Evaluating Ecological Dis-balance in the Fast Growing Cities of Pakistan, by Using Remote Sensing and GIS Techniques

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Abstract:
Rapidly increase urbanization has direct impact on ecological dis-balance associated with reducing the green spaces. Developing countries population is increasing day by day as well as increase in human migration from rural to urban. Everyone wants to get facilities and better life style. Resultantly the urban land use/ land cover is rapidly changing. In this research quantify the ecological dis-balance, spread of urban activity, urban sprawl pattern from year 1990 to 2010 of two major cities of Punjab, Pakistan (Lahore, Faisalabad) by using remote sensing and GIS techniques. Due to land convergences there are certain changes which directly affect ecological balance and sustainable expansion of the city. Spatial temporal variations of green space reduction were derived through image classification analysis. The spatial changes were calculated for the total study area;through GIS analysis and statistical analysis, examine the variation of the green space change rate in the city and compared the both metropolitan cities results. The results shows that the great variation in greenspaces by the urban sprawl. There was significant increase developed undeveloped, planned and unplanned fragmentations. The built up land has been increased and the urban green spaces havebeen decreased in the study time period. On the basis of the results of urban land use pattern and ecological dis-balance, was also built up a projected land use pattern for next 30 years. Suggesting that the local authorities will must planthe every development as well as promote the ecological balance through urban green spaces its necessary for sustainable city development.

Introduction

All over the world urbanization has become change the landscape patterns and significantly effects on biodiversity, urban ecological developments and urban sustainability(and R.T.T. Forman, 2008; Zhou, 2015). To evaluate the ecological dis-balance and urban sustainability its necessary measure the spatial temporal development of urbanization(Luck, 2002)(Wu, 2011). Founded on their long-standing ecological research in the Phoenix metropolitan region, Wu et al. stated that “the general pattern of urbanization was that the increasingly urbanized landscape became compositionally more diverse, geometrically more complex, and ecologically more fragmented” (L. Zhifeng, 2016).
Unpredicted population progressionjoined with unplanned developmental goings-on has increase to urbanization mainly indevelopingcountries. In India the urban population has been increased from 20% of total population in 1951and in 2001 25.5% of total population was increased because of urbanization (EI-shair, 2003; N.Radhakrishnan, 2014).According to this speed India will be the

50% urbanization in the year of 2050 it's the 50% of whole population would be settled in urban areas. The rapidly increase the urbanization also increase the huge urban problems because of unplanned development increase ecological misbalance due to improper planning. Now a day's new towns and colonies are rapidly develop near the highways and in peri urban areas. These developments cause the urban sprawl and directly effect on urban ecological structure. Due to this countryside development loss of agriculture land, open green space in a city(N.Radhakrishnan, 2014). Henceforth, in the current situation, it's essential to add remote sensing and GIS into urban planning and management. The spatial land use and land cover change of ecological dis-balance last several years can be scientifically mapped, observed and preciselycalculated from various satellite recordsbeside thepredictable ground data and appropriate image processing techniques (P. Saravanan and P.Ilangovan, 2010). Chinese metropolises have been sufferingextreme urban land developmentlateron the era of economic improvement that started in 1978, in the resulted producingthoughtful social justice, impartial development and ecological environmental protection problems(Bai.X, 2014)(Wei.YD, 2014)Through geographic information system (GIS) have been spatial analysis methods to identify three major land use expansion pattern in china: infilling, expansion, and leapfrog (and R.T.T. Forman, 1995).Conversely, primearmiesdetermining these patterns and their linkages to the powers of state and commercial areas are mainlyunknown(Han Li, 2014).

Generally in Pakistan, migration takes place for economic reasons. Presently, 35% and more Pakistan's population are expected to be living in urban areas (NIPS, 2000). The remarkable growth of large cities is urbanization in Pakistan. Only Karachi city adds 21.7%, Lahore contributes 12.7% of the total urban population of Pakistan. However seven biggest cities of Pakistan (Faisalabad, Rawalpindi, Multan, Hyderabad, Gujranwala, Peshawar and Quetta) cover 54.6% of the urban population (Cell, 2001).GIS and remote sensing techniques have offered monitoring, assessment and mapping of fast growing urban cities pattern. These techniques are more beneficial for geographer and urban planner to predict the urban sprawl pattern(M. N. Bhalli, 2012).

Open green space parks and green belts are necessary in a sustainable city specially in fast growing cites. Fast growing cities cover the agricultural land to urban development, industrial zone, a large number of migrations from rural to urban as the resultants the number of colonies and towns increasing day by day. These unplanned fragmentations cause the urban sprawl. Population is increasing in an unplanned manner that's why the rate of urbanization is rapidly increased. In this research quantify the ecological dis-balance, spread of urban activity, urban sprawl pattern from year 1990 to 2010 of two major cities of Punjab, Pakistan (Lahore, Faisalabad) by using remote sensing and GIS techniques. Due to land convergences there are certain changes which directly affect ecological balance and sustainable expansion of the city.

Study Area

Lahore is the largest city of Punjab province Pakistan. According to 1998 census, Lahore's population was 6,318,745 and population for year 2010 was estimated at 8,592,000 making it the second largest city of Pakistan after Karachi. It is located within the latitude and longitude of 31°32′59″N and 74°20′37″E. The northern side of the city lies on the bank of river Ravi and the eastern side borders with India (Zaidi, 2011).Urbanization in Lahore has spread beyond its administrative boundaries, although the city continues to be the center of the growing metropolis. However, most of the population is concentrated in the center of Lahore, while the rest of the areas are mostly rural except for narrow ribbon development along arterial roads(Punjab, 2012).

