Urban sprawl pattern and land-use change detection in Yazd, Iran

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A B S T R A C T

Urban sprawl has become a remarkable characteristic of urban development worldwide in the last decades. However, trajectories and rhythms of sprawl may vary in important ways according to specific geographical and historical characteristics, and these differences need to be contrasted with specific case studies especially for the booming urbanization of the Global South. The purpose of this paper is to study urban growth in the city of Yazd, Iran. Urban growth and other land uses were calculated through treated satellite images for four periods: 1975, 1987, 2000 and 2009. Results reveal that from 1975 to 2009, the urbanized area increased from 1843 ha to 13,802 ha; that is a rate close to three times the population growth observed for the same period. The Yazd case is interesting for several reasons: first, it is a case of very fast urban growth even for a developing country; second, it illustrates how the fastest rates of urban sprawl may correspond to middle size cities rather than large centers. Third, it portrays a land substitution process in which agricultural land is not the primary provider of urban land which is relatively rare in urban contexts, and fourth, it also illustrate how sprawl may also hide important internal land uses such as the presence of agricultural plots within urban boundaries.

Introduction

According to United Nations estimates, the population living in urban areas exceeded 50% of the world total in 2006 and will approach 60% in 2020. Most if not virtually all this growth is taking place in developing countries. While the explosive urban growth in the Global South is a well known phenomenon, the specific trajectories and forms of this growth are still relatively unknown. In most of the world, urban growth appears to have taken the form of disperse or sprawled patterns but case studies are needed to ascertain whether the “American model” of urban sprawl (Leichenko & Solecki, 2005) is dominant or, rather, it represents just a version of a much wider process.

Urban sprawl is a pattern of land use exhibiting low levels of eight distinct dimensions: density, continuity, concentration, clustering, centrality, nuclearity, mixed uses and proximity. Density is the average number of residential units per square mile of developable land in an urban area. Continuity is the degree to which developable land has been built in close proximity to the already existing urban fabric. Concentration is the degree to which development is located disproportionately in relatively few square miles of the total urban area rather than spread evenly. Clustering is the degree to which development has been tightly bunched to minimize the amount of land in each mile of developable land occupied by residential or nonresidential uses. Centrality is the degree to which residential or nonresidential development (or both) is located close to the central business (CBD) of an urban area. Nuclearity is the extent to which an urban area is characterized by a mononuclear (as opposed to a polynuclear) pattern of development. Mixed uses means the degree to which two different land uses commonly exist within the same small area. Finally, proximity is the degree to which different land uses are close to each other across an urban area (Glaster et al., 2001).

Because of these characteristics, urban sprawl is said to represent a threat for urban sustainable development since it implies an increase in the consumption of land, water, energy and other resources as well as of pollutants and waste. 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.
Since World-War II urban sprawl has been an important feature of the urbanization process in certain developed countries such as the USA, Australia, Canada, and some European countries (Gill, 2008). Currently, urban sprawl is expanding to Southern Europe (Catalán, Saurí, & Serra, 2008), and also to a number of developing countries such as China (Cheng & Masser, 2003, Zhang, 2000), India (Jothimani, 1997; Lata, Sankar Rao, Krishna Prasad, Badrinath, & Raghavaswamy, 2001), and Turkey (Onur, Maktav, Sari, & Sonmez, 2009), among others.

Studies on urban sprawl have for the most part focused on large cities and metropolitan areas. However, middle sized and small urban areas may be actually those experiencing the highest rates of urban growth. For instance, Weng (2001), in a paper on the Zhujiang Delta in China, concluded that the largest urban expansion in this area occurred in Dongguan, Baoan, Nanhu and Zhuhai, all of them relatively small cities located in the Eastern part of delta. In contrast, older and larger cities, such as Guangzhou and Foshan, did not show a parallel increase in urban land. Jat, Garg, and Khare (2008) revealed that the growth in urban land of Ajmer City, a medium sized city situated in Rajasthan State of India, over a period of 25 years, tripled population growth with an increase of the urban area from 488 ha in 1997 to 1259 ha in 2002 (Jat et al., 2008). Also in India, Sudhira, Ramachandra, and Jagdish (2004), for a city with less than 0.5 million people, reported a population increase of 54% between 1972 and 1999, and an increase of urban area of 146% during the same period, that is, nearly three times the rate of population growth. The sprawl of urban land intermediate and small size cities continues in the developed world as in Santa Barbara, California (Herold, Goldstein, & Clarke, 2003), or in several Swiss municipalities (Gennaio, Hersberger, & Burgi, 2009), among many other examples.

