (2021); Pandey et al., (2013;) Jomehpour, (2015); Jia, (2018); Marsal Llacuna, (2015); Lowe et al., (2015); Liu et al., (2017); Zhan et al., 2018); Chen et al., (2018); Onnom et al., (2018
	e4 Cleanliness and pollution	e4-1 Access to mechanized waste bins and mobile waste bins	150–100 m compared to the residential group and alley (American and Iranian Urbanism Standard)	Municipality of district	Chiang & Ling, (2013); Pandey et al., (2013); Tan et al., (2014), (2016; Jones & Newsome, (2015); Tan & Kaur, (2016); Huang et al., (2016); Li et al., (2017); Bo et al., (2019)

Ramanathan, 2012). A model of this type was made along with a paired comparison matrix to calculate the weights of the indicators and to comprehensively evaluate the variables of housing livability. To ensure the accuracy and objectivity of the matrix, thirty experts from universities, research centers as well as housing and urbanization institutes (Delphi stage experts) were invited to assess the significance of the indicators. The scale of significance had nine levels, from 1 (of the same significance) to 9 (quite significant). Since this process was based on subjective judgment, a test of compatibility was conducted on the AHP result of each expert so as to make sure that the compatibility would be less than or equal to 0.10. In the case of any contrast in the AHP results, the compatibility would be improved by the repetition of the evaluation process (Gorener et al., 2012). The weights were also calculated with the Expert Choice software (Thapalia, 2006) through the following steps and with GIS through the other steps.

Step 1: Data normalization with GIS.

After the selection of the indicators, the first step to take is to determine their range of action based on their effectiveness in housing livability. The corresponding data are collected and analyzed in statistical blocks, and then zonal statistics and GIS are used to calculate the average value of each indicator at the neighborhood level. At this step, the data are normalized as they are made uniform in terms of range. In other words, the variation of the data is set to be from zero to one.

This is the most common method of data normalization in multi-factor evaluation (Kacprzyk & Jain, 2015). The steps are as follows:

$$e_{ij} = \frac{S_{ij-\text{Min}S_{ij}}}{\text{Max}S_{ij-\text{Min}S_{ij}}} \tag{1}$$

(e_{ij} = standardized score of j, s_{ij} = raw score of i belonging to j).

At times, higher scores are given to lower values (as for indicator P4 in the structural-physical group). This is done using the following equation:

$$e_{ij} = \frac{\text{Max}S_{ij-S_{ij}}}{\text{Max}S_{ij-\text{Min}S_{ij}}} \tag{2}$$

Step 2: Calculation of the weights and the multiplication of the values in each row of the paired comparison matrix.

$$\text{LH} = \sum \text{Factor}_1 \times \text{Factor}_2 \times \ldots.. \times \text{Factor}_N \tag{3}$$

Step 3: Calculation of non-normalized weights by summing up the multiplied values in each row of a column with the exponent of $\frac{1}{n}$ (n = number of the criteria).

$$\left[(\text{RMV})^{\frac{1}{\text{Factor}}} \right] \tag{4}$$

Step 4: Determining the weights of the criteria through dividing the non-normalized weights in each row by the total non-normalized weights (Table 2).

$$\text{Weights} = \left[(\text{RMV})^{\frac{1}{\text{Factor}}} \right] \text{first} \frac{\text{Row}}{\text{Sum}} \left[(\text{RMV})^{\frac{1}{\text{Factor}}} \right] \tag{5}$$

Step 5: Calculation of consistency: the calculation of the consistency rate for groups, indicators and sub-indicators is done as follows: formation of AW vector, calculation

Table 2 Binary comparison matrix and weight of group of livable housing variables

Variables	Physical	Social	Economic	Environmental	Multiply the weights	Normal weight	Final weight	AW
Physical	1	3	3	5	2/00	0/50	0/412	1/656
Social	0/33	1	3	3	1/22	0/30	0/387	1/570
Economic	0/33	0/33	1	3	0/64	0/16	0/156	1/638
Environmental	0/2	0/33	0/33	1	0/31	0/08	0/043	0/175
SUM	1/87	4/67	7/33	12	4/17	1/04	1	5/0.39

of agreement vector, calculation of consistency index and calculation of consistency coefficient.

Example of an adaptation coefficient calculation for a group of dimensions (social, economic, physical and environmental).

$$\text{Agreement Vector } \boldsymbol{L} = \frac{1}{n}\left[\sum_{i=1}^{n}\left(\frac{\boldsymbol{Aw}}{\boldsymbol{Wj}}\right)\right] = \left[\frac{1.656}{0.412} + \frac{1.570}{0.387} + \frac{1.638}{0.156} + \frac{0.175}{0.043}\right] = 4.056$$

(6)

$$\text{Consistency Index } I = \frac{L-n}{n-1} = \frac{4.056-4}{4-1} = 0.0189$$

(7)

$$\text{Consistency Coefficientor Agreement Ratio CR} = \frac{\text{CI}}{\text{RI}} = \frac{0.0189}{0.9} = 0.021$$

(8)

RI: The random index proportional to the number of variables is 0.9.

The value of CR $\leq$ 0.1 or the agreement ratio is 0.021 and indicates that the necessary consistency has been made in the judgments.

Following step 4 and determining the weight of criteria and sub-criteria, this process has been done for all the sub-criteria of dimensions (physical, social, economic and environmental) in their own grouping by using AHP weighting: physical dimension with 5 indexes and 7 sub-indexes of weight (0.42), social dimension with 4 indexes and 8 sub-indexes of weight (0.38), economic dimension with 2 indexes and 6 sub-indexes of weight (0.156) and environmental dimension with 4 indexes and 6 sub-indexes. The weight index (0.43) has been obtained to evaluate the housing livability of the neighborhoods (Fig. 3).

Step 6: Combining the weighted layers by GIS.

The multivariable concept of livable housing is defined with a set of physical, social, economic and environmental indicators. These indicators and their subdivisions alone convey no significant information unless they are combined and analyzed together. The layer of weights is multiplied by the layer of data, and then the weighted layers are combined as follows:

$$\text{PI} = \sum_{w=1}^{m}\sum_{1}^{n}(Wj \times Xi)$$

(9)

