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CASE STUDY

Urban growth pattern in Tehran City: Sustainability or unsustainability

A. Kaviani[1], H. Mansourian[2], R. Farhoudi[2]

[1]*Department of Geography and Urban Planning, Science and Research Branch, Islamic Azad University, Tehran, Iran*

[2]*Faculty of Geography, University of Tehran, Tehran, Iran*

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ABSTRACT: Nowadays, metropolises have become as the focal points of production and use of goods and services due to the encompassing a large number of population. This topic has caused their rapid growths and developments and made them face risks concerning the development methods. Without a careful identification and planning, metropolises will plunge into their adverse consequences in the fields of environment, natural resources, human health, and socioeconomic aspects of the urban spirit. Thus, monitoring of spatiotemporal patterns of urban development in conditions of sustainability is of critical importance for urban planning and sustainable growth, particularly in the growing nations. The primary aim of this research is to look into the spatiotemporal changes in the land cover patterns of Tehran metropolis and its environs within the past four decades by employing remote sensing techniques and assessment urban growth pattern in terms of sustainability indexes. To generate land cover maps, Landsat family satellite images were used. To assessment, urban growth pattern, urban service distribution and air pollution have been applied. The results obtained represented the greatest growth has taken place in the territories built, and barren soil. The spatial analysis of urban service shows significant concentration of urban services in the key portions of the metropolis and its significant relation with environmental variables. In other words, polarization of urban services at city center, have created numerous environmental problems. The termination of this work can aid policy makers and urban decision makers to understand the outcomes of this practice.

KEYWORDS: Land cover; Remote sensing; Tehran metropolis; Urban area; Urban services.

INTRODUCTION

Today, urbanization is so rapidly increasing in the world that is unprecedented in the urbanization history, while practically affecting all the countries of the world, including the developing and developed countries (Kazemi Poor and Hajian, 2006). Although the developed world and the developing countries are different in their proportions of people living in cities and the manners urbanization has made them affected, urban growth population is a global trend. Since the Industrial Revolution in late 18th century, world's population has increased exponentially with astonishing speed to reach 1 billion people in 1830 to more than 7 billion people in 2015. On the other hand, the world's urban population has increased much faster than the rural population, reaching from 14% in 1900 to 47% in 2005 and will reach 61% by 2030. In fact, rural people has stopped growing, and it is expected that all the future population growth will occur in urban areas, especially those of the developing countries (Luck and Wu, 2002). The United Nations has estimated that world's urban population in the developing countries will increase from 2.048 billion people in 2000 to 3.991 billion people in 2030 while it expects that the urban population of the developed world will slightly enhance from 870 to 1.01 billion people (Wu, 2008). In other words, most of

*Corresponding Author Email: Telitiss@Yahoo.com
Tel.:+989125494174 Fax: +982122149727

the world's population growth will occur between 2000 and 2025 in the urban centers of less developed countries.

Currently, urban areas have covered only about 3% of the Earth's surface, while 60% of fresh water, 76% of the wood used for industrial purposes, and 75% of global energy are specifically consumed in them and turn, more than 80% of greenhouse gases are produced in those areas. Although urban areas have covered a small fraction of the Earth's surface, it cannot be ignored since continuous dynamic processes of urban changes and in particular, global expansion of urban population and urbanized areas have influenced natural and human systems on all geographical scales (Deng, *et al*., 2009; Bhatta , 2010; Kong *et al*., 2012). Urban growth as a spatial and populational process has two contradictory aspects,1) Large cities act as the engines of economic and social growths and 2), most of these cities face social, economic, and environmental problems, such as poverty, encroaching on valuable agricultural lands, increased use of private cars and fuel consumption, deterioration of capital cities, and low utilization of the currently built areas. Urban growth, especially urban sprawl, is to be blamed due to its negative impacts on the environment, natural resources, human health, and its associated socio-economic issues. The numbers of agricultural lands, forests, pastures, and open spaces have fallen sharply while ecosystems and animal habitats have been tangled air and water qualities with a warning tone, and subsequently, human health and life quality have reduced. Therefore, it is so clear that the growth of cities is a key point in many challenges that we are facing in our interactions with the environment (Barnsley and Barr, 2000; Seto and Fragkias, 2005; Ji *et al*., 2006).

