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Analysis of Landscape Pattern Changes in Isfahan City During the Last Two Decades

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Abstract

Urbanization and urban land-use transition are a global concern and one of the greatest challenges for ensuring human welfare. The landscape patterns resulting from urbanization influence processes at local, regional, and global scales. Quantifying the spatio-temporal pattern of urbanization is important for understanding its ecological impacts and can provide basic information for appropriate decision-making. The main goal of this study was to quantify the changes of landscape patterns in Isfahan city, in Iran, during the last two decades. For monitoring spatial pattern changes, land use and land-cover maps of the area were prepared using supervised maximum likelihood classification of Landsat Thematic Mapper (TM) images taken in 1990 and 2010. Five classes of land use including Water, Agricultural land, Urban area, Undeveloped area, and Bare land were identified. The changes of landscape structure were analyzed using several landscape metrics including: Percentage of landscape (PLAND), Number of patches (NP), Largest Patch Index (LPI) and Contagion (CONTAG), which were derived from spatial analysis software FRAGSTATS. The results indicated that the proportion of undeveloped area decreased from 41.87% to 39.65% and proportion of urban areas was significantly increased from 9.88% to 28.73% during the last two decades, mainly due to reduced agricultural area in Isfahan.

Keywords: Urbanization, Isfahan, Spatio-Temporal Changes, Landscape metrics, FRAGSTATS

1. Introduction

Urbanization, urban expansion and urban land-use transition are a global concern and one of the greatest challenges for ensuring human welfare. Over 50% percent of the world population lives in urbanized areas. Urbanization has profoundly transformed natural landscapes throughout the world, which inevitably has resulted in various effects on the structure, function, and dynamics of ecological systems at a wide range of scales. For example, land transformations associated with urban expansion can significantly affect biodiversity, energy flows, biogeochemical cycles, and climatic conditions at local to regional scales [3]. To improve understanding of urban landscape changes, remote sensed imagery, multiple models, and scenario analysis approaches are widely becoming used. Analyses of land use/cover changes (LUCC) are fundamental for understanding numerous social, economical and environmental problems [5]. To establish this correlation, the first step is to quantify landscape patterns. Landscape metrics are approaches to quantify landscape patterns, mainly, applied to categorical data with spatial interruption [2]. A wide range of metrics are available for the examination of relationships between spatial structure, ecological function,

and landscape change, The selection of the metrics depends first of all on the purpose of the study (mostly ecological process) and also on the landscape characteristics [1]. The common usage of the term 'landscape metrics' refers exclusively to indices developed for categorical maps. Landscape metrics are focused on the characterization of the geometric and spatial properties of categorical map patterns represented at a single scale [4]Applying these landscape metrics, this study attempts to quantificationally analyze the landscape pattern changes of Isfahan during the last two decades.

2. Materials and methods

2.1. Study area

The study area is Isfahan city which is located in centre of Iran and covers 340 km^2 (Fig. 1). The city is located in the lush plain of the Zayanderood River, at the foothills of the Zagros mountain range. Zayanderood River divides Isfahan city into north and south parts. Isfahan is one of the most important cities of Iran because of its historical and economic values. Isfahan attracts a large number of tourists each year. The mean annual temperature of Isfahan is approximately 16 $^{\circ}C$. The altitude of the study area is 1580 meters above mean sea level. The Isfahan metropolitan area had a population of 1,791,069 in the 2010, the second most populous metropolitan area in Iran after Tehran. Urban expansion, population growth, in addition to industrial development, have resulted in degrading environmental quality in Isfahan.

