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Using satellite data and landscape metrics to monitor landscape changes: case study of Iran's south-western Khuzestan plain

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ABSTRACT:

Landscapes, the condition of ecosystems, and their spatial pattern are constantly changing as a result of human activities. Identifying and understanding the changes of Land Cover and Land Use (LCLU) are used as suitable indicators to monitor these changes, to which an important part of the ideas related to planning and regional policy have been allocated. This article attempts to use landscape metrics and satellite images to analyse spatiotemporal changes in the LCLU pattern in the Khuzestan plain. In this research, satellite images of Landsat's 5 and 8 with TM and OLI sensors are used in the range of 1990 to 2014 to extract LCLU maps as well as four metrics of NP, PLAND, MPS, MNND in the class of landscape to analyse composition and configuration. Our results showed significant changes in the composition and configuration criteria of LCLU by increasing the number and area of patches (fish farms, construction and industrial and local agriculture) against patch and area (riparian forest, marsh land and bare land) in the period under study. Results obtained from the overlap of maps showed that classes of riparian forest, marshland and bare land have lower resistance compared to changes. In general, the monitoring of LCLU patterns showed the process of increasing degradation and fragmentation of original pattern of land and reduction in integrity.

Keywords:

Khuzestan plain, landscape metrics, spatial pattern change, land cover, land use, remote sensing

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INTRODUCTION

Nowadays, changes in the patterns of Land Cover and Land Use (LCLU) are known as the most important driving force for environmental changes (Turner *et al*., 1994). The greatest diversity of land use can be seen in industrial and developing countries. Accordingly, there is a great need for comprehensive information on LCLU patterns changes in these countries as a base for planning and resource management (Briassoulis, 2000; Spellerberg, 2005). Change in LCLU has significant effects on ecosystem functions of earth such as participation in climate change (local and regional) as well as dust storms, pressuring the biodiversity, soil degradation and reduction of land's resistance (Houet *et al*., 2010; Fichera *et al*., 2012; Houghton *et al.,* 1999). Many extensive studies have been carried out to analyse LCLU change, depending on spatial scale and the concept of change (Briassoulis, 2000). Two types of change can be considered for land cover change, according to Briassoulis (2000), viz: conversion and evolution. Conversion of land cover includes change from one type of cover to another. Evolution of land cover includes changes in the structure or function without an overall change from one type to another (Skole *et al*., 1994; Turner *et al*., 1994). In the same vein, land use change could include: A) conversion of one type of application to another, which means changes in composition and pattern of land use in an area,and B) reformation of a specific type of land use (Briassoulis, 2000).

In the south-western parts of Iran, which are developing regions, human actions that lack compliance with environmental considerations are the main factor in a variety of changes and evolution of spatial patterns of LCLU. Ecological monitoring programmes are essential to identify and understand the changes and factors that affect it (Briassoulis, 2000; Spellerberg, 2005). Environmental monitoring is carried out with the aim of determining the status or trend in some of the environmental qualities and ecological resources by measuring the environmental properties over a long period of time (Spellerberg, 2005; Busch and Trexler, 2003; McDermid *et al.,* 2005). Environmental planners and researchers have developed extensive ecological indicators to ensure the resource sustainability to be able to use them and monitor the status of the environment (Rapport, 1995). With changes in the field of remote sensing, Geographic Information Systems (GIS) and theories of landscape ecology, focuses on spatial patterns has become the dominant paradigm in environmental planning and monitoring (Turner *et al.,* 2001; Zhou and Kurban, 2008; O'Neill *et al.,* 1997; Uuemaa *et al.,* 2013; Lietao and Ahern, 2002).

The main difference between landscape ecology with other branches of ecology is its emphasis on spatial patterning to multiple ecosystems over a wide range of land (Lietao *et al.,*2006; Ingegnoli, 2013).It is based on the principle that spatial patterns of ecosystems severely affect ecological processes (Cushman *et al*., 2008; Forman and Gordon, 1986). Hence, recognition of landscape spatial patterns and their constant changes creates a powerful tool for interpreting and providing solutions to ecological consequences and providing land spatial problems (Forman, 1995a; Lietao and Ahern, 2002). Spatial patterns of landscape can be analysed with three features, such as shape, composition and configuration (Rutledge, 2003). Many ecologists of landscape metrics have developed and proposed these measures and features. Composition metrics and configuration are among the most widely-used metrics for the wide-scale assessment and monitoring of landscape (Rutledge, 2003). Composition is a non-spatial -explicit characteristic. Compositionmetrics measure landscape characteristics such as percentage of class, number of patches and mean patch size (Cushman *et al*., 2008; Lietao and Ahern, 2002). Connectedness or the isolation of structure or shape of the land is evaluated in the analysis of configuration of the landscape. In other words, in this analysis, the method of spatial arrangement of patch will be evaluated in comparison with other patches (Cushman *et al*., 2008; Lietao and Ahern, 2002; Rutledge, 2003).

