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The Use and Application of GIS and Remote Sensing Techniques for Monitoring Urban Growth in Koya City, Iraq-Kurdistan Region

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Abstract

Nowadays, rapid urban growth and urbanization is continuing to be one of the most important problems of global change, especially in developing countries. This process is most visible and powerful and has a key role in urban land-use and land-cover changes and landscape pattern changes around the world. Remote sensing and geographic information system are a reliable source to understand and quantify urban expansion. This study uses Landsat 5 TM imagery associated with GIS techniques to monitor urban growth in Koya city in the North Iraqi Kurdistan region between 1990, 2000, and 2010. The ERDAS 9.2 imagine software was applied to measure and display land use classes changing utilizing supervised classification of maximum likelihood. The outcomes demonstrate that the land-cover classes faced great changes between 1990 and 2010. For instance, the built-up area increased dramatically from 279.9 hectares in 1990 to 992.79 hectares in 2010; whereas the rate of vegetation cover decreased dramatically from 2,199.87 hectares to 576.09 hectares in 2010. This was due to environmental change and socio-economic and political factors. Total accuracy assessments of all images show that the image classification process was very accurate, with overall accuracy greater than 95%.

Keywords: urbanization, remote sensing, geographic information system, land-use changes, land-cover changes, Iraqi Kurdistan region.

1 Introduction

In recent times, it can be seen that urbanization has been one of the universal phenomena in both cases of economic and social change which are taking place around the globe. This process has developed quickly due to the anthropogenic force which has a negative effect on the land cover and land use changes around the world. Rapid urban growth and urbanization, particularly in the developing countries, could be defined as one of the fundamental problems of global change in the last few decades which affects the physical dimensions of cities. Gao and O'Neill [1] argue that understanding the spatial pattern of land use and urban growth change is of specific significant in the study of urban geography.

One of the common issues in urban expansion is population growth and migration from rural to urban areas [2]. In the 21th century the globe has faced a dramatic expansion in urbanization and urban growth in many countries around the world. According to the World Bank and the development research council of the State Council in China [3] the rate of population who lived in urban areas is more than 50% and this rate will be rise to 60% by 2030. Almost all of this growth is occurring in developing countries. Cai and Vernon [4] estimated that each year nearly 66 million people migrate to urban areas. Secondly, socio-economic factors have contributed greatly urban growth and land use changes in urbanization. In many countries, urbanization is known is a significant phenomenon which mainly influences social change and economic growth, as it offers increased opportunities for specialization, employment, services, production and goods [5].

On the other hand, remote sensing and GIS include two crucial techniques which can be used for monitoring urban expansion and land use change. Spatially consistent data sets over large areas are covered by both high temporal frequency and high spatial detail provided by remote sensing [6]. Also, satellite remote sensing tools have been widely utilized in supervising and detecting land use change at different scales, with convenient outcomes [7]. In the last few decades, remote sensing has been utilized in combination with the Global Positioning System and GIS to evaluate land use change more effectively than using only the remote sensing data [8].

This study is mainly dependent on remote sensing satellite data for answering this question related to the land use and land cover change in Koya city in the north of Iraq. This technique, associated with GIS tools, has a key role in monitoring and indicating urban growth pattern from 1990, 2000 and 2010.

2 Materials and Methods

The study area is Koya city which is situated in the northeastern part of Iraqi Kurdistan. It is strategically located in the middle of Kurdistan, and it connects three big cities of Sulaymaniyah, Kirkuk and Erbil [9]. The geographical location of Koya city is between latitude 36.18° and 35.47° North and longitude 44.57°and 44.15° East of Kurdistan region. The average annual rainfall in Koya city ranges between 154 to 216 mm annually, with about 150 mm in the Western part, over 1000 mm in the mountainous areas in the North, and about 200mm in the Eastern part of the region.

