

## Original Research

## Evaluating population growth and distribution and its relationship to the physical development of Zahedan

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## ABSTRACT:

Most of the cities in Iran have enjoyed a balanced growth until a few decades ago; but in recent decades due to the presence of attractive factors in cities and repulsive factors in rural areas, urbanization has become prior to urban planning and has made urban growth to suffer serious challenges. Zahedan, during its life of more than 90 years, has followed different trends and patterns of physical development and has passed an imbalanced growth. Present review is a descriptive analytical study which by applying Moran and Holdren models, extraction of GIS layers and assesses the physical form of the city. Results revealed that Zahedan did not grow in compressed form; based on the results of the Holdren model analysis 78% of physical growth of the city that happened within 1986 to 2011 was due to population growth and remained 22% was due to the horizontal and sprawl growth, also, Moran coefficient tendency toward negative sign shows the city's sprawl growth. In order to prevent and reduce issues and problems caused by this kind of urban expansion which is affected by its own dispersed pattern of growth, sector-focused pattern was diagnosed as the proper pattern for the future expansion. To achieve this important, with time and place priority, the inner context focused development pattern should be applied along with combined utilization and compact city pattern (smart) and development of crossover and diagonal communication network system. In this way, a reversal of the current trend of urbanization development prior to urban planning will be observed.

## Keywords:

Growth and distribution of population, Holdren Model, Moran coefficient, Zahedan.

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## INTRODUCTION

The first few years of the twenty-first century has been associated with profound developments in human life. These developments in the context of globalization of economy and culture has affected social relations and human life and has manifested the reflection of these relationships in spatial effects especially in cities. Without a doubt, the most important feature of this century is opening new perspectives in human settlements and unprecedented concentration of population in major cities of the world (Razavian, 2002).

Population growth and rapid urbanization in recent decades have been followed by adverse effects such that it can be cited the uneven physical development of cities, creating marginal neighborhoods, poverty and decline of standards of living, lack of service centers, and eventually inequalities in using facilities.

However, the development and growth of cities as a result of various events had their own decline and ascent, in all periods of history. But what founds the basis of modern urbanism and urban development, dates back to the eighteenth century. The Industrial Revolution and subsequent developments that led to the revolution in urbanism in the second half of the nineteenth century, displayed human settlement in the cities in another way (shie, 2006). Therefore, urbanism plays a crucial role in geographical development of population and urban growth (Rabbani and Vahida, 2002).

In recent decades, the expansion and growth of cities have become an issue in Iran and the necessity of attention to the urban issues especially its physical ones in the form of a scientific framework have become more important and necessary (Bagheri, 2001). However, today most of the developing countries are unhappy with

the process of expanding their residential spaces (Zebardast, 2004). In fact, improper growth and development of the cities and out of proportion densities are of the problems and issues of nowadays cities, which has led to phenomenon such as suburbanization (Shie, 2006). So, the most important issues that the uncontrolled growth of cities due to the development of suburbanization have created are as follows: physical abnormalities, facility abnormalities, economic damages, and environmental pollutions (Akbari, 2004). Therefore, despite such deficiencies, urban spaces have failed to correctly answer the needs of rapid and accelerated urbanization. Now, the absence of the rule of fundamental programs of urban planning on urban growth, has led urban planning trend to lag behind urbanization. Because, planning for growth is not only to make houses for the settlement of people; but also, to meet their daily needs and meet the requirements of welfare, education, health, leisure, etc. as well (Dahaghani, 2004).

The past few decades have seen a sharp increase in the world population. In the period of 1950-1990 the world's population grew more than three times and has reached from 730 million to 3.2 billion people. Probably, between the years of 1990-2020 this amount will be doubled to 4.6 billion people. It is estimated that, about 93% of this population increase will happen in developing countries (Devas and Rakodi, 1993). Accordingly, it is required to provide necessary measures for the accommodation of the extra population.

