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URBAN CHANGE DETECTION OF LAHORE (PAKISTAN) USING A TIME SERIES OF SATELLITE IMAGES SINCE 1972

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ABSTRACT

The present study is an effort to explore and detect the urban land use change of Lahore since 1972. The urban area of Lahore has seen tremendous growth during the last three decades. In present study a spatial modeler has been developed with the help of Erdas Imagine to detect the urban land use change in Lahore. Satellite images of different time periods of Lahore has been utilized and classified for present research. The results revealed that the urban area of Lahore has increased 68% during 1972-2009.

Keywords: Change detection, remote sensing, land use

INTRODUCTION

Urbanization is a process of conversion of rural settlements/small towns to urban settlements in the form of expansion of settlement and population increase in the settlement. Now-a- days a large number of factors influence the urbanization such as industrialization, natural population increase, education and health facilities, business, services and government planning. Lahore has been a historical urban settlement. The old walled city has expanded tremendously. At the time of independence in 1947 in spite of one of the major urban centers it was a very small urban centre as compare to urban centers in the developed countries such as London, Paris and New York. The first population census of Pakistan was carried out in 1951 and subsequently in 1961, 1972, 1981 and 1998. The growth of Lahore has been very steady since 1951 to 1981 but it has expanded enormously without any limits since 1980s. The expansion of urban development has forced the government to declare the whole Lahore district as Lahore city district in 2002 (GOP, 2002).

Different techniques and models were established to study urban land use in the past. These models also include the three classical models of urban land use i e (i) Concentric Zone Model; (ii) Sector Model, and (iii) Multiple Nuclei. But the advent of Geographic Information System (GIS) and Remote Sensing has changed entirely the ways and methods to study urban land use of any area. The combination of remote sensing and GIS is considered as one of the most powerful tools in analyzing and detecting the urban land use land cover change and urban sprawl (Ehlers et al. 1990; Treitz et al. 1992; Harris and Ventura 1995). Urban land use and urban sprawl management and monitoring are dependent upon reliable sources of data. Traditional methods of field surveying and mapping of urban areas require a large span of time. GIS and remote sensing, due to their technical soundness, are being widely used for urban applications (Jensen and Cowen, 1999; Mesev, 1998; Lo and Yang, 2002; Yang and Lo, 2003). Lahore's urban reality reveals a number of facts which make it a city of various functions, attitudes and values. The physical, social and economic entity of the city is maintained by a functionally developed urban system which makes it prominent among the other urban centers of the country. In this study GIS and remote sensing are applied to evaluate urban explosion in Lahore.

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STUDY AREA

Lahore District lies on the left bank of river Ravi. It lies between 74˚1′1″E to 74˚38′10″E longitude and from 31˚15′ to 31˚44′2″ N latitude. It is the 2nd largest city of Pakistan after Karachi both in terms of population and urban hierarchy. The total area of Lahore is 1772 square km (177200 hectares). Total population of Lahore was 6.319 million in 1998 with a population density of 3,566 persons per square kilometer. The urban population of Lahore increased steadily since independence in 1947. The urban population of Lahore has increased from 0.859 million in 1951 to 5.20 million in 1998. The urban population of Lahore has increased 6 times since 1951. The current estimates project that the urban population of Lahore has reached almost 9 million inhabitants. The Lahore district is bounded by India in the East, Sheikhupura district on the north and west, Kasur district on the south. River Ravi flows in the north of Lahore district (GOP, 2000; Riaz, 2011).

METHODOLOGY

Research methodology is a systematic procedure for collection, analysis and presentation of data. The present study involves a time series of satellite images acquired from USGS website. After the acquisition of satellite images, these images were geometrically corrected and rectified to a common projection. Than the following change detection method was adopted to get required results.

