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RETRACTED ARTICLE: Investigating the factors underlying cities’ physical growth: Evidence from the city of Rasht

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Abstract: The manner of physical growth of a city, and the motivators of such growth, is considered to be a major issue in urban studies. This paper aims to identify the factors affecting the urban growth pattern in the city of Rasht, taken as a representative of cities in developing countries. A comparison is made with different findings of previous studies to clarify whether there is a universal constant framework for predicting the directions of urban growth. With the assumption that the growth of Rasht is influenced by specific motivating factors, an appropriate theoretical framework and quantitative parameters for urban growth are developed through a literature review. Logistic regression modeling estimates the impact of factors influencing the growth of Rasht. The results show that the first factor with a positive effect on urban growth is roads, and this urban development mostly appears along highways and industrial parks in the south, suggesting that the interaction of land use/transportation is necessary for the future planning of the city. In other words, distance from roads or interurban routes and distance from industrial centers both have a reverse effect on the direction of urban growth. Moreover, the existence of forest lands and high-priced lands have an adverse effect on urban development, but agricultural land (rather than jungle land) is becoming urban, and the only way to improve this process is by efficient planning and surveying and by managing political variables as possible factors.

Keywords: physical growth factors; logistic regression; spatial modeling; urban growth

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PUBLIC INTEREST STATEMENT

As cities are the complex and multi-dimensional products of the modern world, understanding the process of their formation is exceptionally challenging. This study helps to elucidate the factors and motivators that control the physical growth of cities and the directions in which cities will develop. Predicting the direction and location of development for each city will help city councils and mayors to make suitable decisions about the future of their cities. Clarifying patterns of urban growth and cities’ reactions to infrastructures, new projects, biophysical features of the environment, new approaches to management, etc. provides a smart vision for cities, which absolutely improves the quality of life and life satisfaction of urban residents.

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1. Introduction
During recent decades, Iran has experienced rapid urban growth due to the movement of a large percentage of its population from rural areas to cities. According to urban population data, in 2006, 68.46% of the country’s population was urban, showing an increasing trend in comparison with the size of the urban population in 1986 and 1996. Based on UN statistics in 2011, the urban percentage of Iran’s population will reach 70.6% in 2020 and 78.2% in 2050 (United Nations, 2012). As this urbanization process is projected to continue in future years, metropolitan areas will grow faster. Rasht is one of Iran’s cities that has undergone rapid physical growth.

Although urban growth is common, its patterns and causes are somewhat ambiguous and unclear. It is necessary to determine the factors that affect each city based on empirical studies, literature reviews, and consultations with local experts.

Because the indicators of urban growth are unique in each case, and because there has been a lack of concentration in previous studies on the comparative analysis of growth-stimulating factors, this article aims to determine the most important growth factors for the metropolises of Iran (using the sample of Rasht). Using a quantitative modeling approach that compares points of convergence and divergence with other case studies provides an appropriate field in which to understand and organize the complexity of urban growth.

In light of this goal, a conceptual model of urban growth and its complications is presented; this model incorporates theoretical and empirical concepts and recognizes the effects of different factors on urban growth. Then, quantitative measures of urban growth are defined and used as a proper framework for surveying possible factors influencing urban growth. The second part of the article studies Rasht as a representative of Iranian metropolises. Selected variables concentrate on the spatial modeling of urban growth using logistic regression, and a survey of the possible factors affecting the growth of Iranian cities is also performed. Eventually, the factors are analyzed, compared with each other, and categorized by their impact.

2. A review of the experimental and theoretical concepts associated with factors affecting urban growth
Previous studies have proven that because each case study is unique, there are no comprehensive sets of factors that can explain the process of urban growth (Cheng & Masser, 2003; Dubovyk, 2010; Hu & Lo, 2007; Huang, Zhang, & Wu, 2009; Poelmans & VanRompaey, 2009; Verburg, de Nijs, van Eck, & Visser, 2004). Moreover, the variables that influence urban settlements are not necessarily those that control the extension of commercial and industrial areas (Braimoh & Onishi, 2007).

