Spatial and temporal evolution of vegetation cover in Lahore, Pakistan

Sumaiyya Saleem[1] *, Sumaira Saleem[2]

1. Deaprtment of City and Regional Planning, Lahore College for Women University, Lahore, Pakistan
2. College of Earth and Environmental Sciences, University of the Punjab, Lahore, Pakistan

Abstract

The present study aims to evaluate the evolution of vegetation and land-cover practices particularly changes in tree cover, shrubs and mixed vegetation during 1994 to 2014. The rapid urbanization in Lahore has now converted the city into a second largest metropolitan city of the country which, in consequence, is affecting the land cover. Keeping in mind these facts, analyses are performed using calibrated satellite images of the year 1994, 2003 and 2014 in GIS environment coupled with ERDAS Imagine. The study is further divided into two parts; first part illustrates changes in tree cover, shrubs and mixed use areas whereas second part explains the changes in shrubs and tree cover in comparison to the mix use area. It is observed that the shrubs are considerably increased from 7% in 1994 to 52 % in 2014 while the tree cover has drastically decreased from 8% in 1994 to 0.38% in 2014.

Keywords: Tree Cover; Shrubs; GIS; ERDAS; Urbanization; Lahore.

Introduction

Urbanization is a steady transformation phenomenon in which rural settlements such as villages and small towns are turned into more urbanized settlements as a result of population expansion. In principle, urbanization is controlled by land-based practices; nevertheless it is also influenced by industrialization, commercialization and construction of public facilities due to increasing population demands. It has been revealed that the practices may increase the vegetation cover at global scales due to disturbance of climate processes by high CO_2 production and increasing temperatures (Vicente-Serrano et al., 2004).

After independence in 1947, urban development in Lahore was rarely observed despite of the fact that large number of migrants moved from east Punjab (India) to Lahore resulting in population increase (Qadeer, 1983). Lack of developmental knowledge and ignorance of adequate practices have led to disorganized and unsettled living conditions in the city. The style of living remained same until the city witnessed, almost 3 decades ago, a tremendous spatial growth especially in the old walled region; hence, making it a historical urban city.

Rationale of the study: The major problems of urban settlements in Lahore are disorganized growth pattern with unplanned devel-opmental projects; and to cope with this outgrowth, agricultural land is now being encroached. Along with the population growth, socio-economic requirements are also soaring which in turn is ultimately creating a pressure on land cover. This pressure is the elemental cause of unplanned changes in land use and land cover (LULC) that is geting uncontrolled as well (Seto, 2002).

For the monitoring and management of urban sprawl and urban land use, reliable source of data is of key importance; to save up on time, the sources should be efficient enough that the data can be fetched out in short time. As many of the conventional technological methods of field surveys were time consuming; application of GIS and Remote Sensing (RS) have helped researchers to do comprehensive spatio-temporal analysis in a relatively shorter time (Lo and Yang, 2002). The application of GIS and RS ensures the authenticity, accuracy, flexibility and ease of collection, storage and analysis of essential digital data for detection, and timely monitoring of spatial features at larger scale (Zsuzsanna, 2005; Wu, 2006).

Vegetation cover is an important feature in urban development and therefore each development project, within or outside the city, should not compromise the changes in vegetation cover significantly. The NDVI is an index of the state of biomass within an

area. Hence, the NDVI is the most popular indices used to display extent of greenness estimate of an area. Kriegler et al., (1969) was the first to propose NDVI which is calculated from two bands of multispectral SRS data.

For the purpose of land use planning by the experts, and decision making in urban and environmental planning for a sustainable ecological setup, knowledge of urban land cover and the areal extent distribution data is an essential requirement (Stefanov, 2001 and Fan et al., 2007). The researchers' now-a-days are interested in the LULC at micro and macro scale. Additionally, LULC can be caused either by natural or anthropogenic modifications which has resulted in great loss of entities having biological importance i.e., loss of agricultural land, biodiversity, etc. The impact is ecological (geo-environmental) as well, ranging from global warming to raised threat of natural disasters and flooding (Dwivedi et al., 2005).

Study Area

The study is conducted in Lahore (Pakistan), largest city in Punjab province and second largest city district of Pakistan with the rapid urbanization (transforming the city form metropolitan city to meg-alopolis). The city is located between 31° 15' and 31° 43' North latitude and 74° 10' and 74° 39' East longitude. India lies on the east of Lahore, Sheikhupura on the North West, Kasur on the south and River Ravi flows in the north (GOP, 2000; Riaz, 2011). Lahore is situated 213 meters above sea level with an area of 1,772 km^2 (GOP, 2002). The total population of Lahore during 1998 census period was 5,143,495 while, in 2009, Punjab development statistics showed that this number has been increased to 8,462,000 (GOP, 2009).

