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Detection of landscape change (1954-2008) in Isfahan using gradient methods in GIS environment

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Abstract

Urban landscape is rapidly changing due to urbanization and population growth. This phenomenon has a number of social- economical and environmental consequences. Due to the rapid growth of urbanization and enormous changes of the applications, Isfahan`s city landscape has been changed. This study aimed to detect spatial gradients of the city in the period of 1954 to 2008. Therefore, the land used map of years of 1334 and 1386 was provided in six categories of man-made, agriculture, green spaces, arid, road and river. Gradient analysis was used to compare the changes. Transects 17×3 in north-south direction were used to analyze the gradient. The results of the comparison of transect in a certain time period showed that the gradient of the changes of applications and Metrics in 1954had more asymmetry than those of 2008. Thus, transects` margins were occupied with the combination of agriculture and arid lands ant its center was occupied with manmade lands. Comparison of metric values along transects showed the city's downtown landscape pattern has not changed much and variations of the margins are much bigger. The overall mean and standard deviation of the patch size of the BLOB size is greater than the margin transects. In general, the mean and standard deviation of the patch size is higher in the margins of transects and on the contrary, the patch density and margin density is higher in downtown.

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Introduction

Investigation of urban landscape has long been studied in geographical research designing and landscape architecture and urban ecology. (Zhang *et al* 2006). The city landscape and its spatial pattern of physical, ecological, economic and social processes have been followed by lots of consequences (Luck and Wu 2002). Human-caused environmental changes and these changes increase landscape fragmentation and create smaller but more patchs[2]. The method of quantifying landscape by various metrics can be used to investigate the condition of the urban landscape (Luck and Wu2002). In recent decades, many different metrics have been developed to quantify the landscape pattern (Turner 1989). The combination of gradient analysis and landscape metrics is a suitable method to quantify the urban environment (Luck and Wu2002, Zhu *et al* 2006). Gradient analysis first appeared with the objective of vegetation analysis (Whittaker1975). Gradient analysis is an applied method to study the location and usage properties along the gradient of city (Luck & Wu2002). Moving window technique, is a technique that moves the windows containing information on a transect. This technique is a suitable method applied to evaluate the landscape characteristics and its structures. Windows move along the transect by a sampling station and the width of the window is determined by user (Turner and Gardner 1992). The purpose of this study was to investigate the effects of roads on landscape pattern of Isfahan and finding a relationship between the percentage of road coverage and patches `density. The study of spatio-temporal changes of city pattern and quantifying it using a combination of the methods of metrics of landscape, and gradient analysis is an important step in the study of urban patterns of Isfahan and will help policy and decision makers to manage the city more inclusively and effectively. This study aimed at primary understanding of the structure and function of the landscape of the city of Isfahan. The purpose of this study was to evaluate changes in landscape of Isfahan city between the years 1954 to 2008 by analyzing the gradient of the north - south direction.

Materials and methods

Study area

Isfahan city is located at the center of Isfahan province and the east of the Zagros mountain range, its latitude is 32" 28' 30◦ and its longitude are 51" 39' 40◦. It covers an area of about 34,000 acres, and also is the third largest city after Tehran and Mashhad. The city is one of the largest dry cities in the world with very little rainfall and its altitude from sea level is about 1580 meters (Shafaqi 2002).

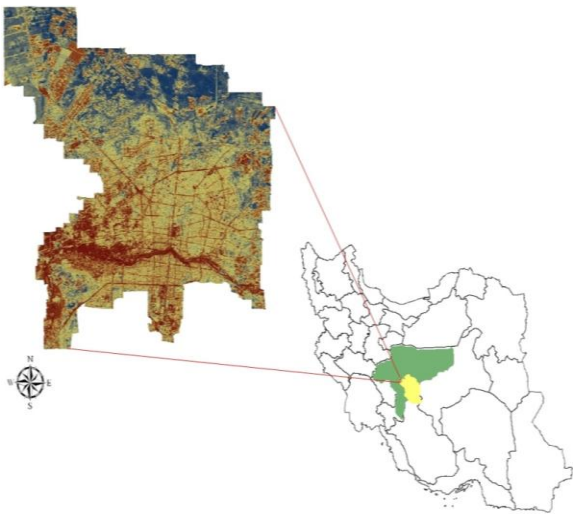


Fig. 1. Position of Isfahan in Iran.