Several factors have been recognized (Table 1), and different approaches are used to classify them. Some researchers, such as Huang and Dubovyk, divide the factors into three groups: Site Specific, Proximity Characteristics, and Neighborhood Characteristics (Dubovyk, 2010; Huang et al., 2009). Some authors, such as Cheng and Masser, classify the factors into spatial ones—such as slope and distance from main roads—and non-spatial ones—such as race and spatial policies—based on their nature (Cheng & Masser, 2003). Other authors, such as Hu and Sietchiping, divide the factors into social, economic and biophysical variables (Hu & Lo, 2007; Sietchiping, 2005).

Verburg, de Nijs, et al. (2004) have recognized five types of determinant factors that describe changes in spatial patterns: biophysical, social, economic, spatial policies, spatial interactions and local features (neighborhoods) in which nature and function are dominant. Factors used in this area of research are often chosen based on various individual theories, and they advance our understanding of the primary process of land use change.

Poelmans and VanRompaey have identified five factors: (1) Bio-physical factors, such as slope, which can affect the utility of the location for a particular type of land use and are often considered within the framework of land use change in rural areas (biophysical variables are also considered...
through urban prototyping due to their relationship to the utility or the price of urban construction); (2) social factors, which can be added to urban growth models using simple indexes such as population density, racial composition, and the per capita income; (3) economic factors, which are often evaluated based on accessible indexes such as distance from the city center, distance from roads, and distance from a water source, as these factors can be counted as alternative variables for employment and job accessibility; (4) spatial policies, which control urban development locally and nationally, especially those that design protected areas with land reserves and assigned areas; (5) interactions among different types of land use (Poelmans & VanRompaey, 2009), such as the ratio of urban space in the vicinity of each cell as a factor in Logistic regression models and the direct interactions of neighborhoods using Cellular Automaton Model (CA) techniques by Sleuth, which were used by Clarke, Happen, and Gaydos (1997) to predict the urban development of North American cities.

3. A conceptual model for analyzing urban growth
Urban growth is a complicated system that includes physical, economic, and social factors. (Figure 1) shows a conceptual model of urban growth and its complexities; this model is then linked to urban modeling. Source: (Cheng, 2003).
Urban growth occurs over a certain period of time. This development depends on three systems of spatial factors: (1) Developed urban systems such as road networks and trade centers; (2) ecological systems and frameworks such as waters, jungles, and agricultural lands; and (3) planned urban systems involving comprehensive, strategic, and constructional plans. From Cheng’s point of view, urban growth patterns can be surveyed using two approaches: studying the urban growth system itself or studying it as part of a larger system. The first only includes new developed units, and the second includes not only urban growth but also three other systems (the urban system, the ecological system and framework, and the spatial urban planning system). The patterns identified in the first approach can vary due to the concentration on the logical arrangement of newly developed units. In the larger system, elements of the other three systems either lead to the creation of newly formed units or prevent their creation. These units can be rivers, water sources, railways, slopes, shopping centers, and road networks (Cheng, 2003).

This article concentrates on the second approach and analyzes urban growth according to the three above-mentioned systems. It suggests that the most important issue is that of recognizing the main factors involved in urban growth and understanding the relationship between these factors and urban developments.

