International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 10, October-2015

Analysis of Land use Changes using Remote Sensing and GIS Techniques: A Case Study of District Peshawar-Pakistan

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***Abstract* - A dreadful transformation has taken place in the land use due to population growth and rapid urbanization. Hence land use (LU) alterations are detected by using the technologies such as Geographic Information System (GIS) and Remote Sensing (RS) in Peshawar District from 1990 to 2010. Supervised classification is done by using the Landsat satellite images in Erdas Imagine software. The methodology adopted consists of layer stacking, merging, extract AOI (Area of Interest) and supervised classification. Land use changes are categorized into four classes i.e. vegetation, urban area, barren land and water bodies. The quantitative analysis shows that there are vast changes in land use. Results show that, from 1990 to 2010, there is a significant increase of 12.98% in urbanization and decrease of 9.97% in vegetation. These results can be useful for future planning and development.**

Keywords- Land Use (LU) Alteration, Geographic Information System (GIS), Remote Sensing (RS), Satellite Images, Classification, Peshawar District.

I. INTRODUCTION

Land is a natural resource on which different human activities are conducted. The term land cover originally referred to the kind and state of vegetation, such as forest or grass cover but it has broadened in subsequent usage to include other things such as human structures, soil type, biodiversity, surface and ground water (Meyer, 1995) [1]. Land is becoming a scarce resource due to massive agricultural and population pressure. Hence, the study of land use changes is very important for proper planning and utilization of natural resources and their management, in order to meet the increasing demands for basic human needs and welfare. Satellite imagery is used for recognition of synoptic data of earth's surface (Ulbricht and Heckendorf, 1998) [2]. Human needs are fastened to land, water and vegetation. Recently, natural resources including land resource have been transformed to serve the increasing demands for food, water, consumption goods, and other public utilities for more than six billion people globally (Turner et al., 2007) [3].

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Singh, 1989) [4]. Geographic Information System (GIS) and Remote Sensing technologies are important tools for evaluation of land use change. Remote sensing data of better resolution at different time interval help in analyzing the rate of changes as well as the factors responsible for change (Ramachandra and Kumara, 2004) [5]. The technologies of GIS and Remote Sensing have been combined to detect the land use changes which are easier and faster than traditional method of surveying (Dacosta et al., 1999) [6]. Changes in land use increases rapidly on local, regional and global scales. An anthropogenic activity such as deforestation, mining, agriculture and construction influences the land change. Bhalli et al., (2012) [7] stated that urban centers and cities are the most dynamic regions on the face of the earth. With the advent of Remote Sensing and Geographical Information System (GIS) techniques, land use mapping has given a useful and detailed way to improve the selection of areas designed for agricultural, urban and/or industrial areas of a region (Selcuk et al., 2003) [8].

Universally, a tremendous change in land use has been detected. Solaimani et al., (2010) [9] stated that several regions around the world are currently under rapid, wide-ranging changes of land cover. Land use changes play an important role in the study of global change. Deforestation, global warming, biodiversity loss and increase in natural disaster like flooding have resulted due to land use changes. Natural land covers decreased rapidly due to an increase of road networks and recreation buildings to accommodate large number of population and tourists (Baban and Yusof, 2001) [10]. Rapid population and economic growth also influenced the increase of urban areas (Shalaby and Tateishi, 2007) [11]. Urban growth has a bad impact on environment. It causes air pollution, water pollution, increased temperature and runoff. The growing population creates a pressure on land use, and this pressure results in uncontrolled changes in LU. In recent years, urbanization is a chief trend in big city all around the world (Weber, 2003) [12]. One of the major factors for these changes is demographic growth. Globally, croplands, pastures, plantations, and urban areas have expanded in recent decades, accompanied by large increases in energy, water, and fertilizer consumption, along with considerable losses of biodiversity. Water resources have been rapidly stressed due to population growth and climate changes. Land use change can play an important role in environmental changes and contributes to global change and biodiversity loss (Chen et al., 2001) [13].

