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FOREST COVER CHANGE DETECTION IN PAKTIA PROVINCE OF AFGHANISTAN USING REMOTE SENSING AND GIS: 1998-2018

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ABSTRACT

Monitoring changes in forest cover is important to address issues like biodiversity conservation, sustainable management, and climate change. The study has been conducted in the Paktia province of Afghanistan to assess the changes in different forest classes which occurred together with political changes by using Remote Sensing and Geographic Information System (GIS). The change was analyzed for a period of two decades, i.e., 1998 to 2018. Landsat TM and OLI satellite images of 30m resolution for the years 1998 and 2018 were used respectively. The overall classification accuracy of the mapping was estimated as 82.67% and the kappa coefficient was estimated as 0.8081. The study area was delineated via visual image interpretation technique into 11 LULC classes' viz., closed forest, open forest, forest scrub, grassland other classes (Agriculture, Agroforestry, horticulture, habitation, waterbody, wasteland, and snow). The comparison of maps 1998 and 2018 revealed that the total area under closed forest, open forest, showed an increase of 0.43%, 0.73%, respectively. While the areas under forest scrub, showed a decline of 0.30%, during the study period (1998-2018).

Keywords; *forest cover, LULC, remote sensing, GIS, Paktia*

INTRODUCTION

Land Use and Land Change are two different terms which always been confused and used interchangeably in the literature and daily practices. Land cover is the observed biological (biotic) and physical (abiotic) assemblage of the earth's surface and immediate surface and Land use is the way or manner in which people use or occupy the land (Mayer and Tuner, 1992). Land cover and land cover change information is very important for natural resource management and monitoring global environmental changes and their consequences (Loveland and Belward, 1997). Remote sensing has emerged as an important tool for assessing the forest resource rapidly and remote sensing techniques are best suited to provide data in several key areas related to the forest landscape pattern (Jansen, 2000). With the recent advancement in remote sensing and geographical information system (GIS) and computer technology, it is possible now to assess and monitor land-use/land-cover changes at multiple spatial and temporal scales (Hansan and Defries, 2004).

Change detection is a method of recognizing changes in the state of an object of phenomena by spotting images at different times (Singh, 1986). In Afghanistan and other regions, the following factories have been listed as main causes of land-cover change: (1) long-term natural changes in climate condition (2) geomorphological and ecological processes (3) human-induced alterations of vegetation cover and landscapes (4) interannual climate variability and (5) human-induced greenhouse effect (Lambian and Strollers 1994, Shalizi et al., 2020, Shalizi et al. 2018). The main objective of land-cover change detection is to understand better the relationship and interaction between humans and the environment to manage and use resources in a better way for sustainable development (Lu *et al*., 2004).

METHOD

Study area

Paktia is a southeastern province of Afghanistan with a total area of 5583.2 km^2 which contributes only 0.9% of the total area of Afghanistan. The total population is about 590668, out of those 301873 males and 288795 females. The population density of this province is estimated to be 106 persons per square kilometer (CSO, 2018). The climate of the study area is cold semi-arid Mediterranean with heavy snow in the winter (NEPA, 2014).