4. Theoretical framework of analysis

In this section, the effects of different factors (positive and negative) on urban growth are identified by surveying various studies and experiments. Quantitative measures of urban growth are selected for use in analyzing the major factors of urban growth in the city of Rasht. A survey of previous studies (Tables 1 and 2) suggests various approaches to urban growth analysis, and different factors and results are chosen according to various constructional, economic, and social fields in different cities. Similarly, selecting each group of factors may result in disregarding others or may be inappropriate for the conditions in Rasht. Thus, out of all studied indexes, 14 measurable indexes are chosen according to the accessibility of city data and whether they are extendible for the purposes of comparison with the growth factors of other large cities as follows: urban growth (dependent variable) (with value 1 for changing from non-urban to urban and value 0 for others). The following independent variables are also used:

(1) Physical and unique features of the area: slope (based on percentage). (2) Proximity features (access to infrastructure, facilities, and city centers), distance from cell to nearest roads, distance from cell to nearest settlements, distance from cell to the nearest business location, and distance from cell to most adjacent industrial centers. (3) Domestic conditions, including imposed conditions of agricultural areas, jungles, and wastelands. (4) Social-economic factors, including population density and land price.
5. Methodology

The research process in this article goes through the following general steps: Surveying time-spatial patterns of urban growth, spatial modeling of urban growth using logistic regression, and surveying factors affecting urban growth.

The first step is studying spatial patterns of physical growth in Rasht during the years before 2011 using existing data. This step is based on data analysis and local information from comprehensive plans regarding economic, social and structural issues.

The second step concentrates on the modeling of logistic regressions according to certain factors. The factors of urban growth are gathered according to related studies and theoretical approaches. Rasht is also studied in the first step using Meta-analysis and the comparative method. The third step explains the effects and determines the main factors affecting the city.

6. Evaluation and description of Rasht

Rasht is the center of Gilan province and also Iran’s largest city on the vicinity of Caspian Sea. The growth of this metropolis has been ongoing since 1750. The first signs of this growth can be found in
the current marketplace, while fields in the countryside have formed other districts of the city. After 1925 and the construction of some new streets, the market was driven to the borders and residential structures were built around the streets; new districts then appeared nearby. Between 1925 and 1948, the city's expansion occurred along the new roads and through these routes, and several factories were built. Between 1948 and 1956, the city's growth was mostly to the south, southeast and southwest. Between 1956 and 1971, growth stepped in the east and moved to the northeast and northwest. Between 1971 and 1978, the city's growth was more perceptible in the north and northwest, and this growth ended with the construction of the Golsar residential complex. The beltway, which links the roads to Bandar Anzali, Lahijan, Tehran and Fouman, is one of the most important elements of the city's growth. Figure 2 shows Rasht's growth between 1926 and 1986. The city has a central core, and its development has occurred along the radial roads leading to this core (Iran Amayesh Consulting Engineers, 1990).

According to the survey of the city's expansion contained in comprehensive plans from the end of the first plan period, 19.5% of the city was bare land, and diffused extensions have occurred in all directions. Also, according to the survey of the third comprehensive plan in 2005, the area of the city at that time was approximately 7,500 hectares, including connected constructions and agricultural fields. The extension has occurred mostly through the northeast, northwest, and north and is oriented toward the suburbs; the surrounding villages are about to join the city. Studying the evolution of the population suggests that between 1956 and 2006, the population has increased by 3.31% per year. This rate is far more than just reasonable population growth, and the only explanation is immigration and a merger of the surrounding villages during the several periods under study (Tarh-o-Kavosh Consulting Engineers, 2005).

Generally, city growth is based on a multi-core pattern that has sorted the CBDs (Central Business District) of the established centralized core of official and commercial centers of the city, and Golsar is the modern commercial and service center. Moreover, Tehran road is the main axis of developing industrial, production and service activities, and city center service activities are also established through some points around the beltway. Similarly, around Lakan road there is a trend of building new settlements and condominiums. Additionally, fast growth along the suburban roads has made the city a circle with several progressive radials directed to the north, south, east and west (Tarh-o-Kavosh Consulting Engineers, 2005).