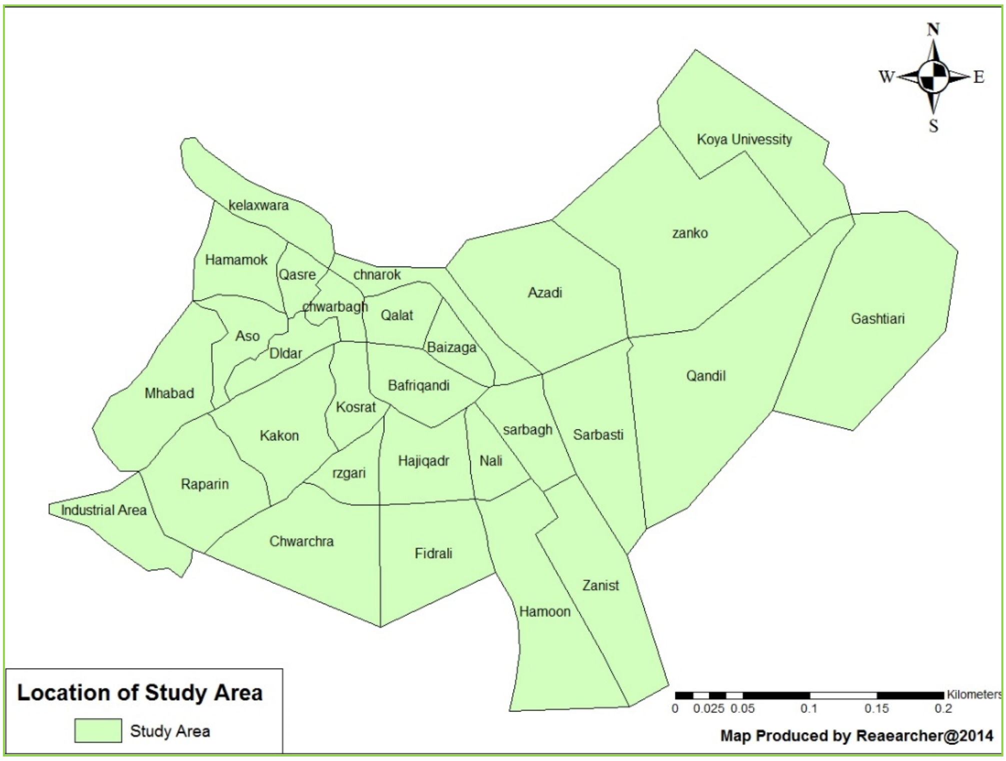

Figure 1: Location of Location of the Study Area, Koya City.

2.1 Data Selection

- Landsat data used was already geometrically corrected.
- Satellite images with cloud cover of less than 5% was acquired.
- Multi spectral Landsat imagery was acquired for better image analysis.
- The time period in terms of year and same season were close for acquired images.

2.2 Landsat Data

This study uses three different Landsat 5 TM satellite images for three different time periods. All three images were obtained from the website of the United States geological survey (USGS) at http://glovis.usgs.gov/. The first image was taken in July 1990, and the second image was taken in July 2000, and the third one in September 2010. Table 1 shows Technical Details of Landsat Images used in this study.

Satellite	Landsat TM 5	Landsat TM 5	Landsat TM 5
Date of image	1990/07/10	2000/07/29	2010/09/14
Time	07:18:43 AM	07:25:21 AM	07:20:50 AM
Spatial resolution	30m	30m	30m
Row	35	35	35
Path	169	169	169
Projection	UTM Zone 38	UTM Zone 38	UTM Zone 38
Source	USGS	USGS	USGS
Band	7	7	7

Table 1: Technical Details of Landsat Image Acquired for this Study.

2.3 Data Processing

The ERDAS imagine 9.2 and the Arc map 10.0 was used for the image processing and analysis in this study. The series of sequential operations undertaken in the image processing is shown in Figure 2.

Figure 2 demonstrates the method utilized to perform the analysis, with three Landsat satellite image processes by using supervised classification in the study area.

2.4 Layer Stacking

Layer stacking is the procedure of combining in layers the different bands necessary for any study into a single output file[10]. The seven different bands of each Landsat 5 TM image acquired were stacked by using ERDAS Imagine. This process was applied to the Landsat image 1990, 2000 and 2010, and Figure 3 illustrates the outcome of the layer stacking image merge in the study area.

