Spatio-Temporal Comparison of Urban Expansion Between Sambrial and Sialkot Tehsils (1990-2018)

Muhammad Miandad*, Syed Shajee Mehdi†, Saira Munawar‡, Hafiza Amna§, Mehtab Ahmed Khan**

Abstract

Global changes are most commonly influenced by urbanization in the past two centuries. The urban population is increasing rapidly without any planning in Pakistan, as population increases due to a high growth rate i.e. 2.20 %. Urbanization in Pakistan is increasing by 3 % annually. It is a burning issue of Pakistan for future planning and growth. Like all other cities, Sialkot and Sambrial are also expanding with significant changes in terms of land use. It is the13th largest city of Pakistan, Sialkot and Sambrial both are tehsils of district Sialkot. The current research was carried out to determine urban expansion between Sambrial and Sialkot Tehsils and also compare Land use changes between two Tehsils, as well as to examine the land-use land cover changes in Sambrial and Sialkot from 1990-2018. Supervised (Maximum Likelihood) processing image technique was applied for the years 1990, 2000, 2010, and 2018. The supervised classification was made in ArcMap 10.3.1 to categorize the images in different land use land cover classes. The imageries of the study area were categorized into five classes' i.e. Build-up area, waterbody, vegetation, barren land, and current fallow land. Accuracy was determined by using a ground control point obtained from Google earth. The results of the study indicate that fast expansion occurs in a built-up area in both Sialkot and Sambrial Tehsils. Built-up area increases from 48.55 Sq.km in 1990 to 121.4 Sq.km in 2018 in Sialkot, while in Sialkot, it increases from 11.81 Sq.km in 1990 to 38.48 Sq.km in 2018. Proper management of urban structure is required for sustainable development for both cities.

Keywords**:** Urbanization; Land Use; Land Cover; Image Analysis; Urban Planning

Introduction

Global changes are most commonly offered by urbanization. In the past 200 years. About a six-fold increase in world population has been

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*Corresponding Author: Department of Geography University of Gujrat, Gujrat 50780, Pakistan muhammad.miandad@uog.edu.pk

† Department of Geography, University of Gujrat, Gujrat 50780, Pakistan, syed.shajee@uog.edu.pk

‡ Department of Geography, University of Gujrat, Gujrat 50780, Pakistan, saira.munawar@uog.edu.pk

§ Department of Geography, University of Gujrat, Gujrat 50780, Pakistan, 17021708-005@uog.edu.pk

** Department of Geography, University of Gujrat, Gujrat 50780, Pakistan, mehtabahmed.geo@uog.edu.pk

observed. This means the urban population has been multiplied over a hundred times (Leao et al., 2004). In 2007 about 50% of the world's population lives in urban areas. It is also estimated that by 2050 about 70% of the world population will be urbanized. This highlights the urban expansion that will result after that much urbanization occurred and it also indicated that major urbanization will be held in the megacities of developing countries. Urban areas are the result of anthropogenic activities; it consists of buildings, roads, industries, parks, etc. (Mehdi et al., 2021; Miandad, 2020). These all mentioned features are placed by replacing the natural features like soil, water, and vegetation cover, etc. basically rapid growth of urban environment created a lot of pressure on the natural resources and created many serious environmental and social problems (Saleh and Al Rawashdeh, 2007; Zhao, 2010).

Urbanization is one of the most evident global changes. Currently, approximately 50% of the world's population lives in urban areas(Bank, 2022). Urban structure basically consists of built-up areas, i.e. buildings, roads, industries, business areas, parks etc. and natural features such as vegetation cover, soil and water inside urban activity zone. Rapid growth of the world's cities has exerted heavy pressure on land and other resources surrounding them and has resulted in serious environmental and social problems for the evaluation of the urban change processes, there is always a need to monitor and portray the existing patterns of land use. This is only possible by the Spatio-temporal observation of land at regular intervals by using available multi-temporal datasets (Kumar et al., 2011). Mostly for the monitoring of changing patterns of land use, high-resolution satellite images are used. But in urban planning lower resolution satellite datasets like Landsat TM are also being used (Carlson, 2003). The only reason behind the use of a low-resolution sensor is that it provides datasets for mapping the early existing trends of urban spatial growth. Availability of large remote sensing imageries allows the comprehensive Spatio-temporal analysis on the land cover changes (Zhou et al., 2004). Geographic Information System (GIS) and remote sensing both provide effective tools for the monitoring and understanding of landscape changes phenomena (Masek et al., 2000; Forsythe, 2004; Jat et al., 2008).

