

Investigating Urban Expansion and Its Drivers in Ardebil

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ABSTRACT: The expansion and growth of cities is a remarkable phenomenon in urban planning literature, so that unpredictable developments have become more evident in recent decades, especially in cities that have undergone changes in their physical structure following the promotion of their political role. The present paper seeks to identify the factors driving growth in the developed areas of Ardebil city and extract basic factors and variables by investigating development of Ardebil. In this study, 27 variables have been tested in 920 expansion blocks during the years 1996 to 2011 using GIS and factor analysis. Four main groups including congestion factor, external factor, access factor and facilities are identified as driving forces of growth. The final combination of four factors in the Arc GIS environment show that the north, east and south east blocks of Ardebil had a higher score than the other blocks; in other words, these factors have the most effect on the growth of these areas. In addition, the Southwest blocks with the lowest score of between 0 and 2 have had the least impact from among the factors mentioned.

Keywords: *Urban expansion, Growth factors, Factor load, Factor analysis*

INTRODUCTION

When cities face rapid growth due to various factors such as changing economic and political or social roles, they undergo many changes in terms of their spatial structure. This phenomenon has been particularly noticeable in recent decades due to the overwhelming growth of urban populations and increased urban migration. In this process, cities are affected by multifaceted urban growth factors and, in a short time, natural areas become urban lands. In the meantime, some factors such as population growth, urban road network, and land use change, government policies, and market trends have more influence on the shape and extent of these changes.

According to Clark's theory, urban growth is a spatial and demographic process. Urban growth occurs when the distribution of population from a large village often changes to urban homes and towns. On the other hand, urbanization is a non-spatial and social process that addresses social relations

and behavioral changes that occur in the social dimension (United Nations, 2005a). Urban expansion is characterized by undeveloped parts that are converted into developed parts, and this kind of growth is not surrounded by more than 40% of the developed parts (Wilson et al., 2003, 275-285).

Suburban development is characterized by a change from underdeveloped land to developed one, which occurs outside existing developed domains (Wilson et al., 2003, 275-285). This type of development was called the out-of-town development (Heimlich & Anderson, 2001, 88). Suburban growth is divided into three separate and isolated branches, linear growth and cluster growth (Wilson et al., 2003, 275-285).

Urban planning has a duty to minimize the negative effects of urban change by deliberately guiding and controlling the city when cities are changing. Currently, a decision-making system for the expansion of cities does not use a comprehensive model or process that includes all affective factors. In such a situation, the growth of cities and the changes in their spatial structure

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occurs in a complex and multifaceted system of uncontrollable and unpredictable economic, social and political factors. The present research seeks to identify and analyze effective factors by reviewing and developing the theoretical framework in relation to urban growth.

The city of Ardebil is one of the cities in Iran, which has been experiencing rapid growth in recent decades due to its spatial and political situation. It is such that the city's boundaries have increased about twice from 1996 to 2011. This has resulted in the construction in a large part of the agricultural land surrounding the city. Therefore, this research seeks to investigate the causes and factors involved in urban growth in the city of Ardebil. In the present research, the relevant theories and experiences in the field of urban growth and development and its effective factors are first studied and then, the theoretical framework of the research is presented. In the following, by familiarization with the city, introducing effective factors, and performing factor analysis, factors that influence the growth and development of the city are introduced.

MATERIALS AND METHODS

Reviewing the Literature and Extracting Factors Affecting Urban Growth and Development

Urban growth is a relatively time-dependent term. Newly developed units will be changed to the built urban area in terms of performance after a certain period of time. These changes are due to various causes and factors. However, a comprehensive theory that can introduce all the triggers is not developed. Different thinkers have introduced a number of causes by examining one or more specific examples.

Jianquan Change and Lan Masser (2003) discussed the many factors influencing urban growth. They believe that decision-making is difficult for local planners because of the complex urban growth process. By providing a spatial analysis of data for the main factors influencing urban growth, they have been focusing on modeling the growth of Wuhan City between 1993 and 2000. In this model, data analysis and spatial logic regression have been used. This model is able to clearly show the spatial effect of each variable and compare the effects of variables. The results of this study showed that during this time period, urban roads and developed areas have had the greatest impact, and comprehensive plans are losing their role (Change & Masser, 2003, 199-217).

