J. Mt. Sci. (2021) 18(2): 416-426 e-mail: jms@imde.ac.cn http://jms.imde.ac.cn
https://doi.org/10.1007/s11629-020-6093-4

Original Article

Forest cover dynamics in Palas Valley Kohistan, Hindu Kush-Himalayan Mountains, Pakistan

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Citation: Haq N, Rahman F, Tabassum I, et al. (2021) Forest cover dynamics in Palas Valley Kohistan, Hindu Kush-Himalayan Mountains, Pakistan. Journal of Mountain Science 18(2). https://doi.org/10.1007/s11629-020-6093-4

Abstract: Forest cover change in the mountainous region is driven by a variety of anthropogenic and natural factors. The Hindu Kush-Himalayan Mountains has experienced a considerable vegetation cover change due to intensive human activities, such as population growth, proximate causes, accessibility, unstable political situations, government policy failure and poverty. The present study seeks to find out the impact of population growth and road network expansion on forest cover of Palas valley based on remotely sensed data and employing geo-spatial techniques. Changes in forest cover were determined by classifying time-series satellite images of Landsat and Sentinel 2A. The images of October 1980, 2000, 2010 and 2017 were classified into six land cover classes and then the impact of population growth and accessibility on forest cover was analyzed. Furthermore, forest cover and land-use change detection map was prepared using classified images of 1980 and 2017. The data were collected mainly from field visits (ground verification), census reports, Communication and Works Department, Kohistan. Satellite imageries were obtained from the United States Geological Survey's websites and classified in ERDAS imagine 2014 and ESRI ArcGIS 10.2.1 using supervised classification-maximum likelihood algorithm. Result of this study revealed that a substantial reduction in forest cover has taken place mainly in the proximity of human settlements. On the average, during the study period, annually more than 460 hectares of forest area has been converted into other uses.

Keywords: Forest cover changes; Population growth; Road networks; Deforestation; Palas Valley; Pakistan

Received: 24-Mar-2020
Revised: 21-Jul-2020
Accepted: 08-Dec-2020

1 Introduction

Generally, a number of socio-economic and biophysical processes are responsible for forest cover changes and usually deforestation and forest degradation cannot be attributed to a single factor (Geist & Lambin 2001). Worldwide, researchers have identified several factors including population growth, agricultural extension, forest governance, rural poverty and improvement in accessibility (Ali et al. 2006; Qamer et al. 2012; Van Khuc et al. 2018; Zeb 2019; Wester et al. 2019; Munawar & Udelhoven

2020). However, in case of Asia, with other factors, demographic development and expansion in road network has played a major role in forest cover change (Geist & Lumbin 2001, p 27).

Since 2010, research studies conducted on deforestation and forest degradation in the Hindu Kush-Himalayas (HKH) region have revealed a number of driving forces such as demographic development (Tsering et al. 2010; Jan et al. 2011; Qamer et al. 2012; Shehzad et al. 2014; Ahmad & Nizami 2015; Poudel and Shaw 2015; Ullah et al. 2016) improved accessibility, and agriculture expansion (Qasim et al. 2011; Rahman et al. 2014; Hussain, et al. 2018; Haq 2019; Zeb et al. 2019) and household dynamics (Diniz et al. 2013; Newman et al. 2014; Robinson et al. 2014; Rahman et al. 2014; Ullah et al. 2016; Haq et al. 2018; Munawar & Udelhoven 2020). Hence, forest areas close to human settlements and all-weather roads suffered substantially (Schickhoff 1995; Sharma et al. 2016; Murthy et al. 2016; Das, Behera, & Murthy 2017; Bhatta et al. 2019; and Munawar & Udelhoven 2020).

The general scenario of forest cover in Pakistan is highly debatable and contested because official statements both on afforestation and deforestation are not consistent and scientific explanation of these figures is quite difficult (Bukhari et al. 2012). However, in most of the research studies large-scale deforestation has been attributed to governance and management practices. Researchers are of the view that forest policies have been formulated without considering the basic needs of local people depending on forest resources for fuelwood, timber, fodder and non-timber forest products (NTFPs) (Shahbaz et al. 2007; FAO 2020). This top-down approach and alienation of the local inhabitants became a major cause of forest degradation (Geiser 2006). In 1990s forest department got fund from international donor agencies to restructure and revise management practices in vogue. In this period social forestry, joint forest management and other terminology became very common in the policy documents (Khattak 1998). Nevertheless, no visible change occurred in reality and the centuries age-old practices initiated by the colonial authorities are still in vogue (Qamer et al. 2016). Moreover, forest ownership and property right issues have also emerged in many localities mainly in the HKH mountains and also led to conflict situation and accelerated the on-going deforestation process (cf. Azhar 1993 p 120; Hasan 2001, p 18 and FAO 2020).