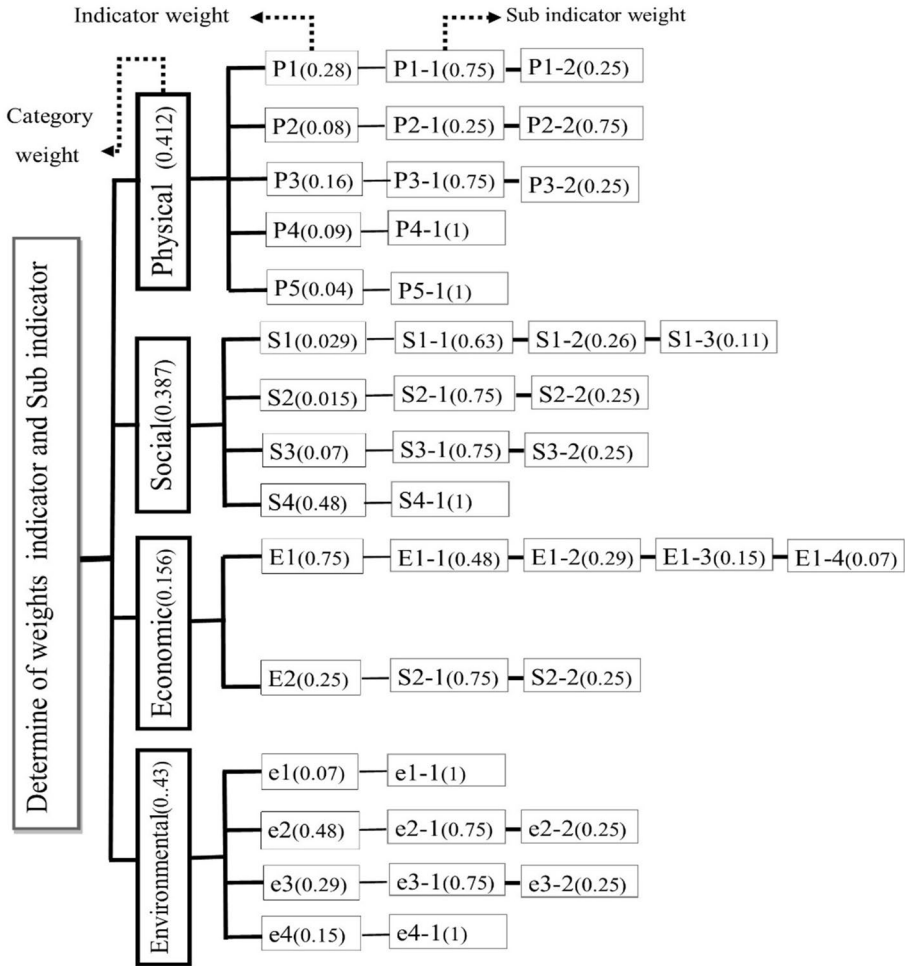Step 7: Classification of the maps by the natural breaks technique.

Fig. 3 Graphs for the weights of the indicators and sub-indicators of livable housing

One of the algorithms used to identify the dominant patterns in the studied region is the classification method of natural breaks or optimization. Implemented based on the Jenks optimization algorithm, this method commonly serves to classify spatial data. It increases the variance among a number of classes by minimizing the medium deviation from the mean of the classes, maximizing the deviation from the mean of the other classes and minimizing the variance within the classes. In order to separate the categories of housing livability based on the standards of the American Economic Association, there are five categories postulated for livability. The maps of housing livability are thus divided into five categories as reported in Table 1.

Step 8: Accuracy of quantitative data and comparison with qualitative data.

Evaluation of the accuracy of the results of quantitative data and comparing it with qualitative data has been done by measuring the residents' opinions. For this purpose, the number of 100 points based on the number of selected neighborhoods in the 5 classes of housing livability, using modeling obtained from quantitative data (extracted from the statistics center,

municipality and detailed plan) and random cluster method, has been selected from among housing viability clusters. A questionnaire with 12 qualitative questions (Table 1 of Appendix C in the supplementary material) was used to evaluate the resident's view of the livability of the housing from the location of the collection points and was measured by the factor analysis method in the SPSS software environment, and the results were mainly 4 factors in 5 livability classes. Comparing the results of quantitative data with qualitative data using the RMSE index, which indicates the absolute error of estimation, has been done from Eq. (10) (Park & Vlek, (2002).

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (O_i - P_i)^2} \qquad (10)$$

In this regard, p_i and o_i are, respectively, the numbers obtained from the modeling of quantitative data (information from the Statistics Center, Municipality and Housing and Urbanism Organization) and the results of qualitative data (citizen questionnaire) and n is the total number of observations. Due to greater sensitivity, RMSE statistic of root mean square of relative error is calculated according to the following equation.

$$RMSE\% = \frac{RMSE}{\overline{X}} \times 100 \qquad (11)$$

Flowchart of the research process that shows the process of selecting indexes, analyzing and weighting indexes, combining weights in the GIS environment, classifying the results obtained from the layers and the weight of sub-indexes, the output of classified maps of the housing livability of the neighborhoods in the form of macro-indexes and the classification of the final map of the housing livability of the neighborhoods is based on the global standard classification. Each of the above steps are part of the three goals of this paper (Fig. 4).

3 Result

The data for the rate of housing livability in all the neighborhoods have been classified, and certain scores are given to the corresponding dimensions and indicators. This classification is based on the available standard five-spectrum format of livability (Tables 3, 4, 5, 6).

Table 3 is the division of the standard of livability, in which the situations of livability are divided into 5 classes. The first floor with the highest score, which is livability in the most ideal possible state and is acceptable as a situation. The lowest level with the lowest score and labeled as a very unfavorable situation where most aspects of life are facing problems. The livability classes provide the possibility to categorize the results obtained from the livability of housing in the neighborhoods. According to the characteristics of each class, the livability status of the neighborhoods housing is specified in macro- and micro-indexes and the possibility of more detailed planning is provided to make livable the housing of that class.

3.1 Housing livability of the neighborhoods from physical, social, economic and environmental viewpoints

Housing livability is a dependent variable under the impacts of a series of micro- and macro-factors and processes. The impacts are exerted with different degrees. This
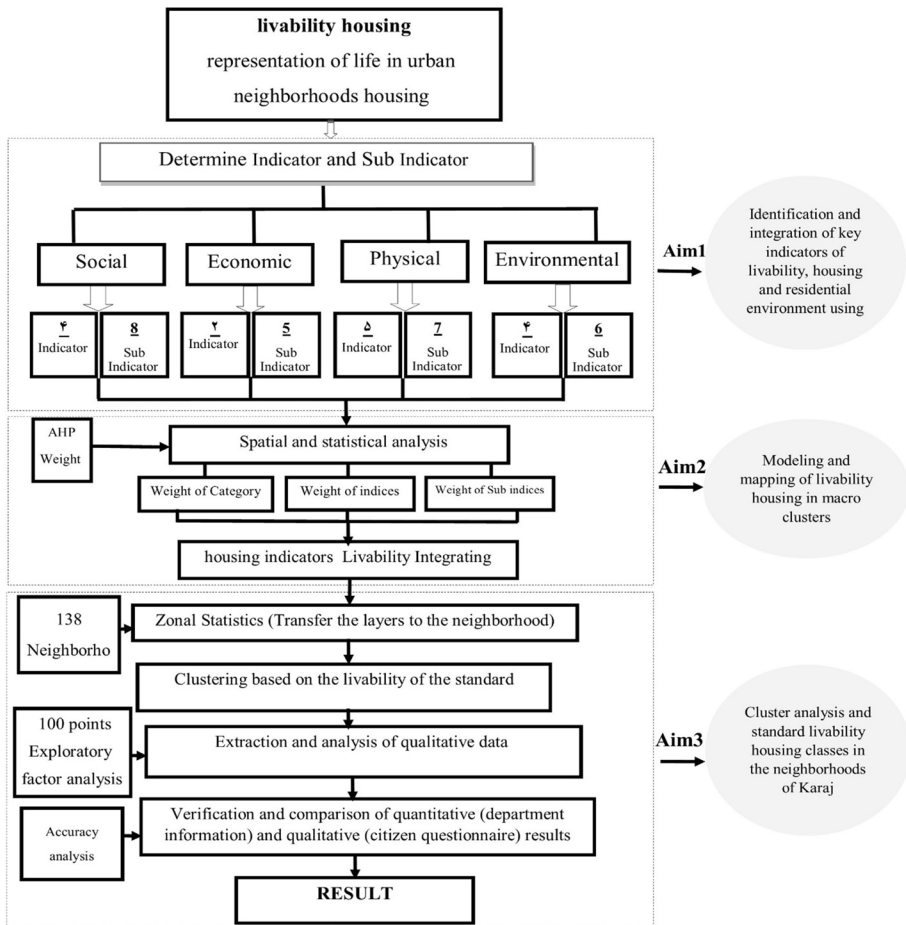
Fig. 4 The conceptual model of the research