While urban sprawl may be a process equally shared by developed and developing countries, specific causes and characteristics differ considerably. In the developed world, for instance, causes for urban sprawl range from consumer preferences to new strategies of capital accumulation in cities through real estate development (Muñiz, Calatayud, & García, 2007). However, the study of the causes behind urban sprawl remains less explored in the developing world. More examples of how this process unfolds in specific areas are needed to explore trends, causes and consequences that enrich our understanding of the urbanization process in areas where this process is more intense.

In this paper the case of the city of Yazd, is presented which is located in central Iran. Both Yazd and Iran as a whole are interesting and relevant cases of explosive urban growth. According to the first Iranian census, in 1956, the number of Iranian cities was 199 and the proportion of urban population was 31% of the total. In 2006, the number of cities had increased to 1012 and the proportion of urban population exceeded 70% of the total (Farhoudi, Zanganeh Shahraki, & Saed Moucheshi, 2009; Iranian Statistic Center, 2009). Urban population in Iran will reach 80% in 2020 according to the United Nations. Large urban centers such as Tehran (Zanganeh Shahraki, 2007), Mashhad (Hosseini, 2008) and Isfahan (Ghiumi Mohammadi, 2001) are experiencing transitional urban growth processes form compact to dispersed forms and sprawling rapidly. Middle size and even small cities tend to sprawl as well perhaps at a greater pace. The city of Yazd is one of these medium sized cities undergoing rapid physical growth and change of land covers and uses. Since the definition of cities and urban hierarchies vary among countries, in this paper we use the Iranian urban hierarchy on the basis of population size. According to the definition of the Ministry of Housing and Urban Development (2008) and the Iranian Statistic Center (2009), cities in Iran are divided into six categories: rural—urban cities (population less than 25,000); small cities (population between 25,000 and 100,000); medium cities (population between 100,000 and 500,000); large cities (population between 500,000 and 1,000,000); metropolis (population between 1 million and 5 million); and, finally, megalopolis (population more than 5 million). Therefore, Yazd can be considered as a medium sized city. The recent urban history of Yazd encapsulates many of the dimensions mentioned at the beginning of the paper. Yet it also presents some distinctive features that offer interesting insights into the nature of urban growth in small and medium sized cities of the developing world.

Trends in urban expansion are examined here through the use of satellite images. Remote sensing is cost effective and technologically reliable, and is therefore, increasingly used for the analysis of urban sprawl (Haack & Rafter, 2006; Yang & Liu, 2005). In addition, remote sensing techniques have advantages in characterizing the spatiotemporal trends of urban sprawl using multi-stage images and providing a basis for projecting future urbanization processes. The use of satellite images will assist us in identifying the spatial and temporal patterns of urban land expansion from the urban core, and in detecting land-use change in urban fringes especially in what concerns the relation between urban and agricultural land uses. To address these objectives, multi-stage remote sensing images, geographic information systems and some secondary data from urban organizations will be deployed. The paper is organized as follows. First, our case study will be presented. This is followed by a section about materials and methods used to generate data through different satellite images. In the third section, population and urban growth variables were correlated. The fourth section consists in the presentation and discussion of more specific land transformation processes. Finally, some concluding comments, regarding the possible significance of Yazd for the understanding of urban sprawl in the context of the developing world are also included.

