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AN ANALYSIS OF URBAN SMART GROWTH INDICTORS (WITH AN EMPHASIS ON COMPACTNESS, ACCESSIBILITY AND ENVIRONMENT) CASE STUDY: PIRANSHAHR CITY, IRAN

Omid mobaraki

(Assistant Professor Geography and Urban Planning University of maragheh, Iran)

ABSTRACT: *The concept of "smart growth" was become popular by Parris Nelson Glendening from 1994 to 2003. The main emphasis of smart growth is on mix land use and the design of compact buildings which produce high densities together with lower environmental effects. The current research aims at investigating urban smart growth indexes based on three indexes of compactness, environment and access to districts and neighborhoods of Piranshahr City, Urmia. The main research method is descriptive-analytical and it is dome through ANP, GIS and Heldren and Shannon's Entropy Models. The finding of this research shows that the Piranshahr city is not of appropriate position in terms. From the point of physical growth this city has developed in term of sprawl growth, in terms of the index of green space the standard of individual green space has not been observed, and finding in term of access to the public transportation this index do not cover the whole city.*

KEYWORDS: Planning, Smart Growth, Land Use, Piranshahr City.

INTRODUCTION

During the past century, the world's population has been rapidly congregating in urban areas. The urban population in the world was estimated at 2.4 billion in 1995 and a doubling is expected at about the year 2025(Mohammadi and et al, 2012). Increasing expansion of cities, depletion of natural resources, abundance and traffic congestion are only some of the detrimental effects of population growth and its unreasonable distribution on the natural and cultural environments of communities. Development of transport has reduced travel costs per day, and has led to move people into the suburbs and surrounding cities. An obvious example of this is the emergence urban sprawl pattern. Distribution patterns of urban habitats have led to social costs. In this regard, since the 1990s, to solve this problem, moving towards traditional patterns of land use has started. (Cervero et and al, 2002). In the meantime, smart growth strategy is one of the main strategies to inhibit the effects of distribution, and is based on the incorporation of land uses and buildings compressed, which leads to high density with less environmental impacts. The characteristic feature of smart growth is compact development patterns, which practically lacks certain features of Distribution (Danielson et al, 1999; Hasse, 2004).

In the past, urban sprawl was regarded as a US phenomenon associated with the low-density outward expansion of the urban areas. Seeds for that growth were already shown during the interwar period. The environmental impacts of urban sprawl have raised concerns among planners and have stimulated other models of urban expansion such as "smart growth" (Gabriel, Faria, Moglen 2006, Litman 2007, Turner 2007) which attempt to reverse the low values of the eight dimensions stated above. Many public health advocates have recommended smart growth as a potential solution to the problem of urban sprawl.(Frumkin

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and et al, 2004) Smart growth can be defined as a policy framework that promotes an urban development pattern characterized by high population density, walk able and bike able neighborhoods, preserved green spaces, mixed-use development (i.e., development projects that include both residential and commercial uses), available mass transit, and limited road construction.(Jackson and Kochtitzky, 2009). Smart growth was originally conceptualized as an aesthetically pleasing alternative to urban sprawl that would offer residents a high quality of life and the convenience of local amenities.

After (1961-1971), in Iran, having an increased cities' population, because of both high natural growth and largescale immigration of villagers to cities, the growth of urban form and construction did not happen based on needs but on land mongering. This led to an unorganized urban land market, especially within urban limits and the negative distribution of cities' sprawl and horizontal expansion (Athari 2000). Today, there are so rare cases of cities not involved with problems of development and spatial and physical spread in Iran. And, Piranshahr city is not an exception. It is an example of such cities whose traditional order and spatial organization have been shattered due to rapid growth and development as a result of natural population growth and increase in the rate of immigration acceptance because of its border markets in recent years. Therefore, its population has reached from 965 to 72722 from 2011 to 1956. In the period, population has increasingly and rapidly grown together with the fact that urban physical body has irregularly spread in such a way that its area has reached from 631 hectares to 844 hectares. It has resulted in the fact that the city has grown in different directions and gone toward agricultural lands. In the other hand, the increase in the migrations to the city has formed suburbia. All of those factors have resulted in irregular urban development and lack of order in urban physical body. Furthermore, environmentally speaking, any crisis can endanger the future of the city. For example, urban sewage and industrial water wastes have not been controlled and it has resulted in pollution of the river waters. And, lack of green spaces, urban open leisure areas and citizens' use of private cars instead of public transportation are among factors caused huge problems in the city and those should be investigated and analyzed. In addition, economically speaking, as a result of urban development and growth in agricultural lands, two problems happen: demolition of farms and transportation expenses increase due to sprawl development. Socially speaking, there are such problems as neighborhoods' lack of access to services, lack of security, citizens' laziness, lack of medical services all over the city, cultural ignorance, and the evacuation of the settlements in downtowns and the construction of new buildings in the city outskirts. Totally speaking, it is necessary to investigate and analyze urban smart growth Indictors for the city.

