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Evaluating housing in urban planning using TOPSIS technique: cities of Isfahan province

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Abstract. The indices of housing serve as an important tool in planning for housing, in that they allow the parameters affecting housing to be recognised and any planning process to be facilitated. The purpose of the study is to investigate and to evaluate the housing situation in cities of Isfahan province. The study is applied and descriptive-analytic in terms of method. Thirty-nine indices were collected in the housing sector. Then the rate of prosperity and ranking of the cities were evaluated by TOPSIS method. Prosperity is defined here as an important index of housing that reflects the welfare of residents. The cities were then categorised into six levels of prosperity: Very important, Important, Partially important, Moderate, Poor and Very poor. The results from the study indicate an imbalance in the studied indices between the cities, and a clear disparity between the levels of prosperity in the cities, and the only city in the very prosperous group is Isfahan, with a rate of 0.813.

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1. Introduction

Housing is one of the most basic human needs. This requirement has played an important role since early settlements. Many researchers in the field of urban studies believe that housing and environmental circumstances serve as the most important factor influencing individuals' satisfaction in terms of region of living and lifestyle (Bartik, 1988; Freeman, 1981; Horsch and Lewis, 2008; Muriel, Abdelhak, Gildas and François, 2008; Patrick and Wade, 1994). Living in an abnormal residential situation destabilises and disturbs the physical and mental health of residents (Won Kim, Phipps and Anselin, 2003). In developed countries, housing is considered to fall within the domain of social welfare, and housing development policies are focused on improving quality of life. By contrast, in developing countries, the lack of adequate resources, poor economic management, lack of comprehensive national planning, and rapid population growth have complicated efforts to supply housing (Woodfield, 1989: 5). At the same time, housing is a determining commodity in the society that plays an influential role in the formation of personal identity, social relations and individuals' goals. Rather than being a purely physical structure, it acts as a unit with multi-dimensional performance, with various spatial, architectural, structural, physical, economic, social, financial, psychological and medical aspects (Short, 2006: 199). In fact, inadequate housing leads to the issue of spatial traps. The spatial trap of housing is generated in terms of forms of both internal and external quality. The external quality of housing means the geographical location. In Iran, housing located in the margins of urban areas or old and impoverished neighbourhoods inside the cities are considered to be the spatial trap. The internal quality of housing refers to inappropriate construction materials and equipment as well as insufficient building footprint sizes (area of substructure), resulting in spatial trap (Marquez, Dodge Francis and Gerstenberger, 2019).

Given that planning for housing development is one of the most important parts of urban planning, economic factors such as cost of living, employment and unstable income play very important roles in housing planning. This planning is one of the priorities in urban planning (Sendich, 2006: 185).

One of the most important ways of determining the status of housing in the planning process is using housing indices. Such indices represent the quantity and quality of housing in each period on the one hand, and serve as an effective guide for improving the future planning process for housing on the other. The importance of this research derives from the development of housing being one of the most necessary issues encountered by individuals in society; thus, a house or dwelling can be thought of as a collection of relevant desired behaviours and spatial qualities (Lich, 1997: 98). Therefore, the need to consider housing and its regional and urban planning is greater than before if citizens' problems are to be resolved using the knowledge and techniques of planning (Judge, Warren-Myers and Paladino, 2019; Siqueira-Gay and Sánchez, 2019).

The general definition and concept of housing include not only a residential unit but also the total residential environment. In other words, housing is more than a physical shelter (Adabre and Chan, 2019; Asfour, 2017). The concept of adequate housing should not be sought in purely physical dimensions, but also in the biological, cultural, social, economic and security needs and desires of its residents (Wolman, 2014). The emergence of the problem called "housing" in Iran and its proposal as a social dilemma coincides with the development of capitalism. Turning housing into a capitalist commodity with increasing prices results in prosperity imbalances between societal income classes. Growing urbanisation and increasing urban population have made the provision of housing into one of the most important problems in many cities (Khos-

hakhlagh, 1999). Compared to other commodities, housing can serve as a major cause of both inequality and, at the same time, social integration due to characteristics such as being non-renewable, investable, durable and unmovable (Gallent and Robinson, 2011). Thus, the achievement of desirable and preferred housing in either urban or rural areas is considered to be an index of socio-economic development in countries around the world (Richard, 2008). Since the enactment of the Charter of Human Rights in 1948, the right to an adequate dwelling has been recognised as an important element of prosperity in the desired quality of life. In this regard, the human settlement committee even proposed a universal strategy to settle humans with the main goal of providing a suitable dwelling for all social groups (Nikooseresht and Kharrat Zebardast, 1996: 611). Using various techniques (Shannon entropy, TOPSIS, Geographic Information Systems [GIS]), the present study analyses the status of housing in cities of Isfahan province by determining housing indices, ranking the cities and explaining regional inequalities.