Study area

The city of Yazd, one of the more ancient cities of Iran, is the capital of the Yazd province. (Fig. 1). Yazd is located in a desert environment with an annual precipitation of 50–60 mm. There is no surface water and the city has historically relied on groundwater through the system of qanat (a system of connected underground wells). This term derives from an ancient semitic word meaning “to dig” and describes an underground water channel consisting of vertical shafts connected at their bottom with a sub-horizontal tunnel. The most important economic activities in Yazd are light industries (textiles, foodstuffs, and paper and furniture) occupying about 42% of the active population, and tourism which benefits from the desert architecture and the historical heritage of the city. Both activities alongside with the administrative functions derived from the condition of province capital serve as a factor of attraction for many immigrants not only from the province of Yazd but also from all Iran. Therefore, the city has experienced very rapid growth to the point that, among the Iranian cities with a population bigger than 100,000 inhabitants, Yazd has the largest growth in urban land development.

Materials and methods

Land cover and land-use change (LUC) recognition provides an essential input for environmental analysis, planning, and management. Nevertheless, land use/cover detection is not an easy task because of several uncertainties. Comparative analyses using classifications produced independently from different dates are called map-to-map comparisons or post-classification comparisons. In this case, two problematic issues appear. First, there may be localational inaccuracy due to the misregistration of polygon boundaries.
In vector formats this problem is known as “slivers” which can be defined as narrow polygons of dubious interpretation (Chrisman, 1987). In raster formats slivers cause the presence of border pixels with false positive or negative changes. False positive changes occur when a change is identified but no change has taken place and false negative changes appear when no change is identified but a change has taken place. The second possibility becomes common when different pixel sizes are involved in land use/cover either because some elements are not detected in the coarser resolution or because some others appear in the finer resolution (Serra, Pons, & Saurí, 2003). In this study, both problems existed.

Four years: 1975, 1987, 2000 and 2009 were selected for analyzing land use/cover. The images used have been provided by Landsat because is the only source that has an enough temporal data to cover for our 35 years of analysis. Dates have been selected in order to calculate land use/cover every 10 years approximately. Table 1 shows the information corresponding to those images, all geometrically corrected. The oldest image, from 1975, was provided by the Multispectral Scanner Sensor (MSS) with a spatial resolution of 79 × 59 m. This resolution was coarser than the rest of images of the Thematic Maps (TM) which had a spatial resolution of 30 m. In order to analyze the same phenological situation, the month of June was selected for all the images because this month is the best to contrast land use and land cover, especially those of an agricultural nature.

Once all the images were available, the first step was to identify LUC through two possible options: automatic classification and photo interpretation. The target land use/cover included four categories: impervious (built-up area), barren land, mountain land, and agricultural land. The impervious (built-up) area is generally considered as a parameter for quantifying urban sprawl (Barnes, Morgan, Roberge, & Lowe, 2001; Epstein, Payne, & Kramer, 2002; Torrens & Alberti, 2000). The “built-up” class encompasses residential areas of single houses and apartment buildings, shopping centers, industrial and commercial facilities, highways and major streets, and associated properties and parking lots. Barren land is characterized for the lack of vegetation with sand or rocks and may include deserts, dry salt flats, beaches, sand dunes, exposed rock, strip mines, quarries and/or gravel pits. Agricultural land corresponds to land with crop production and mountain land to those areas with high slopes with or without forest cover.

Because some land use/cover were very difficult to differentiate with an automatic classification, it was followed a procedure known as “computer-aided photo interpretation of false-colour images” (European Environment Agency, 2010). This procedure consists on making a photo interpretation from false-colour composites of the used images for each year according to our legend. In our case, visual interpretation was clearly the best method to avoid a large number of misclassifications. This method is considered the best way to capture information on urban land-use trends (Akbari, Shea Rose, & Taha, 2003), and makes possible the generalization and distinction between different land uses as well as, the identification of relevant characteristics which are better distinguished by their visual form and pattern rather than by their spectral signal (Cunningham, 2006).

Once the photo interpretation of the first year, 1975, was finished, the next step was to overlay the vector layer obtained to a false-colour composite from next year, 1987. The objective was to modify, from the 1975 results, only those polygons with real changes. With this method, the problems mentioned above (local inaccuracy and different spatial resolution) were avoided. The same process was applied for 2000 and 2009.

