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Spatio-temporal land use/ cover changes analysis using remote sensing and landscape spatial metrics: A case study of Basin Liqvan

Khalil Valizadeh Kamran *1, **Fatemeh Adimi** 1

1University of Tabriz, Department of Remote Sensing and GIS, Tabriz, Iran

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Abstract

Over time, patterns of land cover and land use change and subsequent changes are fundamental and human factor plays a most important role in this process. Ever, scientists have attempted to identify factors that cause land use changes and their impact on the environment. Therefore, in previous decades, researchers have different views collected from the field, as well as aerial photographs to detect land use changes resulting from the imposition of natural and human processes have been analyzed. Today, however, based on technological advances made in the field of remote sensing, satellite imagery can be used to more accurately evaluate the environmental changes during the process and the final results of the illustrated model. The main purpose of the ongoing monitoring of land use changes in river basins Liqvan is 1985-2006-2013. Accordingly, to explore the changes occurring in the study area, Landsat TM and ETM + Landsat images of the years 1985-2006-2013 were analyzed. Accordingly, after applying atmospheric and geometric correction, image enhancement operations performed using the maximum likelihood method of supervised classification algorithms similar actions and thematic maps of land use of the basin has been designed to Liqvan. Finally, moorland in the first place and then irrigated gardens and residential areas in the study area are eventually.

1. Introduction

Although urban areas currently cover only 3% of the earth's surface, these areas have significant effects at both local and global scales (Liu et al., 2002). In the current scenario, cities are becoming places Almost all are human activities (Rajeshwari, 2006). In the last 200 years, while the world's population has increased six times, the world's urban population has reached more than 100 times the initial number (Leo et al, 2004). And it is estimated that more than 5 million people will live in urban areas by 2025, and 80% of them will be in the cities of developed countries (Maser, 2001). In general, in a systemic approach, the development of cities can be divided into two processes: spontaneous and self-organizing (Wu, 2000, quoted by Mir Bagheri and colleagues, 2018).

Land surface gauges are land surface quantification tools, whose variety and variety have led to their wide application in planning related to land studies. These measurements are able to give us a lot of information about the structure and changes of the constituent parts of the landscape in a short period of time. In this research, the measures of spatial distribution and composition of spots were used at the level of the class and landscape of the land. With the aim of providing a rational analysis of land use changes in Liqvan Chai basin.

Remote sensing provides users with the necessary and sufficient facilities to extract and update land cover maps.

By using image processing techniques, it is possible to study more and more terrestrial phenomena and describe surface resources. Today, by using remote sensing images, it is possible to map land use/cover on a local to continental scale in the shortest time and at the lowest cost. The use of various classification methods of satellite images has made it possible to accurately extract the land use ratios of each geographical region (Fyzizadeh, 2016).

The change of land use includes the change of the type of uses and the change in the distribution and spatial patterns of activities and uses (Briasolis: 2000: 12). In other words, land use change means a change in the type of land use, which is not necessarily a change in the land surface, but also a change in land density and management (Pernoun, 2009: 40).

* **Corresponding Author**

*(valizadeh@tabrizu.ac.ir) ORCID ID 0000 – 0003 – 4648 – 842x
(f.adimy@yahoo.com)

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2. Method

In order to investigate the spatial structure and spatial analysis of different measures of land use spots, Fragstats software was used to quantify the measures. Fragstats is the title of a program that is used to quantify the structure and pattern of the land surface. This software is a complete set of land surface measurements.

This program has no limitation in scale (width or magnification) and it is suitable for analyzing the spatial pattern and different measures of the spots that make up the landscape of the land in heterogeneous environments and different conditions. It also expresses the calculated measures based on hectares or meters. For each input in the software, 3 output files are created: PATCH, CLASS, LAND. All files can be viewed as text files. This tool is used to analyze spatial patterns, especially in habitat modeling, wildlife protection and forest management. Some spatial metrics are described here:Indicator CA (Class Area) : The total area of built and unbuilt areas in an entire city. Usually, CA/TA ratio is used where TA is the total area of the region. This metric is an excellent mechanism for analyzing and comparing the development and changes in the area of constructed and unconstructed land, and its numerical value is greater than zero and has no maximum limit.Indicator NP: (Numbor of Patches) :

It measures the number of individual patches that make up a specific land use or land cover class. (Largest Patch Index) Indicator LPI

This metric shows the percentage of the user that is covered by the largest patch in a user class.

