

URBAN SPRAWL IN MID-SIZED CITIES OF MENA, EVIDENCE FROM YAZD AND KASHAN IN CENTRAL IRAN

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Abstract

Urban sprawl is a well-researched topic and its negative effects on transportation, environment and social interactions are shown in many studies. However the related literature mainly comes from developed countries, and the developing countries, particularly those located in the Middle East and North Africa have a small part. This paper investigates the presence of urban sprawl in the urban developments in the periphery of the mid-sized and small large cities of central Iran. Yazd and Kashan are taken as case-study cities. The observation criteria are based on the urban sprawl definitions that are accepted and widely used. The four measures that are observed in case of these two cities are discrepancy between urban growth rate and population increase, decrease in population density, leapfrog and scattered developments, and lack of public open spaces. The findings of the study show that urban sprawl is seen in the urban development pattern of both cities. This sprawl partially started in 1970s and increased dramatically after 1980. The paper argues about the necessity of more in-depth studies about presence and morphology of urban sprawl in mid- sized and small large cities of Iran and other countries of the Middle East and North Africa.

Keywords: Urban sprawl, Iran, density, urban form, Yazd, Kashan

1. INTRODUCTION

During the recent years urban sprawl has drawn the attention of urban planners and thinkers as an urban growth trend that should be controlled. So far many negative aspects of this trend have been considered. This spectrum of negative impacts covers issues related to environment, transportation, finance, etc. The effects of the urban form of sprawling developments on urban travel attitudes have been discussed for the last two decades. Especially it has been shown that low-density sprawled urban textures can affect car ownership and mode choice (Newman, Kenworthy, 1989; F.a.P. Associates, 1992; Levinson, Kumar, 1997; Liu, Shen, 2011; Bento et al. 2013) . The impacts of sprawled urban form on transportation are mainly caused by long distances between the destinations. Long travel lengths are mainly caused by vast areas that are under construction in such textures and also low connectivity of the street network. The advocates of smart growth, new urbanism, and Transit-Oriented Development have emphasized on the necessity of planning more connected street networks to encourage people to use slow modes of transportation (pedestrian/bike) and have face-to-face social interaction (Calthorpe,

1993; Duany et al. 2000). Long-distance motorized urban travels in sprawled areas have also direct or indirect impacts on transportation fuel consumption (Newman, Kenworthy, 1989; Brownstone, Golob, 2009; Liu, Shen, 2011; Marique et al. 2011) . Also the negative effects of low density developments on residential energy use have been examined (Kaza, 2010; Shammin et al. 2010). The high level of car use in sprawled urban configurations is considered to lead to high CO₂ emissions and air pollution (Pohanka, Fitzgerald, 2004; Gonzalez, 2005) and affect the environment in the periphery of the urban areas (Shao et al. 2008). As a consequence of urban sprawl, motorization and lack of physical activity (Li et al. 2005) has led to health problems like presence of chronic diseases and obesity (Kelly-Schwartz et al. 2004; Sturm, Cohen, 2004; Freudenberg et al. 2005; Zhao, Ewing et al. 2009; Lathey et al. 2009; Kaestner, 2010). The financial costs of constructing sprawled cities and towns are also more than building them in a compact form (Burchell, Galley, 2003). Such costs are generally related to construction of urban infrastructure like public water and sewer services (Speir, Stephenson, 2002). Although most of the recent academic studies confirm the negative impacts of urban sprawl, but the sprawling development and fast urbanization still continues. This trend is more inclusive in western societies, but some types of dispersed and low-density developments are found in the rapid urbanization of the developing countries. Such urban textures are seen from Chile (Borsdorf, Hidalgo, 2008; Heinrichs et al. 2009) and Mexico (Borsdorf, Hidalgo, 2008) in Latin America to India (Rahman et al. 2007; Rahman et al. 2011; Kumar et al. 2011), China (Ma et al. 2008; Lv et al. 2011), and Turkey (Doygun, 2009). There are also limited urban sprawl studies on the Iranian cities. For example in 2010, Hosseini et al. investigated the influences of urban sprawl on the traditional water systems (Qanats) in the city of Mashhad in Northeast of Iran. They found that rapid urban growth has damaged 88 Qanats. A year later, Shahraki and his colleagues examined the fast growth of the city of Yazd and found it even faster than that of other developing countries (Zanganeh Shahraki et al. 2011). The effects of urban sprawl on the traditional system of water management (Kariz or Qanat) have been discussed (Hosseini et al. 2010) and its negative effects on tourism in Tehran have been shown (Roshan et al. 2009). The question that is raised in this paper is related to the circumstances of differentiating between normal growth and urban sprawl. Regarding the negative effects of urban sprawl that were mentioned above, it is essential that the planning bodies and decision makers have an exact image of the urban trends of the country. To recognize these two types of growth (natural growth and sprawl) from each other, an exact conceptual definition is needed. Previously some scholars and institutions have defined sprawl. The definitions are different in details but they draw similar image in general. A repeatedly-used definition of urban sprawl is presented by Sierra Club as follows: "low-density development beyond the edge of service and employment, which separates where people live from where they shop, work,

