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Research Article

Exploring the Complexities of Urbanization and Socio-Ecological Challenges in the High Mountainous Region of Chitral, Khyber Pakhtunkhwa (KPK), Pakistan

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Abstract: Rapid urbanization is not only an issue in plain areas but also in mountainous regions. However, urbanization affects the socio-ecological pattern of mountainous regions especially depleting natural resources, e.g., traditional agricultural practices. Although urban sprawl impinges on such fertile productive lands, it also positively affects trade activities, and high-income opportunities, and the region will have high spatial interaction. This paper presents the results of an attempt to gain insight into the mechanisms for the urban growth of district Chitral (Chitral Town) located in the Hindu Kush range north of KPK Pakistan. Over the last few decades, the urban agglomeration has become attractive among migrants from within and beyond the district, further accelerating urban growth in the surrounding area. The landscape transformation phenomenon in Chitral town was investigated with the following objectives: (i) Detection of spatiotemporal change in the study area over the last two decades, (ii) Identification of existing landscape patterns i.e. land-use assessment by analysing the acquired high-resolution remote satellite imageries for the years 2003 and 2020, (iii) Empirical analysis of data within the framework of an object-based approach. Land-use transformations like spatiotemporal change, loss of agriculture, and infrastructure patterns of urban growth were estimated for the past 17 years. This study reveals that the agricultural Land-use has declined by 348 m^2 while the Built-up area has increased by 318 m^2. The research offers practical recommendations for sustainable town planning and management. As such, this study has the potential to propose future strategies and it may be helpful to the policy/decision-makers in the development of future town planning in the similar mountainous regions of Pakistan or elsewhere.

Keywords: Land-use (LU)/Land-cover (LC) Pattern, Urbanization, Mountainous Regions of Chitral, Spatio-Temporal Changes, Socio-Ecological Patterns, Town Planning.

1. INTRODUCTION

Urbanization is a worldwide phenomenon resulting from the industrial revolution and the advancement of contemporary industry and technology [1]. More than half of the globe's population is living in metropolises, urbanization is worldwide in progress, and the city population is predicted to rise reaching 60 % by 2030. Of these, residents living in township areas, approximately 1.2 billion are precarious informal settlement residents [2]. Suitable human use is very limited in mountainous areas, valley floors are usually occupied by settlements, mass transit routes, and economic and social set-ups e.g., educational, health-related, power, and industry-based facilities are usually at risk on one hand while inadequate agriculturally productive land resources on the other hand [3]. Rapid urbanization has not halted the footprint of mountainous areas, gradually affecting small

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and medium-sized communities negatively in mountain regions, posing special socio-ecological concerns such as diminishing natural resources and increasing natural hazard risk which received the least amount of scientific attention [4]. If Land-use planning strategies will be implemented, any urban area could be improved [5]. At the urban margins, there is a lack of availability of appropriate microdata for residential development therefore; as a result, there is diminutive analysis for the vacant lands, which is evident in the introduction of urban growth boundaries (UGB's) [6]. In mountains, urban settlements are mesmerizing locations although modernization is obvious due to cities and towns and mountains are the last sites that preserve wilderness and rural customs [7]. Therefore, rustic livelihood in mountainous sites is taking its last breaths in the existing era.

For waged communities mountainous towns provide an adequate environment of want and demand and the creation of capital and market conditions also provide ample opportunities to the neighboring regions, while geographical research mostly focused on megacities and small towns were given less attention, to the meaning of small and medium towns in the modern urbanization process has constantly grown [8]. However, these mountainous towns have constantly grown and paved the way for urban problems and ecological changes like open space shrinkage, irregular land use, environmental pollution, dwelling problem, increase in land coast, etc. Therefore, a research approach acts as a bridge between the natural environment and the social forces in finding a way to a satisfying environment for the future [9]. The complexities of urbanization in mountainous areas are debatable.