LPI= Indicator ED (Edge Density):

Border density measure: It is equivalent to the length of all borders divided by the area and is obtained from the following relationship.

ED= Indicator MPS (Mean Patch Size)

This metric shows the average size of spots that make up a specific user or class.

MPS= Indicator) pland (Land cover percentage: It measures the percentage ratio of each type of spot (class).

pi: is a ratio of the surface of the land occupied by the spot of type i aij = area (square meters) of spot ij A = the total area of the surface of the land, the sum of all the areas of the spots of type i, divided by the total surface area of the land, multiplied by 100 to convert to a percentage.

Spot density index (PD)

This measure shows the number of spots per unit area and allows comparison between different areas. This measure is used as habitat fragmentation index.

PD= ni/A (10000)(100) ni = number of spots type (class) i و A = The total surface area of the land

The number of spots of type i divided by the total surface area of the land multiplied by 1000 to convert to hectares (multiply by 100 to get the density of spots in 100 hectares.

Edge density index (Total edge): It is equal to the total length of all the edge segments that include the corresponding class type, the unit of which is meter.

Wang used measurement, shape, and size metrics to study the topography changes of the city of Wayne, Michigan, USA, between 1986 and 2000.Herold et al. (2002) used remote sensing and spatial metrics to study the spatial characteristics of the city of Santa Barbara. Herzog-Vlach (2002) used landscape metrics to monitor landscape changes in East Germany. The results showed that the land use spots have little diversity and the landscape of the land is becoming more and more fragmented. Chesia et al. (2009) investigated landscape dynamics in an abandoned rural environment in the Apennine Mountains. First, land use maps were prepared, and then the changes in land cover and landscape structure in three time periods were investigated through the shape, size, separation of spots based on CA, MPS, PSSD, LPI metrics. The results showed that forestry increased by 23.9%, pastures and wastelands decreased by 29.9%, and scattered urbanization and the dispersion of infrastructure such as roads and buildings also increased.

2.1. Study Area

Liqvan Chai basin is one of the sub-basins of Aji Chai and has an area of 76 square kilometers in the northern slope of Sahand between 46-30-20 east longitudes to 46-27-30 degrees and 55-55 north latitudes. - 42-˚37 to˝30-´49˚-37, has been expanded. From the north it leads to Spreh-Koh and Liqvan valley, from the south to Sahand heights, from the east to Saeedabadchai and Ojan watersheds and from the west to the Sardroud river watershed. The general map of Liqvan watershed is shown in Figure (1). (Hosseinzadeh, Hojjat, 1385).

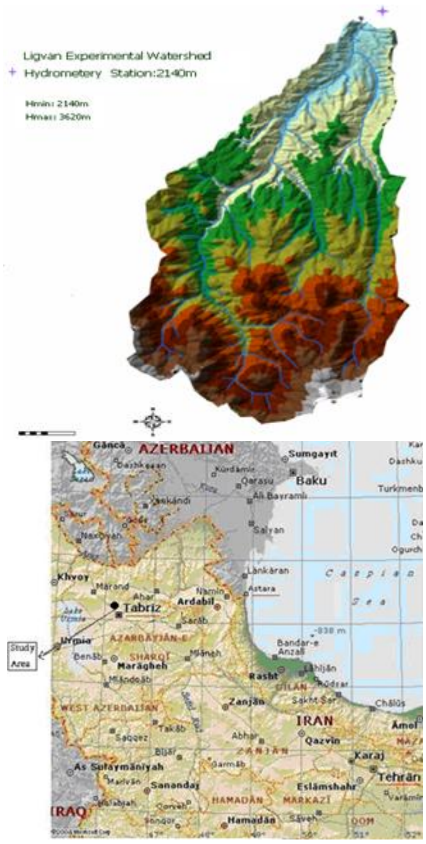

Figure 1. Map of Liqvan Chai catchment area materials and ways:

-Collecting and preparing maps

The data used in this project from the point of view of their source are as follows:

Landsat satellite images of three periods: 1985, 2006, 2013

Observations of field operations

- GPS impressions of points
- General data such as roads, residential areas, etc.
- Materials:

In this research, time series data of Landsat satellite images of 1985-2006-2013 of Liqvan Chai watershed were selected and analyzed.

