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Research Paper

Factors Influencing Unsustainable Intraurban Land-Use Change: Case of Tehran City

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Abstract
Intraurban land-use change and factors affecting it are critical subjects in land-use planning. If unplanned, such changes can reduce the quality of life and spatial justice and ultimately lead to urban unsustainability. This paper aims to identify factors influencing unsustainable land-use change and analyze the intensity of such changes based on those factors. The artificial neural network analysis was employed to model the significant factors. The results indicated that the dynamics of the economy and the capital markets, a boom in the land and housing market, government interventions in the urban texture, gardens, and infill land have a dominant role in determining the rate of change in urban land use. According to the results, relevant indexes of the land and housing market and political and economic factors play a crucial role in Tehran's unsustainable land-use change.

Keywords: *Urban land-use change, Unsustainability, Political economy, Artificial neural network.*

1. INTRODUCTION

In the late 20th century, urbanization was a worldwide phenomenon, which changed the features of cities in developed and developing countries (Deng & Srinivasan, 2016). Such changes have occurred in various aspects, including land-use (Estoque & Murayama, 2015; Hall & Pfeiffer, 2000; Caldas et al., 2010; Liu et al., 2015). Cities are constantly subjected to the complex processes of land-use change (Zhao et al., 2011) because places, as well as the rate of various urban activities, often change over time (Jjumba & Dragićević, 2012). Land-use change involves changing the spatial patterns and land-use intensity (Zhang et al., 2011).

Urban land-use change influences land use in various ways. Such changes lead to different results even in the same urban region (Banzhaf et al., 2017). Urban land-use change leads to a variety of negative impacts such as urban heat islands (Nastran et al., 2019; Gaur et al., 2018; Shi et al., 2018), the migration of citizens from urban regions to poor areas (Li, 2004), an incline in spatial justice (Foldvary & Minola, 2017; Yenneti et al., 2016), degradation in the quality of life (Xiong & Zhang, 2016), and the polarization of cities into poor and wealthy districts (Harvey, 1973), which leads to urban unsustainability.

Identifying the process of urban land-use change, the prediction of the patterns of change, and the planning and management of land-use change require the identification of influential factors in land-use change and the specification of the ratio of such factors. Understanding and analyzing such factors help managers plan for sustainable urban development (Musakwa & Van Niekerk, 2013; Nwokoro & Dekolo, 2012; Klosterman, 2015). Earlier studies on identifying influential factors in intraurban land-use change were in the field of the urban economy. These studies show that the return of

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capital and the significant profit from urban land-use change are the main practical factors (Raharjo, 2005; Harvey, 2016; Barlowe, 1978). Some studies have explored spatial features as well (McDonald, 1984; Wilder, 1985; Carver, 1991; Voogd, 1982). These studies emphasize the distance from the city center as a significant factor in the rate of urban land-use change (Wu, 1998). The emphasis on these factors does not provide appropriate analysis in this field. The city is a mixture of political, economic, social, and physical factors (Pacione, 2009). Therefore, we need to consider the role of these factors in analyzing changes in land use. Due to recent advances in technology, access to sorted data, and software, it is now possible to consider various factors in the modeling of land-use change (Wu, 1998; O'Sullivan, 2009; Stevens & Dragićević, 2007; Bodzin & Cirucci, 2009; Kocabas & Dragicevic, 2013; Newman et al., 2016). A review of various studies shows that the same influential factors cannot account for the land-use change in all cities (Shao et al., 2005; Thapa & Murayama, 2010). Therefore, the identification of influential factors on land-use change in different cities seems necessary. Such differences indicate that factors leading to urban unsustainability through land-use change vary in different cities. This study, apart from other past research, uses secondary data and an artificial neural network analysis model. In this article, by studying the research conducted in the field of land-use changes, the main factors of these changes were extracted, and finally, the key factors of these changes were identified.

