CHANGE DETECTION ANALYSIS OF LAND USE BY USING GEOSPATIAL TECHNIQUES: A CASE STUDY OF FAISALABAD-PAKISTAN

Bhalli, M. N.[1], Ghaffar, A.[2], Shirazi, S.A.[2], Parveen, N[3], Anwar M. M.[3]
[1]Department of Geography, Govt. Postgraduate College Gojra, Pakistan
[2]Department of Geography, University of the Punjab, Lahore-Pakistan
[3]Department of Geography, GC University Faisalabad Pakistan
Corresponding author:nasarbhalli@yahoo.com

Abstract: *Urban centers and cities are the most dynamic regions on the face of the earth. Today cities are the socio-cultural centers in present day life of millions of people around the globe. They are the clusters of population agglomerations. Like other developing countries of the world, Pakistan possessed a number of fast growing cities including Karachi, Lahore, Multan, Hyderabad and Rawalpindi. Faisalabad is one of these fast growing cities of the country and expanding rapidly with varying growth rates and patterns. Two cities of the country viz; Karachi and Lahore have already attained the status of megacities due to their areal extent as well urban proportion in total population. Faisalabad is also on its way to attain this status since the spatial growth is a continuous phenomenon and likely to continue in future. In order to detect and monitor changes in the land use of these fast growing cities like Faisalabad, a variety of techniques and methods can be employed. Among many, geospatial technologies provide essential tools which can be applied in the analysis of LU change detection. This paper is an attempt to assess the land use change detection by using geospatial techniques like SRS and GIS within the defined urban area of Faisalabad city from 1980-2010.*

Keywords: *Change detection, Geospatial, LULC, Image classification, SRS and GIS*

INTRODUCTION

Modification in land use and land cover is most significant in global change studies [1]. The changing patterns of land use and land cover are very noteworthy constituent in the historical perspective of global expansion. Global urban expansion and land use and cover change (LUCC) have been considered leading factors which influence the environment [2]. The growth of urban settlements and its associated activities considerable rapid urbanization taking place in the developing countries are the fundamental features which are changing the environmental and ecological equilibrium at local, regional and global scenario. Urbanization is a significant leader factor that has contributed toward huge changes in the LULC (land use/land cover) patterns. Thus urbanization which is concerned with economic and social infrastructure referred to as the conversion processes of agricultural based society to a contemporary metropolitan society [3].

LULC are all about which is relevant to the activities that man carry out. There are numerous factors such as economic, cultural, political and historical factors that are affecting the Land use patterns. Land cover features such as vegetative cover, water bodies, rocks, soil cover, concrete cover and other consequential changes are due to land alterations [4]. Nowadays, with the growing urban population pressure, increasing land degradation and low man land ratio, the need for most favorable utilization of land assumes much greater significance. The most efficient and quick means to carry out the research in the physical and social sciences are the SRS data and GIS techniques. Change detection is the procedure of identifying the phenomenon by observing it at different time's periods in the state of object. Change detection is a significant procedure for mapping, and monitoring of natural resources and managing urban growth [5].

Urban and rural land use change can be mapped, monitor and manage through the computerized system since the origination of earth mapping system [6]. GIS was introduced for spatial analysis, modeling and demonstrate the geographical features [7]. Currently the remote sensing multi with temporal high resolution images can be cost effective short time tool for analysis of various geographical attributes [8; 9; 10]. Land use and land cover change (LULC) change Detection and mapping through the GIS and RS are of vital significance for every department working for the sustainable development [11]. Land use is human modification of natural environment into built through the agricultural processes, urbanization and industrialization [2]. Land use changes in Faisalabad city were examined during 1980-2010 by using geospatial techniques. Changes in built-up land, barren, agricultural land and water surfaces were exposed. An urban land use characteristic was aligned with particular strategies aiming at urban development and thus was proposed for future land use decisions to native officials and authorities. Information on LULC cover are usually available in forms of maps and statistical data and is very important for regional planning, management and utilization of lands for agricultural studies, economic development etc. [7]. The aim of the study is to analyze LULC changes by using SRS data and GIS techniques.