Classified/thematic maps of land use, land cover or vegetation are used in the calculation of metrics of landscape. This fact has led to the extensive use of GIS and remote sensing data in the studies related to landscape ecology (Aguilera *et al*., 2011). Satellite imagery provides valuable information for the study of landscape changes due to wide, integrated, repeated viewing as well as submitting data in a wide range of the electromagnetic spectrum and meeting the goals of researches based on monitoring and planning in comparison with landscapes. Many researches have been carried out using combined methods of remote sensing, GIS and landscape indicators to improve our understanding of changes in spatial patterns (Lietao and Ahern, 2002; Zhou *et al*., 2008; O'Neill *et al*., 1997; Herold *et al*., 2002; Petit *et al*., 2001). This research, too, tries to use sensor images of TM and OLI of Landsat satellite, GIS spatial analysis functions and landscape metrics to describe and analyse changes of LCLU in the landscape of Khuzestan plain for a 25-year period from 1990 to 2014. In this article, the monitoring of changes is carried out on a large scale using classified maps in the level of landscape class. A little attention has been paid to modelling ecosystems and monitoring changes in them on the level of scale (across the plains of Khuzestan) as a macro-territorial unit. However, the studies of land use have been reported in some urban areas, sub-basins and wetlands of Khuzestan plain, including Ahvaz (Faraji *et al*., 2016), Bamdezh wetland (Madadi and Ashrafzadeh, 2010; Scott *et al*., 1972) and Shadegan wetland (Scott and Crop, 1972; Savari *et al.,* 2002), in which their scale level has generally been the ecosystem and conventional and political boundaries. In fact, the main motivation of this study is to determine the boundaries of Khuzestan plain as a large structural/ morphotectonic unit for planning and preparing a spatial database from applications and land cover in the macro scale of the Khuzestan plain. Partial goals of this research are: (1) Preparing LCLU maps for (1990) and (2014), (2) Detecting changes from one type to another and (3) Determining classes with the highest rate of changes.

MATERIALS AND METHODS

Area of study

Iran's southern plains are in the form of an unequal band in the Northwest–Southeast of the Khuzestan province to Bandar Abbas in the northern border of Persian Gulf and in the west–east direction from Bandar Abbas to Guater Bay in the north margin of Oman Sea. The difference between the widths of these plains is related to the topographic conditions of the land (Stocklin, 1974; Alaie, 2009). The width of the plains has dropped in areas where the structure of folds is near the southern edge of Iran's plateau and when the structure of the land and also the topography are in the form of flat land; the development of the plain can be observed for up to several hundred kilometres. Khuzestan plain (Figure 1) is the most important part of Iran's southern plains, which is located between 30°4′ 56"and 32°23′42″N and 47°28′31″ and 50°22′36″ E longitude. This plain continues the Mesopotamian plain in structural and topographic view (Stocklin, 1974; Alaie, 2009). Its width in the south–north direction is more than 200 km and young alluvial deposits have covered it with a special order (Alaie, 2009; Heyvaert and Baeteman, 2007). The north border of Khuzestan plain and Zagros Mountains are determined by anticlines of Ahvaz and Aghajari with a northwest–southeast trend (Figure 2).The Karkhe, Dez, Karun and Jarahi rivers have cut the anticlines and made dense the materials from erosion of Zagros Mountains in the structural level of Khuzestan plain, and have given it in its current form (Alaie, 2009; Heyvaert and Baeteman, 2007). The large area and uniformity of the Khuzestan plain is, in fact, a