recreate and educate—thus requiring cars to move between zones” (Sierra Club, 1999). The definition of the US Department of Housing and Urban Development contains more keywords: “a particular type of suburban development characterized by very low-density settlements, both residential and non-residential; dominance of movement by use of private automobiles, unlimited outward expansion of new subdivisions and leap-frog development of these subdivisions; and segregation of land uses by activity” (USHUD, 1999). In 1997 Reid Ewing defined sprawl by means of four main characteristics: leapfrog and scattered developments, commercial strip development, low density, and large expanses of single-use development. He adds two more specifications to describe sprawl better: poor accessibility and lack of functional (public) open space (Ewing, 1997). He and his colleagues completed the previous definition in 2002: “the process in which the spread of development across the landscape far outpaces population growth. The landscape sprawl creates has four dimensions: a population that is widely dispersed in low-density development; rigidly separated homes, shops, and workplaces; a network of roads marked by huge blocks and poor access; and a lack of well-defined, thriving activity centers, such as downtowns and town centers. Most of the other features usually associated with sprawl – the lack of transportation choices, relative uniformity of housing options or the difficulty of walking – are a result of these conditions” (Ewing et al. 2003). Later in 2003, Burchell and Galley suggested a newer version: “Sprawl is low-density, leapfrog development characterized by unlimited outward extension. In other words, sprawl is significant residential or nonresidential development in a relatively pristine setting. In nearly every instance, this development is low density, it has leaped over other development to become established in an outlying area, and its very location indicates that it is unbounded” (Burchell, Galley, 2003). The above definitions are taken as an unwanted pattern of development which opposes natural growth that is planned to make a harmony between urban population growth and urban area growth, providing certain densities and facilities.

2. PROBLEM STATEMENT

The problem that necessitates studies like this paper is that there is a lack of evaluations of the urban development processes and outcomes in Iran and other countries of the region. During the past decades, selling urban lands for construction of houses by the municipalities and local governments, providing with affordable housing for the poor people, uncontrolled rural/urban migration, and deteriorated historical cores and downtowns have caused a boom in migration of urban residents of central Iran to the periphery of the cities to build or buy new houses and apartments. The urban plans have been unable to control the dynamics of urban land use and the growth of the cities caused the urban boundaries include nearby villages and make them part of the cities. The basic point is that the

planning organizations and individuals are not adequately aware of the severity of the sprawl of mid-sized cities and they therefore are more involved in containing the outward extension of the metropolitan areas like Tehran, Mashhad, and Esfahan. Sprawl containment of a metropolitan area like Tehran has caused several urban challenges such as traffic congestion and environmental pollutions because a city with millions of people is stopped from more outward development and little infrastructure like public transportation and local centers are added to it. Therefore such large cities remain monocentric large cities that produce thousands of urban travels only because of their urban form and lack of infrastructures. Containing the sprawl of large cities while the uncontrolled growth of mid-sized cities is neglected seems to be a problem that should be investigated carefully. This study raises the case of two cities of central Iran and attempts to indicate the necessity of stopping or at least weakening the dispersal of similar cities. In addition, there are evidences about mid-sized cities of other countries in the Middle East and North Africa (MENA) region. Such observations which come from several countries of the region show that urban sprawl is not just a western phenomenon but is in a more general view a global challenge that needs to be studied generally and should receive comprehensive feedback from researchers of the region. However the forms that urban sprawl is seen in different regions vary. In this study, discrepancy between urban growth rate and population increase, decrease in population density, leapfrog and scattered developments, and lack of public open spaces are considered as some of the characteristics of sprawled developments of the Iranian cities. The paper seeks to answer the following questions: 1) is urban sprawl seen in the development pattern of the mid-sized cities of central Iran? 2) In case the mid-sized cities of Iran are sprawling, who is concerned? And who is the main actors that should plan for containing this trend? 3) How is this phenomenon related to international trends?

