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RESEARCH PAPER

Housing renovation priority in the fabric texture of the city using the analytic hierarchy model (AHP) and geographic information system (GIS): A case study of Zanjan City, Iran

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Abstract Housing is one of the most basic needs of humans, communities and civilizations. In complex societies, the renovation of housing to ensure on-going quality and standards of living is a major issue, causing the institution of urban planners and managers. Renovation of housing in the fabric texture of the cities due to the high wear of residential housing units is complicated when residents are of poor economic status, thus the prioritization and preparation of plans for such renovation entails consideration relative to available resources. This article considers all the units located in the fabric texture of the Zanjan as the statistical population using descriptive, analytical workshops and field methods as well as using census method, and utilizes AHP and Idrisi, ArchGIS data to determine statistically 1385 residential blocks, and uses exhaustion software of the residential housing units of the Zanjan fabric texture, in order to identify the residential housing units' need to modernization (renovation). The outcome of the investigation is the housing prioritization for modernization and its display on the map. 17.86% of the residential blocks belong to the first priority, 77.24% to the second priority the rest belong to and the third to fifth priorities. The results of this study can be presented to a broad range of urban managers and planners such as municipalities, housing and urban development officials to be used in modernization programs.

1. Introduction

Housing is one of the most basic needs of human communities' people. Article 31 of the Iranian Constitution specifies it as the right of every Iranian individual and family. Paying attention to the supply of urban housing is a step to supply the social justice and the distribution of the fruits of the community

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growth, and part of the policy of urban development. Under several decades of the impact and effectiveness of new developments in the field of modern urban planning and urban development, as well as modernization caused by distribution of oil rents in Iranian cities, the socio-economic structure of the country has been transformed, with the formation of a new texture with more suitable urban facilities, more efficient communication networks and more polished urban furniture in developed areas alongside a fabric texture lacking suitable urban facilities, poor access to roadways and disorder and the disproportionate problems becoming visible in the underbelly of modern cities as the original inhabitants of old buildings migrated within the cityscape to new housing and residential areas, being replaced in increasingly dilapidated older areas by rural migrants, immigrants and low-income families. Thus the fabric texture, due to of its residents' economic potency (ability), was confronted with a reduction in investment to modernize existing dwellings.

Suitable land for building is becoming increasingly scarce with the soaring global population and increasing environmental protection due to the ecological crisis. Inattention to the existing ground in the fabric texture of housing is unacceptably wasteful, and the unrestrained illegal development of cities horizontally in favelas exacerbates pressures on infrastructure (particularly electricity networks and transportation) and undermines the efficacy of proper urban planning. Lack of attention to the modernization and improvement of fabric textures causes such locales to degenerate into problematic social textures, characterized by rundown and dirty appearance, and becoming sites of poverty, deprivation and crime.

To avoid the development of such no-go areas, government intervention is often necessary to renovate the fabric texture to achieve sustainable urban development. Sustainable urban development as a part of national development as a whole is achieved only when the entire corpus of the city (both the old and new textures) are simultaneously taken into account by planners to promote social justice in the allocation of resources, so cities can perform equally for all residents. However, classifying problem areas itself is a formidable task, given there are about 100,000 hectares of urban residential areas in Iran, with a population of about 12 million people. Governmental investment cannot meet renovation of the large-scale of timeworn and old residential units. This issue needs the detailed and comprehensive study of new systems and methods for prioritizing of residential units, which requires modernization.

To help in this herculean task, GIS software and the Analytic Hierarchy Process (AHP) were used in this study. GIS is a suitable tool for implementing spatial analysis, particularly information processing and map production, and it enables use of the WLC model for integrating and overlaying maps. The AHP model is particularly expedient for the analysis of statistical data. This article was written to attempt to improve the viability level of the fabric texture and to respond to the following questions:

1. How is prioritization of housing modernization applied in the fabric texture using physical indicators?
2. What is the role of physical indicators in determining the exhaustion of old residential units?
3. What is the general condition of housing in the fabric texture of the city?

Since the physical aspect (appearance) of housing is indicative and representative of residents' social and economic status, and the income level, occupation (profession) and social situation of residents is manifest in the physical parameters such as the size of the residential units, building quality and building density etc., the authors performed this research by assuming that it is possible to address housing modernization priorities by implementing physical analysis of housing units.