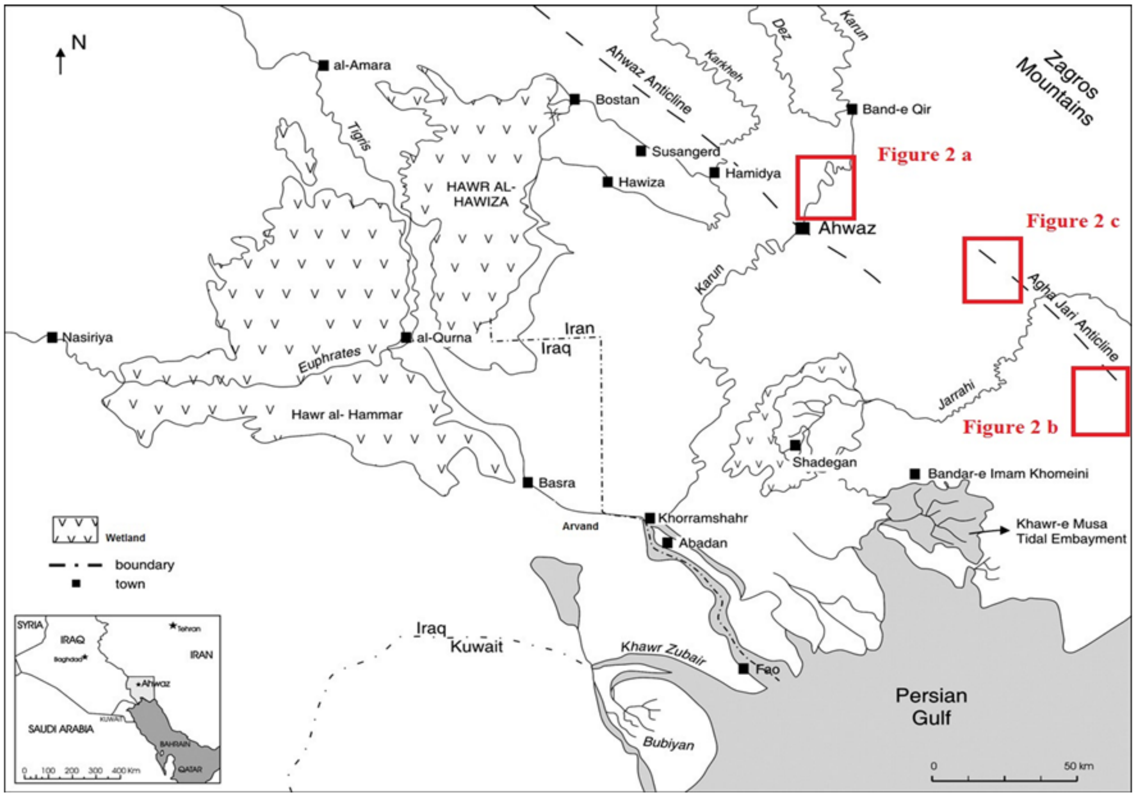


Figure 1. Location of Area of study in south-western Iran (Adapted from Heyvaert and Baeteman, 2000)

function of its simple and uniform structure (Figure 2 and 3). The low depth of the Persian Gulf and semi-diurnal mesotidal regime in these areas make the coastal view of the plains of Khuzestan dynamic and rapidly develop the plain (Haynes and McQuillan, 1974). This is particularly valid, given that large currents such as the Arvand Roud, Karun and Jarahi enter the Persian Gulf in these coasts and make a large amount of dense deposits in the shallow areas of Persian Gulf (Alaie, 2009). Many different land covers can be observed with coarse-grained and bar-shaped patterns in the landscape of the Khuzestan plain under the effect of this context and its morphology process. Wetlands, marshlands, floodplains and riparian forests are some examples of land cover that

Table 1. Features of satellite images and geological maps used in this study

Sensor/ Map	Acquired Date	Used Bands	Spatial Resolution/scale	Path Row	Source
Landsat5- TM	June1990	1,2,3,4,5,7	30 m	165-38 165-39 166-38	(USGS, 2015)
Landsat 8-OLI	July 2014	2,3,4,5,6,7	30 m	165-38 165-39 166-38	(USGS, 2015)
Geology	June1967	6 Sheet	1/100,000	25470 E 25471 E 25472 E 25473 E 25474 E 25475 E	IOC
Topography	May2001	6 Sheet	1/100,000	5652-5653 5752-5753 5852-5853	Iran National Cartography Center (INCC)

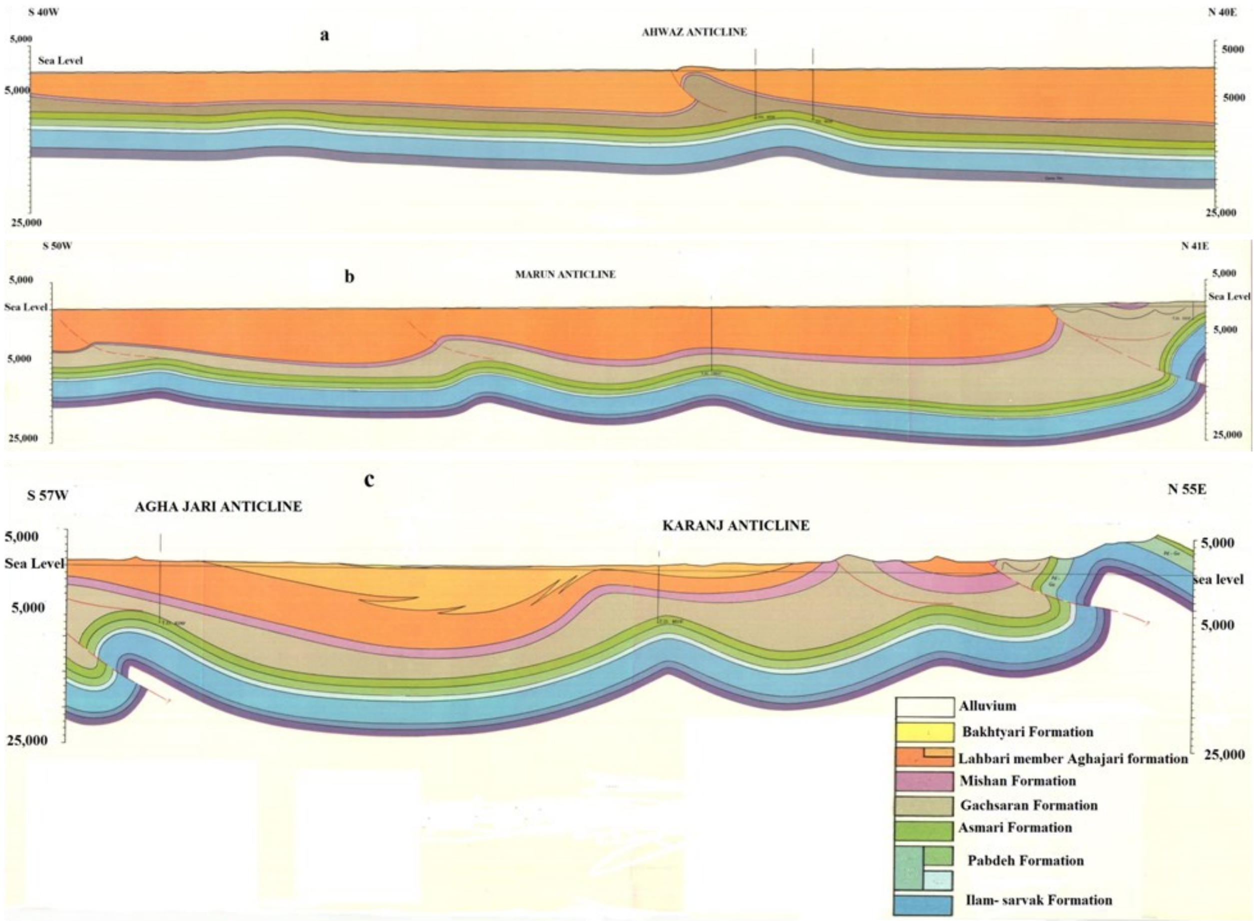


Figure 2. Geological cross-section in three areas of Ahwaz (a), Marun (b), Aghajari (c); the north of Khuzestan plain between Zagros

