SPATIO-TEMPORAL TRENDS AND PATTERNS OF URBAN SPRAWL IN GUJRANWALA CITY, PUNJAB – PAKISTAN

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ABSTRACT: Gujranwala is the 7th largest city of Pakistan which has 2 million of population. The objective of this study was to interpret the geographical setting of urban land use, to evaluate various types of urban land use and to understand the patterns of urban sprawl in Gujranwala city. For this purpose, the remotely sensed data and Geographical Information System techniques were used to classify the land-sat images for the year 1990, 2000, 2010 and 2015.For each remotely sensed data, rectification and classification was done and each image was classified separately. Land use change maps were detected by using different matrixes. The results showed that 97% of built-up area during 1990 to 2015 increased while there was 27% decreased in vegetation cover during this period. Urban sprawl was noticed mainly toward north and south ward along GT Road and toward west of the core of the city. Extensive urbanization in Gujranwala may cause several environmental problems such as smog, urban heat island, pollution and degradation of human health.

Keywords: Urban sprawl, Geographical Information System, land-use change and land sat images.

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INTRODUCTION

Urban sprawl is a land-use pattern showing dimensions of eight distinct including continuity, density, clustering, concentration, mixed uses, centrality, proximity and nuclearity (Shahraki *et al.,* 2011). The industrial revolution is considered as the major cause for rapid growth and expansion of cities during eighteenth and nineteenth centuries. The industrial development between 1750 and 1830 CE converted most of the north-western Europe from rural to large urban centric societies engaged with commerce, factory manufacture and trade (Saravanan and Ilanggovan, 2010).

Although, all major urban areas of the world only occupy less than 0.5 per cent of the world's total land area but they are the home of half of the world population (United Nation, 2008; European Commission, 2010 and Schneider *et al*., 2009). Despite the fact of little percent distribution and coverage of land cover of the whole world by the urban areas, they have profound impacts on urban environment such as biodiversity, ecosystem fluxes and environmental quality (Breuste, *et al*., 1998 and Pickett, *et al*., 2001).

The criteria of an urban area in South Asia is as any place with a population of more than 5,000 and with a population density of 400 persons per square kilometer and minimum 75% of the population engaged with non-agricultural activities is considered as urban area (Sudhira *et al.,* 2004). Due to fast growing urbanization, South Asian regions are facing many challenges such as slums, environmental hazards, crimes, insufficient infrastructure, water inadequacy, traffic congestion,deficiency of energy consumption, change in local climate and poverty (Mohammadi *et al.,* 2012 and Sardar, 2012).The statistical data of population shows that urban population was 15.6 percent in South Asia in the year 1951 which increased to 30.1 percent in 2010 and it will 800 million approximately until the year 2030.

In Pakistan, urbanization is increasing in an attractive way and gradually changing the internal structure of land use.In modern worlds, urban planning is an integral part for future urban development (Gauthiez, 2004) which lacks in Pakistan.

Urban sprawl in several cities of Pakistan is observed during recent years. Gujranwala city is reported to be 50 decades old. This city is also known as the birth place of Maharaja due to Nahansingh and Ranjitsingh. Gujranwala was rapidly extended in second half of the nineteenth century (Government of Pakistan, 1999). During partition 1947, a large number of population shifting was observed in Gujranwala city which converted the socio-economic landscape. A massive inflow of population was observed in Gujranwala city from 1941 to 1971 (Chatta, 2009). The current population of Gujranwala city is about 2 million.

To control the urban sprawl, it is essential to understand the conversion of land from natural surfaces (rural) to built-up areas (urban). The trends and patterns of land use change not only affect the human beings but also the natural environment. There are many challenges

and problems related to land use change functions including disappearance of cultivated land, traffic congestion and many other economic, social and ecological issues (Elena and Nancy, 2007).

Gujranwala is located between 74°9″ north longitude and 32°11″ east latitude. The city is located on plain surface and has an elevation of 226 meters above sea level. It is situated in fertile area of Punjab province which is irrigated by canal. It is a part of Rachna Doab (Proposed peri urban structure plan of Gujranwala). It has lush green fields nearby in Sandal Bar which is very fertile patch of land in Punjab province. The total surface area of Gujranwala District is 8,809 km^2 whereas the city comprises on 87 km^2. The estimated Population of urban area of Gujranwala is 500,000. Gujranwala is known as industrial heart of Punjab. Mostly Industrial activities have been seen along Gondlanwala road, Hafizabad road, Pasrur road and Grand Trunk road (Urban Unit, 2009).

Present study was conducted to interpret the geographical setting of urban land use, to evaluate various types of urban land use and to understand the patterns of urban sprawl in Gujranwala city.