7. Spatial logistics regression modeling approach
In statistics, logistic regression, or the logit model, is a regression model where the dependent variable (dv) is categorical. Logistic regression measures the relationship between the categorical
dependent variable and one or more independent variables by estimating probabilities using a logistic function, which is the cumulative logistic distribution. Statistical analysis methods such as multivariable regression and logistic regression are still being used for planning modeling. Like any complicated social-economic system, city growth does not often follow a normal assumption, and its effective elements are a combination of absolute and dependent variables. The general form of logistic regression is described as follows:

\[ Y = a + b_1X_1 + b_2X_2 + \cdots + b_mX_m \]  

(1)

\[ Y = \log \left( \frac{p}{1-p} \right) = \text{logit}(p) \]  

(2)

\[ p = \frac{e^Y}{1 + e^Y} \]  

(3)

When \( X_1, \ldots, X_m \) are descriptive variables, \( Y \) of the linear equation of the descriptive variables shows linear dependence (Equation (1)). Factors \( b_1, \ldots, b_m \) are regression coefficients that are estimated, and \( p \) is the probability of a new unit occurring, such as the evolution of a village to a city. In Equation (2), \( Y \) is shown as \( \text{logit}(p) \). Through logistic regression, the amount of probability can be a non-linear equation of descriptive variables (Equation (3)). This equation is strictly increasing; the probability of \( p \) or amount of \( Y \) increases, and regression coefficients \( b_1, \ldots, b_m \) imply the collectivity of each explanatory variable to the value of probability of \( p \).

A positive mark means that the explanatory variable helps the increase in the probability of change, and a negative mark means the opposite effect. The probability method is a multi-variable estimating method for examining the intensity of dependence and the importance of factors (descriptive variables). Logistic regression must consider space probabilities such as space dependence. Disregarding these issues may lead to estimating invalid factors or to inadequate estimates and incorrect results when examining assumptions (Irwin & Geoghegan, 2001).

**VIF**—Variance Inflation Factor—an indicator of how much of the inflation of the standard error could be caused by collinearity. The VIF for a given predictor variable can be calculated by taking a linear regression of that predictor variable on all other predictor variables in the model. From that fit, we can pull an \( R^2 \) value. The VIF is then calculated as:

\[ VIF = \frac{1}{1 - R^2_i} \]

Where \( VIF \) is the variable inflation factor for variable \( i \), \( R^2_i \) is the coefficient of determination for a model where the \( i \)th variable is fit against all other predictor variables in the model. On normal VIF in multiple regression, the aim is to eliminate variables with a VIF higher than 10.

**B**—This is the coefficient for the constant (also called the “intercept”) in the null model.

**S.E.**—This is the standard error around the coefficient for the constant.

**Wald**—When assessing the contribution of individual predictors in a given model, one may examine the significance of the Wald statistic. The Wald statistic, analogous to the \( t \) test in linear regression, is used to assess the significance of coefficients. The Wald statistic is the ratio of the square of the regression coefficient to the square of the standard error of the coefficient and is asymptotically distributed as a \( \chi^2 \) distribution.

\[ W_j = \frac{b_j^2}{SE_j^2} \]
SE—The standard errors of the coefficients are the square roots of the diagonal elements of the variance-covariance matrix.

Df—This is the degree of freedom for the Wald $\chi^2$ test. There is only one degree of freedom because there is only one predictor in the model, namely the constant.

Exp(B)—This is the exponentiation of the B coefficient, which is an odds ratio. This value is given by default because odds ratios can be easier to interpret than the coefficient, which is in log-odds units.

### Table 3. The VIF of factors influencing the urban growth of Rasht in logistic regression analysis

| Variables                        | Collinear statistics |
|----------------------------------|----------------------|
|                                  | VIF  | Tolerance |
| Distance from residential areas (X1) | 0.182 | 5.497     |
| Distance from industrial areas (X2) | 0.067 | 12.862    |
| Distance from commercial areas (X3) | 0.375 | 2.667     |
| Forest (X4)                      | 0.631 | 1.585     |
| Areas with low population density (X5) | 0.061 | 16.456    |
| Areas with high population density (X6) | 0.347 | 2.885     |
| Areas with medium population density (X7) | 0.068 | 14.777    |
| Areas with high land price (X8)   | 0.664 | 1.505     |
| Areas with medium land price (X9) | 0.588 | 1.701     |
| Areas with low land price (X10)   | 0.675 | 1.482     |
| Agricultural land (X11)          | 0.260 | 3.848     |
| Slope (%)(X12)                   | 0.677 | 1.477     |
| Distance from main roads (X13)   | 0.076 | 13.098    |
| Barren land (X14)                | 0.346 | 2.888     |
Results and discussion