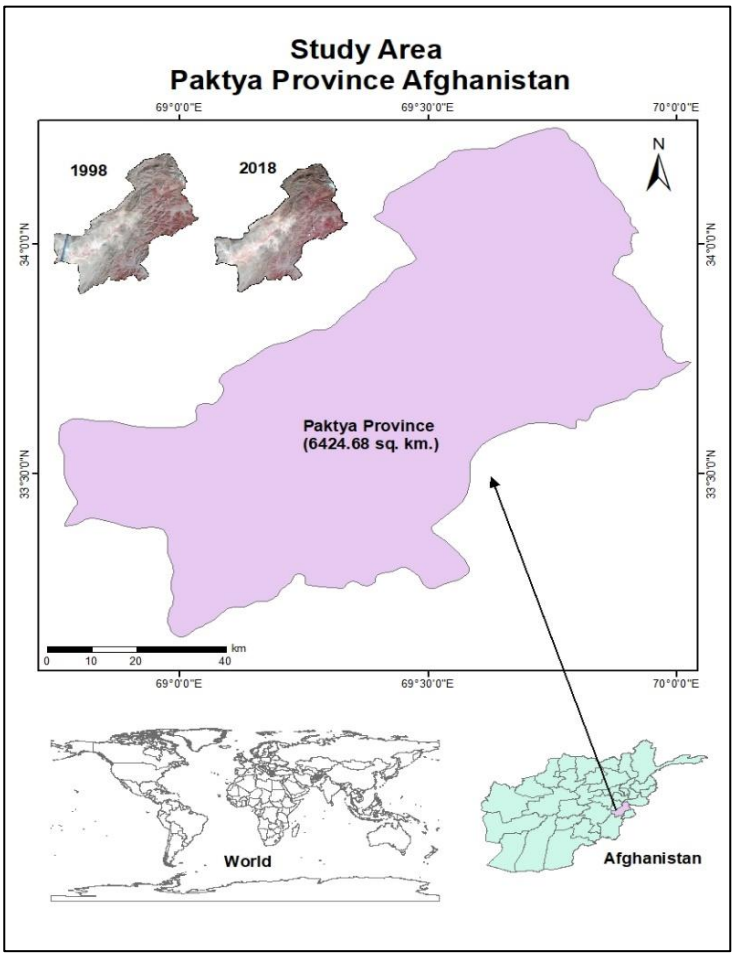

Figure 1. Location of the study area.

Paktia is one of the provinces which have natural forest cover in southeastern parts of the country. Afghanistan sustained more than two decades of internal war and instability, i.e., 1979-till 2000, which severely affected different sectors of the country. Forest and others natural resources experienced high overexploitation rate during the conflict period. After 2002 there was an elected government and a relative political stability in Afghanistan which may have induced tangible improvements in different fields. Hence, the high deforestation rate during the conflict period may be reduced, and some changes might be induced in different forest classes, which are important to study.

Data

Landsat Operational Land Imager (OLI) and Thematic Mapper (TM) satellite images of 30m resolution of the year 1998 and 2018 were used in this study. Mapping was performed on a 1:50000 scale by using ArcGIS software and ERDAS imagine software for image enhancement. Extensive ground-truthing was employed to supplement accuracy assessment and a total of 75 ground truth points were taken for data collection. The study area was delineated via visual image interpretation technique into 11Land Use Land Cover (LULC) classes' viz., closed forest, open forest, forest, scrub, and other classes (grassland, agriculture, Agroforestry, horticulture, habitation, waterbody, wasteland, and snow respectively).

RESULT AND DISCUSSION

The area under different Forest categories of Paktia province of Afghanistan in 1998 and 2018 has been shown in Table.1. From the compression of forest cover density maps of 1998 and 2018 of Paktia province revealed that the percentage of area under open forest categories in 2018 was 11.26%, while it was 10.53 % of the area in 1998. The Forest scrub category also showed a slight decrease from 21.45% of the total area in 1998 to 21.16 % in 2018. Closed forest increased by 0.73 % of the total area during the study period.

Among other land cover classes, the area under the grassland category decreased from 0.68 % of the total area in 1998 to 0.43 % of the area in 2018 due to the conversion of 0.25% of grassland to forest scrub. The other land cover classes showed a slight decrease from 63.92 % of the total area in 1998 to 63.31 % in 2018. The forest cover density maps of 1998 and 2018 have been shown in Fig. 3 and Fig. 4. Different colors have been designated to represent various forests cover density classes with non-forest represented by yellow color and dense forest category by dark green color.

Forest cover density change matrix

The change matrix in ha (forest cover density) of Paktia province from 1998 to 2018 has been shown in Table 2. The forest cover density change matrix (1998-2018) of Paktia province reveals that out of the total area under study non-forest categories occupied the maximum portion of 410852.28 ha and the minimum area of 4373.82 ha was occupied by grassland. The total area under the closed forest category was 21979.50 ha in 1998 which remained constant in 2018. The area under open forest in 1998 was 67683.72 ha with an area of 65077.1 ha remained unchanged while the rest got converted to forest scrub (44.18 ha) and closed forest (2562.44 ha). The area under forest scrub in 1998 was 137885.78 ha out of that 130331ha remained same while the rest got converted to the closed forest (198.81 ha) and agriculture 110.45 ha. The area under other non-forest categories has also shown the same trends.

Table1. Forest classes changes (1998-2018)

Classes	1998(ha)	%	2018(ha)	%	Decrease	Increase
Closed Forest	21979.5	3.42	24740.8	3.85	0	0.43
Open Forest	67683.7	10.53	72388.9	11.26	0	0.73
Forest Scrub	137886	21.45	135986	21.16	-0.3	0
Grassland	4373.82	0.68	2739.16	0.43	-0.25	0
Other Classes	410852	63.92	406920	63.31	-0.61	0
Total	**642775**	**100**	**642775**	**100**	**0**	**0**

Table 2. Forest Cover Change Matrix 1998-2018

		2018					
1998	**LULU**	**closed forest**	**forest scrub**	**grassland**	**open forest**	**other classes**	**Total**
	closed forest	**21979.5**	**0**	**0**	**0**	**0**	**21979.5**
	forest scrub	**198.81**	**130331**	**0**	**7046.71**	**309.26**	**137885.78**
	Grassland	**0**	**0**	**2231.09**	**0**	**2142.73**	**4373.82**
	open forest	**2562.44**	**44.18**	**0**	**65077.1**	**0**	**67683.72**
	other classes	**0**	**5610.86**	**508.07**	**265.08**	**404468.27**	**410852.28**
	Total	**24740.75**	**135986.04**	**2739.16**	**72388.89**	**406920.26**	**642775.1**