Analyzing trends in land use and land cover changes indeed provides valuable insights into the relationship between human activities and the environment. By understanding how land is being utilized and how its cover is changing over time, we can assess the impacts of various human activities such as urbanization, agriculture, deforestation, and industrialization on the environment (Doygun, 2009; Baig et al., 2022).

Urban expansion ratio varies throughout the world, those cities in which the population number is high have experienced more rapid land use and land cover changes. A similar case exists with the Sialkot district whose population number increased unprecedently in the past few decades. Sialkot Tehsil in 1998 has a 1,207,744 population size and it moves to 1,794,658 in 2017, whereas in tehsil Sambrial in 1998 population size was 298,431 which increased to 411,200 in 2017 census (statisics, 2017), which ultimate result is in the expansion of the urban area.

The present study was conducted on the two major tehsils of district Sialkot which is one the major industrial hub of Punjab, Pakistan, and facing rapid urban expansion (NDC, 2022). The major purpose of conducting this study was to develop land use and land cover change maps of these two tehsils to understand the pattern of urban expansion and to relate both tehsils land use and land cover change from 1990 to 2018.

Methodology

Study Area

Sialkot absolute location is between 32˚24'N-32˚37'N latitude and 73˚59'E-75˚02'E longitude in the east of Pakistan between the two main rivers (Ravi and Chenab). Whereas the study area is the two main tehsils of Sialkot (Sialkot & Sambrial).Tehsil Sialkot is located between 32.6078° N, 74.5463° E while tehsil Sambrial is 32.4783° N, 74.3521° E as shown in Figure 1. The district population density is 903 per km^2(Malik et al., 2010) and the 12th most populous city in the northeast (Suleri et al., 2020). Due to the availability of water, agriculture activity has been practiced throughout the district. The main crops are rice and wheat. Guava and citrus are the main fruits while potato, turnip, garlic, cauliflower, peas, and onion are the most commonly grown vegetables. Overall, Sialkot district is an industrial city whereas its major products are leather, surgical instruments, beverages, diesel engines, drugs, sports, pharmaceuticals, and iron, steel, and garments products. Most of the industries are scattered in and around the city (Ullah et al., 2009; Qadir et al., 2008). Its administrative setup consists of 4 tehsils (Sialkot, Pasrur, Daska, and Sambrial) and 129 union councils (Fitriani et al., 2019).

Data Acquisition

Satellite imageries required for the study of land use and land cover are acquired from (Loveland and Dwyer, 2012) the available online portal of the United States Geological Survey (USGS) for the years 1990, 2000, 2010, and 2018. All acquired images are of the same month therefore no particular spectral difference in the images is expected. The description of the satellite imageries has been shown in Table 1.

Table 1: Fact file of the satellite imageries.

Year	Sensor	Band	Date of Acquisitoin	Path/Row	Resolution (m)
1990	Landsat_5 TM	7	3-11-1990	149/37	30
2000	Landsat_5 TM	7	2-11-2000	149/37	30
2010	Landsat_5 TM	7	1-11-2010	149/37	30
2018	Landsat_8 OLI_TIRS	11	5-11-2018	149/37	30