With the increase in population people tend to move from rural to urban areas. In order to fulfill needs of the people,

forests are cut down to agriculture land. The rapid increase in population, industrialization and urbanization demand more water. On the other hand, water bodies are decreasing day by day. People need food and shelter for their survival because of that vegetation has a huge importance. Cyr et al., (1995) [14] stated that vegetation cover of less than 70% induces a critical risk level of soil erosion. Globally, due to rapid urbanization the amount of agriculture land, water spread area, and dense forest area elapses. In addition to this, increasing population density also contaminated the surface and groundwater. These changes greatly affect the local and regional environment, which eventually affect the global environment. Forest and vegetation are depleting day by day. Nasir et al., (2012) [15] stated that the urban areas are changing due to various human activities, natural conditions and development activities.

Pakistan is an agricultural country having four provinces Punjab, Sindh, Khyber Pakhtunkhwa (KPK) and Balochistan with its capital at Islamabad. Pakistan lies between 24° and 37° North latitude and 61° and 75° East longitude. It has a total area of about 796,000 sq-km. The population of Pakistan is estimated in 2015 is over 191.71 million (Pakistan Census 6, 2014-15) [16]. The land use change in Pakistan is affected by environmental, physical and human factors. This increase in population leads to rapid urbanization and conversion of agricultural land into built-up land and the forest land into agricultural or built up land. Due to accelerated advancement, educational betterment, and urbanization, Pakistan has gone through an extensive land use changes in the last decade. The proportion of the total population living in the urban areas has increased from only 17.8% in 1951 to about 32.5% in 1998 and 37% in 2011 (GoP, 2011) [17]. Due to deficit of land use, planning the developmental and construction activities drive to low water table level, contamination of drinking water and poor drainage system cause flood like situation when it rains heavily. Hence, like other countries, Pakistan also experienced a swift increase in urbanization and population in the recent decades. The land use change will continue to increase dramatically for coming years. Rai et al., (2011) [18] presents that Remote Sensing techniques have been used to monitor land use changes; this has an important role in urban and rural development and the determination of natural resources.

The World Bank reports that by 2015, one half of the total population would be urban in Pakistan (Dawn, 2007) [19]. Land development also results in loss of natural vegetation. Khyber Pakhtunkhwa (KP) is one of the four provinces of Pakistan. All of its cities are facing risks of rapid urbanization and population growth due to which land use is changing. Peshawar is one of the fastest and active growing city of KP. Its expansion brings changes in land use and results in reduction of productive agricultural land. The conversion of this land into built-up area is harmful for agriculture and food security. LULC has become increasingly important as the Nation plans to overcome the problems of haphazard, uncontrolled development, deteriorating environmental quality, loss of agricultural lands etc. (Anderson et al., 1976) [20].

Different techniques are available for image classifications. Gupta and Parakash, (1998) [21] used a combined method of color composite band subtraction, band division and supervised classification to prepare a land use map for change detection studies of a coal-mining district in India. Alados et al., (2004) [22] analyze the main processes that determine changes in landscape patterns and vegetation cover from 1957-1994 of semiarid and Mediterranean, to develop a model for land cover dynamics. Pocas et al., (2011) [23] used three different temporal satellite images of the same area and found out the different types of vegetation, barren/fellow land, and used land and used landscape matrices to characterize the spatial heterogeneity, fragmentation and complexity of the landscape and suggested from his study that it shows a trend of decrease of annual crop field, increase of landscape fragmentation. Zafar et al., (2011) [24] studied land use changes using satellite RS data for management zoning of the Margalla Hills National Park based on different environmental factors. Ashraf et al., (2011) [25] studied satellite image data of drought (2001) and post drought (2006) periods in order to assess changes in land use and vegetation cover through hybrid (visual and digital) interpretation technique.

Peshawar has been experiencing a rapid increase in its urban population. The land use alters the soil, water, vegetation, animal feed and others. As a result, land use changes lead to decreased availability of different products and damage to environment as well. Thus, the objectives of this study are to analyze the land use changes that are occurring for the last three decades in Peshawar District.