Urban Change Detection

Different procedures were adopted to detect change in urban spatial pattern of Lahore. The spatial distribution of urban classes was extracted from each map. The spatial pattern of urban sprawl was identified. The spatial modeler in Erdas Imagine software is used to examine the land use change from 1972 to 2009 (figure 1). The spatial modeler function allows creating a graphical model. In this study, a change detection model is created using following equation:

($n1_lhr_1972 - $n2_lhr_2009+128)

Where

$n1_lhr_1972 = image of 1972

$n2_lhr_2009= image of 2009

128= constant

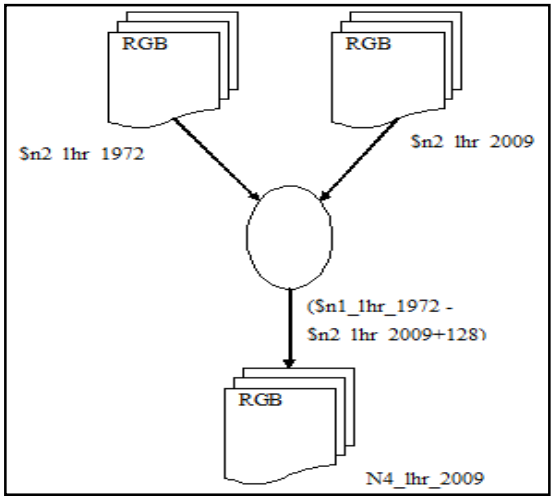

Figure 1. Spatial Model for Urban Change Detection

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However, the above mentioned model is more suitable for visual change detection. In this model, images before classification present better results than that of classified images. So the other method to detect urban land use change was also adopted. The post classified images are used as input through ErdasImagine's change detection command. Resultantly, the output image provided the information regarding the change occurred during 1972-2009. The same method is repeated for all satellite images and the resultant change maps provided the information regarding change in urban land use. This change detection method proved an efficient and accurate tool for urban land use change

RESULTS AND DISCUSSION

The present study focused on the use of remote sensing and GIS techniques in analyzing the urban land use pattern of Lahore. The use of these techniques has substantiated a comprehensive assessment and analysis of recent urban trends of Lahore. This study demonstrated the importance of digital image processing and GIS in producing accurate land use maps of Lahore over past 40 years. Urban land use change of Lahore was detected by the meticulous study of maps produced with the help of ErdasImagin and GIS software. The availability of satellite images during the period of 1972 to 2009 made possible to use the time series of Landsat MSS and TM images with an interval of ten years.

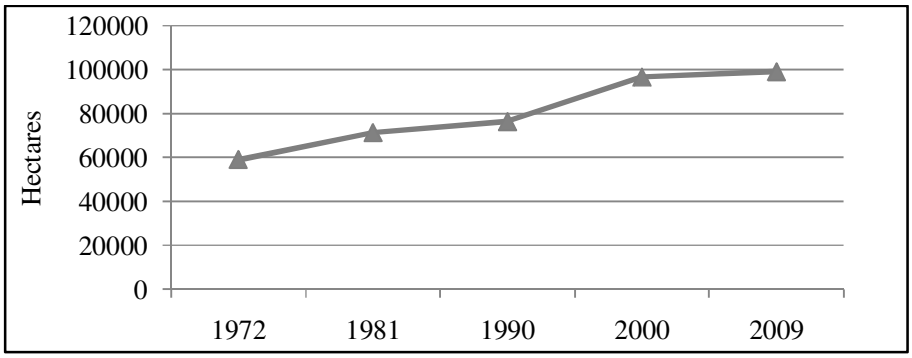

Figure 2. Urban Land Use of Lahore since 1972
Source: Riaz, 2011

Table 1. Urban Land use change for different time periods

Periods		*Urban*
1972-1981	Hectares	12384
	%	21
1981-1990	Hectares	5044
	%	7.07
1990-2000	Hectares	20291
	%	26.56
2000-2009	Hectares	2476
	%	2.56
1972-2009	Hectares	40196
	%	68.16

