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USE OF MULTI-TEMPORAL SATELLITE DATA FOR MONITORING LAND USE PATTERNS IN SARGODHA-PAKISTAN

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ABSTRACT
The study area-Sargodha the "California of Pakistan" has witnessed aerial expansion, growth and developmental activities such as buildings, road construction, change in its planned land use and many other anthropogenic activities for the last three decades. This has therefore resulted change in its land use and a modification and alterations of land over time. In this context, an array of information like land use patterns in time and space as well as demographic data including population number, distribution and growth rates are essential. Population increase exerts pressure on the existing land in terms of demand for new residential/built-up to accommodate growing population, supporting infrastructure and civic amenities like provision of drinking water, electricity, gas, transportation network system and waste disposal employment. The Satellite remote sensing data is more conveniently used to acquire such information and to use this information for the production of required maps with maximum accuracy and reliability in both time and space for a specific region. In present paper we have concentrated upon two land use classes i.e.; built up and open area which will be monitored by land use patterns of Sargodha tehsil for the period of 1992 to 2010 using satellite images. The graphical depiction of all the land use changes which have taken place in Sargodha in the forms of maps provide detailed information about the degree and ratio of urban land use variations occurred in the stipulated time span. Like all previous work of this nature the agriculture fields/lands are gradually diminishing and converting into built-up neighborhoods of the city.

KEYWORD: Land use, Pattern, Sargodha

INTRODUCTION
Today, more than 50% of the world's population is living in areas. The urban population currently estimated is about 3.7 billion people and is expected to be doubled by 2020.It was also projected that 93 percent of this growth will be related to less developed countries of the world particularly that of Asia and Africa(United Nations, 2010). Therefore present century is the most urbanized in the human history of the world. According to the1998 Census Report, growth rate of urban population of Pakistan was 4.4% on the other side rural population growth rate was 2.6% per annum, At present more than 9 cities of Pakistan has one million or more than population where it is estimated that in 2013 more than 15 cities will achieve this mark and in 2030 it is estimated that Pakistan would be primarily urban in character with 49.8 per cent of its population living in cities and urban areas and while about 17 cities becoming larger than one million people and by year 2020 50% of population will be in cities and still we do not have any national urban policy and at present we have lack of space and facilities (United Nations, 2009).

Unfortunately, conventional sources of information on both land use and population are frequently inadequate (Devas and Raked, 1993). This is particularly true for many less developed countries including Pakistan, where the required information and data are often outdated, unreliable or, in most cases, not available at all. This issue requires a quick and reliable set of methodologies so as the researchers, city planners and managers/administrators to overcome the problem. These fast growing urban centers require a sound administrative and managerial arrangement to cope with the changes of urban land use and associated issues with urban population therefore, Satellite Remote Sensing and allied techniques can serve as a significant alternate source of required data (Baudot, 2001).

The study area-Sargodha the "California of Pakistan" (GOP, 2000), has witnessed aerial expansion, growth and developmental activities such as buildings, road construction, change in its planned land use and many other anthropogenic activities for the last three decades. This has therefore resulted change in its land use and a modification and alterations of land over time. Therefore it is necessary for a study such as this to be carried out if Sargodha will have to avoid the associated problems of a growing and expanding city like many others. Sargodha is a planned city and built on the principle of city and regional planning. In this research we will examine land useof Sargodha, "the home of citrus fruit" (GOP, 2000),in Pakistan over a period of eighteen (18) years through available Landsat images (year 1992, 2000, 2005 and 2010). Land use information and associated statistics are very vital for city government, administrative officials as well as for planners who are responsible for the comfort of a city, its people and environment. For this purpose they take decisions related to land resource and use management since it is a strong force for the economic prosperity of the city and region. Since maps are very powerful planning tools therefore all these information is usually presented in this formalong with supporting data for each land use class. This will be followed by identification and delineation of different land use patterns in Sargodha tehsil using remote sensing data. This research aimedat better understanding and empirical analysis of the process of temporal land use patterns within Sargodha since 1992. This research will be beneficial for policy makers, city administrators, planners and other related departments within Sargodha and also for other cities of Punjab. The results and findings of this research will be generalized for other cities of Pakistan. An understanding the patterns of land use can be helpfulin natural resources planning, natural resources utilization and provision of infrastructure facilities (Sudhira, 2004). For this study, LANDSAT multispectral and Landsat TM data were primarily used. The advantages of multispectral data offset the benefits of finer spatial resolution associated with panchromatic data. Although the cost of the satellite imageries is very high but we took advantage of free web Google earth and global land use facility (GLFC) website for the acquisition of information and data as well as of the images used to undertake this research. In order to carry out present research reliance has been placed on the following data sets:

MATERIALS AND METHODS

The study area-Sargodha ranked amongst top ten cities of the province of Punjab and is a tehsil of district Sargodha. It owes its name by the combination of two words *"Sar"* meaning a water pond and *"Godha",* the name of a Hindu *Sadhu* who was resided near it.

With the passage of time this pond was the center of settlement of Sargodha. Earlier it was a small town and upon the introduction of canal irrigation system in the area it gained importance. Sargodha lies between 31°34' to 32° 36' North latitude and 72° 10' to 73° 18' East longitude (GOP, 2000). The city elevation in general is 614 feet above mean sea level while it attains an elevation of 783 feet while going towards the southwest. Sargodha has a continental type of climate. The climate remains hot during most part of the year with a short winter period is December to January. In general May, June and July are considered as hottest months when the mean maximum and minimum temperatures rose to 39°C and 25°C respectively. December, January and February are the coldest months. During this period the mean maximum temperatures drops to 21°C and 6°C respectively. The rains are less frequent throughout the district owing to its location and topography while the hills get more rain than plains even if the rainfalls (GOP, 2000). The Sargodha district has an area of 5,854 km^2 with a population density of 455 beside of 327 persons per Sq. kms in 1981.The total population of the Sargodha district as reported in 1998 census was 2,665,979 persons with an inter-censual percentage increase of 39.4 percent since 1981 census. The urban population of the whole district was 28.1 percent of the total population in 1998 while it grew at the rate of 2.4 percent during 1981-98.The percentage of urban population for Sargodha tehsil was 42.4 per cent (table-1). According to 1998 census Sargodha district comprised of one Municipal Corporation, two Municipal Committees, one Cantonment and ten Town Committees. Presently, the district of Sargodha has been divided into six tehsils namely Bhalwal, Kot Momin, Sahiwal, Shahpur, Sillanwali and Sargodha.

Table 1. Population profiles of Sargodha and Punjab 1981-2011

UNIT	Area (Sq. Kms.)	Population			Sex Ratio	Densi ty*	Urban % 1998	Avg. House hold Size 1998	Avg. Annual Growth Rate (%age) 1981-98
		1981	1998	2011**					
PUNJAB	205345	47292441	73621290	95153000	107.2	358.5	31.3	6.9	2.64
Sargodha district	5,854	1,911,849	2,665,979	3227000	106.2	455.4	28.1	6.4	1.97
Sargodha tehsil	1,536	722,570	1,081,459	1351000	107.8	704.1	42.4	6.7	2.4