Materials and Methods

Landsat data of different years from the US GLOVIS website was retrieved for the spatial and temporal analysis of vegetation. The images, having path 149 & row 38, were extracted for the year 1994, 2003 and 2014 while the choice of years was based on the availability of data during the same month. The extraction of files for each year appeared to have 7, 9 and 13 bands respectively. The layer stacking of the bands was performed in ERDAS Imagine 2010 environment. The resulting output image was a multi-band geo (.tiff) that can be used in further planning of the area and in statistical evaluations.

Three Landsat images were analyzed and unsupervised classifica-tion was performed with the option of NDVI with the input layer stacking in ERDAS Imagine. The output NDVI file was opened in the ArcMap v10.1 and was reclassified using the spatial analyst tool; while break values of the shrubs, tree cover, and mixed use vegetation were added in reclassify dialogue box. The NDVI value ranged between −1 to +1; where +1 denotes a high vegetal cover and −1 signifies non-vegetated areas.

Results and Discussion

In terms of the area covered by different types of vegetation, ur-banization is observed to be beneficial for shrubs as it showed a boosting trend with land consumption of 39 km^2 (i.e., 7.45%) in 1994 and 270 km^2 (i.e., 52.49%) in 2014. However, contradictory outcomes are revealed for tree cover as a drastic downfall was observed from 43 km^2 (8.22%; in 1994) to 2 km^2 (0.38%) in 2014. On the other hand, mixed land use occupied 441 km^2 in 1994 (i.e., 85% of total land cover), which was increased up to 474 km^2

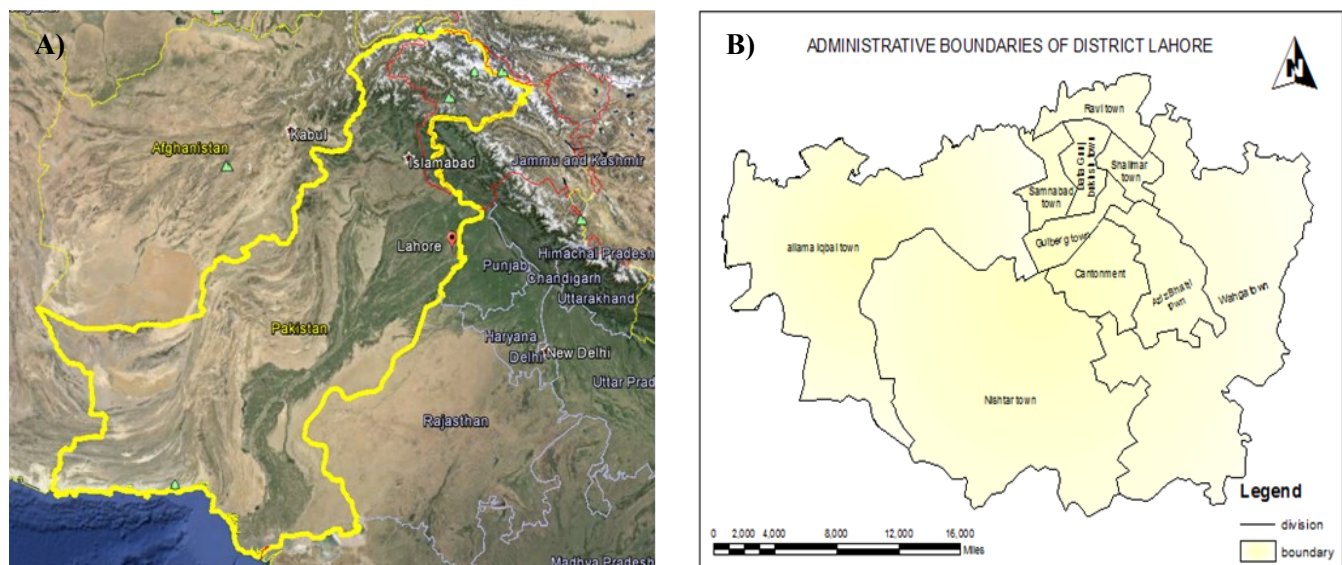**Fig.1: (a). Map location of city district Lahore (b) town boundaries of district Lahore**