Table 3 Scoring of housing livability based on the literature in the field (EIU, 2014)

Condition	Rating (%)	Description
Acceptable	100–80	There are few, if any, challenges to living standards
Tolerable	80–60	Day–to–day living is fine, in general, but some aspects of life may entail problems
Average	60–40	Negative factors have an impact on day-to-day living
Undesirable	40–20	Livability is substantially constrained
Very undesirable	20–0	Most aspects of living are severely restricted

variable, considered as the basis of urban sustainability, is directly related to the social, economic, physical and environmental dimensions of a city. Each of these dimensions accounts for a certain aspect of livability in neighborhoods.

Table 4 Percentages of the neighborhoods located in different layers of housing livability based on macro-dimensions

Category layer	Value	Livable housing classes				
		Acceptable	Tolerable	Average	undesirable	Very undesirable
Physical	Num	14	31	42	*43*	8
	%	10/14	22/46	30/43	*31/16*	5/8
Social	Num	*19*	58	22	16	23
	%	*13/77*	42/03	15/94	11/59	16/67
Economic	Num	*19*	49	34	27	9
	%	*13/77*	35/51	24/64	19/57	6/52
Environmental	Num	7	*63*	*53*	14	1
	%	5/07	*45/65*	*38/41*	10/14	0/72

In terms of the macro-dimensions of housing livability, the neighborhoods of the city are classified by the social, environmental, economic and physical advantages of 55.8% (in layers 1 and 2 as good categories), 50.7%, 49.28% and 32.6%, respectively. This proves that, in terms of livability, the neighborhoods are socially better than physically. Besides, the physical livability of 51% is not desirable. In this regard, the neighborhoods are in the worst conditions as compared to the other dimensions (Table 4). The results obtained from the review of indexes, which are a compilation of sub-indices, are presented in the form of table (6) in the standard classes (5) of livability (Table 3) for 138 neighborhoods Figs. (5, 6).

The results obtained from the review of indexes, which are a compilation of sub-indices, are presented in the form of (Table 6) in the standard classes (5) of livability (Table 3) for 138 neighborhoods.

3.2 The standard groups of livable housing in the studied neighborhoods

Table 6 shows the livable housing in the metropolis of Karaj. The data are organized for each district based on the standard classes and the percentage of the neighborhoods and those classes.

The first class of the neighborhoods (located in the middle section) is in a desirable situation in terms of livable housing standards, and the challenges facing their livability are very few. The second class of the neighborhoods (in the central parts of the city) generally has good conditions of daily life, but it invariably faces a number of livability-related challenges such as transportation, accessibility, and leisure time. The middle class of neighborhoods (marginally located especially in the northern part of the city) suffers from a set of adversities such as inadequate public open spaces, pollution and insufficient public education. The livability in this area is downgraded under the negative effects of these factors.

The fourth class (marginal neighborhoods in the south of the city) is significantly reduced by indicators such as household size and population density, infrastructure and superstructure facilities that make housing livable, and the quality of life in the desired quality of housing is limited. In the fifth class of the neighborhoods (especially located in the eastern margins of the city), many important factors are found seriously limited, such as individual and social security, resistance of buildings, rates of per capita and density,

Table 5 Housing livability status of neighborhoods in macro-indexes

| Category	Indicator	Sub-indicator	Percentage of neighborhoods in 5 classes				
			C1	C2	C3	C4	C5
Physical	Stability and durability of the building	Building Materials	15.22	71.01	7.97	5.07	0.72
		Building Skeleton					
	Per capita and density	Number of rooms in a residential unit	7.97	24.64	26.81	23.19	17.39
		The amount of residential unit area					
	Facilities	Number of infrastructure facilities	14.49	32.61	21.74	20.29	10.87
		Number of superstructure facilities					
	Durability and age	The age of the building	13.77	20.29	35.51	17.39	13.04
	Type of residence	Type of residential unit	2.17	34.06	42.03	17.39	4.35
Social	Population	Population Density Number of Households Dimension	7.97	44.20	41.30	5.80	0.72
	Education	Access to Educational Spaces Access to Library and Cultural Center	21.74	18.12	17.39	20.29	22.46
	Leisure	Access to cinemas and theaters Access to coffee shops, restaurants and dining halls	15.94	21.01	25.36	22.46	15.22
	Individual and Social Security	Access to law enforcement and security centers	14.49	15.94	21.74	18.84	28.99
Economic	Ownership	Type of Ownership	13.04	34.78	26.09	19.57	6.52
	Transportation and Access	Access to bus and taxi stations, train stations and terminals	18.12	24.64	29.71	15.94	11.59
		Access to offices and banks					
		Access to shops and squares Access to the fire station					
Environmental	Energy	Types of fuel for residential units	5.07	44.93	39.13	10.14	0.72
	Sanitation and Health	Access to health centers (clinics) Access to health centers (hospitals)	7.25	10.14	15.22	20.29	47.10
	Open and Public Space	Access to sports venues Access to parks and green spaces	13.04	12.32	7.97	16.67	50.00
	Cleanliness and pollution	Access to mechanized waste bins and mobile waste bins	12.32	16.67	32.61	23.19	15.22

