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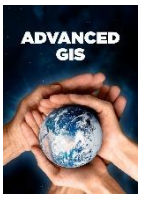

Spatial assessment of forest cover change in Azad Kashmir, Pakistan

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ABSTRACT

In this study spatial assessment of forest cover in Azad Kashmir was carried out. The study is based on secondary data. Satellite imageries of the past 20 years having temporal extent of five years were utilized for assessment of changes in vegetation covers. Supervised image classification and Normalized Difference Vegetation Index (NDVI) techniques were used to achieve objective of the study. The results indicated that forest cover is declining leading to different environmental problems. Increase in population acted as booster for the factors such as deforestation, conversion of forest land into agriculture and built-up land. These anthropogenic activities put pressure on the forest of the study region. After 2005 disastrous earthquake, rapid development of built-up environment was the leading factor behind clearing of forest. It was found from the analysis that forest cover has significantly declined in the last two decades and affected ecosystem services. Location specific management strategies are highly recommended to reduce the rapid decline in forest cover. Strategy must also consider the population growth and traditional forest conservation strategies. Alongside, keeping in view the agricultural activities and infrastructural development in the dense forest cover areas are also recommended.

1. Introduction

Globally, forest cover has been undergoing extensive and unprecedented changes as a result of various anthropogenic activities (Maus et al., 2020; Mishra et al., 2022). Forests offer numerous ecological, economic and societal benefits like conservation of biological and genetic diversity, contributions to nutrient cycling, soil erosion risk reduction, air filtration, climate regulation, and provision of food, fiber, and fuel (Mohamed, 2021a, b). However, deforestation: centuries back human activity leading to depletion of forests and significant environmental, social and economic consequences. It is estimated that from 1990 to 2020, global forest cover decreased by 3.2%. This significant loss of forest cover, estimated at alarming rate of 10 million hectares per annum. Therefore, international conventions have been developed to monitor forests cover on spatial and temporal scales and appraise sustainable forest management strategies (Mohamed et al., 2020). Gou et al. (2022) also suggested that these strategies needs to take into account the particularities of regional socio-ecological contexts at multiple spatial and temporal scales to identify when, where, how and why deforestation is taking place. Forests and forest cover is very significant for the sustainable environment and for survival of life on earth. Increase in population is leading to increase in demands of food and land for living units. Similarly, construction of roads and infrastructure is also responsible for declining of forest cover (Ahmad et al., 2022).

In Pakistan forest cover decreases very rapidly because of anthropogenic activities. Pakistan is losing forest cover at very alarming rate due to rapid population growth, urban expansion and agriculture development. According to UN only 2.2 % of total area of Pakistan is covered with forest and according to state institutes 4.8 % means 4.2 million hectares of land is covered with forests and it is very low area which remains under forest cover (Ullah et al., 2016). The forest size of Pakistan is shrinking continuously. The forest cover in Khyber Pakhtunkhwa is 17.3 % of total forest area of the country. Sindh province has second largest forest area in the country with 923,000 hectares and Punjab province has third largest forest area with 687,000 hectares (Hamilton & Casey, 2016). Due to lack of facilities, most of the people particularly in mountainous areas are highly dependent on the forest and forest products. The universal standard of forest cover is 25% of the total area but Pakistan only has 4 % which is very little (Akbar, 2017. Decreasing forest cover is accelerating glacier-melting leading to floods (Sebald et al., 2019). Forest cover is very significant natural resource which should be protected and conserve properly. There are several techniques that are used to study and analyses forest cover changes around the globe.

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In Azad Kashmir, deforestation is rapid and about 46% of land area is covered with forest. In the past two decades about 400 hectares of forest cover has been lost. The decrease in forest cover may reduce amount of precipitation and change the spatial pattern of rainfall. This may lead to desertification and water shortage (Amjad & Arshad, 2014). Forest act as shield and protect us from different hazards like hinder soil erosion and land sliding (Ahmad et al., 2012).

Therefore, aim of this study is to spatially assess forest cover change and geo-visualize forest cover at various temporal scales in Azad Kashmir. As this is preliminary research of whole area of Azad Kashmir. So, it will be beneficial to identify problems and find solution to the problem. This study will help in making policies about countering the issue of deforestation and decrease in forest cover. And, will be effective by spreading awareness to the people through this research about the significance of forest cover and motivate them for plantation drives and protection of forests.

