Temporal Analysis of Land Use and Land Cover Changes in Lahore-Pakistan

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Today, the population of the world is more than 7 billion and more than half of it is living in cities and defined urban areas. This ever increasing population has altered and modified most of Earth's land surfaces. The processes of urbanization and urban development together with technologies have brought about change in the land use and lands cover (hereafter referred to as LULC), both at global and regional scale in due course of time. Pakistan is by no means an exception and all the major cities of the country are experiencing the change. Remote sensing data with auxiliary techniques provide dependable, updated and precise information for LULC mapping and future planning. This research paper aims at better understanding of the land use and land cover classes and subsequent change for the Lahore district (Punjab) by using three sets of Landsat images (1992,2001 and 2009). A systematic on-the- screen visual image interpretation approach was used to delineate the land use classes using GIS software. Based on visual image interpretation techniques; the author divided the study area into five classes (built-up, vegetation, open area, water bodies and mixed class).All these classes have recorded marked changes. The results of present LULC research can be of use both at macro and micro level in urban and regional planning in the district of Lahore.

Key words: LULC,GIS, Remote Sensing, Spatial Growth, Anthropogenic

Introduction

Lahore is the capital of the province Punjab and is the second largest city in terms of population in the country. Since this City is historical one and has undergone a remarkable expansion, growth and developmental activities such as buildings, road construction, and loss of prime agricultural fields as well as many other anthropogenic activities since 1970's .This situation is like many other provincial capitals of the country, such as Karachi, Peshawar and Quetta as well as many developing cities of the country. This has, therefore, resulted in increased land consumption, modification and alterations in the temporal status of City's land use and land cover. It is the prima foci of this research paper that without any detailed and comprehensive study to evaluate the present scenario of Lahore district as it changes over time, planners and policy makers cannot assess the magnitude of the socio-environmental problems. By under taking this with a view to detect the land consumption rate and also make attempt to predict the same for years to come. This can easily be deduced and the possible changes that may occur in this city can be judged by the planners who can have Remote Sensing and Geographical Information System as a basic tool for planning. It is therefore necessary to undertake study such as this to be carried out if Lahore shall have to avoid the associated problems of a growing and expanding city like many others in the world.

As stated earlier, Lahore is a mega city, as well as the capital of Punjab province. It is located between 31° 15' and 31° 43' North latitude and 74° 10' and 74° 39' East longitude. The city, on the average is 213 meters above mean sea level. The Lahore district has an area of 1,772 sq. km or 680 sq. miles (GoP 2002). In terms of population size it is the second biggest city after Karachi in Pakistan. The total population of the City as enumerated during 1998 census period was 5,143,495 souls while

total estimated population of Lahore according to Punjab Development Statistics-2009 is 8,462,000 souls (GoP 2009).