The purpose of this research is to determine the crucial factors and their contribution to Tehran's unsustainable land-use change. The metropolitan area of Tehran has high urban growth and an increase in built-up areas so that the metropolis of Tehran has expanded without any comprehensive plan. The growth of the urban regions and the need for land for development in the metropolitan area of Tehran has led to the destruction of agricultural land, environmental pollution, threats to the ecology of the region, and significant environmental problems. In recent decades, this trend has continued. As a result, valuable agricultural areas, pastures, and lands have become urban areas and human settlements, and this has added to the environmental problems of the region. This study seeks to present a model by comparing various samples. Modeling provides a proper context for understanding the complexity of urban land-use change and the factors that lead to its unsustainability. A conceptual model is first presented by reviewing previous studies and theoretical principles. The quantitative indicators for these factors are then determined. In the next step, the factors affecting urban land-use change are modeled. The final section involves the analysis of influential factors and their comparison to other studies.

2. THEORETICAL FRAMEWORK

A review of previous studies in the field of land-use change shows that researchers have considered different influential factors (Table 1) based on their theoretical approach and case study (Kaiser et al., 1995; Felsenstein et al., 2007; Ettema et al., 2007; Haase et al., 2008; Loibl et al., 2007; Jie & Hong, 2011; Braimoh & Onishi, 2007; Bello & Arowosegbe, 2014; Axinn & Ghimire, 2011; Cohen, 2016; Dang et al., 2016). Some studies, such as Kaiser et al. (1995), have divided the influential factors into four phases: urban parts, spatial use, structure, and the environment. According to Harvey (2016), the size and the combination of the population, income level and distribution, technology, social organization, government policies, and urban development effectively affect urban land-use change. Wu (1998) highlights factors such as distance from the city center, access to transportation, population potential, foreign investment, and employment. Ettema et al. (2007) divided the factors influential in land-use change into six groups, namely household/individual behavior, location decisions, work participation, location choices, daily activities, patterns of cooperation, firms/institutions, landowners, and developers. Braimoh and Onishi (2007) categorized the influential factors into seven groups, namely topography, distance cost, population factor, neighborhood unit indexes, spatial policies, distance from bodies of water, and income potential. Jie and Hong (2011) have categorized these factors into three stages of population growth, economic growth, and technological processes. Haase et al. (2008) have identified immigration, marriage rate, use of available lands, and block structure as effective factors Loibl et al. (2007) also stated that effective factors in the use changes of intraurban lands consist of pattern land-use change, distance from residential and industrial areas, access to main roads, family and population density, zoning regulations, protection of nature, and workplace density in habitation units. Bello and Arowosegbe (2014) highlight four general factors: management and estate policy and tenement, absorptive factors and petroleum availability, people and regional conditions, regulations, and power structure. Axinn and Ghimire (2011) highlight the three factors of land-use, population change criteria, and social

organization in land-use change. In Shen et al.'s study (2012), population, employment, housing, and transportation are the critical factors affecting land use in cities and suburbs. The combination of such factors creates various patterns of land use in urban regions.

Many theorists believe that the earth is considered a national treasure. Therefore, the land and housing market is not a standard market, because it should not be adapted to demand. Since the added value of land is much higher and faster than other goods; therefore, the surplus value of land is the main factor in changing urban spaces (Bastié & Dézert, 1991). David Harvey, a radical geographer, believes that because the earth has different uses, exchanges, economics, and immortality, it has a particular utility. He expresses the theory of how to use urban lands, the microeconomic theory of urban lands (Harvey, 1973). Harvey (2016) believes that because land and housing are scarce resources, it is essential to maximize efficiency in exploiting them. Therefore, special rules and regulations should be developed in the manner of optimal use of land. In other words, intervention in the land market is necessary to ensure public interests and appropriate land-use strategies in accordance with environmental and social strategies in urban plans (Ziari, 2002). Rapid urban growth and urbanization have created profitable opportunities in the housing and construction industry. With the importance of construction activities, land hoarding and production are the primary sources of huge profits. Especially with the rapid development of urbanization, the land becomes critical, and its hoarding in the market economy becomes the most profitable economic sector of society (Shakoei, 2011). According to the recent case, the article's structure is based on the framework that factors such as rapid population growth, land exchange, economic benefits of land, land scarcity are the main factors of land-use change in the metropolitan area of Tehran. The type and method of intervention in different parts of the city follow various spatial attractions and economic equations. The pattern of interventions in other parts of the city will be different.