Study area

Piranshahr which is considered as political center of Piranshahr country is located in south of West Azerbaijan province and 12 km to Iran and Iraq (Iraq Kurdistan). According to the Management and Planning Organization, the city has a total area of 154.9 square miles (401.3 km^2), of which 1.6 square miles (4.1 km^2), or 1.03%, is water. This city is encompassed from north to Oshnaviye and Naghadeh and from south to Sardasht and from West to Mahabad (Consultant Engineers Armanshahr, 2009:2). Piranshahr has no active or dormant volcanoes and few earthquakes, however many residents of Piranshahr feel one or two minor earthquakes per year, which do little or no damage. Imperceptible quakes are detected by seismometers on a daily basis. Piranshahr's population based on the 2006 and 2011 consensus is 59721 and 70722 (Iran Statistical Center, 2006 and 2010). The city has

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been home to various ethnic groups during its long history. For this reason, the demographics of the city have undergone numerous changes, with Kurds currently constituting the majority of the population. Nonetheless, many historical documents attest to the fact that at the beginning of the 20th century, the majority of the city's population was composed of Azerbaijanis. The Piranshar economy includes that of the city of Piranshar and the surrounding towns and villages. The Piranshar area is an engine of the provincial economy. The city of Piranshar has the most important sugar company in the province. The city of Piranshahr produces a full range of over 100 different granite materials in a variety of colors and textures. The quality and the beauty of Piranshahr granites are one of the Best-known in the world. The ethnic composition of Piranshahr is 94% Kurdish and 6% Azarbaijani, known locally as Ajams or Turks.