Although urbanization is a universal phenomenon, it is dramatically dynamic in Iran in a way that an unprecedented urban growth has occurred in the last five decades. Over the past 55 years, the proportion of urbanization in Iran has increased from 31% in 1956 to over 71% in 2011. Over the past few decades, urbanization in Iran has been increasing as in the other Third World countries and the center of gravity of the country's population has uncontrollably shifted from rural to urban areas (Seifoddini *et al*., 2013). Since the beginning of this century and specifically from 1950s and 1960s, the roles and functions of Tehran as the capital city and center of new developments have become broader and more complex in an unprecedented way as a result of developments such as land reforms, reshuffling of the traditional urban-rural relations, mass influx of rural migrants to the cities, rapid rise in oil revenues, swift growth of service needs, developments of economic and communication infrastructures, rapid increase of main industries and assemblies, and subsequent wide development of administrative and governmental systems. The connected expansion, especially in late 1971, shifted to discontinuous and peripheral growths. The most important reasons for the change in spatial growth pattern in this period include rapid urban growth, geographic context saturation, land expensiveness, the rapid growth of industries and services, and the influx of new immigrants into Tehran city. In the process of discontinuous and peripheral expansions of Tehran city, many changes in land status, human settlements, and types of activities emerged in the region, while many rural areas lost their former functions affected by the increasing urban relations. The transfer of urban growth and urbanization from Tehran city to the surroundings was carried out without any comprehensive plans. The developments of slums and squatter settlements, formation of automotive population centers, irregular growths of cities and villages, and uncontrolled deployment of activity centers around Tehran city have caused destruction of agricultural lands and naturally beautiful landscapes, increased motorized transportation, enhanced energy consumption, environmental, air, water, and noise pollutions, biodiversity loss, and disruption of transport and traffic systems have been sources of many losses and damages in the region and on the other hand, concentration of poverty in the margins, severe economic and social problems, and lack or severe shortages of some urban services, facilities, and equipments have led to an increase of discontents among residents, who are generally immigrants and social disadvantaged groups (Ghamami, 2004 and Mansourian, 2014). However, this trend has continued to move onward with a great haste in later years as well and as a result, more agricultural and forest lands have been turned into urban areas and human settlements since the past few decades, thus adding to the economic, social, political, and environmental range of problems of the area day by day (Mansourian, 2014). Accordingly, the first step in

the management, control, and scientific intervention of Tehran city and its surroundings requires the provision of a comprehensive view of the spatio-temporal processes and patterns of urban growth, analysis of the triggers, and mechanisms impacting urbanization and urban growth in the region. The main objective of this study was to identify the spatio-temporal changes of land use/cover patterns in Tehran metropolis and its surroundings, and the assessment urban growth pattern in terms of sustainabiltiy indicators so as to provide proper tools for managers and urban planners to predict future trends, control and direct those changes towards organization of the future development of the city, estimate land uses, and finally facilitate an efficient and targeted management of Tehran metropolis and its periphery.

This study was carried out at Faculty of Geography, Islamic Azad University, Science and Research Branch during 2016.

MATERIALS AND METHODS

Method

To investigate the spatiotemporal changes of land cover in Tehran city and its surrounding areas we map the land cover of the study area at five time sections of 1973, 1985, 1992, 2000, and 2014 by using satellite images of Landsat. Table 1 depicts the features of the satellite images. To generate the maps of land cover, object-oriented, and eCognition software were employed. In this method, our job was not limited only to the spectral reflections of the phenomena on the Earth, but the shapes, patterns, and areas of the phenomena were also applied. After pre-processing of the images we used in the image classification, the main steps of the procedure are as follows: (1) image segmentation by using a multi-resolution method; (2) classification of images with a combination of both knowledge-based and supervised approaches; and (3) accuracy assessment of the results.Tabel 1.

Segmentation is the first step in the classification of satellite images in the object-oriented method. In this study, segmentations of the images were done using a multi-resolution method. The weights relevant to the parameters of shape, color, softness, and compactness were selected by examining different values to achieve the best ones for the parameters. After various trials and errors, the sets of the final parameters were obtained to be 1, 5, 0.2, 0.8, and 0.5 for the bands, scale, shape, color, softness, and compactness, respectively. Classification is another basic step for the feature extraction of satellite images using an object-oriented method. Accordingly, first, various indices were defined for each segment of the images and then the classification of the images was performed by using a supervised calssification method about the training data. After classifying the images into five main classes of built urban lands, industrial lands, barren lands, vegetation, and water, a visual approach was employed to improve the classification results. In this method, it was attempted to correct the possible errors by reviewing the classification results and complying them with the images.

To assess the accuracy of the results from the classified satellite images, aerial images taken in 1979 and 1995 on 1/10000 and 1/8000 scales, Ikonos images of high qualities taken in 2001 with a resolution of 1 m, and Google Earth software were utilized. In order to investigate the balance between the patterns of physical and population growth in Tehran, first, the maps related to Tehran's physical growth (the current 22 districts of Tehran) were produced in the periods of 1973, 1985, 1992, 2000, and 2014; then, they were analyzed in relation to the population data. The main point regarding the study of physical and population growth of Tehran is the lack of time synchrony in the production of maps of urban growth and the population and housing censuses as the basis for the demographic information. The nearest years of censuses to the time of physical

Table 1: The satellite image data

Row/Pas	Sensor Mode	Sensor	Platform	Date
35/165	Multi Spectral	MSS	LAND SAT-3	1973
35/164	Multi Spectral	TM	LAND SAT-5	1985
35/164	Multi Spectral	TM	LAND SAT-5	1992
35/164	Pan + Multi Spectral	ETM+	LAND SAT-7	2000
35/164	Pan + Multi Spectral	OLI	LAND SAT-8	2014

mapping are 1976, 1986, 1991, 1996, and 2011. In order to establish time coordination between these two sources of data, it has been tried to estimate the population in the required years of study.