Despite considerable improvement in the provision of alternative energy sources and access to cash income in most parts of the HKH region, many remote localities are still heavily dependent on locally available vegetation resources for cooking and heating. According to FAO (2020) the total demand for wood and wood-based products in the country [Pakistan] is estimated at 40.93 million m^3; of which 6.06 million m^3 is demand for timber and of 34.87 million m^3 for fuelwood. Moreover, majority of mountain dwellers still depend on these resources for animal fodder and about 70 percent of required livestock feed is supplied from forests. Currently, 27.302 million tons of dry forage matter is annually available for the livestock, which can be increased considerably under proper management (FAO 2020, p 17). Additionally, many households living close to the forest are dependent on NTFPs for cash income generation.

More than 60% of the economically valuable forest resources of Pakistan are located in the HKH region. There is substantial diversity with respect to forest in terms of ownership, utilization, management and dependence of the local inhabitants on these resources. The ownership varies between two extremes such as state to communal, though Hazara division including Kohistan district have Guzara forest as well (Azhar 1993; Shahbaz et al. 2006). Similarly, the control of forest department on management issues is not uniform throughout this region. All the forest policies from the colonial period till present have been formulated on prejudices without considering the felt need of the inhabitants. Therefore, there have been practical hindrances in the proper implementation of these policies at both regional and local levels (Ashraf 1992, p 17). On the one hand, forest area in Pakistan has registered a slight increase due to large-scale afforestation and regeneration processes (GoP 2019; Nazir et al. 2019; FAO 2020), on the other hand, many studies conducted both at local and regional levels have also revealed considerable deforestation (cf. Rahman et al. 2014; Qamer et al. 2016; Haq et al. 2018; Zeb 2019; Zeb et al. 2019). In this regard, to evaluate the situation of forest cover change and measure the pace of deforestation, a remote locality in the western Himalaya – Palas valley – has been selected. The major objective of this study is to determine forest cover changes from 1980 to 2017. During this period the opening of the Karakorum Highway has worked as a main catalyst of change in the study area. The study area was connected with the lowland market through the construction of link roads. Moreover, business activities and other off-farm cash income sources became available to the local inhabitants. Meanwhile, forest management strategies were also reviewed from time to time with a complete ban on tree cutting around early 1990s. Moreover, in additions to land use change detection in about four decades, the present study will also assess the impact of population increase and accessibility on forest cover change and the effectiveness of state policy measures in combating deforestation and forest degradation.

2 Data and Methods

2.1 Study area

This study was conducted in Kohistan district of Khyber Pakhtunkhwa (KP) Province located in HKH Mountains of Pakistan. It covers 7,492 km^2 and stretches between 34°54′ to 35°52′ North latitudes and 72°43′ to 73°57′ East longitudes. Kohistan has its common borders with Diamer district of Gilgit Baltistan region in the north and north-east, Mansehra district is located in the south-east, Battagram district in the south and Shangla and Swat districts are situated in the west. Topography and climatic conditions have a considerable impact on natural vegetation in the study area. The hills and low altitude mountain ranges are covered with thick forests of cedar, Juniper, Pine, Fir, Olea Erruinea, Chilghoza, Oak, Walnut and Birch trees and the low-lying areas have scrub and thorny bushes, rest of the area, up to 3,000 m altitude have dense deodar and pine forest. A small number of Pine trees, and occasional groves of Birch are found above 3000 m altitude and above 4000 m up to snowline the mountain slopes are seasonally covered with thick short grass, moss, and innumerable flowers. The natural forests of the study area have been officially declared as Reserved and Guzara forests.

The most common tree species of the study area are *Juniperus communis* (juniper), *Pinus wallichiana* (blue pine), *Abies webbiana* (silver fir), *Aesculus indica* (bankhor), *Pinus species*, *Cedrus deodara* (deodar), *Abies pindrow* (palunder), *Pinus gerardiana* (chalghoza), and *Juglans regia* (walnut) etc. (Saqib & Sultan 2005). In the absence of alternate energy sources, the inhabitants of the study area heavily depend on natural forest for cooking and heating purposes. For that purposes large quantity of firewood are extracted from the nearby forest on daily basis. According to Clemens, (2001 p 111) the consumption of fuel wood considerably varies based on household size and seasons. On average every household utilizes 16.3 kg of fuelwood per day in summer and 32.6 kg in winter for cooking two to three meals and heating. Thus, based on the above figures the average annual consumption of fuel wood has been calculated to 9503 kg. In addition to fuelwood, similar to other localities in the HKH region (cf. Haserodt 1989; Nüsser & Dickorè 2002) the branches of Oak are also used as fodder for feeding goats during the long winter season in the study area.

