Appraisal of the Change in spatio-Temporal Patterns of Lulc and its Impacts on the Vegetation of Lahore, Pakistan

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This research paper demonstrates the findings of micro level Land Use and Land Cover (LULC) changes in Lahore District of the Punjab, Pakistan. The topographical maps published by Survey of Pakistan along with 36 year's time series (1973-2009) of Satellite Remote Sensing (SRS) data has been used to document the changes in the urban areas. The maximum likelihood supervised classification method was employed to infer information from SRS data, while post-classification change detection technique was used to identify the land use and land cover change in selected classes. For the detailed candid analysis, the Quick Bird and Geo-Eye Imageries have also been used through the free-web of Google-Earth. The overall accuracy assessment is ranging from 70-80%.The study reveals that the LULC change in Lahore district has caused a substantial decrease in her vegetative cover. The spatio-temporal analysis for vegetation *vis-à-vis* built-up and open areas with the help of geo-spatial technologies has been completed with intervals like 1973-1992 (19 years), 1992-2001 (10 years), 2001-2009 (9 years) and

1973-2009 (37 years) as a whole. The change in vegetative cover *viz-a-viz*; built-up area and open areas have been documented at a micro administrative unit like Union Councils (UCs).Although the damage is catastrophic in various Union Councils, however, in few Union Councils (for example Model Town) vegetation is well maintained. Cartographic analysis reveals astonishing results which ultimately pinpoints the cluster of Union Councils devoid of vegetative cover (few Union Councils from *interior* Lahore).In this paper an attempt has been made to explore the question of drastic changes in vegetation in various UCs of Lahore. It is important to evaluate the green cover of which UC is deteriorating at an alarming rate and which at the lower pace.

Drastic changes in land-use and decline of land-cover is a typical characteristic of the cities of developing countries. Today, the Land-Use and Land-Cover changes and urbanization are considered potent and the most widespread anthropogenic causes of the loss of arable land and decline in natural vegetation cover (Lopez *et al.,* 2001). The transformation of rural areas into urban settlements through economic development and population growth is taking place at an alarming rate in the recent times. At present, the designated urban areas in the world cover only 3% of the Earth's land surface; still they have visible effects on environmental conditions at both local and global scales (Herold*et al.,* 2003), including climate change (Grimm *et al.,* 2000).Since the urban areas around the world are increasing and expanding rapidly, therefore, present century is reckoned as the "urban century". In most countries of the world, the main focus by the administrators has been on the cities, which reflects awareness of the governments regarding a growing percentage of the world's population living in cities. In the environmental context, the cities and major towns are believed to be the key producers of a number of global concerns related to the quality air and water, waste disposal, and loss of vegetation and productive agricultural areas.

Today, the urban vegetation studies play an important role in urban and regional planning, understanding of the environmental issues, and continuity in the development of policy initiatives. Therefore, specific, dependable and consequential measurement of LUL *viz-a-viz* information about urban vegetation cover helps the decision-makers of the City District Government, relevant authorities and the urban researchers to achieve their goals to streamline the future growth of the city. Vegetation incorporated into the urban setting has an environmental role and a societal value that helps sustain public health and well being (Williams *et al.,* 2009). Plants can filter air by physically trapping particles, such as dust, from the atmosphere and absorbing harmful gases (Beckett *et al.,* 1998). Vegetation may also retain and store water; this allows for natural drainage which reduces surface runoff and, therefore, reduces the risk of flooding (de Groot *et al.,* 2002). Vegetation can regulate climate and can reduce effects of wind and provide shelter during both warm and cold weather (NUFU, 1998; Dimoudi and Nikolopoulou, 2003). Vegetation in the urban environment provides habitats for wild life and, therefore, can help maintain and enhance biological and genetic diversity (Attwell, 2000). Disturbed ecosystem always dominated by the alien species and creates an imbalance for the habitats of species. The aesthetic value of vegetation can enhance residents' satisfaction, attachment and sense of responsibility, thereby, improving their overall well being (Groenewegen *et al.,* 2006). Urban greenery can also provide opportunities for education and encourage physical activity (De Vries*et al.,* 2003). Access to urban green spaces is usually free to all, which is why they promote social inclusion and provide opportunities for social interaction (Swanwick*et al.,* 2003). Vegetation can also reduce noise and pollution at the significant levels. Only very dense vegetation cover can physically diminish noise levels, but there is evidence to suggest that screening the source of noise by trees can reduce the perceived noise levels (Anderson, 1984). Studies have found a positive correlation between property prices and a close proximity to green areas (Luttik, 2000; Tyrväinen and Miettinen,