Accessibilities to six types of urban services were measured for 117 Tehran's zones. These 6 types of urban facilities: educational centers (day care centers, elementary schools, schools for talented students, middle schools, high schools and universities); emergency services (fire stations, emergency centers, and police); health services (hospitals, health and treatment centers); recreation and sport centers (parks, sport clubs, sport grounds); cultural services (libraries, mosques, cinemas, and cultural centers) and subway stations, all analyzed using Arc GIS. Distance was used as criteria for accessibility. There are different definitions for acceptable distance to urban facilities. Gehl (2001) cites that the acceptable walking distance to urban facilities is 500 meters. In this research, a 500-meter distance was considered as an optimum distance to urban services. These distances were standardized (0 to 1). The value given to a distance reduces with the increase in distance. When the distance reaches 5000 meters, the value given is zero. After calculating the mean value of distances to mentioned urban services, separately and for every zone, the degree of optimum distance of each zone to urban services were measured with weighted linier index. To give weights to these six indicators, analytical hierarchical process was used on the basis of paired comparisons.

$$\text{Accessibility} = \sum_{i=1}^{N} F_i W_i$$

N is the number of facilities chosen, F_i is the value given to facility i and W_i is the weight given to facility i.

Land cover of Tehran city and its spatiotemporal changes (1973-2014)

Preparation of land cover maps by using satellite images in different years provided the possibility of quantification and monitoring of changes in Tehran metropolis. The results revealed that the overall pattern of changes in Tehran metropolitan area have been directed towards a continued increase of urban land covers. In contrast, barren lands have been declining due to being cultivated and converted into urban and industrial lands.

The area of the barren lands in the study region has been over 102,401 hectares in 1973, which was about 71.7% of the total study area. Between 1973 and 1985, the area of this class of land cover has decreased to about 69 hectares by a reduction of nearly 32000 hectares of the barren land area. In this period, the share of barren lands from the total area of the study region has reached about 48.9% with an annual growth rate of -3.14%. This negative trend has continued in the next periods so that at the end of the period of 1985-1992, the area of barren lands has reduced about 60000 hectares with an annual growth rate of -2.15%. At the end of this period of 7 years, the share of this class of land cover from the total area of the study limits has declined to 42% with an absolute reduction of 9666 hectares of the area of barren lands. In the period from 1992 to 2000, the absolute reduction of barren lands has been about 2,700 hectares. At the end of this period, the share of the barren lands from the total area of the study region has reduced by about 40% with an annual growth rate of -0.59%. In the last study period, i.e. between 2000 and 2014, the area of the barren lands has reached nearly 48000 hectares with an absolute reduction of 8883 hectares. The growth rate of barren lands during this 13-year period has been -1.28 and the share of this land cover class has reduced by 33.9% of the total study area at the end of the period. Generally, it can be said that during the period of 1973 and 2014, 53895 hectares of the area of the barren lands have decreased and their annual growth rate has been equal to -1.85% within this period of 41 years so that the share of the barren lands from the total area of the study limits has declined from 71.7% in 1973 to nearly 33.9% in 2014 (Table 2). The most important reasons for the decline of the barren lands have been the cultivation of part of the lands and their partly conversion into built up lands, including urban and industrial land uses (Tables 2 and 3; Fig. 1).

In 1973, the urban built up lands encompassed over 23000 hectares of the lands in the study area. The main focus of urban lands was on Tehran metropolis in 1973. After 12 years in 1985, considerable changes have occurred in the study area. Urban built up lands had increased to more than 44000 hectares. The absolute increase of urban lands and their annual growth rate in this period have been equal to 21094 hectares and 5.49%, respectively. Most of the variations have occurred to Tehran

Table 2: Land cover pattern in Tehran city (1973-2014)

Land cover/use	1973		1985		1992		2000		2014	
	Area(Ha)	Percent	Area(Ha)	Percent	Area(Ha)	Percent	Area(Ha)	Percent	Area(Ha)	Percent
Built up area	20868.95	14.62	38921.09	27.26	46880.69	32.83	50417.22	35.31	56767.02	39.76
Industrial area	2567.16	1.8	5609.79	3.93	6886.11	4.82	7846.13	5.49	9854.19	6.9
Vegetation	16870.11	11.81	28357.28	19.86	28797.57	20.17	27064.44	18.96	27483.1	19.25
Water	67.33	0.05	67.79	0.05	58.24	0.04	57.71	0.04	164.34	0.11
Bare Land	102401.37	71.72	69818.97	48.9	60152.32	42.14	57389.43	40.19	48506.28	33.97
total	142774.93	100	142774.93	100	142774.93	100	142774.93	100	142774.93	100

metropolis often as a peripheral and continuous growth. In 1985, urban built up lands included more than 44000 hectares of the study area. This rate has reached about 53000 hectares with a tangible enhancement in 1992.