3. RESEARCH METHOD

The study is descriptive and qualitative. The four aspects of sprawl (discrepancy between urban growth rate and population increase, decrease in population density, leapfrog and scattered developments, and lack of public open spaces) that were mentioned in the introduction section are considered about two cities of central Iran called Yazd and Kashan. To do this, the population growth of the cities is considered with their area growth for the time period of 1970-2006. Also the typology of urban development pattern of different parts of Kashan is considered. Also presence of public open spaces of a new development of Kashan is compared with the historical core of the city. The selected case-study cities are located in the hot-arid climate of central Iran. Both are historical cities that have very old background of urbanism. Compactness of the historical core is another specification of the centers of the cities, which has root in the traditional urban form of the Middle Eastern cities. Another similarity of

the selected cities is the cultural and religious beliefs of their people. With more than 400000 residents, Yazd is considered as a small large city of the country. Kashan is the second large city of the province of Esfahan and accommodates about 270000 people (Figure 1. According to the typical aspects of the urban problems, socio-economic issues, cultural, and religious backgrounds of these two cities with many cities of the region, the final recommendations of the study are suggested for cities with similar areas in the center, south and east of Iran. For measuring the area of the cities in different historical eras, the raw data used for two revitalization and renewal projects were taken as the base of calculations. It has been mentioned in the studies, which existing neighborhoods have been in the urban boundaries in different historical periods. To have the exact area of the case-study cities, the boundaries were reproduced and the areas were calculated. The urban boundaries that are used to calculate the areas and densities are the limitations that are perceived and defined by the residents, and no administrative boundaries were used in this study.

4. FINDINGS

Urban sprawl in Iran and several similar countries has the form of rapid urbanization and transition from a compact traditional urban form to a city that is prepared for using new technologies very fast. This can be analyzed in two ways: the speed of transformation, and its nature. Considering the discrepancy between the area growth and population growth rate in Yazd is quite telling. The population of the city increased uniformly between 1956 and 2001. During this period the population increased from 63502 to 388107 (Shamsaei, 2003). The populations that are shown in Figure 2 are gotten from the national Iranian census that is done every 10 years regularly.



FIGURE 1 - LOCATION OF THE TWO CASE-STUDY CITIES: YAZD AND KASHAN.

The original core of the city was located in the present city boundaries, but its location was slightly different from the place that today the core exists. The second core was shaped in the fourth century A.D. The oldest urban texture that is remaining in this part is related to ninth century. Therefore the area of these parts is measurable. The area of the city in different historical eras has been calculated according to the raw data that was collected by a consulting company for a revitalization plan of the historical core of the city. In one thousand years, between ninth century and nineteenth century the city has had consistent increase. The area increased from 15.6 hectares to 101.5 hectares in fifteenth century and 167.2 in seventeenth century. At the end of nineteenth century the city had an area of 369 hectares. By the turn of the century, the arrival of the new transportation technologies to the traditional city was accompanied by the transformation of the urban form. The urban growth got a faster rate. By 1981 the urban area reached 1800 hectares. At this time the fastest growth started; only five years later, it reached 6000 hectares (Figure 3). The same rate continued until 2001 when it became 11000 hectares. In 2009 the city was as large as 13802 hectares (Zanganeh Shahraki et al. 2011). The speed of the city's area growth can be divided into three parts. As seen in Figure 2, the slope of the area growth is mild from twelfth century to the end of nineteenth century. Then it becomes steeper since beginning of twentieth century until 1981 and the highest rate is seen between 1981 and 2001.