2000). According to the Commission for Architecture and the Built Environment (2004), the provision of quality urban green space can enhance a city's reputation for high-quality living environments and urban governance.

In this paper, the word "vegetation" is used for all those plants found in the district of Lahore, hence, refers to the ground cover provided by the plants, trees and forests, weed patches, crop fields, roadside vegetation(natural and planted), privately owned gardens and lawns, parks, aquatic and marshy vegetation and green spaces maintained by public and private enterprise; all are encompassed by the term *vegetation*. (Qureshi *et al.*, 2010; James *et al.*, 2009; Breuste, 2009; Borgström, 2006)

Study Area

Lahore, the capital of Punjab province is the second largest city in terms of population size in Pakistan. It has a westerly location in the sub-continent and has an inland location in the Indus plain far away from the Arabian Sea. It stands on a widely-terraced alluvial plain to the left bank of river Ravi. Lahore extends from 31° 15' and 31° 43' N latitude and 74° 10' and 74° 39' E longitude, which fevers the good amount of vegetation. It covers an area of 1,772 sq. Km (GoP, 2000).The soils are young, show no signs of profile development and are underlain by sand at relatively shallow depths. Since the study area has westerly location in relation to the main monsoon region of South Asia, therefore, Lahore experiences an extreme continental type of climate and experiences three well-marked seasons, *viz*; winter, summer and rainy monsoon. The monsoon rainfall is quite supportive of vegetation which is further supported by canal and river networks of Lahore. The vegetation of the city comprised mainly of numerous indigenous trees like, *Kikar (Acacia arabica), Shisham* or *Tahli (Delbergiasissoo), Beri (Zizyphusjujuba), Toot (Morus alba), Sharian (Albizzialebbek), Dhareak (Meliaazedarach), Phuali (Acacia modesta). Pipal (Ficusreligiosa)* and *Bohr (Fieusbengalansis)* are planted for shade and beauty. Similarly, the growth in the *Rakhs* is

composed mainly of three kinds of trees *Jand (Prosocpisspicigera), Karil (Capparisaphylla)* and *pelu (Salvadoraoleoides)*. Occasionally, *Rero (Acacia ieucophhloea)* and *Farash (Tamarixarticalata)* are also found.Pilchhi *(Tamarixdioica)* is found on moist sandy soil along the river and is used for wicker work, basket making etc. (GoP, 2000). However, many of these indigenous trees are now found in very small numbers within the city, at many places these has been replaced by the fast growing exotic species. Few of these species like *Pelu, Pipal* and *Farash* are about to extinct or found in rare frequencies.
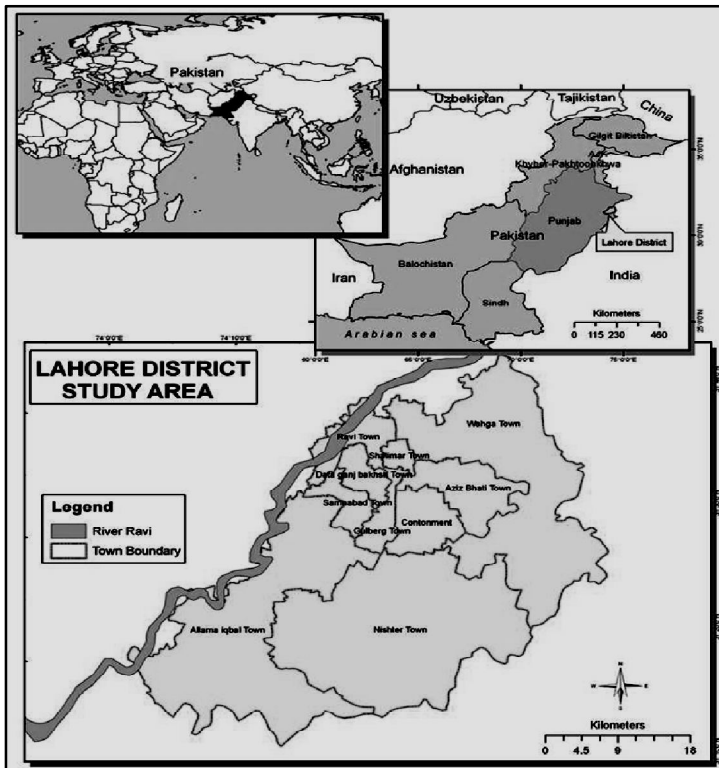