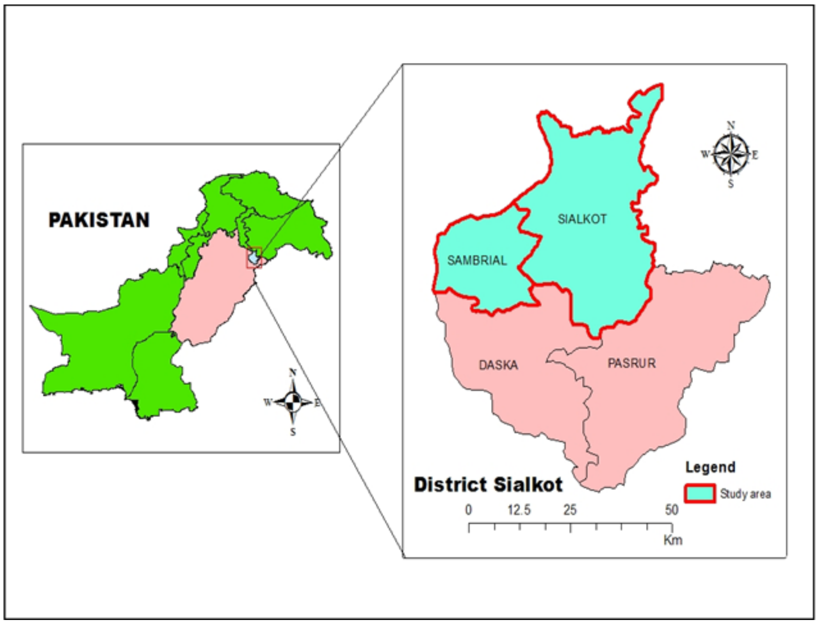

Figure 1: Study area-Sialkot and Sambrial tehsils.

Data Pre-processing & Classification

In satellite images, there is some geometric error that exists which can be the cause of the poor results. Satellite images are not directly used to show or describe the earth's features. It requires some processing, correction, and elimination of errors. It also needs correction to eliminate errors introduced during image obtaining. Without error or perfect remote sensing system has still to be in progress (Jensen and Lulla, 1986; Karsidi, 2004). After the acquisition of imageries the layers have been stacked in ArcGIS 10.3.1, where the area of interest has been extracted from the image after which image geometric corrections, image enhancement has been done. Due to the noise existence in Satellite images, difficulty occurs in clearing or differentiating the features. Differentiating the features within the image can improve with the Image enhancement technique. The image enhancement is done, to create a new image for obtaining more accurate information.

After Geo-referencing GIS layer is created. And it is used to identify the Land-use classes. The classification was developed based on some previous knowledge of the study area and some information from past published documents relevant to the area for study (Shirazi, 2012). Five classes were produced. It includes a built-up area, vegetative, current Fallow land, water body, and mixed sand. In the study, classification was performed in such a way that land cover and land use are identified by a single label. The main object of the image classification is to extract valuable information by placing all pixels in an image into land use and land cover classes (Cheruto et al., 2016). The maximum likelihood classification decision rule is mainly based on the probability that each pixel belongs to a particular class (Qian et al., 2007; Khalil, 2018). Five produced classes are built-up area, vegetative, current Fallow land, water body, and mixed sand as explained in Table 2 based on Afri-cover land cover classification system (Otukei and Blaschke, 2010).

Table 2: Description of the land-use types.

S. No.	Land Use Type	Description
1	Built up Area	All residential, commercial, industrial buildings, villages, Settlements and roads
2	Vegetation	All trees, season crops, shrubs, natural greenery and mixed forest, gardens, parks
3	Water Body	All the swampy area, Ponds, lakes, River Chenab, the River Chenab upper Canal
4	Current fallow land	All cultivated areas, the unoccupied areas, uninhabited places, patches of bare soils
5	Sand	Soil near water body, Clay, Sand

Accuracy Assessment

If reliable classification results are achieved it is important to perform an accuracy assessment on the individual classification (Owojori and Xie, 2005). Mostly accuracy assessment technique is applied on both supervised and unsupervised classification results to verify how well the classification task was achieved. The calculated result of accuracy assessment for the selected years of satellites imageries are given below in Table 3. The results verify that the classification runs on the satellites' imageries reliable and can be used for spatial analysis. The methodological steps followed to achieve research objectives are explained in Figure 2.

