ANALYSIS OF LAND USE CHANGE AND POPULATION GROWTH USING GOE-SPATIAL TECHNIQUES IN LAHORE-PAKISTAN

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ABSTRACT: The research aims to investigate the tehsils population growth and land use change. The study was conducted in megacity Lahore which is the second largest city of Pakistan. The urbanization is a process which enables towns and cities to grow by human migration from rural to urban areas. In addition, it is a progressive population increase in cities and towns, which is hugely influenced by the notion achieved by towns and cities. Changing the Earth is a very regional trend with effects on the environment scale on the regional scale that may vary in the sign of the change. In order to study LULC changes in a city like Lahore, four Landsat satellite images of Lahore district were acquired for 1990, 2000, 2010 and 2020 with the resolution of 30 meters. By using Arc GIS the satellite images were digitized to know the land use change in Lahore from 1990-2020. Lahore tehsils population detection maps from 1990-2020 using GIS were used to show the tehsils population. According to the present study of tehsils population of Lahore including cantonment, city, Model town, raiwind and Shalimar, as observed, the highest trend of population is towards raiwind tehsil. The second highest populating growth is in tehsil model town and the lowest trend of populating is in tehsil Shalimar. Temporal analysis of population and land use change data for the last thirty years from 1990-2020 demonstrates that Lahore's population has increased 156%. Built-up area has increased 57%, vegetation and green cover decreased by 21%, the open area has decreased by 42% and water bodies decreased by 58%..

INTRODUCTION

The world population is around 7.87 billion today (UNFPA, 2021) and 55% of the population is residing in cities, defined urban areas (UN Populations, 2019). The ever increasing population has modified and altered most of Earth's land surfaces. (Shirazi, 2009). As asserted by Aristotle, "in order to attain good life, the authority of the city state must be subjected to the humans". The rapid expansion of the most dynamic urban areas has become a global geographical phenomenon in the world (Minallah, 2017).The urbanization is a process which enables towns and cities to grow by human migration from rural to urban areas. In addition, it is a progressive population increase in cities and towns, which is hugely influenced by the notion achieved by towns and cities (Pawan, 2016). In the urbanization process, people migrate from countryside. It's not a modern phenomenon in which each society tends to adapts to change urbanization. However, a rapid and historic transformation of human social roots on the global scale whereby the rural culture is being rapidly a predominant urban culture.

In past decades, the annual growth of the global population was 1.24 percent comparatively faster than the growth being observed at present which is 1.18 percent. It is determined that the world population would reach 8.5 billion by 3030, 9.7 billion by 2050 and 11.2 billion by the end of the 21st century (Nadeem, 2017). The number of people living in the urban areas is projected to reach 68% by the year 2050 which means 2.5 billion inhabitants would be living in cities with an increase of approximately 90 percent in Asia and Africa (UN Populations, 2019).

Major causes of urbanization (Pawan, 2016) are; Migration, Commercialization, Industrial growth, Social Factor, Employment opportunities, Modernization, Defective town planning. Urbanization has major impacts (Stren, *et al*., 2016); Urban pollution, Global warming, Slums and their consequences of overcrowding, Lack of sanitation, Traffic congestion, Waste generation and Noise pollution

According to Rana *et al*., (2017) and Alam (2017) Urbanization has following challenges; The building laws and regulation are not strictly implemented, There are no check and balance over rapid commercialization and the development which is so

unrestricted, Lack of incorporated and solidified administration with clear jobs and duties, Special attention to provide an improved sanitation system, and Appropriate waste water treatment solution

Land use is highly influenced by cultural, economic, political and historical and the land tenure factors at different scales. Land use referred to as the man's activities and various uses that are carried on the land. Land cover is referred to as natural vegetation, water bodies, soil, artificial cover and others due to land transformation. Since both the land use/land cover are very closely related. They are not mutually exclusive and are interchangeable as the former is inferred based on land cover and on their contextual evidence (Manonmani & Suganya, 2010).

Changing the Earth is a very regional trend with effects on the environment scale on the regional scale that may vary in the sign of the change. In regards to the average flow in areas with significant changes in land use, there is a problem on net radiation ground level up to distribution of that net radiation between two solid energy flows (intelligent heat and light heat). In the audiences thickness land use change majorly includes the biochemistry including Fluidal carbon exchange and flow of the trace gases (such as nitrogen oxide), organic stable organic compounds, and the eucalyptus including dust (Pielke *et al*., 2011).

This study aims to empirically analyze the land use land cover changes and tehsils population growth in Lahore district. Megacities of Pakistan are facing different environmental issues like overpopulation with limited resources and unchecked utilization of urban land, which is affecting agriculture land, forest area, open space and water bodies. The present research study can be beneficial for Environmentalists, Urban planners, Policy makers and Geographers.

METHODOLOGY

Description of study area: Lahore is the capital city of the of Punjab, the second biggest metropolitan city in Pakistan and therefore the 22nd most crowded city on the earth consistent with the positioning of 2019 (World Population Review, 2019). In South Asia, the Lahore is an important historical center. With a rich history going back longer than thousand years, Lahore is a fundamental social point of interest of the Punjab area and Pakistan, and is that the biggest Punjabi city on the world (Emerging Pakistan Govt, 2019). Lahore stays a monetary, political, transportation, amusement, and instructive center point of Pakistan. The town of Lahore is situated between 31.5546° N and 74.3572° E along the eastern bank of the Ravi River with 1772 km2 absolute region at 217-m elevation. As per Census (2017), absolutely the populace of Lahore is 11.13 million with 3% yearly growth rate. The average population density is 6300 people for each square kilometer (Rana *et al*., 2017). The average yearly precipitation is 240 mm. A major segment of precipitation happens during the rainstorm time frame (June to August). The environment of Lahore is cold in winter and hot/humid in summer. The foremost sweltering months are June and July, with greatest temperatures over 42 °C. During winter, the temperature may tumble to 2 °C.