II. STUDY AREA

The research study was conducted in district Peshawar, the capital of Khyber Pakhtunkhwa-Pakistan, and is located about 160 km from federal capital Islamabad. Peshawar lies between 33° 44′ and 34° 15′ North latitude and 71° 22′ and 71° 42′ East longitude. The total area of district Peshawar is 1,257 sq-km. It lies approximately 1173 feet (358 m) above sea level. According to 1998 census record, population of Peshawar was 2,019,118 having population density of 1,606 people per sq-km (DCR Peshawar, 1998) [26]. According to one estimate the population of District Peshawar has increased to 3,575,000 with a density of 2,844 people per sq-km in 2014 (https://en.wikipedia.org/wiki/Peshawar_District). Location map of District Peshawar is shown in Fig: 1.

The district is almost a fertile plain. The central part of the district consists of fine alluvial deposits. The cultivated tracts consists of a rich, light and porous soil, composed of a pretty even mixture of clay and sand which is good for cultivation of wheat, sugarcane and tobacco. Peshawar valley is covered with consolidated deposits of silt, sand and gravel of recent geological times. The district is famous for producing both food and cash crops. The main food crops are wheat, maize and barley. The main cash crop is sugarcane. An important institution in the field of agriculture in district Peshawar is Agriculture Research Institute, Tarnab.