Space sampling data of logistic regression, as raster maps of urban growth (dependent variable $Y$) (Figure 3), present independent variables ($x_i$) (Figure 4) and are analyzed relatedly. In order to provide data, maps prepared in GIS by an Iranian mapping organization in 1994 (named the first period) and maps of the comprehensive plan for Rasht in 2005 (named the second period) are used. Independent variables of the model are moved to Arc GIS 9.3 software so that the desired function can be applied to them according to the type of the place factor. All input data have the same Spatial Extent and cell size ($30 \times 30$), and the image system UTM is geometrically registered (District 39° N) and elliptic. Data are classified into various land use classes for model input and into urban and non-urban areas for model output. The attribute maps are binary or continuous.

All layers are saved in the cell network format; the number of cells toward each area represents the pixel’s desire for urban growth; then the number of cells is moved to the range of 0–1, being divided by the maximum amount of each cell layer. The numbers in each cell layer that are closer to 1 have more desire for urban growth.

The logistic regression method is used for analyzing factors affecting Rasht’s growth, using SPSS and MATLAB. Before applying the model, space dependence between independent variables is checked using the VIF index (Table 3).

Amount VIF >10 implies space dependence of “distance from industrial areas, areas with low population density, areas with medium population density, and distance from roads” with other variables.

### Table 4. Results of logistic regression analysis for independent variables of urban growth

| Variables                                      | B     | S.E.   | Wald   | df  | Sig  | Exp (B) |
|------------------------------------------------|-------|--------|--------|-----|------|---------|
| Distance from residential areas (X1)           | −5.866| 0.143  | 1,690.915 | 1 | 0    | 0.00000 |
| Distance from industrial areas (X2)            | −0.023| 0.031  | 1.094  | 1 | 0    | 0.997   |
| Distance from commercial areas (X3)            | 1.111 | 0.037  | 918.775 | 1 | 0    | 0.329   |
| Forest (X4)                                    | −0.014| 0.048  | 0.828  | 1 | 0.774| 0.986   |
| Areas with low population density (X5)          | 3.751 | 0.102  | 1,521.433 | 1 | 0    | 0.00000 |
| Areas with high population density (X6)         | −0.531| 0.088  | 36.642  | 1 | 0    | 0.588   |
| Areas with medium population density (X7)       | −0.402| 0.032  | 160.073 | 1 | 0    | 0.669   |
| Areas with high land price (X8)                 | −0.042| 0.025  | 7.716   | 1 | 0    | 0.959   |
| Areas with medium land price (X9)               | −0.142| 0.021  | 44.391  | 1 | 0    | 0.867   |
| Areas with low land price (X10)                 | 0.338 | 0.020  | 134.029 | 1 | 0    | 0.796   |
| Agricultural land (X11)                        | 1.069 | 0.028  | 170.038 | 1 | 0    | 2.912   |
| Slope (%)(X12)                                 | 0.816 | 0.029  | 954.59  | 1 | 0    | 2.441   |
| Distance from main roads (X13)                  | −8.983| 0.087  | 10,694.041 | 1 | 0    | 7,963.432 |
| Barren land (X14)                              | 3.015 | 0.026  | 13,145.054 | 1 | 0    | 20.299 |
| constant                                       | −16.014| 0.124  | 16,572.522 | 1 | 0    | 0.00000 |

### Table 5. Results of accuracy percentage of predicting logistic regression by index PCE

| Observed | Predicted | Accuracy (%) |
|----------|-----------|--------------|
| .00000   | 314982    | 12173        | 96.3 |
| 1.00000  | 24114     | 18847        | 43.9 |
| Total (%)|           |              | 90.2 |
Figure 4. Raster layers of independent variables.

