ASSESSING FOREST AND AGRICULTRAL LAND UNDER LAND USE CHANGE USING REMOTE SENSING: A CASE STUDY OF BAHAWALPUR CITY (PAKISTAN)

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ABSTRACT. Rapid urbanization and development build a great pressure on the agricultural land in urban and semi-urban areas. As a result, there is reduction in agricultural and forest areas in different cities of the developing countries. The present study was conducted in Bahawalpur district of Pakistan. Six remote sensing satellite images of Landsat Enhanced Thermal Mapper and ETM+ were obtained from Global Land Cover Facility of United States Geological Survey's Earth Explorer and GLOVISE with an interval of three years from 2003 to 2018 (16 years) were processed for the study area (Bahawalpur City). Major land use classes identified for this study included forest, agriculture, barren and urban. Temporal changes of the four land use classes were detected and its impact on covered area by each land use class over the study period was computed. Results indicated that acreage of forest and barren land was decreased by 89.3% and 57.6%, respectively, while that of agriculture and urban area was increased by 34.5% and 45.5%, respectively, over the period of sixteen years from 2003 to 2018. These changes in land use cover might be owing to urbanization, deforestation and land conversion in the study area.

Keywords: *agriculture, barren land, urban land, image processing, urbanization*.

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INTRODUCTION

Climate change is global environmental issue with more frequent extreme climatic events. Agricultural communities are vulnerable to such climatic events. Only 10% of annual global CO_2 emission is being contributed by the developing countries which are more vulnerable to climate change. South Asian countries are affected due to large number of people and their reliance on agricultural-based rural economies. This causes serious issues in social, ecological and economic systems in the developing countries (Zhuang et al., 2009).

Climate change causes increased variation in the weather elements such as rainfall, temperature and wind. Different research studies confirmed the phenomenon of climatic changes and its potential effects in the coming years (IPCC, 2007). The number of warm days and nights has increased since 1950. The length, frequency and intensity of heat waves will increase in most of the areas worldwide. Climate change has also altered the timing, pattern and intensity of rainfall. There are more extreme events of rainfall with huge variations in the region (Field et al., 2012).

Land cover change is affected by different forces including social and political factors. Changes in land use have been observed at global and local levels due to political, social, economic, technological and environmental drivers (Egbenta, 2009). Changes in temperature and rainfall are causing different stresses on agricultural crops resulting in reduced crop yield, low income and more problem of poverty. In spite of low contribution of greenhouse gases, Pakistan is one of the ten most vulnerable countries to climate change in the world (Smadja et al., 2015).

Remote sensing and geographic information system (RS&GIS) are one of the most important methods and tools in identifying land use change in urban areas. Such methods and tools are used for assessing land use variations. Land cover includes physical and biological cover on land surface and it includes mountains, structures, forests, plants and mountains (Ellis and Pontius, 2006). There are significant impacts of land use change on on natural resources and services. There is rapid urbanization due to Industrialization in urban areas and it has changed marginal areas of cities in developing countries (Foley et al., 2005). Land use change study in Bahawalpur District has been conducted by Ahmed et al.

(2021). In this research, remote sensing tools were used for observing spatio-temporal land use change in Bahawalpur City.

MATERIAL AND METHODS

Study area: Bahawalpur District is located in the Southern part of Punjab province of Pakistan having latitude of 29°23′44″N and longitude of 71°41′1″E. Its elevation from Mean Sea Level is 152 meters. It has a population of more than 650,000 people. Bahawalpur City is comprised of 2,372 Km^2 area. The study area is in arid zone with very low annual average rainfall of 168.6 mm. The surrounding land is irrigated with canal water for growing agricultural crops. Major crops include wheat, cotton, mango and vegetables (Majeed et al., 2018). Climate of study area is dry and extremely hot during summer and is dry and cold during winter. Summer season starts from the month of May and ends in the month of September. The winter season lasts from October to March. There is small area of green spaces, parks and forest area in the city (Anwar *et al*., 2015).