Table 1: Characteristics of different types of vegetation cover during 1994, 2003 and 2014

Classes	1994			2003			2014		
	Pixels	Area (km^2)	Percentage (%)	Pixels	Area (km^2)	Percentage (%)	Pixels	Area (km^2)	Percentage (%)
Others	489504	441	85	2108730	474	90	1104195	248	47.9
Shrubs	43344	39	7	128050	29	6	1216897	270	51.72
Tree cover	47377	43	8	84312	19	4	0.3	2	0.38
Total	580225	522	100	2321092	522	100	2321092	522	100

(i.e., 90%) of total land cover in 2003; and then again decreased to 248 km^2 (i.e., 47.9%) in 2014 (Table 1).

Analysis on the Landsat data of Lahore depicts that, in 1994, most of the land was under mixed use followed by vegetation and least covered with shrubs (Figure 2a). However, the scenario changed quite steadily as the prevalence of shrubs resulted into the decrease of vegetation (Figure 2b). The vegetation pattern in 2014 is contrary to the vegetation pattern in 1994 where maximum of the land can be seen covered with shrubs and least or nominal with the vegetation cover (Figure 2c).

More precisely, relative proportion of the shrubs increased by 86.25% during the study period; as the percentage was 11% in 1994 while in 2003 and 2014, the percentage was 9% and 80% respectively (Fig.3a). On the other hand, the tree cover data depicts a decrease of vegetation by 95.39%; as the relative percentage was 65% in 1994 while approximately 32% and 3% of percentage reduction is observed in 2003 and 2014, respectively (Fig. 3b). The data of mixed use vegetation illustrate the reduction in vegetation by 42.11%; as the percentage was 38% in 1994, while in 2003 it increased up to 40% while reduced to 22% again in 2014 (Fig. 3c). this trend show a meandering variation from a smooth on-going increase to a drastic downfall in its abundance on land. The mixed use such as orchards, bamboo, palms etc. has a natural ecosystem succession process that went on smoothly till the early 21st century. The reason behind this variating trend was studied and explored that the migration of people from smaller cities especially in search of job opportunities and most importantly from disaster prone areas towards safer larger cities put pressure on urban areas for which the vegetation/ flora around the roads were cut in order to widen up roads to ensure the easy movement of traffic. The growing population put serious stress on the land and consequently the flora has been ignored to house growing population on the limited land.

Figure 4 shows an overall temporal trend of different categories under the consideration of this study. It was observed that Shrubs have markedly increased over two decades ranging from 7% in 1994 to 51.72% in 2014. Tree cover/greenery has shown a completely inverse trend from shrubs that have decreased steadily from 8% in 1994 to 0.38% in 2014. Mixed use land cover has been the odd one out which have been struggling with ups and down in the prevalence; as in 1994 the proportion of mixed land uses was 85% slightly went on increasing in 2003 and then showed a drastic downfall (>50%) in 2014

The results obtained in the present study coincide with the trends observed at the same level by Shirazi et al., (2009); who reported the reduction of vegetation cover from 645 km^2 (36%) in 1992 to 249 km^2 (14%) in 2009 in Lahore. The study further predicted, based on local government practices, that the vegetation cover may continue the decreasing trend in upcoming years that can be seen in the current study, i.e., 0.38% in 2014. Besides, contradiction is observed with the findings of Riaz, (2013) who reported the increase of urban area in Lahore by 68% till 2009 irrespective of reduction in vegetation/agricultural land due to its consequent effects. On one side, authors are clarifying that the vegetation index, in generated maps, is not changed while, on the other side, a contradictory statement is made by concluding that the agricultural land has been decreased significantly since 1972 and the urban area is increased tremendously. It is further illustrated that the green area remained constant whereas the urban expansion increased, which appears to be a misleading statement as the development is being done at the expense of vegetation, i.e., vegetation loss. Nevertheless, vegetation index is not constant as it tends to decrease as a result of urban area expansion (Shirazi et al., 2009).