### Table 1

<table>
<thead>
<tr>
<th>Day and month</th>
<th>Year</th>
<th>Path/row</th>
<th>Sensor</th>
<th>Satellite</th>
<th>Original bands</th>
<th>Spatial resolution (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 June</td>
<td>1975</td>
<td>174/38</td>
<td>MSS</td>
<td>Landsat-2</td>
<td>2,3,4,5</td>
<td>60</td>
</tr>
<tr>
<td>7 June</td>
<td>1987</td>
<td>162/38</td>
<td>TM</td>
<td>Landsat-5</td>
<td>1,2,3,4,5,6,7</td>
<td>30</td>
</tr>
<tr>
<td>10 June</td>
<td>2000</td>
<td>162/38</td>
<td>TM</td>
<td>Landsat-5</td>
<td>1,2,3,4,5,6,7</td>
<td>30</td>
</tr>
<tr>
<td>3 June</td>
<td>2009</td>
<td>162/38</td>
<td>TM</td>
<td>Landsat-5</td>
<td>1,2,3,4,5,6,7</td>
<td>30</td>
</tr>
</tbody>
</table>

**Urban planning in Iran and Yazd: a synopsis**

It is important to confront our data on urban growth with the realities of urban planning in Iran and in Yazd in particular. The
urban planning system of Iran is based on master or comprehensive plans. These plans are mandated by ministry of Housing and Urban Planning and constitute the most important instrument of the Iranian multilevel system of land-use planning. In Master plans, maps of projected land uses are provided laying down binding provisions on how land can be used in practice. In addition, plans set urban growth and development patterns for the future based on population growth rates and on land per capita. In this case, plans establish the boundaries between developed and non-developed zones. All construction is prohibited in non-development areas. However, these boundaries and limits are seldom respected and almost all Iranian cities expand beyond the determined boundaries of master plans.

The first master plan of Yazd was enacted in 1966. Estimating the population growth rate of 2.5% and the population density of 100 persons per ha, this plan calculated that the city would occupy some 1750 ha of land in 1992. But, as observed in Table 2 and the data of satellite images, in 1987, the impervious area amounted to 3079 ha in that year (Municipality of Yazd, 2005). Comparing this number with the predicted area in Master plan revealed a vast process of urban sprawl in this period. The second master plan of city was issued in 1993. Acknowledging a large quantity of unused and vacant spaces inside the city, this plan offered not to expand and develop the city in the fringes but to follow the so-called infill development approach. Nevertheless, the boundaries envisaged in the master plan were contravened again in the following years. In the latest master plan of Yazd enacted in 2005 the predicted urban area of city for 2020 was set at 13,415 ha. However, already by 2009 this figure has been surpassed (Table 2). In sum, the established projections of all master plans have been defeated by the dynamics of urban growth fuelled by the high number of immigrants in need of inexpensive habitation. One major problem with Iranian master plans (which is common to many other planning systems) is the lack of enforcement of growth control measures. Because of this lack of enforcement, newcomers usually construct and settle every where they want and can afford.

Results

Population growth and urban sprawl

According to the first official census (1956) the population of Yazd was 63,502. During the 1960s and early 1970s, land reform and other agricultural policies in Iran resulted in mass migration from villages to cities. Hence, at the time of the second official census (1975), the population of the city reached 135,825 people. The Islamic revolution of 1979 followed by the Iran–Iraq war one year later increased further rural migration to cities. Between 1975 and 1987, the annual rate of population growth in Yazd was 5.3%. In 2000, the population reached 326,776 people with an annual growth rate of 3.4%. In the most recent official report (2009), the population of Yazd attained 464,991 persons (Yazd Municipality, 2009). As shown in Fig. 2 and Table 2, the rate of population change is high although smaller than the increase in urban land. Employment in industrial sector is mentioned as the major reason for migrating to Yazd. As it is often the case, lack of urban planning forced immigrants to settle in the periphery of the city where land and accommodation prices are much lower than in the city center. The economic factor or the differential land rents thus appears as a major driver of urban sprawl in Yazd.