Geographically, Azad Kashmir shares borders with Gilgit Baltistan on the north, in south and west it shares its borders with Punjab and Khyber Pakhtunkhwa provinces and on eastern side Azad Kashmir is separated from the Indian illegally occupied Kashmir by line of control (Figure 1). The border between Azad Kashmir and occupied Kashmir is known as Line of Control (LOC). Azad Kashmir's total area is 13,297 Kilometers square. The Total population of Azad Kashmir according to 2017 census is 4.045 million and has population density of 300 per km square. The Capital of the state is Muzzafrabad. The temperature in Azad Kashmir varies from south to north. In south due to lower elevation temperature is hot in summer but in central and north mild. Winter is dominated by snowfall in months of December and January. The region gets rainfall in both summer and winter season. The main rivers are Jhelum, Neelum and Poonch. The mountains are covered with forests. Most of the area is covered with thick forests.

2. Study Area

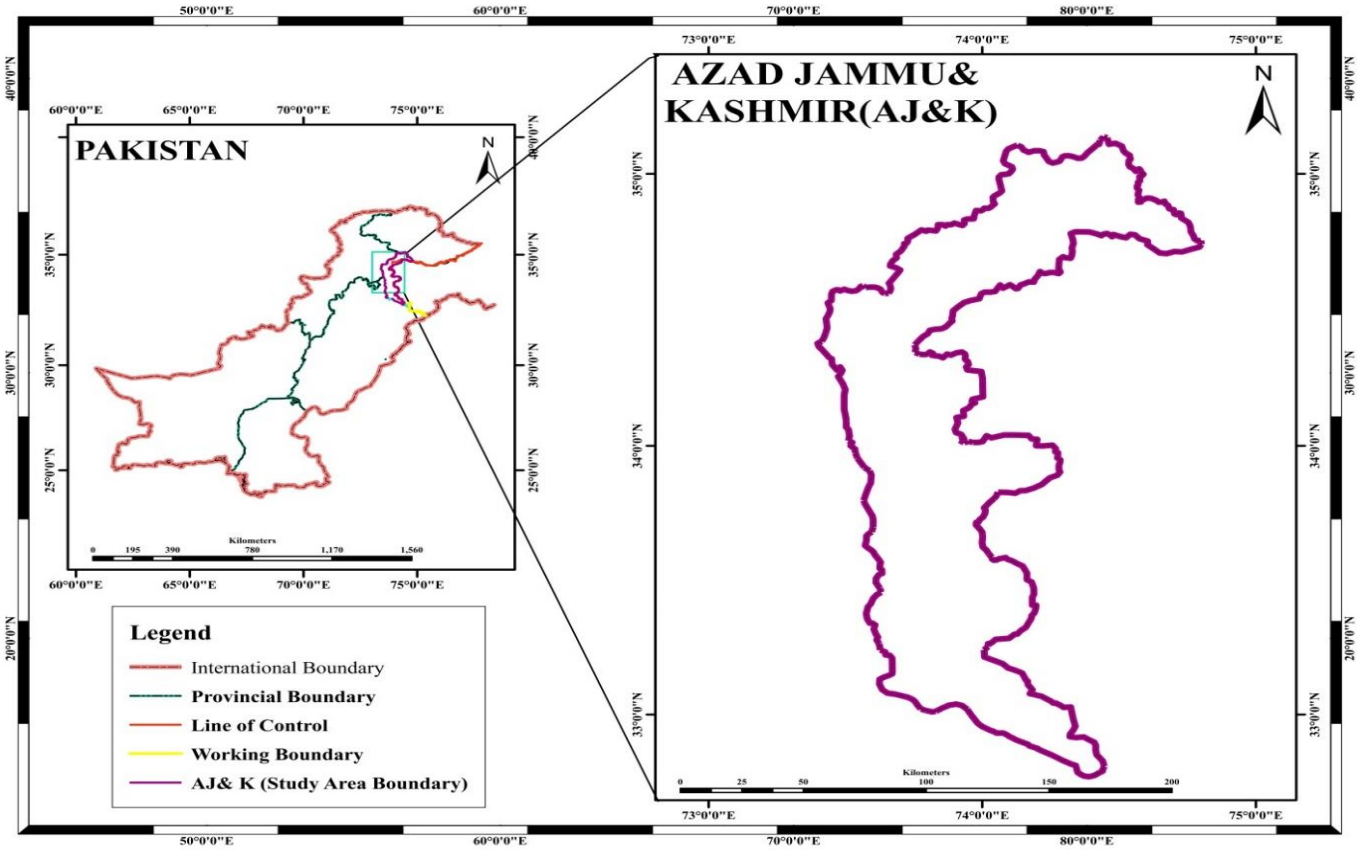

Figure 1. Study area map

3. Research Methodology

The detail and stepwise methodology of the study is given in the following section (Figure 2).