*Persons per sq.km ** Estimated

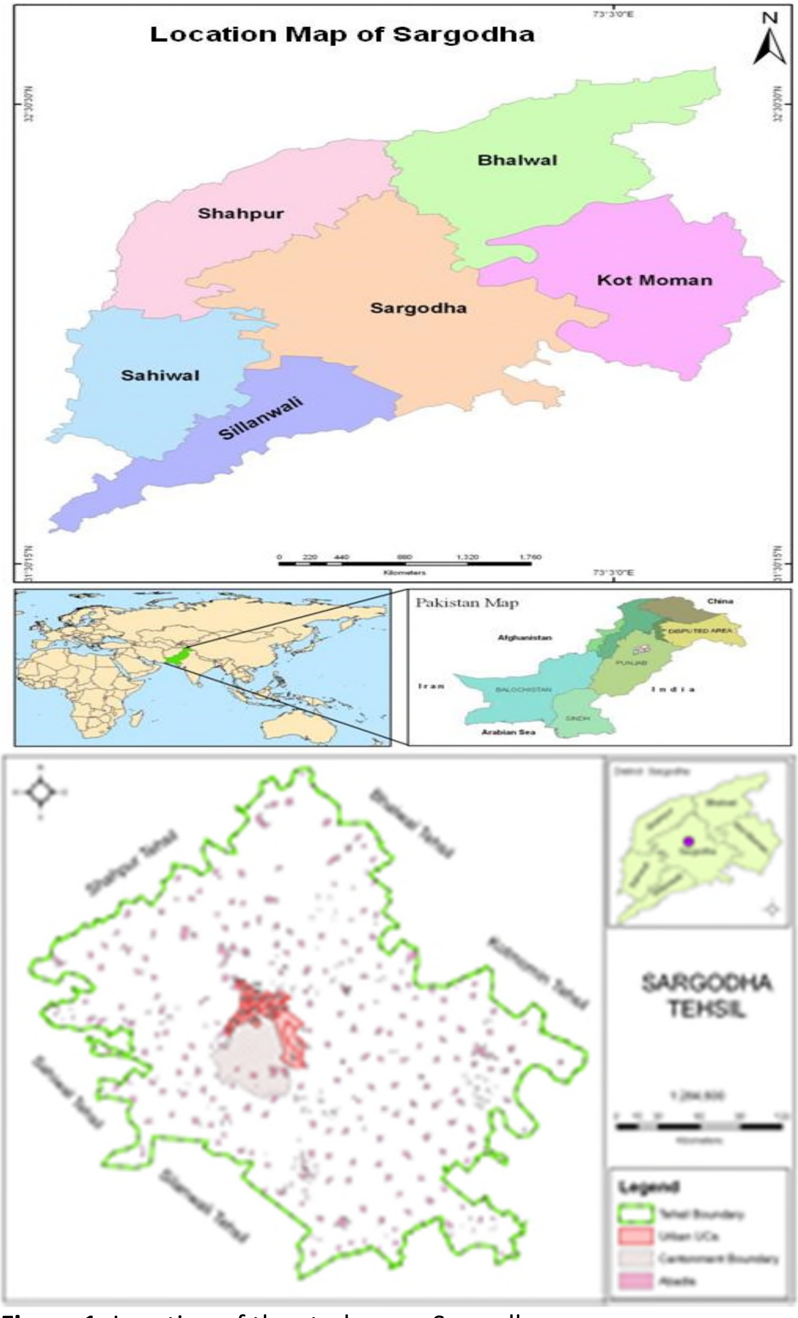


Figure 1. Location of the study area-Sargodha

For this research data have been derived from satellite imageries available on Global land use facility GLFC (USA) which have been shown in table 2. Landsat satellite imageries during a period of 20 years were used for the study. The dates were 1992, 2000, 2005 and 2010 and accessed freely from different agencies and websites GLCF (http://glcf.umiacs.umd.edu).Details of Landsat imageries and their characteristic traits have been given below in table 2.