Plemenz and Romani describe five factors that can be effective in the process of urban expansion and development: biophysical factors such as gradients that can affect the desirability of the position of a particular land use, and are often considered in the form of land use change that predict land changes in rural areas. Social factors that can be included in urban growth models by simple indicators such as population density or racial fabrication and the average income of people and the third is economic factors that are often considered by accessible indicators such as distance from the city center, distance from the road network and distance from water resources; these variables can be considered as an alternative variable for

job accessibility and employment. The fourth one is spatial policies that widely control urban development at national and regional levels, especially policies that design protected areas with land reserves or designated areas, and the last one is inter-neighborhood interactions of different land uses (Majed et al., 2012, 50-52).

Geshkov (2010) introduced three factors of housing prices, population growth, and increased transportation costs as the reason of growth by examining 182 urban areas from a total of 465 urban areas in the United States and reviewing opinions of thinkers such as Whiton, Brookner, Milles and Moss (Geshkov, 2010, 5-6).

Bhatta (2010) introduced a group of factors including the growth of population, economic growth, industrialization, legal disagreements, affordable housing shortages, roadside widths, single-family homes, capital and credit trade, lack of proper planning policies, failure to implement planning policies, and large scale land by examining the uncontrolled growth of the Pimpri-Chinchwad area (Bhatta, 2010, 172).

From the point of view of Olajoke, many factors are causing urban growth, one of the most important of which is the increase in population. In its review of urban growth, he has addressed urban growth and its factors in Ogbomosho city in Nigeria between 1914 and 2003. Studies have shown that the population of the city has risen from around 80,000 in 1914 to more than 12 million in 2003. The growth of the city has been in all directions, but most of the major developments have taken place in the north of the city, i.e. where most of the land was for the state (Olajoke, 2007, 223).

Barnes et al. have identified five types of determinants including the desire to live in the countryside, property investment, land use policies, physical geography, and services (Barnes et al., 2001).

Hasse (2002) describes more than ten factors of the causes of urban growth that can be considered as land use densities, mutated development, development of distinct and separate uses, inconsistent development with regional planning, strip development along highways, new road network efficiency, access to important social nodes, expansion to sensitive and protected open spaces, and more. He studied growth in New Jersey in three areas, including Califern, Rydington and Alexandria (Hasse, 2002, 6-27).

The Methodology Framework

The present study aims to investigate the factors affecting urban development. In order to achieve the research objective, the research method is the meta-analysis method based on the secondary data calculated in the city. First, various factors resulting from literature and texts were extracted in six environmental, physical, social, economic, political and managerial groups, then, with regard to availability, it was possible to measure and be precise, and measurable indicators for the city were extracted.

So, in the first step, the growth and expansion of the city between 1996 and 2011 was examined, then the areas expanded

during this period were extracted in the Arc Gis environment. In the next step, modeling in Model Builder environment was done based on each factor in the new block. Then, each single factor became quantitative and measurable to be used for factor analysis in the SPSS environment. Finally, the importance of each factor was obtained.

Urban Growth in Iran and its Review in Ardebil

Many of today's cities were rural centers with a core of agriculture. These centers have grown over time and have become a city by attracting the population, and now the country faces cities that are widespread on the richest agricultural soils and, with increasing expansion, are destroying the gardens and agricultural lands around them. They are damaging the environment by contaminating surface water and underground water. A look at the statistics of urbanization in Iran shows that the population of Iran in 1901 was about 7 million people raising to over 79 million in 2016. In addition to increasing population in each period of census, we see an increase in urban population and a decrease in rural population, reflecting the increasing expansion of cities. The city of Ardebil has not been the exception, and during the years 1996 to 2011, the city boundary has doubled. The study of the development of the city shows four important periods in the city's development. The first is city's primary nucleus that dates back to 1975, which dates back to the Sassanid period or even before it. The second part, from 1975 to 1980, is a period when the city has faced a rapid growth, a part of which is continuous and a part is sporadic, and the city has grown by 250 hectares that is a significant figure for a period of five years. The third period was from 1980 to 1990, when vacant land between the scattered and continuous expansion of the city has been added to the city boundaries. In essence, the present form of the city is due to the expansion of the city during this period and the city has grown from 1,650 hectares in the previous period to 3120 hectares. The last period occurred between 1991 and 2011, when the city has faced considerable growth with a number of fundamental changes, including being provincial capital, the strengthening of the tourism sector, and so on. Accordingly, the city of Ardebil has been selected as a case study to avoid the unnecessary developments by extracting the causes and factors involved (Tarh and kavosh Consultant Engineers,2011). (Fig.1)