According to population Faisalabad is the third largest city of Pakistan. It is situated between 30°42' and 31°47' North latitudes and 72°40' and 73°40' East longitudes. It is an important industrial

center, located in the central Punjab province of Pakistan, about 130 kilometers west of Lahore. The population of Faisalabad is growing rapidly in the past few decades. At present its estimated population is about 6.7 million, out of which about 40 per cent or 2.7 million lives in Faisalabad city with a growth rate just below 3 per cent (CDGF, 2010).

Study Area Map

Figure 1 Study Area Map
Source: Author 2017

Methodology

The growth of urbanization is rapidly increased specially in developing countries. Pakistan is also facing this problem that's directly effect on ecology of the city. In this study quantify the ecological dis-balance, spread of urban activity, urban sprawl pattern from year 1990 to 2010 of two major cities of Punjab, Pakistan (Lahore, Faisalabad) by using remote sensing and GIS techniques. The assessment of classified images has been made to detect the change patterns of the research area. The digital image classification of the satellite images was done. In the process of image classification total pixels of the image were characterized into land use class. In this study, we have applied the supervised digital image classification on the Landsat satellite images relating to the year 1990, 1995, 2000, 2005 and 2010. These Landsat imageries have been used as basic tool for the determination of image analysis.Spatial temporal variations of green space reduction were derived through image classification analysis. The spatial changes were calculated for the total study area; through GIS analysis and statistical analysis, tables and graphs, examine the variation of the green space change rate in the city and compared the both metropolitan cities results.The results shows that the great variation in greenspaces by the urban sprawl. There was significant increase developed undeveloped, planned and unplanned fragmentations. The built up land has been increased and the urban green spaces have been decreased in the study time period. On the basis of the results of urban land use pattern and ecological dis-balance, was also built up a projected land use pattern for next 30 years.

Figure 2Methodological Frame Work

Source: Author 2017

Result and Discussion

The results obtained by using remote sensing and GIS techniques through multi-temporal satellite imageries. The results shows that urban built up areas are rapidly increase that directly effect on urban ecology because vegetation land is decrease day by day. In the world everything need a balance for survival same like Cites. In developing countries migration level is increased. People

move toward the cities. In 1990 the situation is totally different as compare to 2010. The spatial temporal variations were analysis through image classification. Below table 1 and 2 shows the results of Lahore and Faisalabad City.

Table 1 Spatial Temporal Variations of Lahore City
Source: Author 2017

Table 2 Spatial Temporal Variations of Faisalabad City
Source: Author 2017

The results reveal that built land rapidly cover up the green land, water and barren land that cause the ecological dis-balance. Increasing population rate is also a main factor of increasing built up land and causes the ecological dis-balance. The spatial temporal variation is clearer through image classification.

Figure 3 Land use/ Land Cover change image classification of Faisalabad City from 1990 to 2010
Source: Author 2017

Figure 4 Land use/ Land Cover change image classification of Lahore City from 1990 to 2010
Source: Author 2017

The results of Faisalabad city 1990 Landsat image reveals that the city's urban/ built-up area was 147.79 million hectors. While in 1990 green area/ vegetation land 644.09 million hectors, water area 1.32million hectors, and barren land 75.90million hectors. In 2010 Landsat image reveals that the city's urban/ built-up area was 298.64million hectors. While in 2010 green area/ vegetation land 261.58million hectors, water area 0.70 million hectors, and barren land 18.46million hectors.The results of Lahore city 1990 Landsat image reveals that the city's urban/ built-up area was 553.57million hectors. While in 1990 green area/ vegetation land 1070.18million hectors, water area 34.31million hectors, and barren land 169.44 million hectors. In 2010 Landsat image reveals that the city's urban/ built-up area was 972.02 million hectors. While in 2010 green area/ vegetation land 794.77 million hectors, water area 25.36 million hectors, and barren land 35.35 million hectors.

Figure 5 Land use Land cover change Comparison of Lahore and Faisalabad
Source Author 2017

The figure 5 shows that in 1990 both cities had healthy number of vegetation. In Lahore 1070.18 million hectors area were covered with vegetation land and 553.57 million hectors area were covered with built up land in 1990. While in Faisalabad 644.09 million hectors area were covered with vegetation land and 147.79 million hectors area were covered with built up land in 1990. But situation was different in 2010. In 2010 vegetation land were decreased and urban land increased. In Lahore 794.77 million hectors area were covered with vegetation land and 972.02 million hectors area were covered with built up land in 2010. While in Faisalabad 261.58 million hectors area were covered with vegetation land and 298.64 million hectors area were covered with built up land in 2010.

Figure 6 Temporal green space variation of Faisalabad city
Source Author 2017

Figure 7 Temporal green space variation of Lahore City
Source Author 2017

Above fig:6 & 7 reveal that spatial temporal variation of both cities. The spatial temporal change in Lahore is greater than the Faisalabad because Lahore is the capital of Punjab and the biggest city as compare to Faisalabad. Both cities are highly populated because mostly people prefer to move toward the big cities for facilities, job opportunities and for educational purpose. That's why vegetation land covers rapidly decrease from year 2000 and built up land increase.

Table 3 Spatial Temporal Change Rate of Faisalabad City
Source Author 2017

Table 4 Spatial Temporal Change Rate of Lahore City
Source Author 2017

Above table 3 & 4 shows the spatial temporal change rate of Lahore and Faisalabad city. There are several factors responsible for this change rate patterns such as transportation nodes they lead to create new colonies, residential areasand new residential land cover the urban surround vegetation/ agricultural land. Capable transportation system produces the significant growth of the city. Second major factor is migration both cities are major metropolitan cities Punjab Pakistan. People are migrating for better life style, opportunities and facilities. Third factor is industrialization both have many miner and major different industries. Large number of people attached with the industrial sector they belong to peri-urban areas and rural neighborhoods of the city. All these factors increase the urban land and decrease the vegetation and green land of the city.