Table 3: Accuracy assessment results

	Sialkot 1990	Sambrial 1990	Sialkot 2000	Sambrial 2000	Sialkot 2010	Sambrial 2010	Sialkot 2018	Sambrial 2018
Overall Accuracy	93.48	90.53	89.49	90.42	87.32	94.04	91.22	88.01
Kappa Statistic	0.93	0.89	0.87	0.88	0.85	0.90	0.92	0.94

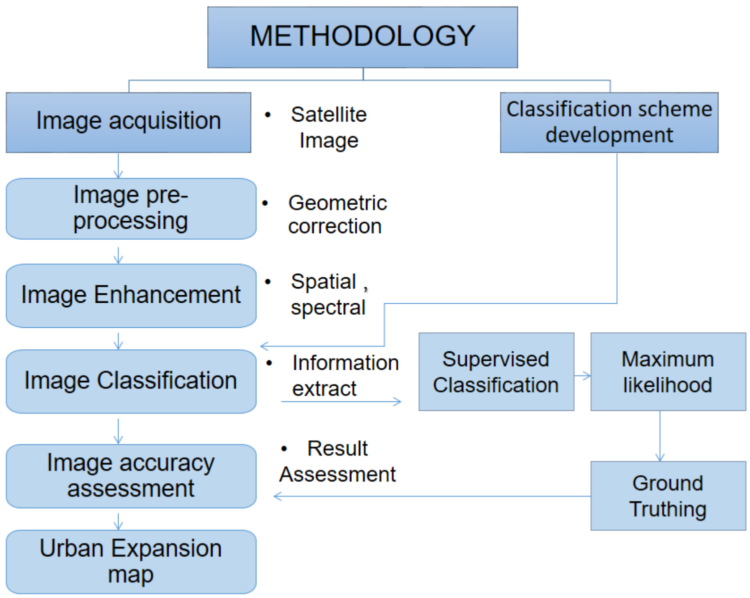

Figure 2: Methodological framework.

Results and Discussions

Comparative Assessment of Sambrial and Sialkot (1990)

The qualitative representation of land cover has been shown in Figure 3 and Figure 4. The static area of each land cover class derives from Figure 3 and Figure 4. It reveals that the built-up area is about 48.55 Sq.km (5%) in Sialkot while land cover with build-up area is about 11.81 Sq.km (3%) in Sambrial. The land under the vegetation cover is 549.1 Sq.km (57 %) in Sialkot and in Sambrial, vegetation cover the area is about 224.4 Sq.km (63 %). Water covers the area of 20.63 Sq.km (2%) in Sialkot and in Sambrial it is about 3.289 Sq. km (1 %). The current fallow land is 331.9 Sq.km (34 %) in Sialkot while it is 119.0 Sq. km (33 %) in Sambrial. Sand cover the area of about 16.08 Sq. km (2 %) in Sialkot while in Sambrial it is merely 0.645 Sq.km. Figure 4 also indicates the land cover area in percentage form.