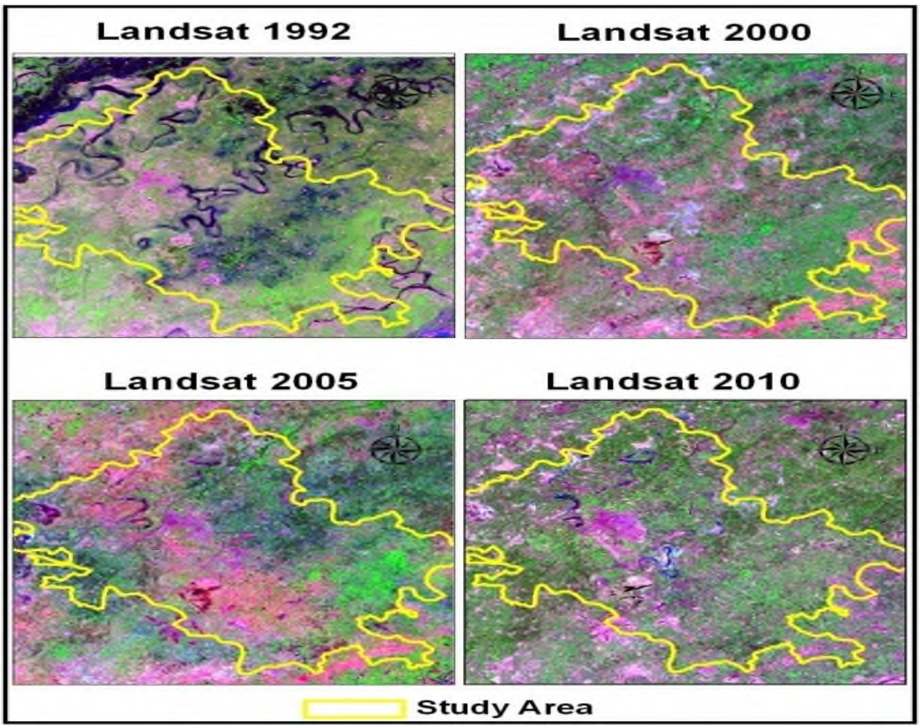
Table 2. Important traits of the Landsat Imageries used 1992-2010 for Classification

Year	Satellite Parameter	Spatial Resolution	Path/Row	Date
1992	Landsat TM	30 m	149/38	20-09-1992
2000	Landsat ETM+	30 m	150/38	10-11-2000
2005	Landsat ETM +	15 m	150/38	16-09-2005
2010	Landsat ETM +	15 m	149/38	10-03-2010

The images used in our research has been acquired free of cost from GLFC website for four different years and their time interval was also different. All the downloaded satellite imageries were accurate and appropriate for our research work and their reliability is of high standard. The available maps of Sargodha even prepared by Survey of Pakistan and Sargodha Improvement Board (SIB) had not been much reliable since these were published and prepared long ago and therefore were found outdated. However this issue was resolved because of the satellite imageries, which gave clear picture of current land use of the Sargodha city. In present research software prepared by Environmental Systems Research Institute (ESRI) and Leica Geo-systems were used to find the temporal patterns of land use of the city of Sargodha. For this purpose Arc GIS 9.3, ERDAS Imagine 9.3, Global Mapper as well as free web Google was extensively used. In addition to this word and excel were used in typing and graphically depicting the results of the research work.

Prior to conduct the research, the data was prepared for an in depth analysis. Therefore we refine satellite imagery to carry out detailed analysis. For the case of change detection it consists of geo-referencing and sub-setting of images. Sub setting of an image is done to clip study area from a complete scene. All the acquired images were in "tiff" format and later on converted into *"img"* format. The purpose of this research is to use the digital data further processing in compatible ERDAS Imagine 9.3 software. All the four images were then imported into *"img"* format to meet the requirement for image pre and post processing. In this manner, composite image layers were made by stacking all required bands into each layers of each image. The staking was done to all the four images as first step to formulate and convert the images into false color composite. After doing this procedure the composed image layers of all the four imageries were later on converted into subset of the study area.

When, the study area images were imported into the ERDAS Imagine 9.1(image analysis software).As a first step assessment of classified images of 1992, 2000, 2005 and 2010 were performed to identify the change patterns. That's why the classification of all four images was required (Jensen, 2004). Classification is the process of sorting pixels into a finite number of individual classes, or categories, of data based on their data file values. If a Pixel satisfies a certain set of criteria, then the pixel is assigned to the class that corresponds assigned to that criterion. This process is also referred to as image segmentation. 4.3.6.2 Image Algebra Change Detection (Band Differencing or Band Rationing) Band Differencing. Another procedure is to register two images and prepare a temporal difference image by subtracting the digital number (DN) for one date from those of the other. The difference in the areas of no change will be reveal larger positive or negative values (Kuepfer, 1987).The image differentiating involves deducting the imagery of one date from that of the other. The subtraction results in positive and negative values in areas of radiance change and zero values in areas of no change in a new image. In 8-bit analysis with pixel values ranging from 0 to 255, the potential range of difference values is –255 to 255.



