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Change Detection of Urban Land Use and Urban Expansion Using GIS and RS, Case Study: Zanjan Province, Iran

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Abstract: *Accurate data and timely information regarding the existing land-uses is needed to manage the natural landscapes effectively. The information related to land-use changes constitutes the basic element in management of natural resources. In fact, the awareness about patterns of land-use changes is conductive of ecosystem toward balance. Therefore, the need to detect, plan and predict such changes in an ecosystem is of great importance. In order to discover these changes, the application of multi-temporal remote sensing data (RS) and geographical information system (GIS) provides the possibility of valuable analysis. In this paper, two images, i.e. ETM+ 2002 and OLI 2015 were used for Zanjan city. To map the pattern of changes, at first the coordinates of two images were integrated, andafter the atmospheric corrections, the considered area was classified to four classes including residential areas, road network, vegetation and other regions using the maximum likelihood method. Then,Post classification and overlapping methods were used to detect changes. The results show that the urban expansion has increased during 13 years. The expansion of Zanjan City has been inclined more toward north and north –west affecting the barren lands, while the garden lands in the south has been less influenced by urban expansion.*

Keywords: *Change detection, Land-use, Remote sensing, GIS, Landsat, Zanjan city*

1. Introduction

The cities accommodate various activities and multiple functionalities where any changes in them are inevitable. In the past fifty years, the spatial organization of the cities and their original structure has changed dramatically, and thus the cities are segmented to different regions, each involving a particular activity. The rapid growth of the cities and urbanization is consequence of industrialization and the changes made in technology. Change detection includes application of multi-temporal data in order to identify the regions in which land-use has changed during different periods of imagery. These changes may be result of short term cover changes such as snowfall, floods, or changes in land-use like urban development and conversion of agricultural lands into residential and industrial purposes (Rabiei et al, 2004). There are different methods to obtain extent and severity of land-use changes, from Principal Component Analysis to Spectro-temporal Classification and using fuzzy logic etc. In places where landscapes, in particular urban land-uses are under change due to human activities and natural processes like erosion, using the geographical information system (GIS), remote sensing and data processing can be helpful in analyzing the changes and extent of them [1-14].

2. PROBLEM STATEMENT

The world we live in is changing all the time and it can be said that as result of such revolutions some phenomena are disappeared or replaced by new ones. We can see many of these changes if we take a glance at our surrounding. The cities are expanded, desertification and soil erosion is occurred, the forests are removed or expanded and the farms are converted to barren lands; in addition, flood and heavy rainfalls lead to destruction of farms, and the phenomena such as marine transgression and regression are other examples of such changes that are occurring permanently in the world around us.

3. RESEARCH IMPORTANCE

Today land-use change maps with high accuracy can become an essential tool to design and manage the landscape and thus such studies are required for different cities. In last four decades, land – use changes in Iran have occurred rapidly and sometimes in negative direction so that intensified the trend of land destruction. Since the land-use change is take place in large scale, therefore, the application of traditional methods in harvest and land measurement requires spending extra time and money;even in impassable places these methods are not applicable. Using satellite images are of crucial importance due to their critical features including vast field of view, cost effectiveness, using different parts of electromagnetic spectra to detect characteristics of phenomena, short recurrence period, possibility of automatic analysis, rapid analysis as well as possibility of regional monitoring (Jensen, 2005). Remote sensing data are characterized by repeated imagery in short intervals, extended land cover surface detected by sensors and spectral and spatial classification of data and thus are good instrument to assess the land cover changes. Today, the advance in remote sensing techniques and GIS has provided substantial opportunities to monitor and manage the rapid growth of cities [15-35].

4. RESEARCH OBJECTIVE

The goal of this research is to discover and express the urban land-use changes and urban expansion of Zanjan City during a 13-years interval.

5. BACKGROUND

5.1. Literature Review

Gong (1993) conducted a research to detect changes in part of Ontario, Canada, integrating principal component analysis and fuzzy procedures and expressed the change information from different image channels in a single-image channel.