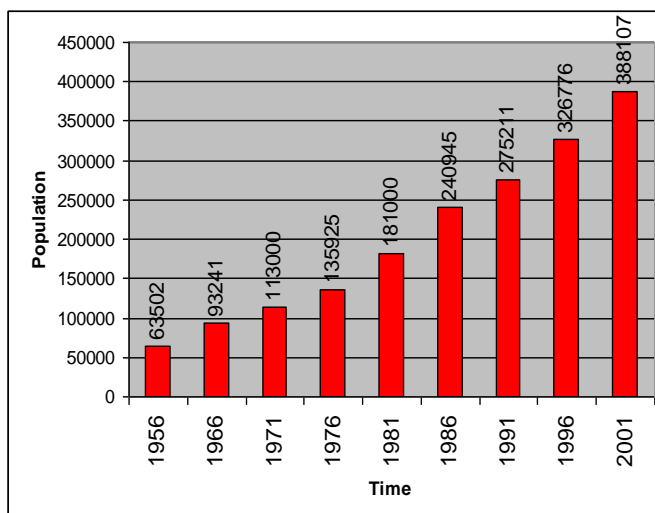


FIGURE 2 - POPULATION GROWTH BETWEEN 1956 AND 2001 IN YAZD

The proportion of area growth divided by the population growth of the city after 1956 is shows a jump after 1981. Between 1956 and 2001 the population of Yazd increased 6.11 times, while the area grew 15.5 times. The proportion shows that the area has grown as much as 253 percent more than the population. The bigger part of this rapid dispersal occurred from 1981 to 2001 (285 percent).