3.1. Data collection

MODIS satellite images for the year 2000, 2005, 2010, 2015 and 2020 were downloaded from United States Geological Survey (USGS) open source geo-database. Survey of Pakistan map was used as base map.

3.2. Data processing and analysis

Pakistan's political map was digitized in GIS environment and study area boundary was extracted by using extract by mask operation. Satellite images with different bands were stacked into one raster file by using ArcGIS 10.5 software.

3.3. Image classification

Supervised classification is used is transform image into different land cover classes including Built-up land, water body, barren land, forest cover and snow cover. The images were classified by using spectral signature obtained from training sample.

3.4. Normalized difference vegetation index (NDVI)

Normalized Difference Vegetation Index (NDVI) is commonly and mostly used for the analysis of vegetation cover. The NDVI is obtained by using Equality.1.

$$NDVI = (NIR - RED)/(NIR + RED) \quad (1)$$

In ArcGIS 10.5, bands of NIR and RED were added. Then, Raster Calculator was used and the query $(Band2 - Band1)/(Band2 + Band1)$ were applied. The NDVI was applied and as resultant classified image with maximum and minimum value is obtained.

3.5. Accuracy assessment

The classified images were vectorized and then converted into Keyhole Mark-up Language (KML). The KML layer was open in Google Earth Pro to check accuracy of different land cover classes. All classes were correct.