1:50000 digital maps of Liqvan Chai basin

-software:

The software used in this research are: Arc GIS 10.2 software: In this software, analysis steps are performed and the change map is produced in this environment. ENVI 4.8 software: It is an image processing software, and all the stages of image preparation and processing were done in this environment. The research method in this research is descriptive-analytical. In this research, the desired information was first collected using library studies and field studies, then quantitative and qualitative methods were used to analyze this information. The used satellite images include TM satellite images of 1985, 2006 and 2013 from the area of Liqvan Chai catchment area.

3. Results

With exploitation from the existing maps and through field visits and visual interpretation and existing documents, the land uses were taken in the pre-classification and post-classification stages. At this stage, the Stack operation was performed on all bands of the images except thermal bands, and then, considering the resolution of the bands, appropriate bands (2, 3, 4 for the years 1985 and 2006 and bands 7, 5, 3 for 2013) was considered for classification.

Pre-processing: due to the fact that the images obtained from satellites, from the point of view of spatial, temporal and spectral resolution, always have the possibility of systematic and non-systematic errors, so preliminary processing should be done on the raw data through the imaging system. or the atmospheric conditions during the measurement (Jensen, 1996).

In this research, the maximum probability classification method was used. After evaluating the probabilities in each class, the pixels are assigned to the classes that have the most similarity, and if the probability values are lower than the introduced threshold, they are introduced as unclassified pixels. (Alavi Panah, 1382: 312). The desired maps were obtained using ENVI 4.8 software and the supervised classification method of the maximum probability type, image classification. In this regard, the images were divided into four classes, including built-up areas, barren areas, green spaces, and hydroponics.

No classification is complete until its accuracy is evaluated (Lylesend, 2001). Therefore, to ensure the accuracy of the classification, the classification accuracy is evaluated. The accuracy of the classification indicates the level of confidence in the extracted map, and in land use maps obtained from remote sensing images, it should be at least 85% (Anderson et al., 1976). The overall accuracy of the map extracted with the maximum likelihood algorithm in this research for 2013 (98.12%), 2006 (94.44%) and 1985 (94.75%) confirms this.

In this research, according to the region, the images were classified into 4 classes: built, gardens and green spaces, barren and irrigated agriculture. Below, the land use maps of three periods (1985, 2006 and 2013) can be seen. These maps were obtained after several operations mentioned above and field surveys as follows. Also, by using the methods available in ENVI software, the statistics and figures of each user can be seen as a percentage in the following tables.