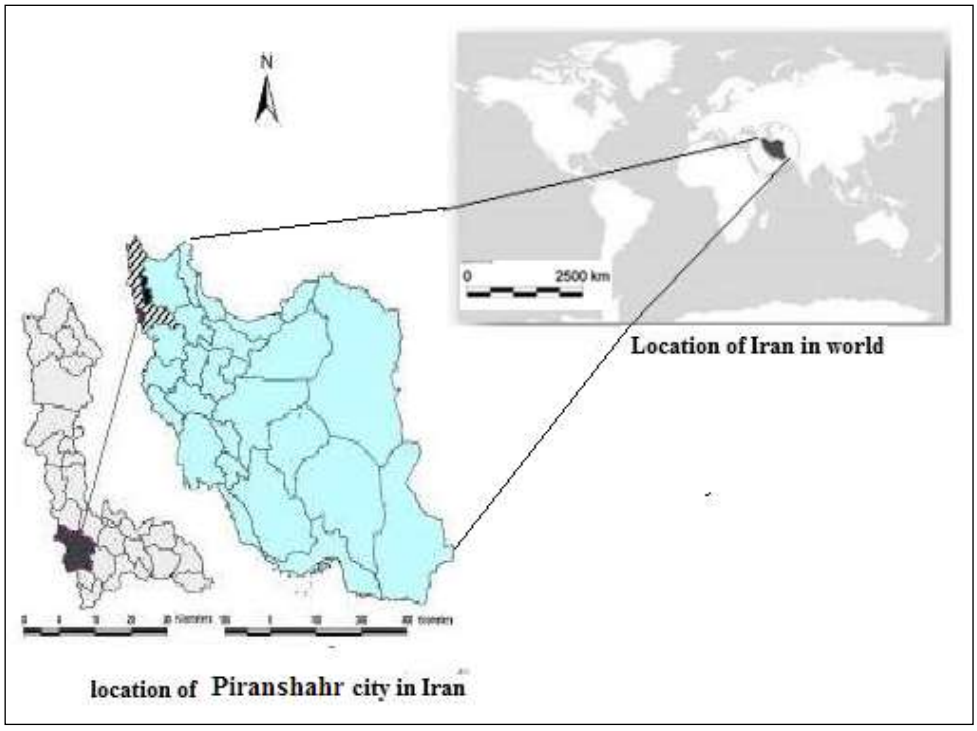

Fig 1- Location of Iran and the study area in the world

METHODS

This study is an applied one and the methods of investigation are both descriptive and analytical. To analyze urban smart growth indexes, Arc GIS, Analytic Network Process (ANP) and Holderen and Shannon's Entropy Models have been employed required data was collected through library research, field operation, master plans and different organizations. The data was analyzed by Excel and Arc View software. And reason for the selection Piranshar city rapid growth, physical development, sprawl growth as a result of natural population growth and increase in the rate of immigration acceptance because of its border markets in recent years. The main effect of growth in urbanism and development of urban areas is destroying services distribution system and weakness of services system. Such a problem exists in many cities of Iran.

ISSN: 2052-6377(Print), ISSN: 2052-6385(Online)

RESULTS

The principles of smart growth

Smart growth involves a set of principles to guide development and land-use decisions. These principles were developed by the Smart Growth Network, a partnership of government agencies, developers, environmentalists, historic preservation advocates, professional organizations and interests from the real estate industry. It was launched by the Environmental Protection Agency in 1996.

1. Mix land uses. Each neighborhood has a mixture of homes, retail, business, and recreational opportunities.
2. Build well-designed compact neighborhoods. Residents can choose to live, work, shop and play in close proximity. People can easily access daily activities, transit is viable, and local businesses are supported.
3. Provide a variety of transportation choices. Neighborhoods are attractive and have safe infrastructure for walking, cycling and transit, in addition to driving.
4. Create diverse housing opportunities. People in different family types, life stages and income levels can afford a home in the neighborhood of their choice.
5. Encourage growth in existing communities. Investments in infrastructure (such as roads and schools) are used efficiently, and developments do not take up new land.
6. Preserve open spaces, natural beauty, and environmentally sensitive areas. Development respects natural landscape features and has higher aesthetic, environmental, and financial value.
7. Protect and enhance agricultural lands. A secure and productive land base, such as BC's Agricultural Land Reserve, provides food security, employment, and habitat, and is maintained as an urban containment boundary.
8. Utilize smarter and cheaper infrastructure and green buildings. Green buildings and other systems can save both money and the environment in the long run.
9. Foster a unique neighborhood identity. Each community is unique, vibrant, diverse, and inclusive.
10. Nurture engaged citizens. Places belong to those who live, work, and play there. Engaged citizens participate in community life and decision-making. (www.smartgrowth.bc.ca)

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Table 1: Design Principles of Smart Growth

Principle	Description
Mix Land Uses (SGP1)	-Supporting the integration of mixed land uses in communities as a critical component of achieving better place to live.
Compact Building (SGP2)	-Providing a means for communities to incorporate more compact building design as an alternative to conventional, land-consumptive development.
Variety of Housing Choices (SGP3)	-Providing a range of housing types, sizes, and prices.
Walk able Neighborhoods (SGP4)	-Creating walk able communities to live, work, learn, worship, and play.
Community with Strong Sense of Space (SGP5)	-Fostering communities with a strong sense of place to craft a vision and set standards for development that respect community values of architectural beauty and distinctiveness, as well as expand choices in housing and transportation.
Preserve Open Space and Critical Environmental Areas (SGP6)	-Open space preservation supports smart growth goals by bolstering local economies, preserving critical environmental areas, improving our community's quality of life, and guiding new growth into existing communities.
Infill Development of Existing Communities (SGP7)	-Directing development towards existing communities already served by infrastructure, seeking to utilize resources that existing neighborhoods offer, and conserving open space and irreplaceable natural resources on the urban fringe.
Variety of Transportation Choices (SGP8)	-Providing a wider range of transportation options in an effort to improve beleaguered current systems.
Cost Effective Development (SGP9)	-Embracing the private sector to help make development decisions to be Predictable, fair, and cost effective.
Community-stakeholder partnership (SGP10)	-Encouraging community and stakeholder to jointly making development decisions.