After the industrial revolution Urban Settlement System has gone through great changes in economy, politics, technology and physical shapes, and in recent years, urban settlements growth has surpassed rural settlements. Due to the increasing growth of urbanization

**Table 1. Population and average annual growth during the years of 1956-2011 in Zahedan**

| Statistical years                              | 1956  | 1966  | 1976  | 1986   | 1996   | 2006   | 2011   |
|--|-------|-------|-------|--------|--------|--------|--------|
| Population (people)                            | 17495 | 39732 | 93740 | 281923 | 419518 | 552706 | 560725 |
| Average percent of annual growth over a decade | -     | 8.55  | 8.96  | 11.64  | 4.05   | 3.07   | -0.24  |

**Table 2. Population and households of Zahedan in decades of 1966-2011 in separation**

| Year | Population | Female | Male    | Sex ratio | The number of conventional households |
|------|------------|--------|---------|-----------|---------------------------------------|
| 1966 | 39732      | 19376  | 20356   | 105       | 8000                                  |
| 1976 | 93740      | 44241  | 49499   | 117       | 19560                                 |
| 1986 | 281923     | 143893 | 200130  | 102       | 48890                                 |
| 1996 | 419518     | 203682 | 215836  | 103       | 70401                                 |
| 2006 | 552706     | 266099 | 286607  | 105       | 131002                                |
| 2011 | 560725     | 277045 | 2830680 | 102.4     | 134088                                |

and urban population and by disrupting the hierarchy system of relationship between cities and villages, urbanization trend was not balanced and has created many problems in economic, social, political, and physical dimensions, and if from applied geographical point of view, growth and development system left unspecified many consequences will be followed, this situation can be called critical, too. In the process of physical and spatial dynamics of the city, the neighborhoods appearance will change quickly and drastically. And urban population increase due to rural migration and natural population growth of the city, highlights the need for housing more than ever.

Zahedan, having service, industrial, and economic attractions and as one of the most fundamental poles of population absorber in the region has gain considerable growth in recent years. This growth, influenced by population growth and immigrant influx, has led to unplanned construction and changes in spatial-physical structure of the city, and also, has led to the city expansion to the nearby farms. It seems that in the future, in the absence of implementation of a particular strategy in determining the pattern and optimal development directions, not only many of the high quality agricultural lands would go under construction, but also face the city administration with various problems in establishment of the infrastructure facilities and provision of public services needed by citizens.

Considering that Zahedan nearby is surrounded by agricultural lands, uncontrolled development and growth of the city will cause destruction of orchards and change of the land use. Furthermore, uncontrolled