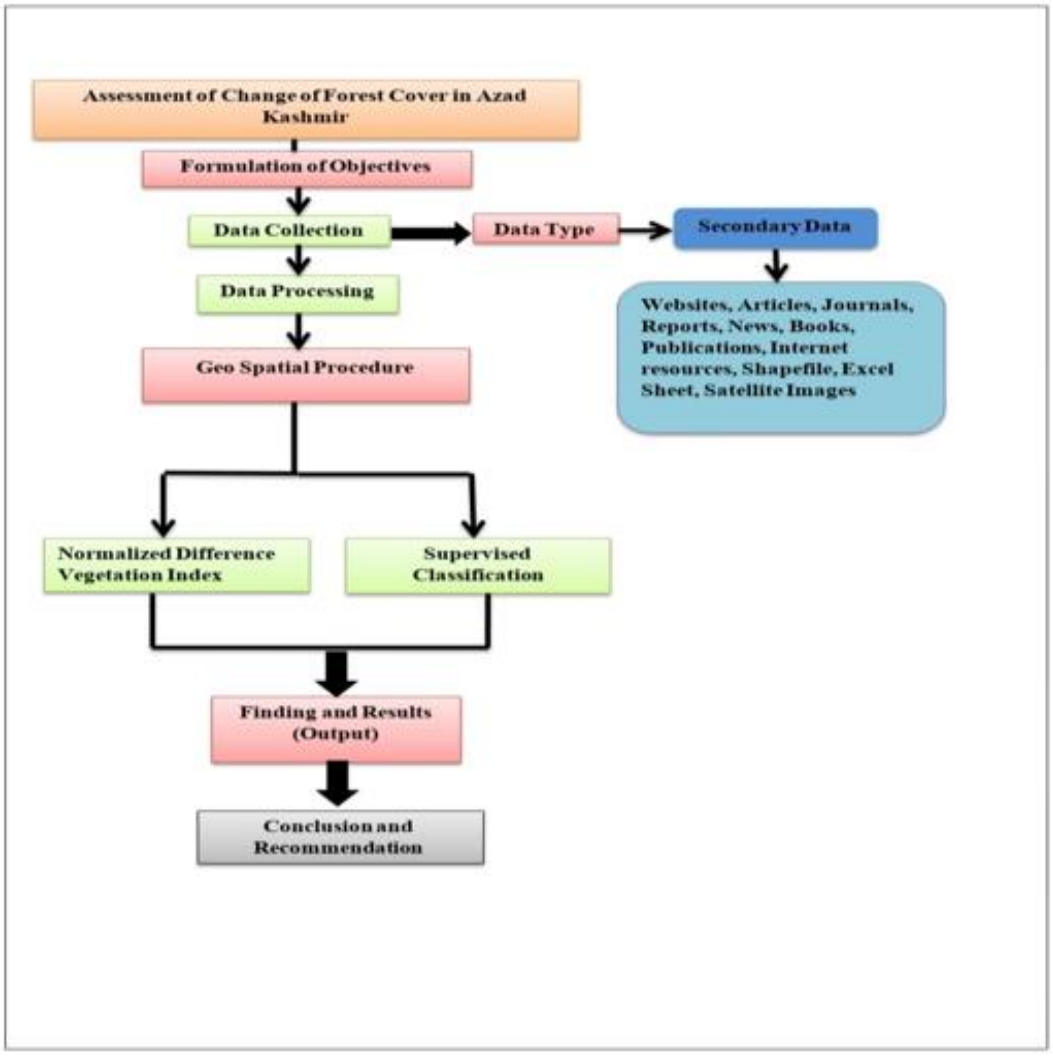

Figure 2. Research methodology

4. Results and Discussion

The Normalized difference vegetation index (NDVI) and Supervised Classification were used to calculate changes in forest cover across the Azad Kashmir from 2000 to 2020. Supervised classification is used to investigate the changes in land cover classes. Which include built up areas, water bodies, forest cover and some other. By using NDVI, the change is calculated and analyzed about vegetation cover across Azad Kashmir.

4.1. NDVI and forest cover trend in AJK

Figure 3 is the normalized difference vegetation index maps of 20 years of Azad Kashmir from 2000 to 2020. In these maps, NDVI is applied on satellite image of Azad Kashmir. In these maps high and low intensity of vegetation cover is represented and from 2000 to 2020. Map of year 2000 represents that the highest value or the green or dark green area represent that most reflection of vegetation and these green areas shows that more forests and in green colored areas there is more forest

cover and the lesser value which shows less reflectance of vegetation are in yellow or dark red and these areas show less vegetation or no vegetation at all. The image of year 2005 of Azad Kashmir shows that the highest value of vegetation decreases, and it is less than the value of year 2000 and this indicates that vegetation cover decreases. Therefore, this means that forest cover decreases in five years from 2000 to 2005. In year 2010, that high value decreases and which is clear that vegetation decreases. This is post-earthquake time and new wave of construction for rehabilitation of people. Therefore, this development is main cause of decrease of forest cover in area. So, this shows that forest cover also decreases in these five years as well from 2005 to 2010. The satellite image of year 2015 of Azad Kashmir represents that the high value get after the NDVI is less than previous image so that represents vegetation cover is tend to decrease. This means that forest cover area of region is decreasing in 5 years from 2010 to 2015. And, we can observe that in year 2020 image clearly represents the decrease in high value of vegetation. This means that vegetation cover decreases during the time of five years from 2015 to 2020. This is the clear indicator that forest cover in the region is decreasing by passing of time. This is due to the increase in population and anthropogenic activities. In 2020 image there is a clear decrease in vegetation cover from image of 2000.