Suburban lands: As these lands can be developed if they join the urban area, they are at the center of attention (Turner et al., 2007).

Central areas: Commercial areas, due to their spatial attractiveness, are important and become the principal place of construction. Changing the use of urban centers to commercial services, etc., are examples of this problem (Mulligan et al., 1999).

High-priced and high-quality urban lands: areas with natural or artificial landscapes and suitable infrastructure with high land prices. High-rise construction, unregulated construction, amd invasion of untamed lands is the result of this.

Worn-out urban texture, low-cost areas, and suburban areas and informal settlements: These areas provide a good opportunity for stakeholders to invest, renovate, change land use (Marx & Kelling, 2019).

The variety of factors identified by researchers indicates the type of theories in the field. Rudel (1989) divides these theories into two main groups of human ecology and political economy. He recommends that these theories be combined to reach an appropriate idea. Kaiser et al. (1995) also divided the theories of urban land-use change into six groups (Table 2).

Table 1. Previous Studies on Factors Influencing the Change of Urban Land-use

Study Area	Effective Factor	Researcher
China's major cities	Population growth and economic development increased foreign interactions	Zhang et al. (2011)
Chili wok-Canada	Cultural, social, economic, access to services, urban infrastructure	Jjumba and Dragićević (2012)
Johannesburg (South Africa), Shanghai (China), Zurich (Switzerland)	Population, governance (local government structure), politics (urban development), economic growth, technology, lifestyle	Yang (2010)
EU cities	Economics, Population, Lifestyle, Usage Policy, planning Tools	Nuissl et al. (2009)
Lagos-Nigeria	Social, cultural, economic, environmental, infrastructural, and institutional	Oduwaye (2013)
Surrey-Canada	Rental prices of land and housing, property, distance from main roads and train stations and airports, distance from employment centers, population density, distance from green space, type of housing.	Kocabas and Dragicevic (2013)

In the book '*Social Justice and City'*, Harvey (1973) classifies these theories into two groups of economic and spatial ones. The criterion for this classification is consuming and exchanging value. Consuming value is the foundation of classical studies in geography and sociology. Exchanging value is the foundation of economic studies in the field of urban land use. Harvey establishes the relationship between consumer value and transaction value as an opportunity to present the issue in the political economy. In each of the classifications, these three well-known researchers have identified the political economy as the best theory of explanation in urban land-use change (Kaiser et al., 1995; Rudel, 1989; Harvey, 1973).

Johnston's (1982) notion of the political economy suggests different concepts of the spatial structure of the city, its determinants, and change processes (Briassoulis, 2000). According to the political economy approach, social construction is the determinant of production and change in urban space (Harvey, 1982; Harvey, 1973). The processes of neo-liberalization also influence social construction. The ultimate goal of the neo-liberalization of cities is capital accumulation (Zieleniec, 2007). Capital accumulation changes urban construction to produce surplus value. In this regard, land-use patterns change to adapt to economic growth (Hamza & Zetter, 2013). Based on the political economy approach, the political factor (government intervention in the urban context) and capital (economy, land, and housing market) have the most significant impact on urban land-use change. Studies have shown that other factors, such as social and physical ones, are also influential in land-use change (Table 3).