Pakistan has a widespread high-rise mountain zone of the Himalayas and Hindukush. Almost 61 % of the geographical area of Pakistan is covered by mountainous areas out of a total of 26.5 % of the world's continental land surface [10]. The high mountain zone of the Himalayas and Hindukush is divided into Northwest Frontier Hills & sub-montane Indus and Himalaya-Karakorum [11, 12]. The Hindukush Range in the North extends Northwest; The Karakoram Range passes through The Himalayas in the center [13]. The estimation in the population resided at mountains rely upon the definition of World Conservation Monitoring Centre (WCMC) [14]. In the mountains and highlands agricultural sites are mostly practiced on the terraces, and in some areas, it is practiced as historical traditions and fragment of cultural ecologies amenities [15]. Among the 17 Sustainable development goals, 15th goal is related to life on land and it is based on protection, restoration and promotion of sustainable use of Earth's ecosystem in which prime most is stop and inverse the land degradation [16]. For centuries diverse and locally adapted agricultural systems developed, managed, trial and tested by people involved in primary activities, a vital combination of cultural, social, economic and ecological of such practices have been induced to men [17].

In Pakistan, all localities, which are metropolitan corporations, municipal corporations, municipal committee, or cantonments at the time of the census, were treated as urban [18]. The present investigation in mountainous regions of Chitral locayed in Khyber Pakhtunkhwa (KPK), Pakistan focuses on analyzing the reasons and consequences of mountain urbanization from a broader and more integrative perspective by addressing questions like: What are the spatiotemporal characteristics of the urbanization process in a high mountain town? What determines the pace and form of urbanization? Which challenges for sustainable urban governance appear? The main objective of this study is to provide insight into the mechanisms for the urban growth of district Chitral (Chitral Town) located in the Hindu Kush range north of KPK Pakistan. To investigate the landscape transformation phenomenon, attempts have been made to detect the spatio-temporal change in the study area over the last two decades, and to identify existing landscape patterns i.e., land-use assessment by analyzing the acquired high-resolution remote satellite imageries for the years 2003 and 2020.

2. MATERIALS AND METHODS

2.1 Study Area

The study area namely Chitral Town (Figure 1) is located in Chitral district; a Northern most districts of Khyber Pakhtoon Khawah (KPK), and Chitral River originates from the Chiantar Glacier located in along with its tributaries and numerous springs,

drained the valley and after draining the region, it enters into Arandu-Afghanistan [19]. Chitral Town is approximately 35.9 km^2 area coverage which is 0.24 % of the total Chitral district's area. Study comprises on three union councils (UC's) namely UC Chitral-1, UC Chitral-2 and UC Broze with the population selected urban area is 49,780 [20].

Chitral is the valley bounded by Hindu Kush Range on the North West, Karakoram Range on the North East and Hindu Raj Range on the South, the famous Lawari tunnels is located there which connect the district to upper Dir. The physiography of Chitral; a diverse mountainous area with glaciers including snow cover mountains, and unembellished rock and sterile ground covered approximately 28.5 % of land while pasture and sparse vegetation spread over 62 % of land [21]. Climatic condition of the region is experiencing cold winter with mid-summer. Since, the area is surrounded by mountains, it does not receive the monsoon rains [21]. Mean rainfall at Drosh meteorological station located at Chitral towns of Lower Chitral ranges 500-650 mm per year [22].

2.2 Study Plan

To assess the urbanization trends, data have been collected through the detection of Spatio-temporal change at town scale over the past two decades. High resolution quick bird 10 meter resolution Satellites images from the SaaS planet have been downloaded for the year 2020, DEM 30 meter from Earth Explorer and High-resolution image for the year 2003 from Google Earth pro (Figure 2).

To detect spatio-temporal change and identify spread patterns of built-up land expansion from the urban core to associated landscape from 2003 to 2020, the acquired images have been processed in ArcGIS in order to get raster data for further analyzing, the manual digitization process is applied through the steps mentioned in (Figure 3). After editing all the raster data, which have been processed through the images, attribute tables have been analyzed further. Object based (manual) analysis [5, 23] have been conducted for creating all the vector data. Finally, the data have been tabulated.