Source: Calculated from satellite images through Erdas Imagine

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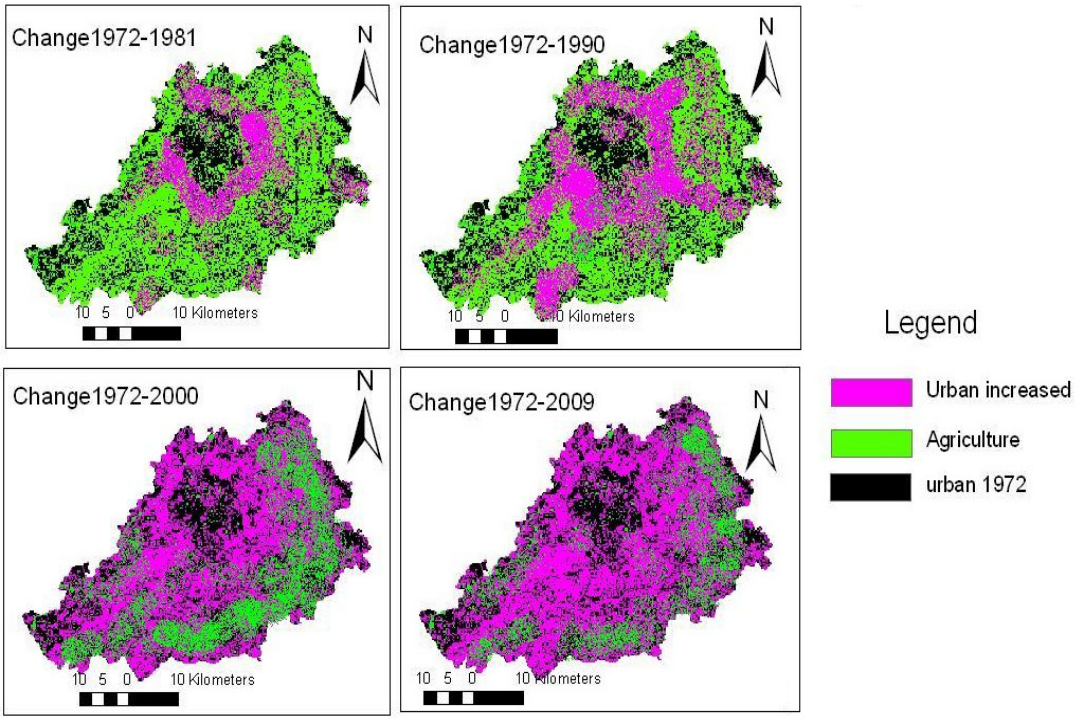

Figure 3. Urban land use change of Lahore since 1972

Lahore has seen tremendous urban growth since 1972. The urban land use of Lahore was 58977 hectares in 1972 which increased to 99173 hectares in 2009 (figure 2). Thus recording an increase of 40196 hectares in urban area during the time period of 1972-2009. There was 68% increase in urban area was recorded (table 1). Figure 3 presents the comparative study of urban change detection maps during the time period. In this figure maps were produced with the help of Spatial Model Developer to detect the urban change of the study area. This model was developed by the author with the help of Erdas software. The pink colour in these figures represents the overall urban expansion taken place since 1972. The green colour represents no change in agricultural land use while black colour reveals the unchanged urban area. Figure 3 presents the time series of comparative maps of urban change from 1972 to 2009. This is evident from these maps that Lahore's urban area has extended tremendously during last four decades. It is found that all the loss in agricultural land use is converted into urban use.

CONCLUSION

The current study proved its usefulness in the present scenario of rising trends of urban population in Lahore. This study has multifaceted implications. It can be useful not only at theoretical level but also at technological level. The importance of remote sensing, satellite image processing, and a GIS technique in urban land use studies is highlighting the technological facet of the study while at theoretical level this research demonstrated the evolution and growth of population and urban land use in Lahore. It is providing us a scholarly body of knowledge on the issue of urbanization which can be useful for both students and researchers. This study investigated the physical expansion of urban spatial structure of Lahore which is another addition in the theoretical framework of urbanization. The present study also proved the application of remote sensing and GIS in urban studies. The current research revealed the facts regarding urban expansion and population growth of Lahore which is also a type of contribution in the urban problem solving.

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The analysis is showing that on average more than 1200 hectares of agricultural and forest land is converted into urban area every year and this practice is repeating itself since 1972. The study revealed that dramatic urban expansion occurred during 1981-1998.

The main focus of the present study was to detect urban land use change of Lahore. The results and analysis of the present study is calling for making a joint strategy for the spatial arrangement of these urbanites. It is necessary to further research on different land use/land cover patterns of Lahore. It is suggested that separate study should be undertaken to analyze the loss in area under natural vegetation and agricultural. Other studies can also be conducted on the role of urban expansion in decreasing agricultural land use. This study can also be helpful in detecting various problems related to urban environment. It is strongly recommended for the urban scholars that the same types of studies must be revised after nominal time intervals so that the settings of urban spatial patterns may be revealed timely and future planning may be managed in a better way.

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