Source: (Ming wey, 2013)

Benefits of Smart Growth

While many Americans have benefited from decades of post–World War II suburbanization, many have not. It is also a development pattern has led to some negative consequences for the community as a whole. Our nation is now experiencing heightened concern over the social, environmental, and fiscal quality of our communities arising from development practices that aggravate the decline of many urban communities and older suburbs, congest streets and highways, demand higher levels of energy consumption, accelerate the loss of natural resources and deteriorate the natural environment, and limit opportunities for the retention and creation of affordable housing. Often these problems are simply and collectively labeled, "sprawl." In response, the Smart Growth movement emerged. Infill development and redevelopment, increased density of development, and the adaptive re-use of existing buildings result in efficient utilization of land resources, more compact urban areas, and more efficient delivery of quality public services. Efficient use of public and private infrastructure starts with creating neighborhoods that maximize the use of existing infrastructure. Special consideration should be given to the location and timing of

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infrastructure extensions in rural areas so as not to encourage growth that will promote inefficient and unsustainable development patterns; create the need for additional inefficient and costly infrastructure; result in the loss of viable agriculture, forest land, and important natural habitat; create conflicts between agricultural and urban land uses; or ultimately harm the character of the rural community. Smart Growth principles have an economic benefit to the communities and regions that employ them. (www.planning.org/policy/guides)

Mixed-use developments include quality housing, varied by type and price, integrated with shopping, schools, community facilities, and jobs. Human-scale design in harmony with the existing urban form and quality construction contribute to successful compact, mixed-use development and also promote privacy, safety, visual appeal, and compatibility among uses and users. In rural areas, a mix of housing types and price ranges should be encouraged to meet the needs of the entire community. Mixed-use development is not limited to vertical mixed-use structures; locating parks, neighborhood retail and services, schools, and housing all within walking distance is another way to create a mixed-use community. Integrating land use and transportation planning to accommodate more than just the automobile and to provide increased transportation choices, including mass transit, bicycling, and walking is a hallmark of Smart Growth. Such development is pedestrian-friendly at a human scale. Rural residents, who range in age and abilities, also have needs for access to public transportation. All forms of transportation must be reliable, efficient, and user-friendly, creating opportunities for access by all segments of the population to housing, employment, education, recreation, and human and community services. Smart Growth includes evaluating the appropriate geographies to improve air quality, water quality and quantity, habitat functionality, economic prosperity, and transportation choices; and for local jurisdictions within these geographies to establish and coordinate policies that address these elements in a manner that is appropriate for their regions and governance structures. Smart Growth does not work without cooperation and partnerships among governments, property owners, developers, financial institutions, and the public. The principles of Smart Growth can form the basis for dialogue between these parties and challenge all to ensure that we create in America communities of lasting value. Smart Growth provides timely tools not only for long-range planning but also addressing current issues related to communities with high foreclosure rates, limited infrastructure, and fiscal challenges (Ibid).

Evaluation of Urban Form

Holderness model

One of the principal methods for determining urban sprawling growth is the use of Holderness Method. In 1991, John Holderness applied a method for determining urban sprawl growth and population growth. Using this method, it could be specified what extent of urban growth is the result of population growth and to what extent it is the result of unorganized urban growth. He employed land gross per capita formula (Hekmatnia and Mousavi 2006).

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$$Ln\left(\frac{\text{population at the end of period}}{\text{population at the beginning of period}}\right)+\text{Ln}\left(\frac{\text{land gross per capita at the end of period}}{\text{land gross per capita at the beginning of period}}\right)$$
$$=Ln\left(\frac{\text{urban area at the end of period}}{\text{urban area at the beginnig of period}}\right)$$

$$Ln\left(\frac{72722}{61250}\right)+Ln\left(\frac{85}{97}\right)=Ln\left(\frac{844.45}{631.62}\right)$$

$$Ln(1.0155)+Ln(0.9711)=Ln(1.0450)$$

$$(0.0153)+(0.029)=(0.044)$$

$$\left(\frac{0.0153}{0.044}\right)+\left(\frac{0.0293}{0.044}\right)=\left(\frac{0.044}{0.044}\right)$$

$$\%34+\%66=1$$

Therefore, 34% of the physical growth in Piranshahr City from 1990 to 2012 is due to population growth and 66% is due to urban growth which is related to urban sprawl and horizontal growth, which results in a decrease in population's gross density and an increase in urban land gross per capita.

