Appraisal the Impact of Urban Evolution and Change on Land Use and Land Cover: A Case Study of Abbottabad District

Khushboo Naz[1*], Dr. Sheeba Afsar[1], Dr. Sumaiya Bano[2]
[1]Department of Geography University of Karachi
[2]Department of Geography Federal Urdu University of Arts, Science and Technology, Karachi
*Correspondence: khushboojadoon25@gmail.com, sumiahmed564@gmail.com, sheebanaeem@uok.edu.pk.

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Introduction/Importance of Study: The Abbottabad District has experienced dramatic urban evolution, significantly altering its land use and land cover (LULC). These changes, captured through remote sensing (RS) and geographic information systems (GIS) techniques, have had considerable environmental impacts and increased stress on the district's resources. Identifying areas at higher risk of urban expansion is crucial for effectively managing future growth and mitigating adverse effects.
Novelty Statement: This research is pioneering in its use of RS and GIS techniques to analyze urban growth in Abbottabad District from 1985 to 2023. It provides a detailed assessment of LULC changes, associated problems, and offers solutions and recommendations aimed at fostering sustainable urban development.
Material and Method: The study utilized Landsat 5 (TM) and Landsat 8 (TIRS/OLI) images from 2000 to 2023, sourced from Earth Explorer. Maximum Likelihood Classification (MLC) was employed to categorize LULC classes within the study area. The Urban Expansion Risk Model was developed using a weighted overlay method that analyzed parameters including LULC, NDVI, LST, NDBI, elevation, and population density.
Result and Discussion: The findings revealed significant LULC changes from 2000 to 2020, with built-up land increasing by 19.1% over the past two decades, while vegetation cover declined due to construction and agricultural expansion. These changes have impacted various aspects of the district, including housing, health, education, sanitation, transportation, security, and employment. NDVI values indicated a decrease in vegetation cover, and Land Surface Temperature (LST) analysis showed a temperature rise of 3°C. The study highlighted environmental issues such as pollution, loss of biodiversity, landslides, topographical changes, and flooding. Field visits provided additional insights into ground realities.
Concluding Remarks: The study underscores the need for government intervention to address issues related to urban growth, pollution, urban flooding, landslides, and deforestation in Abbottabad District. Effective urban planning and management of LULC are essential to prevent further degradation and promote sustainable growth in the future.

Keywords: Urban Evolution, Land Surface Temperature, LULC, NDVI.

Introduction:

Over the past few centuries, the global population has surged, and economies have industrialized, leading to a significant increase in urban migration—a process known as urbanization. While early cities began to emerge, the real acceleration in urban growth occurred in Europe during the seventeenth century with widespread industrialization (Archer, 2012) [1]. Urbanization trends are evident worldwide but are particularly pronounced in developing regions such as Africa and South Asia. Currently, nearly half of the world's population resides in urban areas (Satterthwaite, 2007) [2]. Urban sprawl often accompanies this shift, characterized by the expansion of urban areas into previously undeveloped lands. According to the David Suzuki Foundation, urban sprawl results in the encroachment of valuable agricultural and natural lands, leading to reduced green spaces and increased environmental degradation, including higher traffic, carbon emissions, and smog. This phenomenon is often driven by poor planning and short-sighted development strategies.

Pakistan, blessed with diverse landscapes ranging from snow-capped mountains in the north to the Arabian Sea in the south, and from fertile plains to arid deserts, is experiencing rapid urbanization. The country is urbanizing at the fastest rate in South Asia, with an annual growth rate of 3%. For instance, Karachi witnessed an 80% population increase from 2000 to 2010, making it one of the fastest-growing cities globally (Jabeen et al., 2017) [3]. The urban built-up area in Karachi expanded significantly by 199.68 km² from 1998 to 2018 (Raza et al., 2019) [4]. This rapid urbanization has led to numerous social, economic, and environmental challenges, including significant changes in land use and land cover (LULC).

Study Area:

Abbottabad, located in Khyber Pakhtunkhwa, Pakistan, is renowned for its natural beauty and is situated 50 km northeast of the capital, Islamabad. Often referred to as the "City of Pines," Abbottabad is characterized by its picturesque snow-capped mountains, lush green valleys, and terraced landscapes. The city is a popular tourist destination due to its stunning scenery and historical sites, including St. Luke's Church, Old Lockhart House, and the Lodge of the Civil Surgeon of Hazara. Abbottabad is also known for its educational institutions, such as Army Burn Hall College, Pakistan International Public School, COMSATS University, and Ayub Medical College. Additionally, the Pakistan Military Academy (PMA) is located here.

However, Abbottabad has also experienced urbanization over the past three decades. New neighborhoods have proliferated, transforming once-green valleys into developed areas (Anwar et al., 2022) [5]. Spatial analysis indicates a significant increase in built-up regions and infrastructure surrounding metropolitan areas, while agricultural land has decreased (Anwar et al., 2024) [6]. This study examines the urban expansion in Abbottabad from 1985 to 2023 and analyzes LULC changes from 2000 to 2020, highlighting their environmental impacts and the shift from lush green fields to a concrete jungle.

Study Area:

The study focuses on the urban evolution and LULC changes in Abbottabad, a city in eastern Khyber Pakhtunkhwa, Pakistan. Located 61 kilometers northeast of Rawalpindi, Abbottabad covers an area of 1,967 km² and is situated 1,256 meters above sea level (IUCN, 2004) [7]. It serves as a gateway to the Kagan Valley and is located on a plateau at the southern edge of the Rash (Orash) Plain. Abbottabad is connected by rail to Peshawar and the Indus Plain and has geographic coordinates of 34.168751° latitude and 73.22149° longitude (Britannica, 2023) [8]. The location of Abbottabad District is depicted in Figure 1.