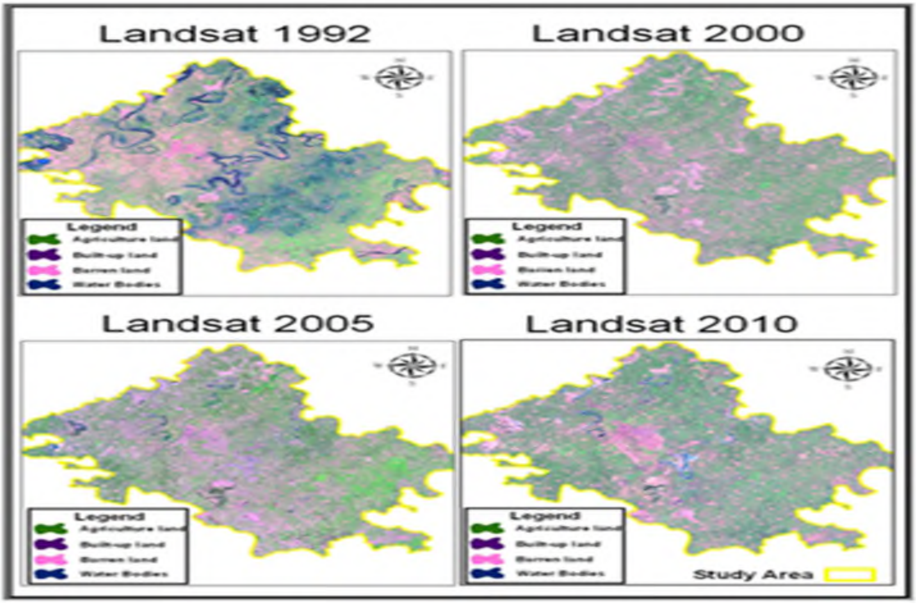


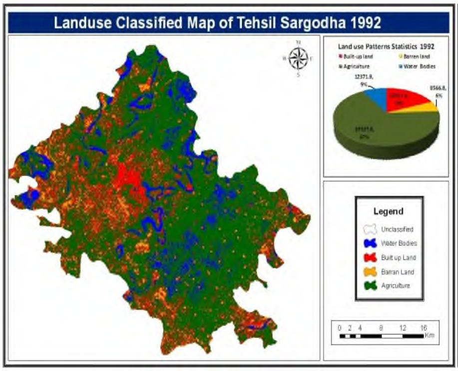
Figure 2 & 3. Composite bands of four subset images showing study area

The Image enhancement was carried out with the help of ERDAS imagine to all available Landsat imageries used for temporal analysis. The purpose was to use all four spectrally enhanced images for the classification and re-classification of built-up areas. In present research different false color combinations were taken into consideration to delineate the diverse land use in Sargodha. For example bands 5, 4, 3 as red green blue were employed for improved identification of vegetative type and water bodies, Likewise band combination of 7,4,2 and 7,4,3 as RGB was utilized for delineation to urban / built-up area and water bodies. Other band combinations like 3,2,1 or 7,4,1, as RGB were also being considered on account of more precise and accurate resolutions of mixed objects which otherwise not possible to identify. After acquiring appropriate images for present study, it deemed necessary to employ image classification for analysis. In this method pixels of the image are categorized into various clusters and groups to acquire more meaningful information of the real world as derived in the thematic maps bearing the information such as built up area, open areas, water bodies and type of vegetation (Mantinfar, 2007). Despite the fact that a number of approaches and methods are currently in use but no method and technique is comparable to each other (Good child, 2000). Therefore determination of a classification system used in research work is generally decided keeping in view the purpose of the study and according to different research projects (Guo, 2000). In unsupervised image classification, a researcher identifies and designed spectrally distinguishable classes with ground truthing carried out by GPS and later information efficiency was defined in connection to these discrete categories to formulate supervised image classification format (Kaiser, 2008).After classifying all the maps they were reclassified into four classes by using reclassification tool in ARC Map and then their respective areas were calculated by using raster calculator option, graphs were also prepared of all the four types for each research epoch. Thematic maps derived from multi-spectral imagery while in present research confusion/error matrix have been used (Congalton, 1999).Thus tables obtained comprised of a number of statistical indices for the measurement of accuracy of thematic maps along with overall classification accuracy, percentage of omission error and Kappa coefficient-an index that approximately calculates the effect of change (Congalton, 1999).