There is rapid growth of Lahore city due to migration, urbanization and industrialization in recent years. Population of Lahore district increased from 634044 (1998) to 11126285 (2017) (PBS, 2017).
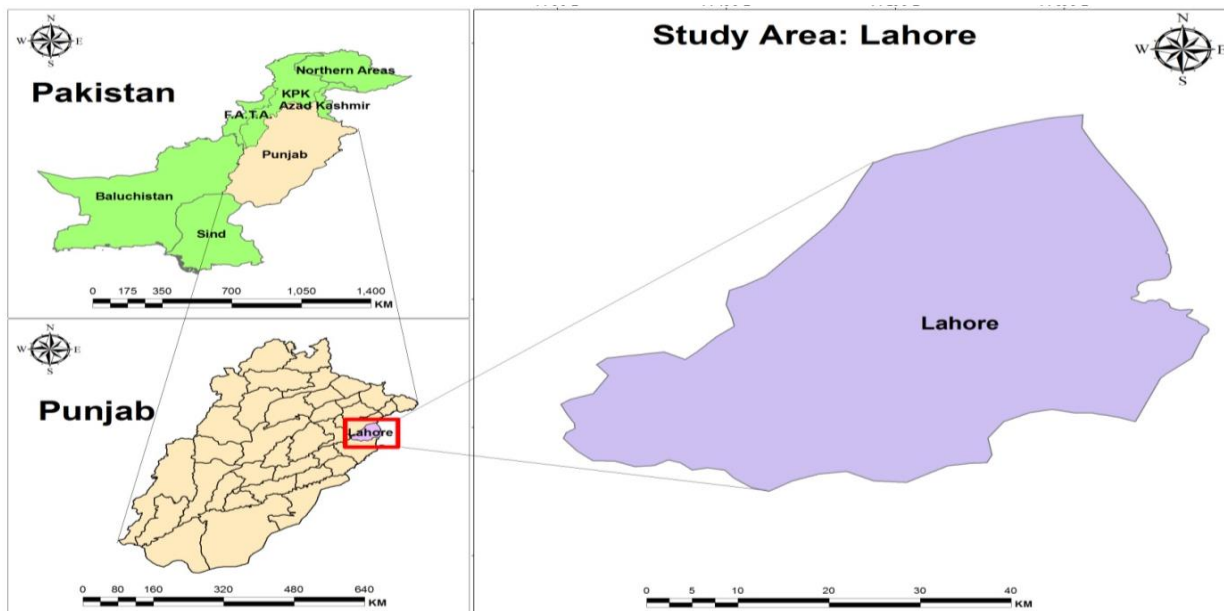
Source: Author, 2021

Data collection
Secondary data: Lahore district and tehsil wise population data were collected from Pakistan Bureau of statistics. Population and annual rate of population data were also collected from United Nations Population Division Department of Economic and Social Affairs. Satellite images of Lahore district were downloaded from Global Land Cover Facility: An earth science data interface's website**.**

Satellite images downloaded

Satellite sensor	Path	Row	Acquisition date	Resolution
Landsat 5 TM	149	38	March 16, 1990	30 Meter
Landsat 7 ETM+	149	38	March 19, 2000	30 Meter
Landsat 7 ETM+	149	38	March 03, 2010	30 Meter
Landsat 7 ETM+	149	38	October 20, 2020	30 Meter

Land use classes for change detection

Sr. No	Name of class	Description
1	Built-Up area	All the buildings, roads and sealed surfaces
2	Vegetation	All season crops area , scrub, grasses as well as aquatic vegetation
3	Water bodies	River Ravi, Lahore Branch Canal and all the swampy areas
4	Open area	Abandoned fields, patches of bare soils and all the vacant areas

Land use change detection of Lahore district 1990-2020: In order to consider LULC changes in a city like Lahore, four Landsat satellite images of Lahore district area were procured for 1990, 2000, 2010 and 2020 with the determination of 30 meters/pixel (Path & Row No. 149-038). These four pictures were downloaded from Global Land Cover Facility (GLCF) an Earth Science Data Interface's website. The primary and preeminent step in picture handling is the securing of a suitable picture. The choice of an appropriate picture could be an aptitude which one can learn with the course of time and encounter. In any case, appropriate time, suitable determination, lesser cost and accessibility are a few of the vital components for getting an image. The geo-referencing properties of all four (1990, 2000, 2010 and 2020) pictures were the same thus in this manner, four software related to present research were used viz; Arc GIS 10.5, ERDAS Imagine, Microsoft Excel and finally MS word was used for the final presentation of the research.

Based on the prior knowledge of the Lahore, a classification scheme was developed. That includes built-up area, vegetative cover, open area and water bodies. The Landsat pictures procured from GLFC (USA) have been utilized as fundamental sources of information and to plan LULC change detection maps. To begin with, the shapfile of Lahore has been arranged beneath ARC GIS environment and after that the same overlaid to the 1990, 2000, 2010 and 2020 images. After that, the regular strategies utilized in LULC studies have been adopted in an efficient way.

LULC changes are visible all over the district of Lahore and although presently, the City of Lahore has been partitioned into towns and union chambers, but this study has been carried out for the complete area of Lahore, and the LULC change detection has been examined at district level. The calculation of the area has been displayed in kilometers.

Finally we compared the results taken through spatial matrix in ERDAS imagine. This sort of choice will give a coherent premise for study. The absence of data pertaining to this project, reliance has been heavily being placed on the satellite images. GCPs and mapping of the surveyed areas with GPS and significant data related to land use changes within the sample zones have been collected by the author himself. As expressed prior, analytical program, ERDAS imagine and ARC GIS 10.5 has been utilized to the accessible information and the GIS spatial databases have been arranged. At last various numerical methods have been utilized to the accessible information for chronological change detection in Lahore 1990-2020.

Lahore tehsils population detection maps from 1990-2020 using GIS: Historical Boundaries paper maps of union councils of Lahore districts were collected from urban unit, metropolitan corporations and tehsils council. Maps were scanned with scanner device to get the soft form of maps. After getting soft maps of all union councils maps have been geo-referenced by using conferencing tool in arc map. After geo-referencing and assigning the projection system WGS 1984 NORTH to paper map. Shape files of boundaries digitized from actual maps of tehsil councils. Which were drone by different government agencies. After digitizing the boundaries shape files data of population added and rheumatic maps have been created to show the historical differences of population and also describes the

comparison of population between the tehsils from 1990-2020..

RESULTS AND DISCUSSION

Land use change classification: The Land use change maps shows the variations in land use in Lahore. Thirty years land use change classification maps included data years 1990, 2000, 2010, and 2020 showing change in built up area, vegetation, water and open area. The land use variation represents the changes in land cover. The population increase has changed the vegetation and open spaces into built-up area. This change has also affected the surface water of Lahore during 1990 to 2020. These changes are depleting the natural resources that can cause the climate change to affect the human life.