2. International experience of old texture renovating

Urban planning as a modern discipline arose to meet the pressing and immediate needs of the populations of bombed-out cities across the world in the aftermath of World War II. The prevailing ethos of the postwar period was comprehensive modernism, which dominated the intellectual landscape in all fields. A matrix of factors such as mass car ownership and cost efficiency resulted in the abandonment of the city core and an exodus to modern housing in the suburbs. What remained of the old urban core became a vacuum for the poor and disenfranchised, such as the African-American 'ghettoes' of the US and the 'deprived inner cities' of Europe. The lack of economic potency of the new inhabitants confirmed and accelerated the degeneration of the fabric texture. While slower and later in Iran and other countries of West Asia that did not undergo Soviet planning, the same general process was observed.

This only began to be addressed as an urban planning problem in academia (and not yet in practice) from the 1960s onward, and that was on the grounds of architectural preservation rather than socio-economic justice and general development. Venture (1960) criticized modern architecture and urban development as the main cause of the destruction of the old and the historical textures, and Sidler (1964) compared the urban development to premeditated murder, indicting modern urban development by comparing new housing and existing housing in the old and historical parts of the city's using photos and authentic documents. While such critiques were essentially esthetic, they did halt the tide of the unspoken abandonment of the city core, and gradually reoriented urban planning toward a more holistic and coherent approach to strengthen the values of existing fabric texture. Early efforts included the modernization and improvement of the fabric texture in the UK cities of Leicester, York, Bath and Chester, mainly on the initiative of local town planners and architects, while a more regulatory response was evoked in other countries.

In 1962 France adopted the André Malraux law tried to prevent the destruction of fabric textures, instituting a classification of buildings as those which: (a) certainly should be refurbished; (b) should be protected; (c) should impose some changes in performance, form and function; (d) and can be demolished due to reasonable and analytical reasons. Similar codes were applied in programs of renovation and improvement in Toronto and Stockholm during the 1970s, and Bologna and Athens in the 1980s. Likewise, in Iran some measures were gradually implemented concerning the renovation of the residential housing and some regulations were adopted, including:

1. The implementation of more than 700 repairing projects in more than 350 historical buildings in the fabric texture.
2. Improvement and modernization project of the Old Zanjan parish in Tehran.
3. The creation of the Maskan Sazan company of development and improvement (for involvement in the urban textures from design to implementation)
4. Article 111 of the municipality (supplementary of the mentioned rule of 1966) to purchase lands for the modernization and improvement.
5. Modernization Act on Urban Development, adopted in December 1327 [Iranian].
6. Article 62 of the low of the fourth plan of redevelopment of the country.

3. Literature review

Since the pioneering efforts of the 1960s and 1970s, a rich and flourishing field of research has emerged concerning housing renovation and urban development generally. One major theoretical development that has continuously nourished the field is the AHP model, initially developed by Thomas L. Saaty in the 1970s and extensively studied and refined since then, with particular prevalence in group decision making (Saaty and Peniwati, 2008). This section presents a review of the major developments in the literature concerning urban fabric redevelopment, particularly concerning Iran.

Rajabi et al. (2015) used AHP and GIS to identify priority areas of old texture case study in Isfahan district 7, according to the standard criteria such life impermeability and instability. The results showed that AHP model integrated with GIS is an optimum method to classify urban textures, and it highlighted the priority of renovating the old texture of Isfahan district 7. Rashidi et al. (2012) used AHP to study sustainable development and prioritization to improve 'urban effete fabrics' in Isfahan city to identify and rank the sustainable development components influencing on the economic, social and physical improvements and the condition of access. The obtained results indicated that economic factors with 0.131 weights have the most effect on the improvement of effete city fabrics. This article stated that AHP model is a suitable method upon which to base final decisions and specify the preferred options among the different criteria.

GIS and multi-temporal satellite imagers was used by Ahadnejad Reveshty (2011) to assess and predict changes in urban land use in Zanjan during the period 1984–2011, particularly to explain the rate and type of change in land use using TM sensor satellite imagery of land sat and fuzzy art map classification method combined with cellular automata and Markov Chain analysis to forecast human impacts on land use change until 2020. The results of the study disclosed that land use in about 44 percent of the total area had changed, particularly the change of agricultural land, orchards and bare land to settlements, construction of industrial areas and highways. This article highlights the necessity of renovation of Zanjan fabric texture in order to avoid uncontrolled horizontal growth, the destruction of agricultural land and escalating pressure upon and costs of municipal services in the suburbs.