Table 2. Classification of Urban Land-use Change Theories by Kaiser et al. (1995)

Theories	Inclusions of Theories	Researchers
Theories of Good City	Suggests operational dimensions for the evaluation of the spatial form of cities	Lynch (1981)
Theories of Land Market	Connections among landowners describe customers and Developers in the context of land progress from peasant to urban and express how rules affect selling and price.	Kaiser and Weiss (1970)
Theories of Human Ecology	Explains urban development based on economic contention of the urban area influenced by the market.	Burgess (1925), Hoyt (1939), Harris and Ullman (1945)
Marxist Theories	Explains urban development in a way Capitalists exploited workers.	Harvey (1982)
Political Economy Theories	Describes urban development in the form of cultural attempts according to the organization of urban area to respond to social needs which has utility in both house and trade context and gainers of deals and tenements context.	Rudel (1989), Harvey (1982)
Ecologic Theories	Describes the phases of balance in the natural environment and threats in these situations	Holling and Goldberg (1971)

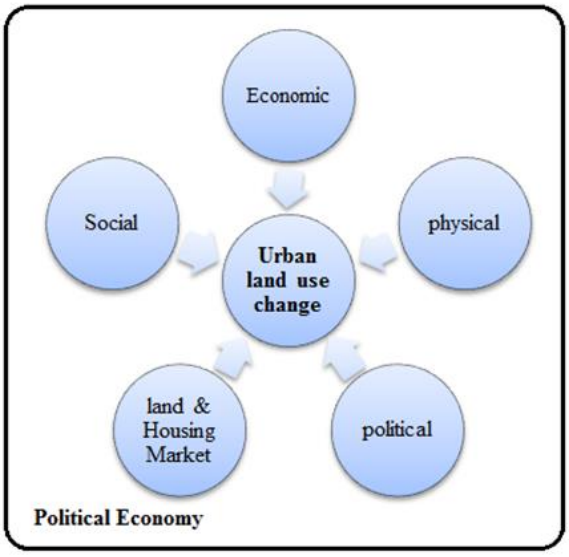

Fig 1. The Conceptual Model

3. METHODOLOGY

Secondary data, including statistical data from organizations, have been used to conduct the research. Secondary data, also referred to as past documents, were used to collect research data. These documents include scientific research on land-use change. In order to be more accurate in gathering information before studying the research, a checklist was prepared, which was used to collect more precise and comprehensive information. The content and items of this checklist are based on interviews with several professors specializing in urban studies; therefore, the tool has content validity and the required reliability. The statistical population of this research includes researchers that have been in the field of land-use change. Due to the small number of community members, sampling was not performed. After identifying the relevant studies, the parts of land-use change factors in the fourth and fifth were investigated, and the parts of the checklist were completed based on these chapters. According to the conceptual model, five adequate dimensions were involved in land-use change, namely the social factor (4 indexes), the economic factor (3 indexes), the political factor (3 indexes), the housing and land market factor (4 indexes), and the physical factor (3 indexes) (Table 3). The artificial neural network procedure was employed for the statistical analysis of research findings. The operational definitions of research variables are listed in Table 4.

Our research involves 22 districts and 134 areas of Tehran megalopolis. According to the General Census of Population and Houses in 2016, the population of Tehran is 8693706 persons. The rate of land-use change is different in Tehran. Land-use change data includes changes such as residential to commercial, green spaces, gardens and open spaces to built-up land, and land for public benefit to the use of land for private purposes. Figure 2 shows the amount of land-use change in five classes.