Figure 1 shows Land use classification of Lahore district in the year 1990. The built up area is 29.3 percent and the vegetation or green area is 63.1 percent. Water in the district is 3.2 percent and open area or fields are 4.4 percentage. It has been observed that the percentage of vegetation in the Lahore district is the highest. The figure shows a wide range of water bodies with greater vegetation in 1990. Figure 1 shows the Land

use classification of the year 2000 in Lahore District. The built up area is increasing with the passage of time and the vegetation decreasing due to the built up area. Vegetation that is shown in the figure is around 60 percent and built up area is 30.4 percent. The water in the entire area is around 4 percent while the open area is around 7 percent. The figure depicts the built up area is replacing vegetation at a higher rate.

Figure 1 shows Land use classification of Lahore district in 2010. The vegetation cover or green area is 57.4 percent and built up area is 35.1 percent. Water is only 1.3 percent and open area is 6.2 percent. the increase of built up area is taking effect on vegetation, water and open area. As a result, the increasing population is gradually decreasing the natural resources. Figure 1 shows Land use classification of Lahore district in 2020, the vegetation is 50.1 percent that is decreasing due the built up area. The Built up area is 46 percent that is replacing the vegetation or green cover. Whereas the water is 1.4 percent and open area is 2.5 percent. Due to the increase in population, the built up area is increasing that is affecting vegetation, water and open area.

Figure 2 shows year wise land use change classification in 1990, 2000, 2010 and 2020.
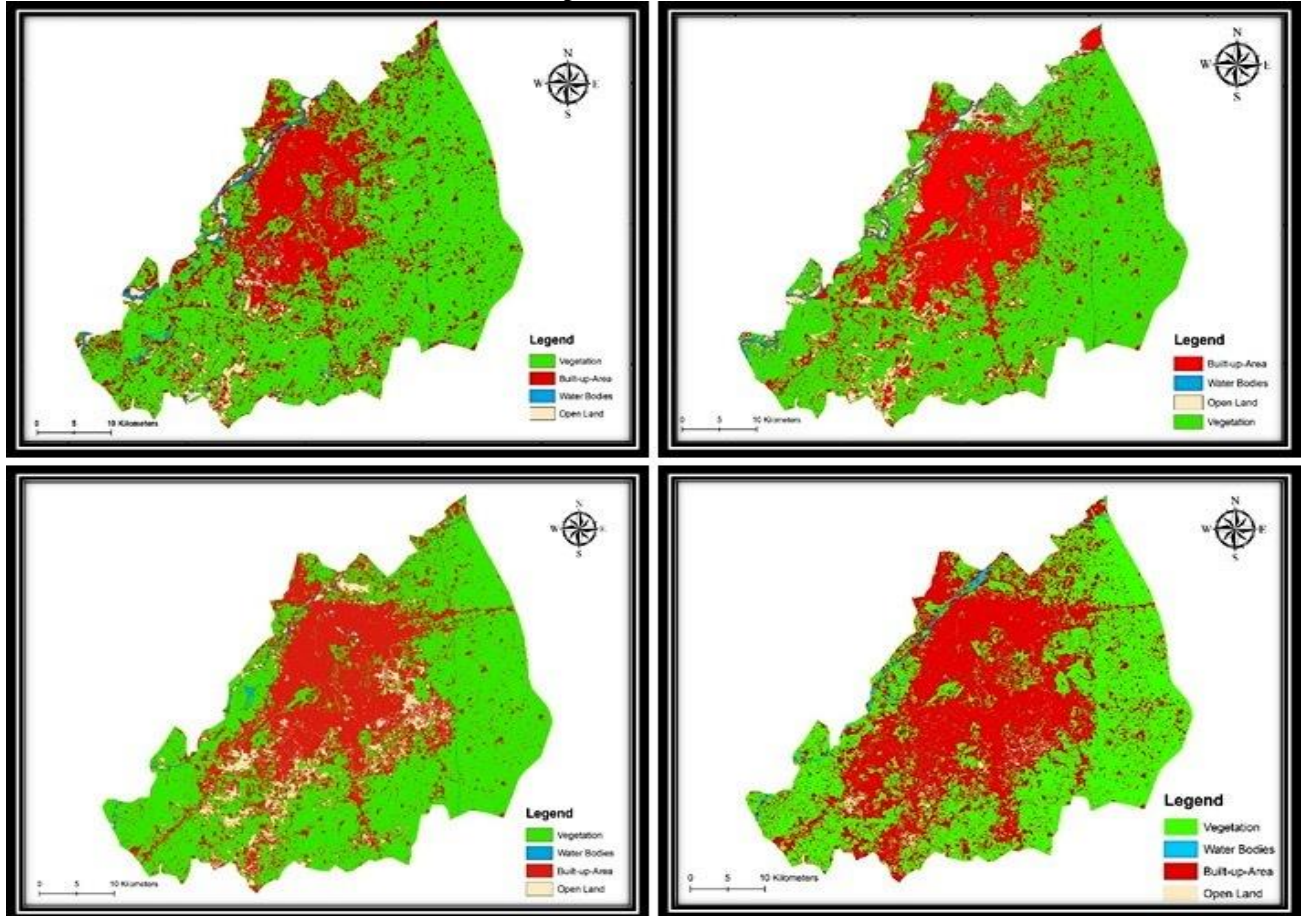
n maps Lahore 1990-2020

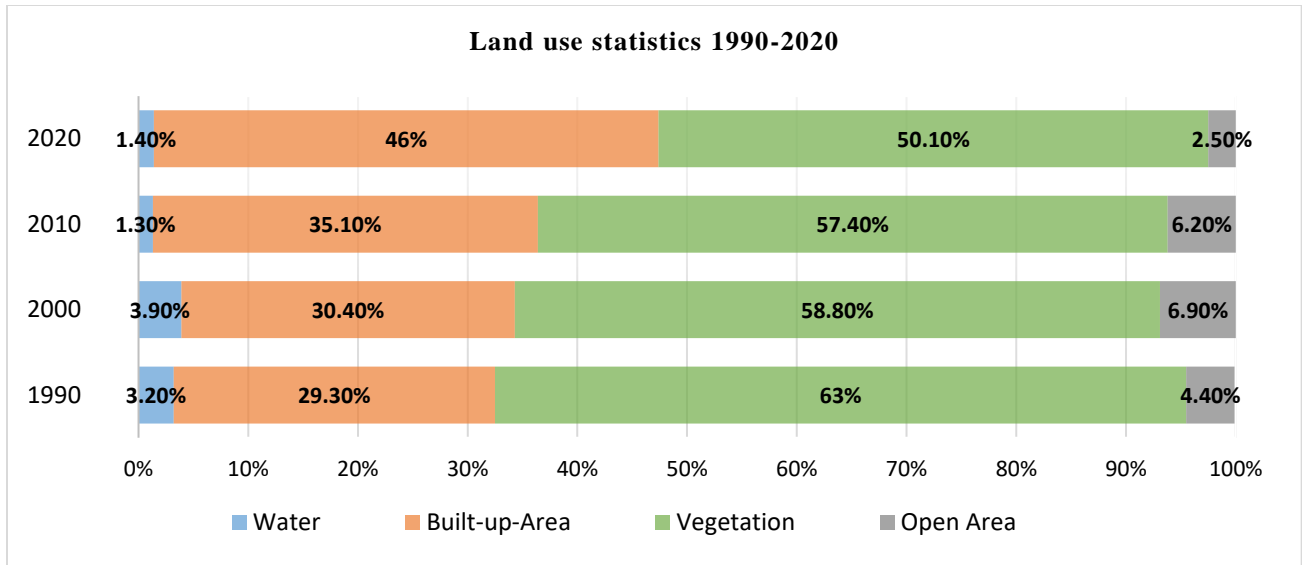**Figure 1: Land use change classification maps of Lahore district 1990 – 2020**