Table 6 The percentage of neighborhoods in the classes of livable housing for each urban district

| Livability class	Value	Region												Total
		R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	
Acceptable	Num	3	0	0	4	**3**	0	4	1	0	0	0	1	16
	%	18/75	0	0	25	**18/75**	0	25	6/25	0	0	0	6/25	100
tolerable	Num	6	6	5	2	7	4	4	6	**8**	3	1	3	55
	%	10/91	10/91	9/09	3/64	12/73	7/27	7/27	10/91	**14/55**	5/45	1/82	5/45	100
Average	Num	2	3	4	2	2	**6**	2	4	4	3	3	3	37
	%	5/41	8/11	10/81	5/41	5/41	**16/22**	5/41	10/81	10/81	8/11	8/11	8/11	100
undesirable	Num	0	0	**6**	2	1	2	1	0	0	5	3	4	24
	%	0	0	**25**	8/33	4/17	8/33	4/17	0	0	20/8	12/50	16/67	100
very undesirable	Num		1		1							**4**		6
	%	0	67/16	0	67/16	0	0	0	0	0	0	**66/67**	0	100
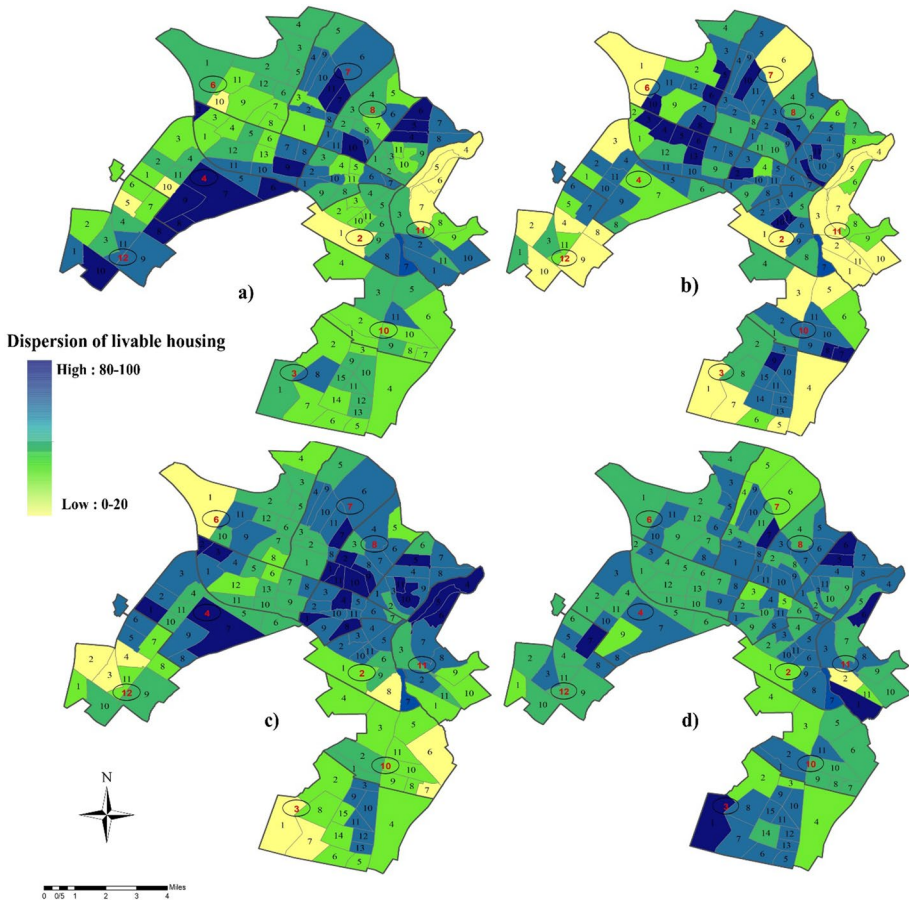
Fig. 5 Distribution of the housing livability of the neighborhoods in the **a** physical, **b** social, **c** economic and **d** environmental groups
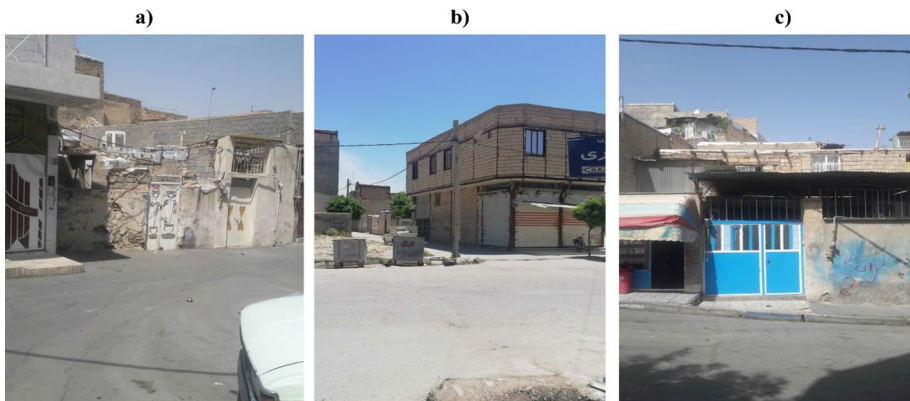
Fig. 6 Representation of housing situation in Karaj metropolis: **a** neighborhood with worn-out tissue, **b** suburban neighborhood, **c** neighborhood with dysfunctional tissue (Source: The authors)
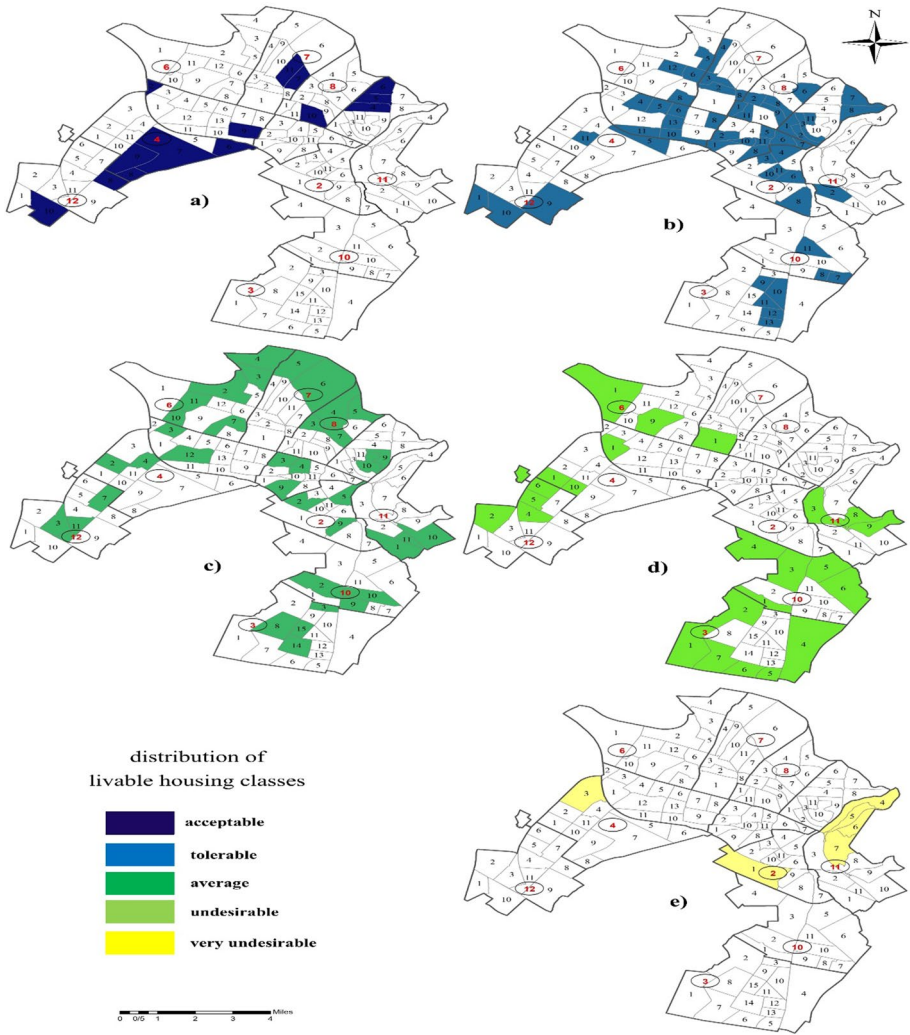
Fig. 7 The distribution of the livable housing classes for the neighborhoods in the metropolis of Karaj: **a** acceptable, **b** tolerable, **c** average, **d** undesirable, **e** very undesirable