4. Principles of renovation (modernization)

Renovation (modernization) is relatively easy to implement, in terms of upgrading the urban space, complex or building, but doing so efficiently and sustainably in terms of relative physical-spatial erosion caused to urban fabric and efficiency of use and cost is a more complex affair. Renovation includes same measures alongside the protection of the old building, complex or urban space, with up-to-date spatial organization and optimal performance. In other words, modernization, namely the revitalization of the building constructions, operations or processes to remove signs of damage, exhaustion and destruction, is synonymous with the concept of new re-construction and re-building. Modernization includes seven categories of measures: urban revitalization, "adaptation, updating", "conversion, transformation", conservation, renewal, "restoration" and "repair".

5. The necessity and importance of housing renovation in the fabric texture

Housing planning is a part of the urban planning system, and as such it should be a dynamic, continuous and rotational process. It should always be based on social and cultural trends and inspired social change. A special kind of housing planning can be successful and efficient that precisely considers the dimensions and perspectives of all users of the housing area and urban area. Inattention to the physical dimensions of housing, whether in the scale of architecture or in the scale of urban planning, impose great damage and enormous costs for society. Modernist new cities and large residential blocks and units for example generally failed to replicate the social fabric of traditional urban communities in British urban development during the 1950s–1970s, and were unable to absorb the needy population into such housing successfully; despite the underlying shortcomings in the housing sector (i.e. high demand for homes), the new founded cities operated very weakly and soon came to be associated with social deprivation and crime. This was due to the underlying incompatibility of the architecture and urban development of the new cities with native architecture and modes of housing recognition and living.

If housing planning does not have enough flexibility to match and balance the contemporary needs of inhabitants within the framework of the broader national culture, the best theoretical projects of urban development and housing (as evidenced in modernist projects) will fail. It is possible that instead of creating new cities and unrestrained horizontal expansion of housing units in the space, and creating uniform buildings in the new cities, urban planners should pay greater attention to the renovation and improvement of residential units in the existing fabric texture, and create residential units according to the national culture and in accordance with the new knowledge and developments by artistic integrating of modern and traditional architecture. In this way, the waste of resources and facilities will be prevented. New cities constructed on greenfield land squander valuable farmland or natural habitats and entail massive investment in urban amenities (e.g. roads, streets, water, sewage, gas and transportation etc.) that could all be achieved more affordably and with less impact by careful redevelopment of existing urban fabric.

However, the infrastructural dimensions of housing are ultimately more straightforward than the social, which are ultimately more important in planning housing in the fabric texture (e.g. failed modernist settlements were fully equipped with generally improved infrastructure, but they failed to take root as living urban communities). The present problems and issues in the fabric texture of cities, such as accelerating the destruction of housing, have themselves been driven by a series of social factors and events that caused the failure of the old fabric. Historically, residents of cities were generally proud of their residential 'parish' as the core of civic pride and identity, but today people have little affiliation to such communities (real or imagined), which makes it easy for them to disconnect from fabric textures and attach themselves to new locales. This is both caused by and contributes to low quality, lack of suitable urban infrastructures and lack of investment in the fabric texture.

Another people-centered issue is the economic viability of the fabric – not in terms of urban investment (in infrastructure etc.), but household aspects of the cost of housing, rent, amenities and access to employment. Since providing service with efficiency and advantage equal to zero, such as social protection of the poor and the needy of the community and preparation the housing for poor is assigned to the government, construction and reconstruction of housing for ineffective poor in the fabric texture would be justified by seeking for social and cultural goals and social balance creation.