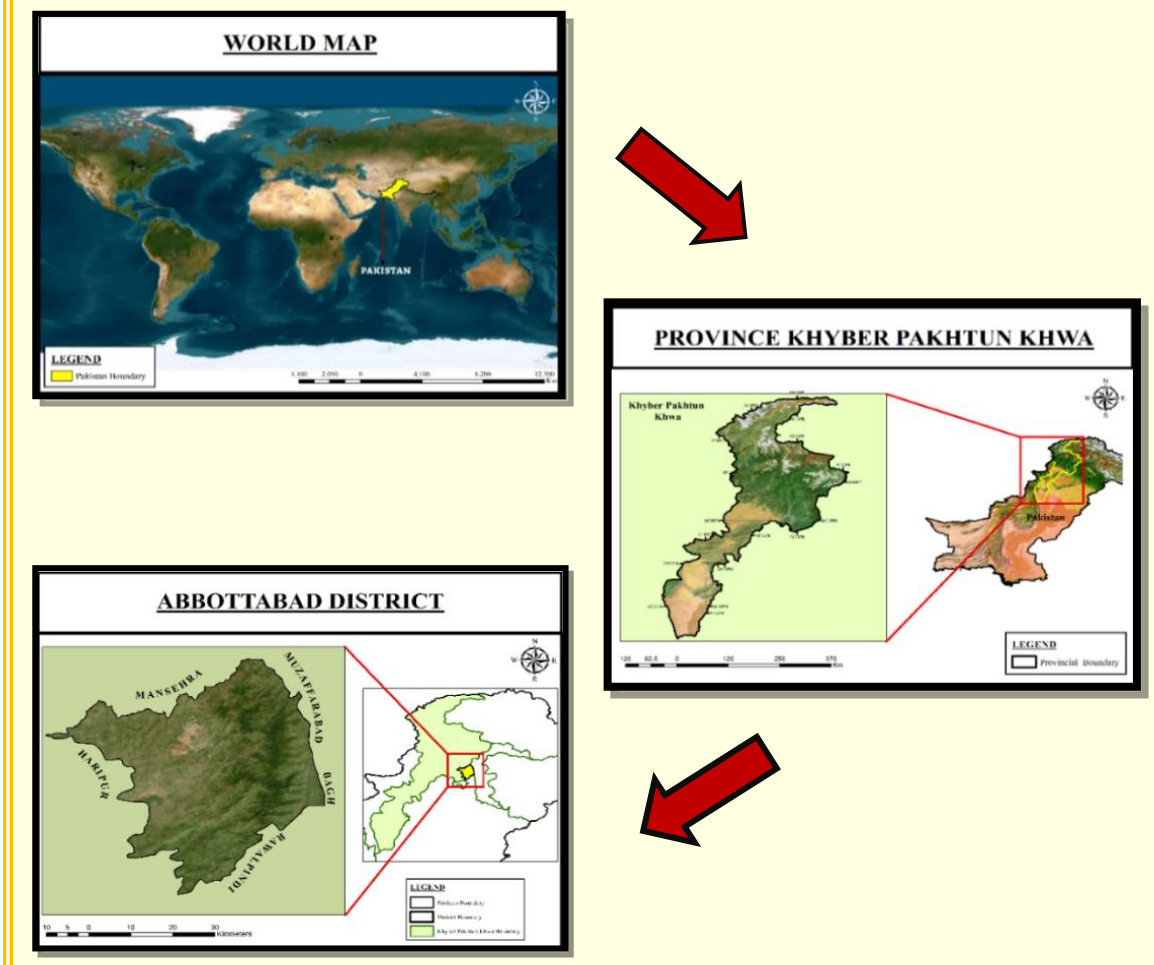

Figure 1: Study Area

Significance of the Research Study:

The land use and land cover (LULC) in Abbottabad district have been undergoing significant changes over time. The city, renowned for its natural beauty, is experiencing rapid urban expansion, particularly noticeable in the past 20 years following the 2005 earthquake. This expansion is reshaping the LULC dynamics of the city, leading to a substantial decrease in vegetation cover. This study aims to analyze these changes in LULC and their impacts on the environment. By identifying the underlying causes of this rapid transformation, the research will provide valuable insights for future urban planning. Additionally, the study will offer recommendations to guide sustainable development in Abbottabad, ensuring that the city's growth aligns with environmental preservation and long-term sustainability.

Objectives:

The research aims to achieve the following objectives:

- To identify LULC classes in the study area using RS/GIS Techniques.
- To show the temporal and LULC changes through maps.
- To detect the change in natural vegetation cover.
- To identify the Environmental issues caused by urbanization
- To highlight the areas under Urban Expansion Risk.

Methodology:

The United States Geological Survey (USGS) Earth Explorer platform provides a comprehensive interface for online searching, browsing, metadata exporting, and data

downloading from a range of remote sensing systems, including satellites and aircraft. For this study, satellite images from USGS were used to generate maps of Land Use/Land Cover (LULC), Normalized Difference Vegetation Index (NDVI), Normalized Difference Built-up Index (NDBI), Elevation, and Land Surface Temperature (LST). The Maximum Likelihood Classification (MLC) algorithm was employed to identify LULC classes within the study area. In this supervised classification approach, representative pixels are selected for each class to train the algorithm (Anwa et al., 2024) [6].

The city's expansion was tracked through the digitization of images spanning from 1985 to 2023. An Urban Expansion Risk Model was developed using the weighted overlay method to highlight areas most at risk from urban sprawl. Satellite images from Landsat-5 and Landsat-8, covering the period from 2000 to 2023 at ten-year intervals, were collected from Earth Explorer. The following methodological framework was employed in this research:

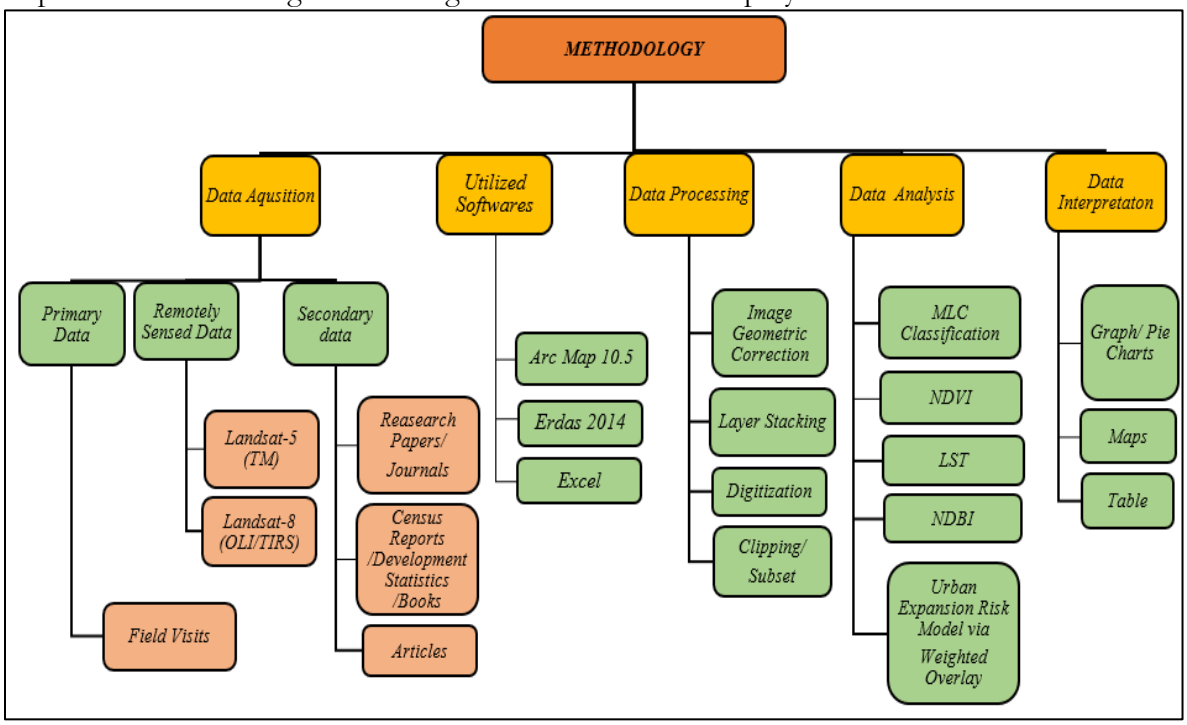

Figure 2: Methodological Framework

Results:

The study employed remote sensing and GIS techniques to analyze Land Use/Land Cover (LULC) changes in Abbottabad District. By utilizing NDVI and LST, the study highlights significant alterations in vegetation cover and temperature, reflecting the broader impacts of climatic changes on the district.

LULC Changes in Abbottabad District: Figure 3 illustrates the LULC changes in Abbottabad District. Maximum Likelihood Classification (MLC) was applied to satellite images from Landsat 5 (TM) and Landsat 8 (OLI/TIRS) to assess changes from 2000 to 2020.

Comparison of Abbottabad's LULC (2000-2020): Significant changes in vegetation cover and built-up areas were observed over the two decades. Specifically, vegetation cover decreased by 31.84%, while built-up areas increased from 7.90% in 2000 to 27% in 2020—a substantial rise of 19.1% (see Table 1). This rapid urban expansion is attributed to population growth, enhanced educational facilities, and substantial migration from areas affected by the 2005 earthquake.