Remote sensing data: Remote sensing is accomplished by different types of sensors, cameras and scanners, which are fixed on satellites in space and on airborne platforms for collecting information through aerial photography in the form of digital images i.e., RADAR and LIDAR data sets etc. Remote sensing data vary in time and space on the basis of different resolution, ground reality, and elevation of the sensors. Data is collected by cameras and sensors. Quick bird, IKONOS, RADAR, LIDAR, LANDSAT, MODIS and SPOT are used for different type of analysis (Ellis and Pontius, 2013). Present study was conducted for a period of 16 years i.e. from 2003 to 2018. United States Geological Survey's (USGS) Earth Explorer and GLOVISE were used to download satellite images (ETM+ and Landsat Enhanced Thermal Mapper) with equal time intervals. Time duration of the study for six satellite images was from 2003 to 2018 with the interval of three years.

Land use classification: Land use change was detected using downloaded remote sensing images in different time spans in the study area. Change of agricultural land into urban area was also estimated by analysis of these images. Satellite images were processed through image processing programs like ANVI for stacking, classification and differencing calculation (Table 1). Ground truth data was collected from field and in software program pixels were trained for accurate classification. Land use cover pattern (spatial and temporal changes) of Bahawalpur district was analyzed using historical imagery and land use classes were measured using ArcMap10 software.

Table 1. Land use classes delineated for study area.

No.	Class Name	Description
1	Forest Land	Mixed forest land with trees and shrubs
2	Agricultural Land	Crop fields and fallow lands
3	Barren Land	Land areas of exposed soil and barren area influenced by human influence
4	Urban Land	Residential, commercial, industrial, transportation, roads, mixed urban

RESULTS AND DISCUSSION

Status of land use classes: Figure 1 shows status of different land use classes in Bahawalpur City in 2003. Largest land use class was found to be urban land with an area of 41.42 km^2 (45.04%), followed by forest land (23.28 km^2) and agricultural area (19.16 km^2). There was an area of 8.11 km^2 (8.82%) of barren land. Changes in precipitation and rise in temperature are affecting availability of water and causing stresses for crops with adverse effects on yield of crops, farmers' income, and poverty. There is need to reconsider management strategies in agriculture under changing conditions. Crop selections according to climatic changes might cause land use change in developing countries (Rounsevell *et al*., 1999).

In 2006, largest land use class was urban land with an area of 44.52 km^2 (48.41%), followed by agricultural land use with an area of 25.47 km^2 (27.69%) and forest land use with an area of 13.92 km^2 (15.14%) (Figure 2). In 2006, there was an area of 8.06 km^2 (8.76%) of barren land in the study area. Changes in land use are happening rapidly which may cause changes in compositions of animal diets and population of species due to depletion of rangelands (PILDAT, 2016). There is need to formulate and implement adaptation strategies in Southern Punjab to minimize impacts of extreme climatic conditions.

In 2009, urban land class was found to be largest land use class with an area of 50.72 km^2 (55.15%) followed by agricultural land use class with an area of 21.54 km^2 (23.42%) and barren land use class with an area of 11.48 km^2 (12.48%) (Figure 3). There was an area of 8.23 km^2 (8.95%) of forest land in Bahawalpur. Land use change and deforestation and agriculture sector are responsible for emission of 22% of global GHGe. Around 9% of GHGe (4.3-5.5 Gt CO_2 eq/y) is caused by ongoing land conversion and deforestation activities (Smith et al.,

2014). Figure 4 shows status of different land use classes in Bahawalpur in 2012. Largest land use class was found to be urban land with an area of 53.54 km^2 (58.21%) followed by agricultural area (20.67 km^2) and forest land (9.26 km^2). In 2012, there was an area of 8.50 km^2 (9.24%) of barren land in Bahawalpur. Different behavioral and structural factors are responsible for land use changes that affect the ecosystem (Verburg et al., 2004).

