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REMOTE SENSING AND GIS APPLICATION IN WETLAND CHANGE ANALYSIS: CASE STUDY OF KALLAR KAHAR

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Abstract

Wetlands are the one of the naturally occurring habitat. They provide invaluable biodiversity resources, aids in water quality improvement, support ground water recharge, help in moderating climate change and supply flood control but they are deteriorated greatly due to economic development and population growth. In the present analysis, the object-based approach of 'ENVI' is presented to derive the change detection inventory information for Kallar Kahar Wetland using Quick bird imagery and Corona imagery. According to the results, agricultural and shrub area has reduced by 43% and 49% respectively whereas there has been an increase in the water-body, uncultivated/soiled area, orchard and built-up area by 40%, 53%, 79% and 38%, respectively. In order to analyse the change detection of Wetlands using very high resolution satellite images, the outcome of the analyses is presented which can help in decision making for the purpose of land development and further assess the implications of the observed changes in the area for making appropriate recommendations.

Keywords: Wetland, Land use/Land cover changes, Satellite images, Object-based analysis, Kallar Kahar Lake, Pakistan.

Introduction

Wetlands are essential ecological features in any landscape. In their natural condition, wetlands supply numerous economical, ecological and cultural benefits to local communities, including water quality protection, flood and erosion control, fish and wildlife habitat, aquatic productivity and unique opportunities for education and recreation (Rai, 2008; Liu et al., 2010; Olhan et al., 2010; Munyat, 2011). Wetlands cover approximately 9.7% of the total area (803,941 km^2) of Pakistan. The country has a great variety of Wetlands, both man-made and natural. However, these Wetlands are now suffering because of ineffective management, urbanisation, poverty and lack of awareness (Rao, 2009).

Recent developments in geographical information system (GIS) and Remote Sensing Technologies (RST) are providing valuable tools to assist with monitoring, inventory and management of wetlands. Many studies were undertaken regarding change detection in wetlands by using GIS/Remote sensing technologies across the world (Jensen et al., 1995; Ndzeidze, 2001; Yang and Lo, 2002; Marcelo et al., 2003; Kiage et al, 2007; Ma et al., 2007; Ndirima, 2007; Yaw and Edmund, 2007; Hui et al., 2008; Zhao et al., 2010). In this research, the attempt is made to document the land use/land cover change detection of Kallar Kahar Wetland of Pakistan which required a more sophisticating and prevailing system such as remote sensing and GIS using a very high resolution satellite image to assess the implication of changes observed in the area.

The aim of this research study was to identify, analyse and visualise with the quantification of land cover/land use changes in the lake of Kallar Kahar since 1972 to 2008 by using the techniques of object-based images.

Study Area

The study area, landscape matrix for the Kallar Kahar Lake, is situated in a famous valley in the southern hilly area of Potohar Plateau in the Salt Range in northern part of Punjab, Pakistan (Rais et al., 2010). Kallar Kahar lake, a small, brackish lake (Chaudhry et al., 2009), is located at 32° 46N, 72° 42E in the eastern part of Kallar Kahar city, which has an area of 220 hectares. Kallar Kahar is at an altitude of about 1500ft

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from sea level. It can be approached from Islamabad by Motorway at a distance of about 100km to the south and from Chakwal (Fig. 1). The lake is not deep, so a lot of natural vegetation can be seen all around it and even in the middle. It is a natural breeding sanctuary for many birds. The area adjacent to Kallar Kahar has different habitat types, having different ecological conditions including wetlands, mountains, human habitation and front gardens (Iqbal et al., 2006).

Fig. 1. Map of study area

Methodology

Methodology included land cover mapping using object-based image analysis which was followed by image enhancement, post-classification processing (recoding) and accuracy assessment for change detection.

Data Acquisition

Two type of data have been utilised in the study undertaken i.e., ancillary and remote sensing data. An extensive field survey was performed throughout Kallar Kahar using Global Positioning System (GPS) equipment. Ground truth data was acquired to construct rules for classification and accuracy assessment.