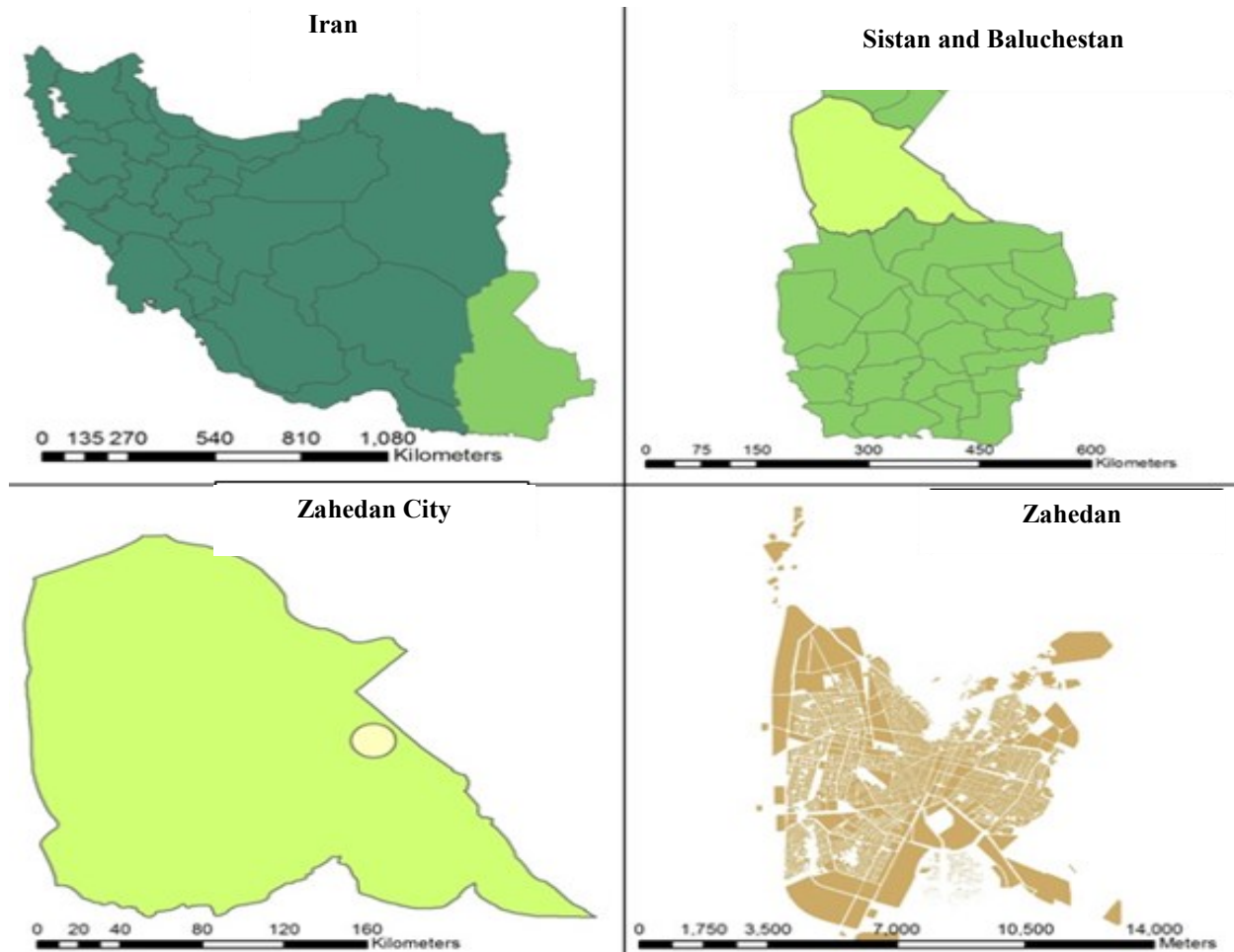
growth will cause extravagance in the use of lands, lack of facilities and urban equipment in marginal areas, and finally, imbalance growth of the city. Since any research has not been conducted in this respect about Zahedan, investigating physical-spatial development trend of Zahedan will lead us to the identification of the causes of uneven development and pattern and shape recognition of the city, and from these findings we can present appropriate solutions to reduce these problems of the present city and similar cities around.

#### Study area

Sistan and Baluchestan province is in the south-east of Iran, and is considered as the one of the largest provinces of the country. This province is located between the latitudes of 25 degrees and 3 minutes and 31

**Table 3. Areas and proposed population of 20 districts of the city of Zahedan horizon 2013**

| District number | Area (ha)     | The proposed population |
|-----------------|---------------|-------------------------|
| 1               | 255.6         | 43144                   |
| 2               | 312.6         | 67355                   |
| 3               | 596.1         | 84811                   |
| 4               | 223.2         | 44332                   |
| 5               | 283.3         | 57821                   |
| 6               | 158.1         | 36253                   |
| 7               | 195.1         | 24018                   |
| 8               | 190           | 34206                   |
| 9               | 223           | 33448                   |
| 10              | 160.9         | 37634                   |
| 11              | 237.1         | 35013                   |
| 12              | 172.3         | 24408                   |
| 13              | 194.3         | 30006                   |
| 14              | 218.2         | 37427                   |
| 15              | 395.9         | 59905                   |
| 16              | 260.3         | 42054                   |
| 17              | 271.1         | 40212                   |
| 18              | 196.9         | 54875                   |
| 19              | 174.4         | 34560                   |
| 20              | 207           | 41400                   |
| <b>sum</b>      | <b>4925.5</b> | <b>862882</b>           |