2.2. Data and preprocessing

For monitoring spatial pattern changes, land use and land-cover maps of the area were prepared using supervised maximum likelihood classification of Landsat Thematic Mapper (TM) images taken in 1990 and 2010. Five classes of land use/cover including Water, Agricultural land, Urban area, Undeveloped area, and Bare land were identified. We applied spatial pattern analysis software FRAGSTATS 3.3 to calculate landscape metrics of each class type and total landscape. We chose several class-level metrics including: Percentage of landscape (PLAND), Number of patches (NP), and Largest Patch Index (LPI), and also some landscape-level metrics such as Number of patches (NP), Patch Density and Contagion (CONTAG) were calculated to qualify the landscape pattern dynamics of Isfahan city.

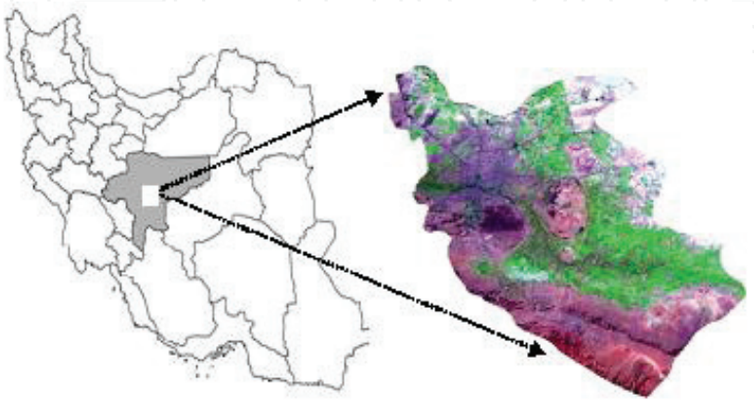

Figure 1. Location of Isfahan Province which is in the center of Iran (left) and Isfahan city extent (right).