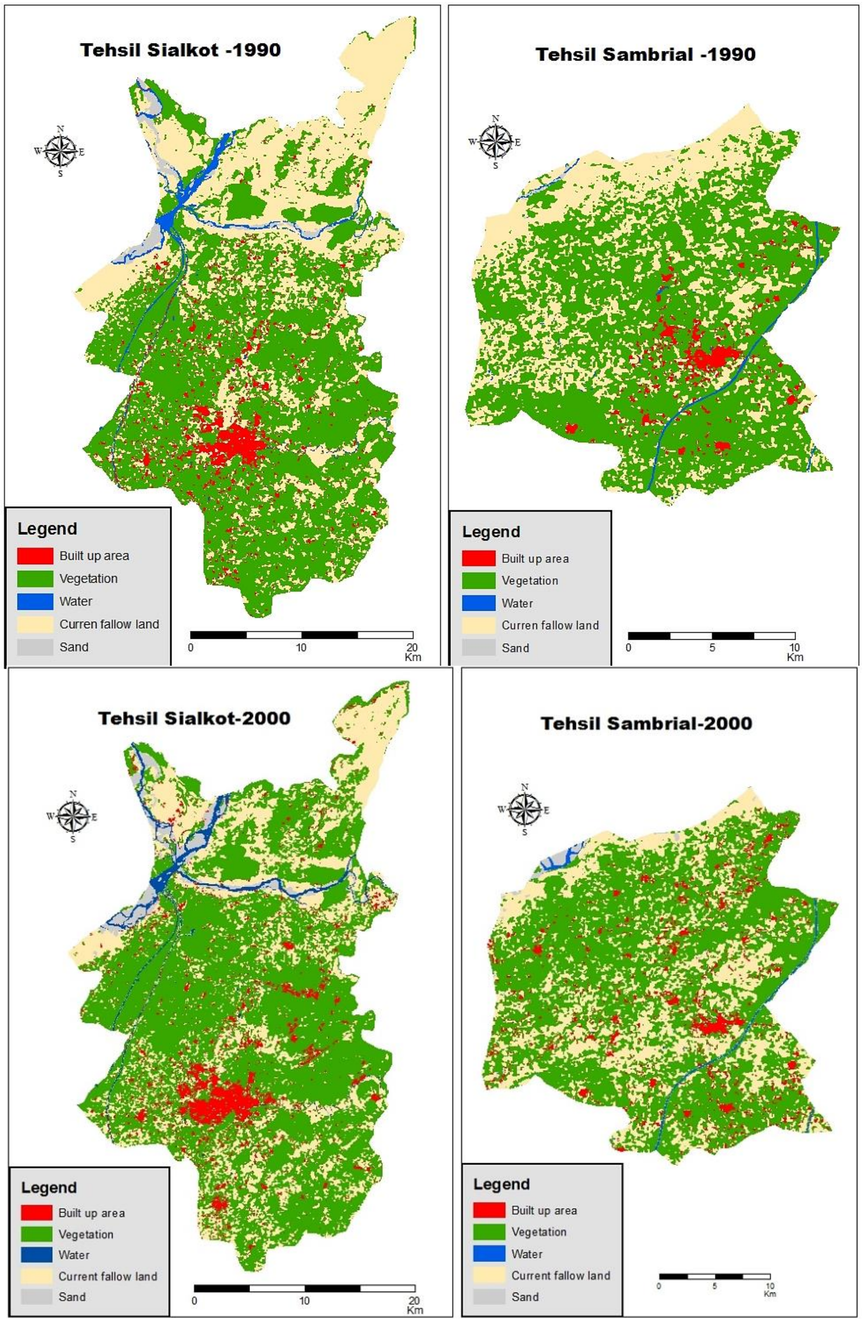

Figure 3: Land cover changes in the tehsils in 1990 and 2000.

The percentage of land cover classes as shown in Figure 4 which reveals that the built-up area in Sialkot is about 5 % while in Sambrial is about 3 %. The vegetation cover area is 57 % in Sialkot while in Sambrial it is also about 63 %. In Sialkot there is water is about 2 %. In Sambrial water is about 1 %. Current fallow land is about 27 % in Sialkot while in Sambrial it is about 31 %. Sand in Sialkot is 2 % and 0 % sand exists in Sambrial.

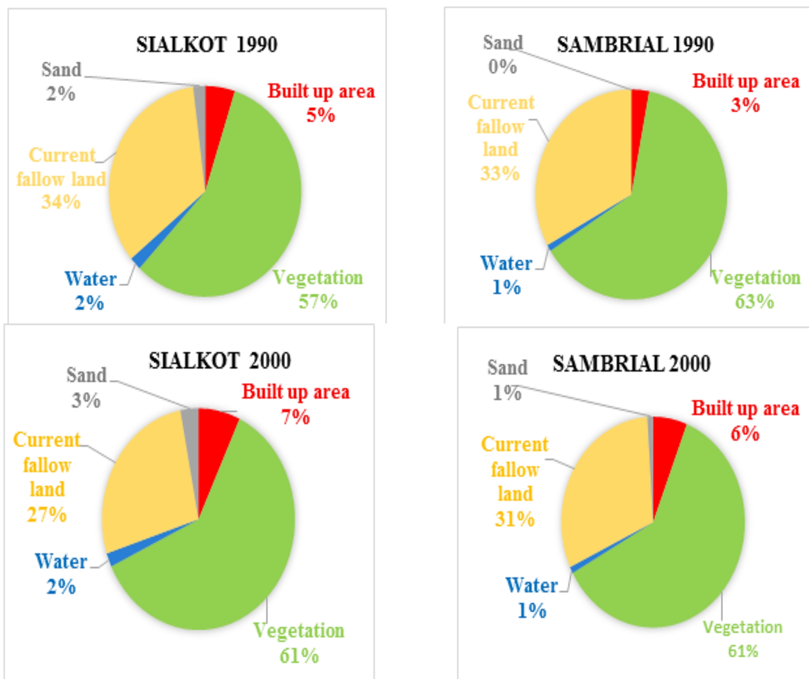

Figure 4: Changes in individual categories of land cover in 1990 and 2000.