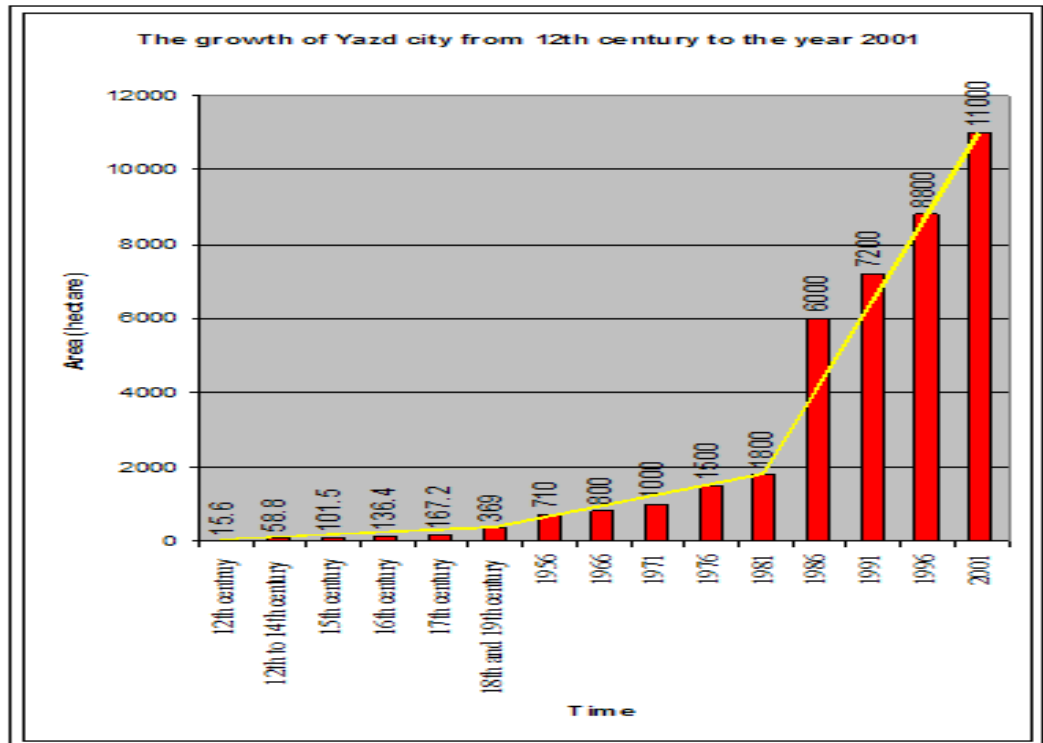


FIGURE 3: AREA GRWOTH OF YAZFD SINCE 12TH CENTURY UNTIL 2001

The same observation was done for the city of Kashan. The results of 1932 census of Kashan show that the population of the city within the boundaries of the late-nineteenth century was 40000 people. The area of the city at this time has been 511 hectares. The next censuses showed that the 45955, 58468, 92777, 151532, 205886, 253731 people lived in the city in 1956, 1966, 1976, 1986, 1996, and 2006 respectively. On the other hand, Kashan's urban area was calculated for doing a comparison with the population growth. According to the raw data of a gentrification project (Tarh-o-Manzar Consulting Engineers co., 2003), around seventh and eighth century the city had an area of 24 hectares. In eleventh and twelfth century the area increased to 267 hectares and at the end of Qajar era (1794-1925) it reached 511 hectares. Today Kashan's urban areas cover 2250 hectares. Taking into account the low-density areas in the periphery of the city, the total area is 4470 hectares. From 1932 to 2006, the population increased 6.34 times, while the area grew 8.75 times. Thus the area growth has been 38 percent more than the population growth. The discrepancy shown above is a direct indicator of urban sprawl. The compactness of the traditional city is replaced by the dispersed urban pattern enhanced by new transportation facilities like wide streets and cars. This analysis is more significant when the population densities of the two cities are considered. The population density of Yazd has decreased from 89.4 persons per hectare in 1956 to 35.28 in 2001. This figure for Kashan is 78.2 in 1932 and

56.76 in 2006. In both cities the population density has dropped dramatically. The third aspect of sprawl that is considered in this study is the urban development pattern. The layout of urban development of Kashani neighborhoods in different periods of time shows meaningful changes. The street networks became more geometric, while the development pattern became less compact. Figure 4 shows these transformations in the development pattern related to different eras. Figure 4-1 illustrates the urban pattern in the historical core of Kashan, in which the houses are closely attached together and there are many dead-end allies. The street network is curvy and was shaped based on pedestrian mobility. Many travels were made towards Neighborhood Unit Centers.

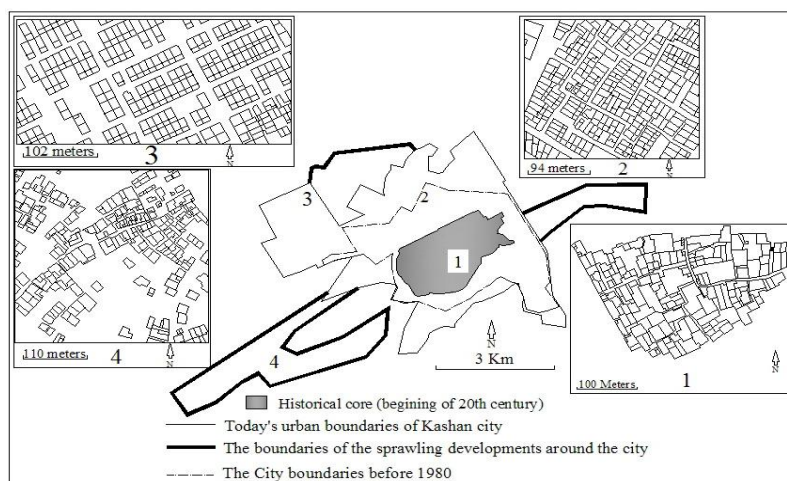


FIGURE 4 - THE TYPOLOGY OF DEVELOPMENT PATTERN IN KASHAN: 1) COMPACT TEXTURE IN THE HISTORICAL CORE, 2) CURVY STREETS AND SEMI-GRIDIRON NETWORK BUILT IN 1940-1980, 3) COMPLETE GRIDIRON NETWORK WITH SOME LEAPFROGS IN THE NEW DEVELOPMENT OF NAJI ABAD, AND 4) DISPERSED UNPLANNED HOUSES AND GARDENS IN A VILLAGE THAT IS GOING TO BE A PART OF THE CITY.