3. RESULTS AND DISCUSSION

The change detection of land-use/land cover of the study area (Figure 4) has been mentioned. There is shrinking of agricultural land-use can easily be identified. In contrast, the extension of built-up land-use has been identified in different places. In many places, extension of built-up towards the city's fringes may be viewed. Around the cities, there is a high demand for land-use for residential purposes and it was estimated that by the year 2025 if the estimated trend continued, then 70 %

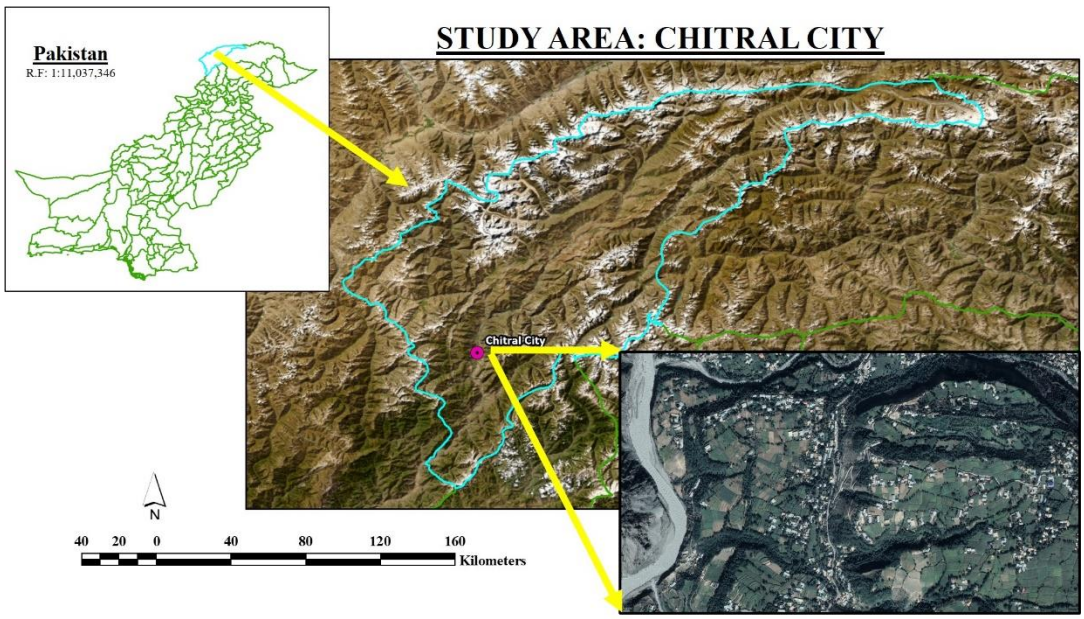

Fig. 1. Study area map of Chitral Town-Khyber Paktunkhwa (KPK)