can be observed and recognized in combination and structure of the plain of Khuzestan. Also, agriculture is traditionally the main economic activity in Khuzestan Plain. The long history of human occupation in Khuzestan Plain—in interaction with land cover—has created patterns of native subsistence farming such as citriculture, crofting, dry farm, palm farm, and arable farming with an irregular geometry. In recent decades, some extensive economic, political and social driving factors—such as the land reforming law, expansion of urban areas and breakdown of sugarcane agro-industry companies and the occurrence of the eight-year war in the plain of Khuzestan—have changed the structure and spatial patterns of LCLU.

Data resources

The monitoring of the changes in the Khuzestan plain relies on two maps that resulted from implementation of an unsupervised classification method on six satellite images. Based on objectives and measures of this research, three important criteria taken into consideration in the selection of satellite images are: (1) Spectral Resolution (2) Spatial Resolution (3) Temporal Resolution. Many studies have been carried out on the amount of effectiveness of aerial photographs and satellite images in the evaluation of landscape features (Loubersac and Populus, 1986; Roy *et al*., 2014;Yavari *et al*., 2015;Aguilera *et al*., 2011; Faraji *et al*., 2016), which showed that high spatial and temporal resolution with high and diverse spectral power in Landsat satellite images with TM and OLI sensors have a good efficiency in the determination of natural phenomena and human activities. Thus, the images of Landsat satellite with

Table 2. Classes of land cover and land use in the plains of Khuzestan, along with descriptions of each class

LCLU type	Abbreviation	Description
Agriculture	Agri	Irrigated and dry agricultural areas with private use of local communities/ indigenous agriculture
Agro-industry	A-industry	Vast areas of the sugarcane industry - monoculture
Riparian forest	R.Forest	Riparian forestscover over 50%/ marginal plant/
Bare land	Bare land	Large pieces of land covered with short salt-friendly bushes/ flood land
Wetland	Wetland	Areas with permanent water coverage - including natural and artificial wetlands
Marsh land	Marshland	Areas with intermittent water coverage and brackish
Fish farm	Fish farm	Zones with regular plaid pattern/aquaculture/ponds+
Built	Built	Urban areas and rural residential and industrial zones and areas dominated by intensive construction

Series 5 and Series 8 in the period from 1990 to 2014 were used in this research to extract maps of LCLU in Khuzestan Plain. The selected images from Landsat were prepared with the lowest percentage of cloud cover from the geology archives of the United States of America (Table 1).

Geological maps of Iranian Oil Operating Company (IOC) with a scale of 1/100,000 and topographic maps of mapping agency with a scale of 1/100,000 have been used to determine the scope of the study area.

Delimiting the study area

Determining ecologically homogeneous units of land is a fundamental concept in environmental planning (Zonneveld, 2005). Large morphotectonic units are large shapes on land that have formed during various stages of geological change (in the form of mountains, lands, vertical movements of global faults, sediment and erosion) in different geological periods (Nabavi *et al.,* 1975). Khuzestan plain is considered a morphotectonic unit in which the structure of land has relative homogeneity and so is separable from its neighbouring units (folded and thrust of Zagros Mountains). A database to select the border of Khuzestan plain was formed with a layer Digital Elevation Model (DEM), derived from topographic maps, Geological Formation and faults in ArcGIS 9.2 software, and the border of Khuzestan plain in the southern Iran was extracted using the Logical Overlay method (Figure 3).

Classification of images to extract LCLU

Before conducting any processing and classification process on satellite images, there is a need for geometric and radiometric correction. Geometric corrections of images were done in the range of 1990 to 2014 by matching topographic maps with Root Mean Square error (RMS) of 0.3 pixel. A general correction

Table 3: Features of metrics used to monitor changes in Khuzestan plain

Metrics	Abbreviation	Description	Range
Number of Patches	NP	number of patches per each class or landscape	PN>1
Percent of landscape	PLAND	Measures the percent of the landscape	0<PLAND≤100
Mean patch size	MPS	The area occupied by a particular patch type divided by the number of patches of that type	MPS>0
Mean Nearest Neighbor Distance (m)	MNND	Mean Euclidean nearest neighbor distance, based on shortest edge-to-edge distance	MNND>1