Figure 8 Prediction of urban land Faisalabad
Source Author 2017

Figure 9 Prediction of urban land Lahore
Source Author 2017

Fig: 8 & 9 reveal that prediction of urban expansion in Faisalabad and Lahore city next 30 years. Images shows that urban area will mostly cover the vegetation land its alarming situation for ecological balance and sustainable urban development. Figure 8 & 9 shows that urban land use in 2010 with blue colour, expected urban land use in 2040 shows with red colour and other land use (vegetation, water, and barren land) shows with white colour.

Conclusion and Recommendation

The main theme of this study is to investigate spatial temporal variation in Lahore and Faisalabad from 1990-2010 that directly effect on ecological balance of the city. GIS and remote sensing image classification technique were used for spatial temporal analysis and statistical techniques were also used for find change rate and prediction. The results shows that urban built up areas are rapidly increase that directly effect on urban ecology because vegetation land is decrease day by day. A sustainable city is need good vegetation land, green belts and parks. But because of urbanization industrialization the urban population and urban area is rapidly increase. This urbanization cause

the climate change, global warming and urban heat land. These entire factors disturb the ecological balance of the city. Further research can be carried out to measure the urban sprawl pattern, amalgamation of villages into city and loss of agricultural fields on more rigorous basis using and integration of the state the art technologies like Remote Sensing and GIS.

Thus, it suggested that the development authorities, policy maker and local community they must be well aware about this urban ecological problem. The government should launch a media campaign to raise awareness. Local government and development authorities should control the urban sprawl and promote the vertical building pattern and lunch the green belts around the road network and healthy number of parks in a city. Local authority and local community should install more and more plants in a city for sustainable ecological balance.

Reference

Bai.X, S. P. a. L. Y. (2014). Realizing China's urban dream *Macmillan Publishers Limited, 509*, 157-160.

CDGF. (2010). Pre-Feasibility Study for Urban Transport and Industrial Waste Management Faisalabad. Faisalabad: District Govt. Faisalabad.

Cell, P. E. (2001). Curriculum Wing. Islamabad: Ministry of Education.

EI-shair, a. I. M. (2003). *GIS and remote sensing in urban transportation planning: a case study of Birkenhead, Auckland*. Paper presented at the 6th Annual Inter- national Conference, Auckland.

Forman, a. R. T. T. (1995). Land Mosaics: The Ecology of Landscapes and Regions. *Cambridge University Press: Cambridge, UK,*.

Forman, a. R. T. T. (2008). The urban region: Natural systems in our place, our nourishment, our home range, our future. *Landsc. Ecol, 23*, 251–253.

Han Li, Y. H. D. W. a. Z. H. (2014). Urban Land Expansion and Spatial Dynamics in Globalizing Shanghai *Sustainability, 6*, 8856-8875. doi: 10.3390/su6128856

L. Zhifeng, H. C., and W. Jianguo. (2016). General Spatiotemporal Patterns of Urbanization: An Examination of 16 World Cities. *Sustainability, 8*(41), 1-15. doi: 10.3390/su8010041

Luck, M. a. W. J. (2002). A gradient analysis of urban landscape pattern: A case study from the phoenix metropolitan region, arizona, USA. *Landsc. Ecol, 17*, 327–339.

M. N. Bhalli, A. G. a. S. A. S. (2012). Remote Sensing And GIS Applications For Monitoring And Assessment Of The Urban Sprawl In Faisalabad-Pakistan, Pakistan. *Journal of Science, 64*(3).

N.Radhakrishnan, S. K. E. a. S. K. (2014). Analysis of Urban Sprawl Pattern in Tiruchirappalli City Using Applications of Remote Sensing and GIS. *Arab J Sci Eng*(39), 5555–5563. doi: 10.1007/s13369-014-1099-2

NIPS. (2000). Population Projections (1998-2025) Pakistan and Provinces

P. Saravanan and P.Ilangovan. (2010). Identication of urban sprawl pattern for madurai region using GIS. *Int. J. Geomat. Geosci, 1*(2), 141– 149.