In addition, Raza et al., (2016) performed spatio-temporal monitoring during 1976 to 2014 using Landsat satellite images for urban sprawl of Sheikhupura (Pakistan). The results illustrated that the high density urban area has grown during 2000 to 2014 which has drastically influenced the fertile agricultural lands due to the industrial progress in the city. The findings are parallel with the present study which established similar concepts. Moreover, as Sheikhupura is being publically considered as the territory of Lahore due to rapid urban growth, the results may be compared with the current findings accordingly. The estimation trends further illustrate that the increasing trends in local urbanization patterns may increase the area under cities up to 2.5 times till the year 2030 by utilizing habitable land. It is because of these reasons, consensus ought to be reached to adopt a sustainable planning in current and future oriented development projects so that the agricultural lands may not be encroached significantly.
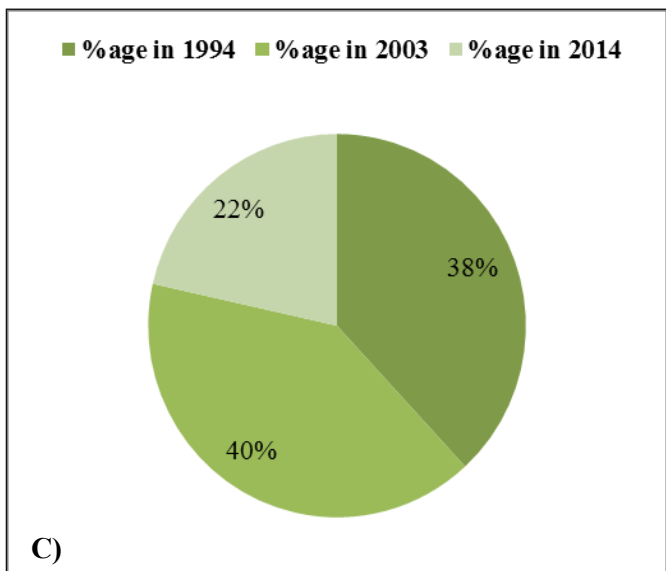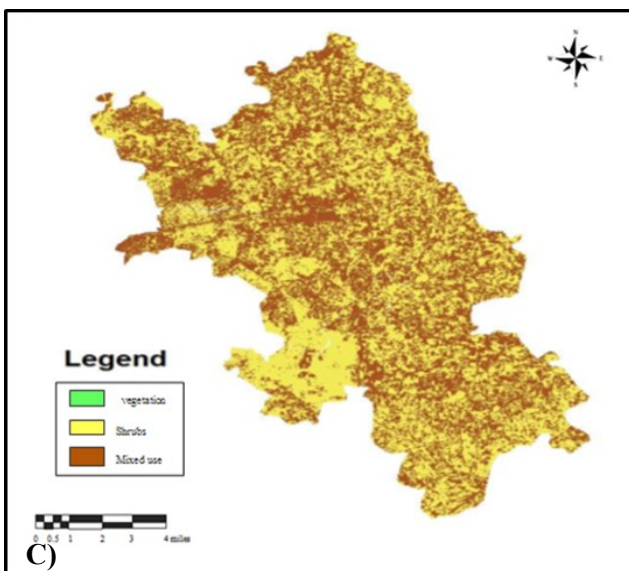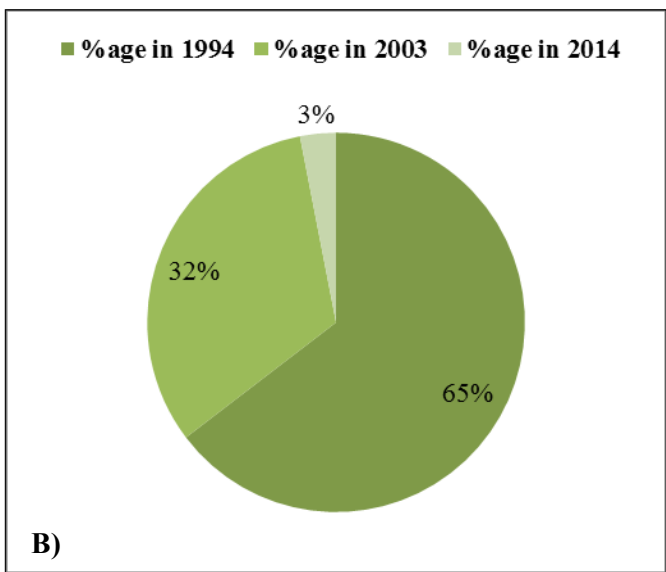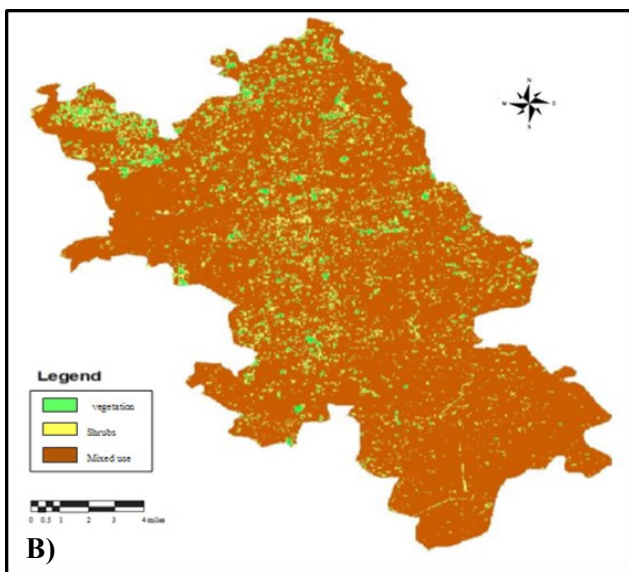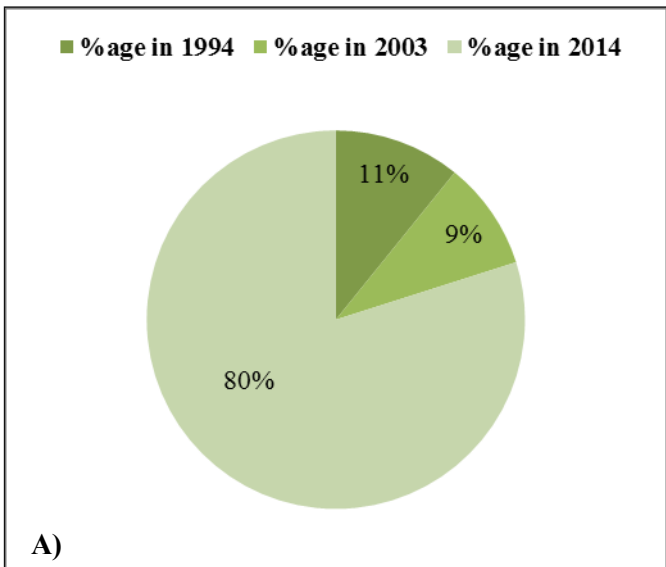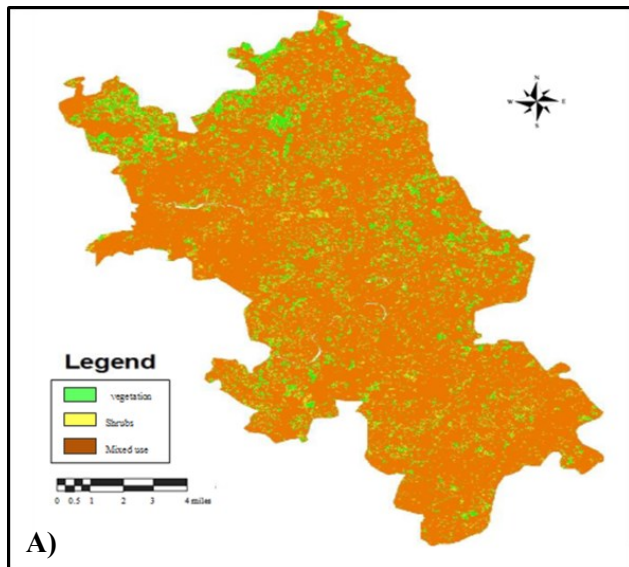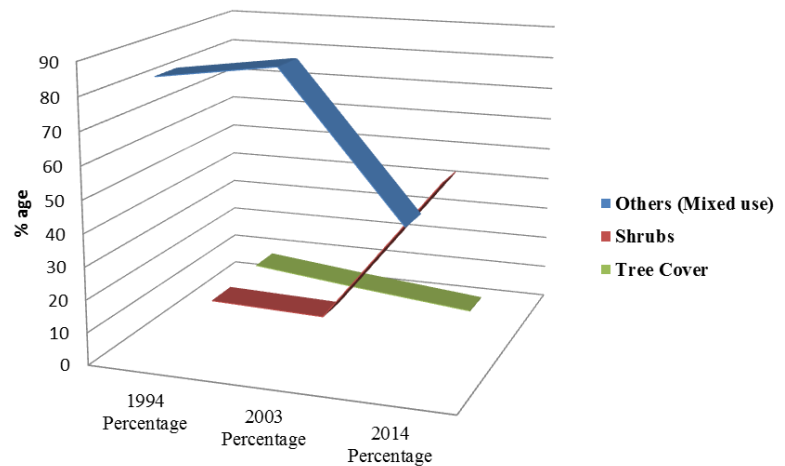
Fig. 2: Landsat data representation for the year (a) 1994; (b) 2003; and (c) 2014