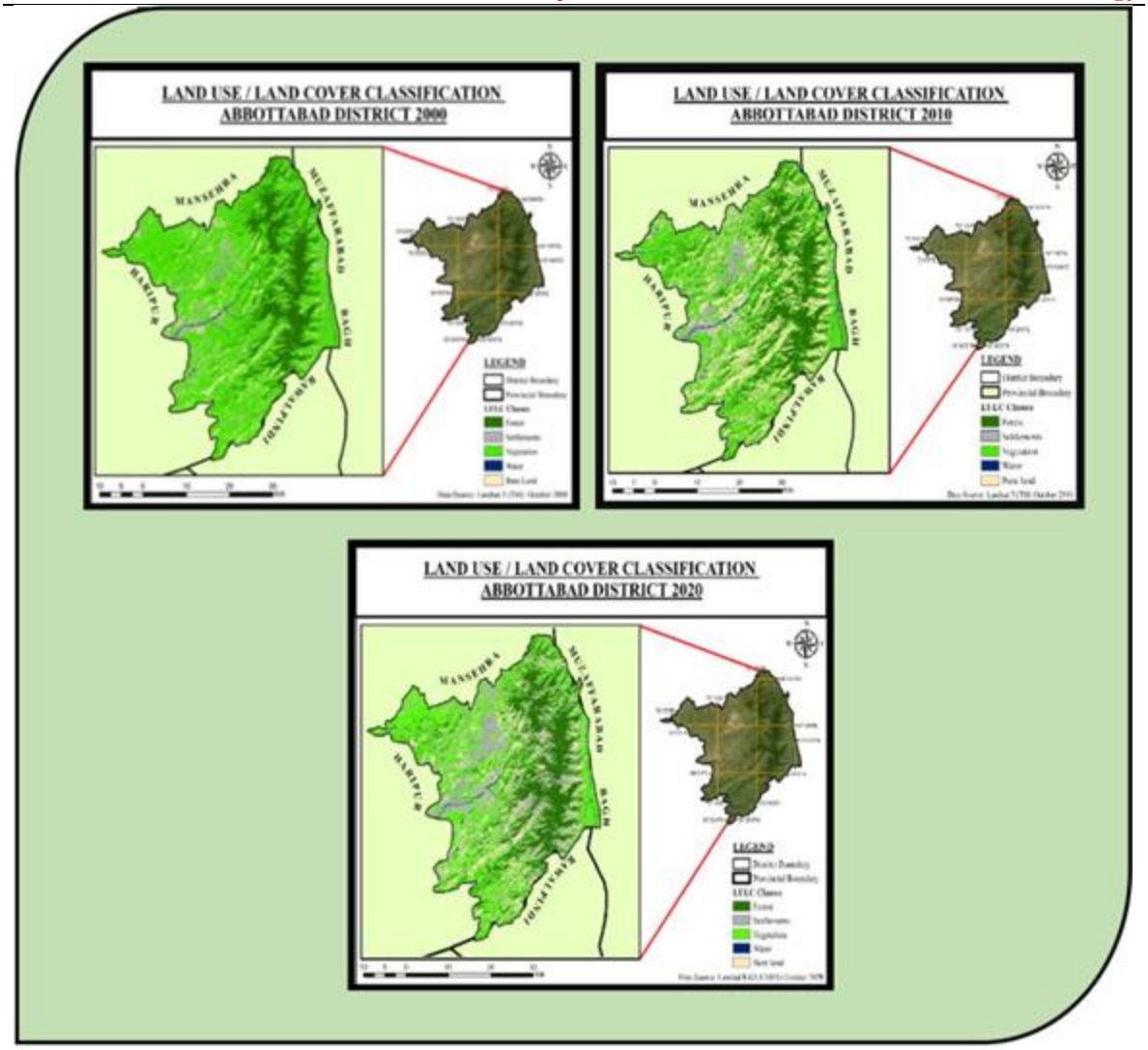

Figure 3: LULC Change Pattern of Abbottabad District 2000-2020

Table 1: Distribution of LULC classes in Abbottabad District 2000, 2010, 2020

	2000		2010		2020	
LULC Classes	**Area(%)**	**Area (Sq.km)**	**Area(%)**	**Area (Sq.km)**	**Area(%)**	**Area (Sq.km)**
Forest	18.45%	298.58	23.53%	380.59	27.03%	437.22
Settlements	7.90%	127.84	9.65%	156.09	27.00%	436.78
Vegetation	65.54%	1060.19	40.93%	662.09	33.70%	545.08
Water	0.88%	14.27	1.70%	27.46	0.96%	15.53
Bare Land	7.22%	116.88	24.19%	391.27	11.31%	182.99
Grand Total	**100%**	**1617.71**	**100%**	**1617.71**	**100%**	**1617.71**

(Data Source: Landsat 5 (TM), Landsat 8 (OLS/TIRS))

The area of water cover remains the approximately same in the year 2000 and 2020 whereas it increased from 0.88% (2000) to 1.70% in 2010 the major cause of this increase is the flood that occurred in 2010 as shown in Figure 4.

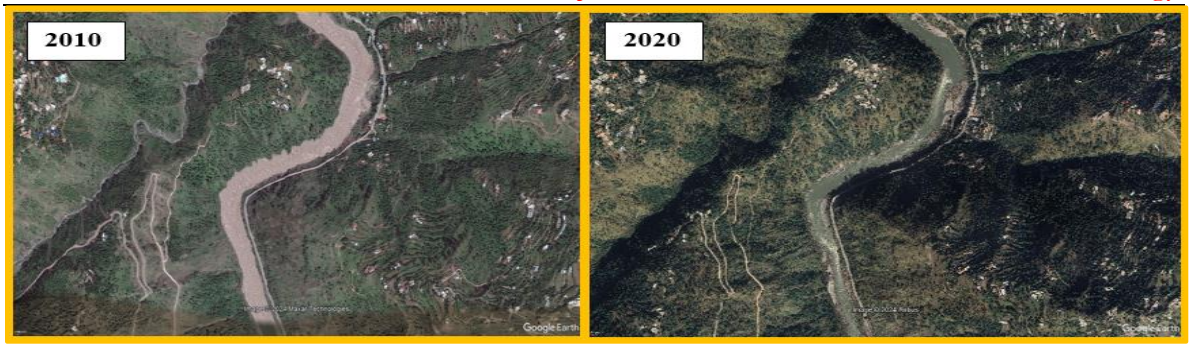

Figure 4: Normal Passage of River in 2020 and Flow of River during Flood 2010.

Bare land increased from 7.22% in 2000 to 24.19% in 2010. This rise in bare land was primarily due to the decline in vegetation cover. However, after 2010, there was a notable decrease in bare land, attributed to the expansion of built-up and agricultural areas to accommodate the growing population. The study also highlighted significant changes in forest cover. In 2000, forest cover was 18.45%, and it increased to 23.53% by 2010, largely due to the "Shajar Kari Muhim," a reforestation campaign initiated in 1998. Following 2015, forest cover continued to rise, reaching 27.03% as a result of the "Billion Tree Tsunami" initiative, which significantly boosted tree planting efforts, as depicted in Figure 5.

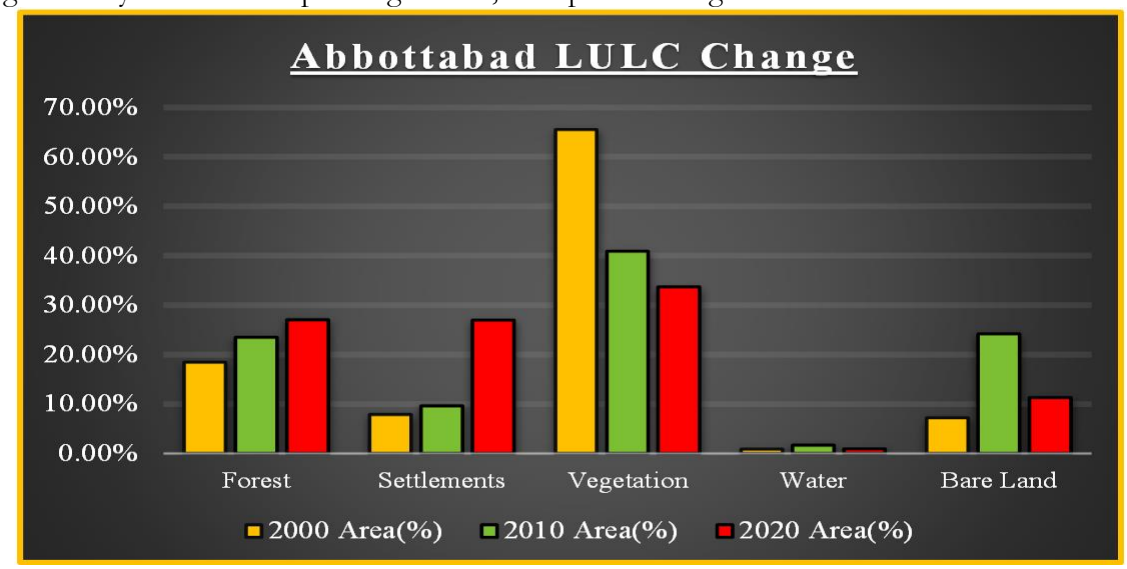

Figure 5: LULC Change Detection in the year 2000, 2010, and 2020
(Data Source: Landsat 5 (TM), Landsat 8 (OLS/TIRS))

Natural Vegetation Cover in Abbottabad District:

Remotely sensed data from 2000 to 2020 was analyzed to calculate the Normalized Difference Vegetation Index (NDVI) for Abbottabad District. The NDVI values range from -1 to +1, with values closer to -1 indicating sparse or no vegetation and values closer to +1 signifying dense vegetation (Poveda & Salazar, 2004) [9].