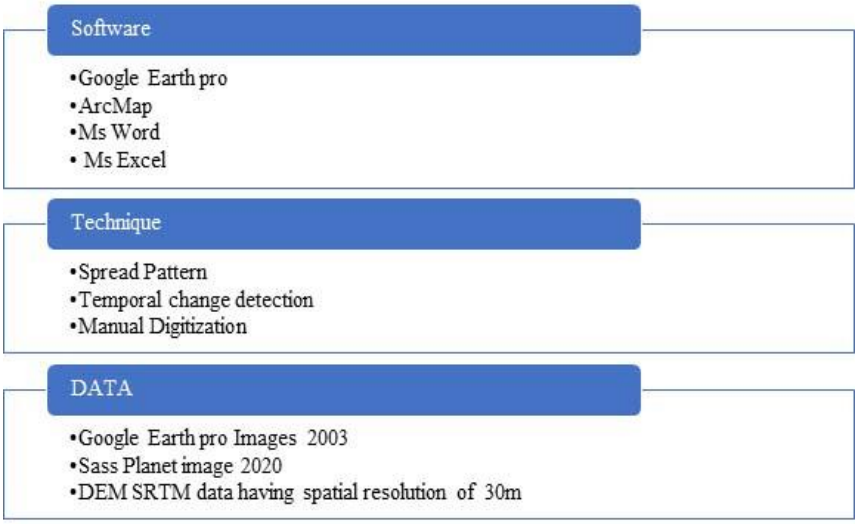

Fig. 2. Data acquisition and processing

of the population would reside in cities. In the year 2003, agricultural land-use was 766 m^2, which was shrinked up to 418 m^2 in the year 2020 (Table 1). Therefore, loss of 348 m^2 of agricultural area has been recorded during a period of 17 years. Kiambu County, the peripheries of Nairobi have lost forty percent of productive agricultural land to city expansion since 1995 [24]. In the year 2003, built-up area mostly for residential purposes was 371 m^2 (Table 1) in the study area, in contrast in year 2020 it expanded to 689 m^2 (Table 1). Therefore, in the study area, the expansion of 318 m^2 of the area have been recorded. Road networks and associated infrastructure remain the prominent sign of arbitrating urbanization, Chitral city resonances the urbanization in a true sense, where in the year 2003, road network was 360,432 meters and it increased by 594,171 meters by the year 2020 (Table 1), therefore in 17 years 233,739 meters roads have been paved. Nevertheless, it is the fact that mountainous areas are mostly unhabituated and Chitral city was also located over the mountainous range, which has been considered the highest mountainous range of the world i.e., The Great Himalayas. One out of ten world's population lives in mountainous areas and these mountainous areas hold 25 % of the land surface of Earth [25]. Number of settlements increased from 3015 (Year 2003) to 4091 (Year 2020) in the study area (Table 1), therefore 1,076 new settlements have developed. Hu et al. [26] stated that Pakistan's Land-use (LU)/Land-cover (LC) patterns have endured huge variations since

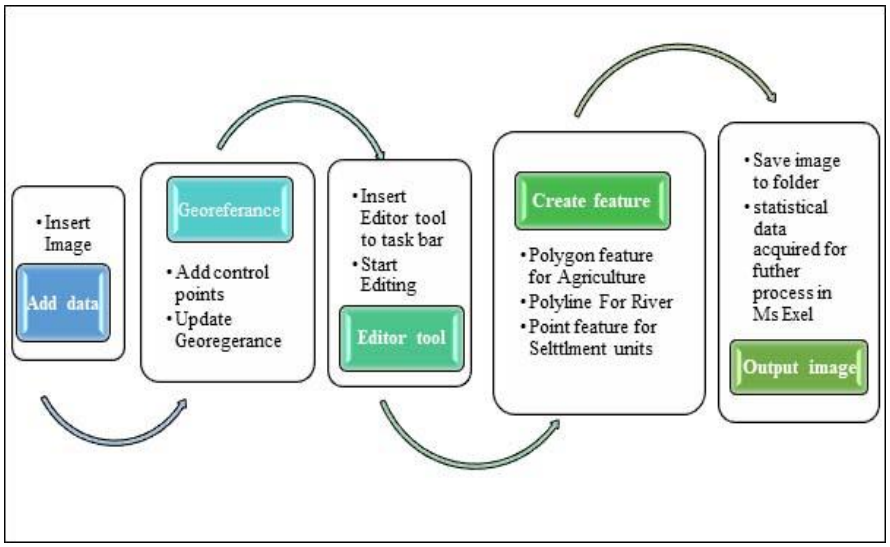

Fig. 3. Image acquisition and process

the 1900s, with no clear modified plan.

3.1 Change Detection of Land-Use for the Year 2003 and 2020

Build-up area included the build-up land and other infrastructure e.g. residential, commercial, or industiral land-use etc. By the comparison of two decade change in build-up land in the study area (Figure 5), it is observed that during the year 2020, the total number of further built-up land-use have been constructed at the fringes of cultivated land stretched to 4091 m^2 which was 3015 m^2 during the year 2003. It is, therefore, evident that the number of settlments in the period of two decades has become two-fold. Through the observation based survey and interviews of respondents were conducted from 8 locations within the study area, it has been detected that the dominant factors are modernization in central area of town, administative infrastructre and residential land-uses have increased with the rapid rate. Kausar *et al.* [5, 23] conducted a research on urban areas of Karachi; the largest metropolitan of Pakistan and suggested that there is a dire need to adapt suitable planning strateiges to gear up the urban sprawl.