Source: The processing is based on land altitude model from USGS, maps prepared in GIS from national survey organization, aerial pictures 1994, maps and information from Rasht comprehensive plan, 2005.
variables. Then, in the two steps, once by omitting “distance from industrial areas, and areas with low population density” (Table 4), and once by omitting variables of “areas with medium population density, and distance from roads”, the model is applied. The model or cutoff value of 0.5% is applied using the Maximum Likelihood algorithm, which finds the best proportion of independent variables for interpreting the dependent variable’s status. The index, which explains PCE, presents proper amounts in both steps, which are the criteria of analysis due to their transcendence at the first step (Table 5). For each independent variable, the odds ratio is produced by the model named (Exp (B)), the quantities larger than 1 show the probability of urban growth more than when they are smaller than 1. Additionally, variables with a higher Wald statistic have more of an effect on urban growth, and factors of the model (B) obtained from the analysis can be used to create a map of the probability of urban growth in the future.

Studying space-time models of urban growth in Rasht, it seems that trends in urban growth during past years are based on a multi-core pattern. The fast structural growth of the city along the suburban roads has changed the city’s shape to a circle with several progressive radial developments in different directions, which is observed more through the physical growth south of the city. Population studies suggest that the highest urban growth rate occurred in the years 1976–1986, which is explained by immigration and the merger of the surrounding villages.

According to the unique structural, economic and social conditions of the city, the factors motivating urban growth have some similarities and differences with the expected effects on urban growth found in the theoretical framework of this article. That is to say, regarding Tables 2 and 6, the results of this research do not support the theories of the following authors: Batisani and Yarnal (2009), Shen et al. (2008), and Poelmans and VanRompaey (2009), suggesting the adverse effect of the slope factor; or of Xie, Huang, Claramunt, and Chandramouli (2005), Braimoh and Onishi (2007), and Cetin and Demirel (2010), suggesting negative distance from commercial areas. Furthermore, the results of this study do not support Braimoh and Onishi (2007), Luo and Wei (2009), and Shen et al. (2008), suggesting the positive effect of distance from industrial centers on urban growth in Rasht.

However, the results of this study do support the results of the following authors: Hu and Lo (2007), Batisani and Yarnal (2009), Huang et al. (2009), Shen et al. (2008), Luo and Wei (2009), Cheng and Hieber (2003), Wu and Yeh (1997), Xie et al. (2005), Poelmans and VanRompaey (2009), Fang, Gerding, Sun, and Anderson (2005), Cetin and Demirel (2010), and Braimoh and Onishi (2007), which suggest the negative effect of distance from roads. Huang et al. (2009), Hagoort, Geertman, and Ottens (2005), Xie et al. (2005), Cetin and Demirel (2010), and Barredo, Kasanko, McCormick, and Lavalle (2003) suggest the negative effect of distance from residential areas. The theories of Hu and

| Variable name                  | The impact on Rasht | Expected impact on urban growth |
|--------------------------------|---------------------|---------------------------------|
| Slope                          | Positive            | Negative                        |
| Distance from highways, main roads | Negative         | Negative effects in most cities |
| Distance from nearest residential sites | Negative          | Negative in some cities within certain neighborhoods |
| Distance from nearest commercial sites | Positive        | Negative effects in most cities |
| Distance from nearest industrial sites | Negative       | Positive effects in most cities |
| Agricultural lands             | Positive            | Positive effects in most cities |
| Forest areas                   | Negative            | Negative effects in most cities |
| Barren lands                   | Positive            | Positive                        |
| Population density             | Positive in low population density areas | Positive                        |
Lo (2007), Batisani and Yarnal (2009), Cetin and Demirel (2010), Fang et al. (2005), and Verburg, van Eck, et al. (2004) suggest the positive effect of agricultural areas on urban growth. Braimoh and Onishi (2007), Poelmans and VanRompaey (2009), Luo and Wei (2009), and Fang et al. (2005) suggest the negative effect of jungle areas on urban growth. Huang et al. (2009), Braimoh and Onishi (2007), Xie et al. (2005), and Hu and Lo (2007) suggest the positive effect of population density, and Cetin and Demirel (2010) indicate the positive effect of wastelands on urban growth in Rasht.