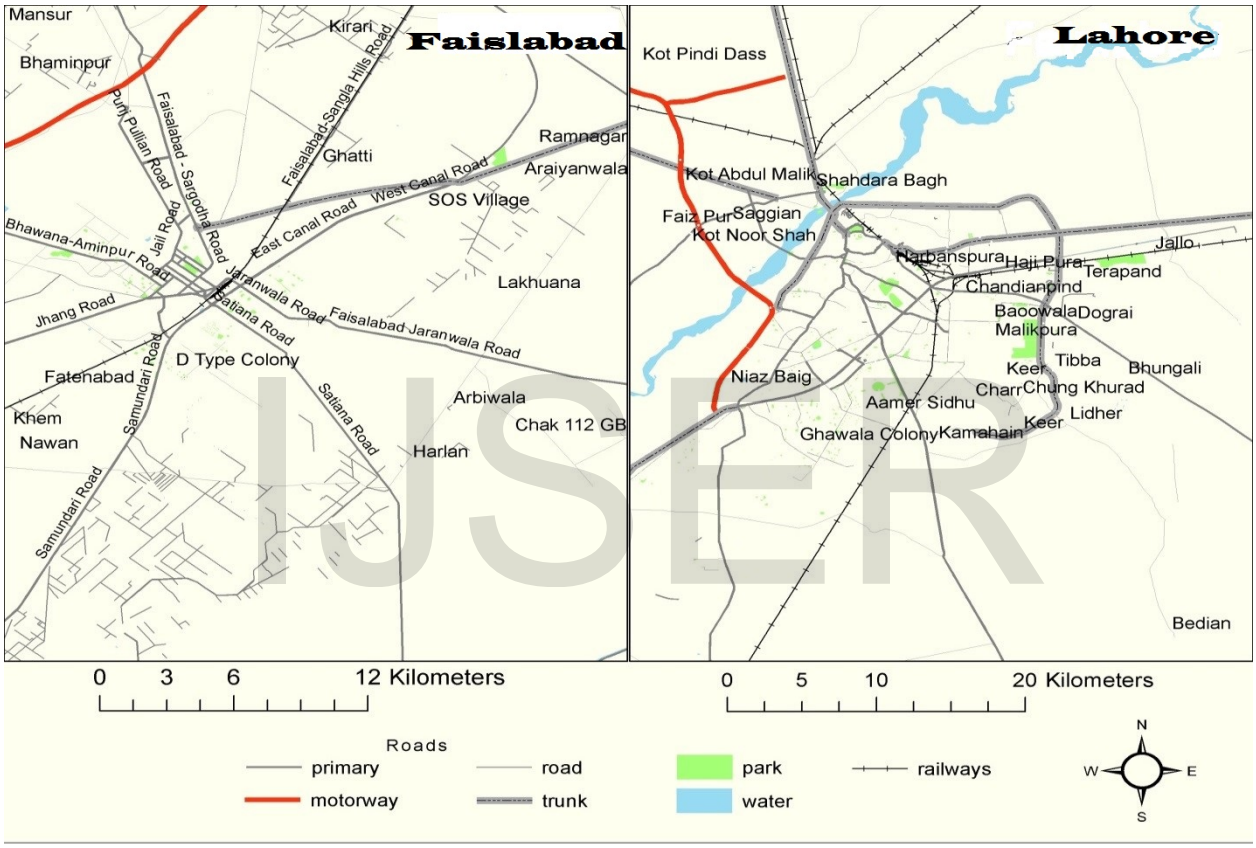
Punjab, J. I. C. A. J. a. G. O. T. (2012). The Project for Lahore Urban Transport Master Plan in the Islamic Republic of Pakistan. Lahore: Government Of The Punjab.

Wei.YD, a. Y. X. (2014). Urbanization, urban land expansion and environmental change in China. *Stoch Environ Res Risk Assess, 28*, 757–765.

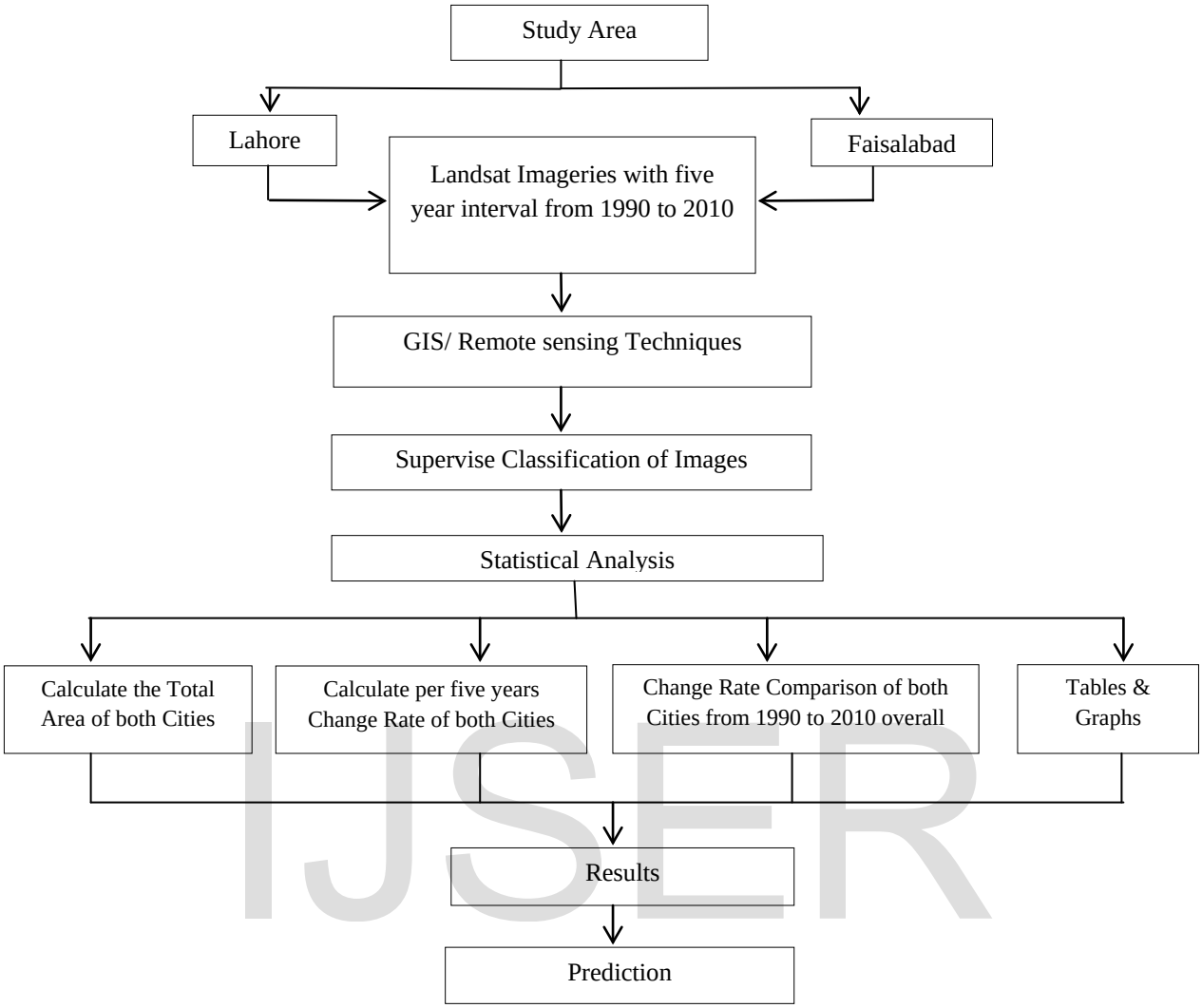
Wu, J., Jenerette, G.D., Buyantuyev, A. and Redman, C.L. (2011). Quantifying spatiotemporal patterns of urbanization: The case of the two fastest growing metropolitan regions in the united states. *Ecol. Complex*, *8*, 1–8.