Moreover, Kong et al (2004) in a paper called ‘Spatial-temporal gradient analysis of urban green spaces in Jinan, China’ created categorical maps of urban space using 1989 spot images, 1989 landsat image, 2004 spot images, topographic maps (1:10000) and census data, then applied spatial analysis techniques for quantification of urban green space pattern. Therefore, they proposed a new method to study patterns of spatial – temporal changes in urban green space by integrating remote sensing method, GIS, landscape parameters and gradient analysis.

In Iran, Kouhkan (2002) investigated change detection in urban lands of Mashhad during 1987-1998 using fuzzy theory method.

In another study, Jafari et al (2010) studied land-use changes in Kashan region during a 15-year interval and concluded that land cover/use changes resulted from human activities would be an important matter in regional and developmental planning.

Jalili et al (2013) in a paper called ‘change detection of land cover/use in Zagros forests using satellite images and GIS during 1989-2010; case study: Dehdez lands’ concluded that among the effective factors on land-use change of Dehdez forests, the distance from the village had the most important effect on change patterns [36-48].

Furthermore, Kolahashemi et al (2013) in a research called ‘change detection of land-use changes using maximum likelihood method and RS-GIS techniques’ studied the Babavali basin in Siahkal region during a 13-years period and obtained results of land-use classification in 2000 and 2013. The verification of results against land realities and field study indicatestotal validity of 0.89 and 0.88 as well as Kappa coefficient equal to 0.88 and -.87 in2000 ETM+ images and 2013 landsat 8 images, respectively.

6. Study Area

Zanjan city is located in east part of Zanjan province alongside the Tehran – Tabriz highway, above 1663 meters from sea surface. This city is located in 48°14′ - 48°44′ E and 36°34′ - 36°46′ N surrounded by altitudes in north, north-east, south and south-west. Tehran – Tabriz highway passing within Zanjan is south east – north westward along the Tehran – Tabriz railway. The development of this city is such that it has affected north parts of this region and by moving toward the north, northwest and northeast the height is increased so that it leads to altitudes in north and north east.

Overall it can be said that during the urban expansion, texture and urban vision of Zanjan has been influenced by topographic qualities particularly the altitudes in north and south of the city; in addition, urban location has been along Zanjan Rood River. Figure (1) presents the location of Zanjan city in Iran, province and county [49-65].