1. Study Area

The "Manchester of Pakistan" as popularly known to the world, Faisalabad is one of the major urban centers of Pakistan. Since Independence of the country in 1947, the city has grown steadily to its present rank as third in terms of population size. Faisalabad always has a prominent share in the economic prosperity of the country owing largely to cotton and textiles produce. Geographically located in the fertile *Rachna doab*, the city is bounded on north by districts of Chiniot and Hafizabad, on the east by Nankana sahib

while Sahiwal and Toba Tek Singh are located on its south. Faisalabad is well connected to the other cities of the Punjab as well to the capital city of Islamabad through Motorway. Multan-Faisalabad expressway is also under construction, which will link Faisalabad to the other cities of the province like Multan and Bahawalpur. Faisalabad district has spread over an area of 5,856 sq. kms., while its metropolis extent is about 1295 sq. kms. The study area for the present research i.e.; Faisalabad City is spread over 213 sq. km. The City District Government Faisalabad has been divided into eight Town Municipal Administrations (TMAs), four of which are predominantly urban. These are further divided into 289 Union Councils.

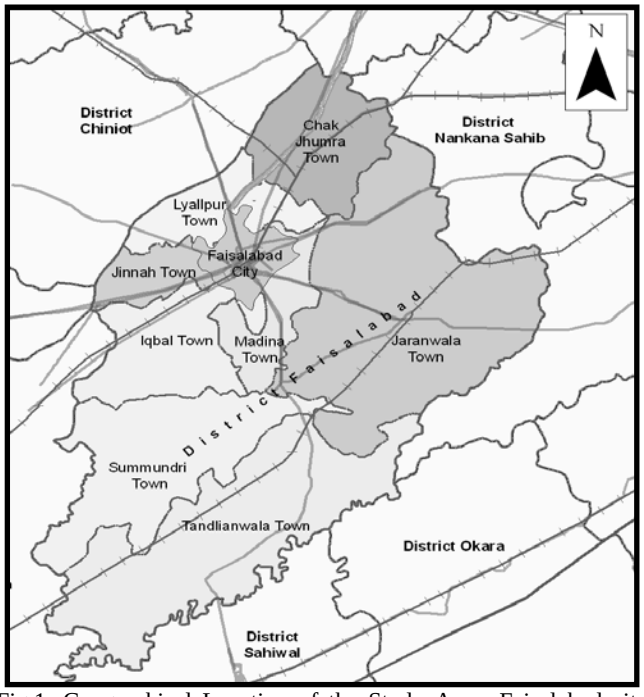

Fig.1: Geographical Location of the Study Area -Faisalabad city **Source:** [24].

2. Objectives of the Study

- to determine the trend, nature, rate, location and magnitude of land use changes.
- to explore the potentials remote sensing and image interpretation techniques
- to create land cover classification scheme and to prepare change detraction maps.

3. MATERIALS AND METHODS

The methodology used in the present research includes the following steps; 1) Data collection, 2) Preparation of datasets, 3) Supervised image classification, 4) Accuracy Assessment.5) Preparation of change detection maps. These processes were carried out using geospatial tools like ERDAS IMAGINE 9.2 and Arc Map 9.3 software's [12]. In order to detect change over a period of time 1980-2010, required temporal Landsat Satellite Imagery were downloaded from GLFC website [13]. Geo-rectification of images was performed in the first stage. Spectral analysis of the datasets chosen was performed in the stage of image processing. Accuracy assessment stage was required to determine whether results of spectral analysis were satisfactory for the study [14].

In order to find change detection with the help of image analysis, post-classification comparison method is widely used in the world. Keeping in view its widespread utility, in present research quantitative method of change detection i.e., post-classification method was selected to find land use/cover in the study area. It requires rectification and classification of each remotely sensed Landsat image. After the classification of image separately, resulting maps are then compared on a pixel-by-pixel basis using a change detection matrix [15]. In continuation with the research methodology, all the images which were already classified using ERDAS Imagine software, of the study period were compared to detect the patterns of change. In order to achieve our goal, the images has to be classified to delineate the various land use categories[16; 17].In RS techniques, classification of digital satellite data(image) is deemed necessary to distinguish and differentiate the SRS imageries into various classes to have better understanding of the available digital data**.** All the material regarding various objects attained through the spectral reflectance has been used in the supervised image classification and to demarcate the requisite data to design each category of classification [18].