Fig. 1 Location Map showing Lahore - the Study Area

In Pakistan, until recently the urban population has been growing at the rate of 2.9 percent per annum, mainly due to rural-urban migration. With increasing share of the urban

economy to country's development, the management of urban areas, particularly the metropolitan areas and the mega cities like Karachi and Lahore will play a key role in the national economic development in the years ahead. Unfortunately, the urban centers in Pakistan are characterized by haphazard growth and development, congestion, loss of prime agricultural lands, problems of pollution, urban sprawl (including unplanned settlements along the national highways adjacent to metropolitan areas), and the loss of indigenous urban vegetation (which, itself, has been the characteristic feature of Lahore's landscape).In Pakistan, for example, the total urban population has increased from 32.5 percent to 36.89 per cent in the year 2009 (GoP, 2009) and two of the major cities in the country (Karachi and Lahore) have achieved the urbanization level of the developed countries, that is, 80 percent of the total population. Rural-urban migration, natural increase, foreign and local investment in the agricultural, commercial and many other sectors were the main factors leading to the growth of cities as well as the urban population in Pakistan. The increase in urban population concentration and new built up areas, directly or indirectly, affect vegetative-cover-changes during the course of a changed geographical set-up.

There are no qualms that the city development is often a compromise on agricultural or forested land. Lahore is no exception to this thumb rule, as LULC changes in this city has caused increased pressure on the urban vegetation and contributed to a big loss of the city's centuries-old green character. Large-scale residential and infrastructural development since 1970s and after had cleaned most of the indigenous vegetation before proceeding with the urban development. It is not only the conversion of green areas into grey areas but city planners are expanding the city without any flora policy and green spaces.

Data Sources

LULC changes and areal expansion of a city and its impact on the vegetation, crops and agricultural land is difficult to monitor with traditional mapping techniques, yet essential for the implementation of effective environmental and urban planning strategies at both macro and micro levels. For the present study, Landsat satellite images of Lahore were acquired for the years 1973, 1992, 2001and 2009. All these four images were obtained from the Global Land Cover Facility (GLCF), *viz;* Landsat MSS (March 23, 1973), LandsatTM (October25, 1992), Landsat ETM (September 30, 2001) and Landsat ETM (September 28, 2009).Though one could develop a consistent time series, however, because of data unavailability and cloud coverage, it was difficult to keep the identical intervals. All of the images are post monsoon season and having a little difference in the date of acquisition except the 1973 on MSS, which was acquired in pre-monsoon season. For the detailed candid analysis, the Quick-Bird and Geo-Eye Imageries have been used through the free-web of Google-Earth to explore the ground reality on a higher scale.
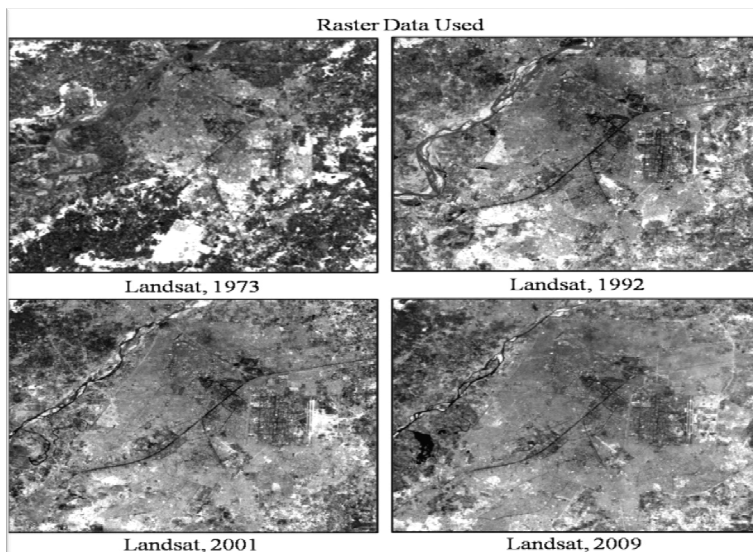