durability of buildings, and specifically natural gas consumption, which is a very important factor. The neighborhoods in this layer are in the worst condition. After the scores are added up for the neighborhoods located in different districts with different degrees of livability, the twelve districts of the city are ranked. The first rank belongs to District 8 in layer 1 with the most neighborhoods. The last rank belongs to District 11 with the fewest neighborhoods and the worst conditions for livability (Figs. 7, 8, 9, 10).
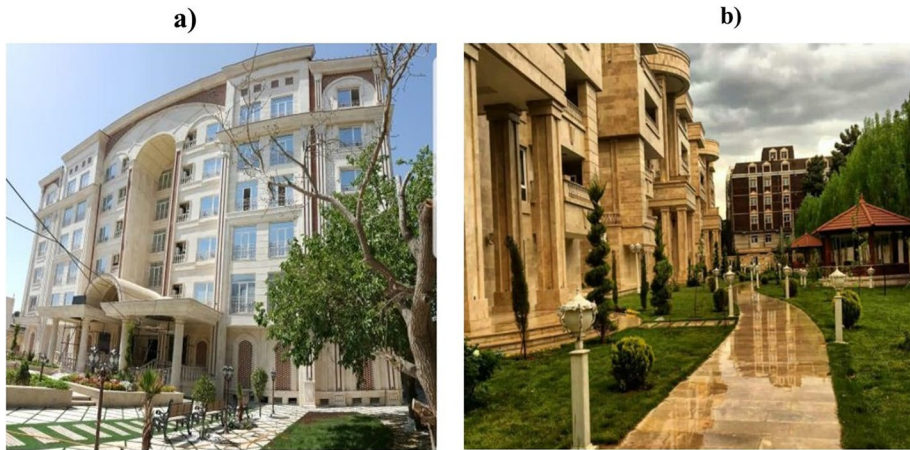
Fig. 8 Representation of housing situation in Karaj metropolis: **a** neighborhood with public housing tissue, **b** neighborhood around the center (Source: The authors)
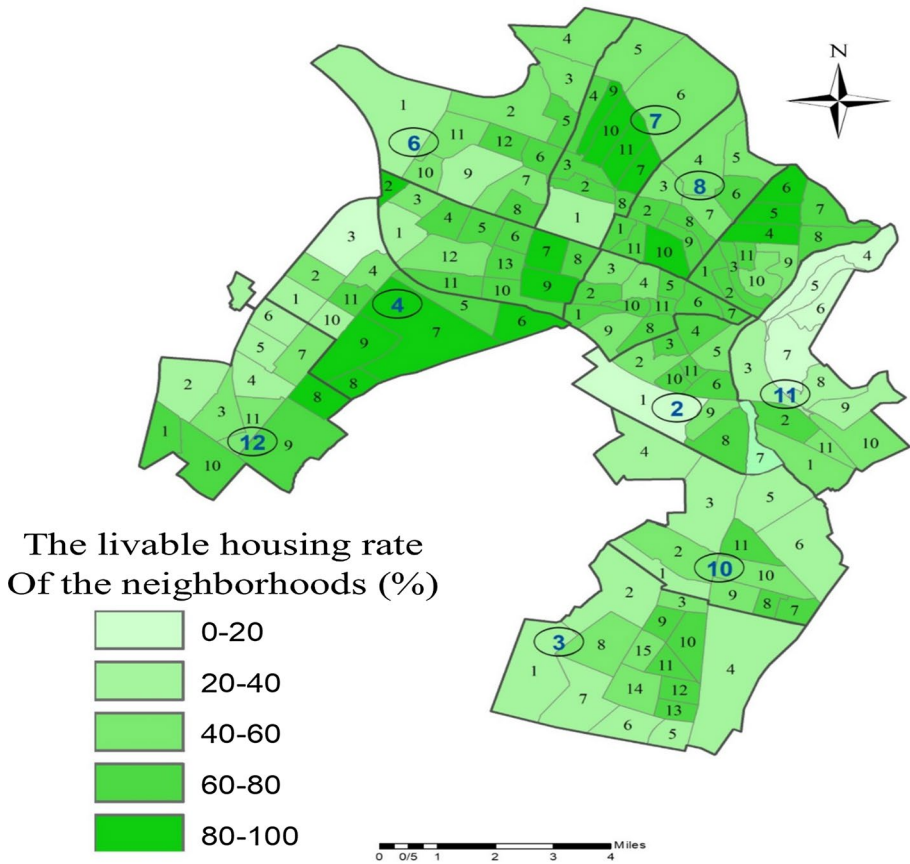
Fig. 9 The map of the livable housing in the neighborhoods of Karaj Metropolis

Fig. 10 Representation of housing situation in Karaj metropolis: **a** dynamic and vitality neighborhood, **b** very efficient neighborhood (Source: The authors)

3.3 Adaptation of qualitative and quantitative data on housing livability in the neighborhoods of Karaj megalopolis

The difference in the livability of the neighborhoods caused by the effects of each of the quantitative data indicators has been determined with the help of residents' views. Residents' opinions about the housing livability complement the perceptions of organizations and departments about the objective environment of housing and residential environment. The certainty index (Relation 10 and 11 of the research method) was used in order to validation of quantitative perceptions and compare them with the views of local residents. The difference between quantitative data numbers and qualitative observed values is at the most minimum value (16.7%). According to the RMSE index standard, the lowest error rate and the highest overlap or accuracy coefficient (83%) have been obtained for the quantitative modeling results of the article. The results of qualitative data as well as quantitative data indicate the unbalanced distribution of housing livability indicators are as a result of inequalities caused by natural, economic, political, ethno-cultural issues, the failure of the top-down planning system, economic duality and a different view of urban management.