Introduction of Factors Affecting Urban Growth

In order to measure factors influencing urban growth based on the specific considerations and circumstances of each society, the criteria and indicators related to it should be used. Based on the texts and theories examined, in the first place, the main causes and factors of urban growth were identified. Then, based on the layers' availability, case-specific conditions and data with quantifiable data were identified in four main groups. Each of the factors in the next step will be tested and evaluated using factor analysis in each of the extended blocks. (Table 1)

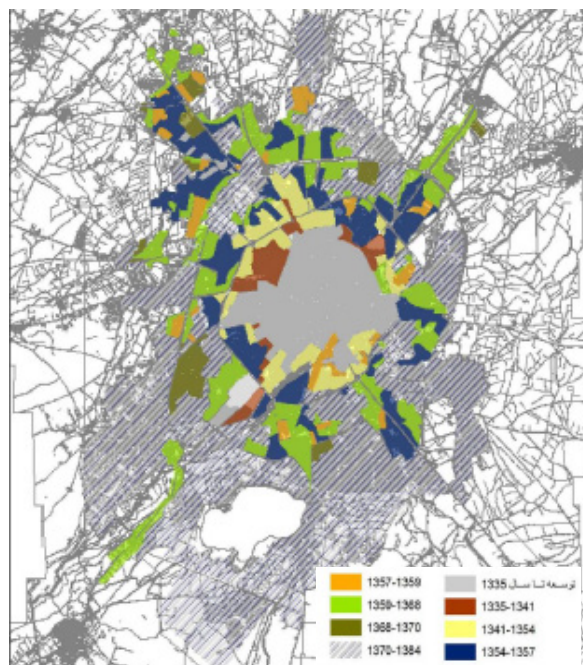


Fig. 1: The trend of Ardebil city growth

RESULTS AND DISCUSSION

Using Factor Analysis and Extracting Factors Affecting Growth Factor analysis is a method for analyzing urban issues in which the goal is to summarize the data and transform them into the main factors, provided that the main data is not lost. Factor analysis is a multivariate method in which independent variables and dependent variables are not considered. This method is not considered as an interdependent technique, and all variables are interdependent and try to summarize a large number of variables in several key factors, which is one of the main advantages of this method in comparison with similar methods. In this way, the hidden connection between all variables is established and ultimately the most effective factors that have greater explanatory power than others are identified by the urban planner. So that without the use of factor analysis, the human mind is not able to identify these complex relationships. On the other hand, the powerful techniques of this method distinguish it from the application of individual expert opinions and replace mathematical logic and accurate statistical tests (Zebardast et al., 2013, 34-35). This technique makes it possible to reduce the number of dependent variables to fewer factors. The purpose of factor analysis is to identify factors based on a set of related variables. In general, the steps involved in factor analysis are:

Step one: Formation of the initial matrix

The first step in the factor analysis method is to form the initial information matrix after extracting the desired indexes from

Table 1: Causes and Factors of Urban Expansion

| Main group | Factors | |
|------------------------------|--|---|
| Environmental-natural | Protected areas, slope, topography, river and fault | Hasse(2002), Cheng and Masser (2003), Bhatta(2010), Majed et al(2012) |
| Physical | Industrialization (the establishment of industry in a range), the possibility of expansion in arid lands, limitation of artificial limits, size of parts, average size of blocks, concentration, clustering, building density, centralization, mixing usage, single-family houses (one story), continuity, centrality (road density), infrastructure network, lack of open space, expansion to sensitive and protected open spaces, strip development along highways | Cheng and Masser (2003), Hasse(2002), Bhatta(2010), Majed et al(2012), (Barnes et al (2001 |
| Economic | Price and value of land, distance from the main roads, distance from the city center, access to work and employment, industrialization, ownership, expansion of the basic economy, the expectation of increasing land value, more welfare facilities, continuity, clustering, nuclear or polarization, and proximity | (Geshkov (2010), Barnes(2001 Bhatta(2010), Cheng and Masser (2003), Olajoke(2007), Geshkov(2010 |
| Demographic-social | Population changes, population density, population growth (natural and migration) and net population density | Olajoke (2007), Barnes et al(2001), Bhatta(2010), Cheng and Masser ((2003), Majed et al(2012 |

