

## **A Spatio Temporal Comparative Analysis of Land Use Land Cover Change (LULC) between Sargodha District and Kaghan Valley, Pakistan**

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### **Abstract**

Land use land cover change (LULC) describes how human activities have altered the natural landscape including forest cover, pastures and water bodies into urban settings. Rapid population growth with urbanization has changed the land surface in almost every part of the world especially developing countries. Current study is the comparative analysis of LULC between Sargodha district (a plain area) and Kaghan Valley (a tourist hill station). The study was conducted over a period of 20 years using satellite images of both sites. These images were obtained from USGS website and classified through supervised classification scheme to create land use maps. The results revealed that natural land cover on both sites decreased while the built up area increased significantly during the time period. The results showed that built up area in Sargodha increased 42% during 2000-2020 while it increased 14% in Kaghan Valley during the same period. Vegetation cover decreased from 59.68% in 2000 to 36.69% in 2020 in Sargodha district.

**Key words:** Built-up, Land use Land cover, Spatial, Vegetation cover

### **1. Introduction**

Land use Land cover change (LULC) is basically the conversion of natural land cover into man -made land uses over a specified time period (Ashraf et al., 2022). These LULC studies have gained the interest of many researchers in recent past as the human activities are swallowing the natural vegetation cover rapidly (Gul et al., 2023). This is not only disturbing the equilibrium of the land surface but also causing climate change and other natural hazards. Many anthropogenic activities are causing severe damage to natural ecosystem (Bhalli, 2013). Physical environment is being altered by human activities at previously unheard rates (Turner et al., 2014). Urbanization along with industrialization and the support of rapid population growth have brought significant changes over the surface of earth (Thandar, 2012). GIS and remote sensing are the most powerful tools to detect LULC especially in urban settings.

A **spatio-temporal analysis of land use and land cover (LULC)** examines how land use patterns change over both space and time (Qasim et al., 2024). This analysis is essential for understanding the impact of natural and human activities on landscapes and ecosystems (Anwar & Qasim, 2024). By utilizing remote sensing, GIS techniques, and historical data, researchers can track changes in forests, agricultural lands, urban areas, and water bodies over different time periods. This information is crucial for sustainable land management and environmental conservation (Farooq et al., 2023).

The changes in LULC are driven by various factors, including population growth, economic expansion, urbanization, climate change, and government policies (Bashir & Ahmad, 2017). For example, rapid urban expansion often leads to the conversion of agricultural or forest land into built-up areas, while deforestation for farming and infrastructure development alters the natural ecosystem (Li et al., 2014). Identifying the key drivers behind these changes helps in formulating effective land use policies and planning strategies to balance development and environmental protection (Qasim et al., 2024).

The rapid urban sprawl is causing a drastic negative change in the vegetation cover of Pakistani landscape (Shaheen et al., 2015; Nasar-u-Minallah et al., 2021). Jiang et al., (2020) concluded that change in the built up area is inversely correlated with the amount of precipitation. In urban areas, vegetation is crucial to improving the micro climate and comfort of the outdoor air. Dense vegetation can have significant cooling effects (Nalawade et al., 2022). Climatic data of Jehlum district over 30 years revealed that LULC has resulted in increase in temperature and variations in precipitation pattern (Majeed et al., 2021).

One of the major characteristics of land use is the increase in built up area that has been getting significant consideration in many studies (Liu et al., 2005). During recent decades, use of GIS and remote sensing for data analysis, data manipulation, digital mapping and modeling LULC have proved basic and most important tool for such studies (Batisami & Yernal, 2009; Bhatta, 2010). The application of GIS and remote sensing techniques are more accurate, time efficient and flexible than the conventional methods (Wu et al., 2006).

Changes in land use and land cover have significant effects on the environment because LULC is directly related to the degradation of the land over time and produces numerous environmental changes (Deng et al., 2009). Establishing connections between regulatory actions, policy choices, and subsequent LULC activities requires tracking the distributions and locations of LULC changes (Hussain et al., 2020). Sargodha is fast growing urban center in the Punjab province while Kaghan valley is an attractive tourist summer resort. Both have witnessed dramatic change in the land use and land cover during past couple of decades. In current study, an attempt has been made to compare LULC between the two sites using GIS and remote sensing techniques (Riaz et al., 2017).