2. Methods

Only recently has the discussion on housing indices attracted scholars and experts (Arjmandnia, 1975: 54). Housing indices may be the most important and fundamental tool in housing planning (Ortiz and Johannes, 2018). One method to identify the properties of dwelling and housing is to investigate which indices best clarify the effective parameters of proper planning and best facilitate decision-making processes (Maleki, 2003). The importance of housing indices has grown, such that housing planners have made use of them to formulate more accurate housing planning. This paper tries to investigate and determine the status of housing and reasons for and barriers to the housing development in cities in Isfahan province (25 counties, 107 cities and 2,470 villages in all) by analysing indices of housing. Isfahan province covers an area of approximately 107,018 km^2 in the centre of Iran, between 30°42′ and 34°30′ N latitude and 49°36′ and 55°32′ E longitude. Isfahan Province can be divided into three topographic and climatic regions based on their distance from the Zagros mountains in the west and the great desert in the east: (1) semi-humid and cold areas encompassing western and southern valleys, including the sub-provinces of Golpāyagān, Ḵᵛānsār, Faridan, Fereydunšahr and Semirom. (2) Arid areas along the edge of the central desert, including Nāʾin, Ardestān and Kāšān, as well as the area of desert climate in the easternmost villages of Anārak, Ḵur and Jandaq. (3) The semi-arid region of the oasis of Isfahan—with the Zāyandarud as the main water resource—marked by a moderate climate and four distinct seasons, including the sub-provinces of Tirān and Karvan, Najafābād, Lenjān, Mobāraka, Falāvarjān, Ḵomeynišahr (formerly Mārbin) and Isfahan, as well as Šahreżā along the road to Fārs and Borḵᵛār o Meyma on the road to Qom and Tehran. According to the 2016 census, approximately 88% are urban residents and 12% reside in rural areas. The province experiences a moderate and dry climate on the whole, ranging between 40.6 °C and 10.6 °C on a cold day in the winter season (Statistical-centre-of-Iran, 2018). The city of Isfahan, however, experiences an excellent climate, with four distinct seasons.

2.1. TOPSIS model

The TOPSIS model is one of the most conventional techniques used in Multiple Attribute Decision Making, and is based on the calculation of the choices' distance from the positive ideal and negative ideal solutions (Lin, 2010). The process for the TOPSIS algorithm generally begins with forming a decision matrix representing the satisfaction value of each criterion with each alternative (Sendich and American planning, 2006; Xia, Li, Zhou and Wang, 2006). Next, the matrix is normalised with the appropriate normalising scheme, and the values are multiplied by the criterion weights. Subsequently, the positive-ideal and negative-ideal solutions are calculated, and the distance of each alternative from these solutions is calculated with a distance measure (Cavallaro, 2010). Finally, the alternatives are ranked based on their relative closeness to the ideal solution. The TOPSIS technique helps decision-makers to structure problems to be solved, and to analyse, compare and rank alternatives. The classical TOPSIS method solves problems in which all

decision data are known and represented by precise numbers. Most practical problems, however, have a more complicated structure, as the current study does (Roszkowska, 2011). The algorithm of this method is as follows:

1) Converting the present decision-making matrix into a de-scaled matrix using the following equation:

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}} \quad (1)$$

2) Determining the weight of each index (W_i) based on $\sum_{i=1}^{n} w_i = 1$ so that the weights increase according to the importance of indices.