Figure 2: Land use in Lahore district 1990-2020.

Land use change during different periods: Figure 3 shows the land use change in ten years 1990-2000, water increase by 21%, Built up area increased by 4%, Vegetation decreased by 7% and open area increased by 56%. From 2000 to 2010, the water decreased by 67%, Built up area increased by 15%, vegetation decreased by 2% and open area decreased by 10%. In 2010-2020 water increased by 4%, Built up area increased by 31%, vegetation decreased by 13% and open area increased by 59%.

Total land use change in thirty years (1990-2020): Figure 4 shows the land use change from 1990 to 2020. Water decreased by 58%, Built up area increased by 57%, vegetation decreased by 21% and open area decreased by 42%. Due to the increase in built up area, the natural resources such as water, vegetation and open areas are decreasing and this is causing greenhouse gasses to increase the effects on the climate of Lahore district.
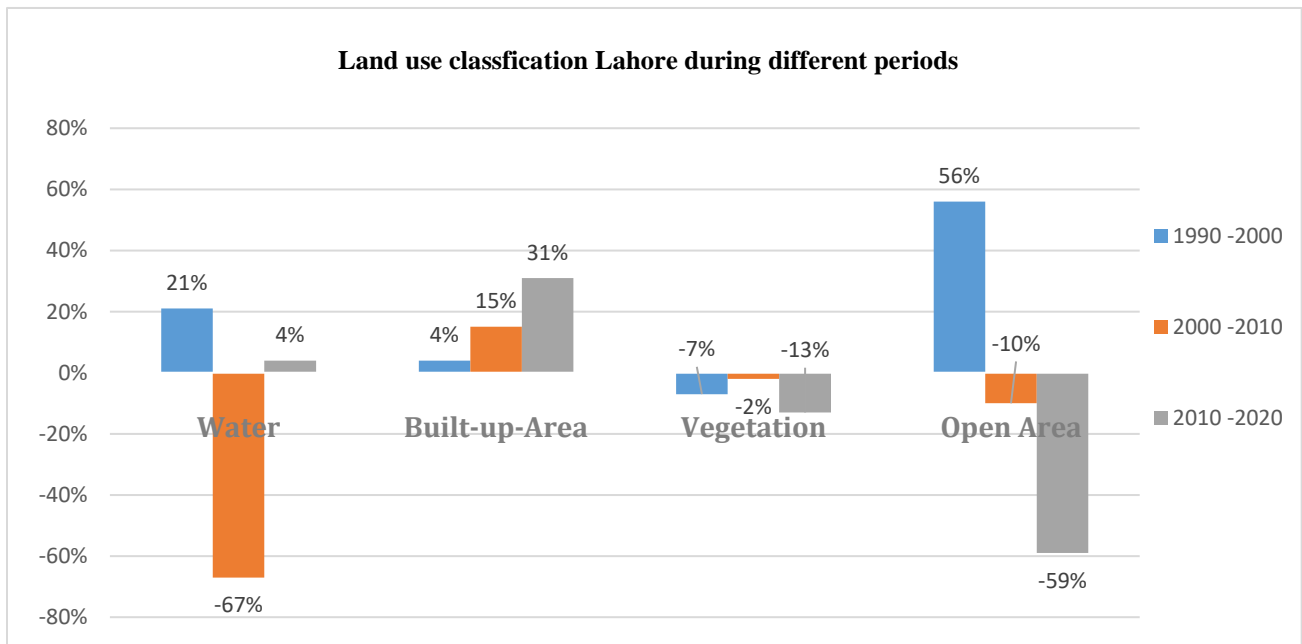

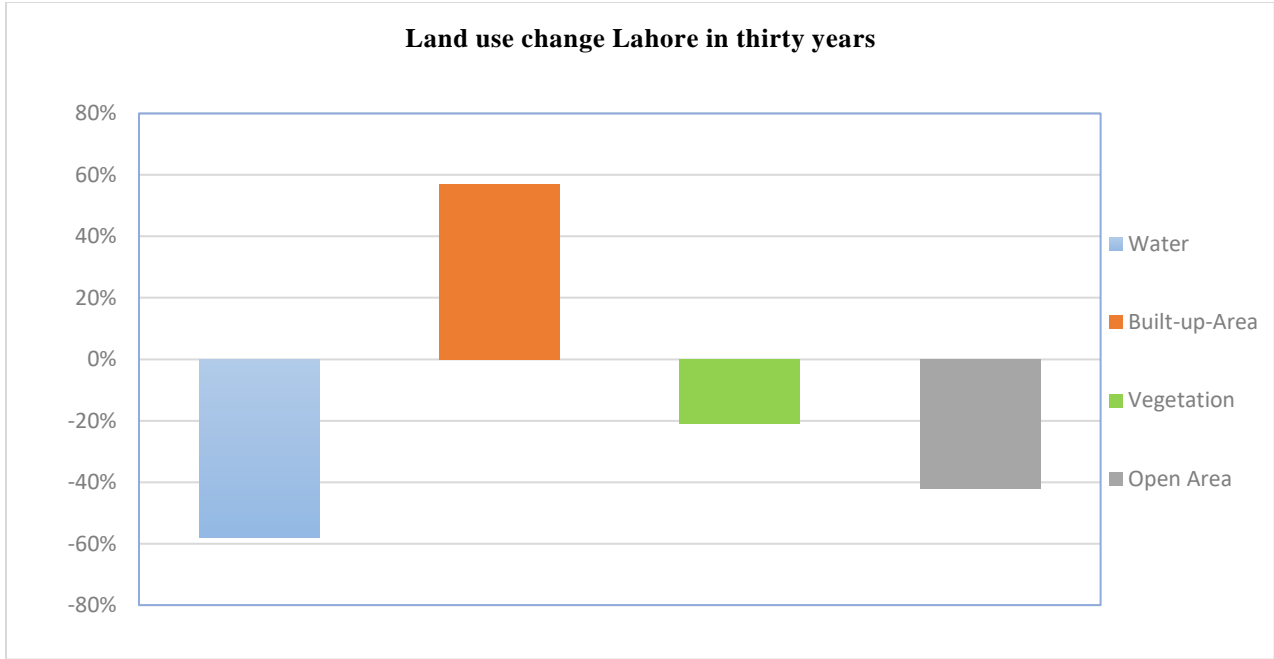**Figure 3: Land use change classification in Lahore with ten years difference**