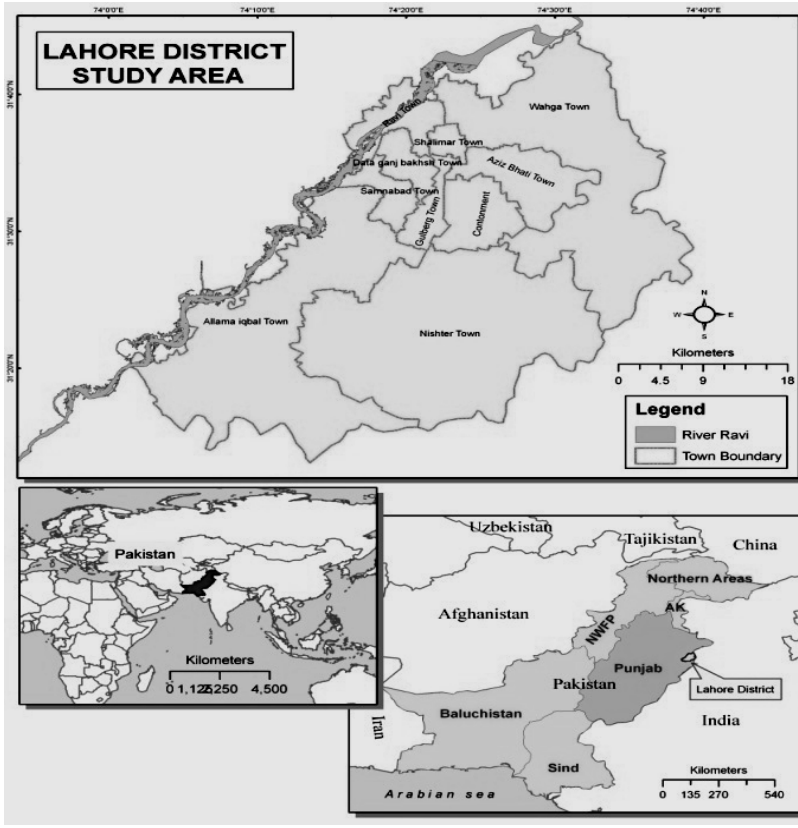

Fig.1 *Lahore-the study area in Pakistan*

The first few years after the Independence in 1947, in spite of a large influx of migrants from East Punjab (India) and a significant increase in the population, Lahore did not experience much of urban development. This was perhaps, owing to the unsettled conditions, but during the last 20 to 30 years a steady spatial growth of the city has been observed (Qadeer, 1983).

Rationale

Out of many, one key problem for developing countries like Pakistan is the haphazard urban development mostly without proper planning strategies. As a result of population growth (natural and immigration) some rapid development outcropping are usually take place and valuable agricultural land is being encroached. On the other hand, city managers and administrators cannot monitor emergence of this haphazard urban development without efficient knowledge and information. The technologies of GIS and Remote Sensing now have been combined to detect and control urban encroachment in a way which is easier and faster than the traditional methods of surveying the urban environment (Da Costa, 1999). Urban land cover types and their areal extent distributions are fundamental data required for a wide range of studies in the physical and social sciences, as well as by the city governments for land planning purposes (Stefanov, 2001). Today, the research related to land use and land cover changes, on both macro and micro scale has become an area of prime importance among the researchers particularly for those who are related to geographical sciences. Presently researches on global LULC change are generally based on regional case studies. The analysis of spatio-temporal process of land use and land cover changes on regional basis is the key factor in understanding the dynamic mechanism which brings about land use changes.

Land use and Land cover changes play an important role in the study and analysis of global changed scenario today. LULC caused by anthropogenic activities and natural modifications have largely resulted in loss of agricultural field, deforestation, biodiversity loss, global warming and increase of natural disaster and flooding (Mas, J.F, et al 2004, Zhao, et al 2004, Dwivedi et al 2005). These geo-environmental problems are often related to LULC changes. Therefore, available data on LULC changes can provide critical input to decision-making of ecological management and environmental planning for future (Fan, et al 2007, Prenzel, 2004).The increasing socio-economic requirements for growing

population ultimately create a pressure on land use/land cover. This pressure results in unplanned and uncontrolled changes in LULC (Seto, 2002). The LULC alterations are generally caused by mismanagement of agricultural, urban, water related issues, mountain eco-system, range and forest lands which lead to severe environmental problems such as landslides, floods etc.

Today, remote sensing and Geographical Information Systems (GIS) are powerful tools to derive accurate and timely information on the spatial distribution of land cover and land use changes over large areas all over the world (Carlson and Azofeifa 1999, Guerschman J.P 2003, Rogana J.; Chen, D.2004, Zsuzsanna, D 2005). Past and present studies conducted by organizations and institutions around the world, mostly, have concentrated on the application of LULC changes using RS and GIS. GIS provides a flexible environment for collecting, storing, displaying and analyzing digital data necessary for studying change detection (Yomralıoğlu, T 2002, Demers, M. N 2005, Wu, Q.; 2006). RSS information is the most important data source used in GIS and related technologies. Satellite imagery is used for recognition of synoptic data of earth's surface (Ulbricht, K.A and Heckendorf, W.D 1998).

Objectives

In this paper we will examine temporal urban land use and land cover (LULC) changes which have been taken place in Lahore, the capital city of Punjab over a period of seventeen (17) years through available Landsat images (1992, 2001 and 2009). In particular we shall concentrate upon two land use classes i.e. built up and open area.