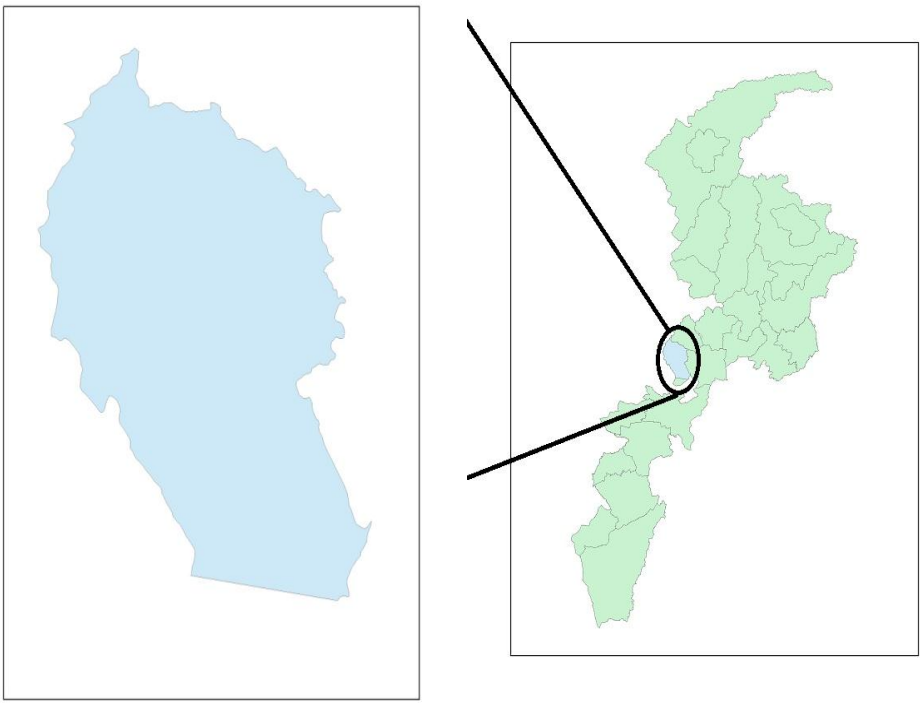


Fig: 1 Location Map of District Peshawar

III. DATA AND METHODOLOGY

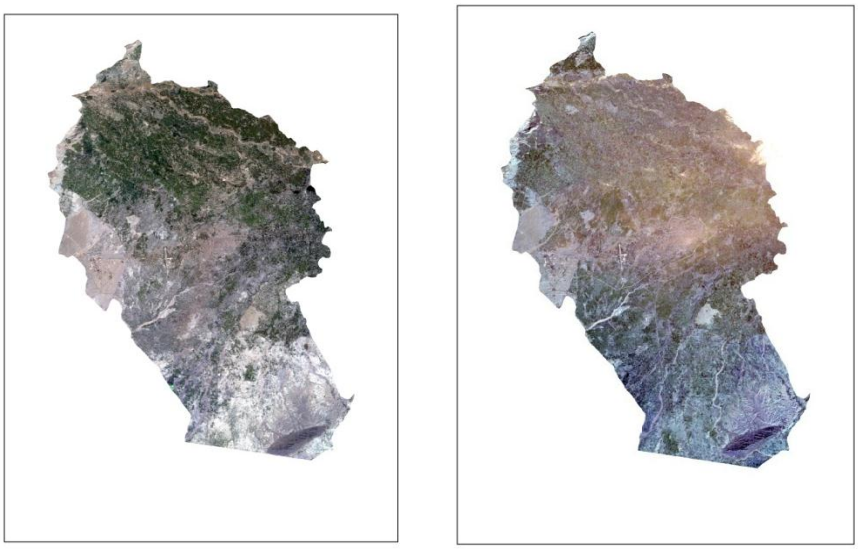
Multispectral and multi-temporal raster images, two of 30 m and one of 15 m resolution of Landsat 7, launched in April 15, 1999 and Landsat 8, launched in February 11, 2013 were acquired from United States Geological Survey (USGS) [27]. The USGS provides free images for research purpose but usually images are of low resolution. Path row for Peshawar District is 151-36. Images of Red, Green, Blue, SWIR-1, SWIR-2, TIR, NIR, and Band 8 (pan) of Landsat 7 were downloaded. Landsat 8 images of Aerosol, Red, Green, Blue, NIR, SWIR-1, TIR-1, TIR-2, SWIR-2, Cirrus and Band 8 (pan) were acquired from USGS site. The satellite image covers an area of 185 km x 185 km. The images were acquired based on the satellite availability for the area as shown in Table 1.

TABLE 1 Satellite Data Acquired, Period and Resolution

Year	Month	Resolution
1990	December	30 m
2000	December	30 m
2010	December	15 m

A. Area of Interest

A complete scene of 151-36 (path-row of Peshawar) was downloaded. The satellite data, in raster format, was opened in Erdas Imagine and the shapefile of Peshawar district was overlaid on these images. The area of interest that lies inside the boundary of Peshawar was separated from rest of the image using subset image tool of Erdas Imagine. Satellite images of Peshawar for the years 1990, 2000 and 2010 are shown in Fig: 2.



Year 1990 Year 2000

Year 2010

Fig: 2 Satellite Images of Peshawar for the Years 1990, 2000, 2010

B. Image Processing

Images acquired from satellite are in layers (bands) form, either of 7 bands image or 11 bands, each band is of black and white color. In order to make it a multispectral image, layer stacking tool of Erdas Imagine is used. To extract the interest area from rest of the image subset command of Erdas Imagine is used to overlay the digitized map of Peshawar on the satellite image. Band combination of image is altered to have natural color image. Band combination for natural color is 3, 2, 1.

Comparing two different satellite images of the same area having different spatial resolution, using resolution merge command of Erdas Imagine. Satellite data of 2010 was having band 8 of 15 m resolution. Using this technique, the spatial resolution of a low resolution (30 m) multispectral image of 2010 was enhanced to 15 m, high resolution multispectral image.

C. Image Classification

In unclassified images features i.e. vegetation, urban area, water bodies, barren land etc cannot be distinguished from each other. Because these images are having features combined by different bands, which do not have attribute tables. To convert images to their respective features, supervised classification tool of Erdas Imagine was utilized. We acquire land use changes by classifying our satellite images.

Supervised classification of satellite data was done according to the following classification scheme (Fig: 3).