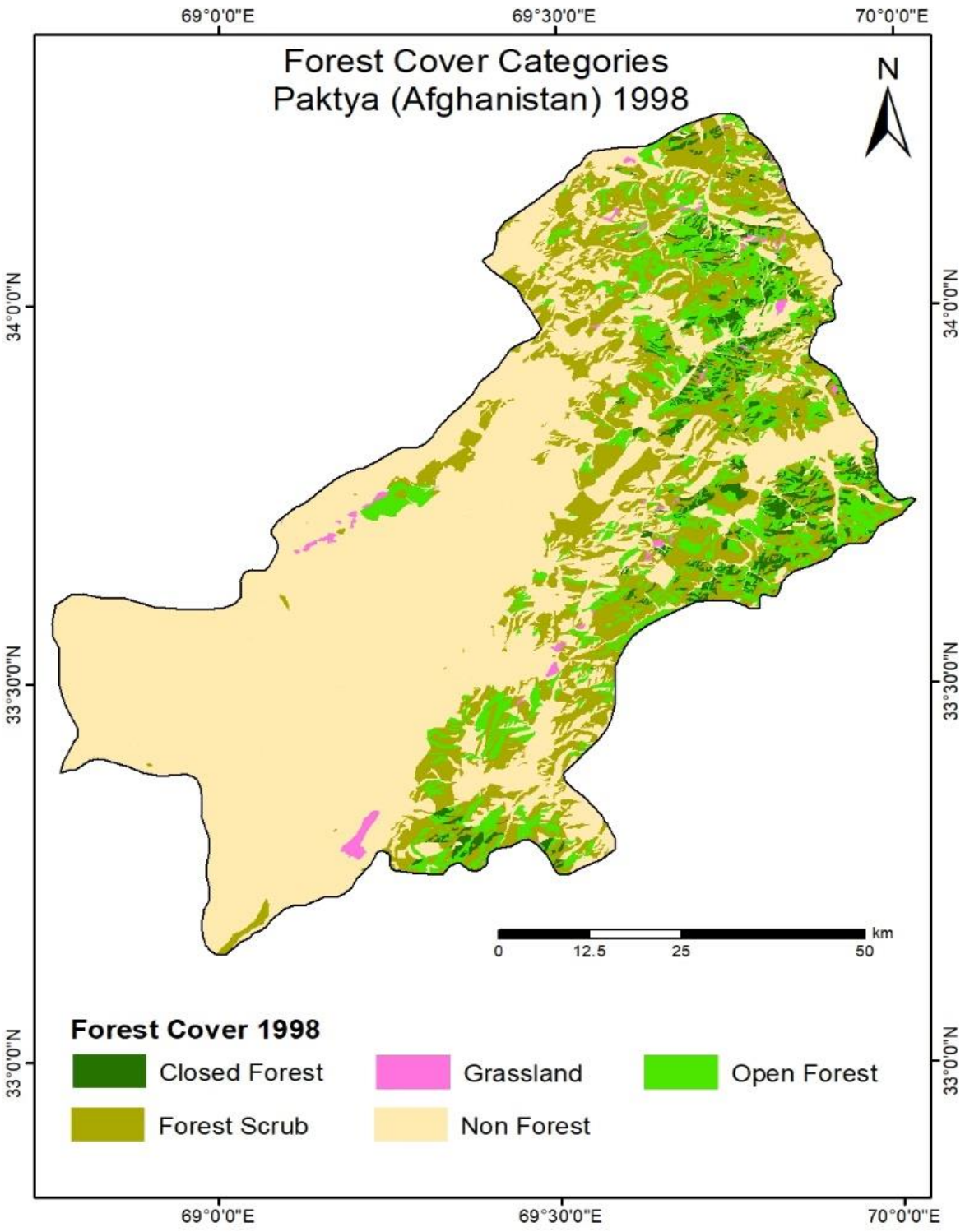

Figure 2. Forest Cover Map 1998.