Remote sensing data consist of satellite images which were under consideration, including multi-spectral Quick bird and panchromatic Corona Satellite images (Figure 2 and Figure 3). Both the geo-referenced satellite images were acquired in month of June for the years of 1972 and 2008 and procured from WWF Islamabad and WWF Lahore (Table 1 and Table 2).

Arc GIS 9.2 was used for map formation, reprojection and overlying field data while ENVI was used for object-based image analysis and accuracy assessment.

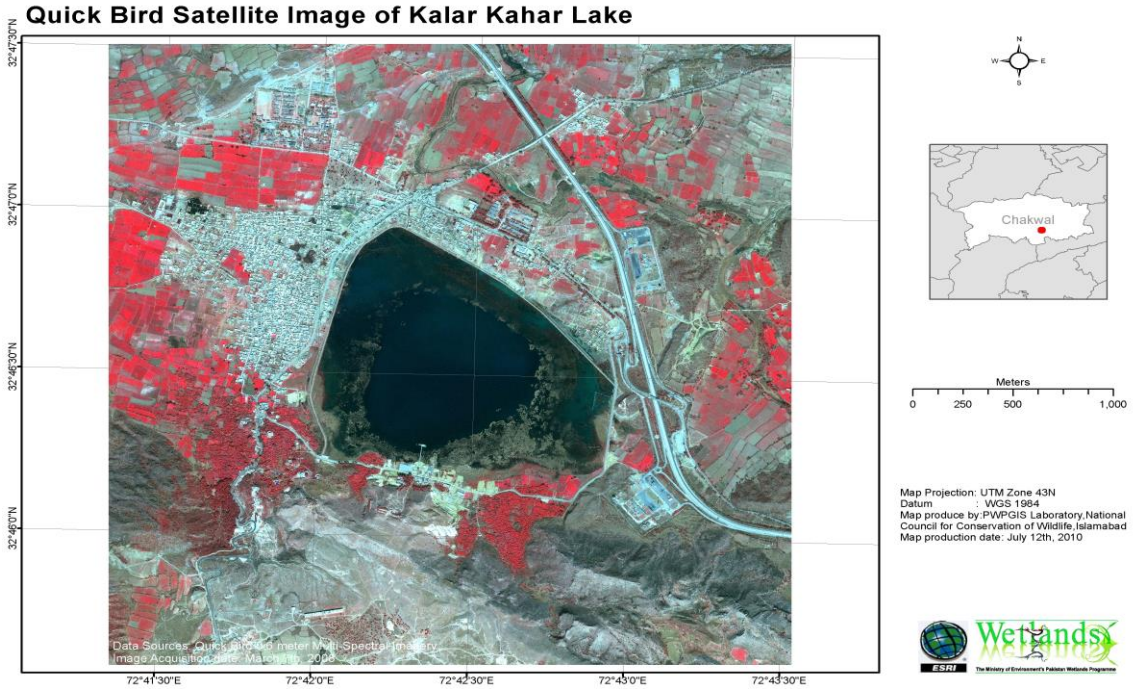

Fig. 2. Quick bird satellite image of Kallar Kahar Lake

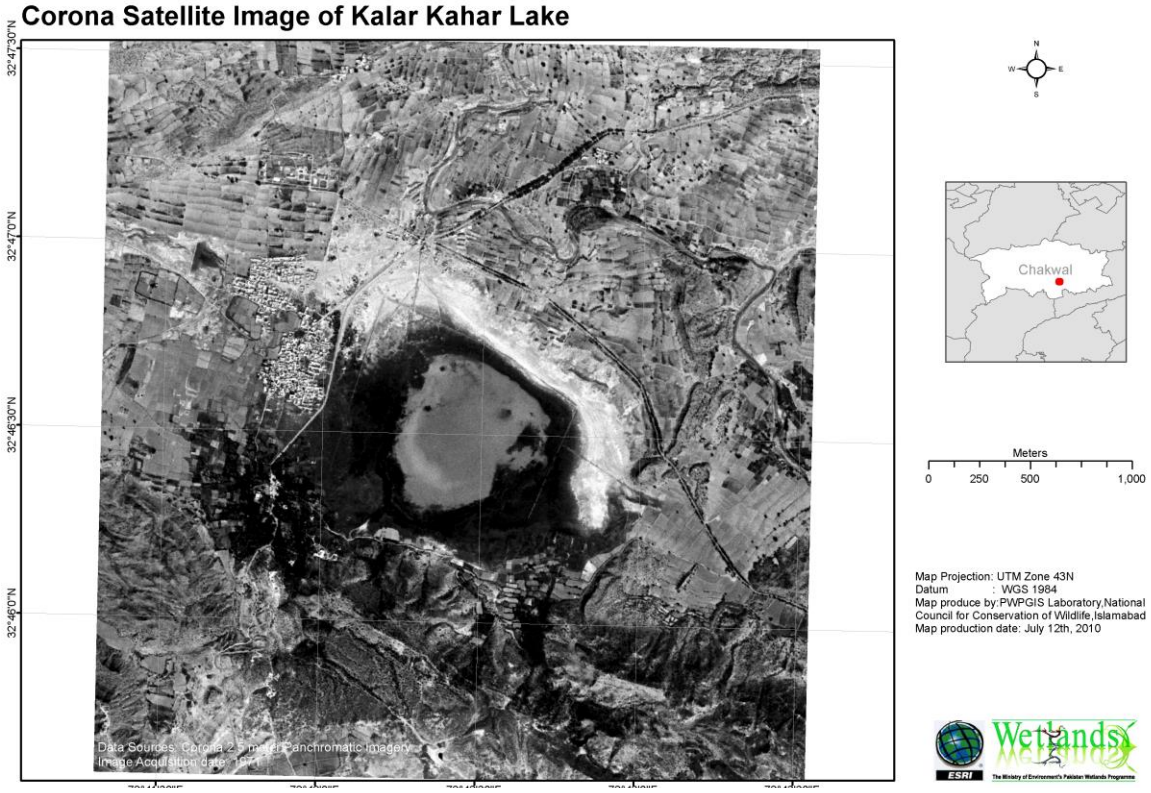

Fig. 3. Corona satellite image of Kallar Kahar Lake

Table 1. Corona Satellite data Specifications (Digital Globe)

Scene 1		
Satellite/sensor	Corona	
Data set	Panchromatic	
Spatial resolution	2.5m	
Radiometric resolution	11 bit (2048 intensity level)	
Spectral resolution/bands	Panchromatic (single band)	
Image acquisition	1971	
	Latitude	Longitude
Extent of data set	3246’0’’N	7241’30’’E
	3247’30’’N	7243’30’’
Orbital altitude	172km	

Table 2. Quick bird Satellite data Specifications (Digital Globe)

Scene 2		
Satellite/sensor	Quick bird	
Data set	Multi-spectral	
Spatial resolution	2.5m	
Radiometric resolution	11 bit (2048 intensity level)	
	Band 1 (blue) : 450-520nm	
Spectral resolution/bands	Band 2 (green) : 520-600	
	Band 3 (red) : 630-690	
	Band 4 (Near IR) : 760-900	
Image acquisition	2008	
	Latitude	Longitude
Extent of data set	32’46’0’’N	72’41’45’’E
	32’47’0’’N	72’43’15’’E
Orbital altitude	450km	
Speed	7.1km/sec (25, 560km/hour)	
Revisit time	1-3.5 days depending on latitude	
Swath width	16.5km x 16.5km at nadir	

Object-Based Image Analysis (OBIA)

During the classification of land use/land cover, object-based image analysis was used which includes different steps like multi-resolution segmentation, classification-based segmentation, inspection of classification and manual editing and accuracy assessment.

Image objects are constructed by image segmentation by using ‘ENVI’. In the present analysis, image segmentation with various combinations of parameters (Scale, shape, brightness and compactness) was performed and analysed. There are multitudes of classification algorithms in ‘ENVI’ to perform classification.

For accuracy assessment error, matrices were generated by selecting samples manually. A total of 719 samples (0.58% of the total image object) and 655 samples (0.53% of the total image object) were selected for scene-1 and scene-2, respectively. Descriptive statistics were computed and analysed. Preliminary classification results with twelve land cover/land use classes were used. Later on, on the basis of statistics derived, assessment of classification results with six classes was also evaluated.