Spatial variations in land use changes highlight regional differences in land transformation. Coastal cities may experience urban sprawl due to economic opportunities, whereas mountainous regions may face deforestation driven by agriculture or logging (Qasim et al., 2023). Similarly, desertification in arid regions and wetland degradation due to industrial activities are location-specific challenges that require tailored solutions. Understanding these spatial patterns aids in prioritizing areas for intervention and sustainable land use practices (Yasin & Qasim, 2020).

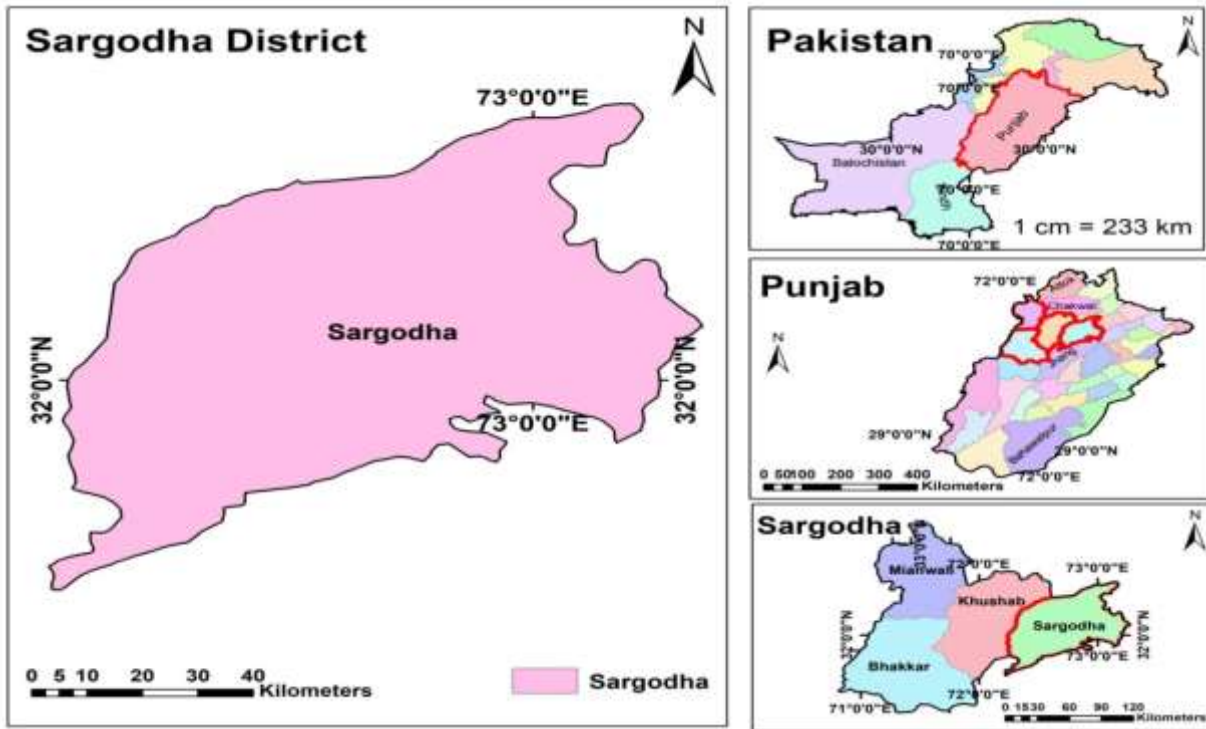
Various methods are used for spatio-temporal analysis, including satellite imagery, remote sensing data, and machine learning-based classification models. Time-series analysis and change detection techniques help in quantifying how land cover has evolved over decades. These tools allow researchers and policymakers to predict future trends and make informed decisions for urban planning, conservation efforts, and disaster risk management (Hashim et al., 2024).

The implications of spatio-temporal LULC analysis are significant for sustainable development. Effective land use planning can reduce environmental degradation, promote biodiversity conservation, and support climate change adaptation strategies (Parveen et al., 2023; Qasim et al., 2024). By integrating technological advancements with policy measures, governments and organizations can ensure that land resources are used efficiently while minimizing negative environmental impacts (Riaz et al., 2017).