3) Determining the positive ideal solution (A^+) and negative ideal solution (A^-):

$$A^+ = \left\{(m_i ax v_{ij} \mid j \in j), (m_i in v_{ij} \mid j \in j)\right\} \qquad A^+ = (v_1^+, v_2^+, ..., v_n^+) \quad (2)$$

$$A^- = \left\{(m_i in v_{ij} \mid j \in j), (m_i ax v_{ij} \mid j \in j)\right\} \qquad A^- = (v_1^-, v_2^-, ..., v_n^-) \quad (3)$$

4) Determining the distance criterion for the ideal option (S_i^+) and the minimum options (S_i^-):

$$s_i^- = \sqrt{\sum_{i=1}^{n} (v_{ij} - v_i^-)^2} \quad (4)$$

$$s_i^+ = \sqrt{\sum_{i=1}^{n} (v_{ij} - v_i^+)^2} \quad (5)$$

5) Determining the coefficient, which is equal to the distance of the minimum choices (S_i^-) divided by the sum of the minimum distance (S_i^-) and the distance of the choices (S_i^+), represented by (C_i^+) and calculated by the following equation:

$$c_i^+ = \frac{s_i^-}{s_i^- + s_i^+} \quad (6)$$

Then the choices are ranked based on the value of (C_i^+), which is between zero and one. The highest and the lowest rank are represented by (C_i^+) = 1 and (C_i^+) = 0, respectively (Chen and Han, 2018).

2.2. Shannon entropy method

To weight the indices, the Shannon entropy method can be used. In this method, the importance of the index increases by values' dispersion. To use this weighting technique, the following steps are applied:

- Forming the decision-making matrix,
- Quantifying the decision-making matrix,
- De-scaling the decision-making matrix:

$$n_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad (7)$$

- Calculating the entropy of each index:

$$E_J = -K \sum_{i=1}^{m} \left[n_{ij} Ln_{ij} (n_{ij})\right] \Rightarrow \begin{Bmatrix} \forall j = 1,2...n \\ K = \frac{1}{Ln(m)} \end{Bmatrix} \quad (8)$$

- Calculating the degree of deviation of data in each index:

$$d_j = 1 - Ej \quad (9)$$

- Calculating the weight of each index: the sum of weights should be equal to one (Abdel-Basset, Saleh, Gamal and Smarandache, 2019):

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \rightarrow (\forall j = 1,2,... n) \quad (10)$$

$$\sum_{j=1}^{n} w = 1 \rightarrow (\forall j = 1,2,...n)_j \quad (11)$$

3. Results and discussion

3.1. Evaluation of housing indices in cities based on census

Average household size

The average household size in Isfahan city (3.29 persons) is below the province average (3.37 persons). The reasons for the low proportion of the household size in Isfahan city compared to the province include lower levels of fertility, the higher growth of nuclear families and increased apartment residency. This figure varies in different parts of the province, so that the average household size increases outwards from the centre of the province to the margins, because, on the one hand, women's fertility rate is higher in these areas, and on the other hand, immigrants typically come to Isfahan city with their large families and their traditional cultur-

al properties. Cities with elderly populations have the lowest average household size due to low fertility rates of women in the cities. This is caused by the poor health and sanitary conditions of traditional families in the underdeveloped and suburban areas of small towns. This usually relates to the previous generations in which the fertility capabilities have been influenced by some obsolete medical methods that were generally prescribed by local uneducated people. This ultimately caused a lower population growth in a certain period in these areas, which was later resolved by the rapid development of modern treatment methods with the help of sanitising organisations, even in these small towns.

Household density index

Calculations performed based on this index show that most cities are in good condition. According to international standards, a density of more than one household per residential unit is equal to the index of homelessness. In other words, the housing shortage indicates the number of homeless families. Unlike many countries in the world, whether developed or developing, this situation is not observed in Iran, nor in Isfahan. This is mainly due to social and cultural factors. In Iranian society, the reality of two or more families living in a single residential unit has a historical background and is considered normal.

Average area of buiding footprint

Average area of footprint (substructure) per residential unit is heavily influenced by social, cultural, economic, physical and environmental conditions. This is extensively explained in the previous studies as a general rule influencing urban planning and housing criteria analysis (Afsoon and Habib, 2016; Makinde, 2015; Mitchell, 1976). The index has two specified characteristics. First, the index of average footprint area per residential unit is much higher in Isfahan (over 100 m^2) compared with many metropolises of the world. Second, there exists a significant difference between different cities in Isfahan province. This difference is mainly due to the difference in level of household income and financial power. In addition to economic factors, environmental factors also affect average footprint area.

Quality of residential units

According to the census, more than 55% of buildings in Isfahan metropolis possess metal structures and 45% are built from reinforced concrete, which indicates a higher proportion compared to other cities in Isfahan province.