Shannon's Entropy Model

This model is used for analyzing and determining the extent of urban sprawl growth phenomenon. The general structure of this model is as follows:

$$H= -\sum^{n}_{i=1} Pi\times Ln(Pi)$$

Where, H is the value of Shannon's entropy; Pi is the ratio of constructed zones area (total housing density) to the total sum of zones area, and n is the total sum of the zones.

The value of the Shannon's Entropy is between 0 and Ln(n). 0 means a very compact (dense) urban physical development, whereas Ln (n) shows urban sprawl physical growth. When the value of the entropy is more than Ln(n), urban sprawl growth takes place.

Table2: Calculating Shannon's Entropy for 2012 in Piranshahr City

Areas	Constructed area	P_i	Ln(n)	$P_i \times \mathbf{Ln}(P_i)$
1	3098485	.3637	-.9845	-.3678
2	1951727	.2353	-1.3368	-.3404
3	1735277	.2092	-1.5633	-.3272
4	1507012	.1817	-1.7053	-.3098
∑	8292501	$\sum P_i = 1$	-5.5899	-1.3452

H= -1.3452

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Tables 2 indicates that the value of entropy is 1.3452 in 2012, while the maximum value is Ln (4) = 1.3862. The closeness of entropy value to the maximum value suggests urban sprawl physical development. The entropy value is 1.3452 in 2012, indicating that physical growth has been in sprawl and incompact form.

Evaluation of Access

To achieve smart growth, the main aim is making more options of transportation available for citizens. Increasingly, the cities are looking for different options of transportation. Specially, they are searching for wider transportation tools so that they could change public transportation systems. Therefore, in order to achieve urban sustainable development, the cities need newer modes of transportation planning including better coordination of transportation use, more access to quality transportation, multiple transportation options, flexibility and inner relationships of transportation network and the warranty of the relationships among passengers, bicycle riders and public transportation. With respect to the investigation done in 22 global metropolitans, Gehl (2002) states that in order to reach special lines, the normal radius of movement for most of the bicycle riders is between 400 to 700 meters. Also, he explains that the normal radius of movement for most of the people is 400 to 500 meters on foot. In the current research, to investigate the radius of citizens' access to bus stops, taxi lines and minivan lines, 500-meter distance is considered as acceptable distance.

Buses

Piranshahr has 47 bus stops and 5 bus lines. According to the observations of the study, the performance of the system is not proper and low use rate of the system shows lack of inclination toward the system against other vehicles transportation such as private cars, taxis and private hire cabs. Of main reasons of this lack of propensity could be higher waiting time due to lack of buses in the lines. Therefore, according to the findings and calculations, 27.26% of urban areas are located in 5-minute (500-meter) distance from bus stops in the city. Also, 72.64% of urban areas are located in over than 5-minute (500-meter) distance from bus stops in the city. The calculations reveal improper distribution of bus stops in the city. The highest coverage belongs to neighborhood 8 with 82.15% and the lowest one to district 14 with no access.

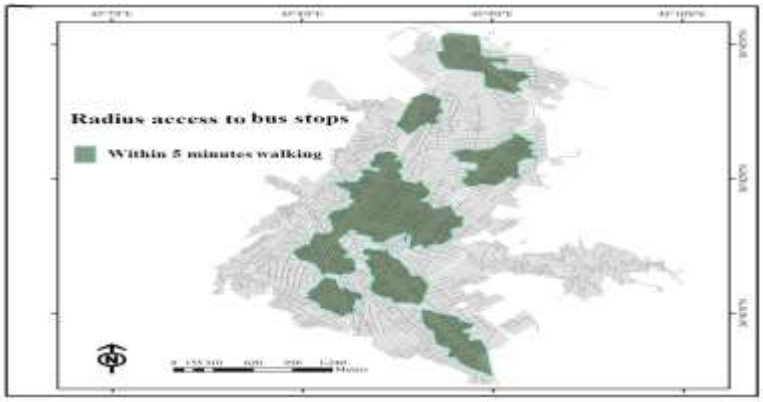

Fig 2: Radius access to bus stops

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Taxis

Piranshahr has 6 taxi lines, 283 regular taxis and 68 line taxis. According to Piranshahr Municipality's Traffic and Transportation Department, most of the travels are done through private cars and taxis in the city. Therefore, according to the findings and calculations, 56.62.26% of urban areas are located in 5-minute (500-meter) distance from taxi lines in the city. Also, 43.27% of urban areas are located in over than 700-meter distance from taxi lines in the city. The highest coverage belongs to neighborhoods 3 and 2 and lowest one to neighborhood 14 with no access.