Figure 6 illustrates the NDVI maps for Abbottabad District for the years 2000, 2010, and 2020. In 2000, NDVI values ranged from -0.33 to +0.67, reflecting a high density of vegetation, particularly visible as dark green areas representing forest cover on the eastern side of the district. By 2010, the NDVI values had shifted to a range of -0.31 to +0.67, and by 2020, they further declined to -0.10 to +0.50. This reduction in vegetation cover over the years is attributed to factors such as urban expansion, deforestation for fuelwood, and land clearing for agriculture. Figure 7 presents a graph of the mean NDVI values, showing a decreasing trend in vegetation cover as determined by linear regression. The mean NDVI values for 2000 to 2020 are detailed in Table 2.

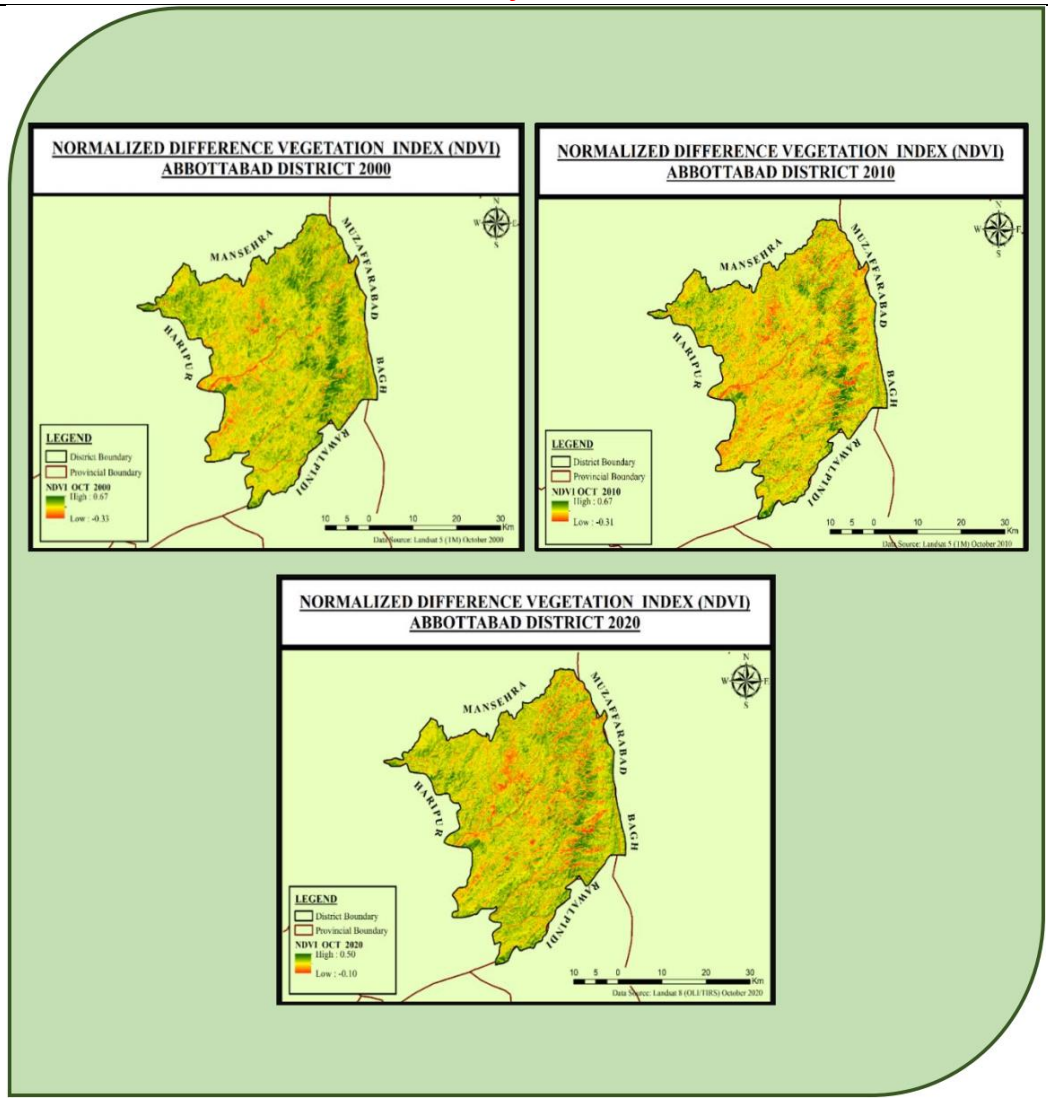

Figure 6: NDVI of Abbottabad District 2000-2020

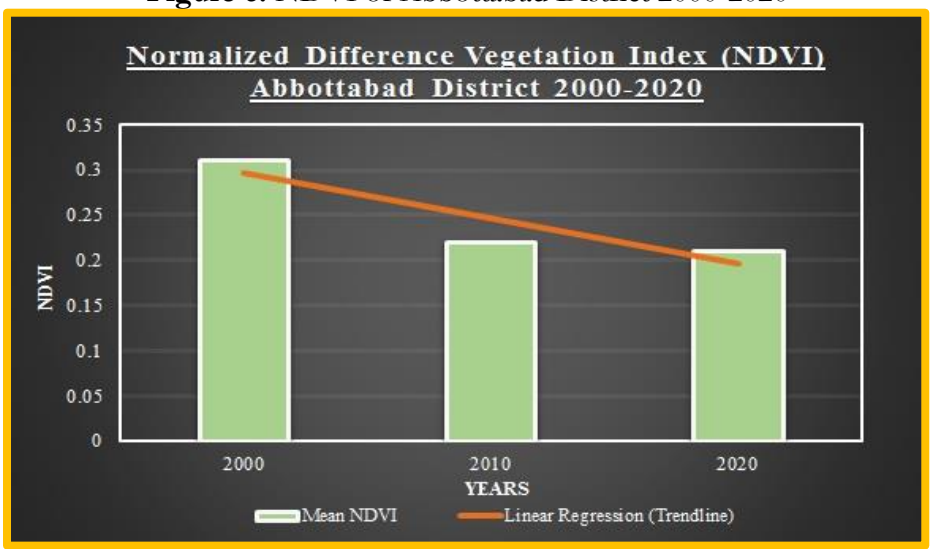

Figure 7: NDVI of Abbottabad District 2000-2020

The observed decline in vegetation cover in Abbottabad District is primarily driven by rapid population growth, increased migration following earthquakes, and expanding settlements. The surge in population intensifies the demand for housing, food, educational

institutions, medical facilities, and infrastructure. Despite these needs, certain areas within the district lack access to natural gas, leading residents to rely on firewood. This increased demand, especially during winter, has led to illegal tree cutting and further deforestation. Additionally, climate change exacerbates the situation by altering rainfall patterns and raising temperatures, which adversely impacts vegetation.

Environmental Issues in Abbottabad District:

Land Surface Temperature (LST):

Land Surface Temperature (LST) is a critical variable within the Earth's climate system, influencing surface energy flow both locally and globally (Li et al., 2023) [10]; (Mao et al., 2021) [11]. The LST for Abbottabad District has been assessed using remotely sensed images for the years 2000, 2010, and 2020. This analysis provides insights into how temperature changes have impacted the district's environment over the past two decades.