Urban sprawl for the years 1975, 1987, 2000 and 2009 has been estimated from data on impervious (built-up) areas obtained from satellite images. Map statistics created from satellite images show that the built-up area encompassed some 1844 ha in the first image (1975). In this year, then, population density attained 73.71 people per hectare. As shown in Fig. 2, the physical expansion and development of Yazd progressed around the historical center under a continuous pattern. However, this trend changed in the next periods. In second image (1987), the urban area had climbed to 3079 ha, and followed a Northwest direction. Between 1987 and 2000, the growth in urban land escalated to 142%, with 7665 ha of urban land in the year 2000, that is, more than two times bigger than in the previous image. During this period, population grew some 42% (Table 2 and Fig. 3).

Finally, in the last studied period, Yazd presented the largest growth in built-up area. The expansion of urban land between 2000 and 2009 almost equals all urban land developed during Yazd 2000-year history. In 2009, urban uses occupied 13,802 ha of land, and the population density had decreased to 33.68 persons per hectare. This form of development shows a disordered pattern that, among other impacts, reduced spatial solidarities (Saraie, 2008) Since 1975, and in addition to rapid expansion, urban growth has remained disproportional, scattered and leapfrogged; in other words, it has followed the classic characteristics of sprawl (see Fig. 4).

Table 2

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Percentage increase in population (%)</th>
<th>Built-up area (ha)</th>
<th>Percentage increase in built-up area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>135,925</td>
<td>–</td>
<td>1843.94</td>
<td>–</td>
</tr>
<tr>
<td>1987</td>
<td>230,483</td>
<td>69.5</td>
<td>3079.36</td>
<td>66.99</td>
</tr>
<tr>
<td>2000</td>
<td>326,776</td>
<td>41.7</td>
<td>7465.2</td>
<td>142.4</td>
</tr>
<tr>
<td>2009</td>
<td>464,991</td>
<td>42.2</td>
<td>13,802.43</td>
<td>84.9</td>
</tr>
</tbody>
</table>

Source: Statistical Center of Iran (2009), Yazd Municipality (2009) and satellite images.
The impervious area of Yazd has increased from 1843 ha in 1975 to 13,802 ha in 2009. Results in Table 2 reveal that the rate of land development in Yazd outpaces the rate of population growth. From the year 1975 to 2009, population in the city grew by about 153.4% while the amount of developed land grew by about 294.3% (Fig. 2 and Table 3). This implies that per capita consumption of land has increased exceptionally over last three decades. The per capita land consumption refers to utilization of all lands for development initiatives, such as commercial, industrial, educational, recreational and residential.

Another interesting feature of the sprawl process in Yazd is the direction followed by the new settlements. Most of the growth has progressed along the Northwest and Southeast axes mainly because the presence of major road networks such as the highways to Ardakan in the Northwest, and to Kerman in Southeast. The expansion towards the western limits is also explained by the location of the most important industrial area of the city here and the tendency of workers to settle next to their jobs. The construction of an airport towards the South has also stimulated urban growth in this direction.

Finally, it is also relevant to note the influence of urban sprawl in the administrative configuration of Yazd and the neighboring towns and villages. Here, the approach has been one of absorbing smaller municipalities instead of adopting, say, a metropolitan administrative structure maintaining existing municipalities. Therefore, some 20 villages have been incorporated into Yazd since the late 1980s (Saraie, 2008). Recently, two small cities, Hamidia (27,611 inhabitants in 2007) and Shahedieh (14,374 inhabitants in 2007), in the Southeast and Northwest respectively have been annexed to the capital, and it is predicted that another city, Zarch, with some 12,000 people in 2007 will be annexed soon too. This strategy of annexation, which on the other hand is rather common in the history of many large cities, certifies the subordination of administrative matters to the dynamics of sprawl.

Land-use transformations

As said before, analyzing changes in land use through remotely sensed data assists us in a better understanding of the history of relationships between human activities and the environment and for the predictions of possible trends for landscape conversions, thus generating more realistic and multidimensional scenarios for developing environmentally sustainable policies and management.
practices (Doygun, 2009). Moreover, analyzing spatiotemporal characteristics of land-use change is essential for understanding and assessing the ecological consequences of urbanization (Deng, Wang, Hong, & Jia, 2009).