Comparative Assessment of Sambrial and Sialkot (2000)

The qualitative representation of land cover has been shown in Figure 3 and Figure 4. It reveals that the built-up area is about 62.66 Sq.km with 7 % of the total class in Sialkot while land cover with build-up area is about 20.32 Sq.km with 6 % in Sambrial. The land under the vegetation is 592.5 Sq. km in Sialkot and Sambrial, vegetation cover an area of about 218.5 Sq.km. Water covers the area of 21.51 sq. km in Sialkot and in Sambrial it is about 2.868 km. The current fallow land is 259.8 km in Sialkot while it is 112.4 Sq. km (31 %) in Sambrial, and sand covers the area of about 31.66 Sq. km (3 %) in Sialkot while in Sambrial it is 5.094 Sq.km (1 %). Figure 4 also indicates the land cover area in percentages.

The percentage of land cover classes as shown in Figure 4 suggested that the built-up area in Sialkot is about 7 % while in Sambrial is about 6 %. The vegetation cover area is 61 % in Sialkot while in Sambrial it is also about 61 %. In Sialkot there is water is about 2 %. In Sambrial water is about 1 %. The current fallow land is about 27 % in Sialkot while in Sambrial it is about 31 %. Sand in Sambrial is 1 % and 3% of sand exists in Sialkot.

Comparative Assessment of Sambrial and Sialkot (2010)

The quantitative representation of classes is shown in Figure 5 and Figure 6 which reveals that the built-up area is about 74 Sq. km in Sialkot while land cover with build-up area is about 33 Sq.km in Sambrial. The land under the vegetation is 744 Sq.km in Sialkot and Sambrial vegetation cover the area of about 301 Sq.km, water cover the area of 19 Sq.km in Sialkot and Sambrial it is about 4 Sq.km, current fallow land 94 Sq.km in Sialkot while it is 19 Sq.km in Sambrial and sand cover the area of about 35 Sq.km in Sialkot while in Sambrial it is 2 Sq.km.

The percentage of land cover classes is also shown in separate Figure 6. It reveals that the built-up area in Sialkot is about 9 % while in Sambrial is also 9 %. The vegetation cover area is 75 % in Sialkot while in Sambrial it is about 84 %. In Sialkot there is water is about 2 %. In Sanbrial water is about 1 %. The current fallow land is about 10 % in Sialkot while in Sambrial it is about 5 %. Sand in Sambrial is 1 % and 4 % of sand exists in Sialkot.

Comparative Assessment of Sambrial and Sialkot (2018)

Figures 5 and 6 expose the built-up area is about 121.4 Sq.km in Sialkot while land cover with the built-up area is about 38.5 Sq.km in Sambrial. The land under the vegetation is 574.1 Sq.km in Sialkot and Sambrial vegetation cover the area of about 218.5 Sq.km, water cover the area of 24. Sq. km in Sialkot and Sambrial it is about 5.2 km, current fallow land is 211.4 Sq.km in Sialkot while it is 43. 5 Sq. km in Sambrial and sand cover the area of about 35.4 sq. km in Sialkot while in Sambrial it is 3.4 Sq. km as also shown in Figure 6. This figure also indicates the land cover area in percentage form. It reveals that the built-up area in Sialkot is about 13 % while in Sambrial is about 11 %. The vegetation cover area is 59 % in Sialkot while in Sambrial it is about 61 %. In Sialkot water is about 2 %. In Sambrial water is about 1 %. The current fallow land is about 22 % in Sialkot while in Sambrial it is about 12 %. Significant changes were detected in the sand and fallow land of both the tehsils.