Thus research paper has been carried out, keeping in view the following objectives:

1). To Identify and delineate different land use/land cover categories in Lahore using temporal remote sensing data (Landsat images)

2). To find temporal land use/ land cover changes in Lahore district (CDGL) and to detect the changes especially in built up areas, vegetative cover and open areas

3). To determine the magnitude of LULC changes in the city of Lahore

Generalized civic pictures as well as the LU and LC data are most important for urban and regional planners since they have to make arrangements for the earth resource management because of their economic importance. These data are usually presented in map form along with regional data sets for each utility component of land-use and land-cover. The acquisition and ultimate usage of RS data are above all suitable for the making of such maps. Presently the most common classification used in LULC studies is the one as advanced by Anderson *et al* (1976). It is easy and purposeful in evolving a broad based classification scheme well-matched with available remote sensing data and hence referred by US Geological Survey to the remote sensing scientists all over the world. All other classification schemes available in literature are based on the one given by Anderson.

Data and Methodology

In order to study LULC changes in a city like Lahore, three Landsat satellite images of Lahore district were acquired for 1992, 2001 and 2009 with the resolution of 30 meters/pixel (Bands 1, 2, 3,4,5,7 Path & Row No. 149-038). These three images were downloaded from Global Land Cover Facility (GLCF) an Earth Science Data Interface's website. The first and foremost step in image processing is the acquisition of an appropriate image. The choice of an appropriate image is a skill which one can learn with

the course of time and experience. However, suitable time, appropriate resolution, lesser price and availability are some of the important elements for obtaining an image. In addition to SRS data, a number of Lahore district maps are available in Department of Geography, University of the Punjab, Lahore and were also used for the research time to time.

The geo-referencing properties of all three (1992, 2001 and 2009) images were the same hence therefore, five software related to present research were used viz; Arc View 3.2, Arc GIS 9.2, ERDAS Imagine, Microsoft Excel and finally MS word was used for the final presentation of the research.

Based on the prior knowledge of the study area and a brief reconnaissance survey with additional information from previous research related to Lahore, a classification scheme was developed for the purpose. This includes built-up area, vegetative cover, open area, water bodies and mixed land use. The classification scheme developed in this paper gives a rather broad classification where the land cover land use was identified by a single digit.

By built-up area we mean all the buildings, roads and sealed surfaces found in Lahore. The definition of vegetation as used in this research denotes to all trees, all season crops and area , scrub, grasses as well as aquatic vegetation found in Lahore district. Similarly all the vacant areas, abandoned fields, patches of bare soils have been designated as open areas. River Ravi, Lahore Branch Canal and all the swampy areas have been classified as water bodies. Finally during classification all objects with spectral resolution less than 30 meters were treated as mixed class.

The Landsat images acquired from GLFC (USA) have been used as basic sources of data and to prepare LULC change detection maps. First, the shapfile of Lahore has been prepared under ARC GIS environment and then the same overlaid to the 1992, 2001 and 2009 images. After that, the usual procedures used in LULC studies have been adopted in a systematic manner.

LULC changes are visible all over the district of Lahore and although presently, the City of Lahore has been divided into nine towns and 150 union councils, but this study has been carried out for the whole district of Lahore, and the LULC change detection has been studied at district level. The calculation of the area has been presented in kilometers and the five land use/land cover types for each study epoch were identified. Finally we compared the results obtained through spatial matrix in ERDAS imagine. This sort of choice will provide a coherent basis for the research. As stated earlier that in the absence of data pertaining to this project, reliance has been heavily be placed on satellite images. GCPs and mapping of the surveyed areas with GPS and relevant information related to land use changes in the sample areas have been collected by the author himself. As stated earlier, analytical software, ERDAS imagine and ARC GIS 9.2 have been used to the available data and the GIS spatial databases have been prepared. Finally numerous numerical techniques have been employed to the available data for chronological change detection in Lahore district 1992-2009. Following is the stepwise description of the methodology adopted in present research. The procedure adopted in this research work laid down the source for deriving statistics of land use dynamics and subsequently in the overall findings of this paper.