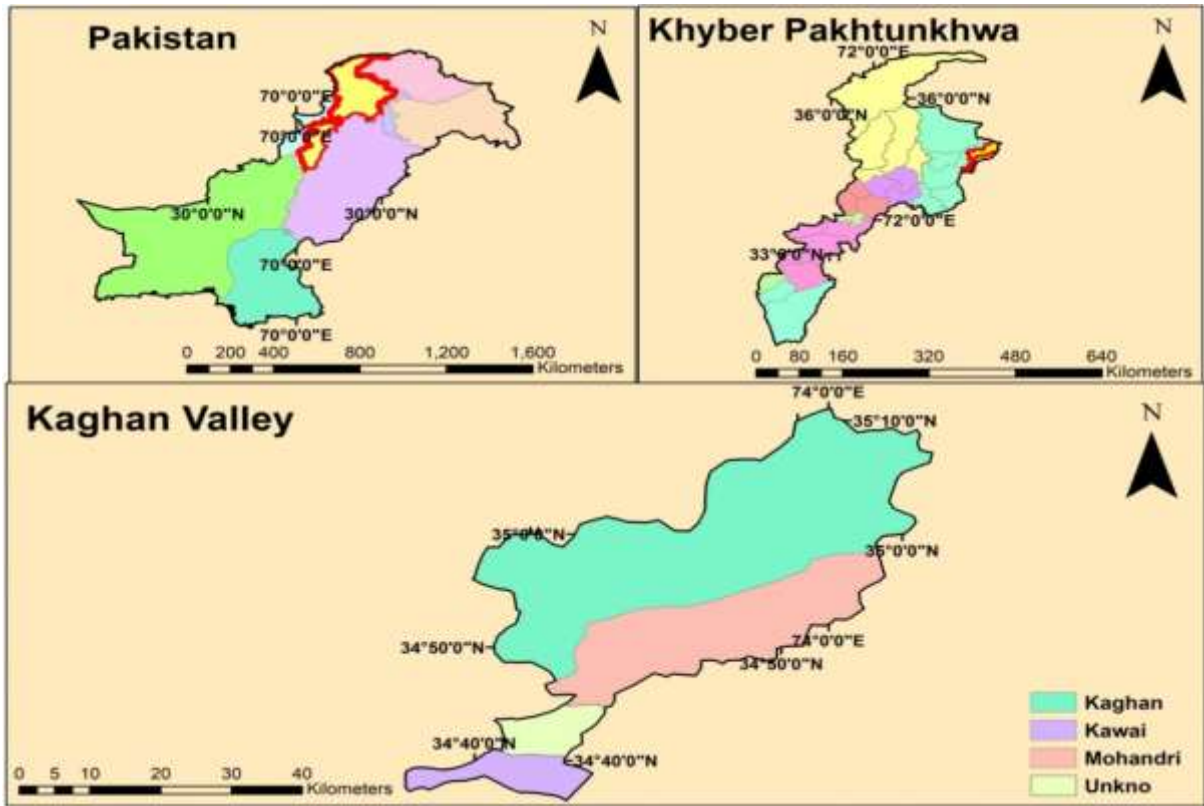
## 1.2 Study Area

The study area of Sargodha district lies at 32.0740° N, 72.6861° E covering an area of 5854 km<sup>2</sup>. It has semi-arid type of climate where summer is hot with average temperature of summer months reaches 38° C while the winter is mild with average temperature ranges between 11° to 20°C. On the other hand the Kaghan Valley is a famous tourist resort at an average altitude of 7500 feet. It has mild to warm temperatures during summer months and cool to cold temperatures during winter months. Snowfall is

common during winter. It lies at  $34.5417^{\circ}$  N,  $73.3500^{\circ}$  E. According to 2017 census, population of Sargodha district was 37,03,588 (GoP, 2017). Figure 1a and 1b depicts the location of both the sites.



**Figure 1a:** Location Map of Sargodha



**Figure 1b:** Location Map of Kaghan Valley

**2. Material and Methods**

**2.1 Data acquisition**

This study is primarily based upon spatio temporal satellite images of the study area from 2000-2020. Three images of both the areas for the year 2000, 2010, and 2020 were acquired from USGS. Major characteristics of these images are shown in table 2.1. After acquiring satellite images, these images were stacked, rectified and study area was extracted. Population data of the area was obtained from Pakistan Bureau of Statistics. The data manipulation and interpretation was performed using Erdas Imagine and GIS software. A field survey was also conducted during the summer season to obtain Ground Control Points (GCPs) for ground truthing. These GCPs were collected using Global Positioning System (GPS) to verify the ground data with the satellite images. The historical images of the study area sites from Google Earth Engine were also consulted to remove any discrepancy in historical data of land use and land cover.