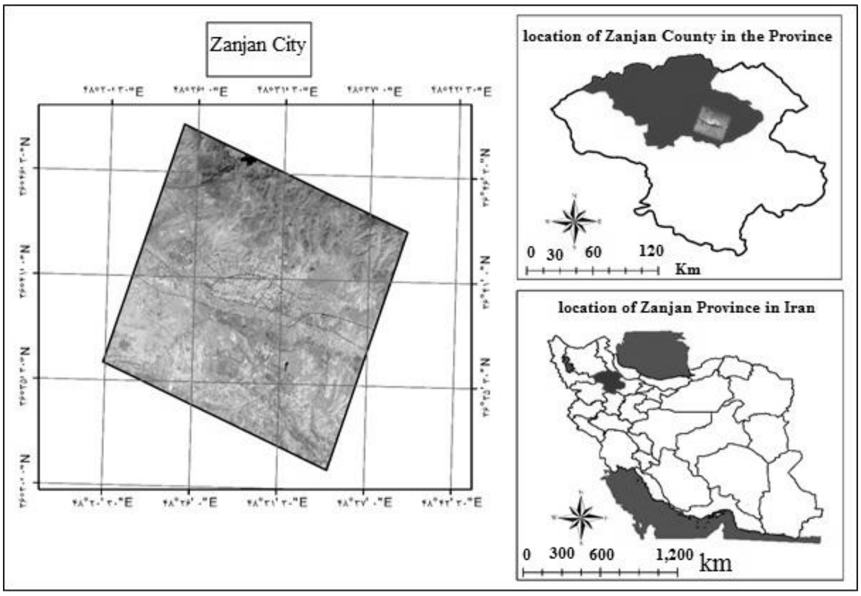

Figure1. *Geographical location of study area (Zanjan City)*

7. Material And Method

7.1. Characteristics of Satellite Image

7.2. Land sat Satellite

The first civil earth-observing satellite called Landsat 1 was launched in 1972. After that, four other satellites from Landsat series have launched gradually. Landsat satellites originally named 'Earth Resources Technology Satellite' or ERTS consist of four series sensors including MMS, RBV, TM, ETM+, TIRS and OLI each with unique features that are optical – mechanical sensors. The last series of these satellites called Landsat 8 was launched in 2013. The orbit of these satellites has been selected such that they cross the equator approximately at 10:00 a.m local time. They cover a 185-kilometer swath in each pass and image the earth every 16 days. The missions and sensors of these satellites are discussed below (Pirnazar & Zandkarimi, 2014:28). a summary of the information related to Landsat satellites is presented in table 1.

Table1. *The information related to Landsat series*

Satellite	Launch	Status/ mission termination	Sensors
1	1972	1978	MSS, HBV
2	1975	1982	MSS, HBV
3	1978	1983	MSS, HBV
4	1982	2001	MSS, TM
5	1984	2013	MSS, TM
6	1983	Failed to reach orbit	ETM
7	1999	Loss of operation	ETM+
8	2013	Operational	OLI, TIRS

The images provided by these satellites have various functions with respect to their coverage band and are available to download with no charge. Table 2 presents the information related to wavelength of bands and spatial resolution.

Table2. *The information related to wavelength and spatial resolution of Landsat bands*

Satellite	Sensor	Channel	Band	Wavelength	Spatial resolution (m)
Landsat 1, 2, 3	MSS	4 5 6 7 8	Green Red Near infra red Near infra red Thermal	0/50-0/60 0/60-0/70 0/70-0/80 0/80-1/10 10/4-12/5	79 79 79 79 240
Landsat 4,5	MSS	1 2 3 4	Green Red Near infra red Near infra red	0/50-0/60 0/60-0/70 0/70-0/80 0/80-1/10	82 82 82 82
Landsat 4, 5	TM	1 2 3 4 5	Blue Green Red Near infra red Shortwave infra red Thermal Shortwave infra red	0/45-0/515 0/525-0/605 0/63-0/69 075-0/90 1/55-1/75 10/4-12/5 2/09-2/35	30 30 30 30 30 120 30
Landsat 7	ETM+	1 2 3 4 5 6 7 8	Blue Green Red Near infra red Shortwave infra red Thermal Shortwave infra red Panchromatic	0/45-0/515 0/525-0/605 0/63-0/69 0/75-0/90 1/55-1/75 10/4-12/5 2/08-2/35 0/52-0/90	30 30 30 30 30 60 30 15

Landsat 8 was launched on February 11, 2013. It is the eighth satellite in the Landsatprogram; the seventh to reach orbit successfully. Originally called the Landsat Data Continuity Mission (LDCM), it is collaboration between NASA and the United States Geological Survey (USGS). Landsat 8 guarantees continuous capturing data and data availability through two sensors, i.e. Operational Land Imager (OLI) and Thermal Infra-Red Sensor (TIRS). These sensors collect imagery data for nine shortwave bands and two thermal wavelengths. It has a design life of 5 years, but carries sufficient fuel for 10 years of operations. The wavelength and spatial resolution of Lnadsat 8 is presented in table 3 [66-89].

Table3: *The information related to wavelength and spatial resolution of Landsat 8*

Satellite	Sensor	Channel	Band	Wavelength	Spatial resolution (m)
Landsat 8	OLI	1 2 3 4 5 6 7 8 9	Coastal / Aerosol Blue Green Red Near infra red Shortwave infra red Shortwave infra red Panchromatic Cirrus	0/43-0/45 0/45-0/51 0/53-0/59 0/64-0/67 0/85-0/88 1/57-1/65 2/11-2/29 0/50-0/68 1/36-1/38	30 30 30 30 30 30 30 15 30
	TIRS	10 11	Thermal Thermal	10/60-11/19 11/50-12/51	100 100

In this study, the following satellite data were used to create land cover and land use maps in given time periods. It's better to use the process of land-use changes in short term projects (5-10 years); therefore, keeping that in mind, the satellite images with 13-year intervals were analyzed to reach the research goals.