The total geographical area of Palas valley is about 139,700 ha and elevation ranges from 700 m to 5200 m above mean sea level (Fig. 1). Administratively, it is a tehsil of district Kohistan. Climatically, the study area experiences dry sub-tropical and temperate type of climate with sharp local variation occurs with altitude and aspect. The metrological station located at Pattan with an altitude of 739 m above mean sea level, the summer mean maximum temperature of June-July is 38°C and mean minimum 22°C, while the winter mean maximum temperature remains above 0°C but does not exceeds 15°C. However, the mean minimum temperature falls up to 6°C in January in the lower parts while it remains below freezing point for more than five months at 3,000 m or above. This valley is located in the rain shadow and hence very little effect of Monsoon rainfall reaches here and most of the precipitation occurs during winter season in the form of snow and it lies on the surface for more than three to five months (Barth 1956; Dichter 1967). The average precipitation of 10 years from 2005-2015 recorded at Pattan Meteorological station was 10 mm in the valley bottom, however, it is scientifically an established fact (cf. Hewitt 1989; Owen & Derbyshire 1989; Miehe et al. 2001) that the higher elevation in the study area usually receive more precipitation that might be between 130-150 mm.

The population of district Kohistan almost doubled in 36 years from 465,237 persons in 1981 to 784,711 in 2017 with an average annual growth rate of 1.9% per annum. Similarly, population density also increased to 104 persons/km^2 (GoP 1983, 2000, 2017). In 1981 the average household size of the district was

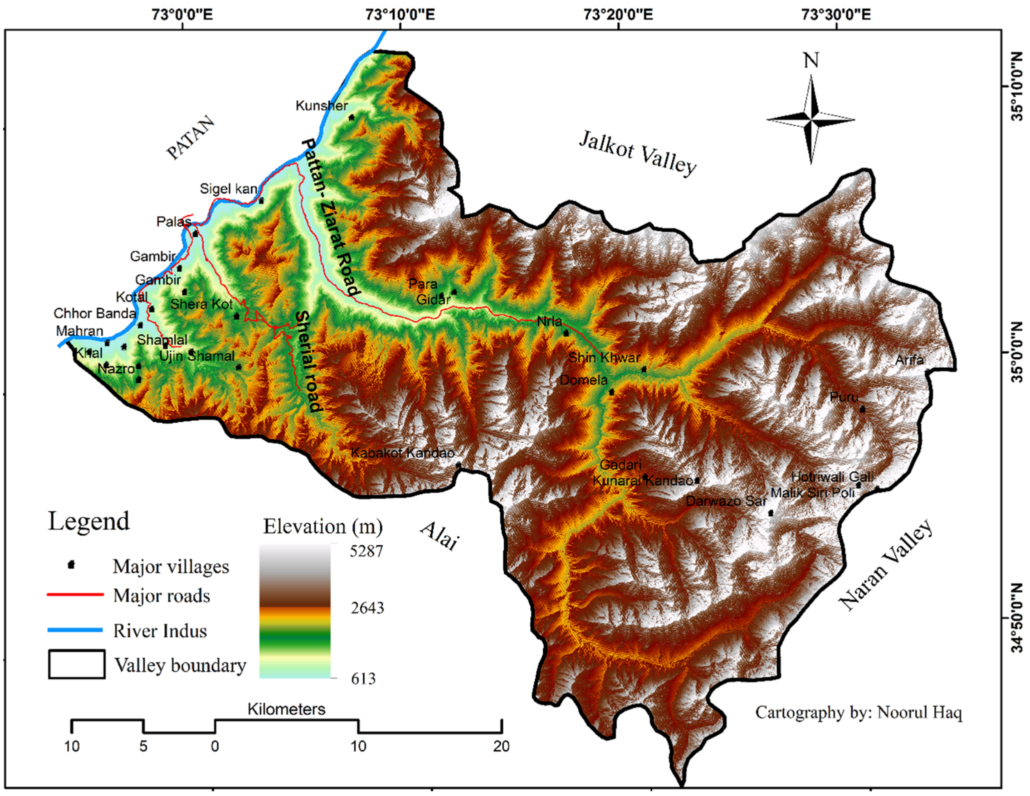

Fig. 1 Physiography and location of Palas valley. (Source: Digital Elevation Model extracted from USGS and prepared in ArcGIS10.2.1)

Table 1 Specification of Satellite data sets (1980-2017)

Satellite	Acquisition Date	Spectral Resolution
Landsat 3 MSS	26 October, 1980	Bands 1,2,3,4
Landsat 7 ETM+	04 October, 2000	Bands 1,2,3,4,5,6,7,8
Landsat 7 ETM+	16 October, 2010	Bands 1,2,3,4,5,6,7,8
Sentinel 2A	03 October, 2017	Bands 1,2,3,4,5,6,7,8,9,10

9 persons which decreased to 6.5 persons in 1998 and again increased to 7.5 persons in 2017. According to official sources, length of the roads increased almost four time from only 54 km in 1972 to 203.26 km in 1998 (GoP 2000). Consequently, most of the villages have been connected with motorized traffic. Similarly, in Palas valley where presently 35% of the district population resides, the road networks also doubled from 64 km in 1980 to 117 km in 2017. Apparently, this improvement in accessibility has a number of positive repercussions on the overall society and economy of the study area. However, it has an adverse impact on forest resources as evidenced in other localities of the HKH region (cf. Schickhoff 1995; Schmidt 2000; Ali & Benjaminsen 2004).