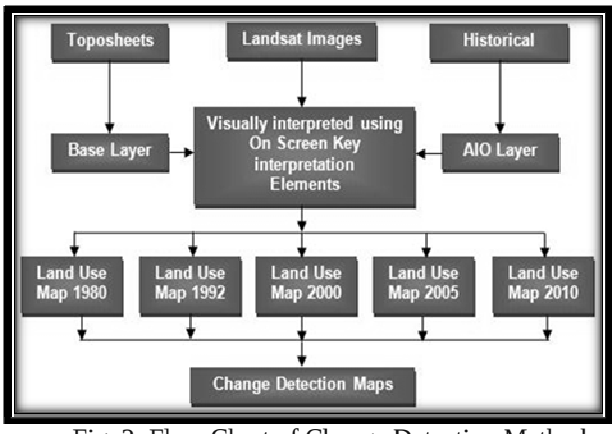

Fig. 2: Flow Chart of Change Detection Method
Source: Author 2012

After the signatures are defined, the pixels of the image are sorted into classes based on the signatures by use of a classification decision rule. Maximum Likelihood method was used to classify the pixels. It is a remote sensing classification system in which unknown pixels are assigned to classes using contours of probability around training areas using the maximum-likelihood statistic [19]. The output file is an image file with a thematic raster layer. This file automatically contains the following data: Class values, Class names, Color table, statistics and histogram [20]. After all the maps were classified they were reclassified into four land cover classes by using reclassification tool in ARC Map 10 and then their respective areas were calculated by using raster calculator option. The consequent results inferred after preparing maps based on five years' time series Landsat land use/cover data with its accuracy have been shown in table 1.In addition to this Kappa (K^**)** index was also calculated for all classified images in order to find the accuracy of classification results [21]. Table 1 also portrays the results of

Kappa (K^) index derived after classification of Landsat LULC maps. This gave overall good results of accuracy assessment of all the images and were found in fair agreement with already conducted researches. In addition to this it also helped change detection analysis for the whole research span. Overall user's accuracy for each chosen category found in the range from 71 to 100 per cent while the producer's accuracy was obtained ranging from 55 to 100 per cent [22].

4. RESULT AND DISCUSSION

4.1. Nature, extent and rate of change

In order to study and analyze the change detection, a supervised classification for all the five images pertaining to the years 1980, 1992, 2000, 2005 and 2010 was conducted and the images were grouped into four LULC classes. The total classified area was 21309.3 hectare, which was later divided into a number of LULC cover categories in Faisalabad- the study area. Each land use category and change over time for thirty years have been summarized in Table 3and 4.For the sake of analysis, the LULC of the city of Faisalabad was divided into four land use and land cover class categories namely agricultural land, urban built up land, water body and the barren land. This sort of categorization of land use and consequent delineation of each class helps the researchers in visual as well statistical identification and interpretation of area statistics. The LULC maps and characteristic data results of the supervised classification have been presented below. There are a number of techniques and methods to quantify the obtained results related to the urban LULC changes. Out of these one of key methods is to put the LULC data into tabular format for every epoch for whole research span and after that a comparative analysis of the urban growth and land use change for each yearly data may be carried out. During the process of in depth analysis, numerous divergent trends of change and patterns have been discovered about different LULC category. It has been observed that since 1980 to 1992, agricultural lands have been decreased to 1108 ha (12 per cent of the total) whereas the urban built up areas have shown substantial increase to 502ha (9 per cent) [22].