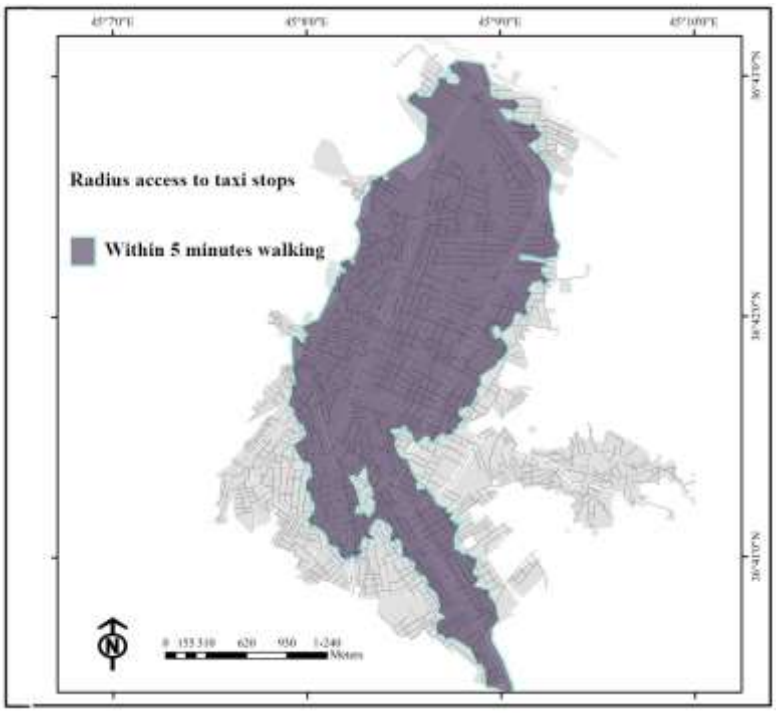

Fig 3: Radius access to taxis stops

Evaluation of green space

Green Spaces

In Piranshahr, an area of 12.77 hectares is located to green use in the form of parks, green spaces, refuges of streets and green parts of squares and it is 1.9 square meters per capita. Its occupation rate against all areas is 2.41% and its percentage against all urban area is 1.7%. Lack of sports green space land (about 22.7 hectares) is notable. In the following parts, the specifications of those two types of green use are shown in the city. Equipped green spaces (parks) enjoy area of 12.77 hectares and include 2.41% of all urban area. This type of land use is 1.9 square meters per capita.

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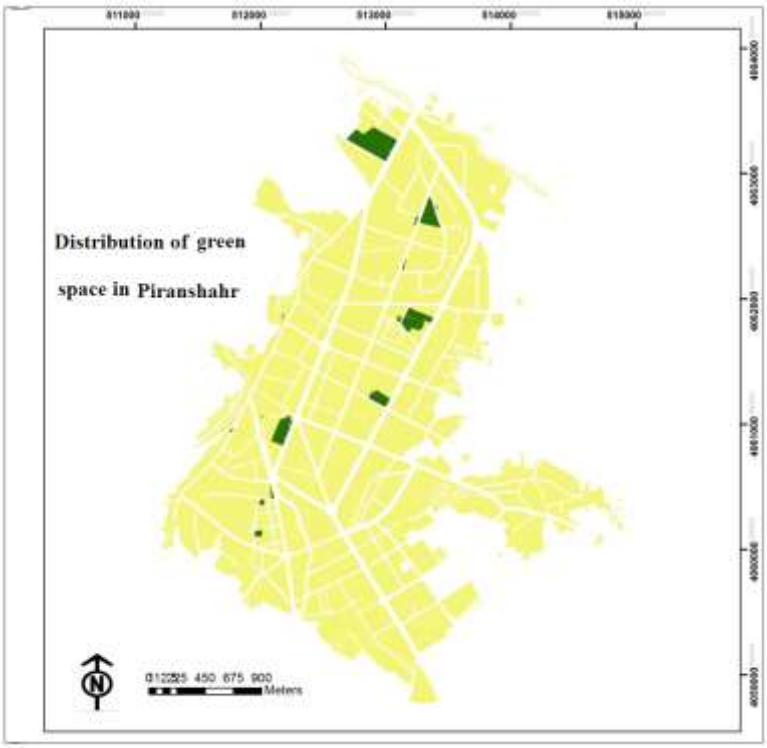