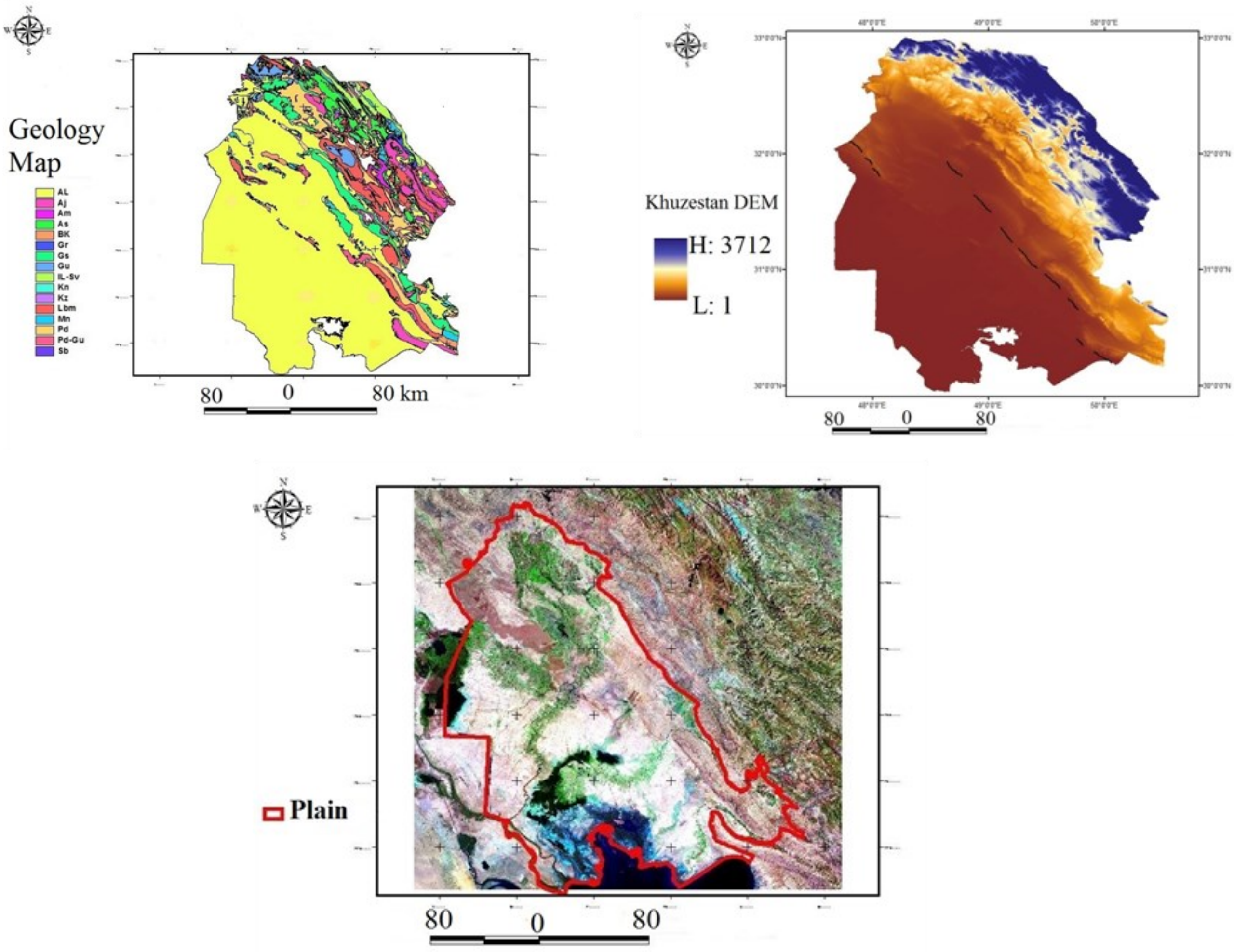


Figure 3: Determination of the Khuzestan plain homogeneous unit: Overlay DEM and Geological Formation

was carried out in the correction of radiometric images due to the lack of required atmospheric parameters and the minimum histogram range of visible–infrared images, which were changed to a number near zero.

Landsat satellite images record the spectral properties of each land phenomenon with digital number in a mosaic structure with a pixel size of 30 metres without gap and overlap between pixels. In addition to these data, satellite images provide an understanding based on a macro scale, which goes beyond its constituent pixels. Identifying spectral features of phenomena and understanding the scale of image and spatial patterns of land play a major role in the reduction of this generality to usable information. Four types—viz., point, line, polygon and gradient spatial data—are used in the analysis of spatial patterns of landscape (Cushman *et al*., 2008). Accordingly, this concept has been used in the analysis of data taken from remote sensing and the set of pixels which their digital number is in a particular spectral range are classified and sorted as a class in the form of polygon-pattern (O'Neill *et al*., 1997; Wiens, 1989). The classification of Remote Sensing data is done using two methods—supervised and unsupervised (Lillesand *et al*., 2014). In this article, the method of unsupervised classification and the method of visual and digitized interpretation on the screen were used to classify all images. Data of Landsat was classified into 28 classes in Envi4.5 software using unsupervised methods, and the interpretation and combination of classified classes were carried out