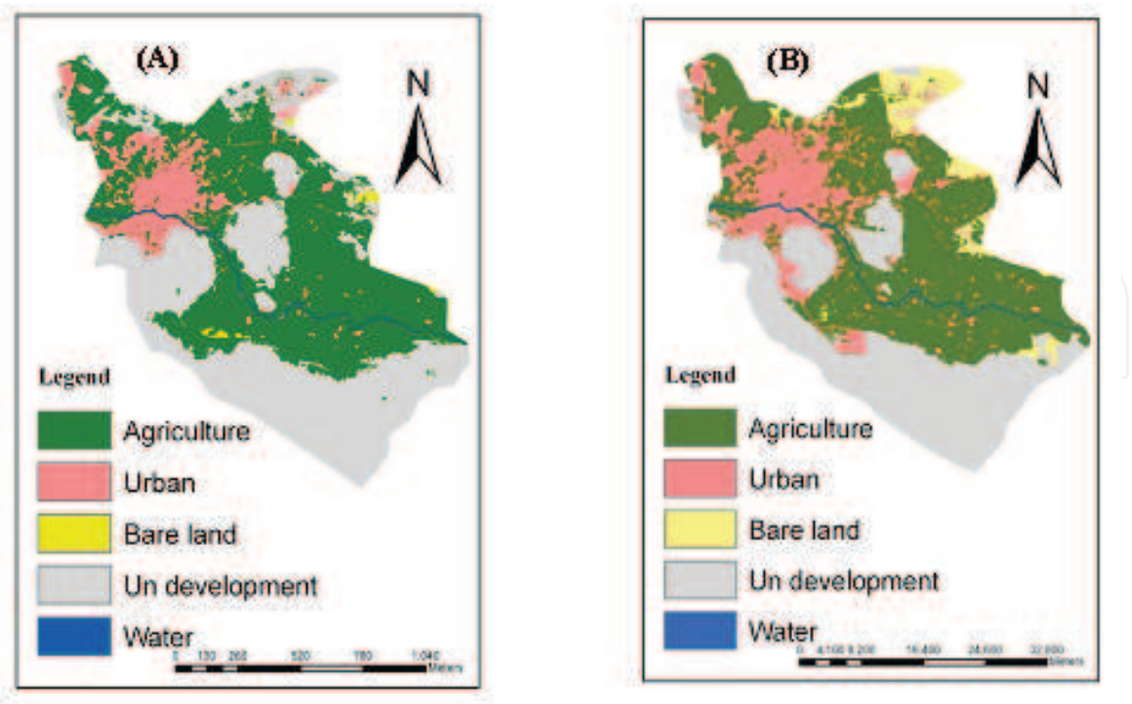

Figure 2. Land cover of Isfahan city: A.1990, B.2010

3. Result

Analysis of PLAND at the class level provides a general representation of landscape composition. The temporal change of PLAND can be used to obtain an overall idea of landscape change in Isfahan city. In 1990, the agricultural area of Isfahan comprised 46.85% of the total area. From 1990 to 2010, the area of agriculture kept declining (Fig.3). The proportion of undeveloped area decreased from 41.87%S to 39.65% in the period of study (Fig.3). Urban growth in the Isfahan maintained a rapid pace during the study period, increasing the percentage of urban area to 28.73% in 2010 (Fig.3).

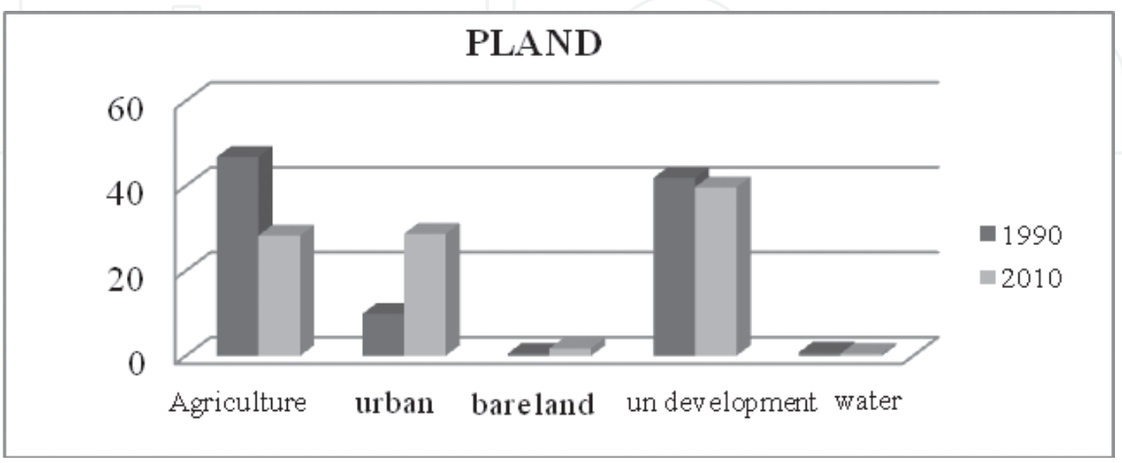

Figure 3. Comparison of Percentage of landscape in Isfahan city in 1990 and 2010.

The number of patches (NP) of all land covers types increased from 1990 to 2010. The most changes in Number of patch are related to agriculture area, with increasing from 1335 to 2979 in this period of time (Fig. 4).