Analysis and Results

The research results include the static and changed land use land cover of each class for the study period 1992-2009. Efficient monitoring of urban growth viz, a viz, LULC changes through SRS, proper management within an urban center and systematic further expansion, however could pave the way in improving the living standards and environmental conditions of the Lahore city. This will ultimately assist in city planners to highlight variety of problems related to city environment and also factors effecting the socio-economic situations and quality of life in the city.

Land Use & Land Cover Distribution

The static land use and land cover distribution for each study year as derived from the images have been presented in the table below:

Table-1
Land Use Land Cover Distribution of various Categories in Lahore District 1992, 2001 and 2009

LULC CATEGORIES	1992		2001		2009	
	AREA (Sq.Kms.)	AREA (%)	AREA (Sq.Kms.)	AREA (%)	AREA (Sq.Kms.)	AREA (%)
Built-up Area	911.14	51.42	1012.11	57.12	1268.85	71.61
Vegetative Cover	645.06	36.40	417.51	23.56	249.70	14.09
Open Areas	174.69	9.86	288.10	16.26	179.26	10.12
Water Bodies	15.95	0.90	25.31	1.43	34.95	1.97
Mixed	25.16	1.42	28.97	1.63	39.25	2.21
TOTAL	1772	100	1772	100	1772	100