As far as the second phase of present study (1992 to 2000) is concerned, there have been a significant increment of 20 per cent or 1221ha in the urban built up area of Faisalabad is recorded. Similarly, there has been a consistent reduction in the agricultural lands in the study area by 248ha (3 per cent). A similar decreasing trend of 476ha (8per cent) in the barren land have also been deduced after the analysis. In the third phase of present study (2000 to 2005) yet another consistent growth pattern can be seen in urban built up category by 907ha or 12per cent , built up land continuously engulfing the agriculture lands which have been reduced to 653ha

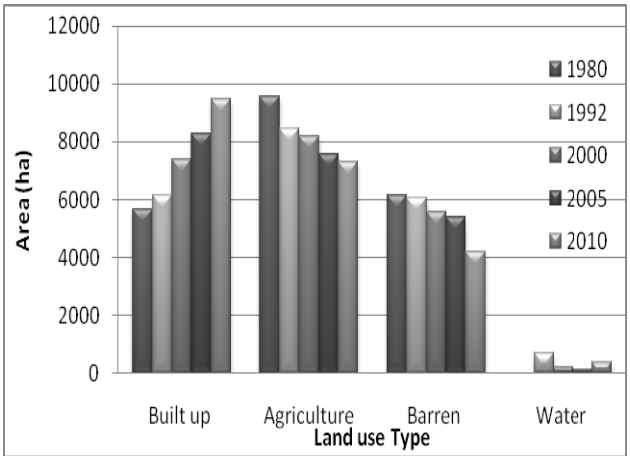

Fig. 3 Nature of Relative Land use Changes 1980 to 2010

(8per cent), barren lands have also been reduced to 188ha or 3per cent . A consistent and continuous increase in the urban built up area have also been recorded by 907ha (12per cent) during the period 2005 to 2010. In the fourth period studied in present research, agricultural land have shown a consistent decrease to 653ha (8per cent), barren/open surface reduced up to 1199ha (22per cent). An overall increase of 40 per cent in urban built up category has been observed during a 30 years' time span i.e., 1980 to 2010. One of the most vital increases observed in

Fig. 3 further portrays the relative LU change patterns and trends since 1980 to 2010 in Faisalabad. A progressive development in the areal extent and hence growth in urban built up surfaces of Faisalabad has been noted while agricultural land and land use have shown a consistent decreasing trend throughout during the four periods. It is evident that all other three categories of LULC have

Table 1: Overall Accuracy and Kappa (K^) Statistics

	1980	1992	2000	2005	2010
Overall Classification Accuracy (%)	73.26%	76.19%	75.42%	85.15%	86.07%
Overall Kappa (K^) Statistics	.5845	.6488	.6405	.7797	.7726

Source:[22]

Table 2: Area Statistics and % of the Land use/land cover 1980-2010

Land Cover Type	1980		1992		2000		2005		2010	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Built up	5661	26	6163.11	29	7384.4	35	8291.36	39	9480.44	44
Agriculture	9562.14	45	8454.14	40	8206.12	38	7552.84	35	7307.67	34
Barren	6167.16	29	6071.49	28	5595.19	26	5406.82	25	4207.91	20
Water	-	-	701.56	03	204.59	01	139.23	01	394.28	02
Total	21390.3	100	21390.3	100	21390.3	100	21390.3	100	21390.3	100

Source [22]

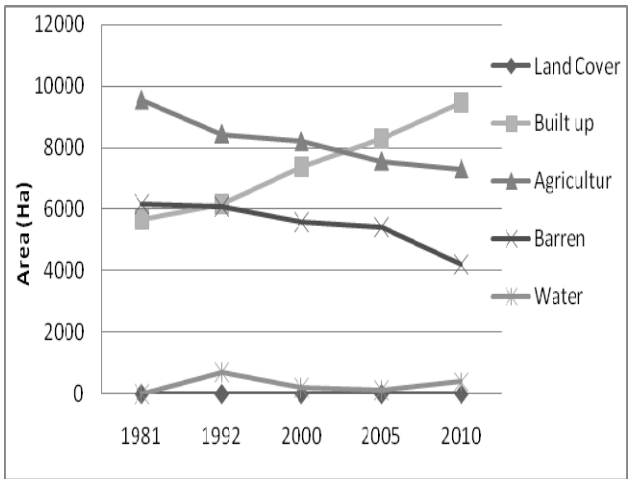

Figure 4: Change Detection of Faisalabad, City 1980-2010

recorded a decrease whereas urban built class have shown continuous increasing trends during 1980 to 2010.In other words, except urban land use class all other land cover classes recording a declining trend which is an indicator of urban development and expansion in city size. The magnitude and percentage change in urban land cover in Faisalabad has been calculated through the following variables and employing some statistical notions.