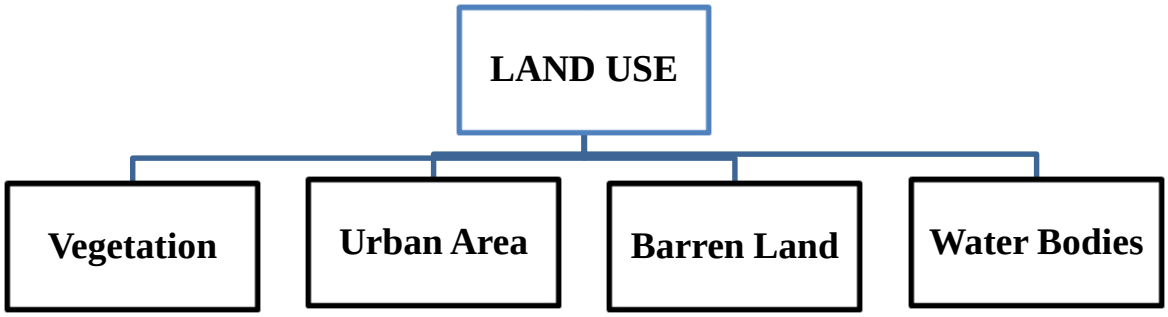


Fig: 3 Flow chart of Land Use

- Vegetation includes all the green area i.e. parks, gardens, cultivable lands.
- Urban area includes building, roads, pavements, permanent structures.
- Barren area consists of fallow lands, uncultivable area, harvested lands.
- Water bodies comprise of ponds, canals, rivers.

D. Supervised Classification

Each year satellite image was classified by supervised classification technique. Supervised classification operation is done in following steps:

- Define signatures
- Evaluate signatures
- Process a supervised classification

Multiple representative sign signatures were collected for each feature from image using AOI (Area of Interest) tools. After the signatures are defined, the pixels of the image are sorted into classes based on the signatures by use of a classification decision rule i.e. by running supervised classification command over raster image using the respective signatures. The output file is a raster image. The attribute table of this image includes class name, and class color. By edit tool we have added the area column to calculate the area covered by each class.

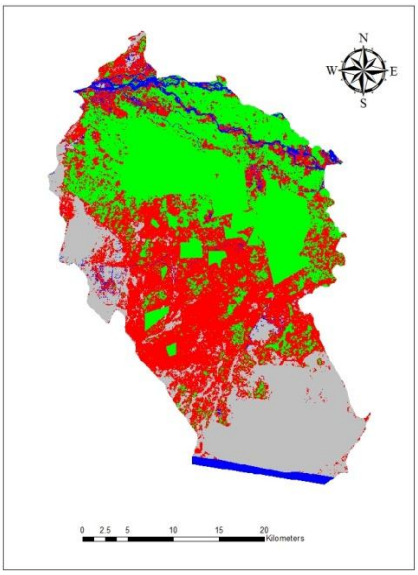
IV. RESULTS AND DISCUSSION

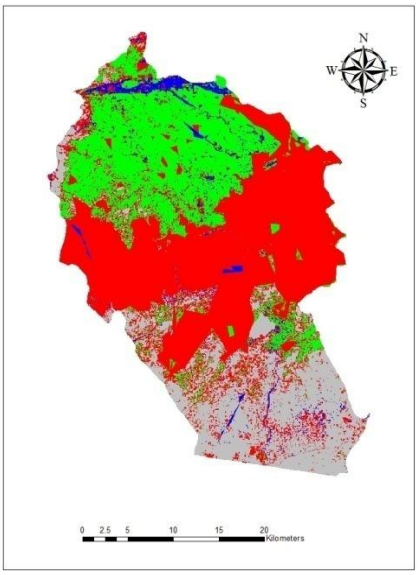
A. Land Use Distribution

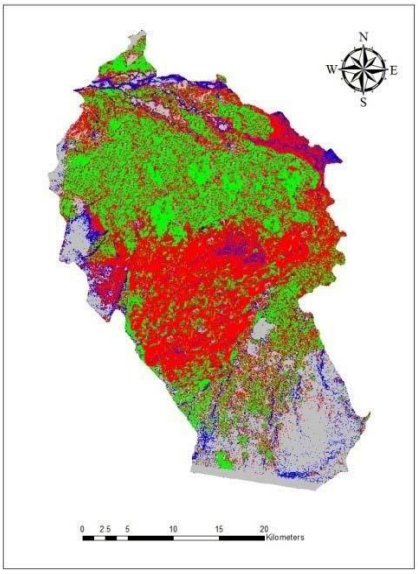
The term land use refers to the manner in which human beings employ the land and its resources or to the human activity or economic function associated with specific piece of land. Land cover is a term that explains the type of features present on the surface of earth or implies the physical or natural state of the earth surface. Land cover information is important for several planning and management activities concerned with the surface of the earth. We analyzed land use changes by performing GIS and RS analysis. The integration of GIS and RS techniques provides unique and useful information regarding land use changes. However, accuracy of results obtain from analysis depends upon expert skills, that how decision were made to separate out different pixels of different land use feature. Classified image of each year i.e. 1990, 2000, 2010, are shown in Fig 4, and was used to determine class area (Table 2). Images were classified for four land use classes. Land use classes were vegetation, urban area, water bodies and barren area. The total classified area was 1,257 sq-km (125700 hectare).