Data Preparation

In this study, the maps of 1: 50000 taken by Geographical Department of the Army in 1346 using aerial photographs were used to provide the map of 1334. Aerial photographs of 1:2000 were used to determine the accuracy of the maps. This map was classified into six categories of urban, green space, agriculture, arid land, roads and rivers. Isfahan`s maps made by city hall`s computer service center were used to provide the use map of 1386. First, all the categories in the maps of 2000/1 were extracted and then according to table 1, they were reclassified in six major categories of urban, green space, farm land, grassland and arid land, roads and rivers. In the next step, the map produced was updated using the *satellite* image *IRS* sensor *Pan*.

Table 1. Classification of urban land use map of Isfahan

description	Acron-yms	Classification types of patch
Residential areas Facilities Industries Areas under construction Service centers (hospitals, etc.) Cultural and historical sites	U	Constructed land
of urban green space types	G	Green space
Agricultural lands Fallow land Gardens and vineyards	A	Agricultural areas
arid land Pastures lands without construction	B	area arid
roads	R	roads
Zayandeh_Rud River basin	W	river

Guiding transects in north - south direction

As it can be seen in Fig. 2, transects were routed toward the north – south direction. The transect route was designed so that both pass the city center (Enqelab Square). North-south transect length was considered to be 17 km and its width was 3 km.

Using the technique of moving windows along the transect

North - south transect was consisted of 8 blocks of 3 × 3 with an overlap of 1 km in accordance with Table 2. Metrics of interest were calculated in both landscape and class level using ARC GIS 9.2 software and FRAGSTST3.3.

Because the river has occupied less than 1% of the whole, it is not included in the calculations. The percentage coverage of different agricultural applications, green spaces; arid lands, road and river vary with having distance from the north towards the south (Fig. 2). In general, the relative dominance of different applications had given a specific pattern: Transformation of agricultural land into manmade. The distance that the application of urban land and roads is maximum, has certainly located in the city center.

Table 2. The distance from the northern margin of city comparing to each blocks of sampling transect

8	7	6	5	4	3	2	1	Block number
14-17	12-15	10-13	8-11	9-6	7-4	5-2	3-0	Distance from northern edge(km)

Table 3. Metrics used in the study [McGarigal *et al* 2002]

definition	abbreviation	Landscape metrics
The ratio of the total area occupied by a patch	PLAND	Percentage of coverage
The number of patches on 100 acres	PD	Patch Density
the whole Margin (per hectare) for each	ED	Edge Density
class or landscape	MPS	Largest Patch Index
The ratio of the patch the total landscape		Mean Patch size
areasize mean of patch(hectare)		