In general, Isfahan metropolis is in a better situation in terms of residential units constructed with metal and concrete materials compared to other cities in the province, based on field research and official statistics; this has caused the city to move toward demolishing old buildings and reinforcing other buildings, especially in the centre of the city, which consequently has increased the contribution of these areas.

Number of rooms per household

Currently about 35% of households in Isfahan metropolis have one habitable room. The cities of Najaf Abad, Kashan and Khomeini Shahr have the highest percentage of households with one habitable room.

Ownership of housing

Social characteristics and conditions are considered to be the most effective parameters in the ownership of houses. In countries of the first group, much of the lands and also urban residential units are owned by municipalities and town councils. Given the level of welfare and functionality, and government programmes for providing housing, people are less motivated to own a house.

In Iran (including Isfahan metropolis), the high rate of home ownership is considered to be the desirable and favoured situation in the housing sector, because, on the one hand, a house is perceived as a dwelling, investment and savings for them and their children, and on the other hand, governments' policies and programmes to provide the rate of housing and to enhance the index of housing ownership are considered a positive policy. Converting housing to a local commodity to be invested in by citizens has driven investment in Isfahan city toward housing properties. Among the urban areas in Isfahan province, the cities of Isfahan, Kashan, Khomeini-shahr, Najaf Abad, Shahreza, Shahin-shahr and Khoras-

gan show land ownership of 37.52%, 6.86%, 5.83%, 5.34% and 3.42%, respectively.

Contribution of residential units of over 15 years old

Compared to other cities in the province, the city of Isfahan currently has the highest proportion of aged residential units (of more than 15 years old), at 43.56%. In the cities of Kashan, Khomeini-shahr, Najaf Abad, Shahreza, Shahin-shahr, Khorasgan, Aran-va-Bidgol, Mobarakeh and Zarrin-shahr, aged buildings comprise 6.23%, 5.92%, 4.91%, 3.20%, 2.47%, 1.60%, 1.58% and 1.56%, respectively.

4.2 Using TOPSIS technique to rank cities in Isfahan province by housing indices

In this study, 39 quantitative and qualitative normalised housing indices were used (Table 1). The most important issue was to properly weight the selected indices. There are various statistical methods to determine the indices' weights. In this study, Shannon entropy was used to weight the indices. In order to state the level of prosperity more accurately and to compare the cities, the weights for the indices calculated by Shannon entropy method were transferred into the TOPSIS algorithm as given weight vectors. Determining the positive and

Table 1. Quantitative and qualitative indices of housing in studied cities in Isfahan province

Row	Indices	Row	Indices
X_1	Average family member	X_{21}	Percentage of residential units containing durable constructive materials
X_2	Density of single family residential building	X_{22}	Percentage of residential units containing semi-durable constructive materials
X_3	Density of residential units	X_{23}	Percentage of residential units containing non-reinforced constructive materials
X_4	Density of people in the room	X_{24}	Percentage of residential units containing steel structures
X_5	Room density in residential unit	X_{25}	Percentage of residential units containing concrete structures
X_6	Percentage of families with 1 room	X_{26}	Percentage of residential units containing land and building
X_7	Percentage of families with 2 rooms	X_{27}	Percentage of residential units containing building
X_8	Percentage of families with 3 rooms	X_{28}	Percentage of rental residential units
X_9	Percentage of families with 4 rooms	X_{29}	Percentage of organisational residential units
X_{10}	Percentage of families with 5 rooms	X_{30}	Percentage of free residential units
X_{11}	Percentage of families with 6 rooms	X_{31}	Percentage of apartment residential units
X_{12}	Percentage of families having electricity	X_{32}	Percentage of non-apartment residential units
X_{13}	Percentage of families having phone line	X_{33}	Average building area less than 50 m^2
X_{14}	Percentage of families having water	X_{34}	Average building area between 51-100 m^2
X_{15}	Percentage of families having gas	X_{35}	Average building area between 101-150 m^2
X_{16}	Percentage of families having central heating system	X_{36}	Average building area between 151-300 m^2
X_{17}	Percentage of families having a central cooling system	X_{37}	Average building area between 301-500 m^2
X_{18}	Percentage of families having kitchen	X_{38}	Average building area more than 500 m^2
X_{19}	Percentage of families having bathroom	X_{39}	15-year-old building
X_{20}	Percentage of families having toilet		

Source: Census of Population and Housing

negative ideal solution for the current research, the relative closeness of the cities to the ideal solution was estimated, and the scores obtained from this process were used as the basis of the city ranking. The cities in Isfahan province are ranked based on housing indices using TOPSIS method in Table 2.