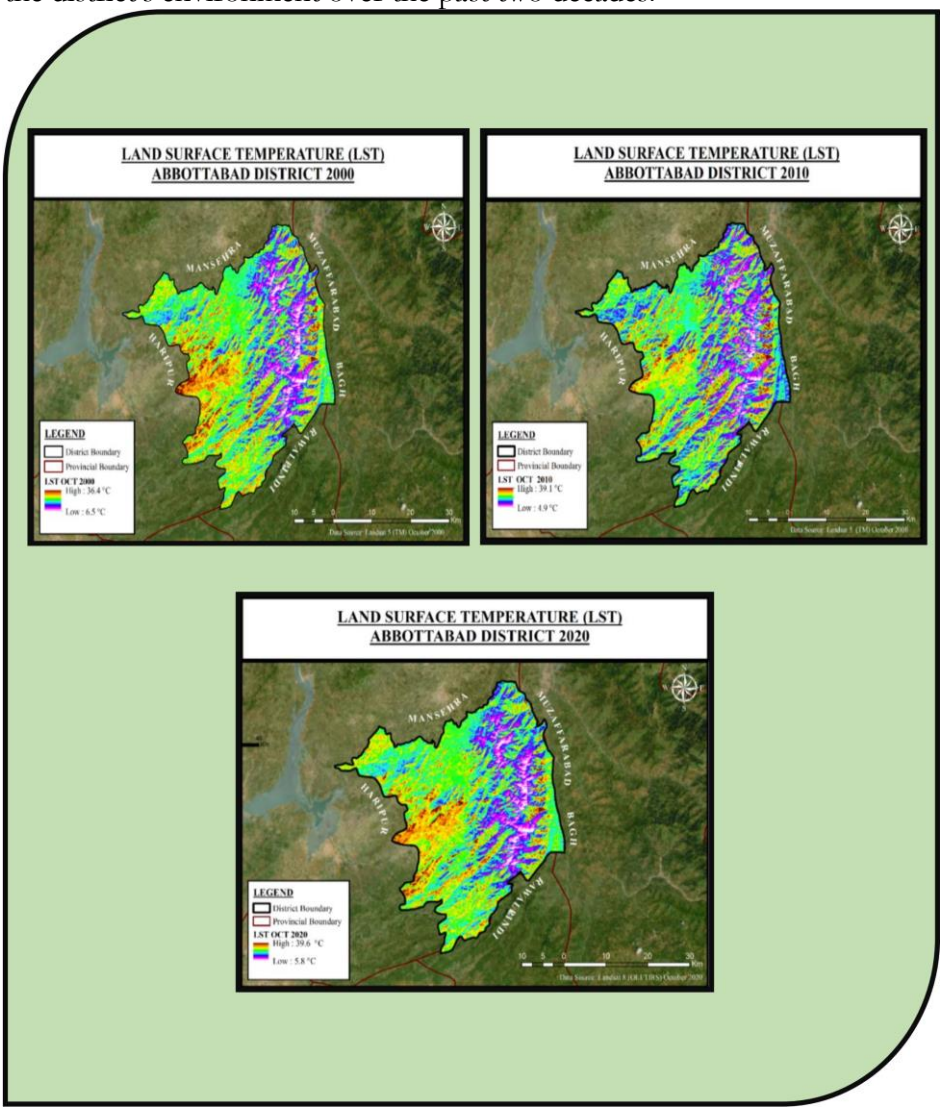

Figure 8: LST of Abbottabad district 2000-2020

As climate change continues to impact cities globally, South Asian cities, including Abbottabad, are experiencing significant environmental changes. In particular, Abbottabad's climate is undergoing notable transformations. Land Surface Temperature (LST) reflects the temperature of an area's surface, which cannot be easily observed directly. Instead, it is assessed through remote sensing techniques. For this study, Landsat 5 (TM) and Landsat 8 (TIRS/OLI) images were collected for October, covering the years 2000 through 2020. Figure 8 displays the

LST maps for these years, highlighting the observable changes. Table 3 provides the minimum, maximum, and average LST values for the study period.

Table 2: Mean NDVI 2000-2020, Abbottabad District

Normalized Difference Vegetation Index (NDVI)	
Year	Mean NDVI
2000	0.31
2010	0.22
2020	0.21

(Data Source: Landsat 5 (TM), Landsat 8 (OLS/TIRS))

Table 3: Minimum, Maximum, and Average LST of Abbottabad District from Oct 2000-2020

Land Surface Temperature (LST) Abbottabad District 2000-2020			
Temperature (°C)	Years		
	2000	2010	2020
Minimum	6.5	4.9	5.8
Maximum	36.4	39.1	39.6
Average	21.6	20.8	21.16

(Data Source: Landsat 5 (TM), Landsat 8 (OLS/TIRS))

In Abbottabad District, the minimum temperature in October has ranged from 6.5°C to 5.8°C between 2000 and 2020, while the maximum temperature has ranged from 36.4°C to 39.6°C. This data reveals a noticeable increase of approximately 3°C in maximum temperatures over the period. This rise is attributed to rapid urbanization and changes in Land Use/Land Cover (LULC). Increased population density contributes to higher greenhouse gas emissions from vehicles and expanded residential areas, which often involve clearing vegetation and altering natural landscapes. These factors collectively contribute to the observed rise in temperature.

Abbottabad District Pollution and Waste Disposal:

Pollution and waste disposal represent significant environmental challenges in Abbottabad District. The primary waste generated includes residential, hospital, and commercial waste. Improper disposal of this waste—either dumped on the ground or into water bodies—leads to water pollution and creates unpleasant odors. This waste management issue also exacerbates health problems such as malaria, typhoid, skin allergies, and asthma, imposing a financial burden on residents. Additionally, emissions from vehicles, including harmful gases such as SO_2, NO_2, CO_2, and CO, contribute to air pollution (Bhandwal & Tyagi, 2022) [12].

Figure 9: Garbage Heaps at Roadside
(Source: Author)

Solid Waste Management:

Improper solid waste disposal is a significant issue in Abbottabad District. Waste is often dumped indiscriminately on the ground or in water bodies, leading to unsightly garbage heaps along roadsides, as shown in Figure 9. This mismanagement not only diminishes the city's aesthetic appeal but also detracts from the tourism experience, as increased tourist activities further contribute to pollution.

Frequent Landslides and Flooding:

The reduction in vegetation cover has exacerbated climate change effects and heightened the risk of natural disasters such as flooding and landslides. Vegetation plays a crucial role in stabilizing soil and preventing erosion. The decline in vegetation, evident from NDVI calculations, has left the soil more susceptible to erosion and landslides. The removal of plants and vegetation compromises soil stability, especially on steep mountain slopes, where intensive farming further aggravates soil erosion.

Frequent rainfall exacerbates this issue by saturating the unconsolidated soil, which then fails to hold together, leading to landslides. Weak soil bonding and the impact of gravity cause the uppermost layers to slip off the slopes. Additionally, urban flooding has become increasingly common during the rainy season. The decreased vegetation cover allows soil to wash away more easily, and the expansion of built-up areas obstructs natural water flow. Roads often become inundated with water due to inadequate drainage. Blocked water channels (nalay) further exacerbate the problem, forcing water into low-lying areas such as Bilal Town and near the Ayub Medical Complex. Figures 10 illustrates the impacts of urban flooding and landslides in the district.

Figure 10: (Left) Urban Flooding. (Right) Landslide, Abbottabad District (Source: Right https://tribune.com.pk/story/1894461/rains-landslide-abbottabad-leaves-3-dead(Source: Left https://tribune.com.pk/story/2376011/heavy-downpour-lashes-abbottabad)

Loss of Biodiversity:

The growing population in Abbottabad District exerts significant pressure on natural resources and adversely impacts local biodiversity. Increased demand for food and residential land has led to extensive clearance of vegetation for agriculture and development, resulting in habitat loss for many species. The expansion of settlements near forested areas and increased human activity in these regions force wildlife to abandon their natural habitats.