Fig. 2 Raster Landsat data showing the radical change in vegetation (in red)
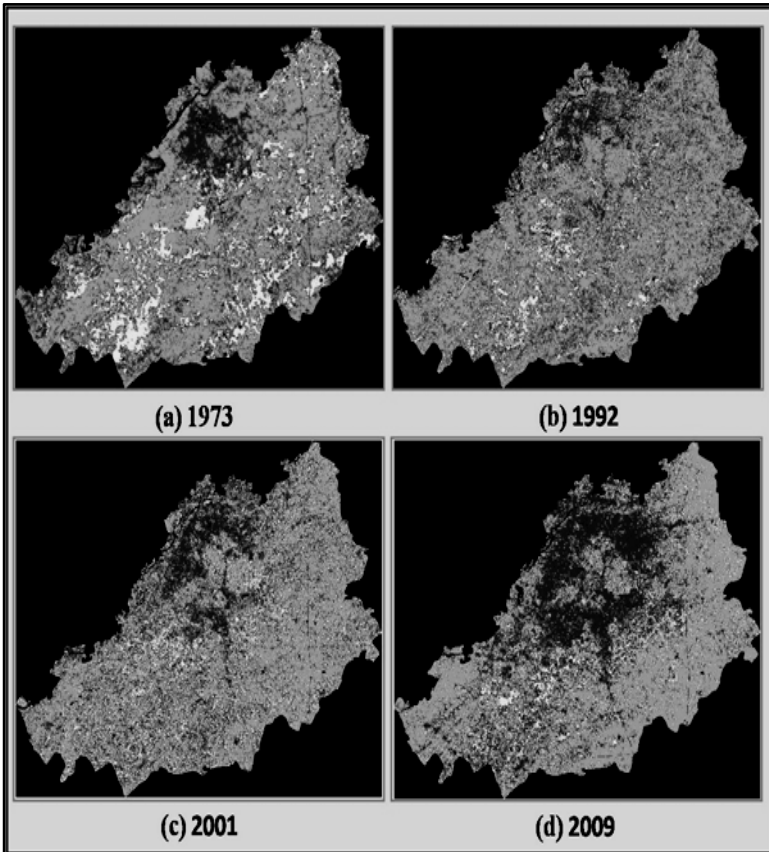
Fig.3 Classified images of CDGL showing the expansion of the Urban areas

   Ancillary data were drawn from various topographical maps published by Survey of Pakistan. These were large-scale maps of 1: 50, 000, while another important source has been the Lahore guide map, which proved useful and removed number of discrepancies. Most of statistical data have been drawn from various sources namely, census of population (various years), *i.e.* from first census report 1951 up-to the latest census of 1998. The latest Census report of 1998 is the only authentic and reliable demographic data available in Pakistan. In addition to this, a number of estimated population data through various

governmental organizations has also been utilized. Similarly, the census report of CDG of Lahore provided socio-demographic data pertaining to Lahore up to UC level. These data sources helped in proper availability of demographic data as well as information of various administrative units. Another important report had been LDA Integrated Master Plan of Lahore 2004, which provided LDA Analysis zone/Union Councils maps and details of land use in Lahore.