Zaidi, B. T. a. A. Z. (2011). Geo-Statistical Dengue Risk Model Case Study of Lahore Dengue Outbreaks. Karachi: Institute of Space Technology (IST).

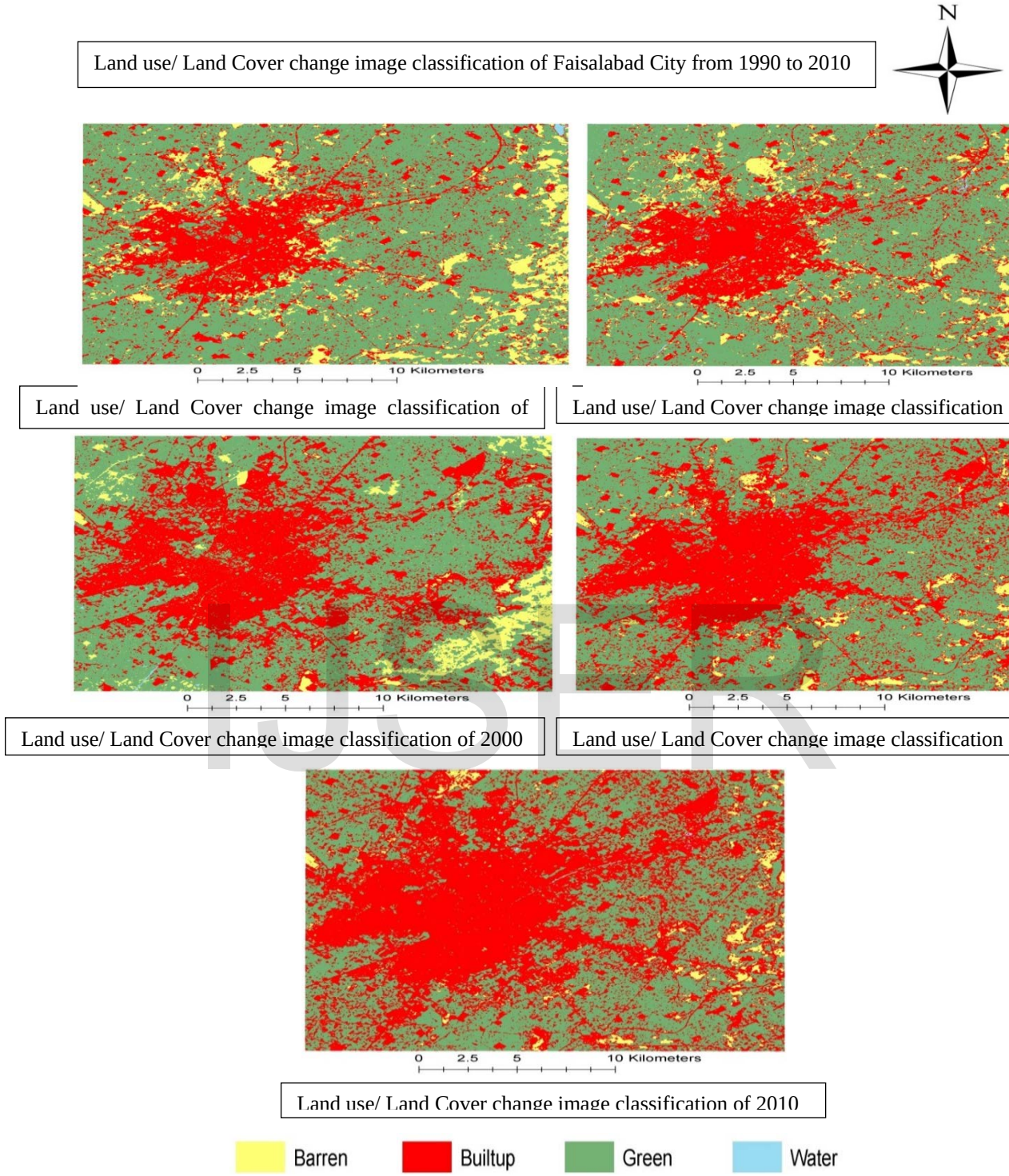
Zhou, Y. Y., Smith, S.J, Zhao, K.G, Imhoff, M, Thomson, A, Bond-Lamberty, B, Asrar, G, Zhang, X.S, He, C.Y and Elvidge, C.D. (2015). A global map of urban extent from nightlights. *Environ.Res. Lett*, *10*(054011).