The absolute increase of urban lands and their annual growth rate within this 7-year period have been equal to 9235 hectares and 3.19%, respectively, thus representing a significant reduction compared to the previous period. Most of the changes can be seen as an endogenous growth at the southwestern parts of the study area. The area of urban built up lands was 53766 hectares in Tehran metropolis in 1992. In 2000, urban lands increased to more than 58000 hectares with a slight enhancement. The absolute increase of urban lands and their annual growth rate in this 8-year period have been equal to 4496 hectares and 1.15%, respectively. Most of the changes have occurred in the North and East of Tehran metropolis. In this period, as the available space has been filled along the main axes of the region, the growth has started around the minor axes and loading has begun in the space between the main axes. The area of urban built up lands in Tehran metropolis has been 58263 hectares in 2000. In 2014, urban lands increased to more than 66000 hectares with a significant enhancement. The absolute increase of urban lands and their annual growth rate have been equal to 8357 hectares and 1.03% within this 13-year period, respectively. Most of the variations have occurred around Tehran metropolis, mainly in its North, Northwest, West, Southwest, and South peripheries. With the social, economic, and political evolutions of contemporary Iran, Tehran metropolis as the country's most complex space organization has experienced significant changes. In the past 40 years, urban lands have unprecedentedly increased within the range of Tehran metropolis so that the area of urban built up lands has incgrown from 23000 hectares in 1973 to more than 66000 hectares in 2014. The absolute increase of urban lands and their annual growth rate have been equal to 43,185 hectares and 2.65% in this period of 40 years, respectively (Table 2).

The area of industrial lands in the study area was more than 2567 hectares in 1973. This rate included about 1.8% of the total study area. Between 1973 and 1985, the area of this class of land cover has increased to about 5600 hectares with an addition of nearly 3000 hectares to the area of the industrial lands. In this period, the share of industrial lands from the total area of the study region has reached about 3.93% with an annual growth rate of 1.8%. This increasing trend has continued in the next periods so that at the end of the period of 1985-1992, the area of the industrial lands has increased to about 6886 hectares with an annual growth rate of 3.93%.

At the end of this period of 7 years, the share of this land cover class from the total area of the study area has increased by 4.8% with an ideal addition of 1276 hectares to them. In the period from 1992 to 2000, the absolute increase in the industrial lands has been about 960 hectares. At the end of this period, the share of industrial lands from the total area in the study area has increased by 5.5% with an annual growth rate of 1.64%. The area of industrial lands in the last study period, i.e. from 2000 to 2014 has reached about 9854 ha with an absolute increase of 2008 ha.

The growth rate of industrial lands has been 1.77 in this 13-year period, and the share of this class of land cover has increased by 6.9% of the total study area at the end of this period. In general, it can be said that in the period from 1973 to 2014, about 7287 hectares has been added to the area of industrial lands and their annual growth rate in this 41-year period has been equivalent to 3.42% so that the share of industrial lands from the total study area increased from 1.8% in 1973 to about 6.9% in 2014 (Table 2) and (Fig.1).