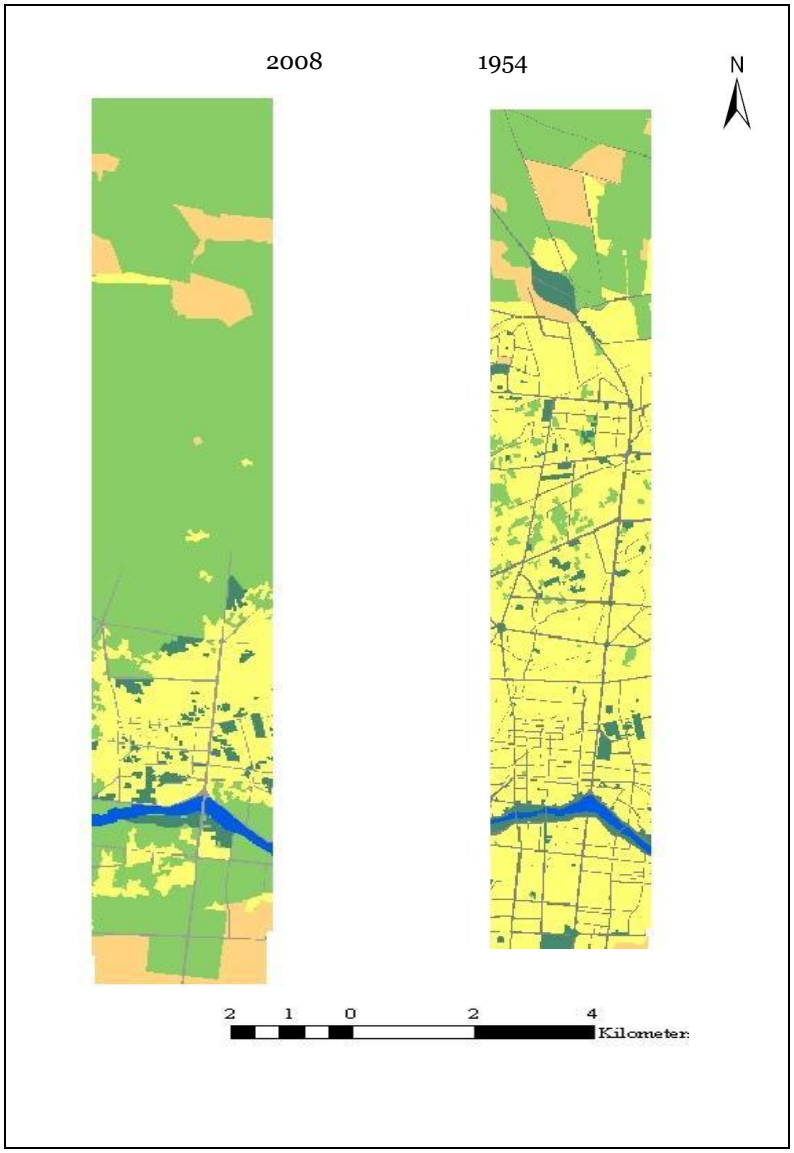


Fig. 2. the North - South Transects of Isfahan city in 1954 and 2008

Gradient analysis of the North – South transect

Compound metrics and spatial distribution analysis was performed in two levels of class and landscape in 1334 and 1386.

- Percentage of classes along transects

The percentage of each class was estimated along the north - south transect. As shown in Table 4 and Fig. 2, percentage of classes has changed in the period 1334-1386.

Table 4. Comparison of different classes of 1334 and 1386 along the north – south transect

of classes the percentage of different 2008	the percentage of different classes of 1954	(Classes) applications
62/14	17/20	manmade
5/64	3/12	Green space
17/68	65/05	farmlands
5/04	10/26	arid lands
8/20	2/49	roads
0/88	0/92	rivers

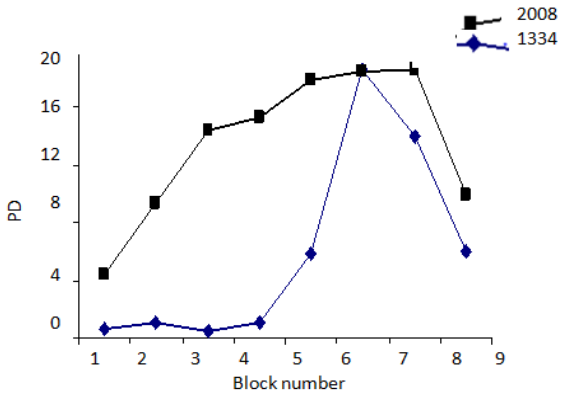
65 percent of the total area of 13343 transect is occupied by agricultural land and 62 percent of 1386 transect has been occupied by manmade patches. In other words agriculture class as a matrix (over 50%) of transects 34 and the manmade is considered a matrix for transect 86. Green space has increased from 1/3 to 6/5 in transect of 1386. The Percentage of arid land has been halved. Roads were increased from 4/2 percent to 2/8 percent, but the percentage of rivers has not changed much.

- Analysis of north - south transects across the city landscape

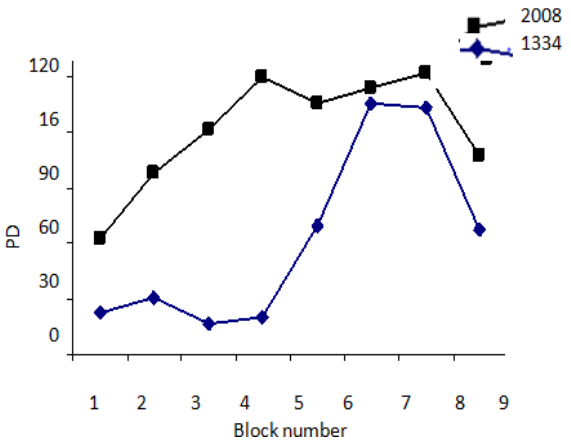
In this part, the result of gradient analysis in the city landscape will be presented. (Later, we call transects of 1954 and 2008, 34 and 86 respectively). According to Fig. 1 - (a and b) margins and patches density (PD and ED) have the same trend along transect. This same trend has been observed in transects 34 and 86 transect. Along transect 34; blocks of northern and southern margins have fewer values than central blocks (blocks 7 and 6). In 86 transect, their values are fewer in margins comparing to center, but in city center block, it reaches its maximum value. The values of margin density and patches are higher all along the 86 transect than 34 transect. The difference between these values in central blocks (6 and 7) is much smaller than the marginal blocks, because urban development has been made towards the periphery and the center has not changed much.