The reason for the positive effect of distance from commercial areas and for the negative effect of Areas with high land prices and medium land prices is the indirect impact of the economic factor. A significant part of the population cannot afford high- and medium-priced areas and therefore tends to invest in the low land price areas.

The results of this article, which are based on an analysis of the results of logistic regression of urban growth in Rasht, are as follows:

(1) Features of Rasht’s physical growth pattern are related to its factors and to the current state of the city.
(2) The most effective factors for urban growth are being close to main roads and to residential areas.
(3) Most change in land use has happened near bare lands, Brownfields, and agricultural lands.
(4) The probability of urban growth increases close to residential areas, industrial zones and main roads, while being close to commercial areas does not increase urban growth, which seems to be caused by the concentration of urban commercial cores in the marketplace (city center) and Golsar (north).
(5) Land price affects urban growth such that the probability of urban growth in areas with low or medium prices is higher than in expensive areas.
(6) Population density affects urban growth such that growth in areas with low population density is higher than in areas with medium or high density.
(7) Although there are not extreme topographic differences in the city, slope is not a limiting factor for urban growth. This is justified according to slumps in the north of the city and the tendency for growth to be directed toward the south and heights.

9. Conclusion
The most important factor in urban growth is roads. Growth mostly seems to occur along the Tehran-Rasht road and industrial park in the south, which suggests that the interaction of land use/transportation is necessary for the future planning of the city. Agricultural land, rather than jungles, is becoming urban, and the only way to change this process is through efficient planning and surveying and through managing political factors as effective elements.

According to the findings of this study, the general concept of land use in urban planning does not have a significant impact on the growth pattern of cities in developing countries. This factor, at least in Iran, is not a determining factor in guiding the direction of development. For example, the new developed residential districts in the South of the city did not have standards for urban planning land use thresholds.

As a result, a significant correlation among urban growth factors can be observed. Thus, they have a synergistic effect, and the practical consequences of urban development can have unpredictable results. In addition to the size of the factor, its location relative to other factors affects the intensity with which it affects the physical growth of the city. In other words, the layout of urban development factors is as decisive as their presence. For example, this case study has various intercity roads in different geographical directions and of relatively similar quality, but the trend of urban development along the Tehran-Rasht road is highest because of its strategic position between two points,
revealing that the effect of the Tehran-Rasht road is greater than that of other similar roads in the city that go in other directions.

This situation has developed for two reasons:

1. The particular arrangement of factors affecting the growth of the city.
2. The special characteristics of some elements of these factors.

Because distinctions among the intensities of the impact of inter-city routes in the sample have not been applied, estimates of growth in different cities along the way will not be correctly predicted. This assumption of the equity of all elements of a factor is repeated in all previous studies. In addition, comparing the findings of this study with the results of previous studies, and noting the existence of obvious contradictions as well as the structural complexity of the factors driving the development of the city, it seems that rule-based simulation models and methods of analysis based on linear relationships cannot provide accurate predictions of the future development of the city, and thus existing methods need to change their approach. Because of many other factors such as urban and regional policies and changing political conditions, current urban management approaches do not have the ability to integrate with this model and make accurate predictions.

Finally, it is suggested that, in completing predictive models of urban growth, some factors such as qualitative dimensions, social trends, and effective policies (such as the Stimulus, or propulsive points of growth) that use methods of spatial data infrastructure (SDI) ensure that the data and resources of urban growth—transformed into data layers—can be used in the process of analysis.

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