the theoretical literature. In this research, 943 urban blocks added to the city boundaries in recent decades are considered as matrix rows and 34 factors affecting the growth of Ardebil are considered as matrix columns forming the primary matrix of information. As mentioned earlier, the different layers required for each part of the model were identified. These layers cannot be used alone and in raw form, but should be processed. Therefore, in order to prepare many layers in this model, fuzzy properties were used in the GIS environment. Finally, the numerical values of each index were extracted. Given the varied units of the variables examined, the original matrix is standardized to be applicable to the factor analysis environment.

Step two: Investigation of the shared values of each variable with other variables

One of the first outputs of the factor analysis method is the table for each variable’s shared values, which shows how much is the shared variance of a variable with other variables used in the analysis. The higher its rate is in each index, the indicator shows that it is more relevant to other indicators used. At this stage, in order to identify the most relevant indicators, 7 indicators were eliminated from the calculation process to increase the KMO amount and model's explanatory power. In this research, the first factor analysis was performed with 34 indicators, and seven indices such as continuity and clustering were eliminated due to the low KMO value, so that the shared values are higher and the KMO value would reach the desired level.

Step three: Bartlett Sphericity Test and Correlation Matrix

One of the methods for selecting the appropriate variables for factor analysis is using the correlation matrix. Since the basis of the factor analysis method is based on the correlation, but non-causal, between the variables, the correlation matrix between the variables should also be calculated in the use of this method. Usually, these correlation matrices show the relationship between some variables and their lack of relation to others. Typically, variables that do not have any necessary correlation with other variables are removed from the analysis. Therefore, the first output of the factor analysis procedure is the correlation coefficient matrix. In this regard, if the matrix determinant is less than .00001, it can be assumed that the matrix is not encountered with the "multiple co-linearity" or "one-linearity" phenomenon and the data are suitable for continuing analysis .

The Bartlett test value should not exceed .05 and the KMO value should be greater than and equal to .6. It should be noted that values less than .5 are not acceptable for KMO and indicate the impossibility of using factor analysis with the data used (Zebardast, 2013, 1339)(Hekmat Nia et al,2013,247).

On the other hand, Bartlett's test should be used to ensure that the data are appropriate for factor analysis. Bartlett's test examines the hypothesis that the matrix of observed correlations belongs to a society with unrelated variables. For a factor model to be useful and meaningful, variables need to be correlated. In the test of case variables, the KMO test is equal to .698 and its sig is zero. (Table 2)

Table 2: Kaiser-Meyer-Olkin and Bartlett values

| | | |
|---|--------------------|-----------|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy | | .698 |
| | Approx. Chi-Square | 13803.683 |
| Bartlett's Test of Sphericity | Df | 351 |
| | Sig. | .000 |

Step four: Investigation of explained variance and determination of the number of selected factors

After the control and fitness of the relevant statistical tests that test and measure the raw data for use in factor analysis, the initial calculation matrix is calculate, in which the variance explained by each factor is determined. In other words, the corresponding matrix shown in the form of the explained variance table clearly indicates that the outcome of the factor analysis in reducing and summarizing the indicators and factors has led to several final factors, and more importantly, the contribution of each of the factors in affecting growth. This table is presented in two parts. The first part is related to the contribution of each factor before the application of the varimax rotation, and the second part after the rotation and the final distribution of factors score after the investigation of the relationship and the correlation of each index with the relevant factor. The review of the topics shows that the four final factors are known as effective factors in the city. The reason for this is that the eigenvalues of each of the four factors are above 1. (Table 3)

Step Five: Calculating the rotated factor matrix and determining the relationship between indicators and selected factors

At this stage, after determining the variance of each of the factors influencing growth, the factor matrix has been rotated so that each of the relevant indices can get the most relation with the relevant factors and facilitate the conditions for naming and identifying the factors associated with the contribution of each index of the factor. In fact, this matrix is the same as the factor matrix whose factors are extracted using the principal

component analysis method and rotated using Varimax rotation method. The output of this stage is a weight for each factor against the corresponding index. These coefficients are important for analyzing in the next steps and calculating factor scores for the investigated areas. Accordingly, based on the final rotated factor matrix after 10 varimax rotations, the final effective factors in the city were obtained. After this step, each group of factors is named based on character closeness.