4 Discussion

For the improvement of life quality and the sustainable development of urban areas, this study delves into the national bulk of research and the international literature on livability and its relationship to human residence. To this end, the housing livability issue is explored in 138 neighborhoods in the city of Karaj. The theoretical data as well as the data obtained in field work are organized into a framework of 15 indicators and 27 sub-indicators in social, economic, physical and environmental domains. Housing can considerably contribute to sustainability. This is one of the main topics discussed ever since early groups of people started to live in fixed dwellings where they could have peace and comfort. This peace is associated with certain indicators that can be found in a residential place. The

indicators get together to make the place livable and ultimately enhance the life quality. Livability is a phenomenon that refers to the relationship between an individual and a constructed place (house) with all its spatial and temporal aspects (neighborhood). Therefore, a combination of housing elements and livability factors (Table 1) can provide an easy path toward a high-quality livable place. Achieving such a place is the main objective of this study. To fulfill it, the qualitative and quantitative elements of housing are evaluated in terms of livability.

- The review of the national and international studies in the field has provided some insight into the matter. The lack of a vivid definition in the reviewed studies for the concept of housing livability suggests that there is no consensus about what this concept is and how to improve it in the context of a house and the whole residential area. An attempt to reach a common definition for housing livability should reflect its advantages and direct future attempts toward the development of houses with guaranteed livability. Similarly, there is no commonly accepted definition for livable housing in the city of Karaj. The present study serves as a jumping point for the construction industry to walk toward housing livability on the side of local and national policies in this regard.
- Urban researchers, decision makers, planners, managers and other stakeholders can benefit from maps and figures to determine the distribution of neighborhoods in terms of housing livability and GIS to identify various urban subsystems. It is worth having the ability to identify the neighborhoods whose residents have different degrees of housing livability. This identification through different techniques in a city with all its neighborhoods can raise awareness about the needs and expectations of the residents and help to achieve sustainable development in the place. Drawing factorial and schematic maps of livability in neighborhoods and specifying how influential its indicators are in those neighborhoods are the research goals depicted in Figs. 5–7.9
- Housing livability maps of neighborhoods in macro-indexes (physical, social, economic, environmental) show the dispersion of housing livability in the Karaj metropolis and the placement of neighborhoods in various livability classes (Table 1) from acceptable to very unfavorable. A score of 80–100 is used for the highest livability of housing, and a score of 0–20 is used for the lowest livability of housing in the neighborhoods (Fig. 5).
- Housing livability classification maps of neighborhoods in five standard classes show which neighborhoods are located in which Regions. According to the classified maps, the neighborhoods with an acceptable and tolerable level of livability are located in the center of Karaj city. The third and fourth classes with average and poor situations are located around the center, respectively, and the last class with very poor situation includes neighborhoods which located in the outskirts of the city (Fig. 7).
- The final map of housing livability of neighborhoods, which is the result of combining all indexes and sub-indexes in four dimensions. In this map, neighborhoods are categorized in five classes with specific points. According to Table 1, the livability classes are specified with a maximum score of 100 and a minimum score of 0. In this map, all 138 neighborhoods have their status in terms of housing livability in 12 regions (Fig. 9).
- The results obtained from the review of indexes, which are a compilation of sub-indices, are presented in the form of (Table 5) in the standard classes of livability (Table 3) for 138 neighborhoods
- The situation of physical dimension indices in the standard housing livability classes in all neighborhoods is as follows. From the total number of neighborhoods in the

index of building stability and resistance (type of building materials and structure), 15.22% are acceptable, 71% are tolerable, 8% are moderate, 5% are unfavorable, and 1% are very unfavorable. Examining the per capita index and density shows that 8% of the neighborhoods are in the acceptable class, 25% are tolerable, 27% are average, 23% are unfavorable, and 17% are very unfavorable. Facilities and amenities index is a total of internal and external facilities of the residential unit. Their livability status in the neighborhoods shows that 14.5% of the neighborhoods are in the acceptable class, 33% in the tolerable class, 22% in the average class, 20% in the unfavorable class, and 11% in the very unfavorable class. The status of the building's age index in total neighborhoods is considered of 14% of acceptable class, 20% of tolerable class, 35% of average class, 17% of unfavorable class, and 13% of very unfavorable class of housing livability. The housing type index, as the last index examined in the physical dimension, shows that the status of this index among the total of 138 neighborhoods is 2% in the acceptable class, 34% in the tolerable class, 42% in the middle class, 18% in the unfavorable class, and 4% in the very unfavorable class. In the physical dimension, the condition of the building stability and resistance index in the housing livability of the neighborhoods is better than other indexes, and most of the neighborhoods have a very unfavorable situation in the housing livability in the per capita and density index compared to other indexes.

- The social dimension has been investigated with indexes such as population, education, leisure time and security. The status of the population index among the neighborhoods in terms of housing livability shows that out of a total of 138 neighborhoods, 8% of the neighborhoods are in the acceptable class, 44% in the tolerable class, 41% in the middle class, 6% in the unfavorable class, and 1% in the very unfavorable class. The description of the effects of the indices in the livability classes is as follows. Education index with 22%, leisure time with 16% and security 15% in the acceptable housing livability class. In the second class, education with 18%, leisure time with 21% and security 16% with tolerable housing livability status. In the third class, education with 17%, leisure time with 25%, security with 22%. In the fourth class and unfavorable education statute with 20%, leisure time with 22%, 18% and on the 5th class with very unfavorable education statute with 22%, leisure time with 15% % and security with 29%. In the social aspect, the housing livability of the neighborhoods in the population index is better than other indexes, and most of the neighborhoods experience an unfavorable situation in the security index.

- The economic dimension has been investigated with two indexes of ownership and transportation and access. Surveys of housing livability in the property index show that 13% of the neighborhoods are in an acceptable situation, 35% in a tolerable situation, 26% in an average situation, 19.5% in an unfavorable situation, and 6.5% in a very unfavorable situation. The transportation and access index with its subindexes put 18% in an acceptable situation of livability, 24% in a tolerable situation, 30% in an average situation, 16% in an unfavorable situation, and 11.5% in a very unfavorable situation. The status of transportation index in housing livability is better than property index. There are several important points in the group of economic indicators. The relationship between income and livable housing is a completely linear relationship. In other words, the higher the income, the more livable the housing, or the higher the ownership of the housing will be more livable. This is obvious. According to this theory, to avoid the alignment of indicators. In order to measure the economic viability of the neighborhoods, not only the housing itself, the relationship between the ownership of the area and the nobility and the type of

ownership (mortgage, lease, and owner) has been measured. The results obtained in Table (5) showed that the neighborhoods that had the most and the highest amount of housing ownership also had a higher level of housing livability. In other words, high-income economic classes with housing ownership were placed in acceptable and tolerable livability classes (desirable livability classes). However, according to studies, the relationship between income and housing is completely linear, and the higher the income, the more livable the housing will be. In the megalopolis of Karaj, according to the size, variety of neighborhoods and available textures, there are different prices of housing. There may be different prices close to each other in a neighborhood or urban area or blocks of the city. For example, the proximity to services such as parks and public transportation stations is a price-determining factor.