Study Area Map



Methodological Frame Work


Land use/ Land Cover change image classification of Faisalabad City from 1990 to 2010
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Land use/ Land Cover change image classification of 1995
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Land use/ Land Cover change image classification of 2010
Barren
Builtup
Green
Water

Figure 3

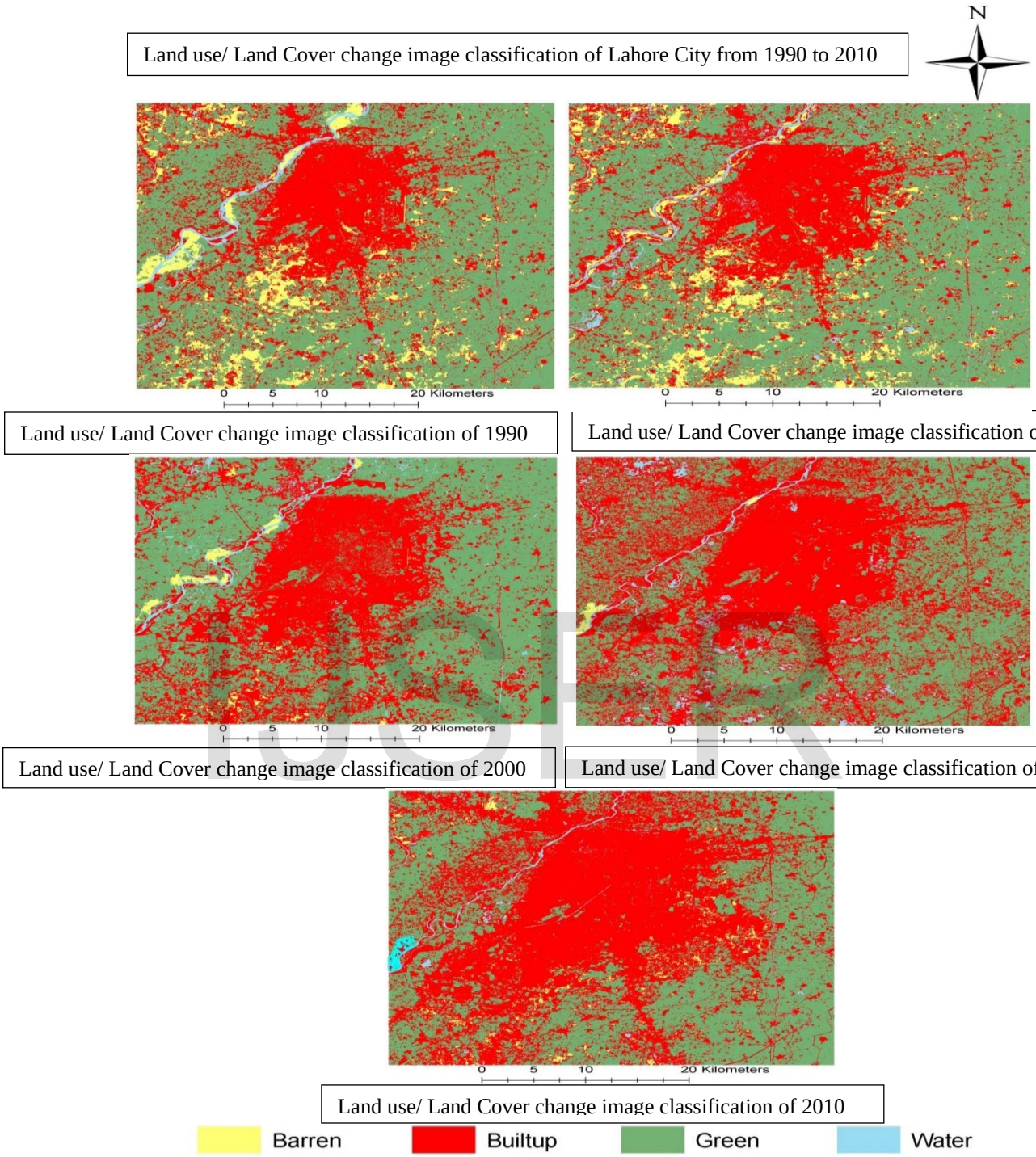
Land use/ Land Cover change image classification of Lahore City from 1990 to 2010
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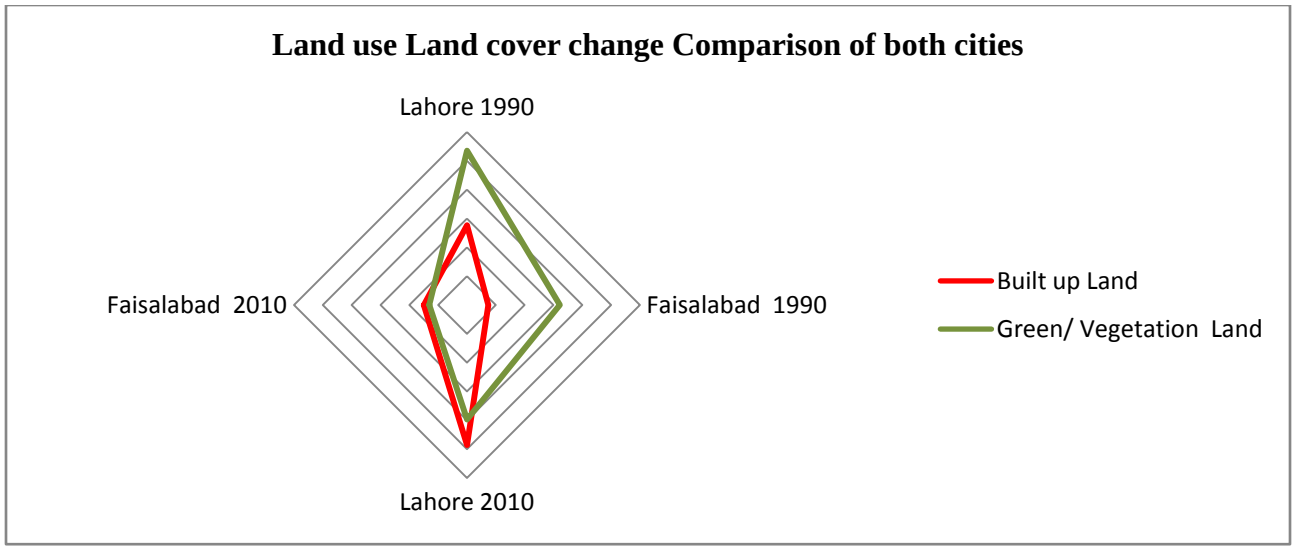
Figure 4