Methodology

In this paper a modified version of the Anderson Scheme Level-I was employed for the comparative assessment of built up area and vegetation changes (Anderso n*et. al*, 1976).In addition to this, two more categories were also evaluated and change was determined. Although spatial resolution of the images varied from 30 to 70meters, yet the same were considered in devising the classification scheme. Five major LULC categories were identified: vegetation/cultivated land, built-up area/land, open area/land, water and mixed land use. As a first step all available LDA maps, topographical sheets of the area and some other maps were scanned and saved in jpeg format (jpg) at different resolutions. JPEG (Joint Photographic Experts Group) files are lossless compressed image files and are commonly used for images. All these maps were geo-referenced by using Arc GIS 9.2 geo-referencing tools. Landsat images were used along with the GCPs collected through GPS devices for image rectification.

Table 2
Land Use/ Land Cover Classification Scheme of Lahore

LULC types	Description
Vegetation/cul tivated land	Trees, parks, gardens, grasslands and cropped areas in and around urban areas of CDGL.

Built-up/ Urban area	High, Medium and Low Built-up areas of the city, Commercial, industrial, institutional and administrative areas. Impervious land and roads.
Open Area/Land	Bare soil ,play grounds, golf courses, abandoned /dry agricultural fields/farmlands for new residential areas
Water	Ravi River system ,canal and seasonal ponds
Mixed	Land cover components, such as roofs, trees, and narrow roads, shadows of buildings and the real complexity of the land cover of Lahore which is difficult to distinguish or resolution less than 30 m with mixed pixels.

All these maps were geo-referenced with UTM WGS84 Zone 43 N Coordinate System as the image was using the same co-ordinate system. Landsat and Google images were also used as background source of information for the digitization of urban infrastructure. These images cover the whole area of City District Lahore and the accuracy was then made through GCPs. These images were then spatially geo-referenced to a Universe Transverse Mercator (UTM) projection using first order polynomial and were re-sampled with nearest neighbour algorithm. Ground Control Points (GCPs) were selected from Landsat TM image and topographical sheets of the Survey of Pakistan. A root means square of one pixel (30 m) was accepted for rectification.

At the first stage, the Lahore Development Authority (LDA) Analysis Zones / Union Council map was extracted from the Integrated Master Plan of Lahore. The map collected from Master Plan 2004 was scanned with the help of HP Desk Scan software. Then, the scanned image was pulled on Arc GIS 9.2 for the on-screen digitization. This file was then retrieved into ERDAS Image as a vector layer.

As stated earlier, four low resolutions (80, 30, 30 and 15 meters) Landsat Orthoready images were acquired from GLCF covering almost 1772 sq. km. (the whole of area of CDG Lahore). It consists of 10 scenes overlapping each other, taken during 1973 to 2009(Fig.2). The images were received in TIFF (Tagged Image File Format) file format which was compatible with many GIS and RS software like ArcGIS 9.2 and ERDAS IMAGINE 9.1, respectively, and then exported to image (img) file format. TIFF (Tagged Image File Format) files can store pixel data at several bit depths and can be compressed with any of a selection of compression techniques. They are the best choice for importing into image editing applications across operating systems (ESRI, 2005).

All the layers captured in Landsat bands were stacked together and the subsets of those images were prepared according to the available shap file of Lahore. After that, each UC was delineated from the major subset of Lahore in order to make the individual subset image of all the Union Councils. Since shap file contained 151 polygons, therefore, subsets were made according to each polygon. Then, a view in ERDAS IMAGINE 9.1was opened and each UC's AIOs were classified (supervised classification) into the desired five classes. Similarly, we repeated the same procedure for remaining Union Councils. In order to verify ground realities, Google earth image was used to arrive at rational classification and to identify the pixel class. While classifying the area of interest / intent, each polygon was exported in to Arc GIS and made KML of each exported polygon/ Union Councils and then overlaid each polygon on to the Google earth for further verification of the classification of area. Change detection technique was utilized to identify the areas of significant change, which derived the areas of major changes through ERDAS Imagine technology.