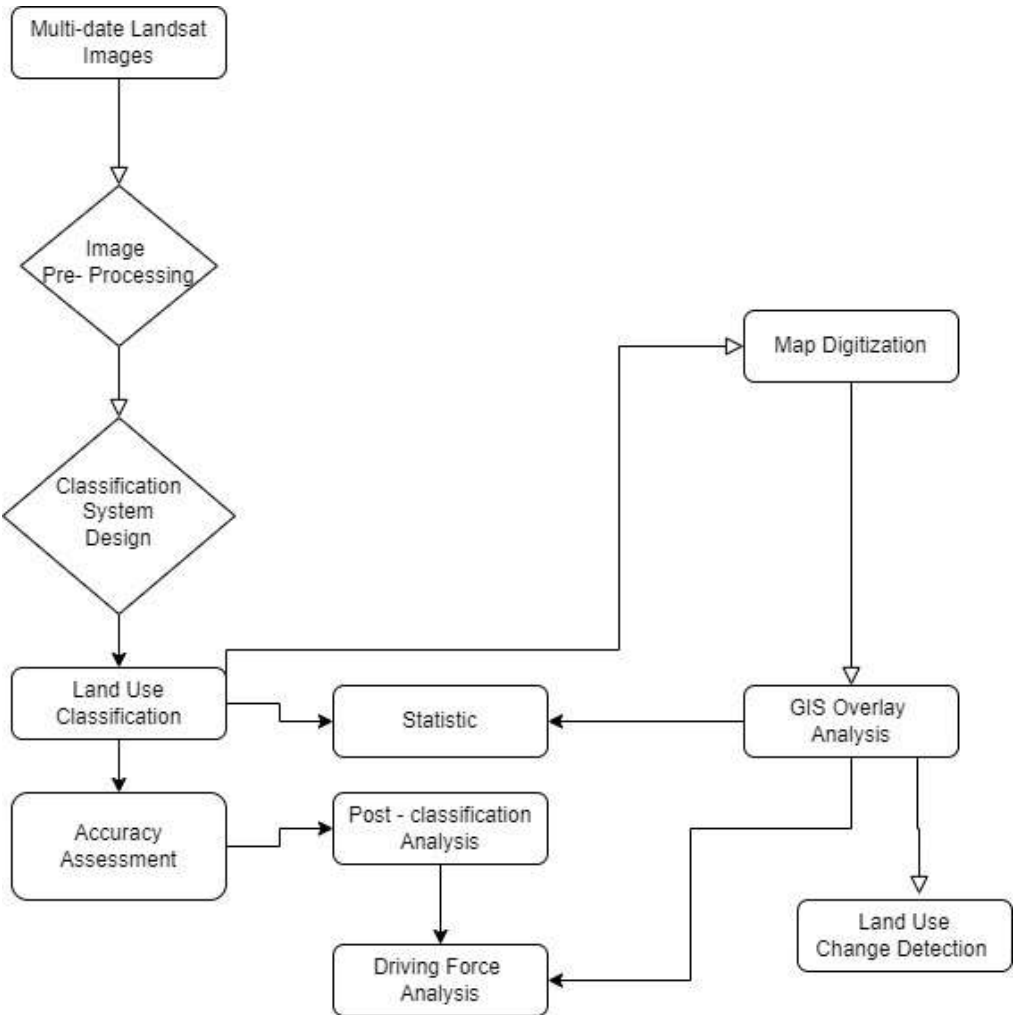
*Table 2.1: Temporal Satellite Images Sources*

Data	Year of Acquisition	Bands/Color	Resolution	Spectral Resource/bands	Source
Landsat 7	2000	Multi-Spectral	30	Band 1-Band 7	USGS
Landsat 7	2010	Multi-Spectral	30	Band 1-Band 7	USGS
Landsat 8	2020	Multi-Spectral	30	Band 1-Band 7	USGS

**2.2 Methodology**

Research methodology is a crucial part of any study. The whole process of the study is illustrated in figure 2.1 in a flow chart. The image processing procedure involves preprocessing, processing, classification scheme, identification of signatures and preparation of classified maps. To achieve the land use land cover statistics, first of all, different layers of the downloaded images were stacked than all the images were geo-referenced to a common coordinate system of UTM and WGS84 datum. The vector layers of Sargodha and Kaghan Valley were used to clip the images of study area.