MATERIALS AND METHODS

Post classification comparison change detection approach was used to define the land cover change (Alphan *et al*., 2008 and Nori *et al*., 2008). For each remotely sensed data, rectification and classification was required. In order to study the land-use trends, its patterns and consequent changes four Landsat images were used for the year 1990, 2000, 2010 and 2015. The supervised classification algorithms were used to all the four images and results were categorized into four classes. The sum of all the identified land use classes of the study area was 142 km^2. For an in depth analysis the land use of the Gujranwala city was distributed into four classes; vegetation, built up area, barren land and water. Each image was classified separately and land use change maps were detected by using different matrixes. Data collections, preparation of data, supervised classification, assay and change detection preparation maps were the main steps for image processing. Arc GIS software and ERDAS imagine were used to accomplish the applications.

Temporal Satellite images were required to determine the temporal land-use changes which were downloaded from Global Land Cover Facility (GLFC). Land use change detection consisted of geo referencing and sub setting of satellite images. Supervised classification technique was adopted for the segmentation of images. It was the act of sorting pixels into categories of data, based on data file values. If a pixel satisfied a certain set of criteria, the pixel was assigned to the class that corresponds to that criterion (Keuchel *et al*., 2003).

Significant patterns in data were identified by pattern recognition. It performed like human eye to enhance an image spectrally. Once signatures were created, they were evaluated by using Signature Alarm utility. Training result was a set of signature that explained a training cluster. Each signature corresponded to a class, and was used with a decision rule to assign the pixels in the image file to a class. Based on the signatures by use of a classification decision rule, the pixels of the image were sorted into classes after the signatures were defined. Maximum likelihood method was used to classify the pixels in which unknown pixels were assigned to classes using contours of probability around training areas using the maximum-likelihood statistic (Mukhopadhyay *et al*., 2013). The output file was in form of image file having thematic raster layer. In this file the data about class name, class table, class values, statistics and histogram was automatically noted.

GIS and Remote Sensing techniques were employed to detect the morphological change, mapping, modeling, analysis and display of spatial temporal data. Data was analyzed through ARC map to calculate the land use classes (Sun *et al*., 2007). Graphs were also prepared to show the all types of land use in each year.

RESULTS AND DISCUSSION

Figure [1a] highlighted the area and percentage of major landuse classes such as water, vegetation cover, built-up area and barren land for the year 1990. It showed that in 1990, the area under water was 12 km^2, vegetation covered 59.7 km^2, built-up area was 45 km^2 and barren land was 36.8 km^2. The covered area of the city comprised of 1% of water, 42% of vegetation, 31% of built-up area and 26% of barren land during the year 1990.

Figure [1b] elaborated the land use classes of study area for the year 2000. It highlights that in the year 2000, water covered 3.2 km^2, vegetation covered 59.3 km^2, built-up areawas 76 km^2 and barren land comprised of 3.9 km^2. The covered area of the city comprised of 2% of water, 41% of vegetation, 54% of built-up area and 3% of barren land in the year 2000. During 1990 to 2000, the built-up area increased faster on the cost of reduction of barren land. Vegetation cover and water body had no significant change during this period.

Figure [1c] explained the land use classes for the year 2010. It showed that in the year 2010, water covered 1.1 km^2, vegetation covered 44.7 km^2, built-up area was 83.1 km^2 and barren land was13.9 km^2. The covered area of the city comprised on 1% of water, 31% of vegetation, 58% of built-up area and 10% of barren land in year 2010. During 2000 to 2010, the built-up area increased faster on the cost of reduction of vegetation cover. Barren land increased as well during this period.

Figure [1d] describes the land use classes of Gujranwala city for the year 2015. It illustrated that in year 2015, water covered 1km^2, vegetation covered 47.1km^2, built-up area had 87.1km^2 and barren land comprised on 7.6 km^2. The covered area of the city comprised of 1% of water, 33% of vegetation, 61% of built-up area and 5% of barren land in the year 2015. During 2010 to 2015, the built-up area increased and barren land decreased. During this period the vegetation cover also increased by 2% during last 5 years since 2010.