First factor: This factor explains 17.8 of total variance and based on final filter matrix, it correlates with and is closely related to the indices of trade density, net and gross population density, single-family houses, and so on. Accordingly, the first factor can be called the condensation factor.

Second factor: This factor explains 11.8 of the total variance and based on final filter matrix, it correlates with and is closely related to the indices of earthquake centers, protective zones, lack of open space, and so on. Thus, the second factor can be named as the external factor.

Third factor: This factor explains 11.8 of the total variance and based on final filter matrix, it correlates with and is closely related to the indices of job accessibility and employment, strip growth along highways and roads, distance from main roads, and so on. Accordingly, the third factor can be called the access factor.

Fourth factor: This factor explains 7.9 of the total variance and based on final filter matrix, it correlates with and is closely related to the indices of industry deployment in a range, more welfare facilities, and so on. Accordingly, the fourth factor can be called facility factor.

Table 3: total variance explained

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|-----------|---------------------|---------------|--------------|-------------------------------------|---------------|--------------|-----------------------------------|---------------|--------------|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 4.946 | 18.317 | 18.317 | 4.946 | 18.317 | 18.317 | 4.797 | 17.766 | 17.766 |
| 2 | 3.594 | 13.312 | 31.629 | 3.594 | 13.312 | 31.629 | 3.192 | 11.822 | 29.588 |
| 3 | 3.002 | 11.120 | 42.749 | 3.002 | 11.120 | 42.749 | 3.183 | 11.789 | 41.377 |
| 4 | 1.777 | 6.583 | 49.332 | 1.777 | 6.583 | 49.332 | 2.148 | 7.954 | 49.332 |

Step six: Calculating the factor scoring matrix in the zones

This stage is one of the most important stages of factor analysis to identify the factors affecting city growth. In other words, this study seeks to identify the factors affecting urban growth. Factor scores are the numerical weights obtained by each of the zones after multiplying the factor weight in the standardized value of the index. (Table 4)

Step seven: Standardization of the factor score matrix

At this stage, in order to calculate the total urban extinction score and the final scores of each block of the extinction factors, we will standardize the previous stage matrix. To standardize the matrix above, the percentage of variance explained by each factor is applied to the factor score matrix resulting in standardized matrix. The standardized score of each of the factors using the factor analysis method has been such that for the first factor (density), this value is between 1 and -.075, it is between 1 and -.219 for the second factor. For the third factor,

it is between 1 and -.075 and between 1 and -.154 for the fourth factor.

Step eight: Convert standardized factor scores to linear scale Data of the standardized score matrix table shows that the values of the factors are among various numerical intervals. Because of the different scale and direction of the variables used, it is tried to standardize the results between 0 and 10 and use these standardized scores to continue analysis. These data show that the city's areas have gained different scores. The final results show that the north, east, and south-east blocks have a higher score than other blocks, and the factors mentioned above have had the most effect on the growth of these areas. Also, the southwest blocks have the least impact from the above factors and their score ranged from 0 to 2. This indicates that in addition to the investigated factors, managerial and political decisions are also considered as other factors affecting urban growth and development. (Fig.2)