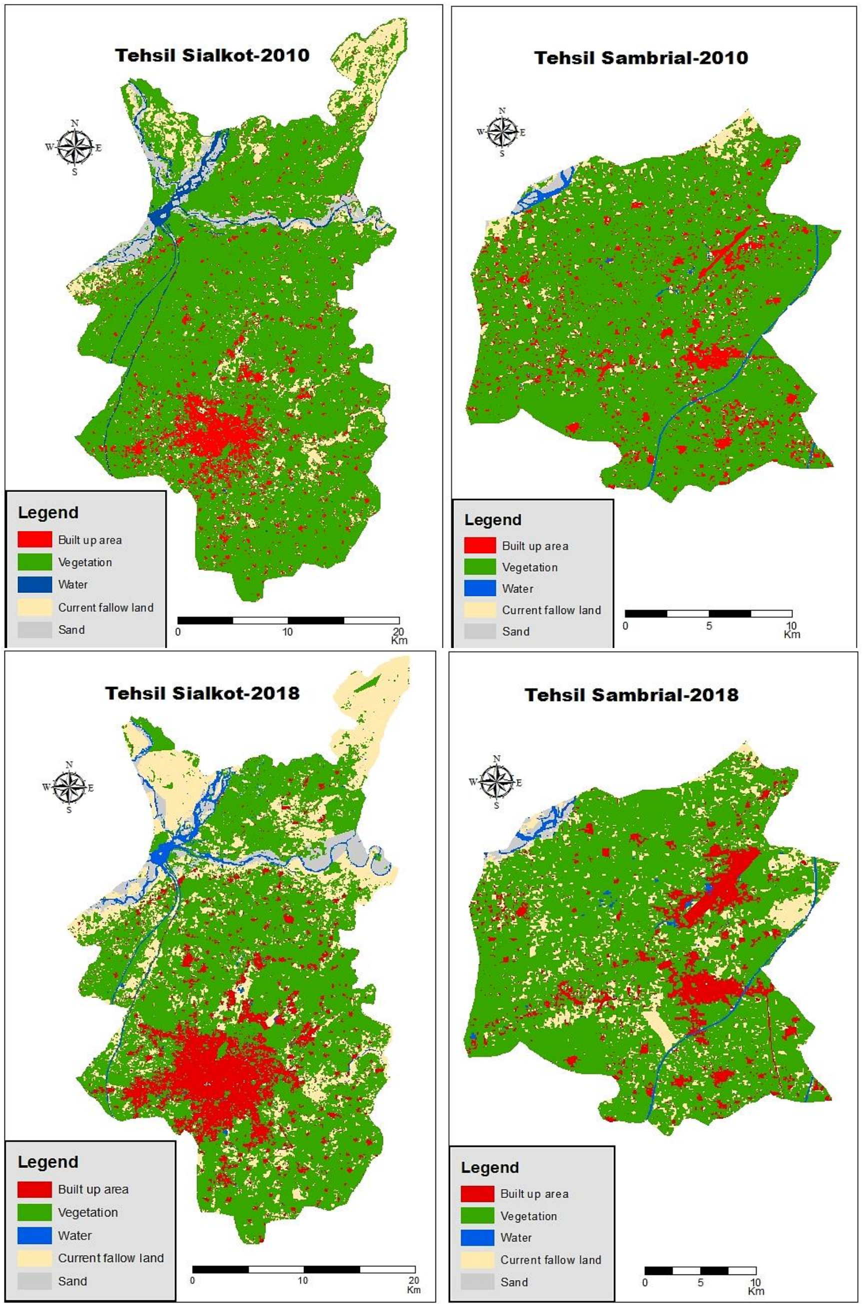

Figure 5: Land cover change in the tehsils in 2010 and 2018

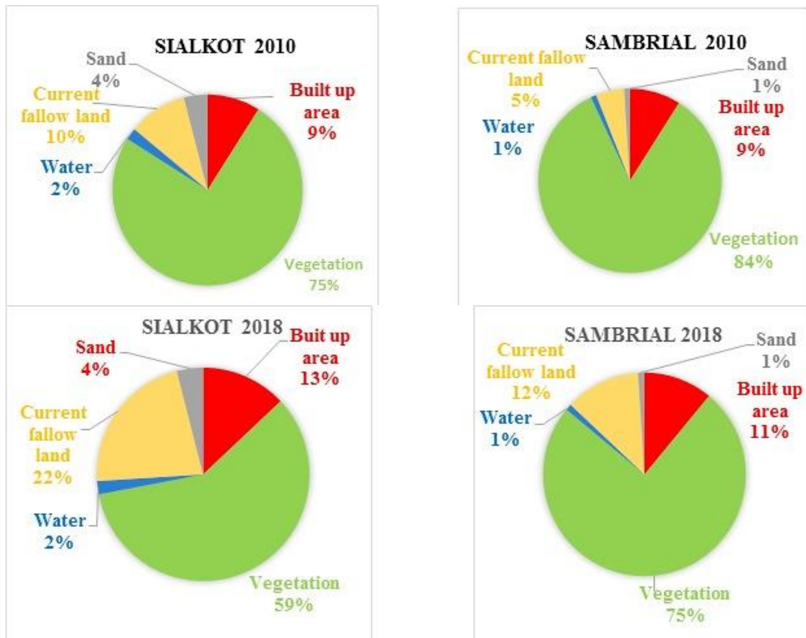

Figure 6: Changes in individual categories of land cover in 2010 and 2018

Comparative assessment of Sialkot and Sambrial Tehsil (1990-2018)

It is clear from Figures 5 and 6 that Sialkot tehsil had more built-area as compared to Sambrial and the increase in both tehsils is continuous from 1990 to 2018. In 1990 both tehsils have current fallow land which means that the soil of this area is quite fertile and agriculture activity is the major economic activity of this area as seen more than 50% of the area was covered with vegetation. In 2000 both tehsils face expansion in an urban area while the reduction in both current fallow land and vegetation this is since the agriculture activity is started to replaced by the industries and in other production units. A reason particular to industries is the presence of dry port in Sambrial tehsil. People of that region have easily assessed to export their products, therefore people started to manufacture different products mostly sports, leather, and surgical related products, and export them all around the world. People of this region started to turn from agriculture to establish a different level of small and large industries. Hence the built area is continuing to grow and vegetation with the current fallow is continuing to decrease. Vegetation land is also reduced due to the increase in population size. The water conditions in both tehsils are almost the same as in 1990 which also indicate the shift of people from agriculture to industrial setup.

After 2010 business community decided to build an airport which is also a fact that the built area is increased in both Sialkot and Sambrial tehsils because people started to engage their current fallow land into the built-area like hotels, restaurants, and shopping malls. It is important to note that the Sambrial tehsil built-up area is increased because of both dry port and airport built-in that tehsil. Whereas Sialkot built-up areas increase because it is well connected with both dry port and airport. It has a cantonment area, many sports, surgical, and leather industries, and many housing societies are formed there. While vegetation is also boomed in that decade because people started to maximize