The area of vegetation in the study area was more

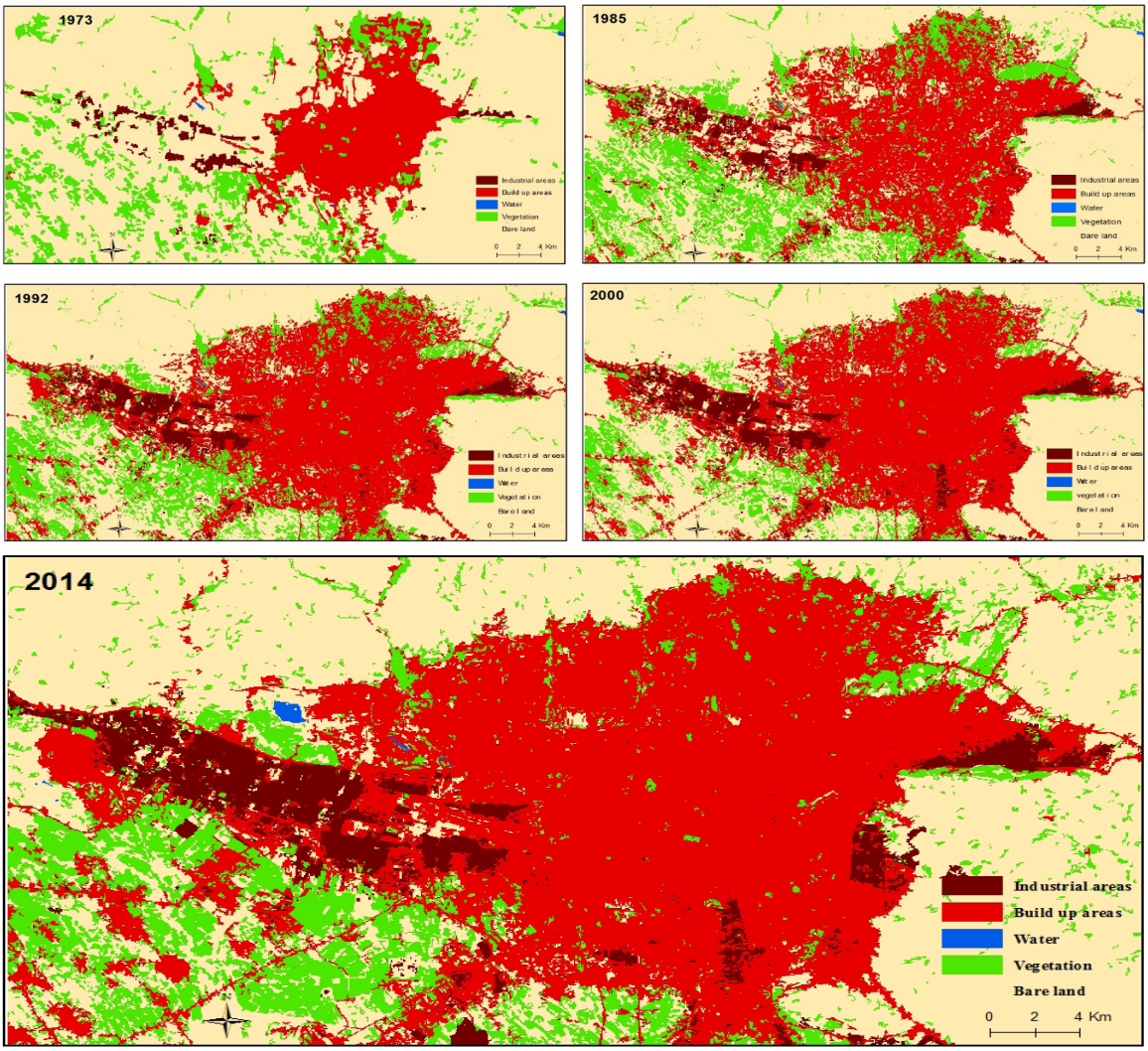

Fig 1: Land cover/use pattern in Tehran City (1973-2014)

than 16870 hectares in 1973. This rate has included about 11.8% of the study total area. Between 1973 and 1985, the land cover class area has increased by about 28350 ha with an addition of about 11000 hectares to its total area. In this period, the share of vegetation from the total area of the study region has reached about 19.86% with an annual growth rate of 4.42%. This increasing trend has continued at a slower pace in the next period so that at the end of the period of 1985 to 1992, the vegetation area has increased to about 28797 ha with an annual growth rate of 0.22%. At the end of this period of 7 years, the land cover class from the total area of the study region has increased by 20.17% with a perfect addition of 440 hectares to the vegetation in the study area. In the period from 1992 to 2000, the absolute reduction of vegetation has been about 1733 hectares. At the end of this period, the share of vegetation from the total area of the study limits has reduced by approximately 18.96% with an annual growth rate of -0.77%. The area of vegetation in the last study period, i.e. between 2000 and 2014, has reached 27483 ha with an absolute addition of 418 ha. The vegetation growth rate in this 13-year period has been 0.12, and the share of this class of land cover has increased by 19.25% of the total area of the study area at the end of the period. In general, it can be said that in the period from 1973 to 2014, about 10613 hectares has been added to the area of vegetation and its annual growth rate in this period

of 41 years has been 1.23% so that the share of vegetation from the total study area has increased from 11.81% in 1973 to approximately 19.25% increased in 2014 (Table 2).

The area of water bodies in the study area were more than 67 hectares in 1973. This rate has included about 0.05% of the total study area. Between 1973 and 1985, the area of water bodies has not changed too much and remained at the same figure of 67 hectares. This fixed trend has turned into a falling trend in the next period so that at the end of the period of 1985 to 1992, the area of water bodies has decreased to about 58 hectares with an annual growth rate of -2.14%. At the end of this period of 7 years, the share of this land cover class from the total area of the study area has reduced by 0.04% with an absolute reduction of 9.55 hectares from the area of water bodies. In the period from 1992 to 2000, the area of water bodies in the study area has remained relatively constant. In the last study period, i.e. from 2000 to 2014, the area of water bodies has reached about 164 hectares with an ideal addition of 106 hectares. The growth rate of water bodies in this 13-year period has been 8.38% and the share of this class of land cover has increased by 0.11% of the total area of the study limits at the end of the period. Generally, it can be said that in the period from 1973 to 2014, about 97 hectares has been added to the area of water bodies and their annual growth rate in this period of 41 years has been equal to 2.25% so that the share of the water bodies from the total area of the study area increased from 0.05% in 1973 to around 0.11% in 2014 (Table 3).

Urban growth and Population changes

The most important factors affecting the physical development of cities are the population growth (in the two forms of the natural growth and migration) and the incorporation of the surrounding rural areas to the urban areas. In recent decades, Tehran has experienced a significant population growth and this issue has led to the massive expansion of the city's space and places. In addition, in the process of physical expansion of Tehran, many rural areas such as Kan and Hesarak, Darake and Farahzad, Evin, Darband, Emam Zadeh Ghasem, Dzashyb, Jamaran, Kashank, and Darabad have merged with the City of Tehran and continued to be a district or part of this city. Now, the question is that if there is any balance between the growth of urban lands and the demographic trends in Tehran metropolis; whether the spatial-temporal changes of urban lands and demographic trends is in the direction of sustainable urban development or the physical and demographic developments are pushing the metropolis of Tehran towards more unsustainability. Simultaneous survey of physical and population growth of Tehran, in addition to assessing the appropriateness or inappropriateness of the growth, will provide useful tips on the manner of Tehran's growth in the horizontal and vertical directions and on the incorporation of surrounding rural areas into the physical scope of Tehran city.