Figure 4: Total land use change in thirty years 1990-2020.

Land use change in km2 1990-2020: Figure 5 shows area in km^2 for all four classes and the changes in land use during 1990-2020. Built-up area increased by 296 km2, vegetation decreased by 230 km2, water and open area decreased by 33 km2.
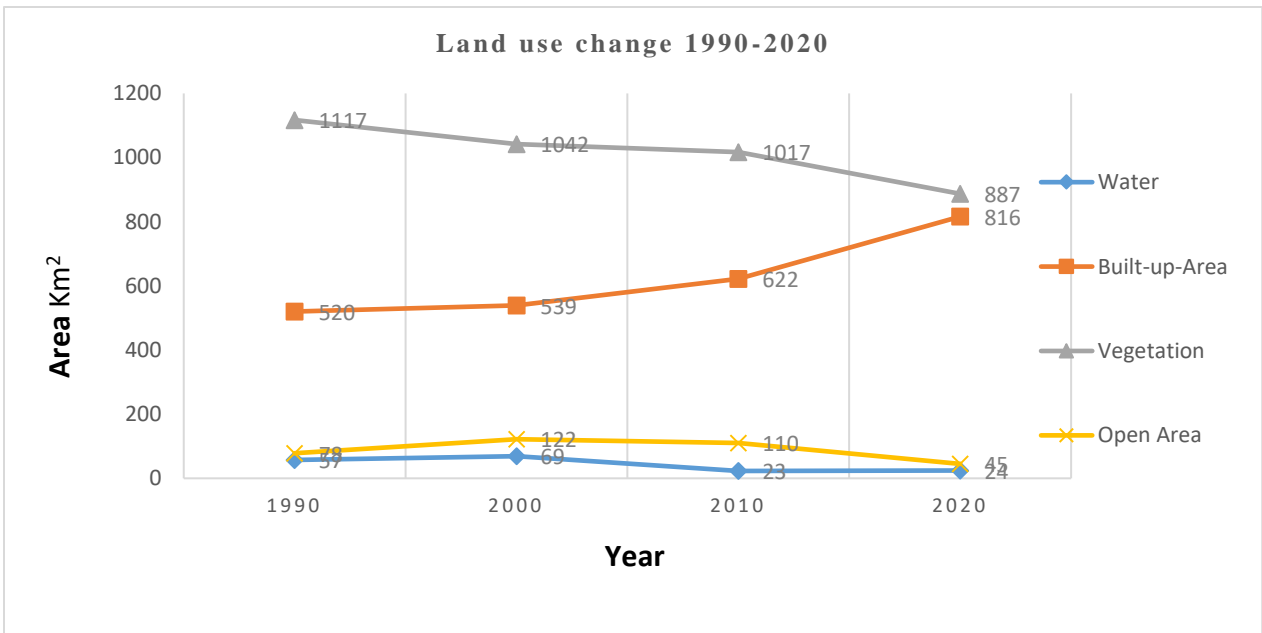

Figure 5: Land use change in Km^2 1990-2020

Area Statistics and Percentage of Land use of Lahore from 1990-2020: For identifying the land use changes in study area, Lahore is divided into four classes: 1) Built-up area, 2) Vegetation, 3) Open area 4) Water bodies. For the interpretation of the study area statistics, the visual quantification and demonstration can be very effective. Land use classification of Lahore for the years 1990, 2000, 2010 and 2020 is presented with area statistics and percentage in table 1.

Table 1: Area Statistics and Percentage of Land use of Lahore 1990-2020.

Year		Land use type				Total area Km2 and percentage
		Built-up area	Vegetation	Open area	Water	
1990	Area Km2	520	1117	78	57	1772
	%	29.3	63.1	4.4	3.2	100
2000	Area Km2	539	1042	122	69	1772
	%	30.4	58.8	6.9	3.9	100
2010	Area Km2	622	1017	110	23	1772
	%	35.1	57.4	6.2	1.3	100
2020	Area Km2	816	887	45	24	1772
	%	46.0	50.1	2.5	1.4	100

Lahore tehsils population maps 1990-2020: Figure 6 shows GIS maps of Lahore tehsils population during 1990-2020. Maps represent the area of all tehsils in different durations. In 1990 there were only town tehsils including Lahore city and Lahore cantonment. In 1998 the two tehsils were further divided into five tehsils, city, Cantonment, Model town, Raiwind and Shalimar. Similarly, three maps 2000, 2010 and 2020 show five tehsils.

Figure 6 shows all two tehsils population of Lahore in 1990. The population of tehsil Lahore cantonment was 329356 and the population of tehsil Lahore city was 4426939. The population of Lahore cantonment was 7 percent and the rest of the population was in Lahore city that was 93 percent. Figure 6 shows the population of all five tehsils of Lahore in year 2000. The tehsil with highest population is Lahore city which is 34 percent. Whereas the Raiwind has the lowest population that is almost 6 percent. The second most populous tehsil is Model town with 22.44 percent of total population. The population of Lahore cantonment is 14.52 percent while Shalimar has a total population of 22.4 percent almost similar to the percentage of Model Town.

Figure 6 shows the population of all tehsils of Lahore in year 2010. The total population of Lahore cantonment is 14 percent. Lahore city is the most populous tehsil with 33.6 percent of total population in 2010. Model Town has 23 percent of the total population of Lahore making it the 2nd highest. The population of Shalimar is 21 percent while the Raiwind has a population of 6.8 percent that makes it the least populous tehsil of Lahore. Like all the previous surveys, Lahore city is has been the most populous tehsil in Lahore. Figure 6 shows the population of all tehsils of Lahore recorded in 2020. The population in Lahore cantonment is 14.72 percent; Lahore city has 32.52 percent of the total population making it the most populous tehsil of Lahore. The population of tehsil model town is 24.5 which is the 2nd highest. While tehsil Raiwind is the least populous tehsil with total population of only 8 percent. Tehsil Shalimar has 20 percent of the total population

which is the 3rd highest in the year 2020. Tehsil Lahore city, as observed, is the most populous tehsil of Lahore with 32.5 percent population.