their income by utilizing the current fallow land into agricultural land. In 2018 built area continues to increase and in all that tehsil Sambrial also continues to grow because this tehsil is also well connected to the capital of Punjab, Lahore after the construction of the Sialkot to Lahore motorway. Another major driving factor is the increase in the population number both by the growth rate of population and by the migration of people from other areas towards it. Because of the availability of employment opportunities, people are readily attracted towards district Sialkot and living in both tehsils. People with low income usually prefer Sambrial because of low house rent and easy assess to the industries.

Conclusion

Sialkot and Sambrial, both the tehsils are facing increasing trend in population and landuse. Therefore, Sialkot Tehsil has a more built-up area and continues to grow due to the presence of industries, cantonment, shopping malls, and housing societies, while Sambrial Tehsil grows due to the government projects like airport, dry port, and motorway. As a result, the area under current fallow land and open land has been decreased. This situation is not good because, with this increase in urban land use, several associated problems will also be increased. There is a need for residential dwellings and other facilities that are increasing daily. This increase affects the economic conditions of the district. So it is recommended that the problem of overpopulation and space requirement should be given priority by the city managers and people should be supported to build new housing schemes towards the outer parts of a town or city by providing motive as well as connected with good transportation network.

The study indicates that rapid urbanization occurs in Tehsils as shown in Figs. 3 and 5. Built-up area increased from 48.55 Sq.km in 1990 to 121.4 Sq.km in 2018 in Sambrial and in Sialkot, it increases from 11.81 Sq.km in 1990 to 38.48 Sq.km in 2018. The government of Pakistan should move toward sustainable urbanization. Launching projects in urban centers with the aim of balancing current residents' quality of life while ensuring opportunities for future residents is crucial for sustainable development. These changes bring planning in the urban areas of Pakistan.

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