The obtained results indicate that there has been a downward trend in the annual growth rate of urban lands and in the annual growth rate of the population in Tehran between the years from 1973 to 2014. In

Table 3: Spatial-temporal land cover/use changes in Tehran city (1973-2014)

Land Cover	Changes	1973-1985	1985-1992	1992-2000	2000-2014
Built up area	Absulate changes (Ha)	18052.14	7959.6	3536.53	6349.8
	Annual growth rate(%)	5.33	2.69	0.91	0.92
Bare land	Absulate changes (Ha)	-32582.4	-9666.65	-2762.89	-8883.15
	Annual growth rate(%)	-3.14	-2.15	-0.59	-1.28
Industrial area	Absulate changes (Ha)	3042.63	1276.32	960.02	2008.06
	Annual growth rate(%)	6.73	2.97	1.64	1.77
Vegetation	Absulate changes (Ha)	11487.17	440.29	-1733.14	418.66
	Annual growth rate(%)	4.42	0.22	-0.77	0.12
Water	Absulate changes (Ha)	0.46	-9.55	-0.53	106.63
	Annual growth rate(%)	0.057	-2.14	-0.11	8.38

the two decades of 1970 and 1980, the annual growth rate of urban lands and the population growth rate have been at the highest degree and there has been a downward trend in them since 1990s. The results of the calculation of population density in the metropolis of Tehran suggest that in 1973, the population density was 189 people per hectare. This situation has continued until the early 1990s; for example, the population density was 158 people per hectare in 1992. At the beginning of the process of increase in the population density, the density has increased to 163 people per hectare in the late 1990s, and this amount has reached to 181 people per hectare in 2014.

Reviewing the time trend of changes in the population density of Tehran metropolis suggests that in 1980s, the expansion of Tehran has mainly been in the form of a horizontal growth and an uncontrolled growth in the area of the city; that is, there has been a downward trend in the rate of population density in metropolis Tehran from the early 1970s to the early 1990s. However, from the early 1990s to the early 2010s, there has been an upward trend in the rate of population density of Tehran City which represents a vertical growth; as the rate of population density has increased from 158 people per hectare in 1992 to 181 people per hectare in 2014. The physical and population changes of Tehran Metropolis have been displayed in Table 4 and Fig. 2.

The results of simultaneous investigation of the vegetation cover changes and population growth as one of the most important environmental indicators suggest that the absolute number of population in the periods from 1973 to 2014 has grown sharply and it has increased from about 3.886 million people in 1973 to more than 8.436 million people in 2014. However, the results of the analysis of satellite images show the area of vegetation cover, after an increase between the years from 1973 to 1985, has been severely reduced and its area has been decreased from about 9778 hectares in 1985 to 5913 hectares in 2014. In fact, from the Tehran's total area of 63554 hectares in 2014, only about 9.03% of this area has been allocated to the class of vegetation cover including agricultural lands, gardens, urban green space, and forests. A simultaneous study of population and vegetation cover in Tehran metropolis in the form of the green space per capita index shows that this index has been equal to 17.11 square meters per person in 1973; this index has decreased to 16.6 square meters in 1985, 12 square meters in 1992, 9.09 square meters in 2000, and 7.009 square meters per person in 2014. Changes of the vegetation cover class and the population of metropolis Tehran has been shown in Table 4.

Spatial distribution of urban services and air pollution

The final index of access to public services is a weighted linear combination of the scores related to the six educational, emergency, health, transportation, cultural, and recreational services. The used weights have also been determined based on the opinions of experts and by using the analytic hierarchy process through the paired comparisons of the elements. The spatial distribution of the final index of access to public services in the areas of Tehran has been displayed in Figure 3. The highest scores for the index of access to public services are related to the central parts of the city; that is, by getting away from the center of city, this index decreases radially. Therefore, the existence of a single-core model is confirmed in Tehran metropolis. This centralized and single-core model has caused to the flow of a bulk of daily trips to the center of Tehran in order to get benefit from the urban services. Accordingly, various environmental effects have been formed in the central areas of Tehran by the influence of the centralized model of urban growth (Fig. 3).