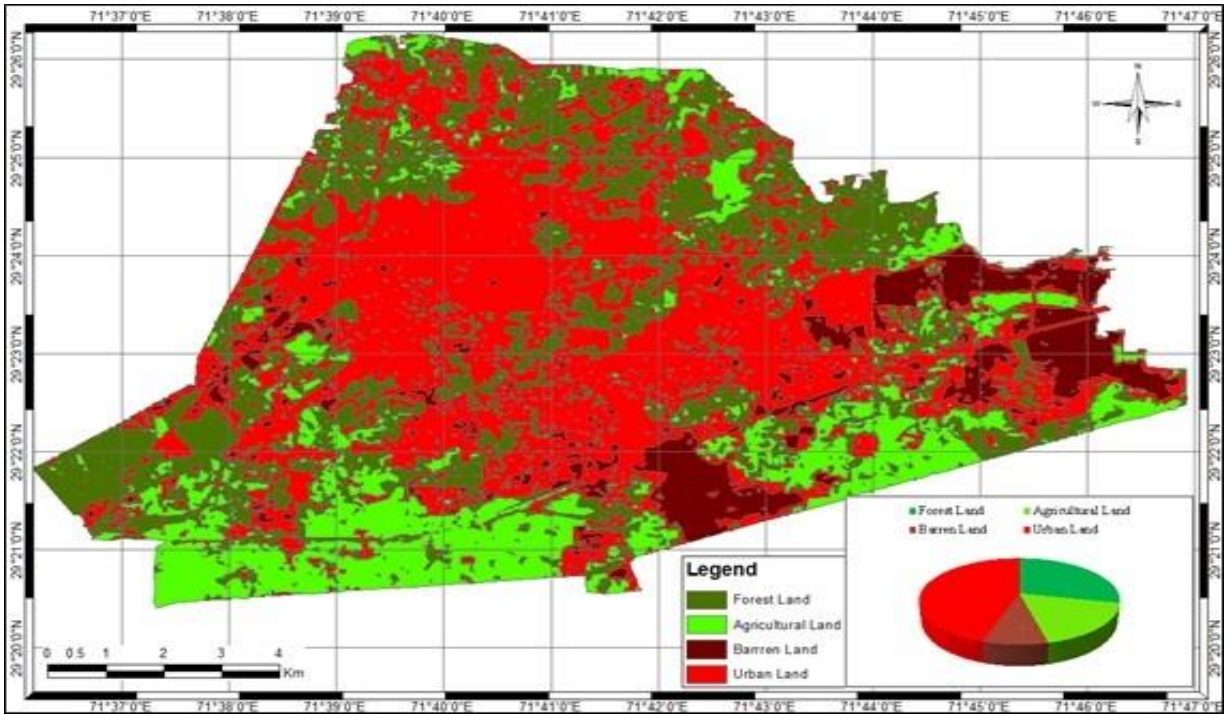

Figure 1. ***Land use classification of Bahawalpur City in 2003***

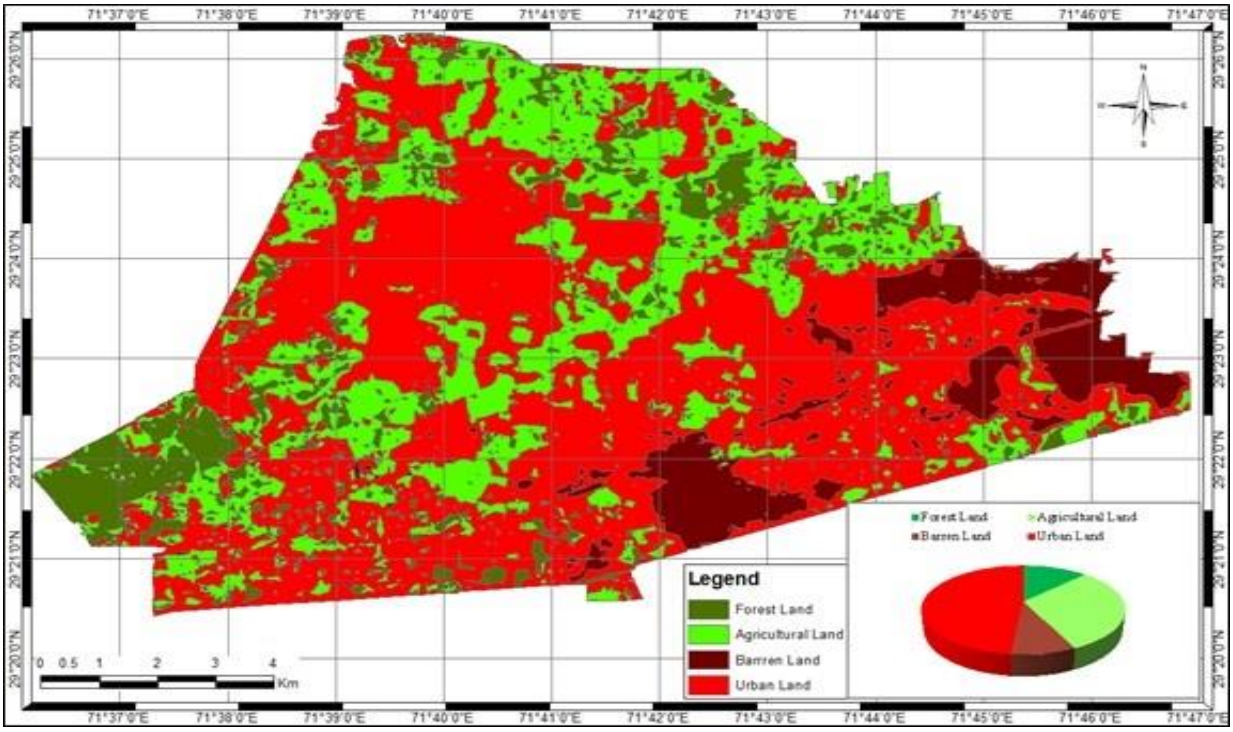

Figure 2. ***Land use classification of Bahawalpur City in 2006***

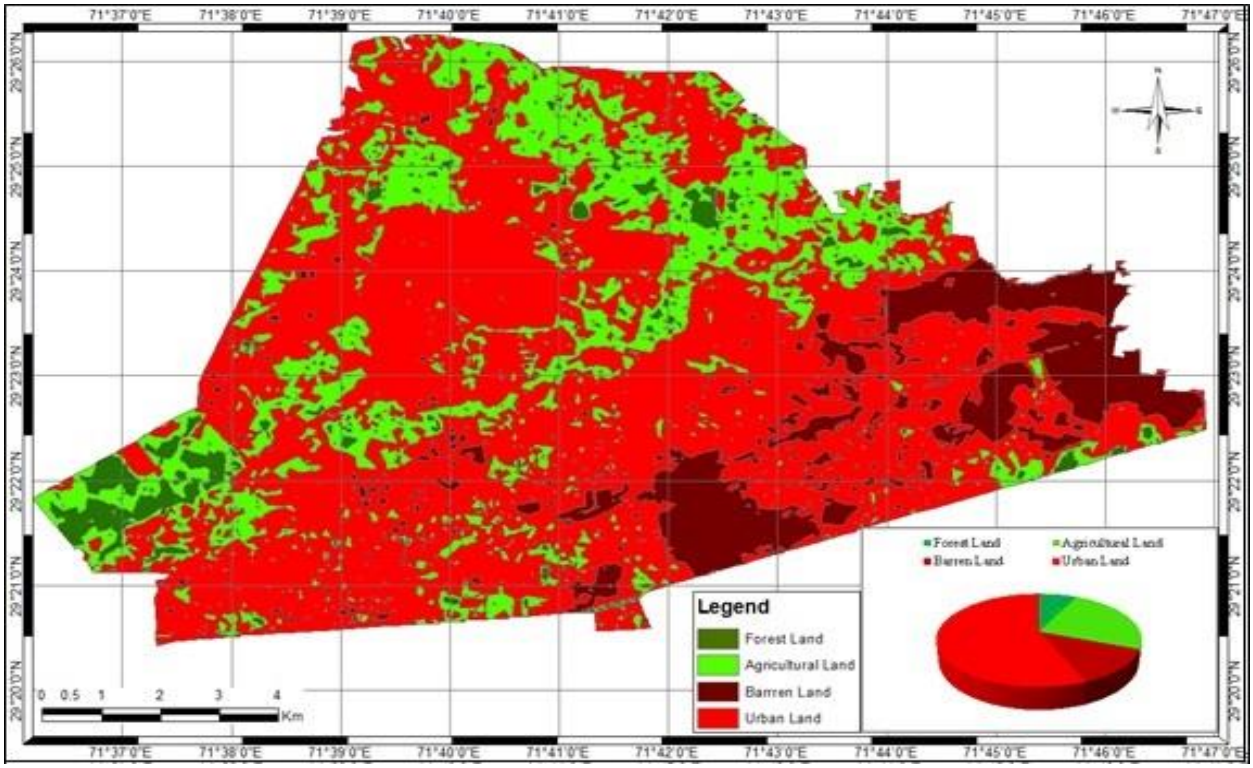

Figure 3 ***Land use classification of Bahawalpur City in 2009.***

In 2015, urban land class was found to be the largest land use class with an estimated area of 58.30 km^2 (63.39%), followed by agricultural land use class with an area of 26.16 km^2 (28.44%) (Figure 5). Other two land use classes, barren land and forest land, had very low area of 5.10 km^2 (5.55%) and 2.41 km^2 (2.62%), respectively. Climatic changes cause changes in management of soils and changes in land use affecting soils and their properties (Rounsevell *et al*., 1999). Figure 6 shows status of different land use classes in Bahawalpur in 2018. Largest land use class was found to be urban land with