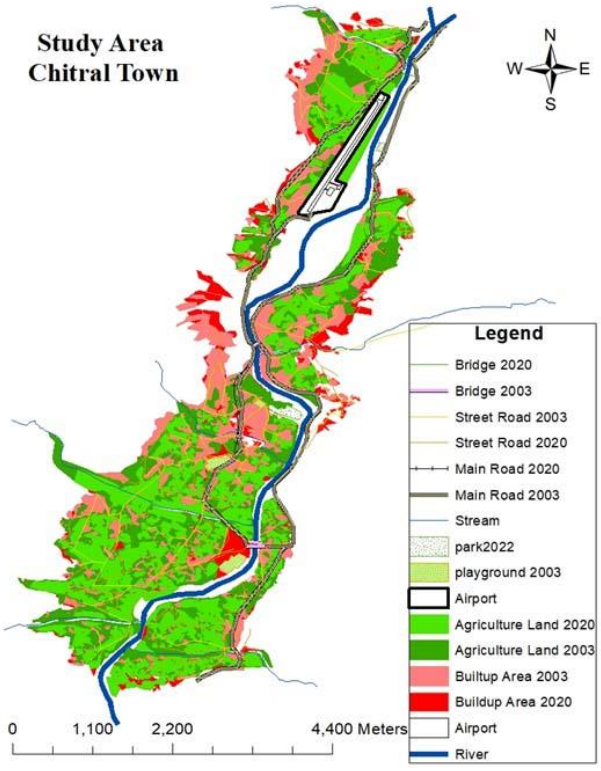

Fig. 4. Land-use of study area

3.2 Shrinking of Agriculture Land-Use

The comparison of agricultural land-use data for the period 2003-2020 (Figure 6) shows that there is a clear decline in agricultural land-use. In the year 2003, the total agricultural land-use was 766 m^2, which educed to 418 m^2 in the year 2020. It is evident that during two decades, the agriculture land-use has declined by 54.6 % which is about half of the area. This decrease is attributed to the direct impact of unplanned and irregular development of fast-growing urbanization. It is evident that the rapid urbanization is the main cause of agricultural land-use decline (Table 1). In contrast, during a study of the LU/LC change detection in Western Nile data in Egypt, Abd El-Kawy *et al.* [27] reported that nearly 28, 14, and 9 % of infertile land was transformed to agricultural land in the periods 1984–1999, 1999–2005, and 2005–2009, respectively.

3.3 The Most Affected Area

As compared to other areas, two highlighted areas (Figure 7) are found more affected in terms of build-up areas. In these areas, primarily the areas having slope topographical feature, the infrastructure and buildup area are observed to be developed very fast. Topographically, both areas are on slope and these slopes were having wilderness. Later, both the areas experienced rapid development of build-up infrastructure. It was observed that these areas became developed in infrastructure and service sector. During the last decade, the provision of basic facilities e.g., frequent supply of drinking water, accessibility in terms of road networks, electricity made the areas more accessible. Such facilities led the area towards fast growing with an irregular settlement pattern. Our results are in-line with Yang [28] who observed major variations in conversion of arable land and grassland into construction land during the period 1990–2020.

4. CONCLUSION AND RECOMMENDATIONS

An object-based approach, combination of high-resolution remote sensing imagery and Geographic Information System (GIS) contribute to the determination of the urbanization pattern in high mountainous towns such as the Chitral Town. This was an attempt to reach deep inside the mechanism of rapid and random development in the small town

Table 1. Temporal change of land-use

Land-Use	Year	
	2003	**2020**
Built-up Area	371 m^2	689 m^2
Agriculture Land	766 m^2	418 m^2
Road Network	360,432 meters	594,171 meters
Main Road	204,755 meters	11,749 meters
Numbers of Settlement	3015	4091