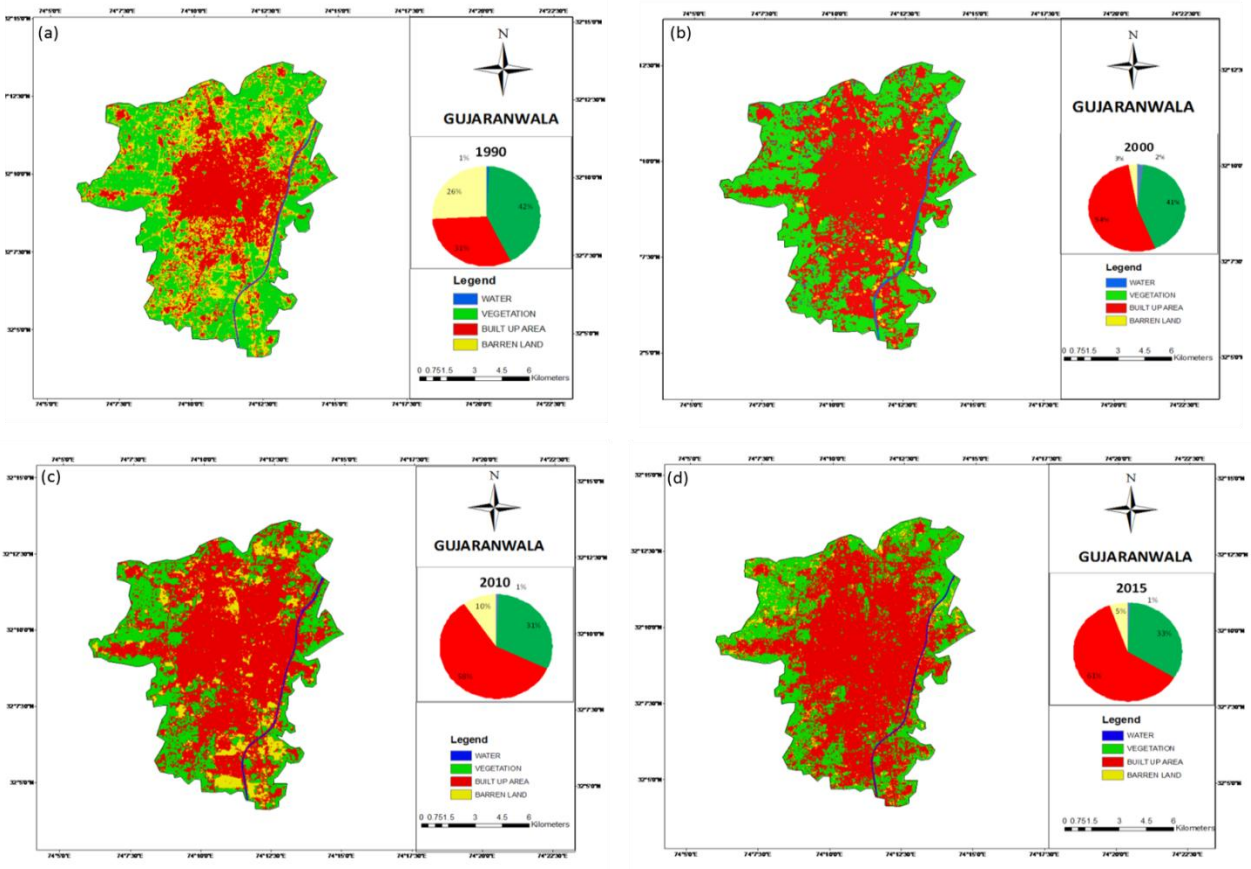

Figure 1: Classified image of Gujranwala city showing different land use classes in different years a: 1990; b: 2000; c: 2010 and d: 2015.

Table-1 summarizes the results of temporal trends and patterns of urban sprawl in Gujranwala city. It was noted that during 1990 to 2015, the area covered by water body did not change. Vegetation cover decreased significantly. In 1990 vegetation cover was 59.7 km^2 that reduced to 47.1 km^2 in 2015 with a reduction of 27% during the last 25 years. Built-up area increased faster and doubled in 2015 than it was in 1990. Built-up area in 1990 was 45 km^2 which increased to 87.1 km^2 in 2015 with an increase of 94% within the period of last 25 years. Barren land decreased to 80% during last 25 years. These results are also illustrated in Figure-2 which highlighted the variation in land use classes in different years.

Table1: Comparison of different land use classes of Gujranwala city from 1990 to 2015.

Land use type	1990		2000		2010		2015	
	Area (sq. km)	Percentage	Area (sq. km)	Percentage	Area (sq. km)	Percentage	Area (sq. km)	Percentage
Water	1.2	1	3.2	2	1.1	1	1.0	1
Vegetation	59.7	42	59.3	41	44.7	31	47.1	33
Built up area	45.0	31	76.4	54	83.1	58	87.1	61
Barren land	36.8	26	3.9	3	13.9	10	7.6	5
Total	142.8	100	142.8	100	142.8	100	142.8	100