- Image of ETM+ sensor in Landsat 7, row 35, pass 166, date: 7/8/2002
- Image of OLI_TIRS sensor in Landsat 8, row 35, pass 166, date: 19/8/2015

7.3. Data Processing

When the images were uploaded in ENVI software and georeferenced individually, the visual data were ready to process. After conducting the required corrections, the study area was isolated from the images. Now it was time to detect changes of urban land-use through classification.

7.4. Geometric, Radiometric, Atmospheric Correction

Preprocessing includes radiometric, geometric and atmospheric corrections. Radiometric correction means calculation of spectral radiance value. To verify the image's geometric accuracy, band 1 was georeferenced to UTM coordinate system- dwg format- by using land-use map of Zanjan city (1:2000); for other bands, the geometric correction was performed in EVNI15.1 software for all images. Then, FLAASH atmospheric correction model was used to relieve atmospheric effects on Lndsat data.

7.5. Primary Detection of Land-Use Changes

The color image is created by combining 3 different bands and attributing three main colors- Red, Green, Blue (RGB)- to each band. Otherwise, the image is referred to false color composite (FCC) [90-102].

In FCC, the red is attributed to infrared band, the green to red band and the blue to green band. As result, the vegetation which has the maximum reflection in infrared band is seen in red, the water in blue and soil is seen in grey-brown color. The aim to choose the appropriate bands to create color images is minimization of trivial data and maximum use of crucial information (Pirnazar, Zandkarimi, 2017:113). Figure 2 presents Landsat 7 image of the region with color composite of 2,4,6 and figure 3 illustrates the Landsat 8 image of the same region with color composite of 3,5,7 [103-129].