Table 4: Urban growth and population changes in Tehran city (1973-2014)

Year	1973	1985	1992	2000	2014
Urban land area (Ha)	20561	35443	41278	43594	46688
Urban land annual growth rate (%)	-	4.64	2.20	0.68	0.49
Population (thousand)	3886	5870	6531	7123	8436
Population annual growth rate (%)	-	3.50	1.54	1.09	1.22
Density (population in Ha)	188.9	165.6	158.2	163.4	180.7
Vegetation area (Ha)	6649.45	9778.17	7968.50	6475.35	5913.10
Vegetation annual growth rate (%)	-	3.265	-2.88	-2.56	-0.646
Per capita vegetation (m^2 per person)	17.11	16.65	12.20	9.09	7.009

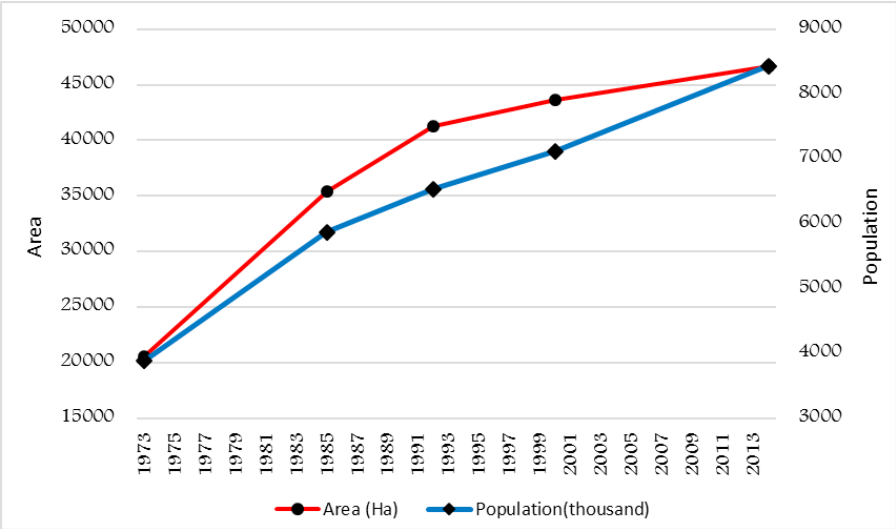

Fig. 2: Urban growth and population changes in Tehran city (1973-2014)

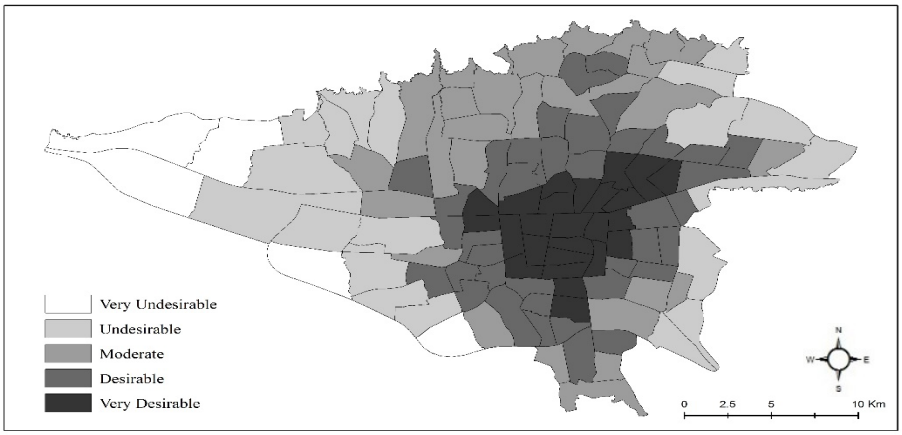

Fig. 3: Access to urban services

One of the important effects of the current pattern of urban growth in Tehran is the existence of high concentration of pollutants in the central parts of the city. The layer of air pollutants (carbon monoxide) has been used to analyze the air pollution in Tehran. The results show that the highest level of air pollution is in the downtown areas (central parts) of the city, while the northern regions have the lowest level of air pollution (Fig. 4).

RESULTS AND DISCUSSION

Urbanization and urban growth as a global phenomenon have affected all the nations of the globe. The essence of this phenomenon in Iran as a developing nation has achieved its heyday in the past few decades. The interactions of different strengths and internal and external driving factors and the developments arising from them have been as the driving engine of urbanization in Iran. Nevertheless, the processes of urbanization and urban growth in Iran have presented themselves in the course of certain patterns about the strengths and weaknesses of the stimuli and changes in the order.

Urbanization and urban growth affected by the operation of the country's centralized structure have taken a step in the direction of centralization to develop peripheral capitalist relations since 1300. This centralization process has demonstrated itself in the shape of the initial urban model. In this theoretical account, due to the benefits of crowdedness, Tehran has accounted for more than a fourth part of the urban population in Iran since late 1350's. Indeed, the

spatial reflections on social, economic, and political developments have indicated that the growing focus has been in Tehran until the mid-1350s. By cutting the benefits of aggregation and rise of problems caused by the initial urban pattern, necessary policies have been taken on to distribute with the rapid and increasing primary urban growth in Iran. Therefore, since the 1970s onwards, urbanization and Iranian urban growth have stepped along the path of decentralization. Nevertheless, the decentralization process in Iran, like any other developing countries, has manifested itself as a centralized distribution.

There are concerns around the environmental, economical, and societal impacts of urban sprawl. The rules of ground cover and urban size have been seen and examined. Urban sprawl, with the expansion of metropolitan areas and consumption of scarce resources are recent issues. In this inquiry, the centering of the analysis was on spatiotemporal changes of ground back in Tehran city. Besides, the practice of concentration of urban installations and its environmental impacts was also examined.