TABLE 2 Land Use Distribution for the Years 1990, 2000, 2010.

Sr. No	Land Use Classes	Area (ha)		
		1990	2000	2010
1	Vegetation	36732.7 (35.60%)	30061.4 (29.13%)	26447.0 (25.63%)
2	Urban area	36930.9 (35.80%)	45200.0 (43.80%)	50327.4 (48.78%)
3	Barren land	25138.1 (24.37%)	23457.1 (22.73%)	22024.8 (21.35%)
4	Water bodies	4351.41 (4.22%)	4479.8 (4.34%)	4358.0 (4.22%)







Year 1990
Year 2000
Year 2010

Fig: 4 Classified Maps of Peshawar for Years 1990, 2000, 2010

During the process of an in-depth analysis, numerous divergent trends of change patterns have been discovered. From Table 2, it has been observed that since 1990 to 2000, due to urbanization, green area i.e. vegetation and barren land in Peshawar District is reduced. Urbanization is because of more migration from nearby area to Peshawar city because Peshawar is having more opportunities of jobs and good educational institutes. While referring to Fig: 5, it can be noted that from 2000 to 2010, there is a consistent decrease in green belt and barren land of Peshawar and an increase in urban area. Whereas, water bodies remain almost stable throughout the study period.

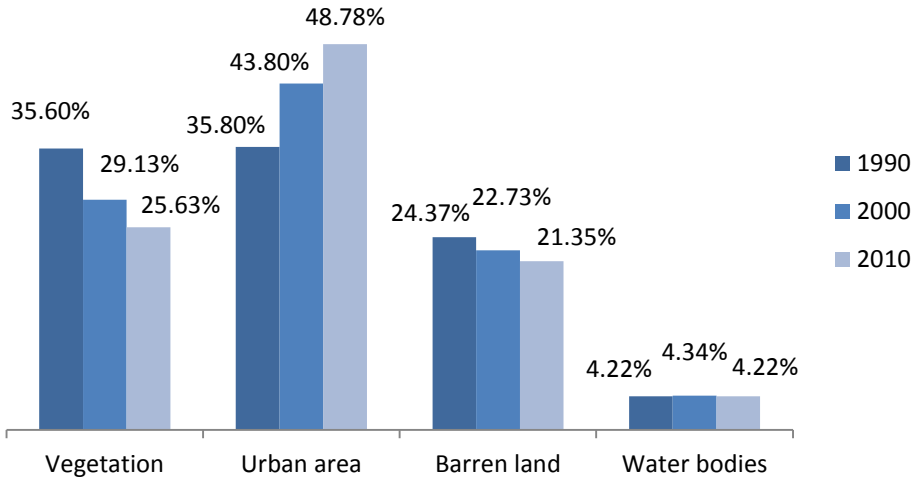


Fig: 5 Analysis of Land Use Change of Peshawar District for Years 1990, 2000, 2010

B. Causes of Land Use Change

Population increase always results in land use change. Major increase in Peshawar population was after the Soviet occupation of Afghanistan in 1979. Peshawar served as a political centre for anti-soviet Mujahideen and was surrounded by huge camps of Afghan Refugees. This increased pressure on land resources thus triggered the land-use changes. The basic need at that time was shelter which resulted in urbanization. Later on, the terrorism activities by terrorist in FATA and other tribal area near Peshawar compelled the residents of these areas to migrate to Peshawar. In the last decade, many new high educational institutes have been established major ones are Sarhad University, Gandhara University, City University, Abasyn University and some Colleges. Similarly, establishment of new and well-equipped health centers attracted people from nearby areas to migrate to Peshawar and settled, resulting in an increase in population. Because of more business opportunities in Peshawar, people from other cities and area keep on shifting here.