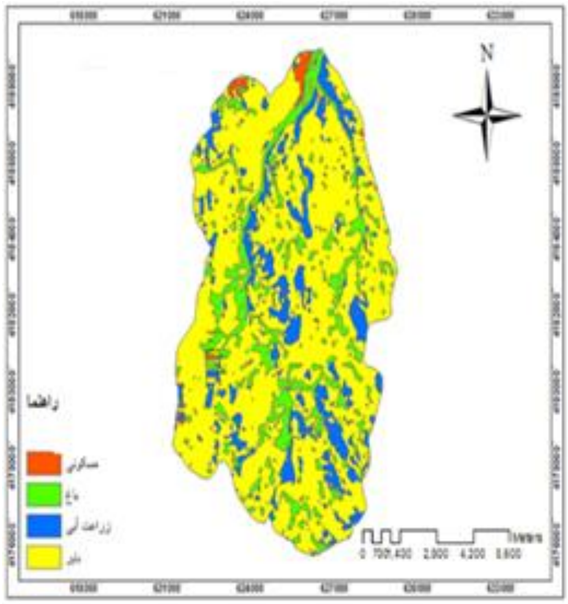

Figure 2. Land use related to the picture of 1985

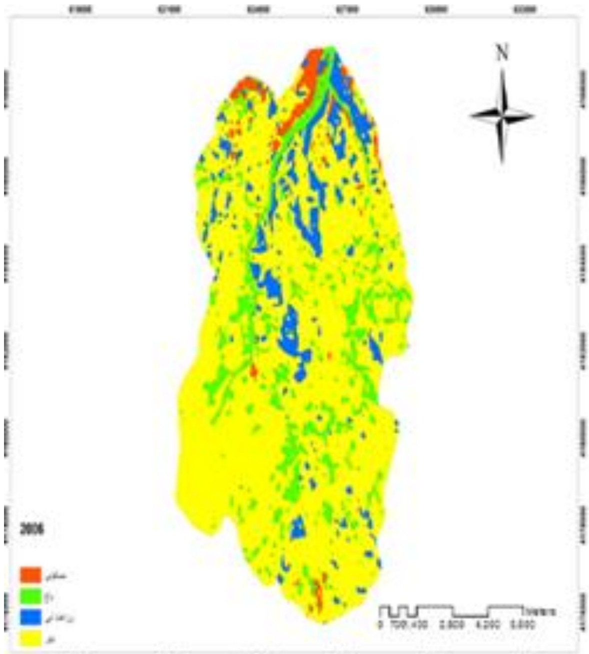

Figure 3. Land use related to the picture of 2006

Table 1. The land use area related to the 1985 picture

Class name	User	Area (hectares)	Area percentage
Residential	Residential	72.5	%0.96
Garden	Garden	1047..25	%13.87
Watery Agriculture	Watery Agriculture	1009.04	%13.37
barren	barren	5417.12	%71.78

Table 2. The land use area related to the 2006 picture

Class name	User	area (hectares)	Area percentage
Residential	Residential	217.92	%2.88
Garden	Garden	906.62	%12.02
Watery Agriculture	Watery Agriculture	690.61	%9.15
Barren	Barren	5730.26	%75.94

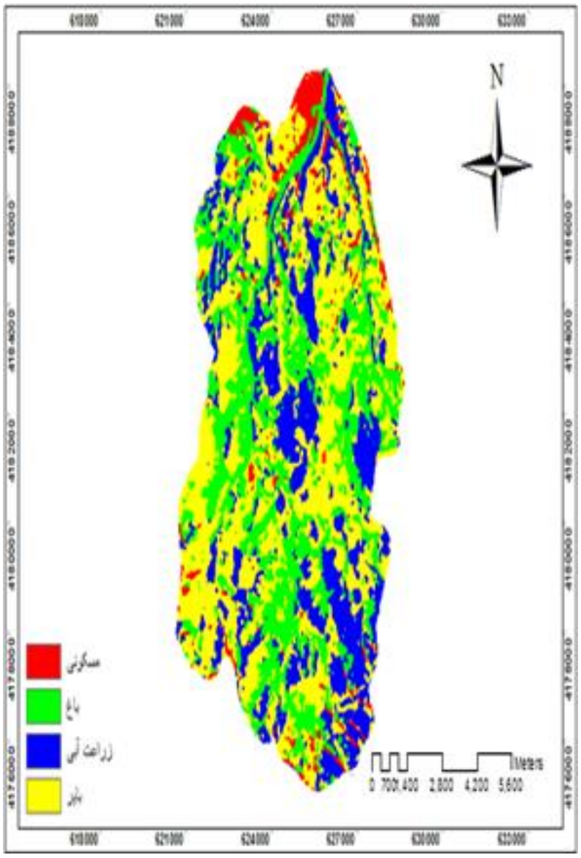

Figure 4. Land use related to the 2013 image

Table 3. The land use area related to the 2013 picture

Class name	User	Area (hectares)	Area percentage
Residential	Residential	362.85	%4.80
Garden	Garden	2175.8	%28.84
Watery Agriculture	Watery Agriculture	1756.6	%23.28
Barren	Barren	3249.3	%43.06

And according to the 2013 land use area table, it can be said that:

Residential areas in the years 1985-2013, although it occupies the least area of land use in the region, but it shows that residential areas are increasing, which is the reason for the expansion of the existing villages in the region, as well as the boom in villa construction. is in this area. The use of gardens shows a significant jump in 2013 compared to previous years. The use of irrigated agriculture has grown a lot in recent years, the reason for which can be the use of water from dams in the region that have been exploited in recent years in the field of irrigated agriculture. The use of barren lands shows that in the study area, the largest share of use during the study period belongs to this use.

Nature, extent and rate of land use/cover changes:

Using the accepted method in the research conceptual model, land use/land cover maps were produced for all three dates and the area of different land use classes in the region and the statistics indicating the change were calculated. The results obtained from these calculations in the different years studied are shown in Tables 3 and 4. There are different ways to quantify land cover changes. Among these different methods, the most basic method is to tabulate the total land cover changes for each land use/cover class and check the changes in different years. In order to determine the extent and rate of changes in land cover dynamics in the region, the following variables were developed and calculated. In order to determine the expansion and rate of changes in land cover dynamics in the region, variables were calculated as follows:

1) total area (Ta)
2) Change area (Ca)
3) Percentage of changes (Ce)
4) Annual rate of change (Cr)

These variables are calculated using the following relationships.

$$Ca= Ta\ (t2) - Ta\ (t1)$$
$$Ce= (Ca / Ta(t1)) * 100$$
$$Cr = Ce / (t2 - t1)$$

In these relationships, t1 and t2 are the beginning and end times of the studied time period. In the above tables, all the users have been calculated once and individual users have been studied once, and the results are given in the following tables.