The ongoing reduction in vegetation cover, coupled with rising human interference and urban expansion, threatens the survival of various species. This trend is evident from field observations: only 19.6% of respondents reported having seen a common leopard in the past twenty years, while 80.4% have never encountered one, as depicted in Figure 11. This data suggests that such species are increasingly retreating to higher altitudes and more remote areas due to habitat disruption and increased human presence.

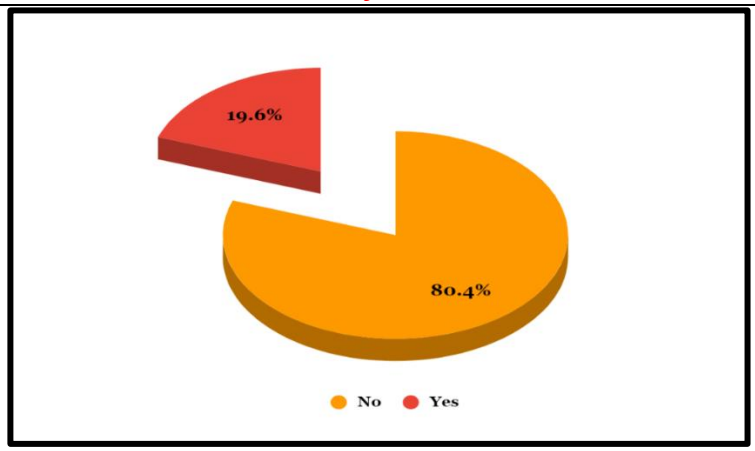

Figure 11: Responses of respondents regarding the sighting of common leopards
(Source: Field Visit)

Abbottabad District Topographical Changes:

The district boasts breathtaking landscapes, including lush green fields, towering mountains, fast-flowing streams, and cascading waterfalls. However, these scenic vistas have been significantly marred by the blasting and cutting of mountains for mining and construction activities. The extraction of minerals such as gypsum, marble, limestone, magnesite, dolomite, barite, and red oxide has led to substantial topographical changes. Figures 12, 13, and 14 illustrate the dramatic transformations in mountain landscapes before and after mining operations.

Figure 12: Mining near Ilyasi Mosque for Minerals.
(Data Source: Google Earth)

Figure 13: Mountain cutting in Bheldheri for construction
(Data Source: Google Earth)

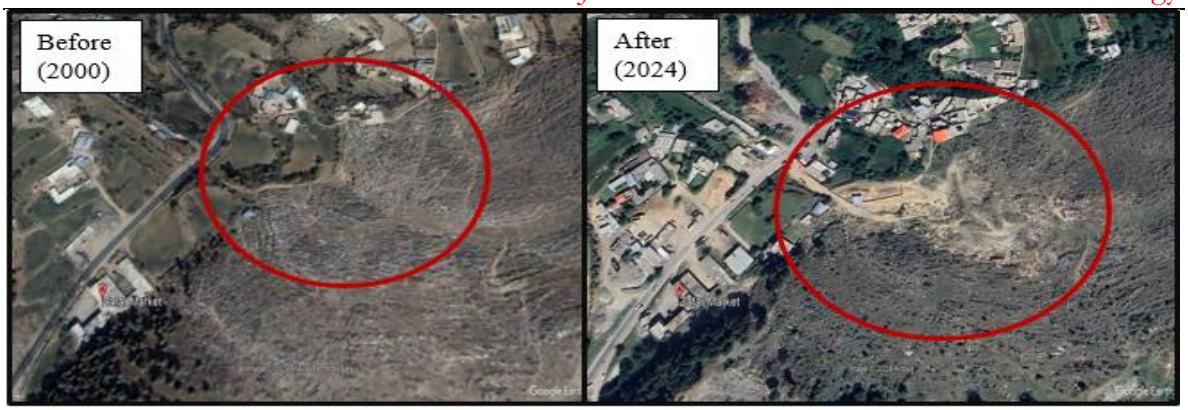

Figure 14: Mountain cutting in Zafar Market for construction
(Data Source: Google Earth)

Abbottabad Over the Years-Urban Growth:

It is almost certain that the world's population will become primarily urban rather than rural (Pham, et al., 2011) [13]. The urban growth of Karachi city has been calculating using RS and GIS techniques (Afsar, et al., 2013) [14]. Similarly, Figure 15 indicates the urban Growth of the Abbottabad district over the years. Landsat imagery from Google Earth has been used for the digitization of the urban growth. The Study is based on earliest available satellite images on Google Earth that was of 1985 till 2023.The rapid growth of city has been observe after 2000.The major reasons for the urban expansion are given below;

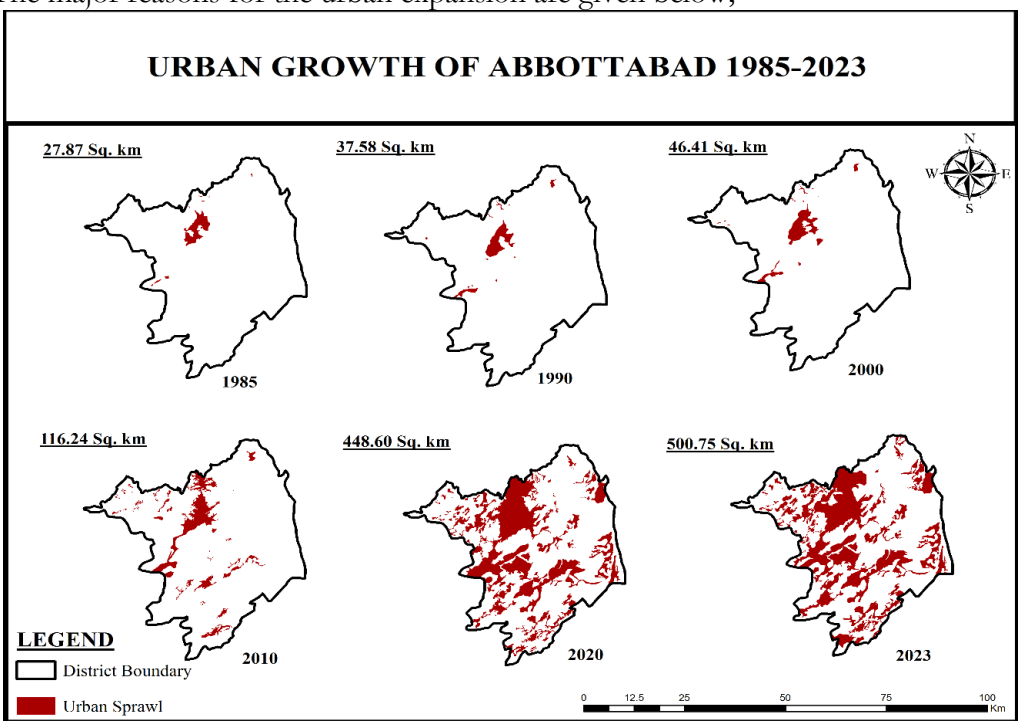

Figure 15: Abbottabad Urban Growth (1985-2023)

The district's stunning beauty, with its lush green fields, towering mountains, and flowing streams, has long attracted residents and visitors alike. The aftermath of the 2005 Great Pakistan Earthquake also contributed significantly to the population surge, as many displaced individuals settled in Abbottabad. The district's reputation for high-quality educational institutions, such as Hazara University, Abbottabad Campus, Frontier Medical College, UET Abbottabad Campus, Ayub Medical College, and International Public School, draws people seeking superior education. Additionally, the city provides ample job opportunities, further

encouraging people from surrounding areas to relocate. This increasing population drives a higher demand for housing, which in turn fuels urban expansion.