Results and Discussion

A large number of various change detection techniques have been developed since the advent of the orbital system (Lillesand and Kiefer, 1987). Remote Sensing data are the primary source for change detection in recent decades and have made a greater impact on urban planning agencies and land management initiatives (Yang and Lo, 2002; Rogan and Chen, 2004). In the present research, Remote Sensing and GIS techniques were used to detect the changes in land cover/land use of wetland i.e., Kallar Kahar Lake. The net results of change detection analysis exhibit significant changes of land used/land cover in the study 1972 and 2008. The rate of change for different time periods is quite consistent (Fig. 4). Six major land cover classes were delineated using satellite data viz., shrubs, soiled/ uncultivated area, water body, build-up area, agricultural area and orchids. According to results, the agricultural and shrub area have reduced by 43% and 49% respectively whereas an increase has been observed in water-body, uncultivated/soiled area, orchid and built-up area by 40%, 53%, 79% and 38% respectively (Fig. 5 to Fig. 8). Accuracy assessments of classification results yield 90.61% and 91.99% over all accuracies of the final land use/land cover maps.

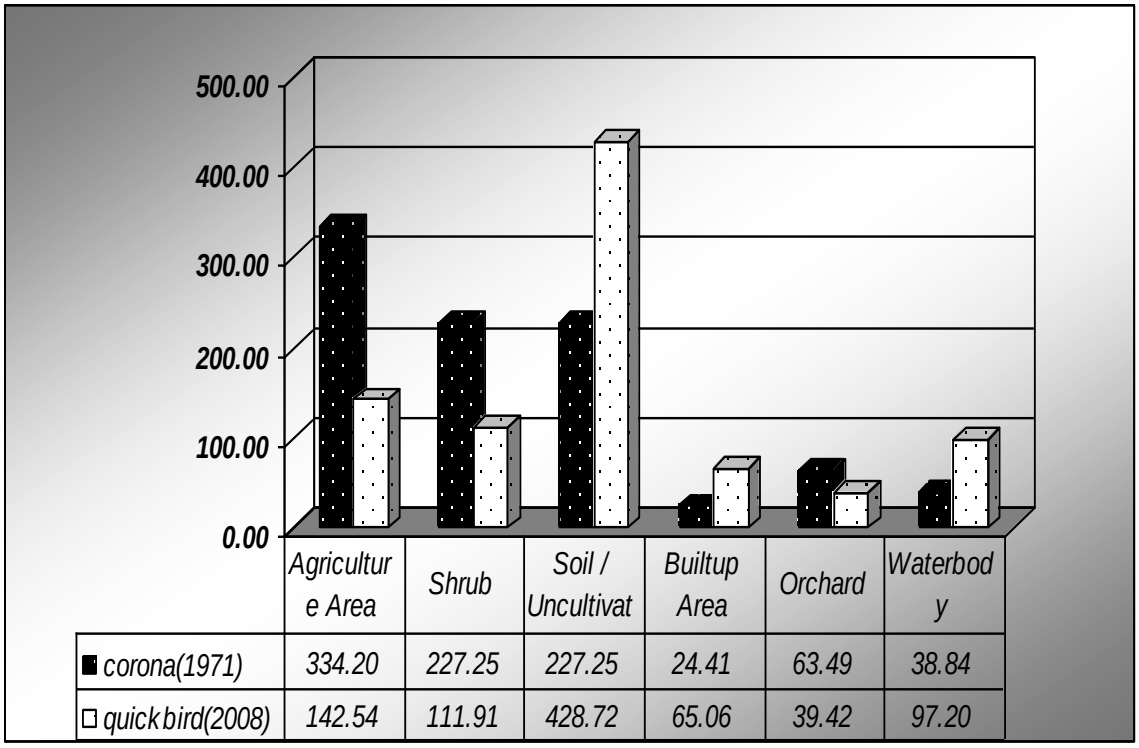

Fig. 4. Graphical representation of Statistics of Quick-bird and Corona Satellite imagery