2.5 Subset of Imagery

A spatial subset of the entire Landsat scene was performed by selecting the portions of the image that correspond to the study area. Many remote sensing images include a very large size, and ERDAS image subset tools were used to select the specific area of case study, Koya. The study area is located between Longitudes (44 35 35.36 E) and Latitudes (36 06 13.09N), with a total area of nearly 3366.9 hectares (Figure 4).

2.6 Geometric correction

The main objective behind the applying of geometric correction is to confirm the accuracy of Landsat satellite images in the study area.

2.7 Radiometric correction

Radiometric correction is applied to the raw digital image data to correct for brightness values of the object on the ground that may have been distorted because of sensor calibration or sensor malfunction issues Due to the distortion from the collection of Landsat images at various times, a normalization of the images would be required. For this reason, a radiometric correction utilizing the histogram matching process was executed on the three sets of Landsat images acquired, utilizing ERDAS Imagine 9.2.

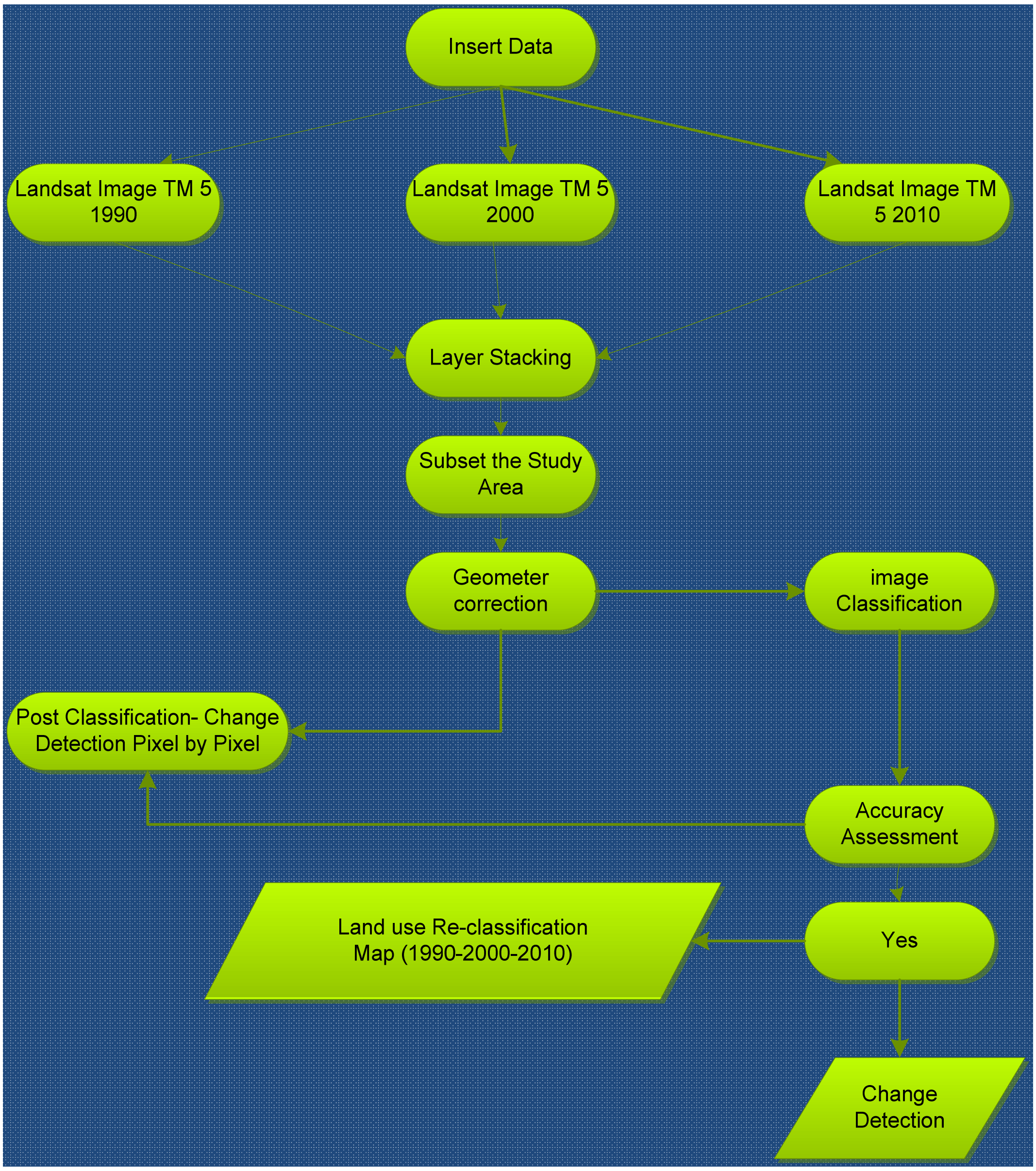

Figure 2: Schematic Diagram Showing Research Methodology.