- Total area (Ta)
- Changed area (Ca)
- Change extent (Ce)
- Annual rate of change (Cr)

The above mentioned variables can also be calculated and demonstrated through following method:

I. **Ca= Ta (t_2)-Ta (t_1);**

II. **Ce=Ca/Ta (t_1);**

III. **Cr=Ce / (t_2-t_1);** Where t_1 and t_2 are the beginning and ending time of the land use studies conducted [23].

IV. **Source:**[22]

The Landsat digital data analysis and deduced statistics have demonstrated a visible average annual rate of change in the urban built up areas ranging from 1 per cent in 1980 to 1992, 2 per cent from 1992 to 2000, again 2 per cent from 2000 to 2005, 3 per cent from 2005 to 2010 while the on the whole 1 per cent rate of change for temporal session 1980 to 2010 has been noted .This change has uncovered, to a large extent, the process of urban development and consequent changes in City's prominent land use. The present study has also observed the change in its size as well as in the areal extent of the city. Similarly the agricultural land use has demonstrated an average decline by 1 per cent while barren land recorded 2 per cent annually decrease. On the other hand, water bodies have shown a meager decrease and change during the period 1992-2000.It is obvious from table 6.2 that the change values which signifies the change from one land use to another specifically agricultural lands in the city. The agricultural lands have consistently shown decreasing trends which is a contributory factor in the development of urban built up lands during the stipulated 30 year of present study i.e.; 1980-2010. The process of conversion of agricultural land into urban built up areas proceeded throughout study period with subsequent pressure on the city managers to foster development in the City. The summary statistics, classification results demonstrated through graphs and visual comparisons have revealed the comparative changes in each distinct class and category concerned with the urban morphology of Faisalabad city.

Table 3: Overall Quantity, Extent and Rate of Change .1980-2010

Land Cover/ Land use	1980-1992			1992-2000			2000-2005			2005-2010			1980-2010		
	change (Δ/ha)	Extent (%)	Rate of Δ (%/yr)	change (Δ /ha)	Extent (%)	Rate of Δ (%/yr)	change (Δ /ha)	Extent (%)	Rate of Δ (%/ yr)	change (Δ /ha)	Extent (%)	Rate of Δ (%/ yr)	change (Δ /ha)	Extent (%)	Rate of Δ (%/ yr)
Built up	+502	+9	+1	+1221	+20	2	907	12	2	1189	14	+3	3819	40	1
Agriculture	-1108	-12	-1	-248	-3	-0	-653	-8	-2	-245	-3	-1	-2254	-31	-1
Barren	-96	-2	-0	-476	-8	-1	-188	-3	-1	-1199	-22	-4	-1959	-47	-2
Watr	-	-	-	-497	-71	-9	-65	-32	-6	255	183	+37	-	-	-

4.2. Spatial Analysis of change detection and patterns

The present study demonstrates LULC change detection and consequential pattern changes for the third largest city of Pakistan with the help of multi temporal Landsat images for the years 1980, 1992, 2000, 2005 and 2010.The image classification technique have been used to analyze temporal changes. In addition to SRS data the ancillary demographic data available in District Census Report of Faisalabad have also been incorporated in the study. The combined results of both these data sets have shown more or less the same results confirming that the city is expanding fast, both in terms of population and size. Table 5 reveals change statistics and allied results which demonstrate the research questions regarding "how" and "where" land cover change dynamics are taking place in Faisalabad.

The post-classification approach requires "from to" change information and thus assists in analysis of growth rates and change and mapping all the phenomena which alter the urban landscape of a city. A noticeable temporal expansion

in the urban built up area of Faisalabad city has been depicted through change detection map in figure 4. The urban extent has increased in all urban landmarks and features throughout the city. The most obvious change and transformation can be seen in agricultural lands converting into built-up areas. Similarly increase in residential neighborhood and colonies, enhanced commercial activities and industrial development, construction of new buildings, road networks, ports and other city's infrastructure designated as non-build up spaces which are gradually transformed it into built up zones throughout Faisalabad city. The post-classification approach requires "from to" change information and thus assists in analysis of growth rates and change and mapping all the phenomena which alter the urban landscape of a city. A noticeable temporal expansion in the urban built up area of Faisalabad city has been depicted through change detection map in figure 4. The urban extent has increased in all urban landmarks and features throughout the city. The most obvious change and transformation can be seen in agricultural lands converting into built-up areas. Similarly increase in residential neighborhood and colonies, enhanced commercial activities and industrial development, construction of new buildings, road networks, ports and other city's infrastructure designated as non-build up spaces which are gradually transformed it into built up zones throughout Faisalabad city.