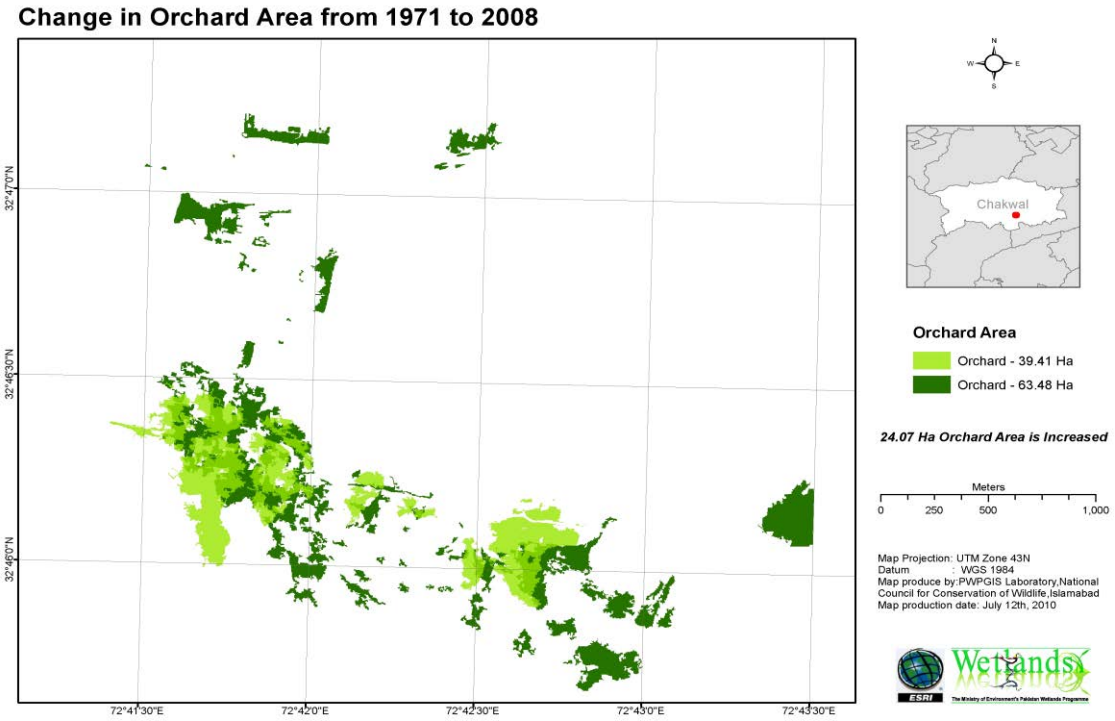

Fig. 5. Land-cover change in Orchard Area of Kallar Kahar

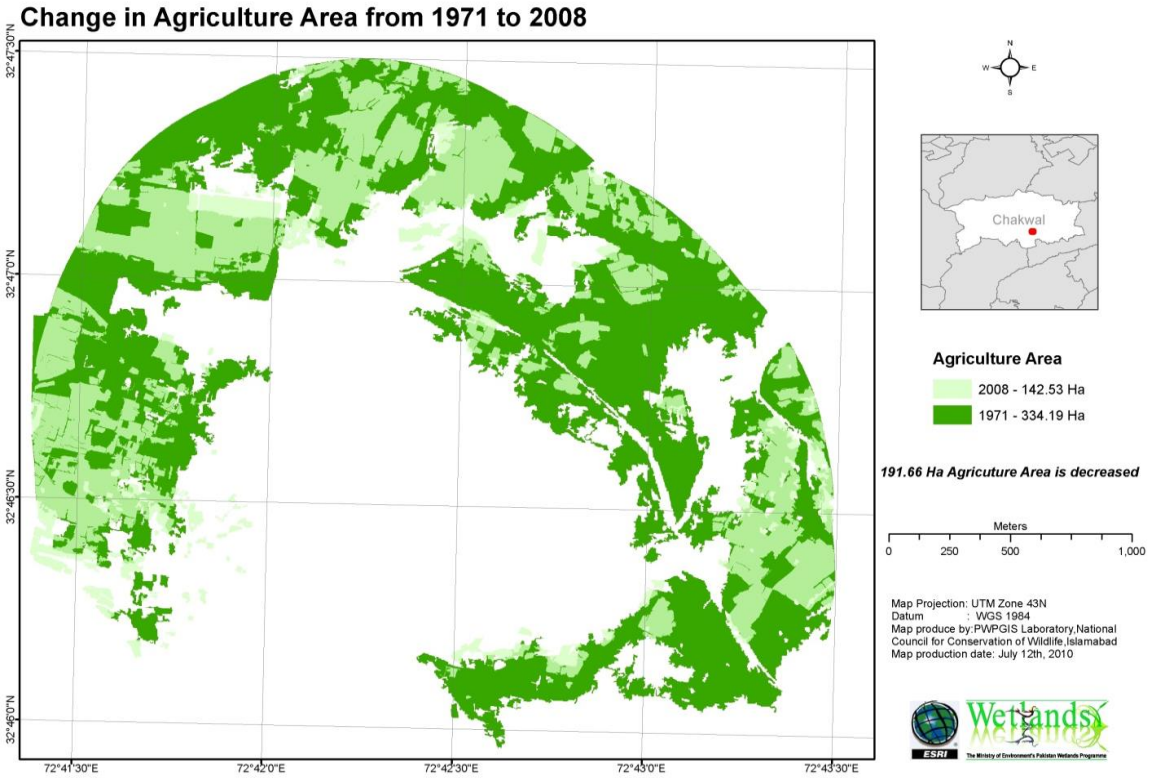

Fig. 6. Land-cover change in Agricultural area of Kallar Kahar

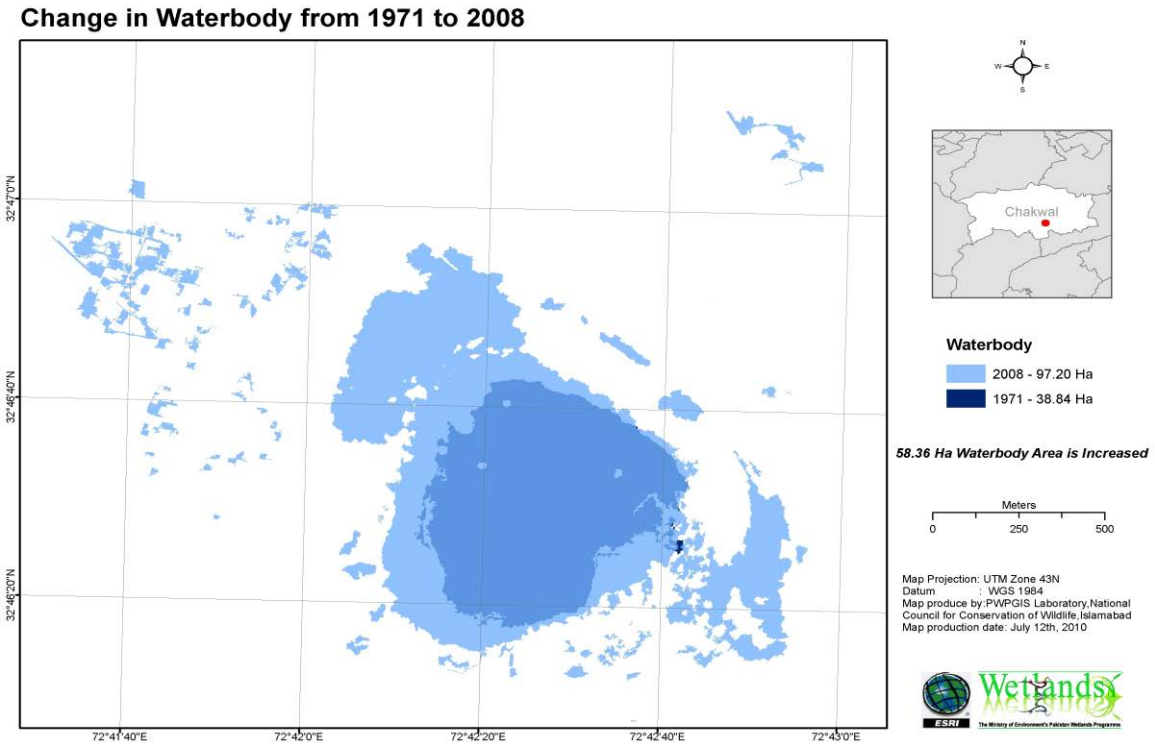

Fig. 7. Land-cover change in Water body of Kallar Kahar

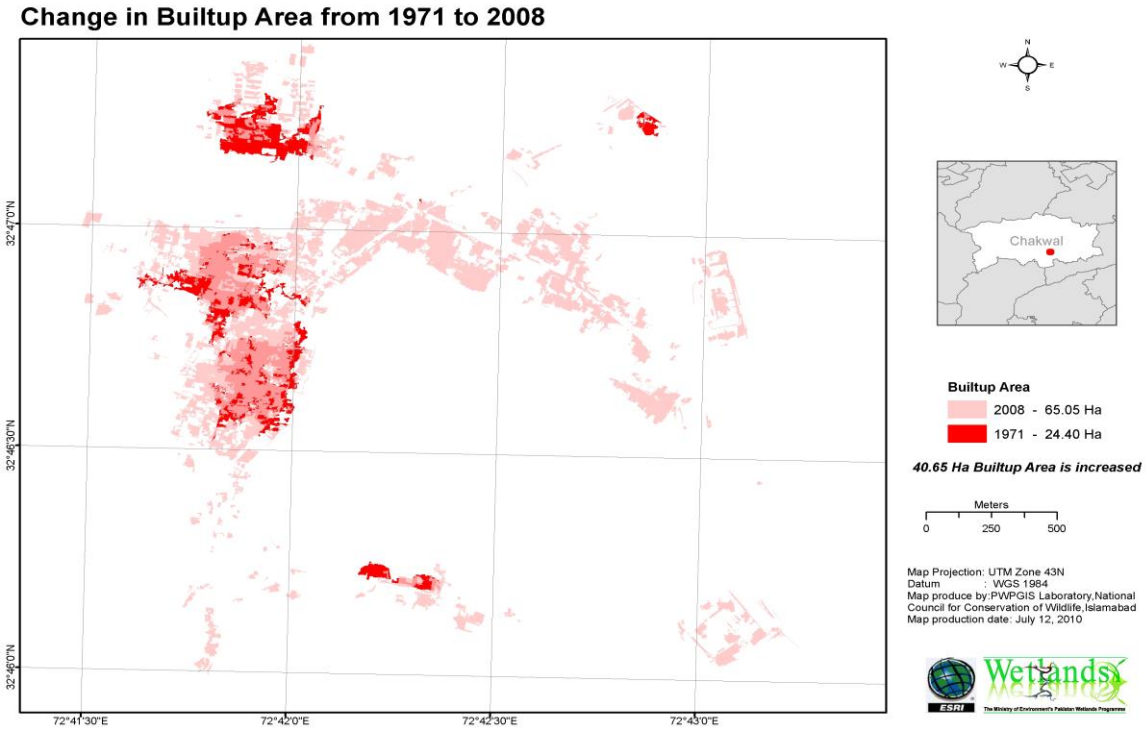

Fig. 8. Land-cover change in Built-up area of Kallar Kahar

Conclusion

The used approach in the present study proved very effective to fulfill the objectives with successful implementation. The study explores a successful use of the object oriented (OO) approach for LULC change detection. The present study shows a great potential for decision makers for generating accurate LULC change detection by exploiting various sources of Remote Sensing and GIS techniques towards successful implementation of sustainable development, natural resource management and safe land use planning.

There are several potential possibilities like selection of source data, set of methodologies to be used, etc., which are to be considered as additional strategies for further study in the future upon the conclusion of present research work. Satellite images with higher spatial and spectral resolution can be utilised for future which will not only improve the classification accuracy but also help in a classification of higher details.

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