**Figure 1. Geographical location of the study area**

degrees and 27 minutes of North, and between 58 degrees and 49 minutes and 63 degrees and 20 minutes of East. The province has an area of 187502 km<sup>2</sup>, which is limited to the province of Khorasan-Jonubi from the north, to the Pakistan and Afghanistan borders from the east, to the sea of Oman from the south, and to the provinces of Kerman and Hormozgan from the west. Its western part is low-lying and is in the vicinity of Lut desert and its eastern part is much higher. The average height of the province is 1350 meters and encompasses more than 11 percent of the total country area. Zahedan with an area of about 36,581 km<sup>2</sup> is located between 29 degrees and 28 minutes of north latitude and 60 degrees and 52 minutes of east longitude of the Greenwich meridian. Its height is 1373 meters above the sea level. City legal area is 6413 hectares (Figure 1).

## **MATERIALS AND METHODS**

Present study is a descriptive - analytical study which by applying Moran and Holdren models, and extraction of GIS layers (distribution of the proposed population in comprehensive plan of 20 districts of horizon 2013), preparing SHP-File, data were entered into the GIS software, after which map of population density and area were obtained, (Figure 2 and 3) to assess the physical form of the city.

### **Holdren's Method**

One of the basic ways to identify bad shape of urban growth is Holdren method. Using this method, we can determine how much of the urban growth was resulted from population growth and how much of it was due to the uneven urban growth (Hekmatnia and Moosavi, 2006). Steps of Holdren's method are as follows:

(Holdren, 1991)

$$a=A/P \tag{1}$$

In equation (1), gross per capita (a) is equal to land area (A) divided by population (P); where,

A = Area of total are (in acres or square miles) of development in city or state

P = Population of that city or state

a = area of city or state used by the average resident (per capita land use)

$$A=P*a \tag{2}$$

If over a period of time ‘Δt’ (e.g., a year or a decade), the population grows by an increment ‘ΔP’ and the per capita land use changes by ‘Δa’, the total urbanized land area grows by ‘ΔA’, expressed as:

$$A+\Delta A=(P+\Delta P) \times(a+\Delta a) \tag{3}$$

Subtracting eqn. (1) from eqn. (2) and dividing through by ‘A’ to compute the relative change (i.e., ΔA/A) in urbanized land area over time interval, ‘Δt’ yields:

$$\Delta A/A = \Delta P/P + \Delta a/a + (\Delta P/P) \times (\Delta a/a) \tag{4}$$

Hence, following the Holdren paradigm, eqn. (3) states that the percentage growth in urbanized land area (viz., 100 percent x ΔA/A) is the sum of the percentage growth in the population (100percent x ΔP/P) plus the percentage growth in the per capita land use (100 percent x Δa/a).

Stated in words, equation (4) becomes:

$$\text{Overall percentage land area growth} = \text{Overall percentage population growth} + \text{Overall percentage per capita growth} \tag{5}$$

In essence, the Holdren methodology quantifies population growth’s share of total land consumption (sprawl) by finding the ratio of the overall percentage change in population over a period of time to the overall percentage change in land area consumed for the same period. This can be expressed as:

$$\text{Population share of growth} = \frac{\text{Overall percentage population growth}}{\text{Overall percentage land area growth}} \tag{6}$$

The same form applies for per capita land use:

$$\text{Per capita land use share of growth} = \frac{\text{Overall \% per capita land use growth}}{\text{Overall \% land area growth}} \tag{7}$$

The above two equations follow the relationship based on. Holdren’s equation (6) in his article. A common growth model follows the form (say for population):

$$P(t) = P_0 (1 + gp) t \tag{8}$$

where ‘P(t)’ is population at time ‘t’, ‘P0’ is the initial population and ‘gp’ the growth rate over the interval.