6. Case study area

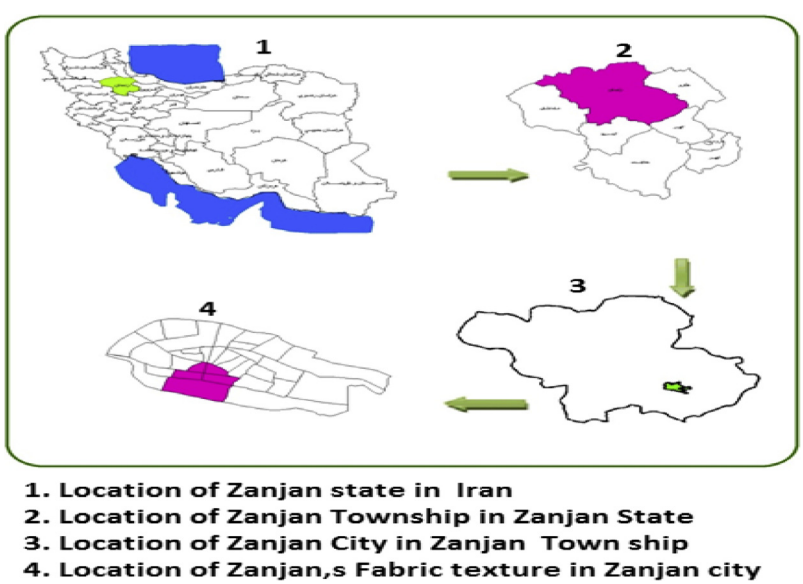
The fabric texture of Zanjan, which is studied in this research, was established during the late Qajar period. Based on the implemented studies, the studied area is bounded by Beesat Street from the north, Khayyam Beltway from the south, Azadi Boulevard and Jomhoori Avenue to the east and Shohada and Babaei from the west (Map 1). This area coincides with parish number 1 of the detailed plan with the exception of District number 5 (which mostly comprises orchards and protected lands). Based on the estimation made in 2004, 35,311 people inhabit the study area. Saadi and Emam streets divide the study area into four areas. In the study there are 11,805 blocks with different functions/uses, 53.3% of which have a residential function, 27.7% have a business function, and 9.2% have mixed residential-business function (Map 2). Data from the block functions show that buildings aged 20–30 years old comprise 43% of all buildings, and buildings less than 5 years old comprise only 4.8% of all buildings (Table 1). The skeletons of the buildings mainly comprise unstable materials. Brick and iron skeletons are used in 46% of buildings, and 37.3% of them are formed from brick and wood (Table 2). The population density in the study area is 117 persons per hectare, which is a high number compared with other areas.

Housing units of the texture are classified into different groups according to their area. Buildings of 100–200 m^2 comprise 41.6%, and those with less than 100 m^2 account for 22.8%. Only 3% of buildings are larger than 1000 m^2 (Table 3). The data for the following tables are derived from field data and primary results of the detailed revision plan of Zanjan city.

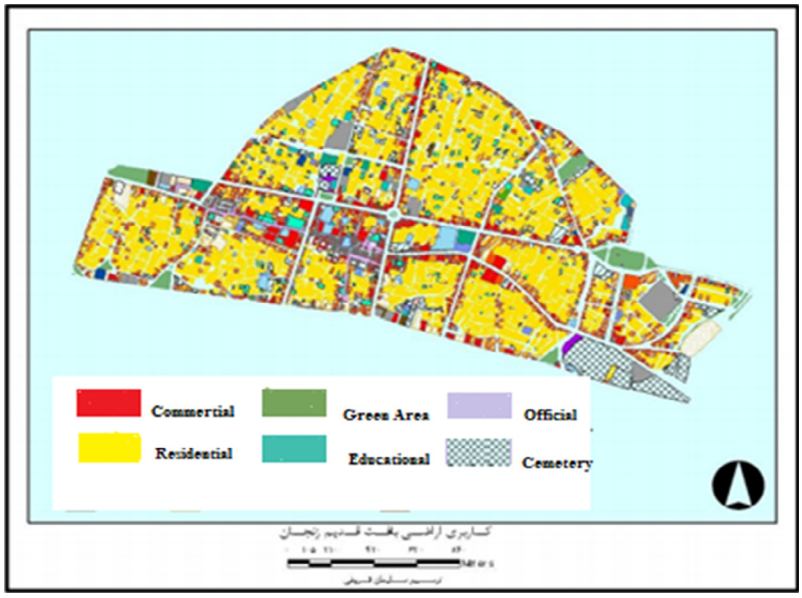
The only significantly aged architecture (early modern) is from the Safavid period, including a caravansary, laundry, finance mansion, central mosque, Abasgholi Khan Mosque, the home of Tofighi and the school of Ahriati. The fabric texture of Zanjan is divided into two parishes with different economic features and social situations: they are Eshagheh Bash and Youkhari Bash. The access road network is based on a special hierarchy. It begins with a dead-end standoff that connects narrow residential units to each other and terminates in wider alleys. The intersection of the alleys forms the center of the parish, which contains of the elements such as mosques, other religious centers, retail shops and squares (Meshkini, 2007).