RESULTS AND DISCUSSIONS

This section of present research work shows the result of satellite remote sensing data analysis and discussion on the findings deduced after making all the necessary maps which highlighted the land use patterns taken place in Sargodha. All the maps were created in GIS environment with the help of supervised classification of Landsat digital data for the subsequent years. It is also complimented by necessary analysis through various techniques used in statistics. These analyses have been carried out to deduce rates and ratios about the change in the temporal land use through maps, numerical data, diagrams, and accuracy assessment. This present research is related to temporal identification of land use and consequent patterns therefore the same have been performed through reclassification of the study area land use maps into built up and non-built up land use categories. The Spatio-temporal change detection and present land use configuration have also been delineated through simple statistical techniques widely used in literature now- a -days. Similarly land use trends of urbanization/urban built-up lands, its patterns and dynamics behind this have also been examined. As mentioned earlier that the main focus of this investigation was to categorize temporal urban land use and its analysis, development/growth and pattern change since 1992 to 2010 and to forecast future trend of urban growth corridors. These objectives have been acquired through the applications of various techniques used in classification of satellite images through different software currently in use.

In order to study the land use trends, its patterns and consequent changes four Landsat images have been used for the year 1992, 2000, 2005 and 2010. The supervised classification algorithms have been used to all the four images and results were categorized into four classes. The sum of all the identified land use classes of the study area is144977.9 hectare. Each land use class area and change detection statistics for nineteen years have been presented in tabular forms. For an in depth analysis the land use of the Sargodha city is distributed into four classes; agricultural land, urban built up area, water bodies, and barren land. All the available results have been shown with table and diagrams, relevant maps have also been prepared. The purpose of this operation is to have a graphical and visual portrayal which can be helpful for area statistics interpretation. The maps have been depicted in Fig. 4 to 5 and the attribute data of the supervised classification results have been given below:



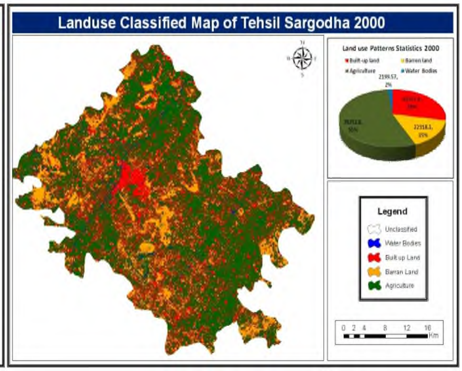
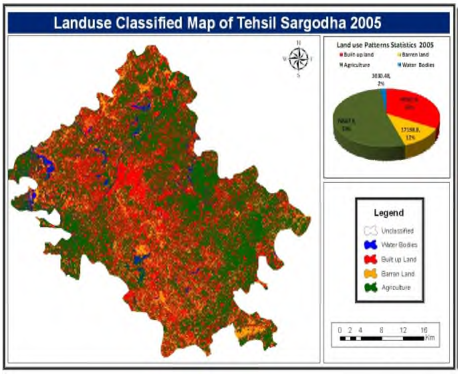


Figure 4. Land use Pattern-Sargodha,1992 **Figure 5:** Land usePattern-Sargodh,-2000