This type of pattern was dominant until the beginning of the twentieth century. Influenced by the so-called modernization period of Iran, after 1930 many Iranian cities experienced transformations so that the cars could move through the streets more easily. Thus the compact texture of the historical cores was changed and the new districts around the cores were built in a less compact form. The street network of this age is semi-gridiron and gives wider space to cars. This type of development started in Kashan in 1940s when the old bazaar and the core's texture were cut through to give way to cars. Figure 4-2 is an example of these developments in Kashan. This type of construction continued until 1980. The next typical pattern that can be recognized in Kashan is shown by figure 4-3. The complete gridiron and still less compactness are the general characteristics of the developments of this type, which were implemented after 1980 to date. The example that is illustrated in figure 4-3 is a part of Najj-Abad district that is similar to many districts built after 1980. According to a Space Syntax analysis, the developments of this type have higher global accessibility compared to the organic and traditional

textures (Masoumi, 2012a). However lack of neighborhood amenities pushes people to have longer travels to other parts of the city. Like many neighborhoods of this kind, there are bare lands between the houses of this district. This makes a leapfrog pattern that lowers compactness. Finally the last type of development that is observed within the textures of Kashan is seen in the peripheries, where the villages and gardens are attached to the city or will be a part of the central city in the future. These areas are becoming parts of the city because of fast urbanization in the second half of twentieth century. These textures have even less density and compactness. They also have less accessibility compared to the neighborhoods of type 3 (Masoumi, 2012b). In many of them, for example in west and southwest of Kashan (like figure 4-4) the houses are located within gardens. The street network is not planned, geometric or complete. These places used to be villages in the countryside that are now getting urban character. The above observation shows that as a representative of the urban development after mid-twentieth century, the urban form of Kashan has been led toward automobile-oriented planning. The form of the streets has been changed so that the cars can move more freely. This has changed the characteristics of the traditional city. That is the thing that has happened to many other cities in the country. Another effective factor is the speed of the urban growth. This speed has been so much that the mainly-governmental planning bodies could not afford to plan for the growth. The lack of planning is particularly seen in the developments of after 1980, where public open spaces, especially those with social function, are very insufficient. Figure 5 indicates the public open spaces in the historical core of Kashan (right) and the new district of Naji-Abad (left). The public open spaces of the historical core can be divided into three types of old social open spaces, new green spaces, and new roundabouts. The old social open spaces were previously spots where people could have face-to-face contact. These places were usually located in the neighborhood centers. When the first new automobile streets were built in 1940s, new open spaces were added to the city, whose main function was motorized transportation. Today these spaces are known as roundabouts. Although there are retail and shops on the edge of some of the roundabouts, but they are not planned and prepared for social behaviors. The type of open spaces that have stronger social aspect are the green spaces that are constructed in the form of urban parks or in smaller scale in the lots between the residential units. However none of these spaces are like pedestrian spaces that can draw people to themselves for socializing.

When the public open spaces of a new district that was built after 1980 is considered, more shortcomings are explored. In Naji-Abad (figure 5- left) just two types of the open spaces are found; green spaces and roundabouts. There are no signs of spaces that are planned for local residents to make it possible for them to socialize with each other. This deficiency is along with the general lack of public amenities in the neighborhood scale in most of the Iranian urban areas. It is also a result of the

disharmony between planning and fast urbanization. The described deficiency about social public open spaces in the new developments of after 1980 is in contrast with the traditional urban form of the Iranian cities that contained human-scaled public open spaces, in which neighborhood residents could have face-to-face social activities (Masoumi, 2012a).