As shown in the Fig. 2 - (c), MPS metric values for both years of 34 and 86 are the same along the transect. The average patches size of 86 transects has decreased dramatically comparing to 34 transect. However, these metric values in both years of 34 and 86 are the same in blocks of the center, but the difference between the values is higher in the margins. The variation trend of standard deviation metric of the patch size is the same as the trend for the average size of the patch (Fig. 2 - (d)).

(A)



(B)



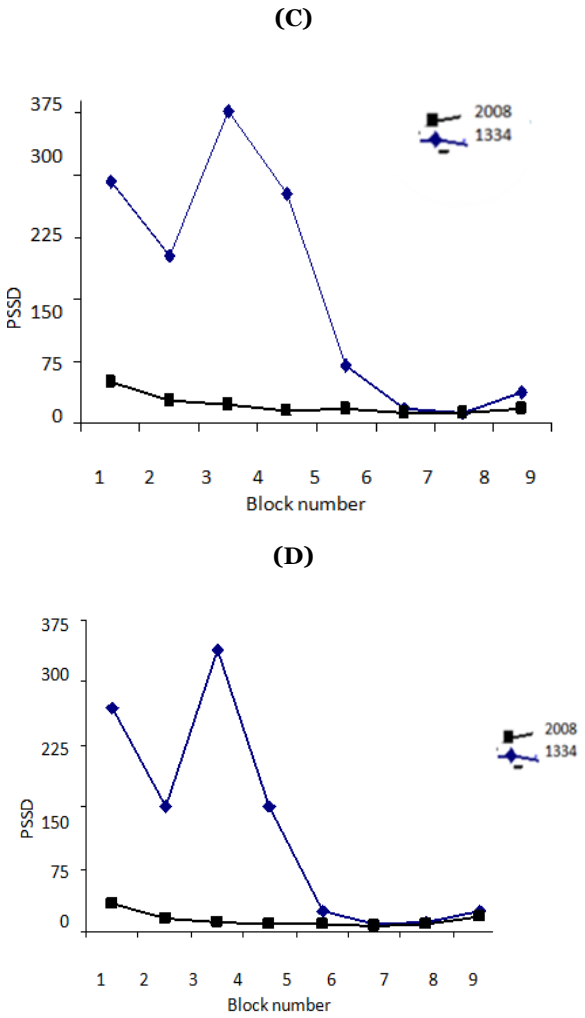


Fig. 1. Comparison of metric variation trends along the metric North - South transect in 1954 and 2008 at the landscape level

A) Density of patch B) marginal density C) average patches size D) standard deviation of patches size

Conclusions

The results of this study showed that north - south transect in 1386 had a more symmetric pattern comparing to 1334 transect. These variations are as combinations of agricultural and arid-agricultural-manmade and combination of agricultural and arid. But this symmetric trend has changed completely in transects of 1386, and has changed into a combination of agricultural and arid-manmade. According to the behavior of metrics of patch density, margin density, index of the biggest patch size and the mean of patch size in 1954 and2008, we can conclude that the expansion of the city has been towards the margins and a great change has not occurred in the downtown landscape. Comparing the two transects of north - south in 1954 and 2008, we can observe that the changes in the city landscape pattern in southern margin is more than northern margin, and changes the eastern margin are more than of the western margin. Southern margin of Isfahan city has changed from normal to manmade. Environmental projects and plans in terms of efficiency often need to quantify spatial patterns. For understanding urban systems, Cities should be studied as an integrated landscape in which the structure and pattern of the city are as important entities of the city. One of the advantages of quantitative analysis is the conversion of irregular and complex features into numerical indices that can be used as a criterion to evaluate various planning scenarios.

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