Supervised classification scheme was applied with maximum likelihood algorithm to map the land use changes on all six satellite images. The maximum likelihood algorithm is based on probability. It evaluates a predetermined group of classes and assigns the pixel to the class with the highest probability (Unger-Holtz, 2007). Nevertheless, it stands out as one of the frequently employed algorithms for supervised classification (Wu & Shao, 2002; Mclever & Friedl, 2002; Maqbool, 2022).



**Figure 2:** Flow diagram of Methodology

Following four classes of land use were established to achieve the required objective:

- a) Built up area
- b) Vegetation cover

- c) Water bodies
- d) Barren land

After classification of these images, accuracy assessment was performed using following equation of Kappa Index, and the pixel based results of all four land uses were extracted.

$$K = \frac{N \sum_{i=1}^k x_{ii} - \sum_{i=1}^k (x_{i+} \times x_{+i})}{N^2 - \sum_{i=1}^k (x_{i+} \times x_{+i})}$$

### 3. Results and Discussion

Figure 3.1 and 3.2 depicts the land used changes occurred during 2000 - 2020 in both the study areas. Table 3.1 reveals that the vegetation cover of Sargodha decreased from 59.89% in 2000 to 54.60% in 2010 and 36.69% in 2020. The built up area in Sargodha increased from 11.34% to 27.95% in 2010 and 53.03% in 2020 describing an overall increase of 41.69%. The water bodies decreased from 16.58% in 2000 to 7.02% in 2010 and 6.28% in 2020. The barren land decreased from 12.17% in 2000 to 0.41% in 2010 and again increased to 3.98% in 2020. Whereas in Kaghan valley, vegetation cover increased from 30.12% in 2000 to 52.11% in 2010 while decreased to 44.28% in 2020 providing that the area under vegetation cover increased 14.16%. The built up area in Kaghan valley increased from 2.57% in 2000 to 18.90% in 2010 and 30.59% in 2020 which means overall built up area increased 28.02% in Kaghan valley. However, the water bodies and barren land in Kaghan Valley during 2000-2020 decreased 66.88% and 10.09% respectively.

**Table 3.1: Land Use Statistics of Sargodha and Kaghan Valley for the year 2000 and 2010**

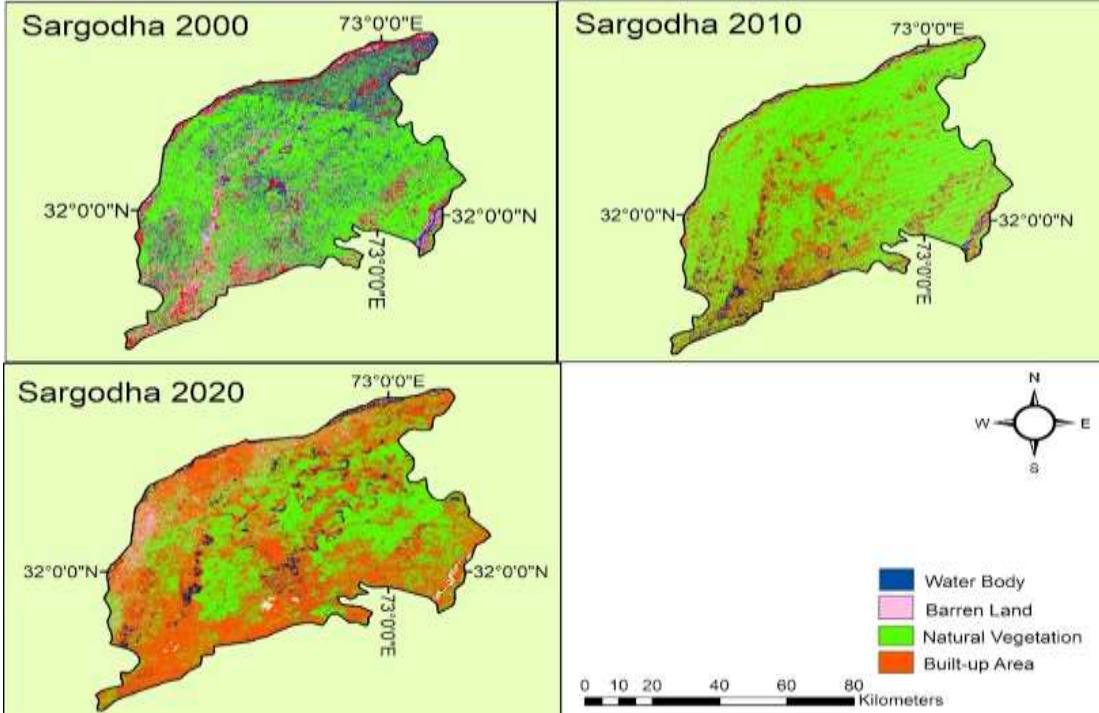
Land Use	2000		2010	
	Sargodha	Kaghan	Sargodha	Kaghan
<b>Vegetation</b>	59.89%	30.12%	54.60%	52.11%
<b>Built-up</b>	11.34%	2.57%	27.95%	18.90%
<b>Water</b>	16.58%	52.98%	7.02%	14.86%
<b>Barren</b>	12.17%	14.32%	0.41%	14.11%