Table 3. Effective Indexes and Factors in Urban Land-use Change

Factors	Indexes	References
Social	Population growth rate, family density in a residential unit, ownership percentage, population density	Turner et al. (1995), Wu (1998), Verburg and Veldkamp (2001), Geist and Lambin (2002), Lambin and Geist (2003), Shen et al. (2009), Thapa and Murayama (2010), Harvey (2016)
Economic	Employment rate, number of banks and financial institutions, number of economic and trade center	Harvey (1973),Turner et al. (1995), Verburg and Veldkamp (2001), Geist and Lambin (2002), Harvey (2007), Shen et al. (2009), Thapa and Murayama (2010), Zheng et al. (2012), Harvey (2016)
Housing and Land Market	Land price, rent rate housing, number of real estates, \share of housing and land market	Harvey (1973), Philip (1993), Hersperger and Bürgi (2007), Harvey (2007), Felsenstein et al. (2007), Braimoh and Onishi (2007), Ettema et al. (2007), Loibl et al. (2007), Thapa and Murayama (2010), Jie and Hong (2011),van Delden et al. (2011), Bieling et al. (2013)
Political	Amount of renewal and reconstruction, accessibility to public transportation, infrastructure conditions	Felsenstein et al. (2007), Loibl et al. (2007), Haase et al. (2008), Braimoh and Onishi (2007), Zondag and Borsboom (2009), Qian (2010), Jie and Hong (2011)
Physical	Area of gardens and infill lands, space occupation coefficient, number of high-rise buildings	Kaiser et al. (1995), Felsenstein et al. (2007), Braimoh and Onishi (2007), Qian (2010), Axinn and Ghimire (2011), Zheng et al. (2012)

Table 4. Operational Definitions of Research Variables

Factors	Indexes	Operational Definitions
Social	Population growth rate	The population growth rate during 2016 to 2017
	Family density in the residential unit	Average of the number of families divided to the number of residential units
	Ownership percentage	Percentage of people who have ownership
	Population density	The ratio of population to area/person in km^2(2016)
Economic	Employment rate	Number of banks and financial institutions
	Number of banks and financial institutions	
	Number of financial and business center	Number of economic and trade units

Factors	Indexes	Operational Definitions
House and land market	Land price	The average price of one-meter land
	Rent rate of housing	Average price rent of building unit (75 m)
	Number of real estates	Number of active real estates
	Share of housing and land market	Share of the districts from all land and housing markets in the city
political	Amount of renewal and reconstruction	Amount of renewal and reconstruction accomplished by the municipality
	Accessibility to public transportation	Average of the total distance from BRT and Metrostations
	Urban Infrastructure conditions	Condition of urban infrastructures
physical	Area of gardens and infill uses	Ratio infill lands and garden use
	Space occupation coefficient	Average of total construction in the region to free spaces in block level
	Number of High-rise building	The ratio of High-rise to total buildings