7. Methodology

Since the purpose of this study is to provide a method for priority of housing renovation in the fabric texture of Iranian



Map 1 Location of case study.



Map 2 Land use map of Zanjan fabric texture.

Table 1 Age of the buildings in the fabric texture of the Zanjan (excluding commercial spaces).

Sum	Percentage	100
	Number	8333
50+	Percentage	15.8
	Number	1318
30–50	Percentage	14.7
	Number	1222
20–30	Percentage	44
	Number	3674
10–20	Percentage	14
	Number	1171
5–10	Percentage	6.4
	Number	532
5–	Percentage	5
	Number	416

Table 2 Building floors in the fabric texture of Zanjan.

Sum	Percentage	100
	Number	11106
6+ floors	Percentage	0.06
	Number	7
5 floors	Percentage	0.2
	Number	22
4	Percentage	0.7
	Number	76
3	Percentage	2.9
	Number	321
2	Percentage	18.5
	Number	2061
1	Percentage	77.6
	Number	8619

Table 3 Classification of residential units in fabric texture of Zanjan (m^2).

Sum	Percentage	100
	Number	6297
1000+	Percentage	0.35
	Number	19
500–1000	Percentage	2.5
	Number	161
400–500	Percentage	3
	Number	191
300–400	Percentage	8
	Number	498
200–300	Percentage	21.8
	Number	1373
100–200	Percentage	41.6
	Number	2621
0–100	Percentage	22.8
	Number	1434

cities, the statistical population comprises all of the fabric textures of national cities; among them, the fabric texture of the Zanjan city was selected as a case study for this paper, based on a systematic approach of applied research. The data were collected based on the library method and use of statistical and map sources such as statistical blocks of the Zanjan city, applied map of the lands and detailed plan approved in Zanjan. The basic steps of the research are as follows.

7.1. First step

Preparation of attribute table of Zanjan fabric textures base map, based on the Zanjan statistical block data in Arc map environment (Fig. 1).