The solutions obtained from the analysis of satellite images proved that in the past 40 years, urban lands unprecedentedly increased in Tehran metropolitan range, so that the arena of urban built lands has risen from 23000 hectares in 1973 to more than 66000 hectares in 2014. The absolute growth of urban soils and their annual growth rate in this period of 40 years have been equivalent to 43,185 hectares and 2.65%, respectively. During the period from 1973 to 2014, about 7287 hectares have been added to the area of industrial lands and their annual growth rate in this 41-year period has been equivalent to 3.42% so that the share of industrial lands from the total area of the study area increased from 1.8% in 1973 to around 6.9% in 2014. Consequently, the drastic reduction of barren grounds and the sharp increase of urban and industrial lands can be recognized as the most significant land use/cover changes in the final four decades in Tehran metropolis and its fencing in regions.

Investigating the practice of ground cover changes in the 22 districts of Tehran shows that the constructed urban lands have had a rapid growth and on the other hand, there has been a downward tendency in the barren soils and vegetation cover. Therefore, the pattern of land cover change in Tehran has been running towards the instability. Nevertheless, the analysis of changes in land cover along with the demographic trends presents more explicit evidence indicating the tendency of Tehran City to-

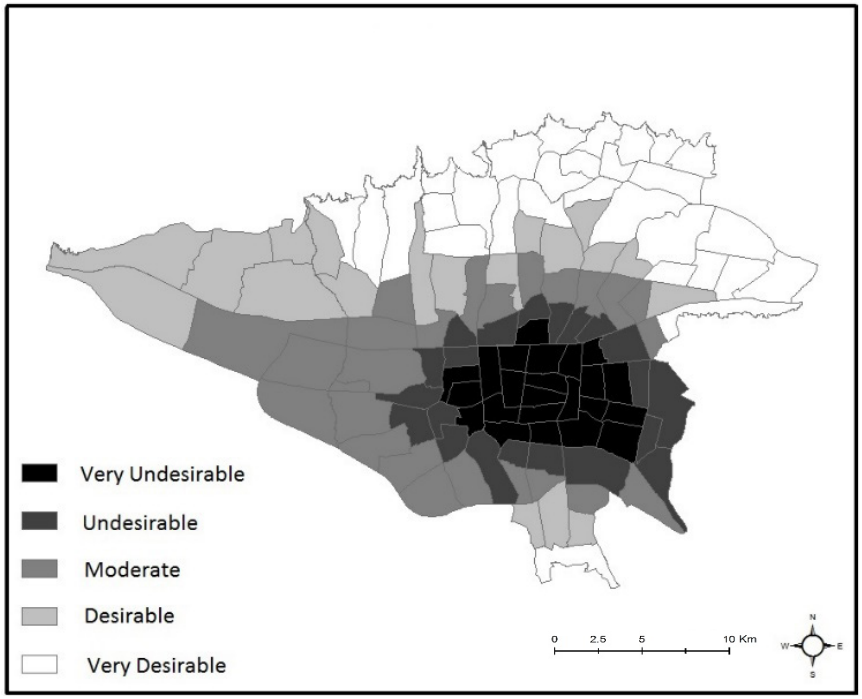

Fig. 4: Air pollution in Tehran City

wards more instability. Although based on the concurrent analysis of data on ground cover and population growth can be averred that the growth pattern of Tehran City has gone towards more vertical growth, only the excessive construction in the urban estates and the rapid expansion of Tehran's span is of big worry. The speedy physical and population development of Tehran has led to the decrease in per capita green space such that it has fallen from 17 square meters per capita in 1970s to approximately 7 square meters per capita in 2014. This decreasing trend is the consequence of converting the agricultural lands, orchards, forests, and pastures to the residential areas, communication infrastructure, and industrial lands.

Although the form of land cover change in Tehran provides sufficient evidence for the cause of a Tehran towards an unsustainable direction, but the pattern of presentation of the urban services also exacerbates this unsustainable trend. The spatial analysis of urban services in Tehran indicates the existence of a centralized and single-core model focusing on the key regions of the metropolis. This single-core and centralized model of urban services has caused special environmental effects in the urban center of Tehran; as the results of psychoanalysis of the air pollution layer caused by the carbon monoxide showed that the central parts have the highest degree of pollution and by getting away from the downtown areas, the degree of pollution has fallen.

The outcomes of research show that the Tehran city has experienced unplanned urban development. Unplanned sprawl has occurred when there has been no plan to decentralize urban facilities from central parts of the urban center and there are significant concentrations of urban services in key portions of the metropolis. In that respect is also a lack of efficient and efficient shipping services. Consequently, there has been an increase in the role of private cars and as a result loss of green spaces, increase in air pollution particularly in key portions of the metropolis.

The results of correlation analysis showed a substantial relation between the form of concentration of urban facilities and adverse environmental impacts. The increasing rates of the urbanization and urban sprawl have made the growth of distance between urban services and home and work. Lack of effective public transportation has encouraged use of private automobiles. Urban sprawl and polarization of urban services have had numerous environmental impacts, especially in the key portions of the metropolis. The most important impacts are the air pollution, and low green space area in the key portions of the metropolis.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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