an area of 60.28 km^2 (65.54%), followed by agricultural with an area of 25.77 km^2 (28.02%). Barren land had an area of 3.44 km^2 (3.74%) and forest land had an area of 2.48 km^2 (2.70%). Agricultural and food production sector is also facing impacts of varying climate. Climatic extremes, such as droughts, may cause food scarcity, further causing an increase in prices of food in recent years. It was found that droughts had been taking place in areas, which are suitable for crop production, turning, them into less favorable areas. Climate change can be a biggest threat for the agriculture sector (Rosenzweig *et al*., 1994).

Changes in land use: Figure 7 shows trend of land use change in study area during 2003 to 2018. There is decreased area of forest land from 23.28 km^2 in 2003 to 2.48 km^2 in 2018. This reduction in forest area is due to deforestation and land conversion in study area. Land conversion and deforestation cause emission of greenhouse gases (Smith et al., 2014). Barren area has also reduced from 8.11 km^2 in 2003 to 3.44 km^2 in 2018. An increase has been observed in agricultural area from 19.16 km^2 in 2003 to 25.77 km^2 in 2018. Land use changes is characterized by different structural and behavioral forces along with social relations, technological capacity, and demand affecting the ecosystem (Verburg et al., 2004). An increase has been observed in urban area from 41.42 km^2 in 2003 to 60.28 km^2 in 2018. This is due to increased population, migration to urban areas and urbanization. There are different causes of land use change in Pakistan including urbanization, soil and water erosion, cutting of trees, overgrazing, poultry discharge in streams, aquatic habitats' fragmentation, water pollution due to deforestation and discharge of untreated industrial and municipal wastewater and pesticide residues (Tanvir et al., 2006).