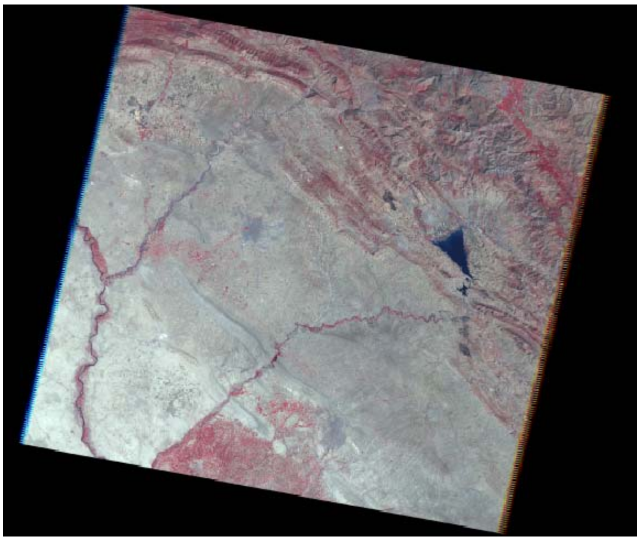

Figure 3: Layer Stacking Process for Landsat TM 5 Images

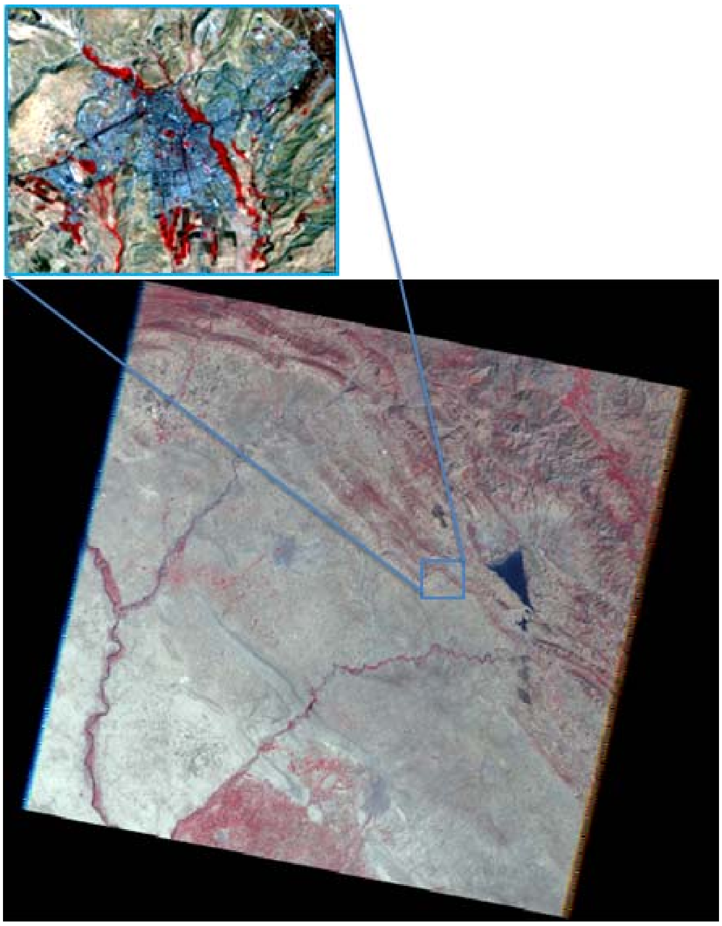

Figure 4: Subset and Clipped Area of the Study for Year 2010,

2.8 Supervised Classification

In this study the supervised maximum likelihood classification technique was used to classify the three Landsat images (1990, 2000 and 2010), as this technique is one of the most commonly utilized algorithms and is a strong classification method in the collection of accurate training data. Applying this classification, the land cover is classified into four classes: Vegetation cover, Urban Build-up, Open land and Barren area. Vegetation cover includes grass land, forest, parks and agriculture. Urban Build-up consists of all buildings such as residential, Industrial, and Urban service and commercial, transportation and roads, mixed urban and other urban. Open land areas are those which do not contain any kind of vegetation or urban areas. Barren land area is the area which has limited capability for urban build-up or vegetation.

3 Results and discussion

3.1 Supervised Classification

The supervised classification method was utilized to classify the land cover class and to detect the changes between various land cover classes in this period. The findings in Table 2 demonstrated that the greatest amounts of land was covered with vegetation in 1990, with 2,199.87 hectares (56% of the land); however, this value decreased to 404.01 hectares (12% of the land) in 2000, and by 2010 this decline had been reversed, with vegetation areas measured at 576.09 hectares (17% of the total land). During the study it was observed that a great change in the proportion of vegetation classes occurred between the year 1990 to 2000. The data presented shows evidence of these significant changes areas the decade. There are several factors that might have had a significant influence on these changes; firstly, climate changes, as the city of Koya faced some drought seasons, especially in the years 1998, 1999 and 2000.