The results of changes in land use are presented in Fig. 4 and Table 3. The most considerable change is the transformation of barren land to impervious (built-up) areas. Thus within the time period of study, 9613 ha of barren land were transformed into agricultural land between 1975 and 2009. The second major change is from barren land to agricultural land. This is also an important deviation from the common pattern of land substitution in many countries by which agricultural land is the main loser in front of the advance of urbanization. In Yazd, however, about 4224 ha of barren land were converted into agricultural land between 1975 and 2009. The third major change has been conversion of agricultural land to urban land, affecting some 2470 ha. This suggests a pattern of frontier settlement by which the conversion of agricultural land to urban land, affecting some 2470 ha. This suggests a pattern of frontier settlement by which the

Table 3
Changes in all categories of land use in four studied years.

<table>
<thead>
<tr>
<th></th>
<th>Agriculture</th>
<th>Urban</th>
<th>Barren</th>
<th>Mountain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>8753.6</td>
<td>1844.3</td>
<td>100,781.9</td>
<td>8105.2</td>
</tr>
<tr>
<td>1987</td>
<td>10,692.3</td>
<td>3079.3</td>
<td>97,608.2</td>
<td>8105.2</td>
</tr>
<tr>
<td>2000</td>
<td>10,577.3</td>
<td>7465.2</td>
<td>93,337.3</td>
<td>8105.2</td>
</tr>
<tr>
<td>2009</td>
<td>9531.4</td>
<td>12,912.6</td>
<td>87,935.9</td>
<td>8105.2</td>
</tr>
<tr>
<td>Total change</td>
<td>777.90</td>
<td>12,068.3</td>
<td>-12,846</td>
<td>00</td>
</tr>
</tbody>
</table>

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According to Table 5 that reveals some agricultural data in Yazd district in comparison with average of Iran; total cultivation area of Yazd district is 9020 ha that this number is so close to calculated number from last satellite image. It also has pointed out in this table that yield per hectare of some products like barely and pistachio are higher than mean yield of Iran, but other agricultural products like wheat, saffron, pomegranate and grapes are much less than mean yield of Iran.

Table 5
Agriculture in the Yazd district, 2008.

<table>
<thead>
<tr>
<th></th>
<th>Cultivation area (ha)</th>
<th>Production (ton)</th>
<th>Yield per hectare in Yazd (kg)</th>
<th>Mean yield per hectare in Iran (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>744</td>
<td>2263</td>
<td>3042</td>
<td>3786</td>
</tr>
<tr>
<td>Barley</td>
<td>158</td>
<td>455</td>
<td>2880</td>
<td>2834</td>
</tr>
<tr>
<td>Saffron</td>
<td>2</td>
<td>2</td>
<td>1000</td>
<td>1070</td>
</tr>
<tr>
<td>Pomegranate</td>
<td>5869</td>
<td>10,067</td>
<td>9926</td>
<td>10,250</td>
</tr>
<tr>
<td>Pistachio</td>
<td>426</td>
<td>458</td>
<td>1074</td>
<td>852</td>
</tr>
<tr>
<td>Grapes</td>
<td>1330</td>
<td>131,000</td>
<td>9850</td>
<td>11,000</td>
</tr>
<tr>
<td>Greenhouses</td>
<td>491</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: Agricultural Organization of Yazd County (2008).

According to Table 5 that reveals some agricultural data in Yazd district in comparison with average of Iran; total cultivation area of Yazd district is 9020 ha that this number is so close to calculated number from last satellite image. It also has pointed out in this table that yield per hectare of some products like barely and pistachio are higher than mean yield of Iran, but other agricultural products like wheat, saffron, pomegranate and grapes are much less than mean yield of Iran.

Table 4
Land use/cover matrix, 1975–2009 (ha).