- The environmental dimension has investigated the livability of housing in the neighborhoods with four indexes. In this dimension, the status of the household energy consumption index of the total neighborhoods is 5% in acceptable status, 45% in tolerable status, 39% in average status, 10% in unfavorable status and about 1% in very unfavorable status. Treatment index with sub-sections of access to hospital and pharmacy, 7% is in acceptable situation, 10% is in tolerable situation, 15.22% is in moderate situation, 20.30% is in unfavorable situation, and 47% is in very unfavorable situation. The index of access to green and sports spaces has 13% acceptable status, 12.32% tolerable status, 8% average status, 17% unfavorable status and 50% very unfavorable status. In health index with the sub-index of the number of mechanized garbage cans, 12.3% of the neighborhoods are in tolerable situation, 17% in tolerable situation, 33% in average situation and 15.22% in very unfavorable situation. In this dimension, the livability of housing in the energy index is favorable. The status of the index of access to treatment and green spaces in the housing livability of the neighborhoods is very unfavorable compared to other indexes. Determining the livability of housing in the neighborhoods according to the investigated indexes is an accurate index of the status of the neighborhoods in relation to each other and to the whole city. This can provide very appropriate additional information to stakeholders and city managers for accurate and efficient neighborhood and area planning.

- An ideal relationship between urban environments and sustainable social life calls for specific attention to housing livability. It is possible to have this relationship only if there exist solid grounds for livability. The categories of livable housing are formed in the neighborhood, and special attention is paid to the neighborhood element as a small element of the city and a systematic and comprehensive view of the city with its set of elements is formed to generalize to the whole city. In addition, the categories of livable housing have specific features in physical, social, economic and environmental domains. As Table 3 shows, these features have been used to cluster the neighborhoods in the studied area based on their livability (Fig. 6–8.10).

- Representation of the housing status in the neighborhoods of Karaj city, where the livability of the neighborhoods is inappropriate and too inappropriate. These neighborhoods are facing high deprivation in having all the necessary and vital indexes of livable housing. These neighborhoods are in the last two classes with scores of 0 to 20 and 20 to 40. Many of the housing livability items have challenges and limitations. These neighborhoods are often referred to by titles such as worn-out, marginal and inefficient texture (Fig. 6).

- Representation of the housing livability in neighborhoods located in the middle class. These neighborhoods are located in the surrounding Regions of the center in public

residential areas. These neighborhoods are facing challenges in terms of having some livable housing indexes, including accesses and infrastructures (Fig. 8).

- Representation of the housing livability of the neighborhoods in the first and second classes (acceptable and tolerable), which are among the good and very good neighborhoods. These neighborhoods often have all the indexes of livable housing and have a high quality of housing. These neighborhoods are known as dynamic and lively and very efficient neighborhoods (Fig. 10).

Regarding the characteristics of regions in two general categories, it can be said that; In the process of physical expansion of the city of Karaj from 6 thousand hectares at the time of its formation to 17 thousand hectares in 1400, several types of districts and textures have been formed in terms of housing and residence. In other words, the city of Karaj has a multi-core structure, which is formed by the joining of surrounding neighborhoods and villages, and has several central and peripheral districts. A different situation of the type of housing and residence prevails in each of the central cores (older) and inner areas (newer). In some of the central districts or the older core, old houses are seen in poor physical condition and sometimes dilapidated. In some cases, there are also renovated houses in this central core. With these interpretations, it cannot be said that the city of Karaj only consists of two central districts (the older part) and peripheral districts (the newer part), but there are many areas or in other words textures in the city, which have major differences in terms of content and indicators of housing and residence. This difference in zones obtained from housing livability classes in different directions of Karaj city is explained in the central and walking areas of the city.

- In this paper, housing is studied from the point of view of livability, and livability of a city is considered to be dependent on the conditions of its neighborhoods and its lowest level element, namely house. The livability at the house level provides conditions for a high-quality, active, dynamic, safe and attractive place to live where the basic needs of all the residents are met. By evaluating the livability in the neighborhoods of a city, as reflected in Table 4, urban planners can realize the differences among those places, assess the satisfaction of the residents, and make plans on that basis. Local satisfaction is one of the housing evaluation methods. In this article, with the ultimate goal of measuring local satisfaction with specific data (objective indicators taken from the statistics and population center and municipality databases), local satisfaction has been discussed from a different perspective. Also, the results obtained by field investigation and completing questionnaires from the residents of the neighborhoods were evaluated and compared, and the accuracy of 83% of the quantitative data was confirmed by the results of the qualitative data.
- Local and national governments play different roles in cheap and affordable housing according to their prevailing economic and political approach. Urban land and housing policy, centered on the role of the government, acts as a discursive issue in increasing livability. In Iran, this role is mainly played by the local government as the agents of the national governments (Pacione, 2005; Seiedbaigi et al., 2018) in the form of many solutions such as the investment fund for rental projects, renovation loans for rental units, providing higher density in spaces without enough land, applying tax deductions; Construction financing along with providing tax-free bonds, building social housing, expanding public transportation around cities and providing land and services, etc., support the provision of cheap housing (Ministry of Roads and Urbanism and Organization National land and housing). In order to make housing more livable up to the level of

urban neighborhoods, the local government prepares comprehensive and detailed housing plans. In order to make housing more livable up to the level of urban neighborhoods, the metropolis's local government prepares comprehensive and detailed housing plans. The philosophy of preparing these plans is mainly to increase the livability and quality of life to the lowest levels of the city, i.e., neighborhoods. In the framework of the above plans, Karaj Municipality as the representative of the local government and the Road and Urbanism Department and mainly service providers as the representative of the central and national government improve the housing affordability by providing land for housing and other mainly service uses that the private sector does not want to enter. In this regard, they play roles by providing basic infrastructure such as water, electricity, gas, crossings and sidewalks, especially in the margins and boundaries of the physical expansion of the city, formulating the construction engineering's laws and regulations to improve the quality of housing, especially (framework and type of materials), creating the mechanisms for the renewal of worn-out tissues to reduce the age of the building, promoting apartment living for the optimal use of land for services, creating various types of cooperative ownership and renting on the condition of ownership, purchasing with long-term government installments, creating contexts for educational, therapeutic, cultural, security, welfare, sports access in the form of establishing justice and balance, using of the clean energy and finally implementing the details of detailed and master plans.

5 Conclusion

In the urbanized world, economic-social-physical heterogeneity is considered a fundamental challenge. Therefore, urban livability is a complete necessity and efforts to identify and develop its indicators around the world have been raised as a necessity. The common point in all livability studies is that it prepares urban societies to achieve a higher quality living environment. Also, one of the conditions of a living place or a house is its livability which is mainly provided by the facilities and services in the corresponding neighborhood. In other words, the criteria for housing satisfaction expands beyond residential units and includes the context of the neighborhood. In this paper, the relationship between livability and housing is investigated under the concept 'livable house' on the smallest scale of analysis, namely neighborhood. The results of the investigation are reported below.