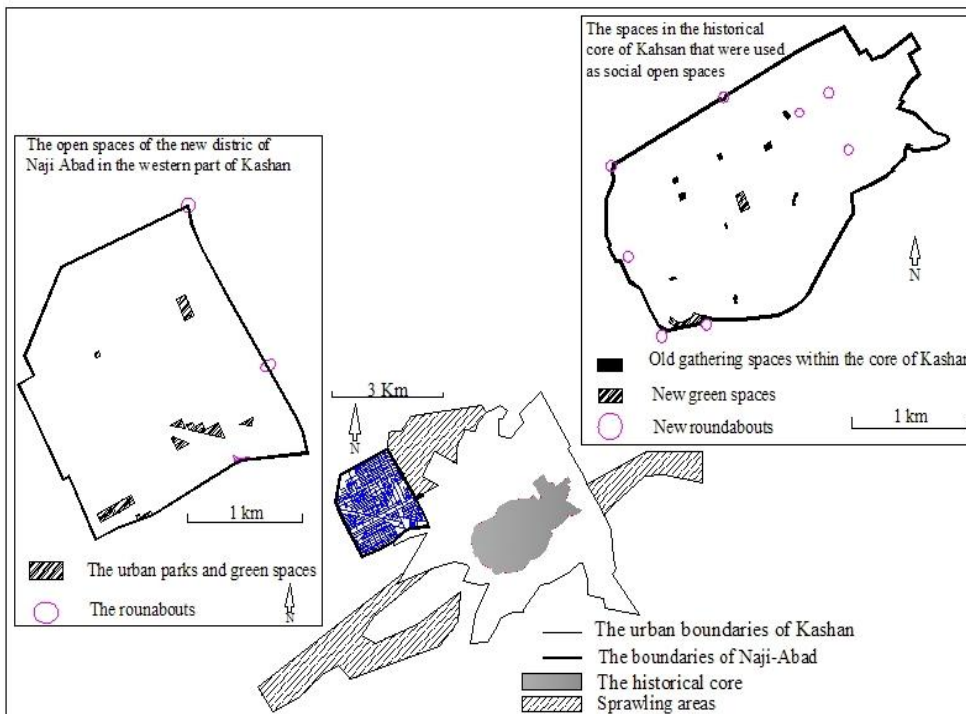


FIGURE 5 - DISTRIBUTION OF PUBLIC OPEN SPACES IN THE HISTORICAL CORE OF KASHAN AND THE NEW DEVELOPMENT OF NAJI ABAD IN THE WESTERN PART OF THE CITY. THE MISSING ELEMENTS IN NAJI ABAD ARE PUBLIC SPACES WITHOUT TRANSPORTATION FUNCTION.

As seen here, four aspects of urban sprawl's different definitions were analyzed in case of Yazd and Kashan. These aspects are especially found in the definitions suggested by Ewing. The rapid population increase during the last decades, along with the jump in the urban population has occurred together with deficiencies in planning. This has resulted in low population densities and lack of public amenities like public open spaces in the new developments. These new urban areas were meant to accommodate large groups of urban dwellers after 1980. However because of lack of local facilities of many of these districts, the residents have to travel to the central parts of the cities to raise the daily needs. These urban travels are made more problematic when the public transportation systems are weak and inefficient. The mentioned planning-related problems of the urban form and also absence of strong public transportation systems have encouraged people to use personal cars. Hence even many of the mid-sized cities of the country are experiencing serious traffic problems that are partially caused by sprawling urban development pattern.

5. DISCUSSIONS

The findings of this study shows that apart from the large cities that are most of the times under monitoring of planners and researchers, the medium-sized cities or small large cities are also subjects of urban sprawl and should be studied thoroughly. The recent sprawl studies of Iranian scholars are oriented toward both mid-sized and large cities, but they are mostly targeted on cities such as Tehran, Mashhad , Esfahan, and Shiraz, etc. (for example see (Roshan et al. 2009; Roshan et al. 2010; Zanganeh Shahraki et al. 2010) about Tehran, (Hosseini et al. 2010; Zanganeh Shahraki et al. 2011; Ghanghermeh et al. 2013) about Mashhad, (Soffianian et al. 2010) about Esfahan, and (Sabet Sarvestani et al. 2011) about Shiraz).