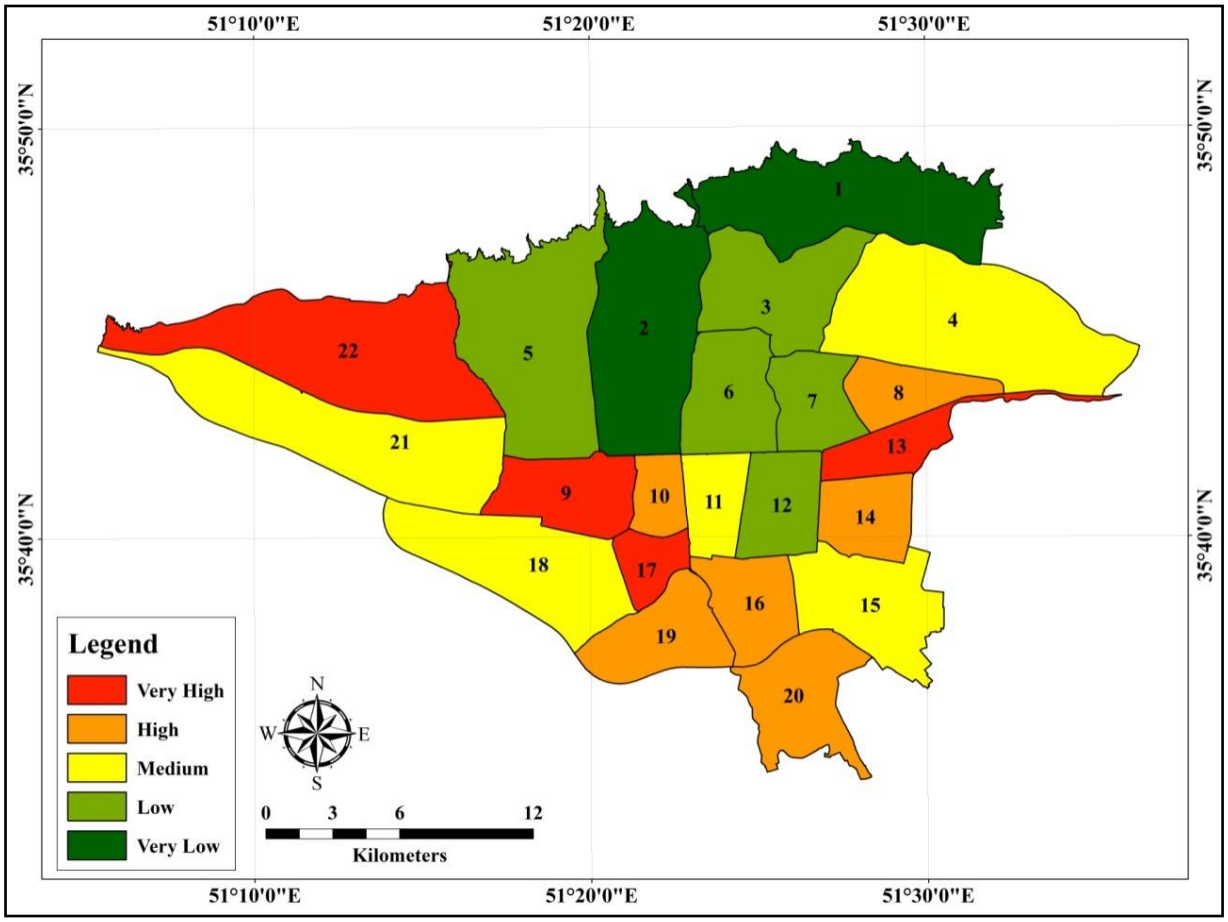

Fig 2. The Intensity of Unsustainable Land-use Change

4. ANALYSIS

4.1. Artificial Neural Network for Modeling Land-use Change

Different methods are available to researchers in order to explain the factors affecting urban land-use change. The linear multivariable regression method is traditionally used to describe the causal relation. However, artificial neural networks are more suitable for modeling land-use change because they can detect non-parametric and nonlinear trends, complex nonlinear relationships, and hidden layers between dependent and independent variables (Cross et al., 1995; Pijanowski et al., 2002; Ray & Pijanowski, 2010).

Artificial neural network models have the same overall structure despite their diversity (Mehrotra et al., 1997). An artificial neural network usually consists of three layers: 1) the input layer, 2) the hidden layer, and 3) the output layer (Priddy & Keller, 2005). The input layer consists of units whose number equals that of the explanatory variables of the model. Hidden and output layers include data processing units. The output layer units are identical to the dependent variables in the regression model. However, the only method for determining the number of hidden layers is trial and error.

4.2. Determining the Contribution of Use Changes in Urban Land Using the Artificial Neural Network Procedure

The artificial neural network model implemented in this study consists of one dependent variable (urban land-use change) and 17 independent variables (Table 2). The model proposes six hidden layers for analysis. The case processing summary shows 92 areas in the training sample and 42 regions in the testing group (Table 5).

Table 6 displays information on the neural network. The information table is helpful in ensuring the accuracy of the classification by the network. There are 17 units in the input layer. The units have been rescaled through the standardization method. The hyperbolic tangent activation function is used for the hidden layer. The identity function is the activation method for accessing the output layer. The function error is calculated using the sum of squares.

The extent of explaining the variance of the dependent variable (intensity of land-use land-use change) is the criterion for ranking the measures. This amount is also the basis for the sensitivity analysis of the artificial neural network (Table 7).