Distribution of parameters of Urban Expansion Risk Model of Abbottabad District:

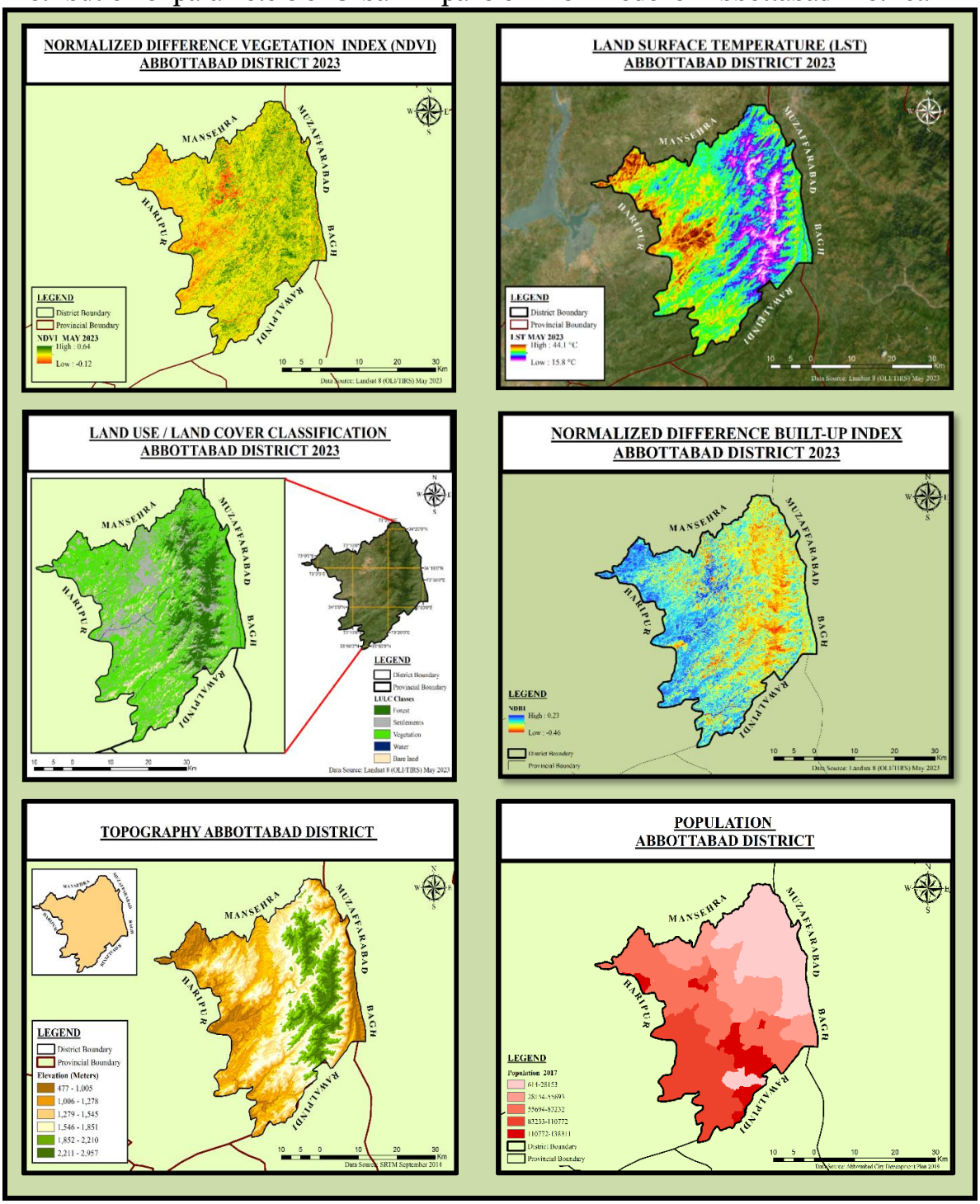

Figure 16: LULC, NDVI, LST, NDBI Maps of the year 2023, Population (2017) Elevation (2014), Abbottabad District

Abbottabad Urban Expansion Risk Model:

The Urban Expansion Risk Model was prepared through the method of weighted overlay. The parameters that were considered for weighted overlay were population, NDVI, NDBI, LST LULC, and Elevation as shown in Table 4. The weightage has been given to the parameters according to the influence of these parameters as shown in Table 5.

Table 4: Parameters of Urban Expansion Risk Model

Parameters for Urban Expansion Risk Model											
LULC Classes	Rank	Population	Rank	NDVI	Rank	LST	Rank	Elevation	Rank	Built Up	Rank
Forest	1	614-28153	1	0.48-0.63	1	15.84-21.47	1	2460-2956	1	(0.46) - (0.32)	1
Vegetation	2	28154-55693	2	0.33-0.48	2	21.45-27.11	2	1964-2460	2	(0.32) - (0.19)	2
Water	3	55694-83232	3	0.18-0.33	3	27.11-32.74	3	1468-1964	3	(0.19) - (0.05)	3
Bare Land	4	83233-110772	4	0.03-0.18	4	32.74-38.38	4	973-1468	4	(0.05) - 0.08	4
Settlements	5	110773-138311	5	-0.11- 0.03	5	38.38-44.01	5	477-973	5	0.08 - 0.23	5

Table 5: Percentage of Influence of Parameters for Urban Expansion Risk Model

S no.	Parameters	Influence
1	NDVI	20%
2	LULC	15%
3	Population	20%
4	Elevation	20%
5	LST	10%
6	NDBI	15%

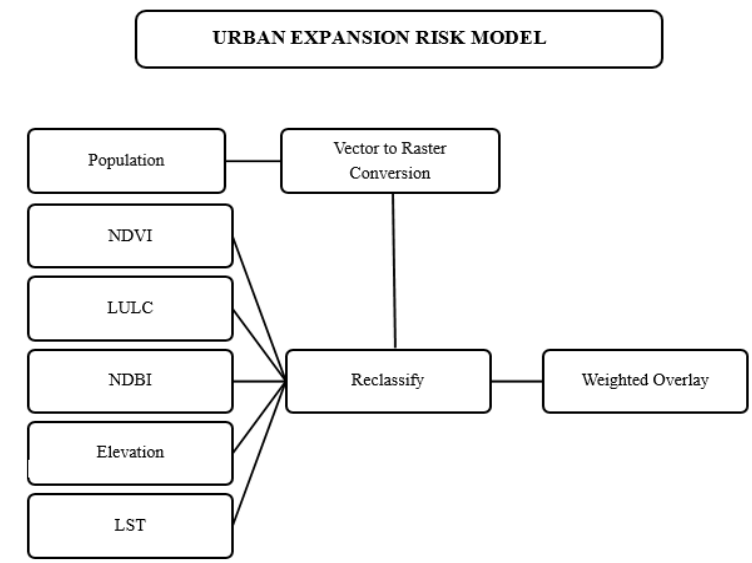

Figure 17: Flow Diagram of Urban Expansion Risk Model

Figure 18 illustrates the Urban Expansion Risk Model for Abbottabad District. High-risk areas, indicated in red, are characterized by dense populations, elevated temperatures, and diminished vegetation cover. Conversely, low-risk zones, marked in green, are predominantly forested areas where the temperature remains cooler due to the presence of trees. Moderate-risk areas, represented by a different color, include regions with sparse settlements and barren land.

Discussion:

Urbanization is a global phenomenon impacting developing countries such as Pakistan. Spatial and temporal studies reveal significant urban expansion in cities like Lahore, where the built-up area has grown by approximately 532 km² over the past 50 years (Abbas et al., 2018) [15]. Abbottabad District is experiencing similar urban growth, which has led to notable changes in Land Use/Land Cover (LULC). Between 2000 and 2009, land use dynamics shifted notably due to rising settlement numbers and population pressure. The influx of residents

from earthquake-affected areas in 2005 further accelerated this change (Un Nisa et al., 2018) [16].

Our study indicates a 19.1% increase in built-up land from 2000 to 2020. The decrease in vegetation cover, as evidenced by the NDVI values, is attributed to both population growth and climate change. Figure 19 demonstrates a significant population surge, particularly after the 2005 earthquake, which drove migration to Abbottabad. Additionally, the city's appeal—bolstered by job opportunities, prestigious educational institutions, and the Pakistan Military Academy—has attracted individuals from other regions, further increasing the district's population. This growing population necessitates the clearing of more vegetation for agricultural and residential development.