The same is seen in the English-language literature about urban sprawl in Turkey. Most of such studies focus on larger metropolitan areas including Istanbul, Ankara, and Izmir (for example see (Altınok, Cengiz, 2008; Eryilmaz et al. 2008; Terzi, Kaya, 2008; Kucukmehmetoglu, Geymen, 2009; Terzi, Bolen, 2009; Terzi, Serdar Kaya, 2011) about Istanbul, (Cihangir Çamur, Yenigül, 2009) about Ankara and (Hepcan et al. 2013) about Izmir). The Egyptian sprawl studies are mainly about Greater Cairo (Taubenböck et al. 2009; Hassan, 2011; Hereher, 2012) and Alexandria (El Menchawy et al. 2011), the two most populated cities of the country. While megacities like Tehran, Istanbul, and Cairo have been the case study of most of the observations, and a limited number of them are targeted towards other large cities like Esfahan, Shiraz, Izmir, and Alexandria. Very little attention is directed toward medium-sized and small-large cities. Studies on smaller cities such as Ma'daba and Irbid in Jordan (Saleh, Al Rawashdeh, 2007), Kerman (Hosseini et al. 2010), Ardabil, Sanandaj, and Kashan (Ahmadi et al. 2010-2011), Yazd (Masoumi, 2012a), and Kashan (Masoumi, 2012b) in Iran, and Kahramanmaraş (Doygün, 2009) in Turkey are exceptionally seen. The observations of this study show that the growth of the mid-sized cities of the region can hardly be considered as natural. Nonetheless more studies are needed to gather considerable evidence that monitors the dynamics of these cities.

The top-down system of planning in Iran and most of other countries in the MENA region limits the decision making process to central and local governments. The planning companies and individuals have consulting roles with little or no share in decision taking. Although the process of unsustainable sprawling patterns in Iranian cities is becoming more obvious, but since the linkage between the research body and urban governors is weak, the process of stopping sprawl has become gradual and in some cases has gone the wrong way. The example is blocking the growth of the megacity of Tehran while Yazd has grown limitlessly. The population and construction density of Tehran has jumped in the past two decades while the urban and local facilities have not been improved in parallel. As a result a

crowd of millions of people living in only 750 square kilometers have tough living conditions compared other metropolises of the world. On the other hand Yazd has become a low-density city that is widely car dependent, particularly in the peri-urban areas, while little has been done to stop this trend. Finding ways for presenting an actual perspective of the conditions of urban sprawl in the medium-sized cities of MENA region to the urban strategists and local governments is of absolute importance. For that, firstly the scientific observations and research on this topic must be developed more.

In addition to the size of the cities and the main actors, the content of the recent publications about urban sprawl in MENA can be discussed according to their contents. Most of the abovementioned papers focus on the side effects of urban sprawl on urban environment, identity, car use, etc. as well as GIS and RS observation about land use change. However the body of recently-produced literature about pattern and morphology of sprawling areas of the region is really thin. A recent study shows that there are dissimilarities between the morphology of western sprawl and the dispersed developments in the mid-sized cities of central Iran, but because of large amount of similarities these developments can be defined as urban sprawl (Masoumi, 2012b). Such studies are especially needed to make give a better understanding of the contemporary trends in urban development of MENA countries.

6. CONCLUSIONS

The purpose of this paper is to indicate the presence of urban sprawl in the cities of central Iran and emphasize some of the negative results of this growth pattern. Four measures selected based on the recent urban sprawl definitions admit the presence of sprawl in the development patterns in the cities of the region. These measures include discrepancy between urban growth rate and population increase, decrease in population density, leapfrog and scattered developments, and lack of public open spaces. Although the extent of the sprawl seen in Yazd and Kashan are different, but the present study can distinctly confirm that both cities are sprawling. This finding is important because the selected case-study cities can be the representative of many other mid-sized and small large cities of the center of the country. It is likely that several similar cities have the same situation.

However a positive answer to the question about the presence of sprawl can only be a starting point for finding suitable solutions in planning process and growth management of cities like Yazd and Kashan. Studies with the aim of identification of nature of the Iranian-type sprawl are highly needed. The result can be possibility of recommending efficient solutions to limit or stop this growth pattern. Another topic that needs more research is related to the differences between the Iranian and the western sprawl as well as urban sprawl in mid sized cities of the Middle East and North Africa. According to the literature

presented in this paper, urban sprawl within the mid-sized cities of MENA are under studied and need more investigations especially focusing on morphology and pattern of developments.

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