The number of banks and financial institutions, housing rental rates, the amount of renewal and reconstruction, infrastructure status, areas of gardens, infill uses, and land prices have the highest explanation of the dependent variable. The artificial neural network proposes two levels of error groups: 1) Sum of Squares Error, and 2) Relative Error.

The amount of relative errors, which have been kept entirely separate in training and testing samples, is constant. This means that there is no additional training in the model and that future errors reported by the network will be close to the errors reported in this table. The sum of square error and the relative error in the training and testing group is less than 0.05, which is a statistically acceptable error (Table 8).

The presented diagram is of the biform type and displays importance on a scale from 0 to 1 in a normalized form. This amount has been presented in Diagram 1. According to the analysis of this diagram, land-use changes are generally influenced by six indexes (the number of banks and financial institutions, average rental rates, the amount of renewal and reconstruction, infrastructure status, the number of gardens, infill uses, and land prices). The factors have noticeable effects on the prediction of land-use change.

Table 5. Case Processing Summary

		N	Percent
Sample	Training	92	68.65%
	Testing	42	31.35%
Valid		134	100.0%
Excluded		0	
Total		134	

Table 6. Network Information

Hidden Layer(s)	Number of Units		17
	Rescaling Method for Covariates		Standardized
	Number of Hidden Layers		1
	Number of Units in Hidden Layer 1[a]		6
	Activation Function		Hyperbolic tangent
Output Layer	Dependent Variables	1	Land-use change
	Number of Units		1
	Rescaling Method for Scale Dependents		Standardized
	Activation Function		Identity
	Error Function		Sum of Squares

a. Excluding the bias unit

Table 7. The Importance of Independent Variables affecting Urban Land-use Changes

Measures	Importance	Normalized Importance	Rank
Number of banks and financial institutions	0.107	100%	1
Rent rate of housing	0.106	98.40%	2
Amount of renewal and reconstruction	0.103	95.60%	3
Infrastructure status	0.93	86.90%	4
Area of gardens and infill uses	0.89	82.70%	5
Land prices	0.81	75.60%	6
Share of housing and land market	0.59	54.70%	7
Population growth rate	0.56	52.20%	8
Number of economic and commercial centers	0.52	48.60%	9
The occupancy rate of space	0.44	41.40%	10
Number of high-rise buildings	0.42	39.20%	11
Access to public transportation	0.43	32.10%	12
Employment rate	0.33	31.20%	13
Population density	0.31	29.30%	14
Number of real estates	0.24	22.70%	15
Household density in residential unit	0.023	21.10%	16
Ownership percentage	0.022	20.80%	17

Table 8. Model Summary

Training	Sum of Squares Error	0.011
	Relative Error	0.001
	Stopping Rule Used	1 consecutive step(s) with no decrease in error[a]
Testing	Sum of Squares Error	0.030
	Relative Error	0.009
Dependent Variable: Urban Land-use change		