Solving for ‘gp’ the growth rate yields:

$$\ln (1 + gp) = (1/t) \ln (P(t)/P_0) \tag{9}$$

Since ln (1 + x) approximately equals ‘x’, for small values of ‘x’, equation (8) can be written as:

$$gp = (1/t) \ln (P(t)/P_0) \tag{10}$$

The same form of derivation of growth rates can be written for land area (A) and per capita land use (a)

$$gA = (1/t) \ln (A(t)/A_0) \tag{11}$$

$$ga = (1/t) \ln (a(t)/a_0) \tag{12}$$

These three equations for the growth rates allow the result of equation (4) to be restated as:

$$gP + ga = gA \tag{13}$$

Substituting the formulae (equations 9 through 11) for the growth rates and relating the initial and final values of the variables ‘P’, and an over the period of interest into equation (12), the actual calculation relationship becomes:

$$\ln (\text{final population} / \text{initial population}) + \ln (\text{final per capita land area} / \text{initial per capita land area}) = \ln (\text{final total land area} / \text{initial total land area}) \text{ (Holdren, 1991)} \tag{14}.$$

## RESULTS

### Population change trend in Zahedan

Considering that age is one of the inherent features of human being and consequently one of the main variables in population geography, therefore, the age composition study of men and women who operate in

| Spatial Autocorrelation Report   |                  |
|--|------------------|
| <b>Spatial Autocorrelation Report</b>  |                  |
| Moran's Index  | : -0.021836      |
| Given the Z-score: The pattern does not appear to be significantly different than random |                  |
| p-value  | 0.560266         |
| Global Moran's I summary   |                  |
| Moran's Index:   | -0.021836        |
| Expected Index:  | -0.052632        |
| Variance:  | 0.030603         |
| z-score:   | 0.176036         |
| p-value:   | 0.360266         |
| Dataset Information  |                  |
| Input feature class:   | Navahi           |
| Input field:   | Hectares         |
| Conceptualization:   | Diverse_distance |
| Distance method:   | Euclidean        |
| Row standardization:   | False            |
| Distance threshold:  | 1643 1601355     |
| Weights matrix file:   | None             |

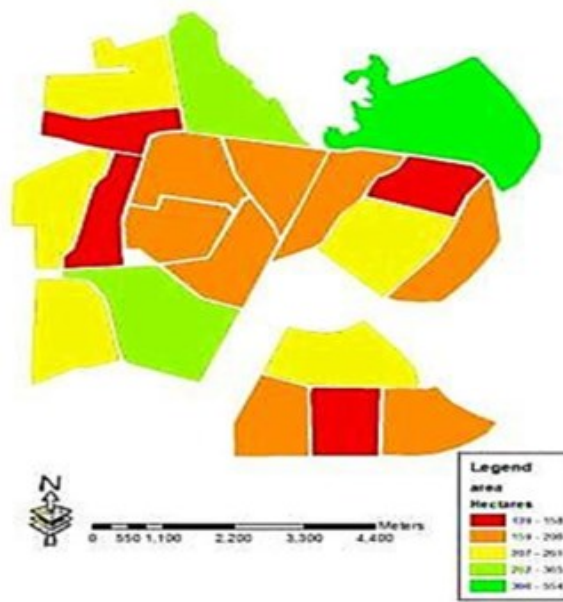


Figure 2. Distribution of the proposed population, in comprehensive plan of 20 districts, in horizon 2013, in GIS environment and the results of data processing in the Moran model.

| Spatial Autocorrelation Report  |                  |
|---|------------------|
| <b>Spatial Autocorrelation Report</b>   |                  |
| Moran's Index   | : -0.021836      |
| Given the Z-score : The pattern does not appear to be significantly different than random |                  |
| p-value   | 0.522479         |
| Global Moran's I summary  |                  |
| Moran's Index:  | -0.029684        |
| Expected Index:   | -0.052632        |
| Variance:   | 0.042804         |
| z-score:  | 0.639543         |
| p-value:  | 0.522470         |
| Dataset Information:  |                  |
| Input feature class:  | Navahi           |
| Input field:  | Population       |
| Conceptualization:  | Diverse_distance |
| Distance method:  | Euclidean        |
| Row standardization:  | False            |
| Distance threshold:   | 1643 1601355     |
| Weights matrix file:  | None             |