Fig. 3: Evolution in different types of vegetation cover (a) shrubs; (b) tree cover; and (c) mixed use

Fig. 4: The temporal trend indicating evolution of each type of vegetation during study period.

Conclusions

In a nut shell, study reveals significant variations in vegetation cover in a notable fashion where relative percentage of shrubs has increased over the years while tree cover is being decreased significantly. Urban development proved to be as cherishing the shrubs prevalence abundantly and cutting down the abundance of tree cover drastically due to human encroachment. The current study in an updated view of changes in vegetation and land cover may help detecting various problems related to urban environment.. It is therefore required to make a joint strategy for the spatial arrangement of these urbanites. Further research is recommended on different land use/land cover patterns of Lahore particularly focusing on to analyze the loss in area under natural vegetation and agricultural. Similarly, the role of urban expansion towards decreasing agricultural land use may also be emphasized. Similarly, the role of urban expansion towards decreasing agricultural land use may also be emphasized. Additionally, similar studies can be done with nominal time intervals so that the settings of urban spatial patterns may be revealed towards better planning projects.

Compliance with ethical standards

Conflict of Interest

The authors declare that they have no conflict of interests.

References

Bhalli, M. N., Ghaffar, A., Shirazi, S.A. and Parveen, N. and Anwar, M. M. 2012. Change Detection Analysis of Land Use by Using Geospatial Techniques: A Case Study of Faisalabad, Pakistan. Science International (Lahore) 24(4), 539-546.

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

Demers, M. N. 2005. Fundamentals of Geographic Information Systems, John Wiley & Sons, Inc., New York, ed. 3rd, pp.134-45.

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.

Government of Pakistan. 2000. District Census Report of Lahore. Islamabad.

Government of Pakistan. 2009. Economic Survey of Pakistan - 2009 Islamabad, p.180.

Government of Punjab. 2009. Punjab Development Statistics-2009, Lahore, p.300.

Lo, C. P. and Yang, X. 2002. Drivers of land-use/ land-cover changes and dynamics modeling for the Atlanta. Georgia Metropolitan Area. Photogrammetric Engineering and Remote Sensing 68(10), 1073–1082.

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

Raza, A., Raja, I. A. and Raza, S. 2012. Land-Use Change Analysis of District Abbottabad, Pakistan: Taking Advantage of GIS and Remote Sensing Analysis. Science Vision 18(1&2), 43-50.

Raza, S. M. H., Mahmood, S. A., Alvi, F. S., Atif, M., Yahya, S., Ahmad, J. and Hanif, A. 2016. Spatiotemporal Monitoring of Urban Sprawl and its Impact Assessment in District Sheikhupura through Remote Sensing and GIS using Satellite Images from 1976-2014. Science International (Lahore) 28 (2), 1583-1588.

Riaz, O. 2011. Impact of Population growth on Urban Expansion in Lahore, 1951- 1998. (Unpublished PhD thesis). University of the Punjab, Lahore.

Riaz, O. 2013. Urban Change Detection of Lahore (Pakistan) Using a Time Series of Satellite Images since 1972. Asian Journal of Natural & Applied Sciences 2(4), 101-105.

Seto, K.C., Woodcock, C.E., Song, C., Huang, X., Lu, J. and 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.

Shirazi, S. A. 2009. Temporal Analysis of Land Use and Land Cover changes in Lahore-Pakistan. Pakistan Vision 13(1), 187-206.

Shirazi, S. A. Kazmi, H. J. 2014. Analysis of population growth and urban development in Lahore-Pakistan using Geospatial Techniques: Suggesting some future options. Journal of South Asian Studies 1(29), 269-280.

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 77, 173-185.

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.

Yang, X. and Lo, C. P. 2003. Modelling Urban Growth and Landscape Changes in the Atlanta Metropolitan Area. International Journal of Geographical Information Science 17(5), 463-488.

Yomralıoğlu, T. 2002. SistemleriTemelKavramlarveUygulamalar, SeçilOfset, Istanbul, Turkey. p.22-34.

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.