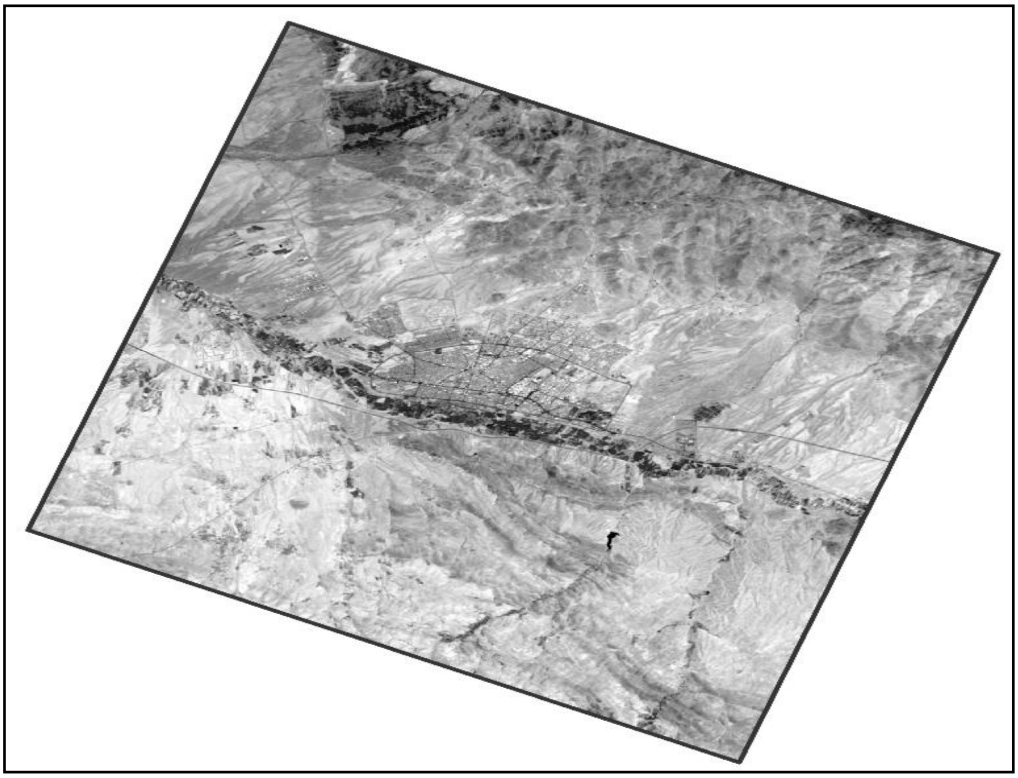

Figure2. *False color composite of Zanjan city in 2002*

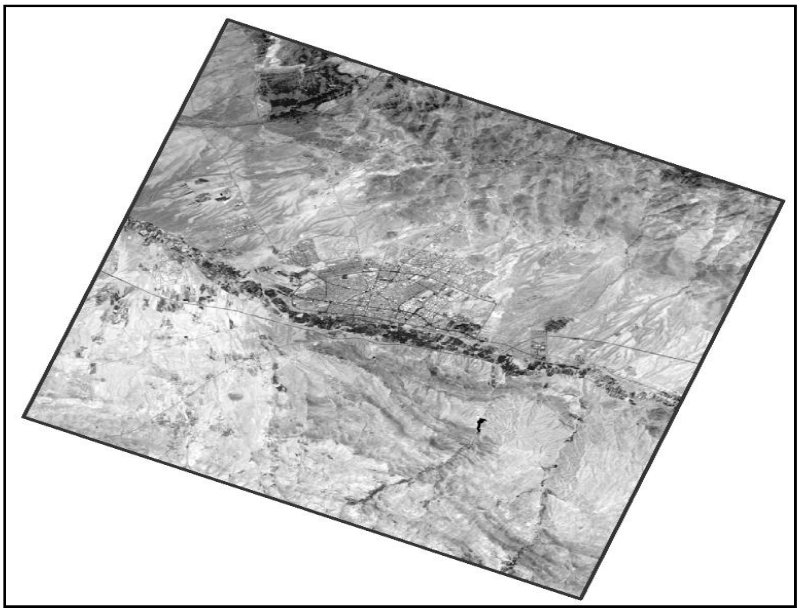

Figure3. *False color composite of Zanjan city in 2015*

8. CLASSIFICATION

Digital classification is relied on spectral differences of various phenomena on different spectral bands (Campbel 2002, Jensen 2005, Mather 2005). However, it doesn't mean that each phenomenon is perfectly divisible on every given band, and thus for this purpose the supervised classification method was chosen. Maximum likelihood algorithm is widely used classification method in most of studies [130-143].

8.1. Data Collection

When choosing sampling method, it should be taken into account that only pixels to be selected that are member of a specific class. In addition, the selected pixels should be a comprehensive sample of all pixels belonged to a certain class. It means that the statistical and non-statistical parameters calculated from the sample pixels must be so precise that they could be considered as a relatively accurate estimation of parameters belonging to all pixels in that class. The reference of sampling data should be reliable and compatible with the images were already used. After selecting the training samples, image of Zanjan area was classified to four classes, including:

1. Residential area
2. Road network
3. Vegetation
4. Other regions

Results of image classification and assessment having performed classification, the accuracy of classification was calculated based on reference training regions in ENVI 5.1 software. Table 4 presents overall accuracy and Kappa coefficient for all images.

Table4. *Overall accuracy and Kappa coefficient for classified images by maximum likelihood method*

Kapa Coefficient	Overall Accuracy	Imagery time
0/88	90/25	2002/08/07
0/90	92/05	2015/08/19

Overall accuracy reflects overall agreement between two maps throughout the region under a single classification. Normally, the acceptable standard for confidence interval is set to 85 percent of the class (Avery, Berlin 1985). In this study the overall accuracy of classification was above standard level. Kappa coefficient for agreement between two maps was obtained 2. Kappa was used as a given criteria for difference between the maps (reported as overall accuracy) and the likely agreement resulted from the random compatibility between two maps. This index defines a standard for random adaptive assessment [144-159].

9. CHANGE DETECTION

Change detection operation was performed after image classification and results verification analysis. Change detection is a method used to compare two classified images, in order to make clear that how land-uses are transformed during the interval between two imageries (Shahabi et al, 2009:197). Figure 4 illustrates the change detection of Zanjan land-use using maximum likelihood classifier method.