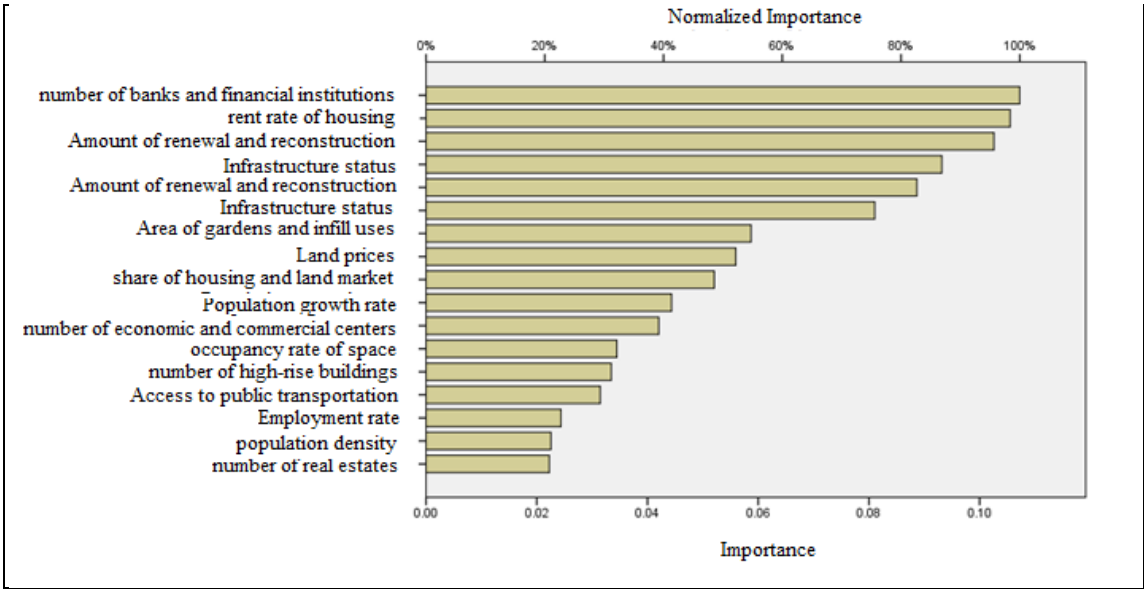

Diagram 1. The Importance and Importance of Normalized Measurements on Urban Land-use Change

5. CONCLUSION

In Tehran, land-use change is intended to achieve financial gain. It does not consider the interests of the majority of citizens, and it damages the urban environment. The adverse effects resulting from land-use change have led to urban unsustainability. In order to achieve sustainable urban development, planning and management are of prime importance in the field of land-use change. Such planning and

management require the identification and analysis of factors influencing land-use change. The authors employed meta-heuristic regression methods (artificial neural network analysis) to explain such factors. The results of the sensitivity analysis of the neural network indicate that indexes related to the land and housing market as well as economic and political factors play a crucial role in land-use change. A boom in the land and housing market has increased the intensity of land-use changes. These changes aimed at achieving more profit and returning capital. This relationship is interactive. Land-use change also leads to a boom in land and housing markets. Economic dynamics have also increased the intensity of urban land-use change. When urban space impedes economic growth, the economic factor changes the use of urban space to achieve more significant profit. Ultimately, the economic factor will lead to a change in urban land use. Other studies, including Jauhiainen (2006) and Witt and Nemnich (2011), confirm the role of the land market and housing and economic factors in land-use change. The political factor is also identified through intervention in the urban context. This intervention aimed at removing the barriers of capital. Interventions in the urban context by the government lead to changes in the type and intensity of urban land-use and urban land-use change. Studies such as Howard (1960), Dhananka (2016), and Gennaio (2008), also show the role of government involvement in the urban context in land-use change.

In addition, the physical factor is also effective in changing land use. The physical factor is shown with the existing land-use pattern. Finding a use for infill lands is economically beneficial. As a result, higher infill land always leads to higher rates of land-use change. In addition, the floating rate of commercial use in urban master plans and infill land-use has created an excellent opportunity to change to commercial use. The use of garden land creates public and environmental benefits for citizens. However, the maintenance costs for such lands are high in cities. This has led to a higher tendency among garden owners to change the use of the garden to commercially viable uses. In general, the land and housing market, economic factors, physical factors, and social factors exert the most significant impact on land-use change, respectively. Considering the role of political and economic factors that have played the most role in the process of land-use change in the metropolis of Tehran, it is suggested that city managers slow down the process of these changes by making policies in the field of proper and efficient management and creating robust monitoring devices. In the economic field, the lack of stable sources of income in municipalities and the lack of solid executive guarantee factors in urban planning laws and regulations are related. Accordingly, the management and planning of urban land-use change must take the various aspects of the urban political economy into account.

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