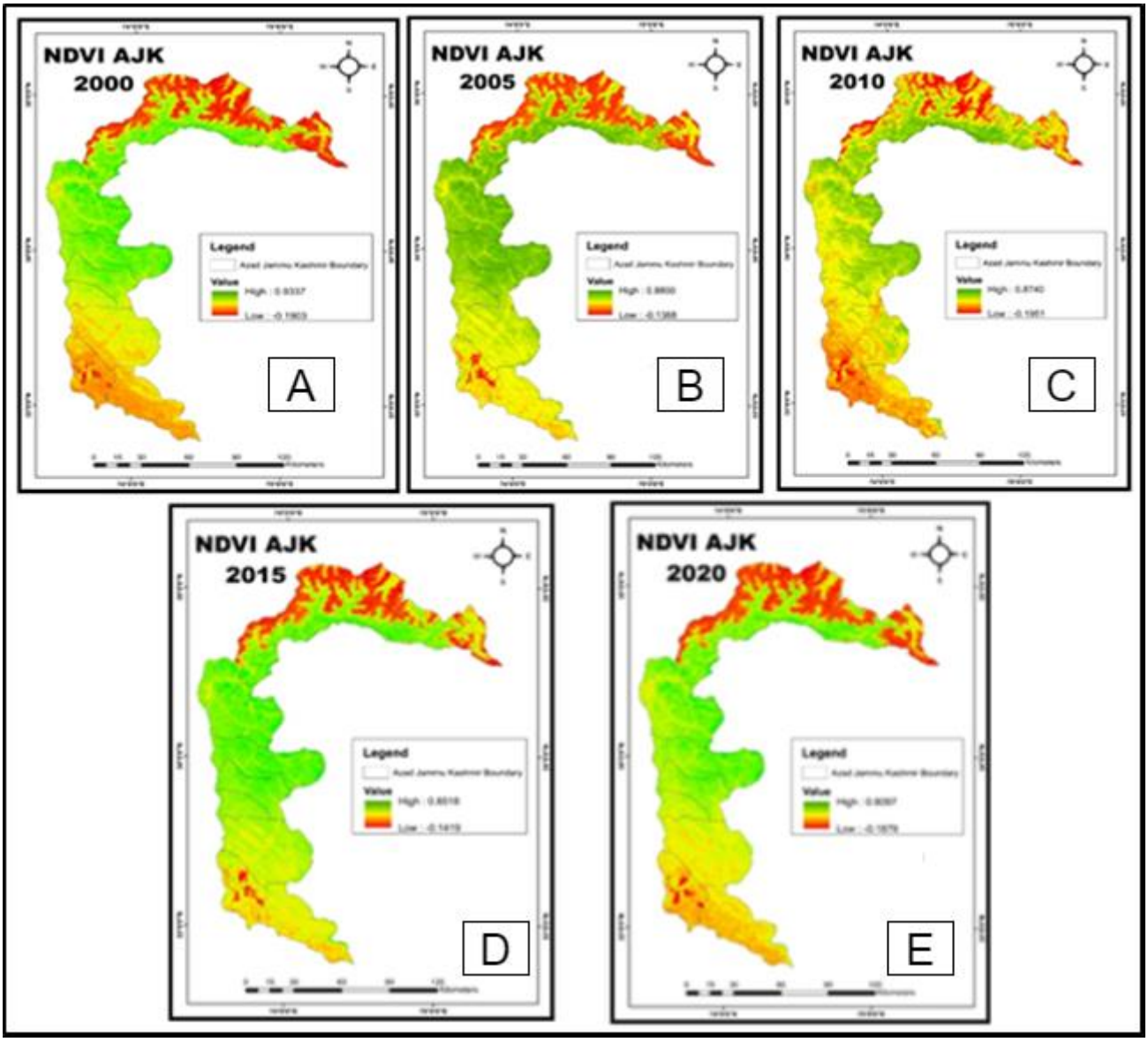

Figure 3. Trend of vegetation cover over these 20 years from 2000 to 2020.

The figure 4 represents the trend of vegetation cover over these 20 years from 2000 to 2020. In this, it is represented that vegetation cover decreases gradually with passing of time. As it is clearly represented that in 2000 the forest area is high and after 5 years, in 2005 it decreases and again after 5 years more forest cover decreases until 2020 where forest cover is lower ever.

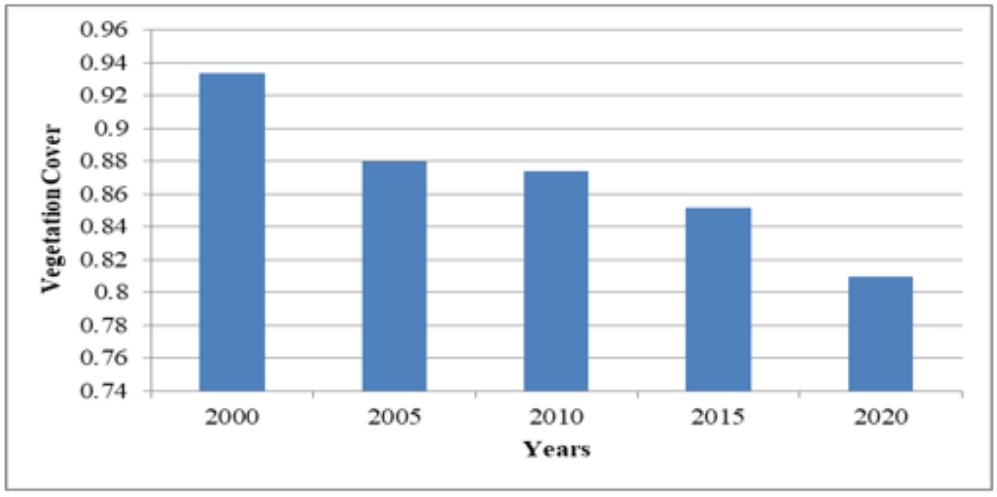

Figure 4. Graph of NDVI and forest cover trend land cover variation in AJK from year 2000 to year 2020