2.2 Methodology

In this study we used remotely sensed data and GIS techniques to determine the impacts of population growth and road networks expansion on forest cover. The data sources include satellite images of 26 October 1980, 10 October 2000, 16 October 2010 and 03 October 2017, which were processed in ArcGIS and ERDAS Imagine software (Table 1). The time-based duration of the study is almost 4 decades from 1980 to 2017. Based on the availability of relevant data three study periods were created, i.e., period 1 from 1980-2000; period 2 from 2000-2010 and period 3 from 2010-2017. The impact of population growth and road networks on forest cover was analyzed by Geospatial techniques like Euclidean distance and Buffer analysis in Arc GIS. Changes in forest cover have been calculated within 1 & 3-km of the selected settlements and roads. Euclidean distances were subsequently overlaid on forest cover maps and changes in forest cover within 1 & 3-km from settlement and roads were determined for 1980 and 2017.

2.2.1 Image processing and analyses

The satellite imageries were processed through ArcGIS and ERDAS Imagine 2014 software. The spectral bands for each image were stacked together and the study area was extracted from the mosaic scenes with the help of extract by mask tool in Arc Map. Visibility of the images was enhanced by stretching their histograms using standard deviation stretch (Qamer et al. 2012; Hussain et al. 2018). False-color composite of Infra-Red was used for classification processes and based on the standard land use/cover categories of published sources (Qasim et al. 2011; Bukhari et al. 2012; Shehzad et al. 2014; Hussain et al. 2018) and classes were created (Table 2). The computer was trained for creating a signature file for each land use/cover class. More than a hundred training samples were taken for each class and signatures files were developed in ERDAS Imagine as well as in Arc GIS. Similar to the standardized work of other researchers such as Rogan et al. (2002; Gong et al. 2003; Keuchel et al. 2003; Gautam et al. 2004; Rozenstein & Karnieli 2011; Brinkmann et al. 2014; and Hussain et al. 2018), maximum likelihood supervised classification algorithm was used for images classification and area for each class was calculated using field calculator. Digital land use/cover classes were prepared and the area was calculated using calculate geometry. Based on classified satellite images, change detection map was prepared from classified images of 1980 and 2017 using reclassification and addition tools in ArcGIS. This map clearly shows that when, where and how many changes have occurred in forest and other land use/cover categories in thirty-seven years. Moreover, it also explicitly reflects the impacts of population growth and road network expansion on forest cover during the study period.

2.2.2 Satellite imageries accuracy assessment

Accuracy assessments of the satellite data sets were created utilizing the Landsat and Sentinel-2 images information of the selected years. A total of 985, 1017, 764 and 619 reference points were distributed in 1980, 2000, 2010 and 2017 images. Moreover, using a stratified random sampling method more than a hundred points were taken for each class in all the data sets. For the creation of ground truth or reference points, shapefile of the point features were created. The sample data of the selected years were converted to Kmz. file format and plotted on Google earth-based Very High-Resolution Satellite (VHRS) images. User and producer accuracy, commission and omission errors were calculated and Kappa coefficient statistics were applied to test the agreement between classified images and actual ground situation. The accuracy of the classified satellite images are 932/985, correctly placed out of the total, (94.6%) in 1980, 971/1017 (95.5%) in 2000, 721/764 (94.4%) in 2010 and 576/619 (93%) in 2017 with Kappa Coefficient values of 0.93, 0.94, 0.93 and 0.91 for the selected years. The user accuracy remained more than 90% in all the classified images. Commission and omission errors are less than 10% in most of the land use land cover classes, except water bodies which are (23.44%) for the year 2000 and (20%) both for 2010, 2017 and agriculture land 17.59% and 14.42% for 2010 and 2017 respectively.

3 Results

Analysis of the satellite data revealed that the overall trend in forest cover decreased consistently during the study period. In the first period (1980-2000) more than 2,300 ha of forest were cleared and forest area decreased by 6.2% with an annual average rate of 115.5 ha (0.31%). From 2000-2010 the annual deforestation rate increased more than eight times to 822 ha. Similarly, in the third period (2010-2017) forest clearance further increased with 934 ha per annum (Table 3). During the study period from 1980-2017 more than 17,000 ha of forest were cleared and as a result 12.22% reduction in forest area has taken place.