Results and Discussion

At present CDGL has been divided in to nine Towns, and these towns have been further divided into 150 Union Councils. Out of these 150 UC's, 132 are urban while remaining 28 are rural by definition. There is no rural Union Council in Ravi Town, Shalimar Town, Data Ganj Baksh Town, Samanabad Town and Gulberg Town as these Towns comprised of urban areas only. As stated earlier, 28 Union Councils are part of rural Lahore. In addition to this, there is a Cantonment in CDGL covering a sizeable space of the study area. One of the most important components of a GIS is the development of the geo-database. The initial stages of GIS development entailed a need assessment. Data sets for specific purpose are taken. The most significant available data includes geographical entities and attribute data. After this the database was integrated with spatial objects on the map.

Since the research is related to LULC and vegetation loss, therefore, a comparison between the two is logical in order to understand the temporal changes. In addition to this, an important aspect of land use assessment is the monitoring availability of open spaces in order to grow vegetation and built-up area. Tables drawn from SRS data shows the percentage change in vegetation, built-up area and open area in Lahore by the Union Councils during the study period, that is, 1973-2009.

For more details of the vegetation loss and LULC changes within Lahore, it looks appropriate to analyze the change during 1973-2009 (Fig.4). For the sake of temporal analysis of change in the percentage of vegetation in Lahore, we have calculated the change for the periods 1973 to 1992, 1992 to 2001, 2001 to 2009 and from 1973 to 2009. The rationale behind this is to find the change from each time period and then for the whole study period, that is, 1973 to 2009. During 1973 to 1992, 86 Union Councils of Lahore have recorded loss of vegetation ranging from -0.32 percentage points (Ganj Kalan) to -63.49 percentage points at Bhamman, while 2 Union Councils have shown no vegetation

change or loss, which includes Qilla Lachhman Singh and inside Bhatti Gate. Remaining 61 Union Councils have recorded an increment of vegetation during the period under question. This change ranges from 0.62 percentage points at Green Town to a maximum of 71.72 percentage points at Tajpura (Fig.4). The rest of the Union Councils were enlarged to a maximum of image, there were 58 Union Councils with vegetation cover more than 50 % of their geographical area. They include upper level UC 52-Manawan (91.24%) to lower level UC 59-Al Faisal Town with 50.18%. The rest of 57 Union Councils have vegetative cover between these two extreme values. Similarly, in 1992, 53 Union Councils were having vegetation cover more than 50% and the upper and lower limit was UC 42-Daroghawala with 85.71% and UC 94-Shadman with 50%.
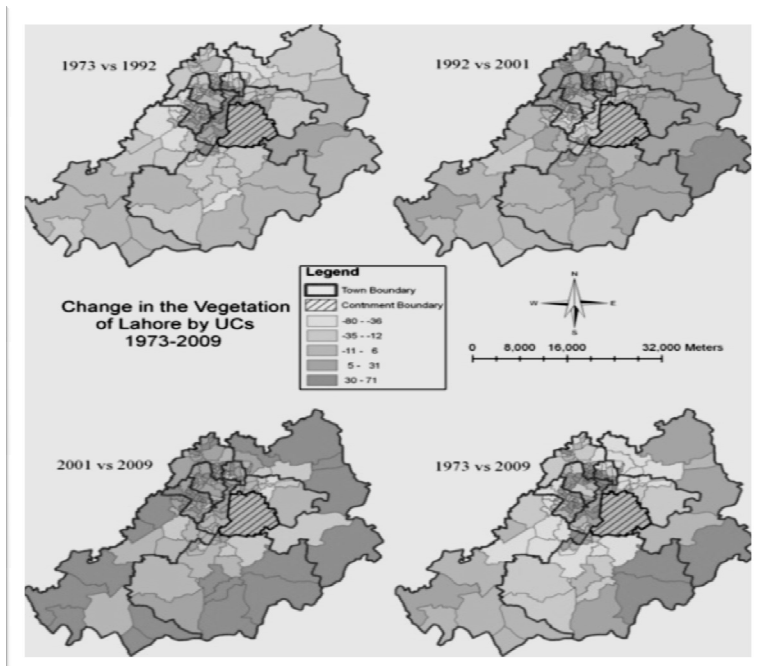