The figure 5 represents the supervised classification maps of 20 years of Azad Kashmir. Through supervised classification land cover classes are separately identified and analyse the increase or decrease in certain class.

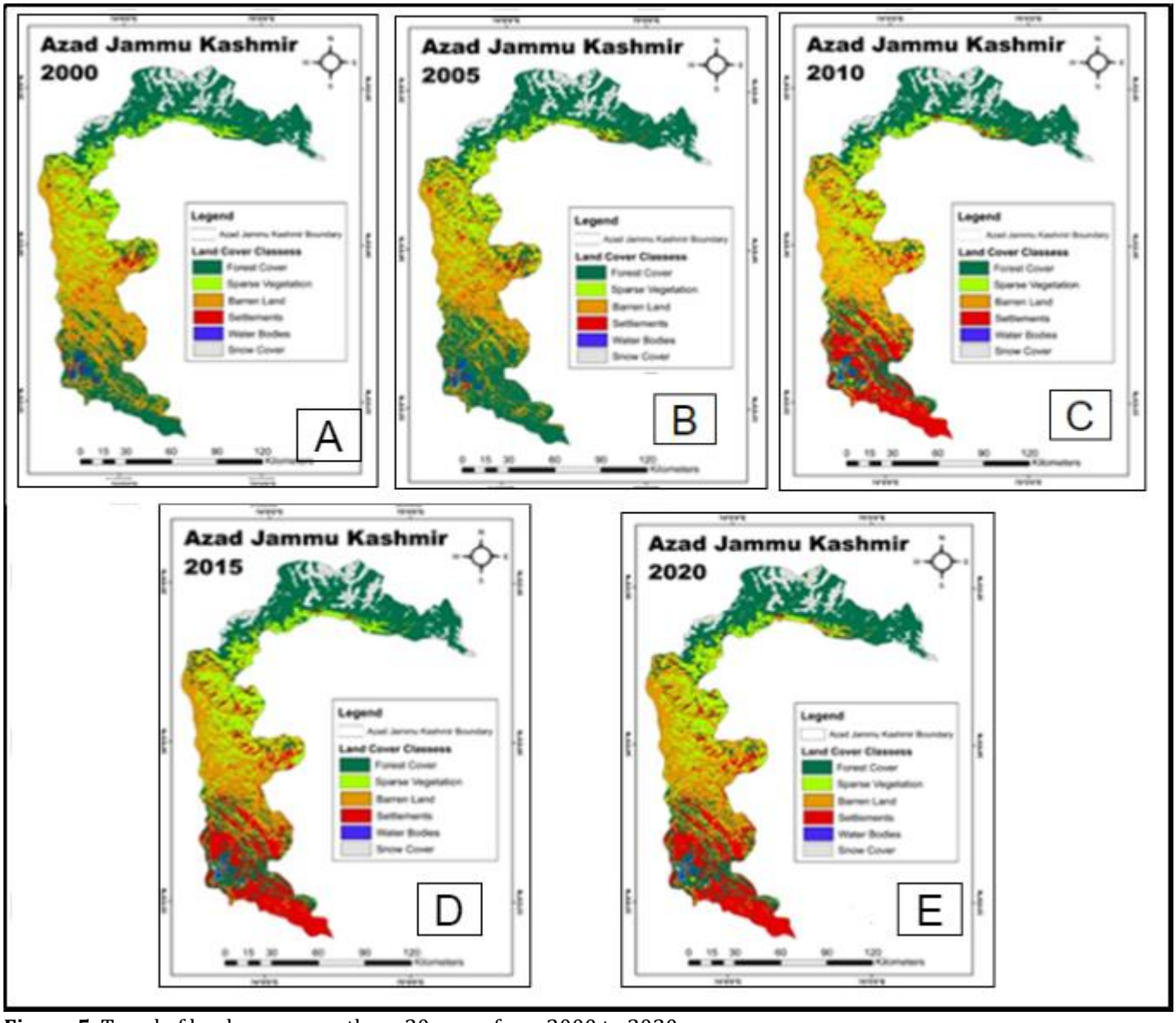

Figure 5. Trend of land cover over these 20 years from 2000 to 2020

Land classes are settlements, forest cover barren land, sparse vegetation, water bodies and snow cover. The forest cover gradually decreases, and settlements are main reason of it and population is core factor behind this decrease in forest cover. The image of year 2000 represents the different land cover classes, you clearly