CONCLUSION

The aim of present study was to delineate and detect LULC changes in Faisalabad city using geospatial techniques and Landsat imageries. In order to achieve our goals, we used supervised classification approaches and algorithms available in one of image analysis software ERDAS imagine. The results inferred from the classified Landsat digital data revealed that in 1980, total built up land was 5661 hectors (26 per cent) of whole area (213 sq.km). While the result inferred from the classified Landsat images for the year 2010 revealed that total built up land was 9480 hectors (44 per cent) of total area (213 sq.kms). Therefore, a total areal transformation through 1980-2010 was 40 per cent in built up land while non-built-up area decreased to 32 per cent. Similarly, classification results of latest image used in present study i.e.; year 2010 has shown that agricultural lands have been rapidly modified and converted into urban built up land parcels throughout the Faisalabad city. This unprecedented growth and development is visible everywhere from the previously existing built up land to areas once cultivated in the rural-urban fringe of city. In conclusion, it is pertinent to mention that present momentous urban evolution and development in Faisalabad has been taking place on the expense of fertile lands all around the city's suburbs and its fringe area.

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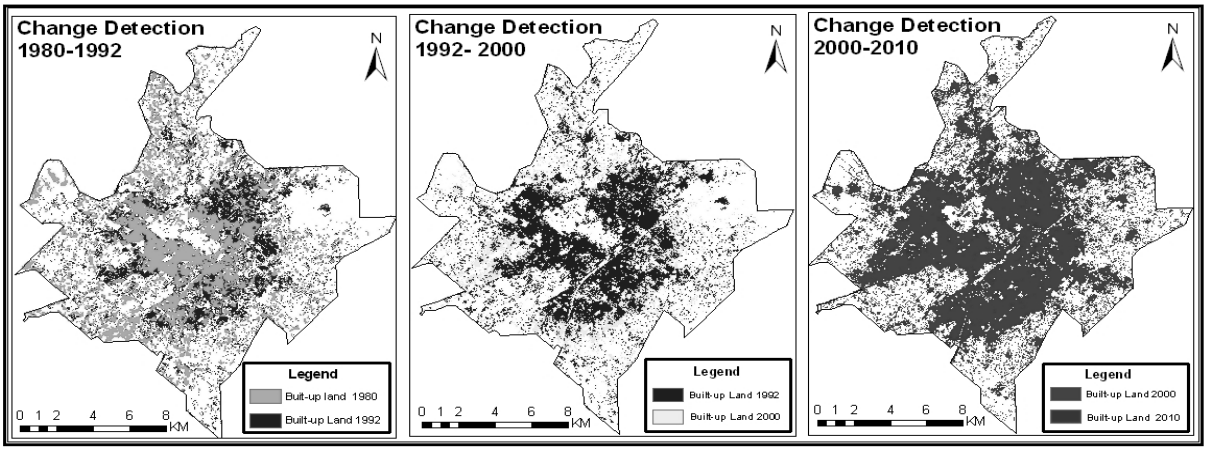
Fig. 5: Temporal Patterns of Land Use Changes 1980-2010.



Source: [22]

Table 4: Area Change in Hectare and % of land re-classes

Land Use	Area In hectare					Area Change In %				
	1980 - 1992	**1992 - 2000**	**2000 - 2005**	**2005 - 2010**	**1980 - 2010**	**1980 - 1992**	**1992 - 2000**	**2000 - 2005**	**2005 - 2010**	**1980 - 2010**
Built Up	+502.11	+1221.3	+906.9	+1189.1	+3819.4	+9	+20	+12	+14	+40
Non- builtUp	-502.1	-1221.3	-907	-1189	-3819.4	-8	-8.	-6	-9	-32

Source: [22]

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