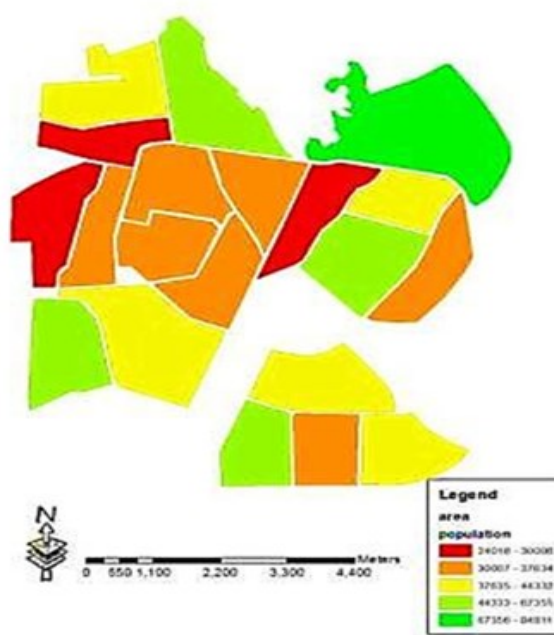


Figure 3. Distribution of the proposed area, in comprehensive plan of 20 districts, in horizon 2013, in GIS environment and the results of data processing in the Moran model.

areas of social life of a community are very important. The sex ratio reflects the socio-economic conditions prevailing in each country and also, it is a useful tool for the analysis of each region in terms of population. In fact, all conflict related to the sex ratio in time and space is due

to the impact of three factors: Abundance of boys at birth, different mortality rate between both sexes at different ages, and gender differences in migration.

According to Table 1, Zahedan population in 1956 census was 17495 people, in 1966 census was

39731 people, in 1976 Census this number has reached to 93740 people, means that, the city population has become 2.5 times greater than previous census. The population growth rate in this period was 8.55 percent. In 1986 census this number reached to 281923 people. This means that, at this census the city population has become three times greater than the previous census, and the population growth rate at this period was 11.64 percent. In 1996 census, the city population has reached to 419518 people, which means that, the city population has become 1.5 times greater than the previous census, and the population growth rate at this period was 4.05 percent. In 2006 census, the city population has reached to 552706 people, which means that, the city population has become 1.5 times greater than previous census, and the population growth rate at this period was 5.38 percent. In a rare occurrence, Zahedan population in 2011 census reached to 560725, with the population growth rate of -0.24 percent (Population and Housing Census 1956 to 2011).

In short, according to (Table 1 and 2) above, in all periods the city's population has a trend of rapid increase, until 2011 Population and Housing Census which Zahedan population has experienced a declining trend, this means that, the number of 560725 people, shows negative growth. Afghans' leave and migration to the privileged provinces could be important factors affecting this decline.

#### **Is there any significant relationship between population distribution pattern and area of Zahedan?**

This coefficient potentially determines the city spatial construction, and ranges between -1 to +1. Its high value represents a high accumulation of small areas with high density and value close to zero shows a random accumulation and value equal to -1 indicates checkerboard (dispersed) pattern of development. 'N' determines number of small areas, 'Xi' determines population or employment in 'i' small area, 'Xj' determines population or employment in 'j' small area, 'X' determines av-

erage population or employment and 'Wij' determines weight between the area 'i' and 'j'.

In this study, the area of study is selected based on the vigesimal division done by Shahr Khane consultant engineers (Zahedan's comprehensive plan), in which, population and the area was projected as the basis to determine the continuity and distribution of the above mentioned characteristics (Table 3).

After preparing SHP-File, data were entered into the GIS software, after which map of population density and area were obtained.

With the desired pattern, the degree of compactness and spatial distribution were determined; accordingly output shows that: (Figure 2, 3). The results of Moran coefficient are -0.021836 for the area, and -0.079684 for population, both show the population and area distribution in the study area. Because there was a tendency toward -1 which represents dispersed pattern of population and urban area and it is very close to the pattern of random distribution.