see most of the area is covered with forest, and after that, there is a huge area that is barren and sparse vegetation. Only Mangla dam is visible water body and due to less population, there are no such huge settlements. In northern parts, mountains are covered with snow. Year 2005 map clearly shows that forest cover area decreases. There is small increase in barren land and small decrease in sparse vegetation but there is a change in settlements due to increase in population. There is no such change in snow cover and no such increase in water body. The image of 2010 displays a clear and huge difference in land cover classes from previous years images. This is the image after earthquake and in this image, there is a certain decrease in forest cover and there is a very large increase in settlements due to post earthquake development and population increase. There is no such change in barren land, sparse vegetation and snow cover and sudden increase in water body. The map of 2015 shows that the huge increase is in settlements and only in southern part because these areas are closer to the mainstream Punjab areas and due to these more developed areas and increase in their population. Forest cover is decreasing, and, in this time, sparse vegetation increases, and barren land decreases. The 2020 satellite image of Azad Kashmir shows the increase in density of settlements due to increase in population of the area. The forest cover of the region is decreasing and as compared to 2015, the barren land increases in these 5 years and sparse vegetation decrease. Due to issue of global warming and climate change snow cover slightly decreases and no such changes in water body. In this whole time period only, settlements increase mean built-up area in region increases largely.

Figure 6 graph represents the percentage of forest cover in Azad Kashmir over 20 years. In this graph it is represented that how forest cover decrease with passing of the time. In year 2000 the percentage of forest cover is higher than ever, it continuously decreases, and from 2005 to 2010 the forest cover changes drastically due to post Earthquake and in year 2020 the percentage is lower than all past years (Table 1).

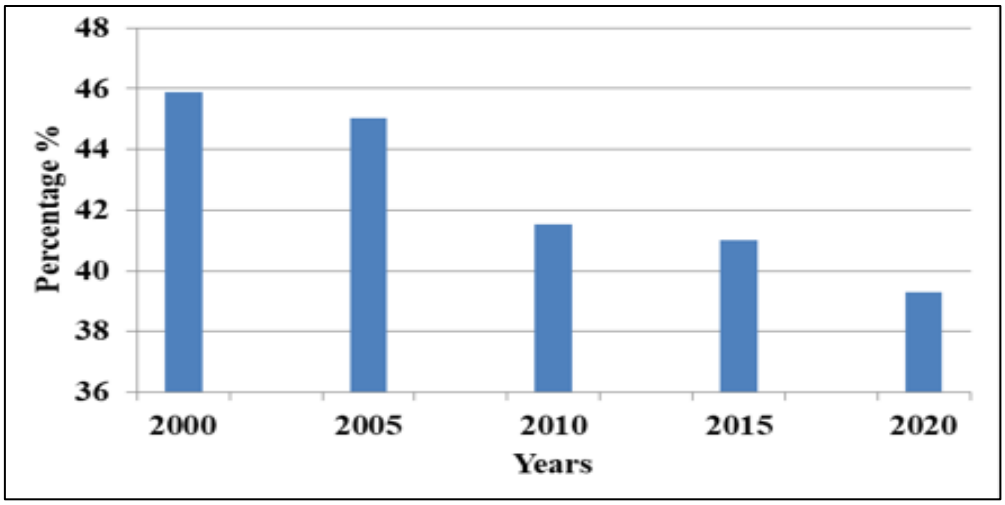

Figure 6: Forest cover variation from 2000 to 2020

Table 1. Total Areas and Area Percentage of Land Cover Classes

Classes	Year 2000		Year 2005		Year 2010		Year 2015		Year 2020	
	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)
Forest Cover	6102.54	45.89	5990.25	45.04	5521.90	41.52	5450.46	40.99	5226.36	39.30
Sparse Vegetation	2960.35	22.26	2900.72	21.81	2851.90	21.44	2725.50	20.49	2690.91	20.23
Settlements	193.60	1.45	482.80	3.63	991.70	7.45	1095.40	8.23	1390.42	10.45
Barren Land	1980.00	14.89	1888.21	14.20	1880.70	14.14	1960.74	14.74	1870.81	14.06
Water Bodies	328.10	2.46	327.70	2.45	329.80	2.48	326.69	2.45	326.90	2.45
Snow Cover	1732.41	13.02	1700.82	12.79	1721.00	12.94	1737.92	13.34	1791.60	13.47