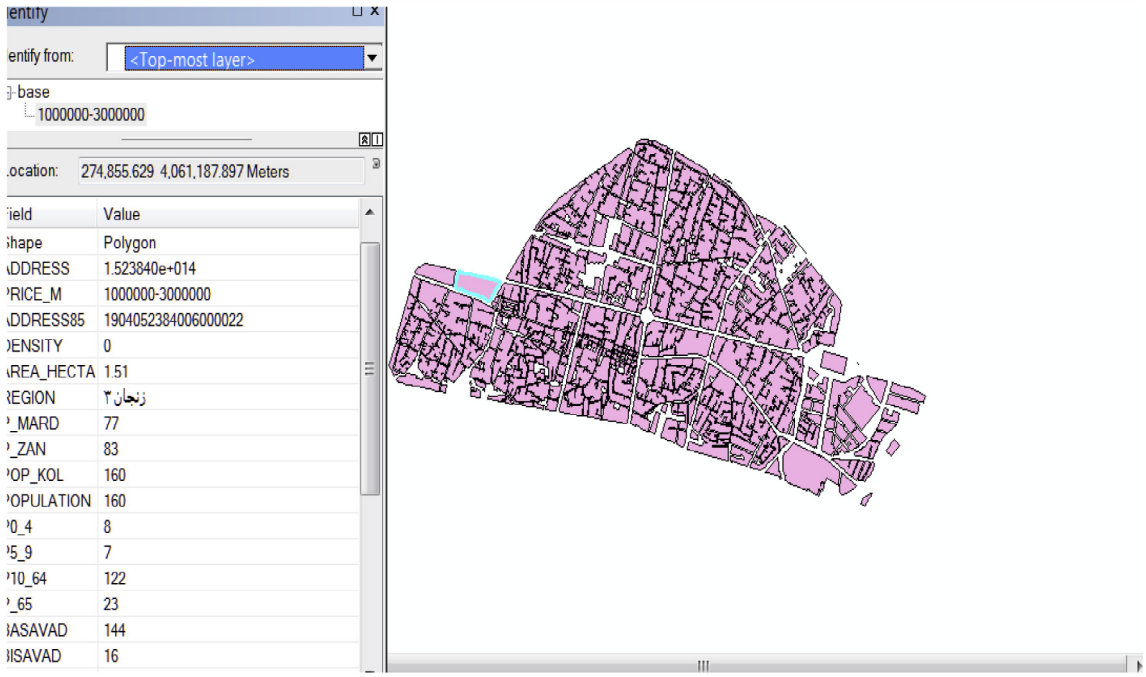


Figure 1 Preparation of attribute table in Arc map.

Table 4 Random index.

n	15	14	13	12	11	10	9	8	7	6	5	4	3	2
RI	1.59	1.57	1.56	1.48	1.51	1.49	1.45	1.41	1.32	1.24	1.12	0.9	0.58	0

7.2. Second step

Preparation of the thematic maps based on the required attributes according to the Category of Arc GIS software (maps of building age, quality, structure type, density, and floors number).

7.3. Third stage

Allocation of the preliminary weight to the layers according to the expert opinions in the Arc GIS software environment; division of the layers into five classes and weight of 1, 3, 5, 7 and 9 (Table 4).

7.4. Fourth stage

Converting all polygon-based vector format layers to raster format, because the AHP model in Idrisi Silva software is performed on the raster layer, and overlaying of layers to make the final map is possible by this format (the value field for this conversion is AHP weight, with cell size equal to 7.2) (Fig. 2).

7.5. Fifth step

Entering of all Raster layer into the Idrisi software environment, and performing the analysis steps of the AHP model using the weight tool. At this stage, the relative importance of each criterion in proportion to its importance in the process of modernization priorities will be determined according to the expert opinions, and based on the relative importance of each of the indicators in the weighting matrix the weights will be entered. Idrisi is considered as important software to process the Raster image. This software has the ability to perform multiple criteria and analysis to represent results as maps, tables or graphs. For example, AHP model is one of the Idrisi tools that automatically calculates the final weight of each criterion and consistency ratio in order to know whether the calculated weight is reliable or not (Table 6).

7.6. Sixth step

Estimation of the agreement consistency ratio. At this stage it will be determined whether the comparison made between the criteria is compatible. This step includes the following phases:

1. Determination of the vector of sum of the weight by multiplying the first criterion in the first column of the original pair wise comparison, then multiplying the second criterion in the second column; the third criterion in the third column of the original matrix and so on, until multiplying of seventh criterion in the seventh column of the original matrix and finally summing the amounts in the rows (Table 4; Zabardast, 2001).