#### **Is there any direct relationship between Zahedan's horizontal growth and increase of gross per capita of land use?**

In the case of Zahedan this formula would appear as:

$$\ln(\text{final population} / \text{initial population}) + \ln(\text{final per capita land area} / \text{initial per capita land area}) = \ln(\text{final total land area} / \text{initial total land area})$$

$$(15) \ln(560725/281923) + \ln((130.188)/(107.15)) = \ln(7300.3021)$$

$$\ln(1.988) + \ln(1.215) = \ln(2.416) \quad (16)$$

$$0.687 + 0.194 - 0.822 \quad (17)$$

$$((882.0) / (882.0)) - ((882.0) / (194.0)) + ((882.0) / (687.0)) \quad (18)$$

$$0.78 + 0.22 - 1 \quad (19)$$

Thus, we note that in the case of the Zahedan from 1986 to 2011, only 78% of physical growth was related to population growth and 22% of it was related to horizontal and sprawl growth of city which resulted in

decrease of gross population density and increase of urban land gross per capita, which in turn can have several causes such as: excessive concentration of investments in land and housing, religious and ethical affiliations, the benefits of housing construction followed by high demands for real estate purchases by other cities' investors, and also remained immovable property (real estate) of Afghan refugees.

## DISCUSSION

History of research in the field of physical development of cities in Iran, obviously dates back to the Pahlavi period, during the Years of 1926-1979. In this period, the government, for the first time in the history of urbanization and urbanism, influenced by the cross-border (West) thoughts intend to change the city's face and structure. In this way, physical expansion first starts from Tehran and then extended to other cities) Avalizadeh, 2005)

In relation to the physical development of cities in Iran, several studies have been conducted. Abedindorkoosh in "urban economy" (1985) reviewed the pattern and shape of cities such as Tehran, Qazvin, Golestan, Urumia and etc. Abadi (1992), attributed physical development of Kerman to the political, economic factors, geographic position and population growth.

Chagani (2002), investigated migration and other factors influencing physical development and socio-spatial construction of Sabzevar, and counted migration as the one of the most important factors affecting physical development and social construction of Sabzevar.

Ivan et al. (2002) in a research that have conducted about spatial structure of city and urbanization suburbs in the metropolitan area of Barcelona city. The studies show that the urbanization of population is much broader than employment and the model of Single-core metropolis has a limited use to describe the metropolitan area of Barcelona. Finally, rising utilities and improvements that have occurred in private transport have pro-

vided conditions of employment provided for suburban population. Most of the results are in order to of this study.

## CONCLUSION

Undoubtedly, the ultimate goal of urban planning is to create a permanent welfare for citizens. Thus, one of the most important issues of urban planning, is to determine how cities will physically develop in the future, that should lead to the urban development in the proper sense. In this study, form and physical structure of the city was investigated in relation to population growth and distribution with the use of related models in different periods, and considering the conditions prevailing the city it was revealed that during the years of 1922 to 1986 the growth and development of the city was compact and in line with the population growth, but from 1986 onwards the phenomenon of sprawl urban growth had happened in Zahedan. Also, considering the existing physical pattern of the city which is dispersed and sprawled, now with the use of Moran and Holdren models, sector-focused pattern was diagnosed as the proper pattern for preventing sprawl and future expansion of the city. Regarding the factors affecting the development and growth of urban physical structure and the superposition of all characteristics, suitable locations for future expansion are south and south-west.

## SUGGESTIONS

### Land Value Taxation (LVT)

This tax is an efficient tool to stabilize the land market. In this type of tax, it makes no difference that the owner of the land performs optimal use or land is left unused. However, these taxes must be paid. Obtaining this type of tax places a tax burden on the shoulders of the owners and besides being a revenue for managing city triggers construction of such lands and doubles the structural cohesion and prevents commercialization of lands.



**Land transfer by an organ or trustee**

According to Article 9 of Urban Land Act of 22/06/66 (Ministry of Roads and Urban Development of the Islamic Republic of Iran, 2016) Ministry of Roads and Urban Development is responsible for the supply of the land needed for the construction of housing and public services, while using all of the public wastelands in cities which are suffering from inadequacy of such lands, from urban established lands and wastelands in order to reduce excessive and illegal use of urban lands. While in recent decades, numerous lawlessness has actually witnessed in the transfer of urban lands. Therefore, in order to settle this problem effective legislation should be drafted and enforced by government.

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