4.2. Causes for the variations in land cover

This study has indicated the on-going trend of forest cover change. This underlines the changes in in the forest cover and other land use classes such as built-up area, snow cover, barren land, water body and some others. This shows that how increase in population is main cause of changes in forest cover in Azad Kashmir but there are many other factors that are responsible for decrease of forest in Azad Kashmir. That includes illegal logging, dependency of people on the forest for livelihood. Almost 400 hectares of forest have lost or destroyed in past 20 years. In 2000, there is approximately 46 % area is under forest cover, in 2005 it decreases to 45 %, in 2010 it decreases to 41 %, in 2015 it decreases to 40 % and in 202o it decreased to 39 %. From 2005 to 2010 major change in forest cover was seen in this 5 year time and there was a huge drastic change in land cover classes of Azad Kashmir because this was post-earthquake time and for the rehabilitation phase there were start of billion dollar investment and that are the reason of huge increase in settlement land. Further passing of time population increases. The current rate of deforestation is also very high than past years. There are some drivers that are causing deforestation in these years. Expansion of settlement area tends to be the major cause of

deforestation. Although increase in population is biggest reason but it has boosted other drivers. Pressure on forests increases due to absence of facilities and people have to fulfil their need of livelihood from forests. Construction and development for local and tourism purpose also responsible for decline in forest cover. Azad Kashmir is also the tourist destination and tourism is the huge contributor to the economy of Azad Kashmir. Due to this, many development projects are being construct and new hotels and resorts are being made by removing forests. Roads are being constructing and these roads gave access to people to the different remote destinations of Azad Kashmir. So these areas are now under the pressure of anthropogenic activities. Forests in Azad Kashmir consist of much type of rare trees and plants, which include medicinal plants and shrubs and other precious wood. Some woods like timber that has very high demand in the market. Due to this reason, illegal logging cutting of timber and other such wood is also factor that cause change in forest cover. Degradation in forest cover area has many side effects and one of biggest and currently facing is climate change. The other issues we face are the change in weather patterns, increase in emission of carbon dioxide and destruction of biodiversity in forests of region. The forest cover kept decreasing with passage of time. There are many factors that are responsible, and many other things got affected but wildlife is most affected by these changes. Because they are inside the forests and some of their species are at brink of extinction.

5. Conclusion

This study helps to understand the trend of change in forest cover of Azad Kashmir that it is decreasing at very fast speed. This is very dangerous for the environment, biodiversity and people of the region. In this research it is find out that increase in population, expanding of settlements and agricultural land, illegal cutting down of trees are causes behind the change in forest cover. Also, people of region are very much dependent on the fuel wood for livelihood is the main driver behind change in forest cover. Despite there is a separate forest department in the region and in presence of rules and regulations about forests the trees are being cut down and forest area decreases. This happened due to negligence and lack of monitoring and check and balance on forest areas. Failure on institutional level is also behind issues like deforestation. As population is increasing the need for the settlement and agricultural land rises and demand of timber and other important woods rises. The decline in forest cover has also affects our environment. Due to this reason the region, face the problems like climate change. That has unpleasant impacts on area. It affects the population and other life and has also affects the vegetation and weather pattern. Forests are main source behind sustainable environment but decrease in forest lead to problems.

The study further concludes that land cover particularly forest cover has significantly changed in the last two decades and affected ecosystem services. Location specific management strategies are highly recommended to reduce the rapid decline in forest cover. Strategy must also consider the population growth and traditional forest conservation strategies. Alongside, keeping in view the agricultural activities and infrastructural development in the dense forest cover areas are also recommended.

Author Contributions

The contributions of the authors of this article is equal.

Statement of Conflicts of Interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

Research and publication ethics were complied with in the study.

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