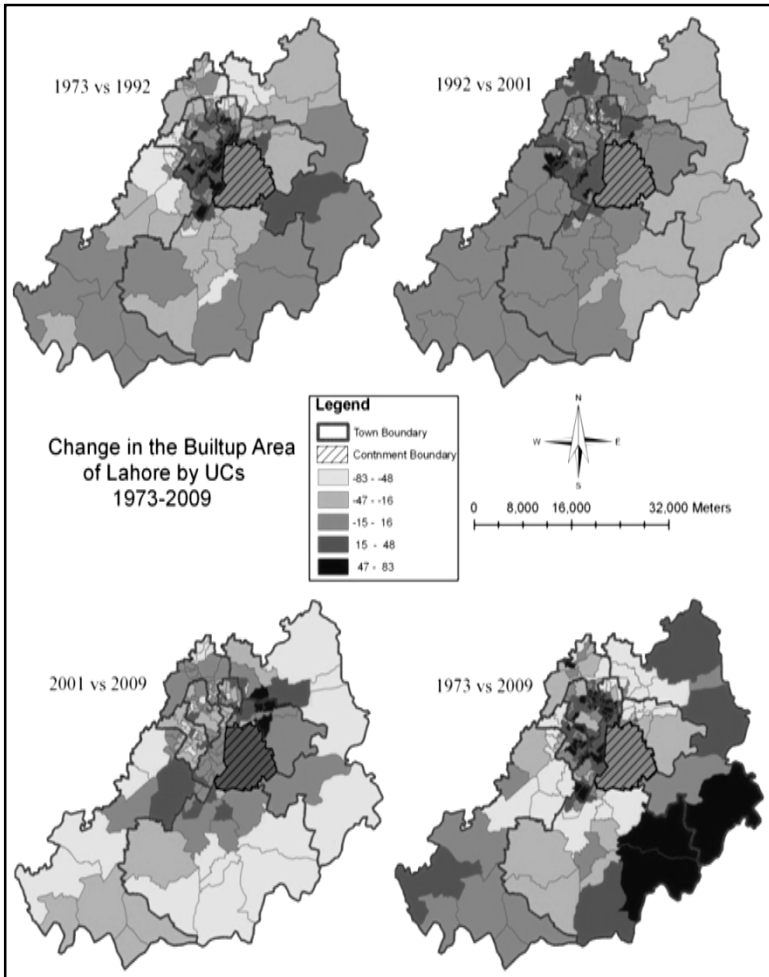Fig.4: Drastic Change in Vegetation Cover(1973-2009)

Fig. 5: Obvious Change in Built-up Land 1973-2009

The Fig.4 indicates the UC-wise change in the vegetative cover in the study area from 1973 to 2009. First of all, analysis about the change in vegetation cover in 1992 as against 1973 is given. It is apparent that, of 150 Union Councils, more than half (87 Union Councils) have shown a declining trend in the vegetative cover ranging from a maximum of -63.41% (Bhamman) to a minimum of -0.32% at Ganj Kalan, while Qilla Lachhman Singh and inside Bhatti Gate have shown no change in