In 1980 more than one fourth 36,942 ha (26.5%)

Table 2 Forest and other land use/cover description

Land Cover Classes	Explanation
Forest cover	It contains all types of natural' forests. The deciduous trees, found in agriculture fields, are not included in this class.
Agriculture land	Contains all types of cultivated land
Shrubs/Bushes	It contains wasteland, grazing ground, shrubs and bushes.
Bare soil/rocks	It contains non-vegetated, unusable land and bare soil and rocks.
Snow cover/Glaciers	Contains snow cover and permanent glacier areas
Water bodies	Contains all water bodies i.e., river and streams lakes

of the study area was covered with thick forest which decreased to 19,863.17 ha (14.22%) in 2017 with an annual decrease rate of 0.33%. During the study period a continuous decrease has been registered in forest cover. Nevertheless, agriculture land and shrubs/bushes recorded persistent growth throughout the study period. Similarly, area under bare soil/rocks was also continuously increased except in the last period (2010-2017) as glacier/snow was converted to it. The detail information of forest cover and other land use/cover changes were shown in Table 4.

3.1 Forest cover change within 1 and 3-km of the selected settlements (1980-2017)

In 1980 more than half (50.54%) of the area located within 1-km of the settlements was covered with forest which decreased to 997 ha (39.9%) in 2000. It further reduced to 769 ha (30.63%) in 2017. Hence more than 80% of the area has been cleared from natural vegetation. Similarly, area under shrubs/bushes also increased to 49.97% in 2017. Agriculture land increased from 0.42% in 1980 to 2.61% in 2017 with increasing rate of 2.28% during the study period. The share of bare soil/rocks fluctuated between 23.33% in 1980 to 15.61% in 2017. However, a decrease of 7.75% has been recorded in that category from 1980 to 2017 within 1 km from settlements. Similarly, within 3-km of the settlements, forest cover was 9,511 ha (44.8%) which decreased to 6,004.5 ha (28%) in 2017, with an annual decrease rate of 16.53% during the study period from 1980-2017. Likewise, area under shrubs/bushes also increased substantially from 6,051 ha (28.51%) in the year 1980 to 10,495.9 (49.5%) in 2017. Agriculture land also increased more than four times from 150 ha to 590.46 ha (2.78%) and an increase of almost (2.07%) has been recorded from 1980-2017 (Fig. 2). The results of the analysis indicated that within 3-km of the settlements 3,509 ha (16.6%) of forest area was converted into other uses during the study period. Furthermore, the analysis revealed that change in forest cover is relatively more prominent in the periphery of settlements as the inhabitants can easily extract timber and firewood and livestock can easily browse on the existing grass and trees saplings. Hence, deforestation declines as we move away from the settlement/villages and changes in forest cover is relatively more within 1-km of the existing settlements compared to 3-km. Agricultural land and shrubs/bushes have been increased while other land use/cover classes slightly decreased. This increase in agricultural land and shrubs/bushes can be attributed to growing human population and increasing number of livestock. Apparently, forest area has been cleared for agriculture expansion and house construction to feed and accommodate increasing population.

3.2 Forest cover change within 1 and 3-km of the roads (1980-2017)

The analysis of the satellite images indicated that within 1-km of the existing roads, forest and shrubs/bushes decreased while other land use/cover increased. In 1980 within 1-km of these roads, 4,625.28 ha (36%) was covered by forest which decreased to 4,337.79 ha (33.79%) in 2017, a decrease of 288 ha (2.24%) has been recorded during the study period. Similar to forest, area under shrubs/bushes also shrunk from 3,283 ha (25.9%) to 2678 ha (20.8%)

Table 3 Periodical forest cover change in Palas valley, Pakistan

Forest cover change	Area in Period 1 (1980-2000)		Area in Period 2 (2000-2010)		Area in Period 3 (2010-2017)	
	ha	%	ha	%	ha	%
Overall change	2311.11	6.2	8226.45	2.3	6538.75	2.5
Annual change	115.5	0.31	822.6	0.23	934.0	0.35

Table 4 Forest and other land use/cover change in Palas valley (1980-2017)

Land use/cover	Area in 1980		Area in 2000		Area in 2010		Area in 2017		Change in 1980-2017	
	ha	%	ha	%	ha	%	ha	%	ha	%
Forest cover	36,942.00	26.45	34631.35	24.79	26374.93	18.88	19863.17	14.22	-17078.83	-12.23
Agriculture land	1,323.00	0.95	1752.04	1.25	2552.17	1.83	3139.80	2.25	1816.80	1.30
Shrubs/bushes	35,400.00	25.34	38321.53	27.44	46310.00	33.15	56703.17	40.60	21303.17	15.25
Bare soil/rock	50,614.00	36.24	52950.45	37.91	56901.10	40.74	48671.21	34.85	-1942.79	-1.39
Glaciers/snow	15400.00	11.02	12023.63	8.61	7540.80	5.40	11301.65	8.08	-4098.35	-2.93
Total	139679.00	100.00	139679.00	100.00	139679.00	100.00	139679.00	100.00	-	
Overall accuracy	94.60 %		95.50%		94.40%		93.00%		-	
Kappa coefficient	93.41%		94.39%		93.20%		91.40 %		-	