Table 2. Ranking cities in Isfahan province based on housing indices using TOPSIS method

Towns	Coefficient of TOPSIS	Rank	Towns	Coefficient of TOPSIS	Rank	Towns	Coefficient of TOPSIS	Rank
Isfahan	0.813	1	Ardestan	0.03	36	Imanshahr	0.027	71
Dehaqhan	0.186	2	Zavareh	0.03	37	Manzariyeh	0.027	72
Kaashan	0.173	3	Chamgardan	0.03	38	Harand	0.027	73
Khomei-ni-shahr	0.15	4	Dehaq	0.03	39	Ghamsar	0.026	74
Najaf-abad	0.137	5	Karkevand	0.029	40	Mahabad	0.026	75
Shahin-shahr	0.121	6	Meymeh	0.029	41	Segzi	0.026	76
Kelyshad	0.104	7	Zibashahr	0.029	42	Varzaneh	0.026	77
Shahreza	0.092	8	Koshk	0.029	43	Zayandeh rod	0.026	78
Baharestan	0.086	9	Daran	0.029	44	Charmahin	0.026	79
Majlesy	0.082	10	Goldasht	0.029	45	Niasar	0.026	80
Khorasgan	0.072	11	Koohpayeh	0.029	46	Rezvan-shahr	0.025	81
Baharan-shahr	0.072	12	Fereidoon-shahr	0.029	47	Moham-mad-abad	0.025	82
Foolad-Shahr	0.068	13	Damaneh	0.029	48	Jozdan	0.025	83
Dorcheh	0.064	14	Jandagh	0.029	49	Nick-abad	0.025	84
Zarenshahr	0.063	15	Bouin-myandsht	0.028	50	Habib-abad	0.025	85
Golpayegan	0.056	16	Baaferan	0.028	51	Asgaran	0.025	86
Mobarakeh	0.055	17	Joshaghan-va-kamo	0.028	52	Rezveh	0.025	87
Aran-va-bidgol	0.054	18	Dastgerd	0.028	53	Hasanabad	0.025	88
Falavarjan	0.046	19	Abu-Zeydabad	0.028	54	Shadpurabad	0.025	89
Khansar	0.046	20	Komeshcheh	0.028	55	Sefidshahr	0.025	90
Varnamkhast	0.043	21	Golshahr	0.028	56	Khaledabad	0.024	91
Naien	0.04	22	Alavijeh	0.028	57	Nasrabad	0.024	92
Tiran	0.039	23	Afus	0.028	58	Meshkat	0.024	93
Badrod	0.039	24	Noosh-abad	0.028	59	komeh	0.024	94
Baghbahadoran	0.039	25	Vazvan	0.028	60	Hanna	0.024	95
Abrisham	0.038	26	Azeh	0.027	61	Laaybid	0.024	96
Qahderijan	0.036	27	Barzok	0.027	62	Khoor	0.02	97
Semirom	0.035	28	Chadegan	0.027	63	Vanak	0.02	98
Dolatabad	0.035	29	Lenjan	0.027	64	Barfanbaar	0.019	99
Talkhooncheh	0.034	30	Kahrizsang	0.027	65	Farrokhi	0.018	100
Googad	0.033	31	Golshan	0.027	66	Anarak	0.01	101
Pirbakran	0.033	32	Tudeshk	0.027	67			
Khorzooq	0.033	33	Natanz	0.027	68			
Gaz-va-Borkhar	0.032	34	Qahjavrstan	0.027	69			
Dizicheh	0.032	35	Gorgab	0.027	70			

Table 3. Classifying the rate of prosperity in cities in Isfahan province

Rate	Towns
Very important	Isfahan
Important	Dehaqhan, Kelyshad
Partially important	Shahreza,Zarenshahr
Moderate	Golpayegan, Dehaq
Poor	Karkevand, Vanak
Very poor	Barfanbaar, Anarak