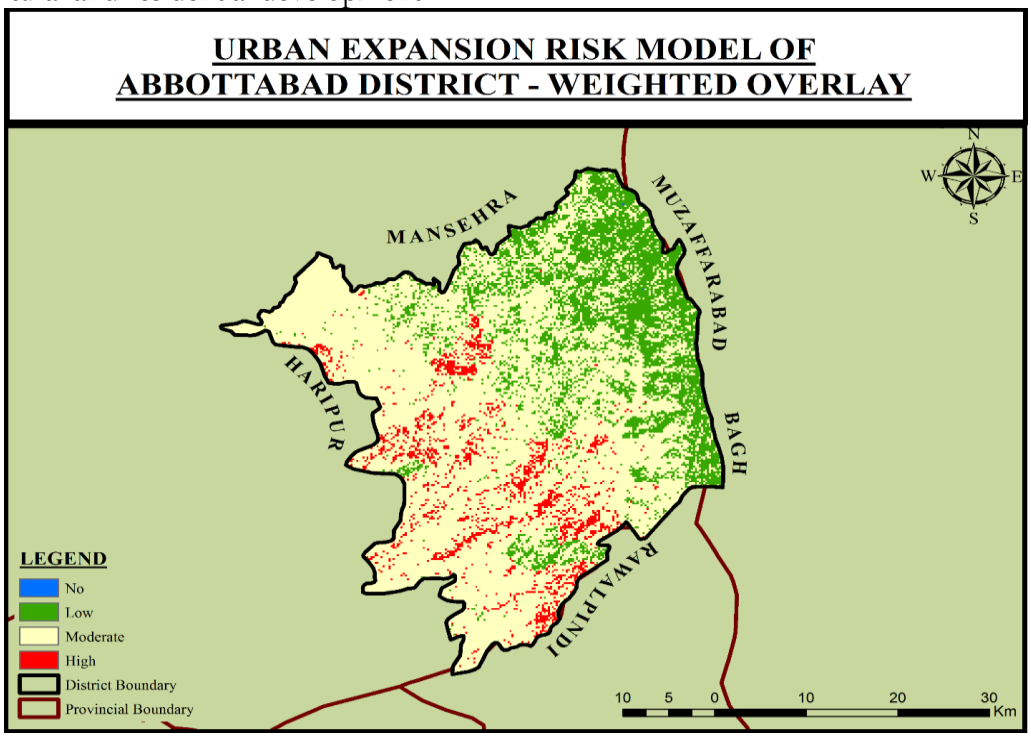

Figure 18: Urban Expansion Risk Model, Abbottabad District

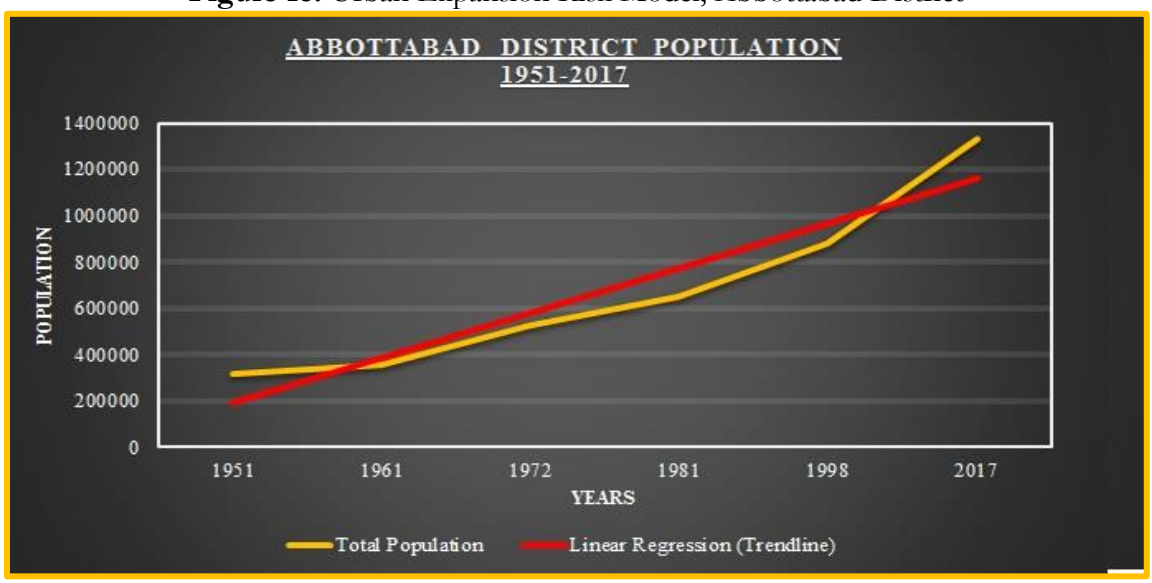

Figure 19: Graphical representation of Population of Abbottabad District 1951-2017

The study reveals significant changes in Abbottabad District's land use and land cover (LULC) over the past two decades. Notably, forest cover increased due to various government-

led plantation drives. However, bare land saw a substantial rise from 2000 to 2010, before decreasing by 2020 as more land was developed for built-up areas and agricultural purposes to accommodate the growing population. The clearing of trees for firewood, medicine, and furniture has further disturbed local habitats and reduced carbon absorption.

Our study found a 3°C increase in Land Surface Temperature (LST). Another study reported extreme weather conditions in Abbottabad due to unplanned urban growth, with LST rising from 17°C to 23°C during winter and occasionally reaching 31°C (Waseem et al., 2021) [17].

The urban expansion and associated LULC changes have led to increased flooding and landslides. Additionally, many endangered species have lost their habitats due to deforestation and human activities. Pollution, exacerbated by both locals and tourists, has also risen. The transformation of small hills and mountains into residential and commercial areas has altered the district's topography. For instance, the mountains behind Ilyasi Mosque were blasted for mineral extraction, and the land cleared for residential plots, significantly changing the landscape.

From 1985 to 2023, the urban area in the district expanded dramatically from 27.87 km² to 500.75 km², indicating rapid growth. The Urban Expansion Risk Model highlights that low-elevation areas have been more affected by this growth, experiencing higher temperatures and reduced vegetation cover compared to higher elevations, which remain less developed and maintain more vegetation.

Conclusion:

Abbottabad District is undergoing rapid transformation, with both positive and negative impacts. Using remote sensing (RS) and Geographic Information System (GIS) techniques, this study documented LULC changes from 2000 to 2020, revealing a 19.1% increase in built-up land. This expansion is attributed to natural population growth, migration following the 2005 earthquake, and improved employment and educational opportunities. The study's findings will aid future urban planners in addressing these challenges. The results indicate a decrease in vegetation cover, which has contributed to climatic changes, biodiversity loss, deteriorating air quality, and increased flooding and landslides. The observed 3°C rise in LST underscores the effects of reduced vegetation and rising pollution. Addressing these issues will be crucial for sustainable development in the district.

Recommendations and Suggestions:

Here are the initiatives that should be taken in order to maintain the radiance of the district.

- The government should take action to have a keen eye on the future growth of the city. They should cater that the urban sprawl should not affect the natural beauty of the city.
- The master plan should be made for the sustainable development of the city. Such strategies have to be designed to handle the increasing population and its demands.
- Strict actions should be taken against the people who are doing illegal cutting of trees and they should be fined heavily.
- Government should take steps for the conservation of National parks and endangered species.
- The mass transit system of the city needs to be improved. New bus services should be introduced for the locals and the tourists.
- Underground parking and vertical parking can help to reduce the traffic congestion on roads
- Promote the usage of cloth bags rather than paper bags and these bags can be presented to the tourist as souvenirs, which will not only eradicate pollution, but this kind gesture will attract more tourists which will be beneficial for the economic condition of the district

- Sewage channels (Nalas) should be cleaned regularly for the easy flow of water in the rainy season.
- More plantation drives should be carried on the slopes of mountain that will help in reducing landslides.
- Pollution is big problem that the district is experiencing. A proper waste management system should be there and the waste should be treated in order to avoid any manmade hazard. The role of AMC should be revised.

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