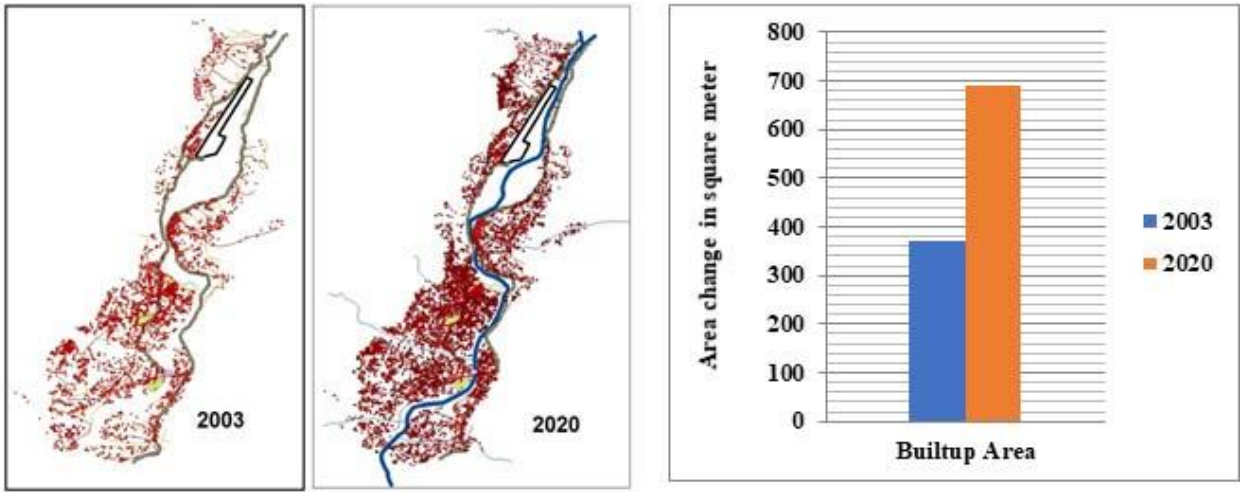

Fig. 5. Change detection of build-up area

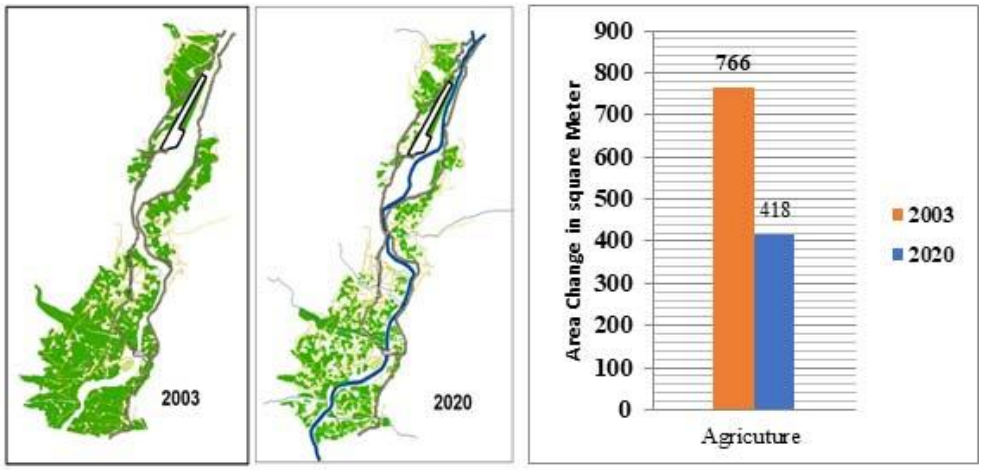

Fig. 6. Change detection of agricultural land-use in the study area (Chitral Town)

of Chitral, which has ultimately resulted in serious planning glitches today, and near future. Following results have been concluded from the present investigations in Chitral Town:

(i) Agricultural Land-use has declined by 348 sq-meters in Chitral city since 2003;
(ii) Built-up area has increased by 318 m^2 since 2003;
(iii) The number of settlments has become two-fold since 2003;
(iv) During the 17 years, 2,33,739 meters roads was surfaced.

The present investigations suggest that there is an urgent need to develop policies and adapt land-use planning strategies to alleviate the negative