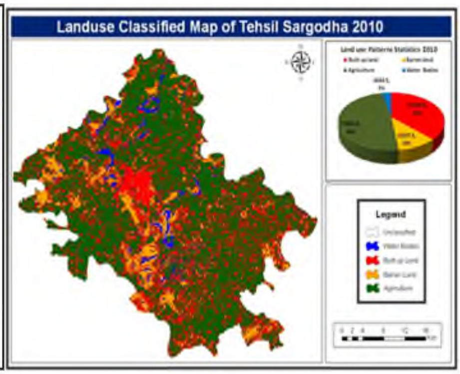


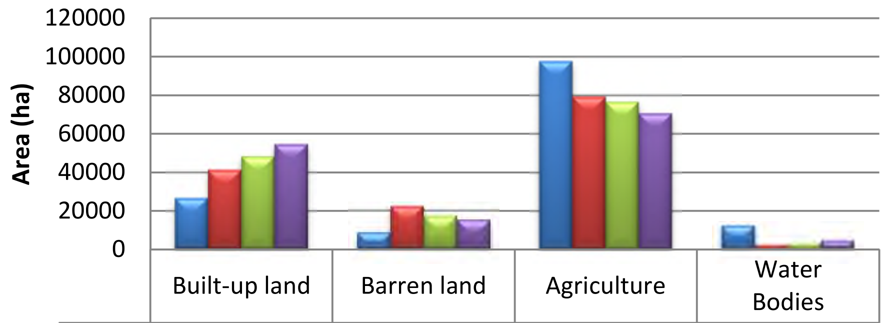
Figure 6: Land use Pattern-Sargodha- 2005 **Figure 7:** Land use Pattern-Sargodha 2010

Table 3: Area statistics and pattern percentage of land use units in 1992-2010

Land use category	1992		2000		2005		2010	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Built-up land	26511.4	18	41207.4	28	48160.6	33	54440.9	38
Barren land	8566.8	6	22318.1	15	17198.8	12	15247.5	10
Agricultural land	97527.8	67	79252.8	55	76587.9	53	70594.9	49
Water Bodies	12371.9	9	2199.57	2	3030.48	2	4694.5	3
Total	144977.9	100	144977.87	100	144977.78	100	144977.8	100

There are many methods for the measurements and interpretation of the results related to urban land use. Out of many, one of the most important methods to present the data of every successive year about the land use change in the form of a table and from these tables comparison about the yearly urban growth and land use change statistics may be calculated. During the process of examining several distinct trends and patterns of change have been analyzed about the land use/land use types. Fig. 8 depicts the relative land use change trend from 1992-2010 for the Sargodha city. There was growing trend in areal extent and also increase in urban built up. Land use changes have taken place during the study period, whereas agricultural land decreased consistently during the four periods. It is pertinent that all other categories are showing declining trends during the study period.

It is also evident from the change values shown in the Table 3 that other land use categories especially agricultural land in the city have been converted into built up land use category which in itself and contributed towards the growth of urban built up land during the 19 year of study period (1992-2010). These land use changes have shown a noticeable change in the city in the form of residential colonies around main roads leading to other cities of the Punjab. The detailed information and relevant statistics, classification results and their graphical depiction through graphs and visual comparison to demonstrated the relative land use changes in each defined category of the concerned urban morphology.



	Built-up land	Barren land	Agriculture	Water Bodies
1992	26511.4	8566.8	97527.8	12371.9
2000	41207.4	22318.1	79252.8	2199.57
2005	48160.6	17198.8	76587.9	3030.48
2010	54440.9	15247.5	70594.9	4694.5

Figure 8. Nature of relative land use changes from 1992 to 2010

The result of the accuracy assessment has been shown in a random sample Listing and as an accuracy statistic. The Random Sample Listing report is used to decide which category was classified correctly or not. The results derived from temporal pattern maps of Landsat digital data regarding land use for four different years e.g.; 1992, 2000, 2005 and 2010 images confirmed an overall accuracy of 79%, 80%, 81% and 82%, respectively. Overall this result is considered to be good for an accuracy assessment and practically recognized for the change detection and following analysis. Kappa statistics/index was calculated for each classified map to determine the results accuracy. Table 5 revealed the Kappa statistics conclusion in percentage derived after classification of Landsat land use/cover maps of the four years of 1992, 2000, 2005, and 2010.