class	Area hectares 1990	Area hectares 2000	Area hectares 2010	Coverage % 1990	Coverage % 2000	Coverage % 2010
Vegetation	2,199.87	404.01	576.09	65	12	17
Built Up	279.9	348.21	992.79	8	10	29
Barren Land	250.74	92.79	49.05	8	3	2
Open Land	636.39	2,521.8	1,748.97	19	75	52
Total	3,366.9	3,366.9	3,366.9	100	100	100

Table 2: Land Cover Changes in 1990, 2000 and 2010 in Koya.

3.2 Post-classification Change Detection

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The study implements post classification techniques in order to monitor change in the land use classes. A considerable amount of vegetation area was transformed to open land as shown in Figure 5. vegetation cover was 2,199.87 hectares in 1990 and decreased to 576.09 hectares in 2010 which shows a decline of 1,623.78 hectares, and 1,250.28 hectares of vegetation area was transformed to open land from 1990 to 2010, whereas 469,62 hectares were changed to built-up by 2010. Although, 8.73 hectares of bareen land were converted to vegetation area by 2010 while the vegetation cover was only (576.09) hectares in 2010. This was due to a lacking of vegetation cover around the city and transferred to other classes. 279.9 hectares of built-up area in 1990 were altered to 992.79 hectares in 2010, which means that the built-up area increased by 712.89 hectares from 1990 to 2010. However, 63.03 hectares of built-up land were converted to open land, 11.07 hectares changed to vegetation area and 4.95 hectares transformed to barren land. At the same time, open land area were increased dramatically from 636.39 hectares in 1990 to 1,748.97 hectares in 2000, and rose to 1,112.58 hectares by 2010.