**Table 3.2: Land Use Statistics of Sargodha and Kaghan Valley for the year 2020 and change**

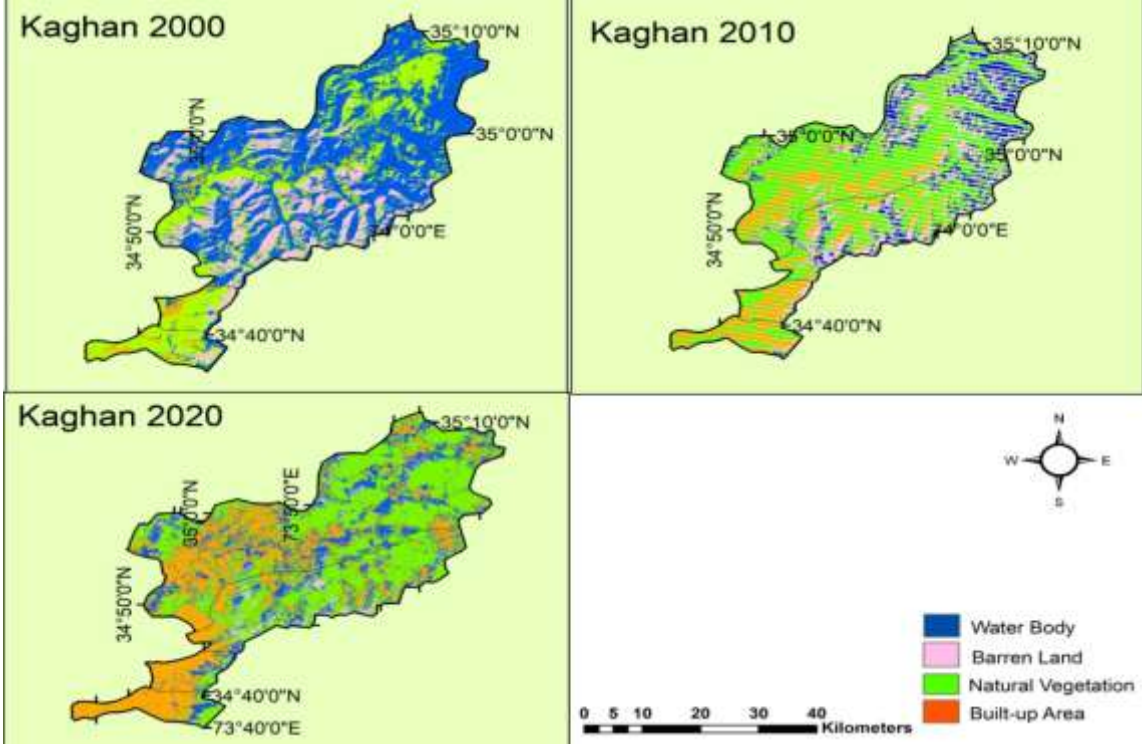
Land Use	2020		Change 2010-2020	
	Sargodha	Kaghan	Sargodha	Kaghan
<b>Vegetation</b>	36.69%	44.28%	-23.2%	14.16
<b>Built-up</b>	53.03%	30.59%	41.69%	28.02%
<b>Water</b>	6.28%	20.88%	-10.3%	-66.88%
<b>Barren</b>	3.98%	4.23%	-8.19	-10.09%

The results for different land uses in both the study area between the year 2000 to 2020 reveals that the vegetation cover in Sargodha decreased by 23.2%; built up area increased by 41.96%; water bodies decreased by 10.3% and the barren land decreased by 8.19%. On the other hand, vegetation cover in

Kaghan Valley increased by 14.16%; built up area increased by 28.02%; water bodies decreased by 66.88% and the barren land decreased by 10.09%.