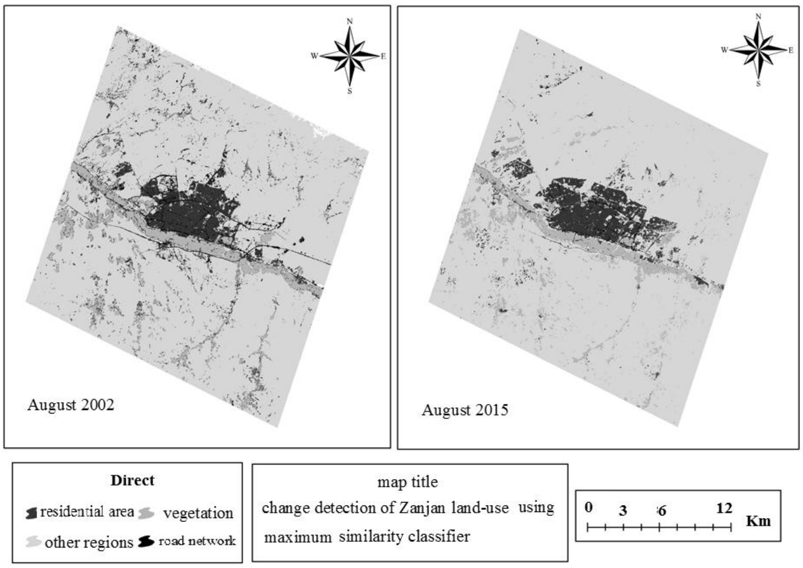

Figure4. *Change detection of Zanjan land-use using maximum likelihood classifier method*

9.1. Conclusion

Immigration and rapid expansion of cities in one hand, and unprecedented destruction of agricultural lands, forests, pastures, etc and their conversion to residential areas on the other hand, are some problems which are seen in different parts of the world. In our country, moreover, severity of these changes is tangible. The analysis of maps and results suggested that the most changes in our study area had been resulted from human activities and conversion of agricultural lands to residential areas. Table 5 presents percent of changes obtained by maximum likelihood classifier method. Figure 5 illustrates land-use changes and expansion of Zanjan City too [160-165].

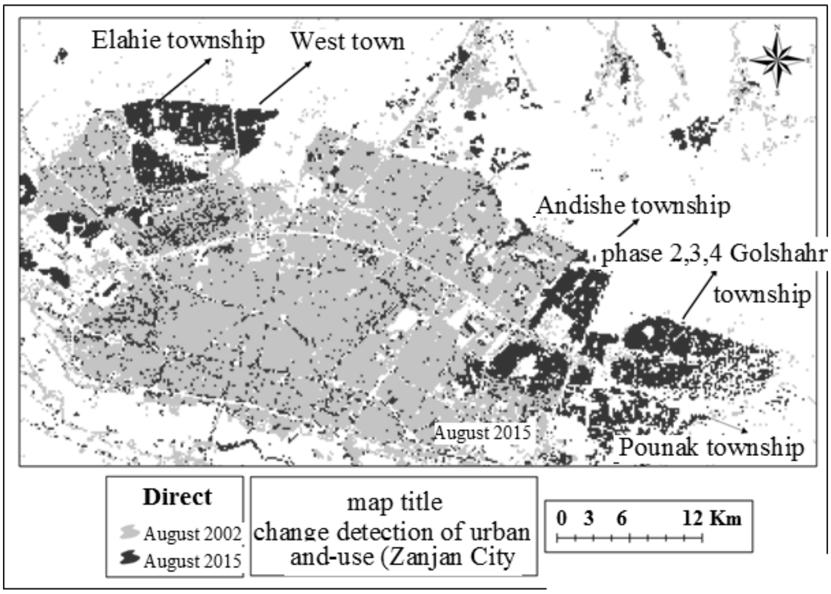

Figure5. *Land-use changes and urban expansion of Zanjan city*

Table5. *Changes obtained from minimum distance classification in terms of percent*

Land-use	Residential areas	Road network	Vegetation	Other regions	Sum of class
Residential areas	56/951	39/678	8/29	48/394	100

Road network	9/828	45/434	0/465	0/917	100
Vegetation	3/569	3/818	64/07	1/263	100
Other regions	29/652	11/071	27/175	49/426	100
Sum of class	100	100	100	100	-
Changes of class	43/049	54/566	35/93	50/574	-

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