Source: Author

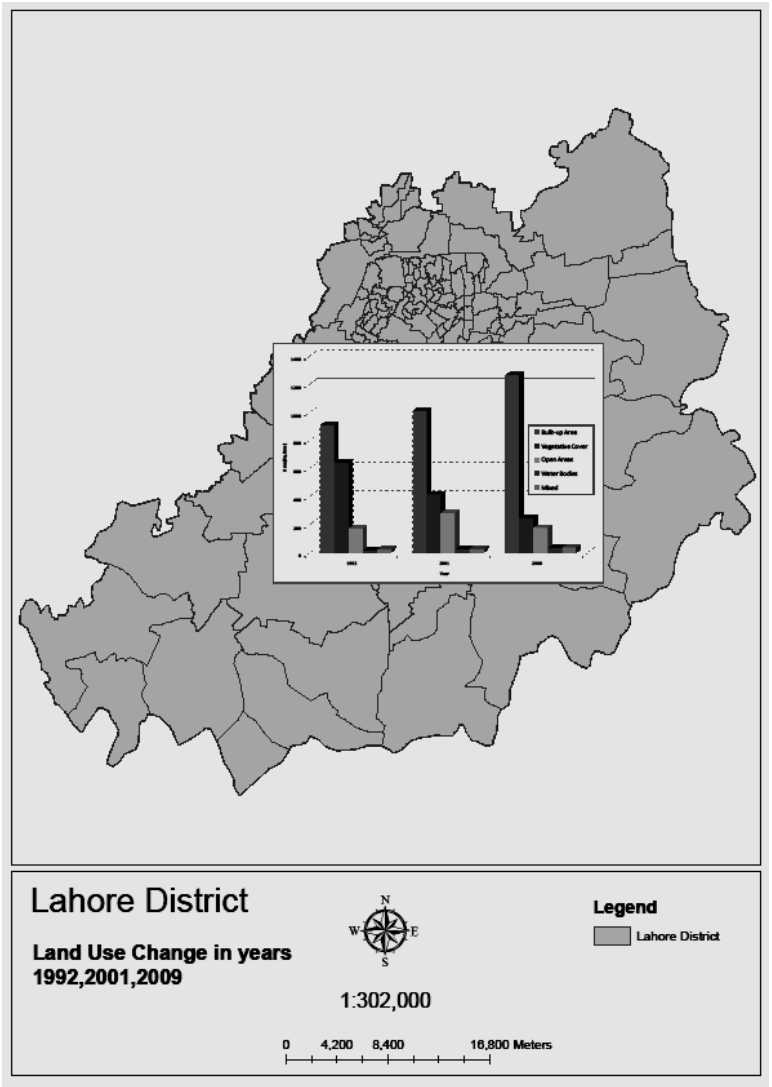

Fig.1 Source: Author

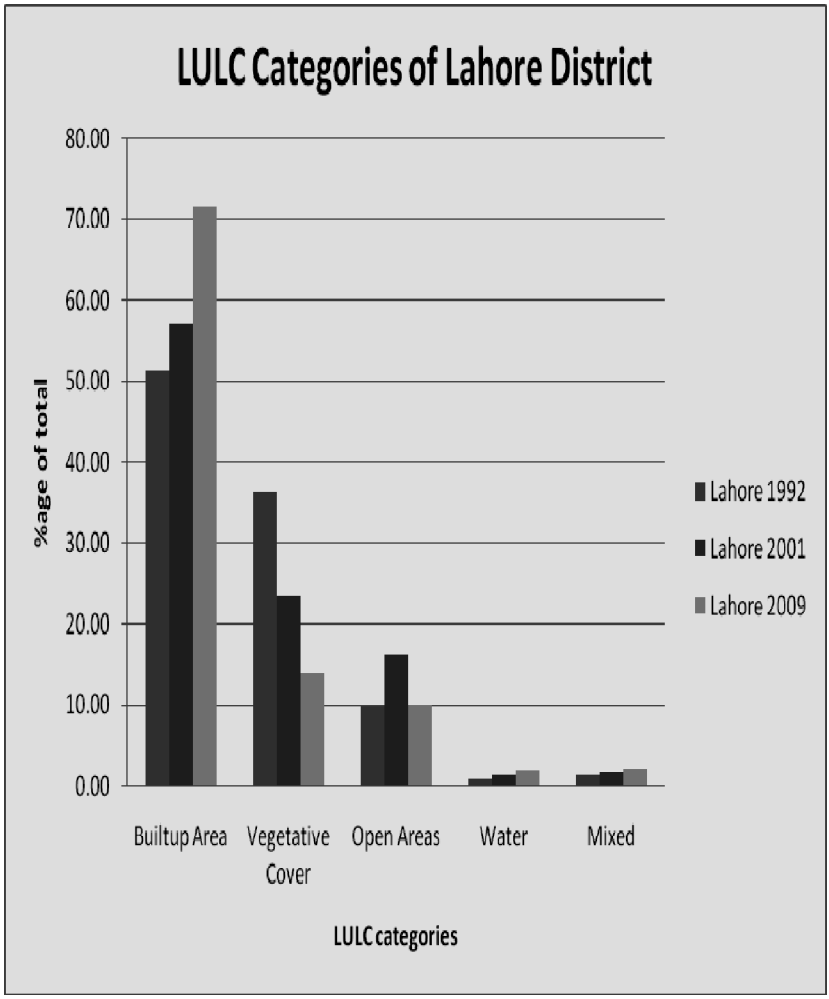

Fig.2

Source: Author

The figures presented in table 1 and Figs.2 & 3 above represents the static area of each land use land cover category for each study year. Built-up area in 1992 occupies more than 51.42% of the total area, followed by vegetative cover (36.40%), opens area (9.86%) and mixed and water bodies' categories 1.42% and 0.90%. The major category of built up area has been

shown consistent increase since 1992 i.e.; from 51.42% to 57.12% in 2001 while in 2009 it was 71.61 %. This may be due to the fact that Lahore being the provincial capital of the Punjab province remained major recipient of the migrants from all over the province as well as from many other areas of Pakistan.

Table-2
Change in LULC of various Categories in Lahore District 1992, 2001 and 2009

LULC Categories*	1992	2001	2009	Change 1992-2001	Change 2001-2009	Change 1992-2009	Annual Change
Built-up Area	911.14	1012.11	1268.85	100.97	256.74	357.71	21.04
Vegetative Cover	645.06	417.51	249.70	-227.54	-167.81	-395.36	-23.26
Open Areas	174.69	288.10	179.26	113.41	-108.84	4.57	0.27
Water Bodies	15.95	25.31	34.95	9.36	9.63	19.00	1.12
Mixed	25.16	28.96	39.25	3.80	10.28	14.08	0.83
Total	1772	1772	1772				