1. The livability of housing brings different results in macro-indicators. In order to reveal these results, this study has addressed the housing livability of the neighborhoods at the smallest scale. The results indicate that in housing livability with physical indicators, about 10% of the neighborhoods are in an acceptable condition and also 60% are in average and unfavorable conditions. This issue in the field studies also shows the unfavorable physical condition of housing in the neighborhoods. This has made it a challenge to achieve the ideal level of livable housing. In the livability of the economic indicators of housing in the neighborhoods, 19 neighborhoods or 14% are in an acceptable condition and 49% of them are in an upper average condition. In the environmental indicators of housing livability in the neighborhoods of Karaj city, among the 138 neighborhoods, 7 neighborhoods or 6% are in an acceptable condition and 51% of them are in an upper average condition in terms of standard classification. In the indicators of social livability of housing in the neighborhoods as well 19 neighborhoods or 14% are in an acceptable

condition and 57% of them are in an upper average condition. According to the scientific evidence that units with poor infrastructural quality and insufficient facilities inside the house lead to a decline in the housing livability, in addition, the facilities of the residential environment also play a decisive role in livability. For this reason, only the existence of services in a city, even if it is more than the actual need or equal to the standard per capita, cannot provide the livability of the whole city. Therefore, it is necessary to pay special attention to the way of distribution of these services and their spatial distribution pattern in order to eliminate the existing differences of neighborhoods in physical, social, economic and environmental indicators.

2. By studying another aspect of housing viability variables (Table 7) in terms of the division of the global standard of living, it can be concluded that the distribution of 138 neighborhoods in the 12 districts and standard situations is as follows: The first or acceptable housing livability condition of 16 neighborhoods with a percentage of 11.10% of the area and 11.41% of the total population of the city, the second or tolerable condition of 55 neighborhoods with 24.28% of the area and 39.14% of the total population of the city, the third or average condition of 36 neighborhoods with 28.76% of the area and 31.02% of the total population of the city, the fourth or unfavorable situation of 24 neighborhoods with 29.26% of the area and 15.74% of the total population of the city and The very unfavorable condition of 6 neighborhoods with 6.58% of the area and 2.67% of the total population of the city. Totally, 52% of the neighborhoods have good livability, while 12% suffer from undesirable conditions. As the results show, the neighborhoods have different conditions of livability. The most bordering neighborhoods do not enjoy the same rate of housing livability and despite their vicinity, there exist many differences among them in terms of the livable housing indicators. In other words, the imbalanced distribution of indicators has led to inconsistent and heterogeneous patterns of growth and development in the city and have a scattered distribution in the city. A Spatial distribution pattern of neighborhoods with the first rank of housing livability is focused in the middle districts of the city, but this advantage begins to decline as one moves to the neighborhoods in the old as well as marginal parts of the city. This can be attributed to the centralized economic structure of the city and the further attention of the authorities to urban development plans for specific neighborhoods.

3. The results of the study of residents' environmental perception of housing livability showed that a set of interactions and residents with their environment determines their level of satisfaction with housing livability and their residential environment. The difference in the livability of the neighborhoods comes from the impact of each of the indicators with the views of the residents. The difference in the effects of indicators in neighborhoods shows their unbalanced distribution as a result of inequalities caused by natural, economic, political, ethno-cultural issues, the failure of the top-down planning system, economic duality and a different view of urban management. These factors have been manifested in the objectivity of the neighborhood and have formed the mental views of the residents. Therefore, providing appropriate regional planning for fair access to resources for all urban neighborhoods can reduce the severity of inequalities and make neighborhoods more continuous in terms of housing livability. Combining objective information with residents' opinions is one of the most successful and effective surveys in the field of measuring housing livability. Although this study faced the following limitations, it was able to find deep results and show clear directions to researchers for future studies. One of the limitations of this study is the excessive expansion and dispersion of the Karaj metropolis in examining different aspects of the indicators, the uneven expansion of the city of Karaj and the location of different neighborhoods and

blocks next to each other in terms of indicators, the excessive difference and contrast between neighboring neighborhoods and as a result of the limitation in calculations and analysis, the urban difference and conflict in terms of the structure governing the neighborhoods. For the future study related to this topic, it can be pointed out to study things such as the study of worn-out, inefficient and marginal tissues in order to further increase the livability of housing, compiling studies with its new concept, i.e., smart city and creative city, in order to improve the livability of housing. The study of influential external factors such as national and local government policies in order to improve the quality of livable housing pointed out.

4. This research by systematic review of the relationship between housing and livability is related, in agreement with the findings of Allen & O'Donnell (2020); Bennett, (2010); Galal et al., (2020); Mouratidis, (2020); Nirfalini Auli, (2016); Kovacs-Györi et al., (2019), the study by Simpson & Parker (2018) and the study of Ezennia & Hoskara (2019); Ghasemi et al., (2018). By examining the results obtained from previous studies, it can be said that each of the studies has named part of the components and elements to achieve urban livability, while in order to achieve urban livability, all elements must be seen as a comprehensive whole. Previous studies in the results of livability have mentioned housing as a part of the city's livability (Table 1 of Appendix A in the supplementary material). In other words, once the city becomes livable, housing will also become livable, while the livability of the housing itself is a wide issue as big as the livability of the city. And vice versa, by achieving the livability of the housing, it is possible to achieve the livability of the city. In order to achieve comprehensive livability such as the livability of the city, one should start from the smaller components, i.e., the livability of housing. In housing studies, the livability of residential environments has not been considered (Ilesanmi, 2012; Aribigbola, 2008; Prochorskaite, 2015, Kovacs-Györi et al. 2019). These studies have been done to achieve the quantity and quality of housing without considering the livability approach. But they have not been able to comprehensively examine the housing and provide acceptable results to increase the quality of life in the whole city. However, all housing and livability studies should be able to provide livability for city residents even in the smallest part of a neighborhood (urban block). Therefore, this article tries to complete the previous studies with a set of indicators in various dimensions (Table 1), a comprehensive study of housing livability in order to sustainable development of the neighborhood and increase the quality of life in housing. The results of this study can be used to complete studies related to urban livability. This is because this study has started livability both from the neighborhood and housing, which are the main components of the city's livability.

5. Adopting a new approach to livable housing with an emphasis on the enhancement of life quality and the achievement of a reasonable, affordable and inclusive living place is not possible unless an appropriate pattern of livable housing is presented to urban planners so that they can use it not only to deal with the affairs at the level of a neighborhood but also generalize it to the whole city. The following guidelines may help to achieve such a pattern:

a. Allocating a special section to livable housing in urban development plans (comprehensive and detailed) for planning at the city and neighborhood level

b. Identification of the resources, potentials and capabilities of each neighborhood so as to make accurate plans for the use of land and the reduction of injustice in the housing livability of neighborhoods

c. Substantial revision of the detailed and comprehensive plans of Karaj Metropolis and, while taking the current situation into account, giving priority to the subjective views of the citizens as the main stakeholders of residential areas

d. Increasing the citizens' participation in the execution of the plans for urban services so that structural and strategic programs can function better on the basis of the sustainable development principles and a pattern can be obtained based on the residents' priorities

e. Introduction of an accurate and detailed protocol for the development of neighborhoods which meets their present and future housing needs and makes the houses there more livable.

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