Table 4: Metrics calculated forclasses in 1990 and 2014

LCLU class	Class metrics	1990	2014	∆ 1990-2014
Agri	NP	6	14	+133%
	PLAND	1	5	+400%
	MPS	5541	14520	+162%
	MNND	3800	5100	+ 34%
A-industry	NP	100	63	-37%
	PLAND	27	34	+26%
	MPS	11364	22087	+94%
	MNND	2510	1950	-22.3%
R.Forest	NP	29	21	-27.6%
	PLAND	4	2	-50%
	MPS	3774	2724	-27.8%
	MNND	11900	9310	-21.8%
Bare land	NP	50	74	+48%
	PLAND	42	34	-19%
	MPS	33839	18914	-44.1%
	MNND	6000	5135	-14.41%
Wet-land	NP	35	36	+2.8%
	PLAND	15	16	+6.66%
	MPS	17674	17874	+1.13%
	MNND	6238	8333	+33.6%
Marsh land	NP	32	19	-40.6%
	PLAND	11	5	-54.5%
	MPS	13629	11111	-18.4%
	MNND	13430	18400	+37%
Built	NP	136	181	+33%
	PLAND	1	3	+200%
	MPS	251	648	+158%
	MNND	5700	5100	-10.5%
Fish farm	NP	0	161	+
	PLAND	0	1	+
	MPS	0	212	+
	MNND	0	1900	+
Total	NP	388	569	+46%

(Figure 4). A total of seven classes was finalized and classified for 1990 and eight classes were finalized and classified for 2014 (Table 2, Figure 4). In the end, a 3 * 3 majority filter was applied on data classification to reduce the effect of 'salt & pepper' (Lillesand *et al.*, 2014).

The value and usability of each generated map depends on its degree of accuracy. The usual method for determining the thematic accuracy of classified maps is by using a Confusion Matrix. There is a need for reference data in determination of the accuracy of the maps mentioned (Congalton and Green, 2008). Reference data includes sample areas of intended applications, which is prepared by field surveys and aerial photographs. In this study, in order to prepare the reference data in 1990, interviews with local communities in the completion of reference data for operation were also carried out in addition to aerial photographs. Thus, accuracy assessments for classification maps from 1990 and 2014 have respectively been obtained as 85.1 and 87.7, using kappa index.

Detection of the type of change

In the past two decades, there have been many advances in the methods of detection of changes using remote sensing science (Weismiller *et al.*, 1977; Sun *et al.*, 2016). The method of comparison after classification has been used in this article to detect changes of classes from one type to another. In this study, comparing after classification is used as a standard method for detecting the extent and type of changes of landscape elements. The analysis of changes of classified images was conducted by change detection tool in Arcview3.3 software by changing the format and then performing the overlap operation of both layers.

Landscape metrics

Monitoring changes are determined in landscape spatial patterns, depending on the type of data collected, method of collection, and research goals (McGarigal and Marks, 1995; Lietao and Ahern, 2002). In the present study, a small set of metrics has been selected with appropriate usage for coarse-gain to analyse the composition and configuration (Cushman *et al.*, 2008; Lillesand *et al.*, 2014) of Khuzestan plain (Table 3). Metrics used in landscape class were calculated using patch analyst tool in ArcGIS 9.2 software.

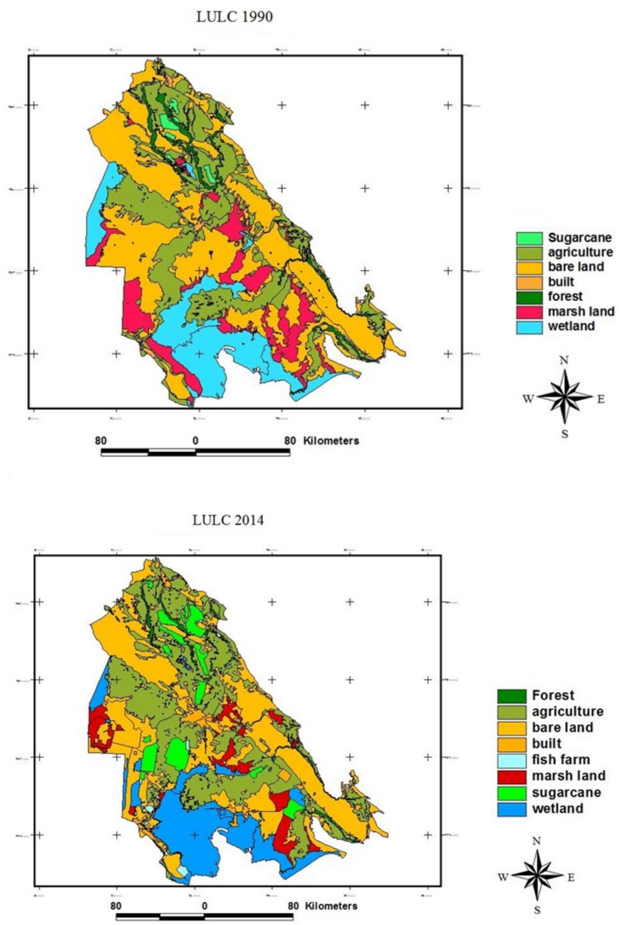


Figure 4: Classification map of LCLU (Land use/ Land cover)for Khuzestan plain in 1990 and 2014