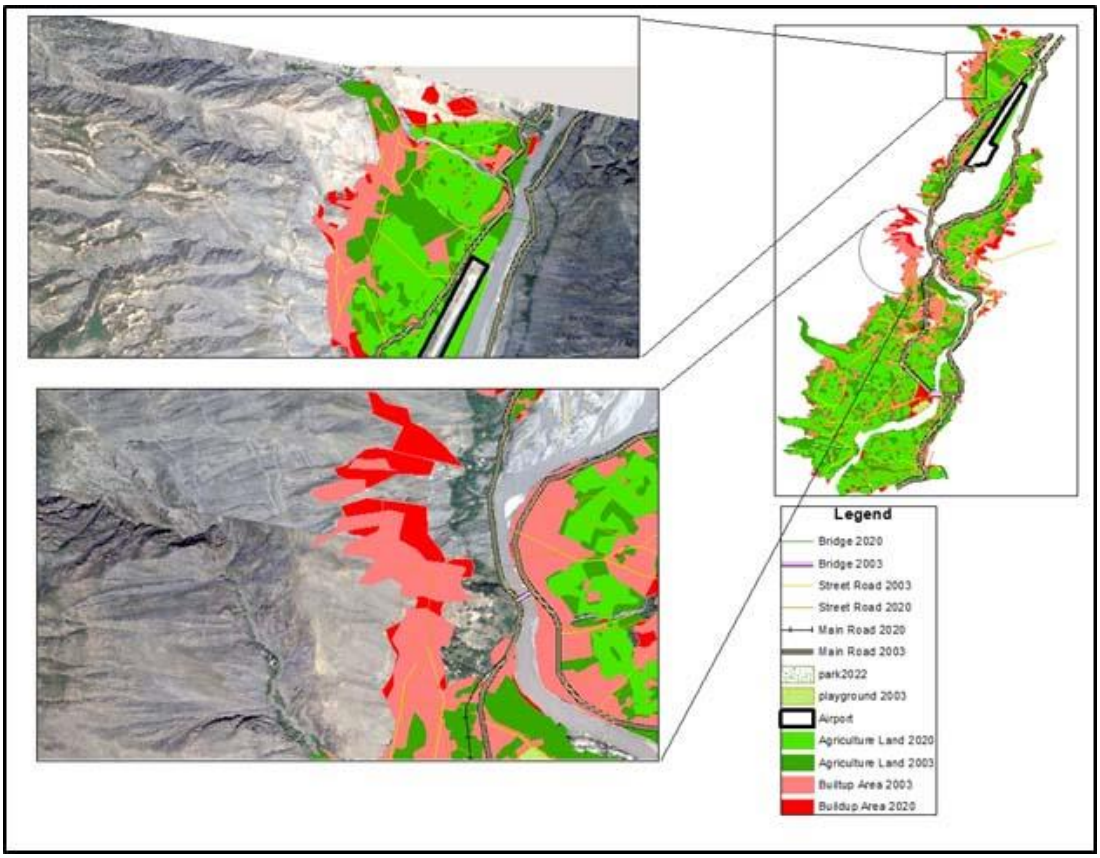

Fig. 7. Most affected areas in Chitral Town (KPK, Pakistan)

effects of rapid growth in build-up land in the study area. There should be implementation of "smart growth" strategies, especially the transfer of development rights and implementation of urban growth boundaries. Smart growth concentrates on compact development, and redevelopment of built-up area in the town, therefore inventive and efficient management is required to control the negative impact. On the Government level, the Municipal Committee (Chitral Town) has already divided the whole Bazar (market) into three zones, but it is not implemented yet and there is a dire need for micro-scale planning for the future growth of the town to avoid urban sprawl. There is future need for land-use planning at both; the government and private level to stear for the right direction of urban development in the study area.

5. CONFLICT OF INTEREST

The authors declare no conflict of interest.

6. REFERENCES

1. G. Crane-Kramer, and J. Buckberry. Changes in health with the rise of industry. *International Journal of Paleopathology* 40: 99–102 (2023).
2. United Nations, P.D. The world's cities in 2016. *Data Booklet* 1-5 (2016).
3. V. Chandel, K.K. Brar, and Y. Chauhan. RS & GIS based landslide hazard zonation of mountainous terrains a study from Middle Himalayan Kullu District, Himachal Pradesh, India. *International journal of Geomatics and Geosciences* 2(1): 121–132. 2011.
4. P.C. Tiwari, A. Tiwari, and B. Joshi. Urban growth in Himalaya: understanding the process and options for sustainable development. *Journal of Urban and Regional Studies on Contemporary India* 4(2): 15–27 (2018).
5. A. Kausar, S. Afsar, Z. Wazir, A.H. Lahori, A. Afzal, J. Arif, and V. Tyshchenko. Land Use Analysis of Central Business District (CBD) of Metropolis Saddar Karachi through SRS/GIS Techniques. *Ecological Questions* 33(1): 1–25 (2022).
6. M. Ball, M. Cigdem, E. Taylor, and G. Wood. Urban growth boundaries and their impact on land prices. *Environment and Planning A* 46(12): 3010–3026 (2014).
7. C.D. Allen. Romantic geography: In search of the sublime landscape. *The AAG Review of Books* 3(2): 60–62 (2015).