Lahore tehsils population during different durations: Figure 6 shows tehsil population from 1990 to 2020 with different durations. In 1990-1997 the Lahore had two tehsils, Lahore cantonment and Lahore city. During 1990-1997 the population increase in both tehsils was 20%. From 1998 and onwards, the Lahore district was divided into 5 tehsils. In 1998-2009 the population increase in Lahore cantonment was 40%, Lahore city 33%, Model town 46%, Raiwind 65% and Shalimar 31%. In 2010-2020 population increase in cantonment was 35%, Lahore city 30%, Model town 41%, Raiwind 58% and Shalimar 28%.

Population rate of change in Lahore during different durations: Figure 7 shows Lahore population rate of change from 1990 to 2020 in 5-year period. 1990-1995 rate of change was 3.17, 1995-2000 3.62, 2000-2005 4.13, 2005-2010 4.14, 2010-2015 4.14 and 2015-2020 3.96.

Lahore district population during different during periods 1990-2020: Figure 8 shows population increase in 1990-2000 41%, 2000-2010 34%, 2010-2020 35% increase and total population increase in Lahore district during 1990-2020 was 156%.

Population increase and land use change during different periods in 1990-2020: Figure 10 shows the increase in population of Lahore and change of land use classification during different periods. The increase in population demands built structure for living, industrialization and for the offices etc. Urbanization is the main cause of population increase in the metropolitan city of Lahore.

Land use change and population increase in thirty years 1990-2020: Figure 11 shows the population increased by 156% from 1990 to 2020. With the increase of population in Lahore district, the built-up area increased and the water, vegetation and open area

decreases. The unsustainable population growth in study area is affecting the natural resources that is causing environmental issues.

Regression analysis of population and land use classes between 1990 to 2020: Figure 12 shows the regression analysis of land use parameters in relation to population factors strengthened the influence and role of all these factors in land use conversion pattern in the study area. The coefficient of determination of 0.925, 0.960, 0.25, and 0.64 computed for built-up area, vegetation, open area and water bodies respectively revealed that 92%, 96%, 26% and 64% of variance of change in the land use classes in the study area during specified time period can be explained by the selected under-laying factors.