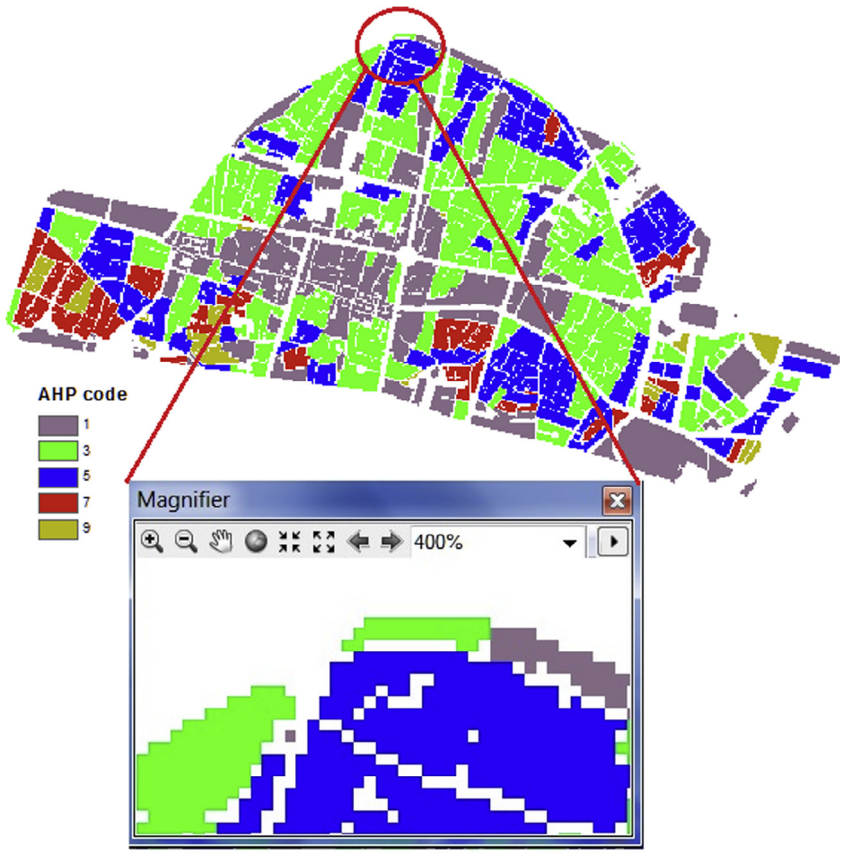


Figure 2 Raster format of building density.

2. Determination of the consistency vector by means of division of the vector of the total weight on the index (criterion) weights determined previously. After calculating the compromise vector, we need to calculate the values of two terms: (λ), which is equal to the average of the consistency vector, and consistency index (CI), which is obtained from the following formula (Saaty, 1980):

$$\mathrm{CI} = \frac{\lambda - n}{n - 1}$$

Likewise, the consistency ratio (CR) can be calculated by the following (Saaty, 1980):

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}}$$

where RI is a random index which obtains for different values of the criteria number (n) shown in Table 5. CR is designed such that if CR 0.1 $\geqslant$, it shows the consistency-able level.

7.7. Seventh Step

Integration of the maps in the Arc GIS software environment based on the calculated weight of the Idrisi software. Then obtained maps are reclassified using the Reclassify order. After reclassification, the resulting map will be a map of the housing renovation prioritized in the fabric texture (Map 3).

8. AHP model analysis

As explained previously, this research evaluates the residential units of the Zanjan fabric texture in order to prioritize the modernization and improvement. For this, purpose the basic map of the Zanjan fabric texture was prepared. Since our research operations were implementing only on the residential units, in order to omit other functions such as commercial, religious and health etc., other functions were omitted from the research process through the "category" of the GIS software. After preparation of the required layers such as the quality, the lifetime of the building and types of materials etc., the weight was allocated according to expert opinions (Table 5), then the layers were converted into grid format and ASC in the ARC VIEW software environment. Finally, in the Idrisi software environment, the expert opinions and AHP was used to allocate weighting (Table 6). To determine the accuracy of AHP weights (prepared based on the expert opinions) and to regard the consistency in the adjudications, the consistency ratio was estimated using the following:

$$\mathrm{CI} = \frac{\lambda - n}{n - 1} = \frac{7.25 - 7}{7 - 1} = 0.041 \qquad \mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} = \frac{0.041}{1.19} = 0.02$$

Table 5 Weight of the sub-criteria based on AHP.

Indicators	AHP weight	9	7	5	3	1
Age of the building blocks (yrs)	< 5					*
	5–10				*	
	10–30			*		
	30–50		*			
	50^{+}	*				
Material of the block skeletons	Concrete					*
	Metal				*	
	Brick & iron			*		
	Brick &wood		*			
	Brick & mud	*				
Building density of the blocks	0–40					*
	40–80				*	
	80–160			*		
	160–320		*			
	320^{+}	*				
Quality of the building blocks	Under construction					*
	Newly constructed				*	
	For repair			*		
	Maintainable		*			
	For destruction and ruin	*				
Number of floors	0	*				
	1		*			
	2			*		
	3				*	
	4^{+}					*
Blocks separation (block size)	0–100	*				
	100–200		*			
	200–300			*		
	300–400				*	
	400^{+}					*
Occupation area of the block	0–100	*				
	100–200		*			
	200–250			*		
	T0 500				*	
	500^{+}					*

Table 6 Matrix of pair-wise comparison of the evaluation criteria.