*In Sq.Kms
Source: Author

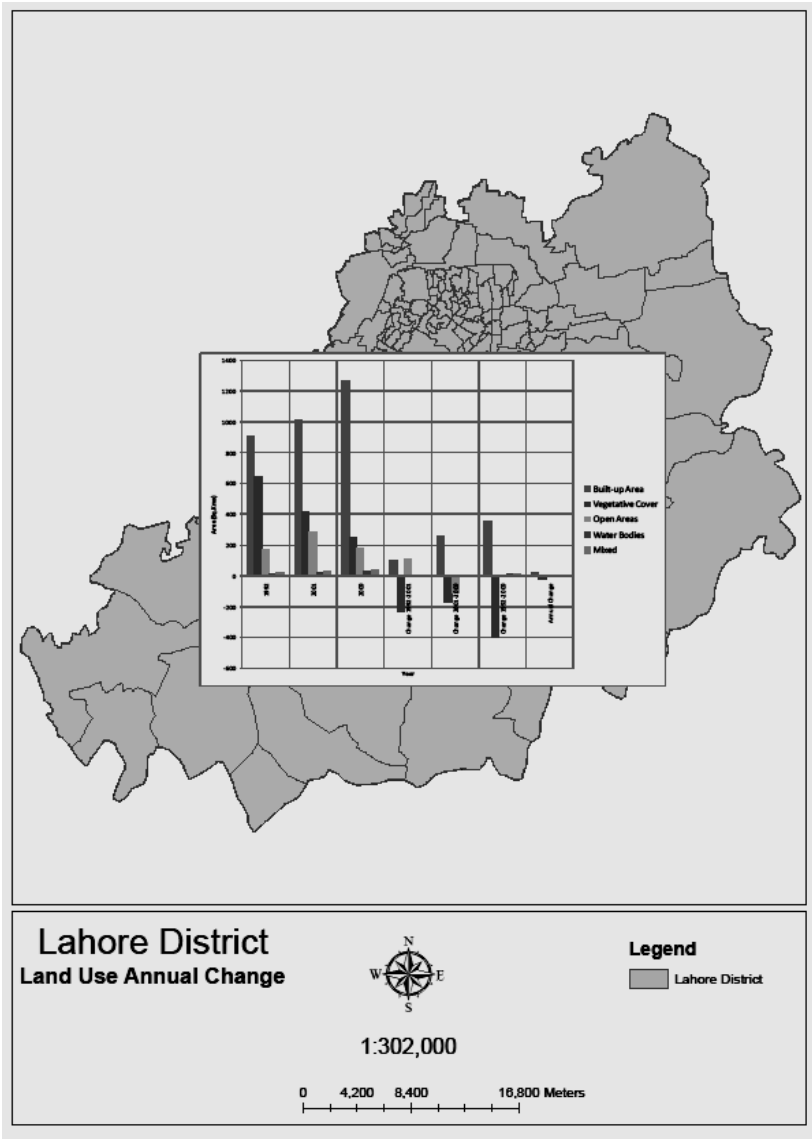

Fig.3Source: Author

From Table 2 and Fig.3 it is evident that the built up area has increased from 911.14 km^2 in 1992 to 1268.85 Sq.Kms in 2009 with annual increment of 2104 sq.kms. The temporal change in

this category was 100.97sq.kms during 1992-2001, 256.74 Sq.Kms in 2001-2009 while an overall change of 357.71 Sq.Kms was recorded during the entire research period i.e. 1992-2009 (17 years).On the other hand there has been recorded a constant decline in the vegetative cover in Lahore (Fig.3). This continuous decrease in vegetative/green cover in the CDGL is also an indication of rapid urban development which normally takes place at the expanse of prime agriculture lands and green areas of a city. On the contrary open areas have also shown a profound decrease e.g. 1992 this land use occupied an area of 174.69 Sq.Kms as against 179.26 Sq.Kms in 2009.Although water bodies have shown an increasing trend i.e. 1992 this LULC occupied an area of 15.92 Sq.Kms as against 34.95 Sq.Kms in 2009.The same is with mixed class categories of Land Use and Land Cover with an area of 25.16 Sq.Kms in 1992 to 39.25 Sq.Kms in 2009.