RESULTS AND DISCUSSION

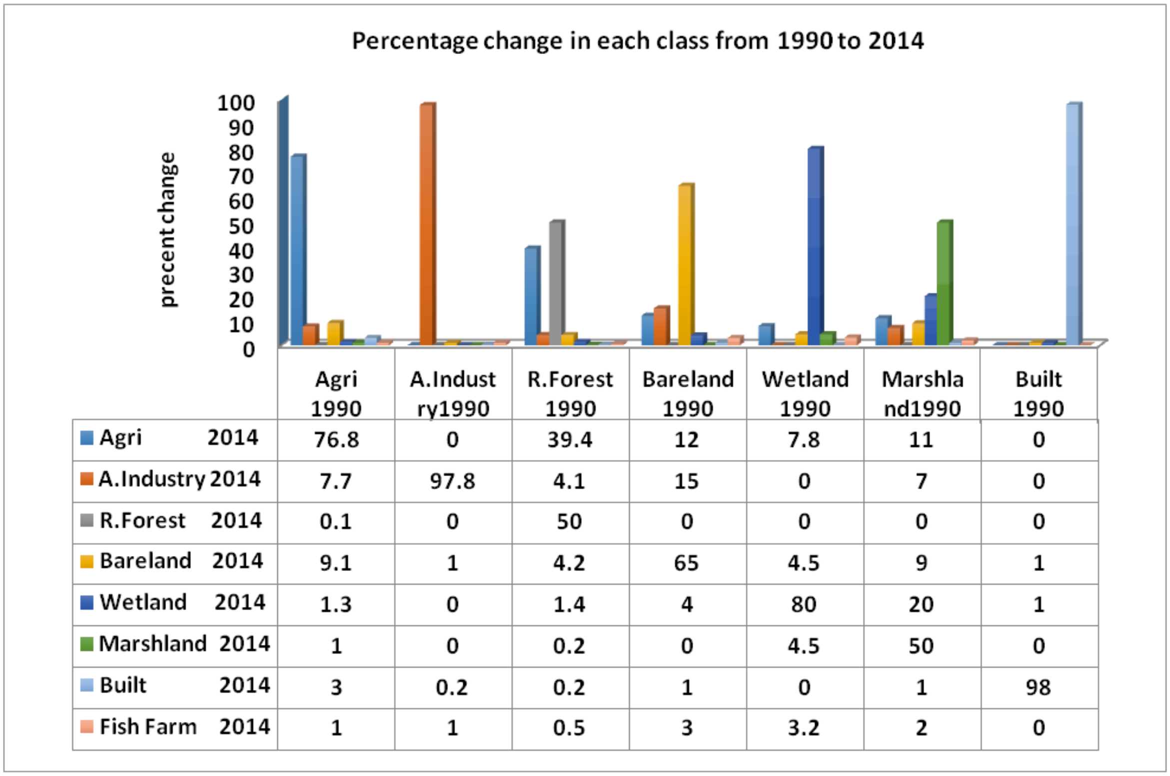
Changes in type of land use

The results of the overlapping of two layers of land use in Khuzestan plain related to 1990 and 2014 have been presented in the form of a relevant diagram and table (Figure 5). The calculated values showed level of changes of LCLU classes and types of changes in application at 25 values between 1990- and 2014-year periods. Based on the values presented, the classes of riparian forest and marsh land had 50 percent of change, which is the greatest level of change in the period studied. The class of riparian forest had the greatest level of change for native local agriculture, with 39.4 percent, among which all values calculated for the class of riparian forest had the greatest level of change. There found no change from other classes to the class of riparian forest in the period that was studied. The class of marsh land had also shown maximum changes along with the class of riparian forest with the change of 20 to wetland class (handmade). Two classes of industrial agriculture (sugarcane industry) and construction had the lowest conversion rate in their original location, compared to 2014, with respectively 2.2 and 2 percent of reduction. Also, the results of the detection of changes at this stage showed that the composition of land mosaic in the scale of Khuzestan plain had higher heterogeneity by the addition of class of fish farms from 1990 to 2014. The class of fish farms had the greatest effect on classes of wetland, bare land and marsh land with 3.2, 3 and 2 percent respectively. Also, the class of native indigenous agriculture has maintained 76.8 percent of its initial state during the 25-year period studied and had a high level of impact on the riparian forest class and integration, with classes of bare land, marsh land and wetland having shown changes. In general, and based on the diagram, the classes of riparian forest, marsh land, wetland and bare land have shown less resistance compared to other classes from 1990 to 2014. This effectiveness has led to significant changes in the mosaic landscape of the Khuzestan plain. The main sources of conversion of these classes have respectively been native on indigenous agriculture, industrial agriculture and fish farms.

Landscape metrics of the area

Table 4 shows the values calculated for landscape metrics for 1990 and 2014 in all the Khuzestan plains. The spatial pattern of land use and cover in the class during a 25-year period from 1990 to 2014 in terms of composition and configuration has changed as follows:

Based on the values provided in Table 4, the total number of patches (NP) in the Khuzestan plain in the years 1990–2014 has increased from 388 patches relating to seven classes to 569 patches relating to eight classes that showed an increase of 46% in the number of different patches of land. Increased NP of whole land



	Agri 1990	A.Industry1990	R.Forest 1990	Bareland 1990	Wetland 1990	Marshland1990	Built 1990
Agri 2014	76.8	0	39.4	12	7.8	11	0
A.Industry 2014	7.7	97.8	4.1	15	0	7	0
R.Forest 2014	0.1	0	50	0	0	0	0
Bareland 2014	9.1	1	4.2	65	4.5	9	1
Wetland 2014	1.3	0	1.4	4	80	20	1
Marshland 2014	1	0	0.2	0	4.5	50	0
Built 2014	3	0.2	0.2	1	0	1	98
Fish Farm 2014	1	1	0.5	3	3.2	2	0