Lahore tehsils population maps 1990-2020
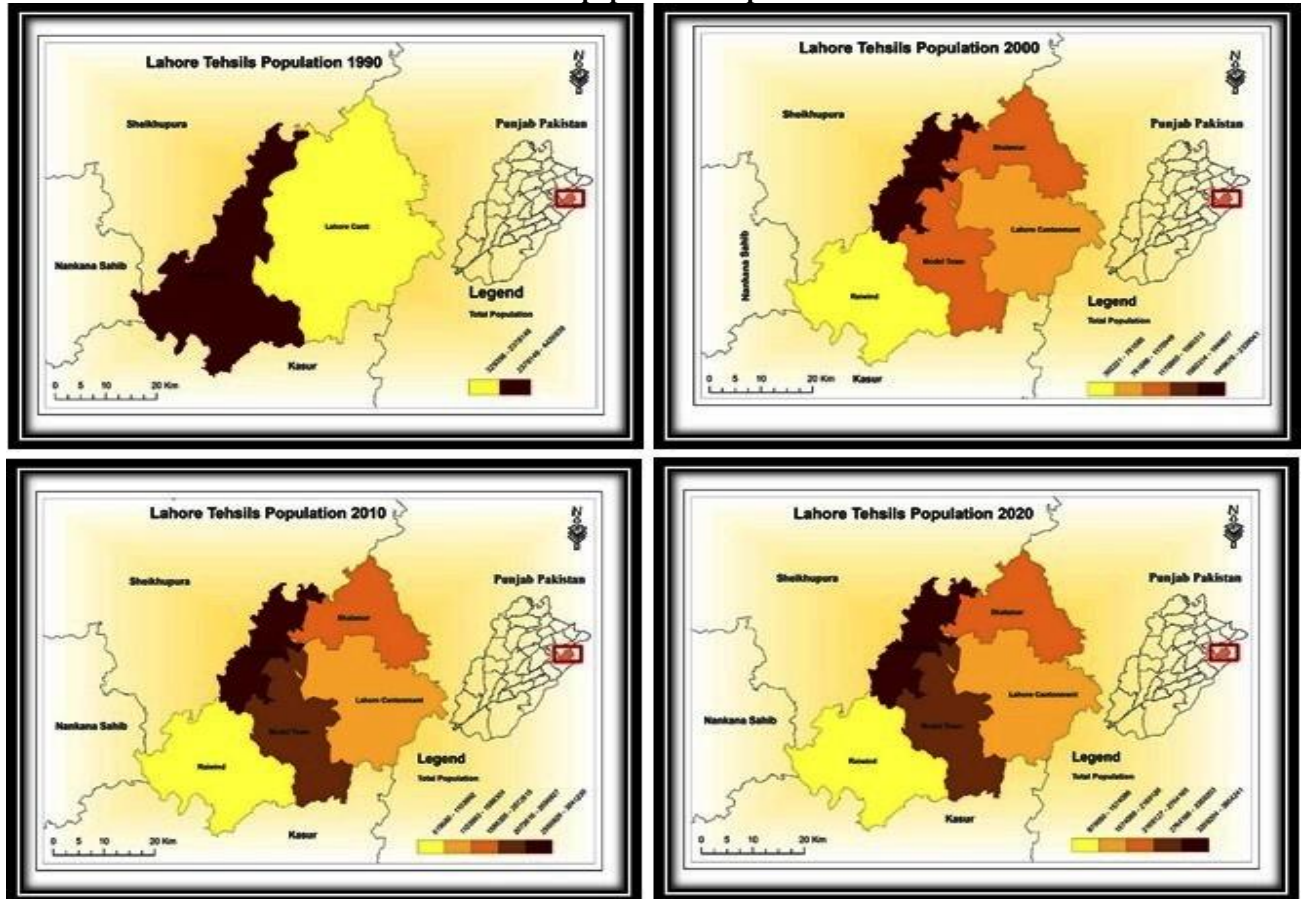
Figure 6: Lahore tehsils population maps 1990-2020
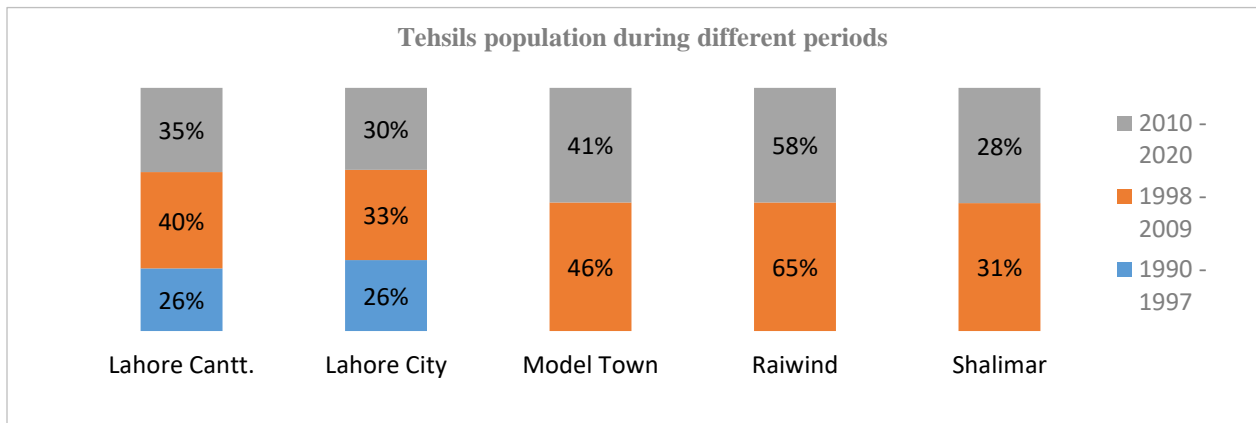
Figure 7: Lahore tehsils population increase during different periods
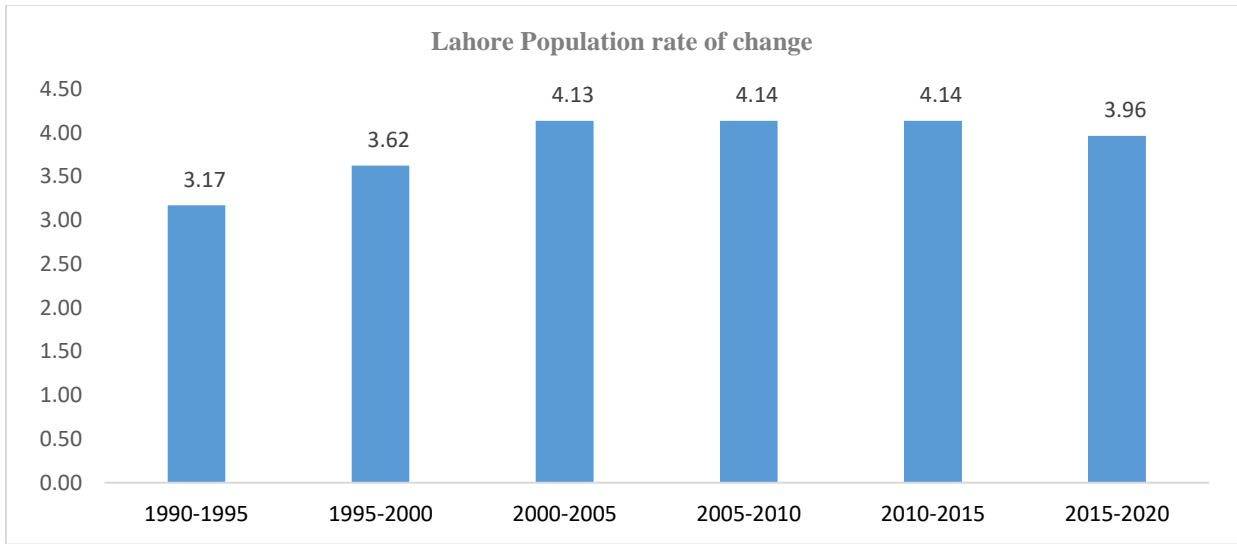
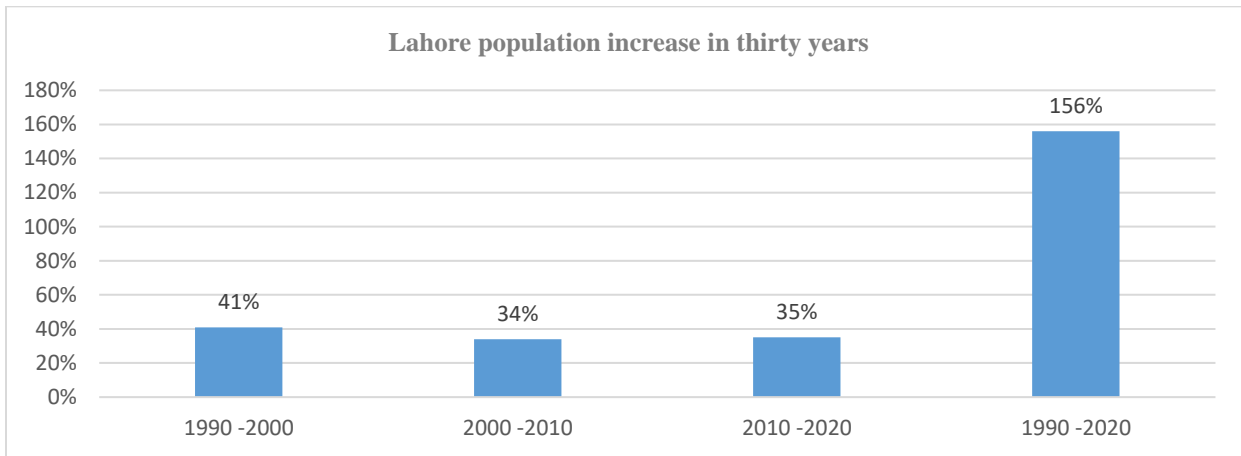**Figure 8: Lahore Population rate of change during different periods**