Table 5. Overall Accuracy and Kappa (κ) Statistics

Division	1992	2000	2005	2010
Overall Classification Accuracy (%)	79.19%	80.42%	81.15%	82.07%
Overall Kappa (k) Statistics	.6766	.6909	.7327	.7326

Our major concern related to this study was to have an insight into various land use present in the study area. However this study also placed an emphasis on the urban growth analysis keeping in view the class of urban built up and non- built up land use category. Today, adetailed land-use map is no longer required for city and regional planners and policy makers in mega cities of the world as well as in Pakistan. Presently double classification of Satellite Remote Sensing data is sufficient for the city managers and related administrators. Table 6 depicts the numerical deductions derived after images reclassification. The purpose of reclassification of all the four images into two main classes of built-up and non-built up parts for four temporal intervals will help in having a bird's eye view of the study area and help us to understand the gravity of the issue under consideration. These maps are actually evidence and later verify about the current dynamics related to spatial urban land use development and growth patterns. The graphical depiction of all the land use changes which have taken place in Sargodha in the forms of maps provide detailed information about the degree and ratio of urban land use variations occurred in the stipulated time span. Like all previous work of this nature the agriculture fields/lands are gradually diminishing and converting into built-up neighborhoods of the city .This can be easily identified through these maps. In conclusion, quantification processes have been used for calculation, comparison and summarization of the data regarding the spatio-temporal changes which have taken place in the urban land use of Sargodha.

Table 6. The Spatio-temporal Patterns of the Built up area change

Land use	Area in hectare			
	1992	2000	2005	2010
Built-up land	26511.4	41207.4	48160.6	54440.9
Non- built-up	118466.5	103770.47	96817.18	90536.9
Total	144977.9	144977.9	144977.9	144977.9

Fig.9 revealed the change of statistics with regard to built-up and non-built up Land use classes. It is evident from the numerical illustrations that the built-up region has grown tremendously during the study period; 1992 to 2010. However urban built land use is highly interrelated to the urban population growth which in most of the cases served as an impetus to bring change in built up land use to increase with a great deal.

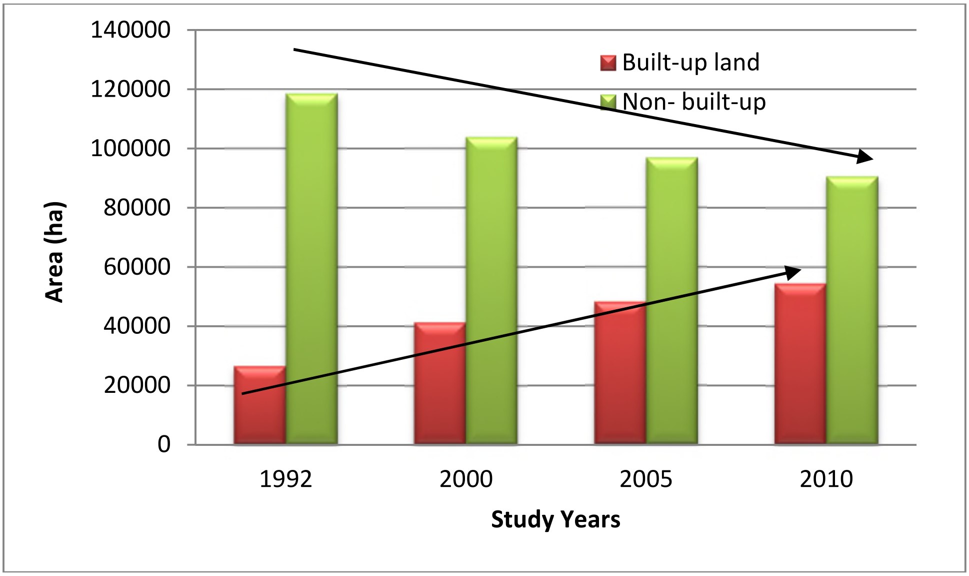


Figure 9. Land usepattern quantification in 1992, 2000, 2005 and 2010

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