Table 4: Factor loads of urban growth indices from selected four factors

| Variables | Factor 1 | Factor 2 | Factor 3 | Factor 4 |
|---|----------|----------|----------|----------|
| Tendency to a large-scale residential land | .764 | - | - | - |
| More welfare facilities | .731 | - | - | - |
| Proximity | .726 | - | - | - |
| Single-family houses (one-storey) | .674 | - | - | - |
| Commercial density | .673 | - | - | - |
| Population density | -.657 | - | - | - |
| Distance from city center | -.606 | - | - | - |
| Net population density / centrality | -.458 | - | - | - |
| Distance from city center | -.377 | - | - | - |
| Protected areas | - | .863 | - | - |
| Price and value of land | - | .744 | - | - |
| Earthquake centers | - | .703 | - | - |
| Density of roads | - | -.638 | - | - |
| Lack of open space | - | .512 | - | - |
| Continuity and clustering | - | -.295 | - | - |
| The size of the parts | - | -.122 | - | - |
| (Industrialization (industrial congestion | - | - | -.706 | - |
| River | - | - | .649 | - |
| Average block size | - | - | .628 | - |
| Strip growth along highways and roads | - | - | .627 | - |
| Job access and employment | - | - | .553 | - |
| Match with the desire to expand the city | - | - | -.472 | - |
| Expansion towards sensitive and protected open spaces | - | - | .464 | - |
| The distance from the main roads | - | - | -.446 | - |
| Establishment of the industry in a range | - | - | - | .749 |
| More welfare facilities (area) | - | - | - | .670 |
| Slope | - | - | - | -.149 |

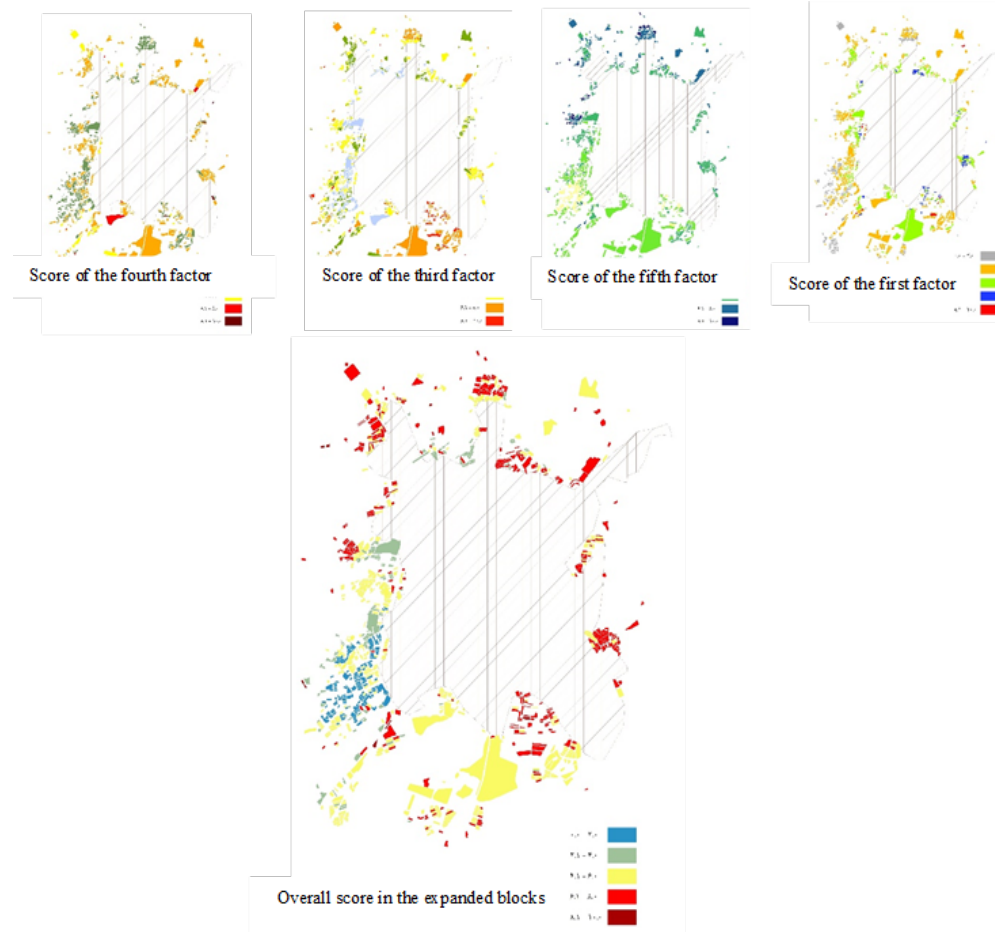


Fig. 2: Factor Score Maps of the Selected Four Factors and Overall Score of Effective Factors for Each Expanded Block