<table>
<thead>
<tr>
<th></th>
<th>Agriculture</th>
<th>Barren</th>
<th>Mountain</th>
<th>Built-up</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>5247.1</td>
<td>4204.6</td>
<td>0.0</td>
<td>95,31.4</td>
<td>8753.8</td>
</tr>
<tr>
<td>Barren</td>
<td>991.4</td>
<td>86,943.3</td>
<td>1.3</td>
<td>0.0</td>
<td>87936.0</td>
</tr>
<tr>
<td>Mountain</td>
<td>0.0</td>
<td>1.4</td>
<td>8103.8</td>
<td>0.0</td>
<td>8105.2</td>
</tr>
<tr>
<td>Built-up</td>
<td>2515.3</td>
<td>9631.0</td>
<td>0.0</td>
<td>1764.3</td>
<td>13192.6</td>
</tr>
<tr>
<td>Total</td>
<td>8753.8</td>
<td>100,782.3</td>
<td>8105.1</td>
<td>1844.0</td>
<td>119485.2</td>
</tr>
</tbody>
</table>

Conclusions

Urban sprawl has increasingly become a major issue in the global trend towards urbanization. Faced by not only by developed countries but also by developing counties, and by large urban centers and medium and small cities alike, sprawl raises social and environmental concerns at the same time that shows a multiplicity of divergent trajectories that somehow defy the dominance of homogeneous characteristics around the world.

In this paper, we presented the case of Yazd. This is a middle sized city located in central Iran that has experienced a rapid process of urban growth since the mid 1970s. Since then, the physical size of the city has doubled every ten years or so, and between 2000 and 2009, the new urban area added to Yazd was as large as all the urban area developed in more than 2000 years of history. Growth rates of this nature are rare in Iran and may be relatively rare in other areas of the world as well.

As in many cities of the developing countries, sprawl in Yazd appears as an unplanned and disordered pattern which has emerged after the location of existing highways, villages and towns and has been created by the realities of differential land rents, industrial location, and communication networks. Also, such rapid and unplanned growth has created important problems such as lack of enough services and facilities for the residents, insecurity,
increase of commuting length, and of energy consumption, and local climate change, among other matters. Finally, sprawl leave behind numerous interstices that may be used for other functions such as agricultural land or for infilling policies, although the former appears more important than the latter.

And yet, Yazd may be also interesting to explore because of some distinctive traits. First, this is a case of not just urban sprawl but of “agricultural sprawl” as well. In this sense, it is interesting to note how in certain cases urbanization does not proceed at the cost of agricultural land (as would be the case in many recent processes such as those affecting Southern Europe) but at the cost of original land covers, in this case barren land. Land substitution also implies the transformation of agricultural land into urban land but the remarkable case in Yazd is the growth of agricultural land between 1975 and 2009 in almost 1000 ha in what resembles a case of land use and land-cover change in the tropics. Of course, in the case of Yazd agricultural expansion would have been impossible without access to water. Even though, urban sprawl in Yazd has not destroyed much agricultural land, for future urban growth and development, the quality of land at the periphery of city should be studied to find out how fertile the land is, and what the class of land is. Lands that are less fertile should be used for urban constructions. For example, in Northern part of Yazd, the fertility of land is low, and cannot be used for agricultural purposes. However, evidence shows that the direction of future development of the city is towards the Northwest and the South which has the best and most fertile lands.

According to the findings of this study, uncontrolled urban sprawl in Yazd has caused many changes in the land use of the peripheral areas. The causes of having such widespread urban sprawl should be studied in order to develop strategies for controlling the city’s growth. Some of the strategies and policies that can be used for controlling the urban sprawl are: creating a regional balance to reduce migration from rural areas to urban areas or the renewal and improvement of the central-historical fabric and the inner city of Yazd. This would cause the continuous settlement of population in these areas for living and would prevent migration from center to the suburbs. Also, the policy of infilling development can be used to provide for the future growth of the population, and for implementing strategies addressed to manage the construction in the undeveloped peripheries.

In sum, to unravel the many facets of urbanization in general and of urban sprawl in particular around the globe, more case studies are needed to reflect different geographical and historical realities. Urban growth may not necessarily be a negative feature of social and economic development if properly managed. In this sense, it is important to understand the causes of sprawl and also to acknowledge that what is known as “urban sprawl” may hide a myriad of situations not all leading to environmental deterioration (for example, the presence of agricultural land and of gardens in the interstices of the growing city). However, to take advantage of these situations while at the same time contain and direct growth to more desirable patterns remains a gargantuan task for the rapidly growing cities of the global South.

References