Figure 5. Results of the overlapping of two layers of LCLU in Khuzestan plain related to 1990 and 2014

with regard to the comparison of values calculated for NP for each of the classes of land showed that the highest level of patches is related to the patches of fish farms with 161 patches that have been added to the face of the plain of Khuzestan over the last 25 years as new application. The values of MNND, PLAND and MPS for the class of fish farms showed that this class contains fine-grained and scattered patches and is leading the Khuzestan plain towards increased heterogeneity by the process of perforation. For the values of PLAND, the increased level has occurred for classes of local agriculture, agro-industry, wetland and construction compared to 1990, and a significant reduction is shown for classes of riparian forest and marsh land and bare land. As referred earlier (Changes in type of land use), the classes of riparian forest and marsh land have shown the lowest level of resistance to changes compared to coal agriculture and agro-industry. According to the Forman (1995b), large patches of natural vegetation and crossings filled with plants which protect the water are top-priority patterns for protecting and monitoring, and also by the consideration of the key role of riparian forests, marsh lands and wetlands in ecosystem services for flood plain of Khuzestan such as provisioning, regulating, cultural, and supporting services, we evaluate the metrics calculated for evaluating the changes in these classes in contrast to other classes.

By referring to Table 4, the metric values for 1990 related to riparian forest showed that this class has covered an area of about 4% of the total Khuzestan plain with 29 patches with MPS of 3,774 hectares. In a 25-year period, these values have been reduced to 21 for NP 2% for PLAND and 2724 for MPS. In fact, eight riparian forest patches have been completely removed during this period and the remaining patches are also losing their area, according to the reduction of MPS. Also, the metric of MNND with a reduction equal to 2590 showed the fragmentation of the riparian forest in Khuzestan Plain with a decreasing trend and intense desire to isolation. In terms of the class of wetland, combination metrics of

PLAND, MPS, and NP showed that an increased patch increases the unit of volume for a 1 percent increase in the MPS for 200hectares. This increase in features in the shape and composition of wetlands occur in circumstances in which the MNND of average Euclidean distance of wetland patches has increased by 2100 metres. Evaluation in the changes of wetland class is discussed by matching these results with Figure 5.

Figure 5 show that the class of wetland had the grates expansion in the class of marsh land while it has shown the greatest effectiveness in case of classes of local agriculture, fish farms and bare land. Based on these results, the increase value of PLAND of class of wetland in a 25-year period can be related to expansion of artificial wetlands in patches of marsh lands' class and conversion of seasonal and fine-grained wetlands to fish farms can be considered the affecting factor for increased MNND metric and, finally, in terms of great patches of land use, the total amount of PLAND in two classes of local indigenous agriculture and agro-industry has increased by 11 percent from 28 percent in 1990 to a total of 39 percent in 2014, which showed an increased development of intensive agriculture in the plain of Khuzestan. This claim is improved with a reduction in the number of patches in local indigenous agriculture from 100 to 63 and an increased average number of patches. Also, increased MNND and increased MPS of agro-industrial class showed development and distribution of this class in the plains of Khuzestan. The results obtained are in line with the results of the studies of Faraji *et al.* (2016) and Madadi and Ashrafzadeh (2010) on the tendency of agricultural lands to more dense patterns. But it should be noted in terms of the results of Faraji *et al*. (2016), which emphasized the monotony of the landscape that different results could be obtained, based on the selected scale for analysis, in a way that in the scale of the present study, fragmentation had an increasing trend across the plain of Khuzestan. Hence, according to the maps of LCLU and the results obtained, the spatial patterns of riparian forest, marsh land and wetland are under the pressure of local indigenous agriculture, industrial agriculture and fish farms through removal of patches, reduction of area and isolation under the pressure. Through the consideration of the growing trend of agricultural activities and aquaculture in the study area and financial support from the government for these activities, the changes in land cover patterns are expected to increase and preparing maps at different scales of time and space can provide a proper database to monitor changes.

CONCLUSION

Landscapes, the condition of ecosystems, and their spatial pattern are constantly changing as a result of human activities. Identifying and understanding the changes of Land Cover and Land Use (LCLU) are used as suitable indicators to monitor these changes, to which an important part of the ideas related to planning and regional policy, have been allocated. The combined methods of satellite imagery, GIS and landscape metrics, with a focus on spatial analysis and understanding of the processes of changes in landscape at different spatial and temporal scales, can be used to detect many future processes of land and development of planning scenarios in areas that do not have enough information in terms of ecological conditions. The study area is in an environment in which the status of human activities is increasing with a notable trend. Patterns and different land covers in Khuzestan plain, which are correlated with its spatial characteristics as sedimentary flood basin, coarse-grained natural patches and river corridors with riparian forests form the natural environment of the Khuzestan plain. Based on the results obtained and changes in the application of land, especially to local indigenous agriculture, and severe impacts on riparian forest, wetland and marsh land, structural integrity of this network has suffered severe fundamental changes. The set of riparian forests and large natural patches of wetland are among indispensable patterns of Khuzestan Plain. Thus, conservation and restoration of these patterns with a set of management strategies are the main condition for long-term sustainability of the Khuzestan Plain. Different types of protective, defensive, offensive or opportunistic strategies can be analysed, based on the data of this research as well as the completion of spatial database in the scale of each cover, including riparian forest, wetland and marsh land in future researches.

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