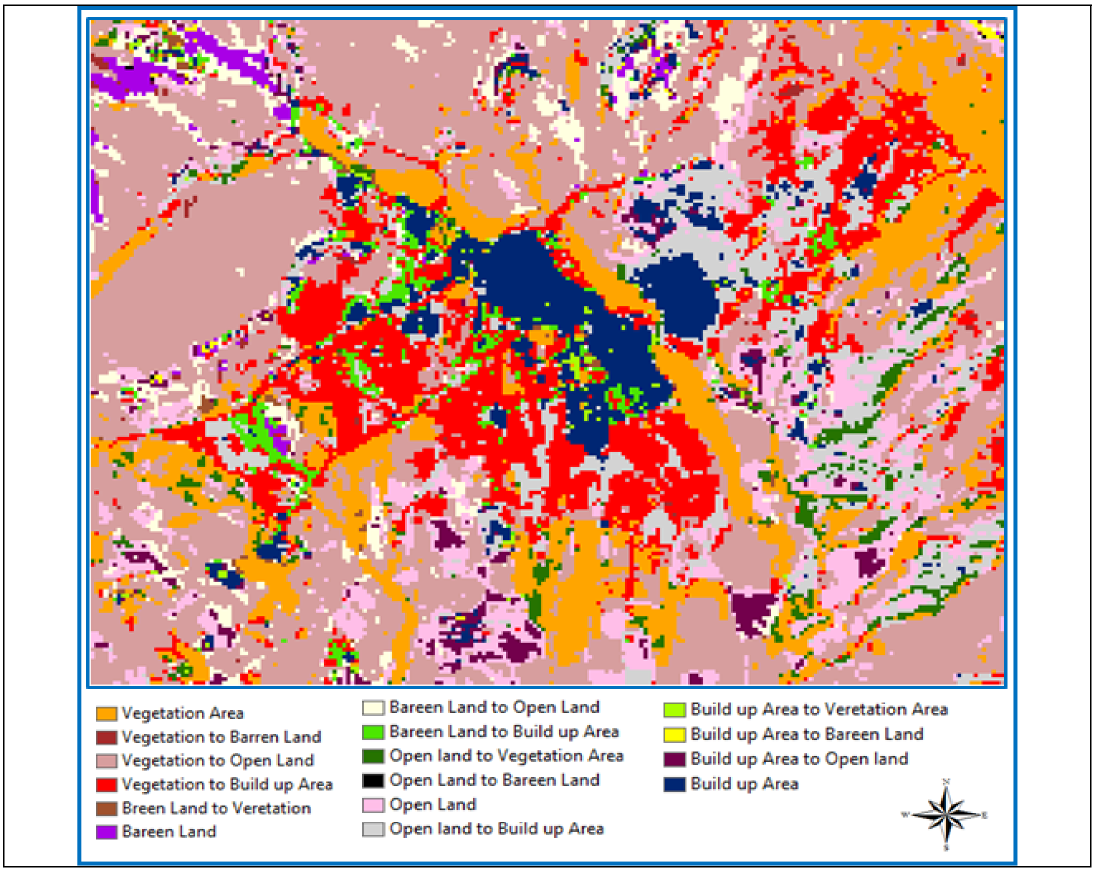

Figure 5: Demonstrates Urban Expansion via Overlay Classification in 1990, 2000 and 2010.

3.3 Accuracy Assessment Classification

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The study applied accuracy assessment to gain superb classification with the lowest stage of inaccuracy in the satellite image classification. The total accuracy outcomes were gained by dividing the total number of pixels in the matrix by the sum of classified pixels (120). Also, the Kappa statistics were used to show an error matrix since the Kappa coefficient rate reflects the variations between the actual agreement and the agreement predictable by chance. The Kappa statistical rate extends between 0 and 1.1, signifying a complete match between the two groups of data, whereas 0 value demonstrates an agreement as coincidence, or the outcome of chance. The total Kappa value in the research was 0.9295 in 1990, 0.8965 in 2000 and 0.9138 in 2010, meaning that there is almost complete agreement between the groups of data. The overall accuracy in this study, which was 96.67 % in 1990, 95 % in 2000 and 96 % in 2010.

4 Conclusions and Contributions

It is clear that social research is a major part of research in urban growth. This research is based on society and some important techniques to represent the new guidance for land use and land cover changes from 1990 to 2010, and it shows the impact on future urban growth in the case study. The general result of the case study research demonstrates that using remote sensing data from Landsat satellite imagery 5 TM to supervise classification maximum likelihood played a key role in representing the rate of land cover changes during the period of the study. The results proved that a great amount of vegetation area was transferred to open land from 1990 to 2010, which was 1,250.28 hectares, while 469.62 hectares were altered to built-up area by 2010. This is because of the environmental change that was happened in the study area after 1997.

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