Table 4. Changes in 1985-2006

Ca	Ce	Cr	Land cover in 1985-2006
145.42	200.58	9.55	Residential
140.63-	-13.42	0.64-	Gardens and green space
318.43-	31.56-	1.50-	Watery Agriculture
313.14	5.78	0.28	Barren lands
0.5-	161.38	7.69	Total

Table 5. Changes in 2006-2013

Ca	Ce	Cr	2006-2013 Land cover in
144.93	66.51	3.91	Residential
1269.18	139.99	8.23	Gardens and green space
1065.99	154.35	9.08	Watery Agriculture
2480.96-	43.29-	2.55-	Barren lands
0.86-	317.56	18.67	Total

Table 6. Changes in 1985-2013

Ca	Ce	Cr	Land cover in1985-2013
290.35	400.48	14.30	Residential
1128.55	107.76	3.85	Gardens and green space
747.56	74.08	2.64	Watery Agriculture
2167.82-	40.02-	1.43-	Barren lands
1.36-	54.23	19.36	Total

As seen in the above tables, the average annual rate of change in residential areas in the period of 2006-1985 was 9.55 and in the period of 2006-2013 it was 3.91 and in the whole period of 1985-2013 it was 14.30.

Spatial transformation analysis of land use/cover changes using spatial metrics:

In this research, the calculation of spatial metrics is based on land use/land cover maps resulting from the classification of satellite images and showing the appearance of the land consisting of spatial spots classified in different classes of spots. The landscape pattern analysis has been done at the level of user/coverage classes. For each cover class, the total area, the average size of the spot, the number of spots, the percentage of the class from the total landscape and the index of the largest spot are listed in table number (7).

Table 7. The metrics of the image of the land of the year 2013

The area of each user (CA) hectares	Percent coverage of each class (PLAN)	The number of spots (NP)	Measure the largest stain (LPI)	Total margin (TE)	Edge density (ED)	user name
370.53	3.47	192	0.88	123390	11.51	Residential
2174.04	20.39	253	6.25	432720	40.58	Gardens
1758.96	16.49	269	10.41	353520	33.16	Watery Agriculture
3244.5	30.43	281	3.32	571470	53.60	Barren ands
3098.16	29.06	4	10.20	91440	8.57	Study area

By comparing the NP metric and the TA metric, it can be seen that the highest number of spots belong to the barren land class, and the highest area and percent coverage belong to the barren land class, and the least number of spots belong to the residential land class, and the least area and percent coverage belong to the residential land. Is. Measuring the biggest spot related to irrigated agriculture and the smallest one related to residential lands, the density of the edge and the entire edge is the same. In general, from 1985 to 2013, it can be concluded that the percentage of vegetation and the LPI index have increased in parallel in these years. The number of residential spots has increased, but the residential area has decreased. And the largest area and the biggest stain in 1985 belongs to the gardens, which has been greatly reduced during these years, and the reason for this is the creation of villas that have been created.

4. Conclusion

Residential areas in the years 1985-2013, although it occupies the least area of land use in the region, but it shows that residential areas are increasing, which is the reason for the expansion of the existing villages in the region, as well as the boom in villa construction. is in this area. The use of gardens shows a significant jump in 2013 compared to previous years. The use of irrigated agriculture has grown a lot in recent years, the reason for which can be the use of water from dams in the region that have been exploited in recent years in the field of irrigated agriculture. The use of barren lands shows that in the study area, the largest share of use during the study period belongs to this use.According to the tables obtained from the measurement of land metrics, which were produced from the results of the classification of land cover for the years 2013-2006-1985, there have been many changes from 1985 to 2013. This shows the intensity of construction in this area. On the other hand, irrigated agriculture and gardens do not show drastic changes, and these areas do not show drastic changes except for the period of 2006-2013, in which the transformation of these areas into residential areas is also observed.

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