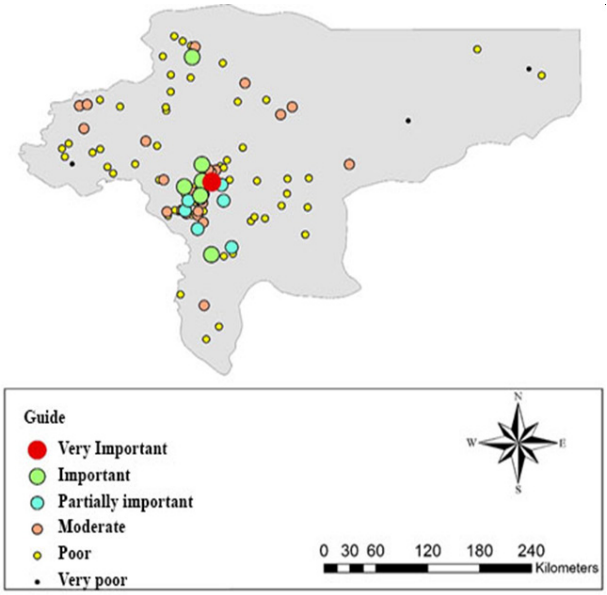

Fig. 1. Spatial distribution of cities in Isfahan province in terms of residential welfare

According to the results of the TOPSIS technique, the cities of Isfahan (0.813), Dehaghan (0.186) and Kashan (0.173) are ranked as first to third places and the cities of Anarak (0.010), Farokhi (0.018), and Barfanbar (0.019) are the bottom-ranked places. To facilitate the evaluation, the cities were classified into six groups in terms of prosperity level and based on the scores obtained by TOPSIS method (Table 3 and Fig. 1). Accordingly, only Isfahan city is ranked first, by the index value of 0.87, and the cities of Anarak (0.010), Farokhi (0.018) and Barfanbar (0.019) are ranked as very poor cities in terms of prosperity.

5. Conclusions

Most previous studies have concentrated mainly on big cities, and particularly Isfahan, to emphasise the importance of housing indices among the province cities. Using this methodology, much useful data buried in the small cities and towns has usually been ignored, which has consequently led to research being superficial and not yielding deep results about the province. The proposed method and the provided results have been innovative and instrumental in terms of gathering comprehensive information for the whole province, while all the cities are analysed statistically using the mathematical model provided in the context. In the present study the level of prosperity of cities of Isfahan province in terms of housing index and definition of inequalities has been analysed and evaluated. For this purpose, a total of 39 indices were collected in the housing section and then the indices' weights were determined using Shannon entropy method. TOPSIS method and GIS software have been used to rank and map the cities. The results show that the cities of Isfahan (0.813), Dehaghan (0.186), Kashan (0.173) and Khomeini-shahr (0.150) are ranked as the first to fourth places. And the cities of Anarak (0.01), Farokhi (0.018), Barf-anbar (0.019) and Vanak (0.020) are ranked in the lasts places. To simplify the evaluation, based on the results of TOPSIS technique, the cities have been categorised into six prosperity groups: Very important, Important, Partially important, Moderate, Poor and Very poor.

In this classification only the city of Isfahan, with the coefficient of 0.813, is placed in the group of Very important, and 6, 8, 24, 59 and 4 cities have been placed in the respective groups of Important, Partially important, Moderate, Poor, and Very poor. These results indicate the inequality and imbalance in the studied parameters and the differences between cities in the province. Given the importance of the issue of housing, and to reach the desired position and remove the existing heterogeneity, it

is necessary to raise the areas in the lower ranks up to a higher position. Considering the different conditions in the province, areas at a similar level do not necessarily exhibit the same natural, economic and social conditions. Therefore it is necessary to provide suitable models for each area in order to improve housing conditions through effective and practical planning. Measuring, evaluating and comparative ranking of the cities of the province helps to recognise and determine the most deprived and prosperous cities, which is an important step in order for decision-makers to be able to provide regional plans and land-use programmes. To do that, the cities with the worst ranks are recognised as the most deprived, and should thus be prioritised in terms of plans and developments.

Overall, according to the data gathered from local authorities, the issue of lack of housing is not quantitatively significant in Isfahan. The problem could be broadly analysed in three parts: 1: Public affordability is limited. 2: Many housing units are used as an investment commodity. 3: Private properties have been restricted for personal use only.

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