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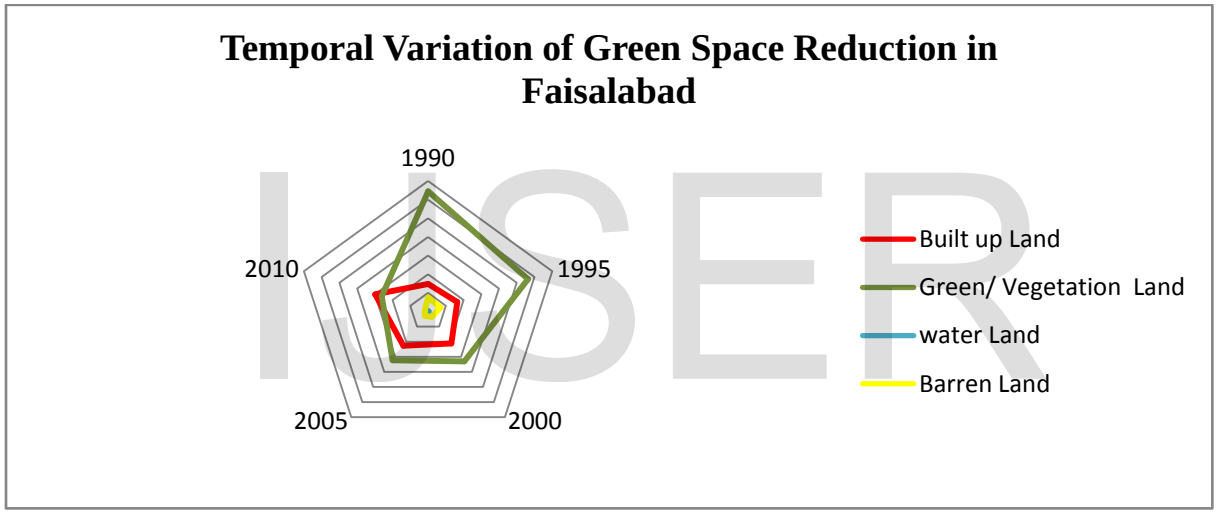

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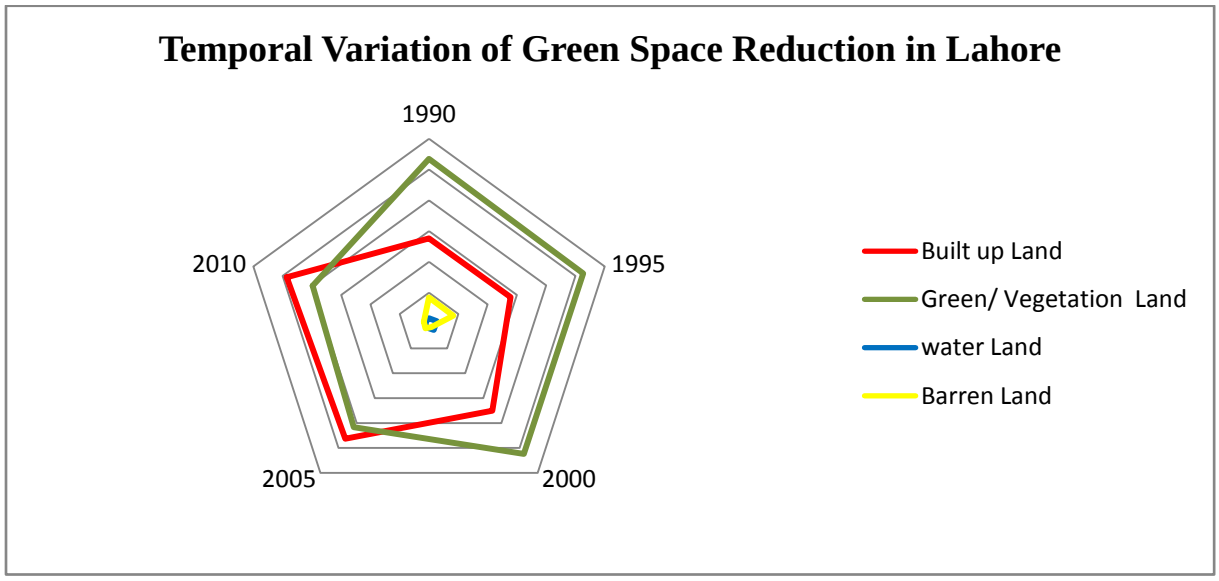