CONCLUSION

The present study sought to investigate the concept of urban growth and development in Iran. This is because unplanned growth in recent decades have created a lot of problems in large cities, especially in cities that have undergone changes in their physical structure following the promotion of their political role. One of the most important of these problems is the disappearance of high quality lands around the cities. An overview of theoretical literature of the research also showed that this issue has been a concern for the thinkers of this field since the mid-1990s and has since been widely studied by scholars. Since there is no comprehensive set of factors that can explain their role in the urban growth process, this research sought to investigate the growth and extract its affective factors by means of factor analysis. In this study, proportional to the texts examined and the characteristics and circumstances of the case study, the measurable factors were formed in a matrix of 27 at 920. In this matrix, 27 was the number of factors identified and 920 revealed the expanded blocks in recent decades in the city of Ardebil. The value of these factors was determined according to the type of spatial factor using ArcGIS 10.2 software. Using factor analysis, the final factors were extracted and introduced under the headings of congestion factor, external

factor, access factor and facilities. The spatial analysis of each of the factors indicated that the congestion factor consisting of variables of trade density, net and gross population density, single-family houses, and etc. had the greatest effect on eastern expansions, and the external factor as the second group of factors affecting the development of Ardebil has been able to play a role in the northern expansion of the city. The third factor, named as access, consisted of variables of job access and employment, strip development along highways and roads, distance from the main roads, and so forth. This factor has had the greatest impact on the southeastern expansion of the city of Ardebil. The factor of facilities was another factor under study with the greatest impact on the expansion of the northeast, east, and south east of Ardebil. The final map drawn from the combination of these factors suggested that the southwest blocks of the city have earned the lowest factor score, and the north, east, and south-east blocs have gained the highest score.

REFERENCES

- Barnes, K.B., Morgan, J.M., III, Roberge M.C. and Lowe, S. (2001) *Sprawl Development: Its Patterns, Consequences, and Measurement*. A white paper, Towson University.
- Bhatta, B. (2010). *Analysis of Urban Growth and Sprawl from*

Remote Sensing Data. Springer, p. 172.

Tarh and kavosh Consultant Engineers, Ardebil City Master Plan (2011), *Ministry of Roads and Urban Development*.

Geshkov, M.V., (2010). *The effect of land-use controls on urban sprawl*, Graduate Theses and Dissertations, Graduate School, University of South Florida.

Hasse, J.(2002) *Is It Sprawl Or Smart Growth? A Dozen Geospatial Indices Of Urban Sprawl*, Department of Geography Rowan University.

Heimlich, R.E. and Anderson, W.D. (2001). Development at the Urban Fringe and Beyond: Impacts on Agriculture and Rural Land. *ERS Agricultural Economic Report*. No. 803, p. 88.

Hekmat Nia, H. and Mousavi, M. (2013). *Application of Model in Geography with Emphasis on Urban and Regional Planning*. Azad Peyma Publication, Third Edition.

Cheng, J., & Masser, I. (2003). Urban growth pattern modeling: a case study of Wuhan city, PR China. *Landscape and urban planning*, 62 (4), 199-217.

Majedi, H., Zabardast, E., and Mojarabi Kermani, B. (2012), Analysis of Factors Affecting the Pattern of Physical Growth in Large Cities (Case Study: Rasht City). *Fine Arts - Architecture*

and Urban Development, 17 (3), pp. 49-60.

Olajoke, A. (2007) The Pattern Direction and Factors Responsible for Urban Growth in a Developing African City: A Case Study of Ogbomoso, *J. Hum. Ecol.*, vol 22 (3), pp. 221-226 .

United Nations (2005a). *World Urbanization Prospects: The 2005 Revision. Pop. Division*, Department of Economic and Social Affairs, UN. URL: <http://www.un.org/esa/population/publications/WUP2005/2005wup.htm>.

Wilson, E.H., Hurd, J.D., Civco, D.L., Prisloe, S. and Arnold, C. (2003). Development of a geospatial model to quantify, describe and map urban growth. *Remote Sensing of Environment*, 86 (3), 275-285.

Zabardast, E., Khalili, A., and Dehghani, M. (2013). Application of Factor Analysis Method in Identifying Urban Worn out Texture. *Fine Arts - Architecture and Urban Development*, 18 (2), pp. 27-42.

Zebardast, E. (2013) Constructing a Social Vulnerability Index to Earthquake Hazards using a Hybrid Factor Analysis and Analytic Network Process (F'ANP) Model, *Natural Hazards*, Vol 65 ,pp-1331-1359.