Human activities are also responsible for land use changes. Human activities that alter the land-use are; agriculture, livestock rising, urbanization, deforestation, construction, and development etc. These have some serious implications for sustainable development, climate, and livelihood systems.

C. Impacts of Land Use Changes

The changes of land use patterns certainly provide many social and economic benefits. However, they also come at a cost to the natural environment. Some of the adverse impacts include global warming, air and water pollution, noise pollution. Conversion of cultivable land to urban areas i.e. houses, roads etc, results in an increase in temperature of Peshawar. Also population increase demands increased transport facilities that cause air and noise pollution. Vehicles are mobile source of pollutants and fuel combustion in stationary sources, including residential, commercial, and industrial heating and cooling systems also release air pollutants. Air pollutants and particulates can penetrate deep into lungs and have adverse health effects.

One of the major direct environmental impacts of land use change resulting from urbanization is the degradation of water resources and water quality. Increased urbanization results in an increase in impervious surface, which alters the natural hydrologic condition of an area. It is well understood that the outcome of this alteration is typically reflected in an increase in the volume and rate of surface runoff during heavy rainfall, and decrease in ground water recharge. Impervious surfaces collect pollutants either dissolved in runoff or associated with sediments, such as nutrients, heavy metals, sediments, oil, grease, pesticides, and fecal coliform bacteria, are washed off and delivered to aquatic systems by rainfall and sometimes make their way to the drinking water supplies and results in health problems.

Unplanned and unmonitored land use change can make the situation even worse in the coming years, if proper attention is not given to this unchecked land-use change. It is of great importance to deal with the present impacts of land use change and predict the future status in an effort to restore the environmental quality of Peshawar District.

V. CONCLUSIONS AND RECOMMENDATIONS

District Peshawar has gone through extensive increase in population in the last three decades due to accelerated establishment of higher educational institutes, good medical facilities and Soviet occupation of Afghanistan in 1979. To analyze these changes in district Peshawar, change detection techniques based on Geographic Information System and Remote Sensing were used. Landsat satellite images with spatial resolution of 30 m were used for the year 1990, 2000 and image of 15 m was used for the year 2010. The supervised classification methodology has been employed in Erdas Imgine 9.2 software. The image of study is categorized into four different classes namely water bodies, barren land, urban area and vegetation. Results indicate that during the last three decades urbanization has gone up by 12.98% while vegetation has decreased by 9.97%, very

significant changes that have been observed. Due to the increase in population, more people tend to move from rural areas to urban areas. Thus urbanization is increasing day by day. This increase in population and urbanization demand more food, water and fresh air for survival. Thus people turns to the lands where there was no vegetation for years. One more effect of increasing urbanization is that people build infrastructure and homes in fertile lands and the food producing area is decreasing. With the increase in urbanization and building infrastructure is thus causing an impervious layer on the surface of soil. In other words, we can say that hard cape area is increased and soft cape area is decreased. Thus rain water cannot be properly infiltrated into the soil. And ultimately the soil doesn't get enough water and as a result run-off occurs and hence the chances of intense flood increased.

A. Conclusions

The following specific conclusions are drawn from this study:

- In 2000, vegetation has decreased to 6.47% with respect to 1990 and urban area has increased to 8.00%. In 2010, urban area is noted to be increased to 4.98% and 3.50% reduction in vegetation has been observed with respect to 2000.
- An overall increase of 12.98% in urbanization and overall decrease of 9.97% in vegetation has been noted since 1990 to 2010.

B. Recommendations

The following recommendations are suggested from this study.

i. An appropriate planning should be adopted to protect the agricultural land from urbanization, so that in upcoming days, the basic needs like food and water demand can easily be fulfilled.

ii. This study results can be compared by using different image processing methodologies.

iii. Different classifications should be used for land use detection by using high resolution images and find out the most accurate method.

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