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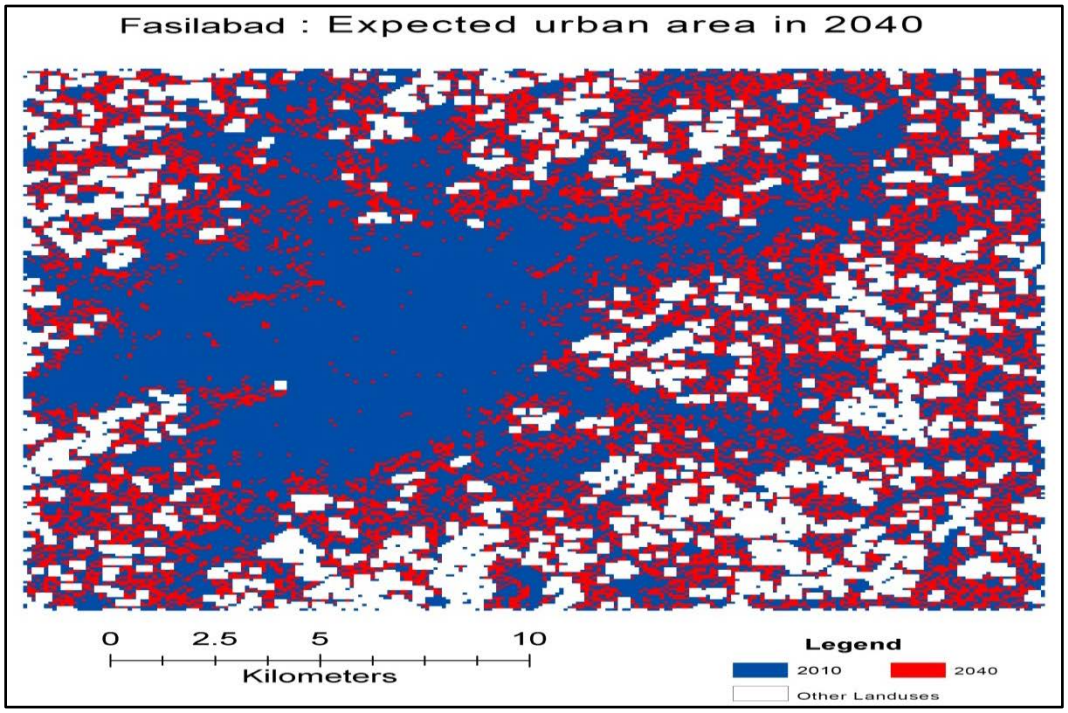

Figure 8

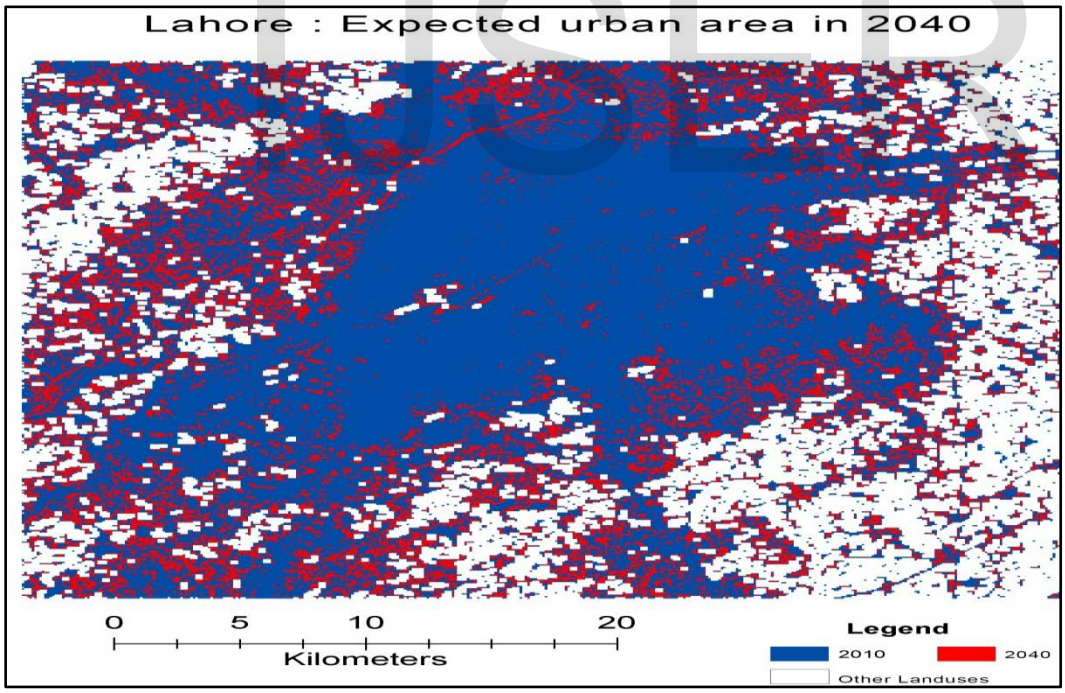

Figure 9

Spatial Temporal Variations of indicators (in million hectares)					
Lahore	**1990**	**1995**	**2000**	**2005**	**2010**
Built up Land	553.57	557.35	701.01	925.49	972.02
Green Land	1070.18	1053.10	1047.11	832.03	794.77

Water Land	34.31	51.51	50.97	30.88	25.36
Barren Land	169.44	165.54	28.40	39.10	35.35
Total Land	**1827.50**	**1827.50**	**1827.50**	**1827.50**	**1827.50**

Table 1

Spatial Temporal Variations of indicators (in million hectares)					
Faisalabad	**1990**	**1995**	**2000**	**2005**	**2010**
Built up Land	147.79	164.55	211.88	226.18	298.64
Green Land	644.09	562.97	330.03	323.07	261.58
Water Land	1.32	2.89	2.57	0.81	0.70
Barren Land	75.90	69.33	34.88	29.31	18.46
Total Land	**579.37**	**579.37**	**579.37**	**579.37**	**579.37**

Table 2

Spatial Temporal change Rate of indicators (in Percentage)					
Faisalabad	1990-1995	1995-2000	2000-2005	2005-2010	over all from 1990-2010
Built up Land	10.19	22.34	6.32	24.26	50.51
Green Land	-14.41	-70.58	-2.16	-23.51	-146.23
Water Land	54.12	-12.15	-216.01	-16.04	-88.67
Barren Land	-9.47	-98.75	-19.03	-58.80	-311.25

Table 3

Spatial Temporal change Rate of indicators (in Percentage)					
Lahore	1990-1995	1995-2000	2000-2005	2005-2010	over all from 1990-2010
Built up Land	0.68	20.49	24.26	4.79	43.05
Green Land	-1.62	-0.57	-25.85	-4.69	-34.65
Water Land	33.38	-1.05	-65.09	-21.75	-35.31
Barren Land	-2.35	-482.84	27.36	-10.62	-379.34

Table 4