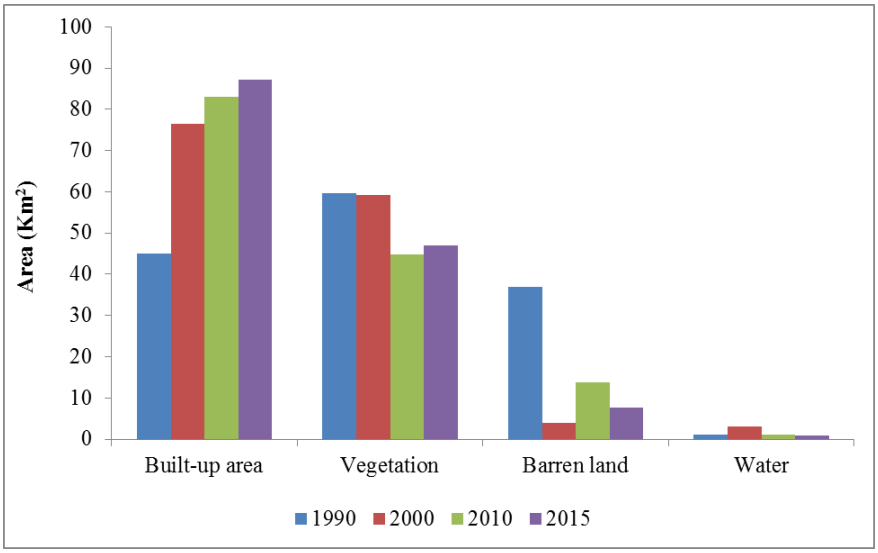

Figure 2: Collectively comparison of all land useclasses of Gujranwala city from 1990 to 2015.

Urban sprawl has become a worldwide phenomenon now days and was considered a worth-able characteristic for the development of urban areas. All the above classified images for different years from 1990-2015, tables and graphs showed the temporal trends and patterns of urban sprawl in Gujranwala. The above results were analyzed by using GIS techniques and remotely sensed time series data. The tables and graphs were also used to represent the data more accurately. The land use was divided into four classes; vegetation, built up, barren land and water body. The time series data indicated that built-up area was increased, although it was not a tremendous increase but it expanded as compared to previous year. The built up area increased by 31% to 61% during the period 1990 to 2015 and the total increase was calculated to be 30% while in the same period vegetative land decreased from 42% to 33% and barren land also decreased from 26% to 5%. These results of study area demonstrated the sprawling condition of the city and it illustrated that city was expanding with the passage of time and mostly this expansion was observed along the major roads of the city.

The results of Gujranwala city were conclusive with other regional and global studies of different cities of the world. This study revealed that since 1990 to 2015 an annual expansion of the city remained 2 km^2 which was inline with work conducted by (Butt *et al.*, 2012 ;Qureshi, 2010 and Shirazi, 2009) who highlighted the annual urban sprawl of 2.3 km^2,12.7 $km^2$and 20 km^2, annually. Recent study about Dhaka city also revealed an annual expansion of the city from 1993 to 2015 was 6 km^2 reported by (Shakrullah, 2015). The built-up area of Banglore city increased from 7.3 per cent in 1973 to 57 per cent in 2015 reported by (Geospatial World, 2010 and Jagadeesh *et el*., 2015). New Delhi, the capital of India faced massive urbanization where urban built-up area increased from 25 per cent in 1989 to 45 percent in 2011. Like these cities the urban built-up area of Central part of Jordan increased by 9 percent in 1987 to 20.4 per cent in 2005 as has been reported by (Alsaaideh *et al*., 2011). All these studies showed that urban sprawl was obvious at regional scale including the city of Gujranwala in Pakistan.

The results revealed that the rapid urban sprawl of Gujranwala during last 3 decades caused the land surface denser and overpopulation was one of the biggest reasons behind the urban sprawl. The continuous rapid growth in urban population led to unplanned development of the city which caused a massive cover of built-up surface and reduced the vegetation. Another centrifugal force of rapid growth of the city was industrialization which significantly grew during the last three decades. Industrialization was a centrifugal force for the people to get better job opportunities. Many people, who had been working in these factories, settled down along the edge of the city and became the reason of city expansion.

Conclusion: Globally urbanization is one of the important issues and its impacts are also observed in Pakistan as the cities are expanding faster and causing severe socio-economic and geo-environmental issues. In the present study it was found that Gujranwala city expanded faster during last 25 years. The built-up area (buildings, roads and other concrete infrastructure) of the city also increased at a rapid pace on the cost of removal of vegetation cover (open spaces, cultivated land, bushes etc.). The city expanded mainly toward north-south direction along the Grand Trunk road and on Gujranwala-Hafizabad road. The results revealed that the expansion of the city toward eastern side was minimal due to the presence of major link canal. As the cities expanded, the vegetation cover was minimized and built-up area also

maximized. It caused to modify the urban area's energy balance as the built-up surfaces of urban areas first absorbs the solar radiation and then re-emits the absorbed heat into the atmosphere. Such variability in surface and atmospheric heat causes to modify the urban area's weather conditions than its surrounding non-urban areas. Further expansion of the cities will further accelerate the local areas environmental issues which will ultimately affect the human health.

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