Findings and Recommendations

For balanced development of the City after 1947, a number of projects and plans were prepared. Prior to this study there have been a number of planning studies which highlight the land use as well as that of the city structure in the recent past. This daunting task therefore always carried out by government organizations. Notable work in this regard being the Master Plan for Greater Lahore, 1966, Lahore Urban Development and Traffic Study (LUDTS), 1980 and Integrated Master Plan for Lahore-2021 (executed by LDA). In all these studies the existing and proposed land uses were discussed but due to multifarious factors none of the study could come up with the recommendations set forth in each one. These plans however set a trend for all-round development of the city with emphasis on that city structure should be multi-functional and shall control strategic issues like housing, business centers, construction of new roads etc. The LULC change study of Lahore city opens many new areas of research in the subject.

Following is a brief review of the findings and recommendations of this research.

1. Marked changes in LULC in Lahore have been observed in Lahore within a time span of 17 years. As evident from the table and fig5.4, the area under built land use has increased from 911.14 km^2 in 1992 to 1268.85 km^2 in 2009(overall increase as percentage is 71.61%). Consequently the area under vegetation and open land has decreased. This situation is alarming because with this increase in urban land use, a number of associated problems will spring up. The demand for housing units and other civic amenities are increasing day by day. This brings implications to the fragile economy of the province. It is therefore recommended that the problem of crowdedness and congestion should be given priority by the city managers and people should be encourage to build new housing schemes/units towards the outskirts through the provision of incentives as well as constricting road network coupled with efficient transportation network.

2. The change in built-up area during 1992-2001 was 100.97% as compared to 256.74% during 2001-2009. The annual increase in the same has been observed 21.04 %. Similarly the percentage decrease in vegetative cover is much more rapid as compared to built-up area. The vegetative cover decreased by -227.54% during 1992-2001 period as against -167.81 from 2001 to 2009 time period. The overall change in this land use is astonishing i.e.; -395.36 % during the entire research span (1992-2009). On the other hand yearly change in vegetative cover was -23.26 %.This rate is higher than the rate of change in built up area during the corresponding period. This change

has transformed the valuable agricultural lands around the city to built-up areas causing numerous changes in its retail structure. Further, a number of environmental issues have been raised by NGOs and other human rights activists. In order to keep Lahore as a green city with its old green look, the city managers should invite local and foreigner investors to invest in the real estate, housing and construction enterprise.

3. Although there are different reasons for radical changes in LULC in Lahore. The growth and spread of the city is seen towards south-west direction. The reason is that the availability of well-constructed and connected roads provide means to residents for having residences far away from the main city center. It is the hypothesis of this research that there is likely going to be crowdedness brought by compactness in Lahore in the years to come. This condition will have adverse repercussions in the area because of the allied difficulties connected to the urban sprawling, environmental issues, transportation problems, lack of civic amenities, crime and associated social issues. It is therefore suggested that people of Lahore should be encouraged to build new residential neighborhood towards the outskirts through the provision of incentives and forces of attraction that are available at the city center.

4. The population of Lahore is increasing rapidly since 1951 Census and has also shown remarkable changes between the period of 1992 and 2009. It has now become very difficult for the CDG of Lahore to provide residential facilities to this ever growing population. The union councils which are part of old Lahore or located within walled City are overcrowded and congested because of this

population increase in the City. The physical expansion of Lahore does not seem to be halt in near future and there are possibilities of continual reduction in two of its main LULC class i.e. vegetative and open area over the next few decades. This may therefore be suggested that the city has to be developed along the main roads particularly towards Raiwind road, Multan road and along Canal road towards Wagah border. It is also suggested that CDG of Lahore may increase urban producing functions at the periphery of Lahore that attracted migration into the inner City. It is also suggested that Punjab government should encourage investors both local and foreign and more importantly to invest in construction and real estate sectors.

Notes and References

Anderson *et al* (1976). *"A Land Use and Land Cover Classification System For Use With Remote Sensor Data"* Geological Survey Professional Paper 964United States Government Printing Office, Washington

Carlson, T. N.; Azofeifa, S. G. A (1999). Satellite Remote Sensing of land Use changes in and around San Jose´, Costa Rica. *Remote Sensing of Environment*, *70*, 247–256.