**Figure 3.1:** Land Use Maps of Sargodha



**Figure 3.2** Land Use Maps of Kaghan Valley

#### 4. Conclusion

Present study has effectively utilized the temporal images of Sargodha and Kaghan to explore the land use changes over time. It has been concluded that the built up area of both the sites has increased i.e 41.69% for Sargodha and 28.02 % for Kaghan. This increase in built up area reflects the ever-increasing population in Pakistan. Interestingly, Water bodies for both sites have decreased significantly. It proves the water shortage is getting worse in Pakistan. In 2017, Pakistan ranked 8<sup>th</sup> lowest country in the world in terms of water resources. However, the vegetation in Kaghan increased while it decreased in Sargodha. The decrease in vegetation cover in Sargodha is alarming as this decrease reflects the lessening of agricultural land that ultimately affects the food resources of the country. This study will help in understanding the spatial and temporal land use changes that have occurred over time.

#### Conflict of interest

The authors have no conflict of interest in the present article.

#### References

1. Anwar, H. M., and Qasim, M. (2024). Geopolitical Incarnation of Gilgit Baltistan on Political Horizon of Pakistan. *Uswa Journal of Research*, 4(1), 1-16.
2. Ashraf, H., Mobeen, M., Miandad, M., Khan, M. A., Rahman, G., & Munawar, S. (2022). Assessment of urban sprawl in Sargodha city using remotely sense data. *Ecological Questions*, 33(4), 1-16.
3. Bashir, H., & Ahmad, S. S. (2017). Exploring geospatial techniques for spatiotemporal change detection in land cover dynamics along Soan River, Pakistan. *Environmental monitoring and assessment*, 189, 1-11.
4. Batisani, N., & Yarnal, B. (2009). Urban expansion in Centre County, Pennsylvania: Spatial dynamics and landscape transformations. *Applied geography*, 29(2), 235-249.
5. Bhalli, M. N. (2013). An Analysis Of The Normalized Difference Vegetation Index (NDVI) And Its Relationship With The Population Distribution Of Faisalabad-Pakistan. *Pakistan Journal of Science*, 65(4).
6. Bhatta, B. (2010). *Analysis of urban growth and sprawl from remote sensing data*. Springer Science & Business Media.
7. Deng, J. S., Wang, K., Hong, Y., & Qi, J. G. (2009). Spatio-temporal dynamics and evolution of land use change and landscape pattern in response to rapid urbanization. *Landscape and urban planning*, 92(3-4), 187-198.
8. Farooq, M. U., Rahman, A., Qasim, M., Hashim, M., and Batool, S. (2023). Evaluation of Physical Expansion of Built Environment in District Sargodha Pakistan. *Journal of Asian Development Studies*, 12(3), 1223-1235.
9. GoP (2017). Provisional Summary Results of 6th Population and Housing Census 2017. Population Census Organization, Statistics Division Islamabad: Govt. of Pakistan. Retrieved from <http://www.pbscensus.gov.pk>
10. Gul, S., Bibi, T., Rahim, S., Gul, Y., Niaz, A., Mumtaz, S., & Shedayi, A. A. (2023). Spatio-temporal change detection of land use and land cover in Malakand Division Khyber Pakhtunkhwa, Pakistan, using remote sensing and geographic information system. *Environmental Science and Pollution Research*, 30(4), 10982-10994.