their vegetative cover during 1973-1992. Remaining 60 Union Councils registered an increase in their vegetative cover ranging from 71.72% at Tajpura to 0.62% at Green Town during the same period. During 1992-2001, of 150 Union Councils, 124 have shown reduction in their area under vegetation. Maximum loss has been recorded at UC Bilal Park which is -75% to a minimum of -2.16% at Dhaloke. Fourteen Union Councils have not recorded any change in the vegetation during 1992-2001. Remaining 14Union Councils have shown net increase in their vegetation, ranging from 40% (Makhanpura) to 1.06% at Hadiara. During 2001-2009, Chah Miran has recorded -63.89% decrees in its vegetative cover to a minimum of -0.13% at Paji. Twenty three Union Councils have not shown any change in their vegetative cover, while remaining 21 have registered positive change in the vegetative cover. As far as change for 1973-2009 is concerned, 132 Union Councils have lost their vegetative cover ranging from -80.14 (Salamat Pura) to -0.05% at Garden Town. Four Union Councils have not recorded any change in the vegetative cover. Remaining 16 Union Councils have shown increase in the vegetation cover with a maximum of 25.85% at Mughalpura to 0.09% at inside Delhi Gate. The second parameter used in the present study is the change in built-up areas of the CDGL. As the table reveals, during 1973-1992, sixty one administrative units / Union Councils have shown decrease in their respective built-up area ranging from a minimum of -0.42% at Aziz Colony to a maximum of -69.07% in Bilal Park, while remaining 90 have recorded increase in the built-up areas ranging from 0.07% at Awan Town to a maximum of 57.33% at Bhamman. The analysis pertaining to 1992-2001 reveals that, out of total 151 administrative units, only 46 Union Councils have recorded a decrease in their built up area ranging from -45.45% (Islampura) to minimum of -0.23% in Kamahan. Eight Union Councils have shown no change in their built-up area, while remaining 97 Union Councils have recorded an increase in the built-up area ranging from 0.23% (Bhamman) to 53.12% in Awan Town. As we look at the change during 2001 to 2009, we came

across this fact that the change in this period in the built-up area is ranging from -20.00% at Rang Mahal to -0.57% at Gia Bagga. Altogether, there are only 24 Union Councils to have shown reduction in the built-up area. Ten Union Councils remained unchanged in their built up area while all remaining 127 Union Councils have recorded an increase in their built up area ranging from 1.08% (Bahawalpur House) to 83.33 % at Tajpura. Finally, during 1973 to 2009, only 25 Union Councils have shown a decrease in the built-up area, for example, -56.22% at Chah Miran to -0.72% at Jinnah Hall. Remaining 126 Union Councils have recorded increase in their built-up area during 1973-2009. This includes 80.09% at Johor Town to a minimum change of 0.09% in Chohan Park.

Conclusion

In this paper an appraisal of the spatio-temporal patterns of LULC changes and its impact on the vegetation has been carried out for Lahore City District Government of Pakistan with the help of topographic maps and SRS data. Post-classification comparison method has been employed to delineate various land use/cover categories and consequent changes. The findings revealed that Lahore has been experiencing momentous LULC causing loss of vegetative cover, open areas and agricultural lands. This growth has taken place on the expense of agricultural land, which was once part of the rural out srickts of Lahore. Urban built-up at micro level of union councils increased significantly throughout the district since 1973. This is mainly because of increase in population which is attributed to rural urban migration since 1947.Conversely vegetation, open areas, cultivated lands and water bodies are reducing accordingly. It was also inferred that the Lahore's rapid growth in population has been accommodated in new settlements built on lands which were once covered with vegetation/agricultural crops. No serious effort has been put forth by city managers to consider its adverse environmental effects. In order to combat the environmental concerns related to LULC changes and vegetation loss, effective planning parameters need to

be adopted and implemented. An efficient and coordinated effort should be ensured to save the rapid vegetation loss for sustainable development. It is also suggested that urban growth should be restrained from vegetation and cultivable lands. This will protect fertile agricultural fields around Lahore city from unprecedented LULC changes and likely to help save ecology of this green city of Pakistan. It is increasingly imperative to encourage vegetation preservation and maintenance in newly developed areas of the City District Government Lahore and should also be addressed through regulation. New regulations should be considered as the current regulations need to be modified in order to have a better vegetative cover. It is proposed that an Integrated Urban Vegetation Plan should be developed (involving active participation of the public and collaboration of the public and private enterprises) in a manner that it incorporates all policies and programmes for the management of urban vegetation in the territorial jurisdiction of the City District Government Lahore. This urban vegetation plan should address the management of LBD Canal vegetation, roadside green areas and dividers between roads, green belts, parks (public and private), significant trees and street vegetation and trees and house gardens. The accuracy assessment is satisfactory and this study has taken the integrated advantage of remote sensing and GIS techniques to measure the land cover changes in Lahore district for a period of 37 years. The impact of the change in the green cover is quite obvious as the habitats of many species have been vanished and new strains of diseases such as dengue have been spread at an enormous rate in recent past.

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