Criteria	Skeleton material	Lifetime of the building block	Building quality	Floor number	Occupation area of the building	Building density	Block separation	Unmoral weight	Final weight
Skeleton material	1	9	9	9	9	9	9	7.225	0.458
Lifetime of the building block	0.11	1	2	2	3	3	4	2.163	0.176
Building quality	0.11	0.50	1	2	2	3	3	1.568	0.099
Floor number	0.11	0.50	0.50	1	2	2	2	1.231	0.085
Occupation area of the building	0.11	0.33	0.50	0.50	1	2	2	1	0.074
Building density	0.11	0.33	0.33	0.50	0.50	1	2	0.803	0.063
Block separation	0.11	0.25	0.33	0.50	0.50	0.50	1	0.625	0.045

Since the consistency ratio is less than 1.0, the weights were accurate and had the necessary scientific accuracy. In the next step, using the calculated weights is integrated in the Idrisi software environment using the WLC model and weights of AHP of the layers (Map 3).

9. Results

The final map (Map 3) revealed that 2018 residential units (17.86%) belong to the first priority for renovation; 9118 (77.24%) belong to the second; 553 (4.68%) belong to the

Map 3 Final map of the housing renovation priority in the fabric texture using the AHP model and GIS.

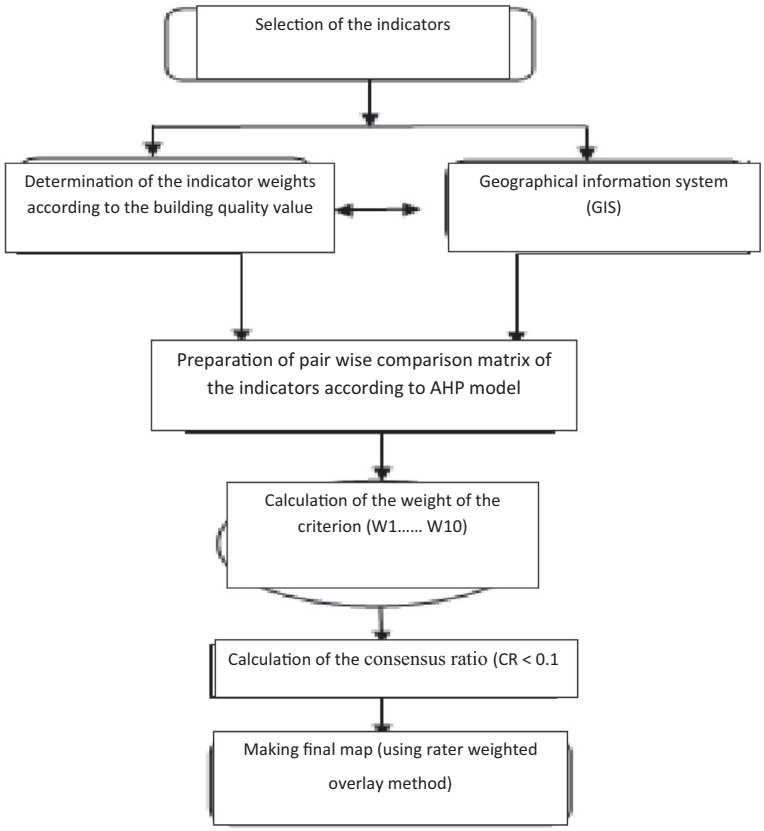


Figure 3 Process of the research implementation using AHP model and Arc GIS program.

third; 12 (0.17%) belong to the fourth; and three units (0.2%) belong to the fifth. It can be seen that the vast majority of the residential units belong to the second class, which reflects the events of recent decades, including migration from the fabric texture and lack of interest in modernization among the residents. The buildings located in the third category are units renovated or constructed in recent years that do not generally need modernization or improvement.

By studding the data distribution it can be seen that most of the residential units are away from the normal limit; that is, the majority of the data pertains to the first and second groups. This is indicative of the high deterioration of the residential units in the fabric texture, which need urgent renovation activities. Likewise, placement of very few and insignificant proportions of units in the fourth and fifth groups is due to the lack of the renovation and repairing (of the residential units) activities due to the social and economic conditions. This fact indicates that government intervention in building renovation issues is essential (See Fig. 3).

10. Discussion and conclusion

This research can help the custodians (authorities) and city managers (such as housing foundations) to modernize residential units and allocate funds in this sector associated with social justice, creating circumstances whereby residents can benefit from governmental support based on equality and in accordance with the economic needs of residents, which means that the individuals and the families that are living in smaller, more dilapidated and nonstandard houses must be targeted for more planning and intervention.

Conflict of interest

None.

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