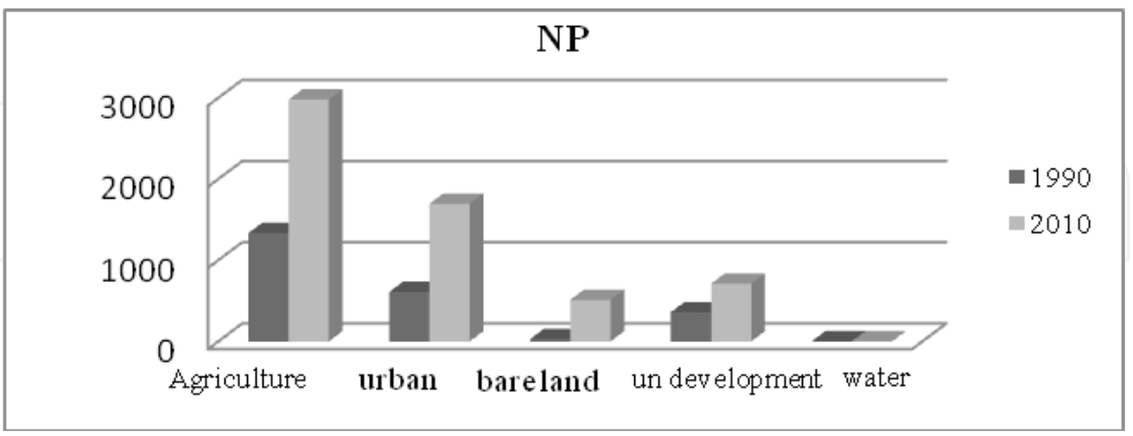

Figure 4. Comparison of Number of patches (NP) in Isfahan city in1990 and 2010 .

Undeveloped area had the highest values of LPI metric (Fig.4). From 1990 to 2010, the largest variation of LPI metric is associated to agriculture area, with decreasing from 26.22 to 7.6 % (Fig.5).

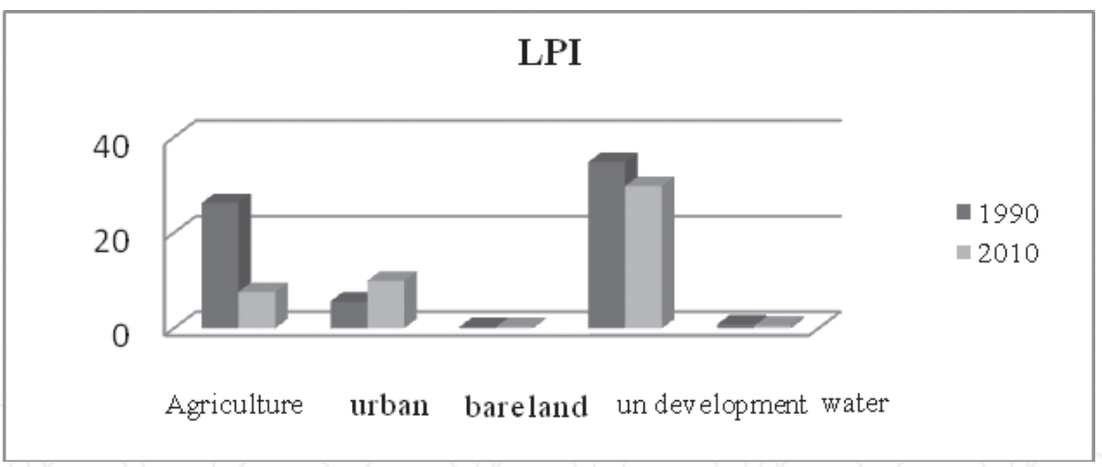

Figure 5. Comparison of Largest Patch Index in 1990 and 2010 in Isfahan city

The synoptic analysis of selected metrics for landscape level indicated the metric values of NP and PD increased from 2333 to 5898 and 1507.53 to 3418.73, respectively in past two decades (table1). The metric values of CONTAGE reduced from 67.63 to 63.22 (table 1).

Year	Spatial metrics		
	NP	PD	CONTAG
1990	2333	1507.53	67.63
2010	5898	3418.7	63.22

Table 1. Synoptic analysis of spatial metric for Isfahan city

4. Conclusion

The effectiveness of information on land covers change for spatial planning and decision making. Satellite images and landscape metrics, can be extremely useful for planners in assessing and monitoring the ecological consequences of landscape patterns. The proportion of agriculture reduced from 46.85 to 28.31, The proportion of urban was significantly increased from 9.88 to 28.73 during the study period, mainly due to reduced agricultural area in Isfahan. The synoptic analysis of selected metrics in landscape level showed the landscape has been more fragmented in Isfahan during the last two decades.

5. Acknowledgments

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