Fig 4: Distribution of green space in Piranshahr

Sewerage Network

The important indexes of safe life is acceptable urban sewerage system. In addition to wastewaters produced by residents, the wastewaters of industrial and agricultural centers are polluting underground and surface waters, specially rivers, lakes and seas. Piranshahr's wastewater collection network includes notable share of the city in such a way that the length of the network is about 90 to 100 kilometers with diagonal of 200 to 800 millimeters and 14000 main offshoots. 74% of population is covered by wastewater collection network (traditional through transition to urban outskirts and modern through transition to infiltration system); the rest of the population removes of their wastewaters in traditional wells (Piranshahr Water and Wastewater Company, 2014). There is no wastewater infiltration network in public centers, hospitals, industries, big public and private organizations located in the city and wastewaters of the city's waste removal center and butcher house enter into river and pollute its waters. Urban wastewaters are dangerous due to high amounts of Nitrate and sever bacterial pollution. The drainage of urban wastewater into wells and removal of it in rivers threaten supply resources of urban waters and, in turn, it endangers the health of citizens. Among urban districts, district 2 or downtown has the highest density and highest coverage of wastewater collection network and district 3 has the lowest coverage of the network.

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CONCLUSIONS

Smart growth is a flexible, while wide, expression including vast volume of new meanings and concepts struggling for the improvement of urban environments. Unlike urban sprawl development, it tries to adopt a sustainable approach against different dimensions of urban life. For so doing, regarding urban physical growth, it leads development toward inner city capabilities and natural resources protection. Therefore, the current research attempts at investigating and analyzing urban smart growth indexes among Piranshahr's districts in terms of neighborhoods using different methods and models. Findings reveal that Piranshahr's neighborhoods have different discrepancies with each other regarding indexes investigated. Shannon's Entropy Model indicates that the city has sprawl development. Heldren Model shows that regarding city physical growth or its area development, its 66% belongs to population growth and 34% to urban sprawl development. Regarding environmental indexes, green spaces sub index, district 1 has the highest green spaces per capita with area of 89471.11 and population of 27279 and district 4 has no urban green spaces with population of 7758. In sub index of access to sewer network, district 2 with average population has the highest coverage of urban sewer network and district 3 with the population of 19797 enjoys the lowest coverage of the network. In addition, in the sub index of wastes among the districts, districts 1 and 2 has the highest rate of waste production and in the sub index of old textures, districts 1, 2 and 3 consisting of neighborhoods 1, 7 and 11 with the population of 21729 have the highest extent of old textures.

In the sub index of access to bus stops, the highest coverage belongs to neighborhood 8 (located in district 2) with 82.15% while neighborhood 14 (located in district 3) has no access to the stops. Furthermore, in the sub index of access to taxi lines, neighborhoods 2 and 3 are at the first place (located in district 1) with 100% of citizens covered whereas the lowest coverage belongs to neighborhood 14 (located in district 4). And, in the sub index of access to minivan lines, neighborhoods 2 and 3 (located in district 1) enjoy the highest access with 100% of the citizens received the service while the lowest coverage belongs to neighborhood 15 (located in district 4) with 35% of citizens covered. Ultimately, regarding three indexes of compactness, accessibility and environment, Piranshahr is not in an acceptable condition. However, in order to approach to smart growth indexes, the following items are recommended:

- creating more green spaces and parks in the neighborhoods for such purposes as coordination and unity with other spaces and buildings as well as citizens' use and enjoyment, in addition to environmental effects such as air pollution control and noise pollution control
- creating compactness in the neighborhoods, including a balanced combination of different activities such as living, shopping, working and spending leisure times area
- developing needed mixed land uses including educational-cultural uses
- reconstructing inner city old textures in order to avoid leaving those old parts of the city alone as well as forbidding new constructions in the city outskirts
- Allocating more urban spots to bus stops and taxi lines in order to deliver better service to the citizens
- correcting urban transportation system and creating facilities and infrastructures for walking in the passages having attractions for the citizens
- promoting public culture in order to reduce fuel consumption and use public transportation vehicles

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- regulating efficient, clear and scientific strategies in order to avoid irregular urban forms
- correcting and reviewing available patterns of urban limit protection and regulating necessary laws in this regard
- creating vast variety of residents, sizes and ownerships.

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