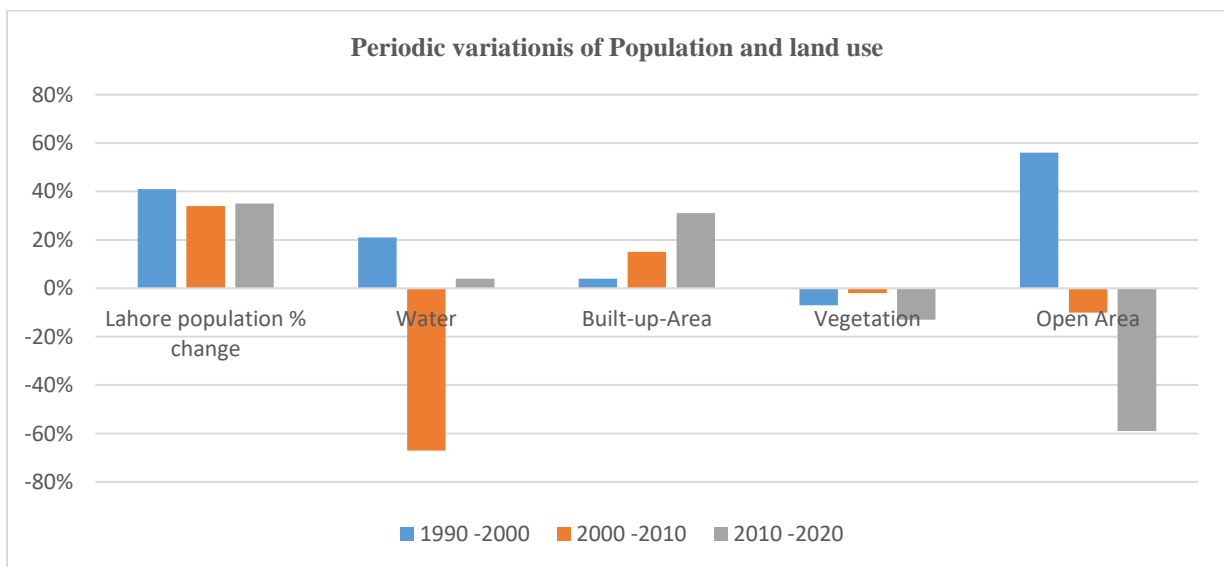**Figure 9: Lahore district population increase in thirty years 1990-2020**

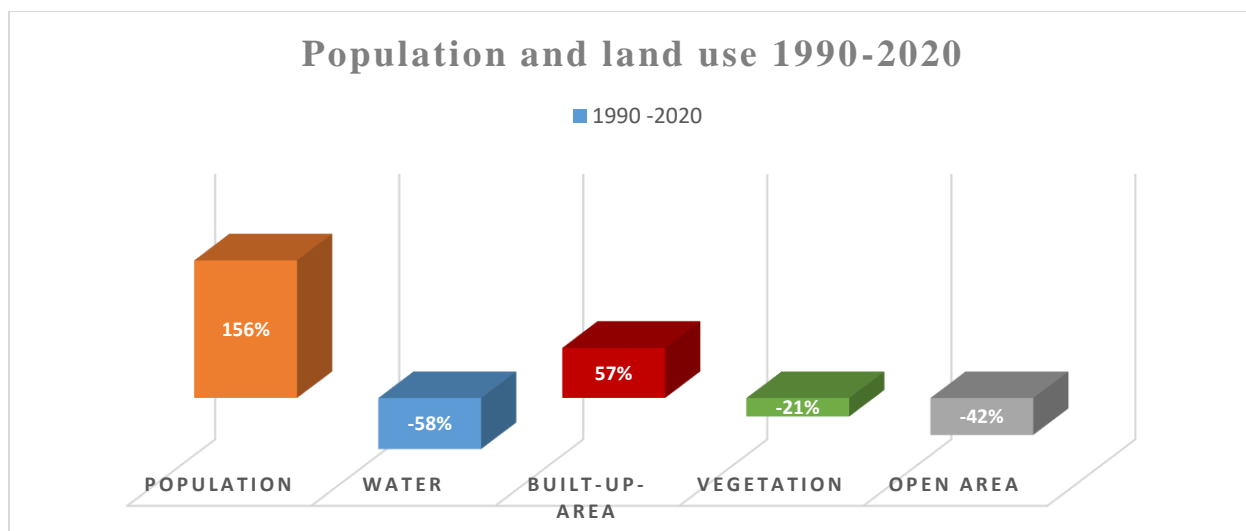**Figure 10: Population and Land use variations during different periods**

Figure 11: Population increase and Land use change 1990-2020

Regression analysis between population and land use classes between 1990 to 2020

	R	R Square	Adjusted R Square	SE of Estimate
Built-up area	0.961582061	0.924640059	0.886960089	45.48582281
Vegetation	0.979876794	0.960158532	0.940237798	23.4135367
Open area	0.508037106	0.258101701	-0.112847448	36.47604504
Water	0.800552962	0.640885044	0.461327566	17.12227999

Figure 12: Regression between population and land use classes 1990-2020

Conclusion and Recommendations: In last thirty years 1990-2020 the Lahore population increased by 41% in 1990-2000, 34% in 2000-2010, and 35% increase in 2010-2020. According to the present study of tehsils population of Lahore including cantonment, city, Model town, raiwind and Shalimar, as observed, the highest trend of population is towards raiwind tehsil. The second highest populating growth is in tehsil model town and the lowest trend of populating is in tehsil Shalimar. Temporal analysis of population and land use change data for the last thirty years from 1990-2020 demonstrates that Lahore's population has increased 156% that demanded more built structure. With the increase of unplanned urban population, the built-up area has increased 57% that has affected the vegetation, open land water bodies. The built-up area took place of vegetation and green cover decreased by 21%. Decreasing of vegetation cover. Also, it's depleting the agriculture land that fulfil the food requirement of the population. The open area has decreased by 42%. Open areas are also the public spaces and that are the source of recreational activities for the community. Decrease in public space means to deprive the right of entertainment that can cause stress. Water bodies decreased by 58% that means the surface water of the Lahore will not meet the requirement of citizens. Urbanization in the metropolitan city of Lahore is creating stress on natural recourses. The more and more build structure creating many environmental issues in Lahore. Due to the built-up area, it creates problem of ground water recharge because of depletion of open spaces and vegetation. Waste management, traffic problems, water supply management, air, water and soil pollution are due to the population increase and land use change. Modern construction technique should be adopted, vertical development should be encouraged. Government should introduce eco-cities, more and more hospitals, educational institutions and industrial zones should be introduced in the other districts of Punjab so that the load of urbanization can be minimized in Lahore. And also the Punjab government should review the policies to control the urban sprawl in Lahore. In order to maintain the Lahore as a green city, the city government should invite local and foreign investors to invest in real state, housing and construction enterprise.

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