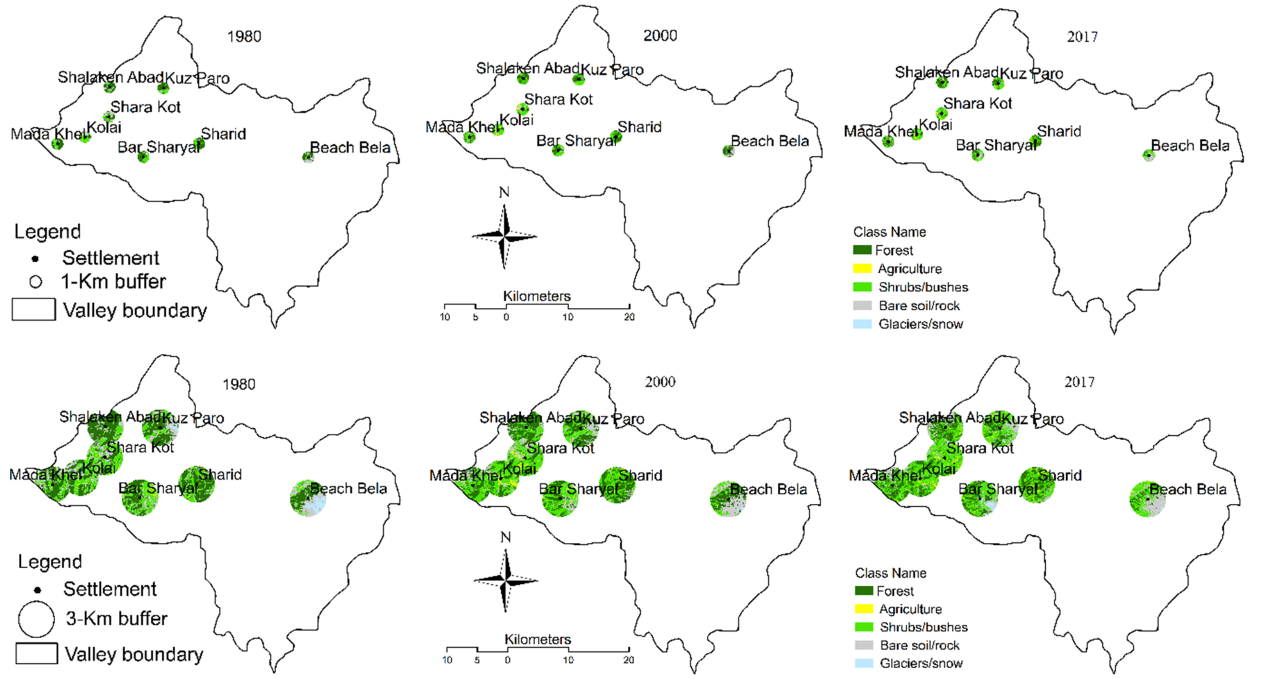

Fig. 2 Forest and other land use/cover within 1 and 3-km of the settlement (1980-2017).

Table 5 Forest and other land use/cover change within 1 and 3-km of the roads (1980-2017)

Land use/ cover classes	1 km						3 km					
	Area in 1980		Area in 2017		Change in 1980-2017		Area in 1980		Area in 2017		Change in 1980-2017	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
Forest cover	4625.28	36.03	4337.79	33.79	-287.49	-2.24	13847.4	41.29	13519.37	40.31	-328.03	-0.98
Agriculture	191.88	1.49	768.92	5.99	577.04	4.50	405	1.21	1515.25	4.52	1110.25	3.31
Shrubs/ bushes	3283	25.58	2678.61	20.87	-604.39	-4.71	10691.64	31.88	10572.83	31.53	-118.81	-0.35
Bare soil/ rock	4736.52	36.90	4356.35	33.94	-380.17	-2.96	8593.56	25.62	7929.57	23.64	-663.99	-1.98

during the same period. However, agriculture land increased more than four times from 1.5% to 6% (Table 5). Likewise, in 1980 within 3-km radius of the existing roads forest cover was 13,847 ha (41%) which reduced to 13,519 ha (40.3%) in 2017. A shrinkage of 328 ha almost (1%) has been detected. The shrubs/bushes also shrunk from 10,691 ha to 10,572 ha from 1980-2017. However, during the same period agriculture land increased more than three times from 405 ha (1.2%) to 1,515 ha (4.5%). In almost four decades 1,110 ha of forest area located within 3-km has been brought under plough. Moreover, forest cover changes are relatively more obvious within 1-km of the roads as the residents can easily extract fuelwood and timber (Fig. 3). Therefore, changes in forest cover declines as we move away from the existing roads.