Da Costa, S.M.F., Cintra J.P., (1999), Environmental Analysis Of Metropolitan Areas in Brazil, ISPRS Journal of Photogrammetry & Remote Sensing, Vol.54, pp.41-49.

Demers, M. N. (2005) Fundamentals of Geographic Information Systems, John

Dwivedi, R.S.; Sreenivas K.; Ramana, K.V. (2005) Land-use/land-cover change analysis in part of Ethiopia using Landsat Thematic Mapper data. *International Journal of Remote Sensing*, 26(7), 1285-1287.

Fan, F.; Weng, Q.; Wang, Y (2007). Land use land cover change in Guangzhou, China, from 1998 to 2003, based on Landsat TM/ETM+ imagery. *Sensors*, *7*, 1323-1342.

Govt. of Pakistan, (2004) City Report Lahore Population and Housing Census 1998, Islamabad Statistics Division Population Census Organization

Govt. of Pakistan, (2009) Economic Survey of Pakistan -2009 Islamabad p.180

Govt. of Punjab, (2009) Punjab Development Statistics-2009 Lahore p.300

Govt.of Pakistan, (2004) City Report Lahore Population and Housing Census 1998, Islamabad Statistics Division Population Census Organization p.21

Guerschman J.P.; Paruelo, J.M.; Bela, C.D.; Giallorenzi, M.C.; Pacin, F. (2003) Land cover classification in the Argentine Pampas using multi-temporal Landsat TM data. *International Journal of Remote Sensing*, *24*, 3381–3402.

Mas, J.F.; Velazquez, A.; Gallegos, J.R.D.; Saucedo, R.M., Alcantare, C.; Bocco, G.; Castro, R.;

Fernandez, T.; Vega, A.P. (2004)Assessing land use/cover changes: a nationwide multidate spatial database for Mexico. *International Journal of Applied Earth Observation and Geoinformatio*n, *5*, 249-261.

Prenzel, B. (2004) Remote sensing-based quantification of land-cover and land-use change for planning. *Progress in Planning*, *61*, 281–299

Qadeer M.A (1983) Lahore Urban Development in the Third World Vanguard Books Ltd. Lahore pp.70-88

Rogana J.; Chen, D. (2004), Remote sensing technology for mapping and monitoring land-cover and land use change. *Progress in Planning 61*, 301–325

Seto, K.C.; Woodcock, C.E.; Song, C.; Huang, X.; Lu, J.; Kaufmann, R.K. (2002) Monitoring land use change in the Pearl River Delta using Landsat TM. *International Journal of Remote Sensing*, *23*, (10), 1985-2004.

Stefanov, W.L., Ramsey, M.S., Christensen, P.R., (2001), Monitoring Urban Land Cover Change: An Expert System Approach to Land Cover Classification Of Semiarid to Arid Urban Centers, Remote Sensing Of Environment, Vol.77, pp.173-185.

Ulbricht, K.A.; Heckendorf, W.D. (1998) Satellite images for recognition of landscape and land use changes.*ISPRS Journal of Photogrammetry & Remote*

Sensing, *53*, 235-243.Wiley&Sons, Inc., New York, USA pp.134-45.

Wu, Q.; Li, H. Q.;Wang, R.S.; Paulussen, J.; He, H.; Wang, M.; Wang, B.H.; Wang, Z. (2006) Monitoring and predicting land use change in Beijing using remote sensing and GIS. *Landscape and Urban Planning*, *78*, 322–333.

Yomralıoğlu, T. CoğrafiBilgi (2002) SistemleriTemelKavramlarveUygulamalar, SeçilOfset, Istanbul, Turkey pp.22-34.

Zhao, G.X.; Lin, G.; Warner, T (2004) Using Thematic Mapper data for change detection and sustainable use of cultivated land: a case study in the Yellow River delta, China *International Journal of Remote Sensing*, *25* (13), 2509-2522

Zsuzsanna, D.; Bartholy, J.; Pongracz, R.; Barcza, Z (2005). Analysis of land-use/land-cover change in the Carpathian region based on remote sensing techniques. *Physics and Chemistry of Earth*, *30*, 109-115.

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