8. C. Chen, R. LeGates, and C. Fang. From coordinated to integrated urban and rural development in China's megacity regions. *Journal of Urban Affairs* 41(2): 150–169 (2019).
9. Y. Deng, W. Qi, B. Fu, and K. Wang. Geographical transformations of urban sprawl: Exploring the spatial heterogeneity across cities in China 1992–2015. *Cities* 105: 102415 (2020).
10. G. Rasul, and A. Hussain. Sustainable food security in the mountains of Pakistan: Towards a policy framework. *Ecology of food and nutrition* 54(6): 625–643 (2015).
11. M. Nüsser, and W.B. Dickore. A tangle in the triangle: vegetation map of the eastern Hindukush (Chitral, northern Pakistan). *Erdkunde* 37–59 (2002).
12. A.S. Griffin, K. Netto, and C. Peneaux. Neophilia, innovation and learning in an urbanized world: a critical evaluation of mixed findings. *Current Opinion in Behavioral Sciences* 16: 15–22 (2017).
13. A. Zanchi, and M. Gaetani. The geology of the Karakoram range, Pakistan: the new 1: 100,000 geological map of Central-Western Karakoram. *Italian journal of Geosciences* 130(2): 161–262 (2011).
14. H. Buhaug, L.E. Cederman, and J.K. Rød. Disaggregating ethno-nationalist civil wars: A dyadic test of exclusion theory. *International Organization* 62(3): 531–551 (2008).
15. P. Tarolli, and E. Straffelini. Agriculture in hilly and mountainous landscapes: threats, monitoring and sustainable management. *Geography and sustainability* 1(1): 70–76 (2020).
16. M. Mohieldin, and P. Caballero. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. *UN Chronicle* 51(4): 34–35 (2015).
17. P. Koohafkan, and M.A. Altieri. Globally important agricultural heritage systems: a legacy for the future (p. 41). Rome: Food and Agriculture Organization of the United Nations (2011).
18. I.A. Rana, and S.S. Bhatti. Lahore, Pakistan–Urbanization challenges and opportunities. *Cities* 72: 348–355 (2018).
19. S. Riaz, A. Ali, and M.N. Baig. Increasing risk of glacial lake outburst floods as a consequence of climate change in the Himalayan region. *Jàmbá: Journal of Disaster Risk Studies* 6(1): 7 (2014).
20. Pakistan Bureau of Statistics, Government of Pakistan. https://www.pbs.gov.pk/content/brief-census-2017 (accessed 1 February 2023)
21. J. Din, S. Hameed, K. Shah, M. Khan, S. Khan, M. Ali, and M. Nawaz. Assessment of canid abundance and conflict with humans in the Hindu Kush Mountain Range of Pakistan. *Wildlife Biology in Practice* 9: 20–29 (2013).
22. D. Archer. Hydrological implications of spatial and altitudinal variation in temperature in the upper Indus basin. *Hydrology Research* 35(3): 209–222 (2004).
23. A. Kausar, A. Afzal, G. Saeed, A. Maqsoom, O.I. Khan, S. Afsar, Y. Anis, S.M. Zehra, V. Vambol, and S. Vambol. Land-Use/Land Cover Analysis Through Object Based Technique: A Case Study of Shahrah-e-Faisal. *Ecological Questions* 34(2): 1–5 (2023).
24. E. Joy. Impacts of rapid urbanisation in the urban fringe of Lokoja, Nigeria. *Journal of Geography and Regional Planning* 9(10): 185–194 (2016).
25. B. Löffler. Integration in Deutschland. *Oldenbourg Wissenschaftsverlag* (2011). https://doi.org/10.1524/9783486710137.
26. Y. Hu, A. Raza, N.R. Syed, S. Acharki, R.L. Ray, S. Hussain, H. Dehghanisanij, M. Zubair, and A. Elbeltagi. Land Use/Land Cover Change Detection and NDVI Estimation in Pakistan's Southern Punjab Province. *Sustainability* 15(4): 3572 (2023).
27. O.R. Abd El-Kawy, J.K. Rød, H.A. Ismail, and A.S. Suliman. Land use and land cover change detection in the western Nile delta of Egypt using remote sensing data. *Applied geography* 31(2): 483–494 (2011).
28. Y. Yang. Evolution of habitat quality and association with land-use changes in mountainous areas: A case study of the Taihang Mountains in Hebei Province, China. *Ecological Indicators* 129: 107967 (2021).