3.3 Spatial and temporal change in forest cover (1980-2017)

Despite considerable changes in the vicinity of settlements and existing roads, the generalized picture of the whole study area is quite different. Due to remoteness more than half (52.5%) of the study area remained unchanged. The main changes were observed in forest cover (6.8%) and shrub/bushes (12.3%) which were transformed to bare soil/rocks. However, during the same period some of the bare soil/rocks were converted into forest (1.8%) and shrub/bushes (2.1%) as well. Furthermore, during the study period 8% and 0.9% of forest cover was converted into shrub/bushes and agriculture land while 1.5% of shrub/bushes was converted back to forest. These results indicated that major transformation in forest cover is due to the conversion of forest land to shrub/bushes followed by bare soil/rocks. However, during the study period from 1980-2017 continuous shrinking in forest cover took place and it decreased by 12.2%. The details of other minor land use/cover changes were presented in the Table 6 and Fig. 4.

Fig. 3 Huge timber stack and transportation of logs in Palas valley 2017.

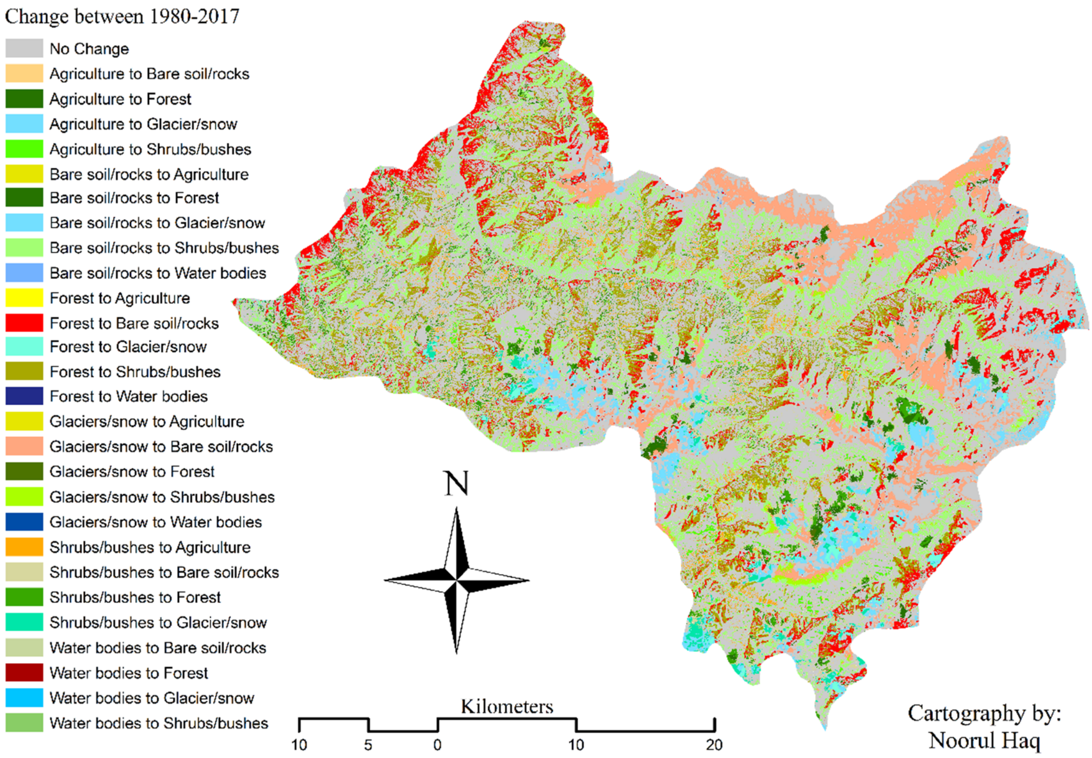

Fig. 4 Forest cover and other land-use/cover change detection of Palas valley (1980-2017).

Table 6 Change detection of forest and other land-use/cover in Palas valley (1980-2017)

Land use/cover change	Area		Land use/cover change	Area	
	ha	%		ha	%
No change	73317.8	52.5	Water bodies to Glaciers/snow	5.7	0.0
Forest to Bare soil	9470.3	6.8	Bare soil to Forest	2521.3	1.8
Shrubs/bushes to Bare soil	17162.8	12.3	Shrubs/bushes to Forest	2055.6	1.5
Glacier/snow to Bare soil	4184.3	3.0	Glacier/snow to Forest	216.9	0.2
Agriculture to Bare soil	45.3	0.0	Agriculture to Forest	1.0	0.0
Water bodies to Bare soil	12.8	0.0	Water bodies to Forest	0.4	0.0
Forest to Shrub/bushes	11128.2	8.0	Forest to Water bodies	3.3	0.0
Bare soil to Shrubs/bushes	2991.4	2.1	Bare soil to Water bodies	49.6	0.0
Glacier/snow to Shrubs/bushes	1222.0	0.9	Shrubs/bushes to Water bodies	0.05	0.0
Agriculture to Shrubs/bushes	2116.9	1.5	Glacier/snow to Water bodies	51.3	0.0
Forest to Glaciers/snow	174.8	0.1	Forest to Agriculture	1258.9	0.9
Bare soil to Glaciers/snow	9717.3	7.0	Bare soil to Agriculture	332.0	0.2
Shrubs/bushes to Glaciers/snow	764.1	0.5	Shrubs/bushes to Agriculture	849.33	0.6
Agriculture to Glaciers/snow	0.2	0.0	Glacier/snow to Agriculture	12.8	0.0
			Total	139666.4	100