11. Hashim, M., Rahman, A., Nadeem, B., Aziz, F., Dawood, M., Qasim, M., Farooq, M. U., and Muneer, S. (2024). Spatio-Temporal Analysis of Land Use Land Cover Changes and Spectral Normalized Difference Indices in Multan City, Pakistan. *Al-Qantara*, 9(4), 685-699.
12. Hussain, S., Mubeen, M., Ahmad, A., Akram, W., Hammad, H. M., Ali, M., . . . Sultana, S. R. (2020). Using GIS tools to detect the land use/land cover changes during forty years in Lodhran District of Pakistan. *Environmental Science and Pollution Research*, 27, 39676-39692.
13. Jiang, Q., He, X., Wang, J., Wen, J., Mu, H., & Xu, M. (2020). Spatiotemporal analysis of land use and land cover (LULC) changes and precipitation trends in Shanghai. *Applied Sciences*, 10(21), 7897.
14. Li, H., Wei, Y. H. D., & Huang, Z. (2014). Urban land expansion and spatial dynamics in globalizing Shanghai. *Sustainability*, 6(12), 8856-8875.
15. Liu, J., Zhan, J., & Deng, X. (2005). Spatio-temporal patterns and driving forces of urban land expansion in China during the economic reform era. *AMBIO: a journal of the human environment*, 34(6), 450-455.
16. Majeed, M., Tariq, A., Anwar, M. M., Khan, A. M., Arshad, F., Mumtaz, F., ...&Shaukat, S. (2021). Monitoring of land use–Land cover change and potential causal factors of climate change in Jhelum district, Punjab, Pakistan, through GIS and multi-temporal satellite data. *Land*, 10(10), 1026.
17. Maqbool, N. (2022). *Water crisis in Pakistan: Manifestation, causes and the way forward* (No. 2022: 60). Pakistan Institute of Development Economics.
18. McIver, D. K., &Friedl, M. A. (2002). Using prior probabilities in decision-tree classification of remotely sensed data. *Remote sensing of Environment*, 81(2-3), 253-261.
19. Nalawade, P., Gadakh, B., & Kadam Amol, B. (2022). Vegetation Change Detection using Remote Sensing and GIS, 2001-2021–A Case Study of Nashik City, Maharashtra. *Eco. Env. and Cons.*
20. Nasar-u-Minallah, M., Zia, S., Rahman, A. U., &Riaz, O. (2021). Spatio-Temporal Analysis of Urban Expansion and Future Growth Patterns of Lahore, Pakistan. *Geography, Environment, Sustainability*, 14(3), 41-53.
21. Parveen, T., Qasim, M., Aziz, F., and Farooq, M. U. (2023). Status of Minorities of Pakistan and India: A Legal and Constitutional Comparison. *Journal of Education and Social Studies*, 4(3), 712 - 724.
22. Qasim, M., Ali, N., and Aqeel, M. (2023). Trends and Patterns of Temporal Urban Population Growth in Pakistan. *Pakistan Social Sciences Review*, 7(3), 551-564.
23. Qasim, M., Ali, N., Haider, S., S., Zainab, I., and Ali, M. (2024). Socio-Ecological Dynamics in Gilgit Baltistan: Insights of Human Geographic Perspectives. *Journal of Education and Social Studies*, 5(2), 372-385.
24. Qasim, M., Ali, S., and Aqeel, M. (2024). Geographic Diversity and Landscape in Transition: Analyzing the Physical Features of Gilgit Baltistan Region. *Journal of Social Sciences Development*, 3(2), 154-169.
25. Qasim, M., Hussain, S., and Ali, K. (2024). Political Evolution in Gilgit Baltistan: A Historical Analysis of Governance Structures and Regional Dynamics. *Journal of Asian Development Studies*, 13(1), 341-349
26. Riaz, O., Munawar, H., u Minallah, M. N., Hameed, K., & Khalid, M. (2017). Geospatial analysis of urbanization and its impact on land use changes in Sargodha, Pakistan. *Journal of Basic & Applied Sciences*, 13, 226-233.

27. Shaheen, N., Baig, M. A., Mahboob, M. A., Akbar, S., Khokar, M. F G., (2015). Application of Remote Sensing Technologies to detect the vegetation changes during past two decades in Islamabad. *Pakistan. Journal of Social Science*, 4(3), 886-900.
28. Thandar, S. (2012). Analysis of Spatio-temporal changes of urban land use using remote sensing and GIS: A case study of Bhubaneswar City, Odisha. *Dagon University Research Journal*, 4, 19-29.
29. Turner, B., Meyer, W. B., &Skole, D. L. (2014). Global land-use/land-cover change: towards an integrated study. *Ambio Stockholm*, 23(1), 91-95.
30. Unger-Holtz, T. S. (2007). Introductory digital image processing: A remote sensing perspective.
31. Wu, Q., Li, H. Q., Wang, R. S., Paulussen, J., He, Y., Wang, M.,& Wang, Z. (2006). Monitoring and predicting land use change in Beijing using remote sensing and GIS. *Landscape and urban planning*, 78(4), 322-333.
32. Wu, W., & Shao, G. (2002). Optimal combinations of data, classifiers, and sampling methods for accurate characterizations of deforestation. *Canadian Journal of Remote Sensing*, 28(4), 601-609.
33. Yasin, S. A., and Qasim, M. (2020). China Pakistan Economic Corridor and the Significance of Gilgit Baltistan Constitutional Status. *PUTAJ Humanities and Social Science*, 27(2), 79-93.