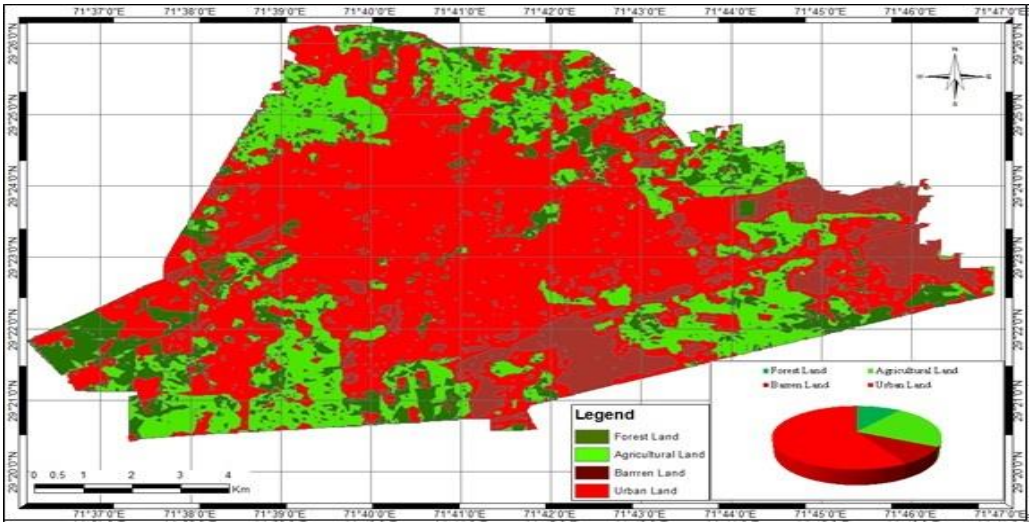

Figure 4. ***Land use classification of Bahawalpur City in 2012***

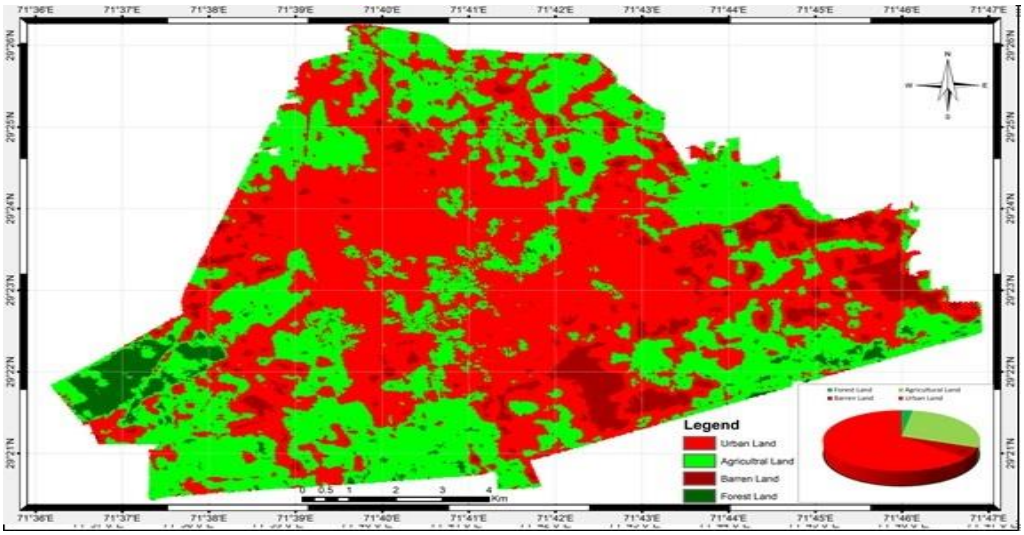

Figure 5. ***Land use classification of Bahawalpur City in 2015***

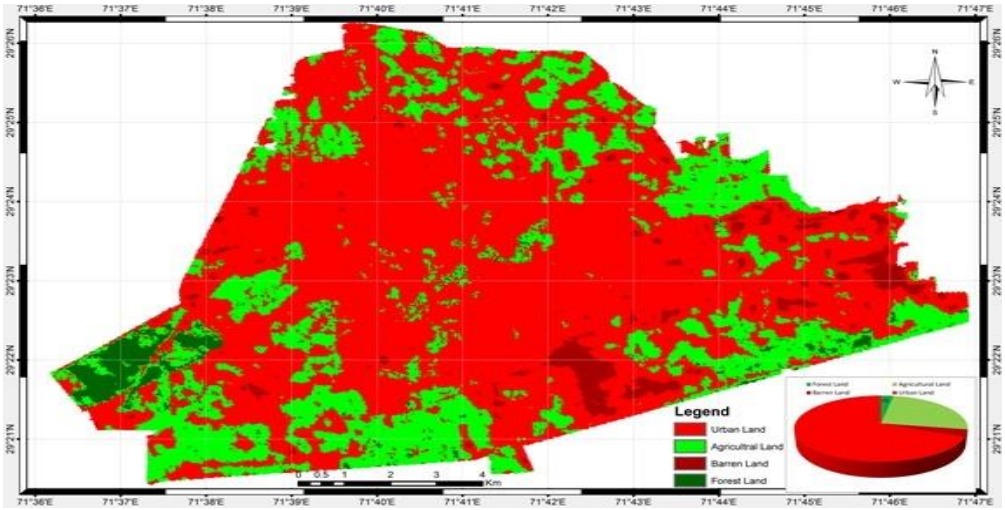

Figure 6. ***Land use classification of Bahawalpur City in 2018***

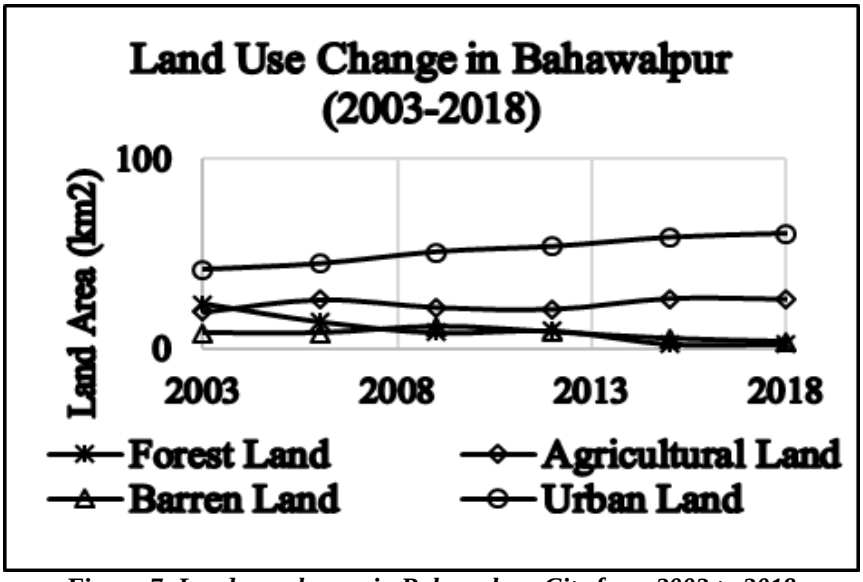

Figure 7. ***Land use change in Bahawalpur City from 2003 to 2018***

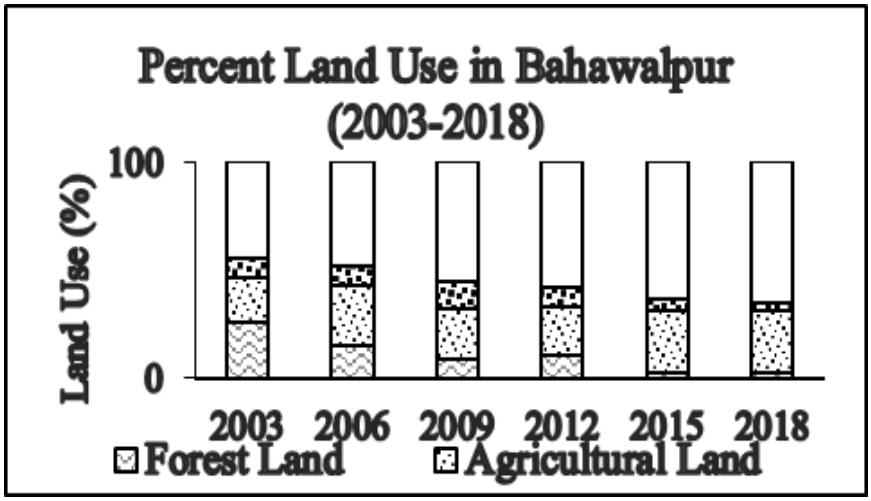

Figure 8. ***Percent land use change in Bahawalpur City from 2003 to 2018***

Potential impacts of land use change on land cover: Land use change affects ecosystem processes and patterns disturbing supply of its services. Ecosystem services are affected by climate change directly or indirectly by changes in levels of greenhouse gases and hydrological processes (Nelson et al., 2013). Water quality deterioration, reduction in carbon storage, and biodiversity losses have been observed due to urbanization, overgrazing, increase agricultural areas and other related factors. As a result, there is significant decline in services by ecosystems (Li et al., 2013; Polasky et al., 2011). The direct and indirect benefits provided by the ecosystems including different services and products are collectively known as ecosystem services. Humans are changing the nature constantly with population growth, urbanization, development and technological progress. As a result, there are changes in energy flow of ecosystems and chemical cycling. There are two main factors affecting ecosystem services. These driving factors include land use and climate change (Bateman et al., 2013). It is important to note that existing forest area is small in Pakistan. This forest area is decreasing due to land use change, grazing, deforestation, erosion. Other possible reasons include increasing human population and livestock sector. These practices might increase forest deficient in the coming years due to combined effect of increased socio-economic pressures on forests and climatic changes. Land use changes have more adverse effects on forest areas as compared to climate change (Siddiqui et al., 1999).

Conclusion: Forest land, agricultural land, barren land and urban land use classes were defined and their areas were estimated using downloaded satellite images. A decrease in area of forest land was observed from 23.28

km^2 (2003) to 2.48 km^2 (2018). Reduction in barren area was also found from 8.11 km^2 during the study period of sixteen years. In contrast, an increase has been observed in urban area from 41.42 km^2 in 2003 to 60.28 km^2 in 2018. An increase of agricultural land was also estimated from 19.16 km^2 (2003) to 25.77 km^2 (2018). Agriculture should be made environmentally friendly by enhancing technology of land use and better assessment of environmental health. Adaptation strategies should be formulated and implemented in Southern Punjab to minimize impacts of extreme events of climatic factors.

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