4 Discussions

The results of the present study confirm and substantiate other research studies conducted in the northern mountainous belt of Pakistan, that forest cover is persistently shirking with the passage time (cf. Qasim et al. 2011; Qamer et al. 2012, 2016; Rahman et al. 2014; Hussain et al. 2018; Haq et al. 2018; Zeb 2019; Zeb et al. 2019). However, the pace of forest degradation substantially varies from one locality to another depending on availability of forest resources, location, topography and accessibility. This aspect is quite clear from the results of this study that almost half of the forest cover in the study area remained unchanged. This can be attributed to its peripheral location, socio-economic set up and egalitarian society. Moreover, the efforts of the provincial forest department and other non-governmental organization to increase forest cover and improve management practices and minimize deforestation are not explicitly visible from the findings of this study. Similar to other studies conducted in the HKH region (Nüsser 2000; Ali & Benjaminsen 2004; Zeb et al. Rahman et al. 2014; Munawar & Udelhoven 2020), the analyzed data revealed relatively more deforestation and forest degradation in the proximity of human settlements and existing link roads. In this case, most of the forest area has been converted into either shrubs/bushes or agriculture land. Based on ground verification and field work, we have attributed this phenomenon to demographic development and increase in the number of livestock though there are contrary research results both in the Himalaya and Eastern Hindu Kush (Ives & Messerli 1989; Fox 1993; Rahman 2009) where population increase has a positive impact on natural vegetation and other rangeland resources.

Nevertheless, the negative impacts of accessibility and tenure related issues on natural vegetation identified by other researchers (cf. Kreutzmann 1991; Abdullah 2001; Hasan 2001, 2007; Ali & Benjaminsen 2004 and Shahbaz et al. 2006) cannot be refuted based on the results of the present study that these issues are continuously widening the gap between forest managers and local stakeholders. Moreover, the findings of this research also nullify the effectiveness of new innovations and policy shift in forest management practices initiated in the 1990s (Khattak 1998), because most of the studies conducted in the last two decades reflect no tangible improvement in the forest cover and rate of deforestation. Nevertheless, official reports and research conducted on afforestation have also reported a slight increase in forest area (Bukhari et al. 2012; GoP 2019; Nazir et al. 2019).

The physical environmental conditions of the study area its economic backwardness, limited access to higher education and heavy reliance on vegetation resources for fuel, livestock fodder and absence of cash income sources other than forest has further deteriorated the status of forest cover. In this respect, our results further substantiate other studies conducted within the HKH region and elsewhere (Diniz et al. 2013; Newman et al. 2014; Rahman et al. 2014; Ullah et al. 2016). In the backdrop of existing forest policies and similar to other marginalized rural localities (cf. Qasim et al. 2011; Qamer et al. 2012; Shehzad et al. 2014; Ahmad & Nizami 2015; Poudel & Shaw 2015), the forest in the study area has been deteriorated due to lack of trust between the stakeholders and forest officials and resulted in mismanagement of valuable natural resources.

5 Conclusion

Based on the results of this study it is concluded that despite the efforts of the state and non-governmental organizations, forest degradation and deforestation processes are still going on at micro level even in the remote areas. For the last about four decades a continuous decrease has been found in the forest cover. In this regard historical setting and geographical location have its impact on the ownership and utilization of forest resources. Two broad categories such as Guzara and protected forest have been very highly vulnerable to deforestation. During the study period the study area has been linked with the Karakorum Highway through the construction of link roads. This development along with the formation of forest cooperative societies for management and exploitation of forest resources for more than a decade has a profound effect on the vegetation cover of the study area. Consequently, these societies were abolished and a complete ban was imposed on tree cutting in 1993 and ironically deforestation was not controlled. However, with the passage of time population of these localities also increased and it is still increasing, along with other household dynamics that are also constantly changing the land use and land cover. Nevertheless, in the light of this study the on-going deforestation process cannot be attributed solely to population growth and accessibility, but an in-depth appraisal of tenure related issues, forest policies in vogue, role of forest department and timber business is needed to effectively combat deforestation and forest degradation in the fragile mountain environment.

Acknowledgment

This research is part of the research project within the framework of National Research Program for Universities (NRPU), Project No. 20.2396/ NRPU/R&D/HEC 2014/163, generously funded by the Higher Education Commission (HEC) of Pakistan. We are very thankful and obliged to HEC for financial support and the authors gratefully acknowledge the help, cooperation and hospitality of the inhabitants of Palas valley, Kohistan, rendered during the field survey. We would also like to thank the anonymous reviewers for their constructive comments and valuable suggestions.

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