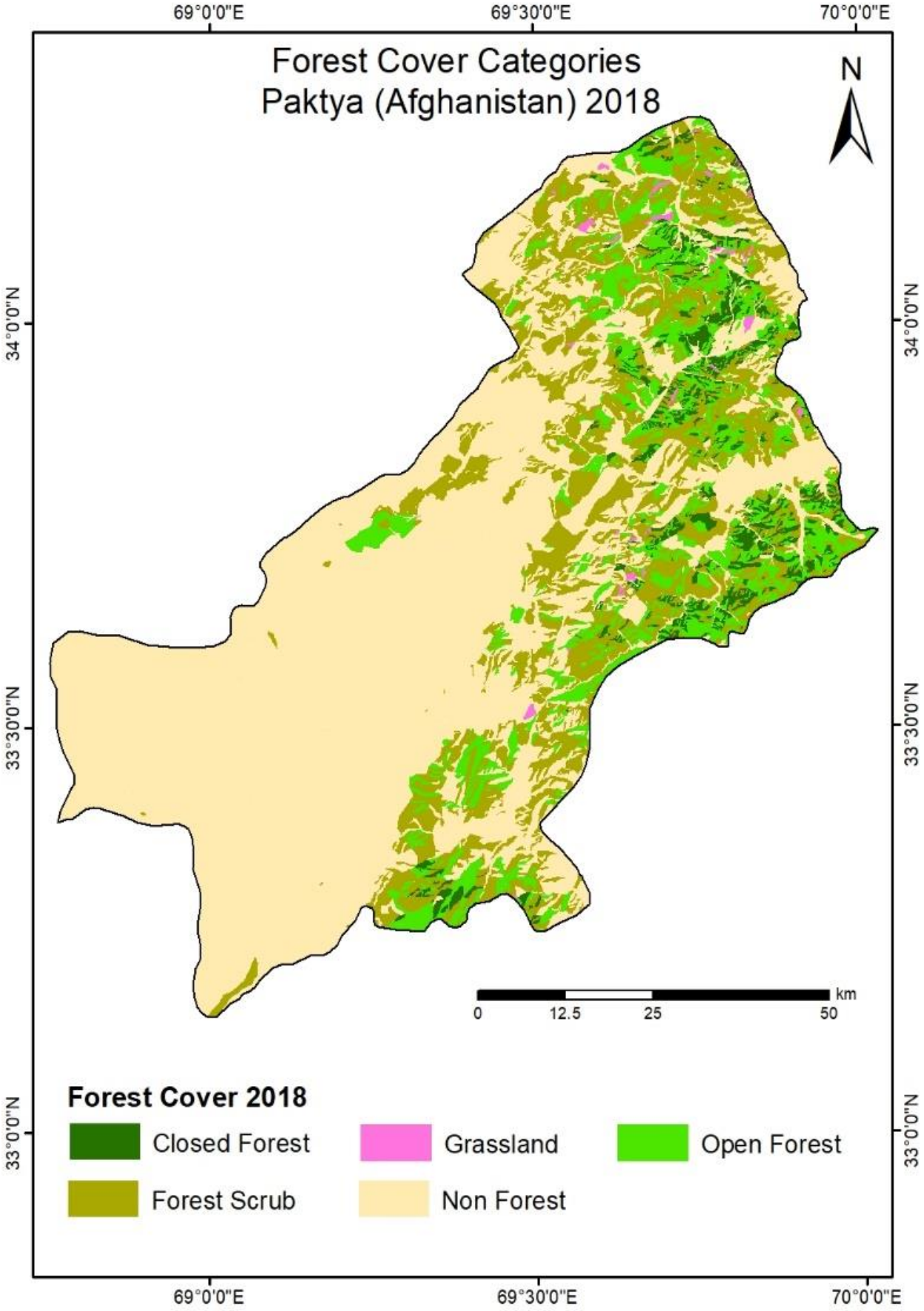

Figure 3. Forest Cover Map 2018.

The Forest cover density map was classified into three classes on the bases of crown density *viz*., closed forest (40-70 %), open forest (10-40 %), and forest scrub (less than 10 %). The forest change matrix (1998 to 2018) as shown in Table.2 reveals that there are some positive quantitative and qualitative changes in different categories of the forest as follow:

In general, the area under closed forest is increased by 0.43% from 1998 to 2018 due to the conversion of open forest to close forest. The area under open forest also increased by 0.73% during two decades, due to the conversion of forest scrub to open forest. Forest scrub decreased by 0.30% due to conversion of forest scrub to open forest. Similar results were obtained by Mishra *et al*. (2019); Reddy *et al*, (2017); Reddy *et al*. (2016); Wani *et al*. (2016); Wani *et al*, 2009. These all-positive changes in all forest classes are due to the prevailing current stability in security and political situation compare to 1998 and before 1998 there was no central government and the internal war was going on so the deforestation rate was in high level but after 2000 governmental organizations which take care of the forest and natural resources functional and local people (Tribes) also have an important role in forest conservation.

In this study, we generate LULC maps and forest cover density maps of 1998 and 2018. Before generation the change matrix (1998-2018) the maps were subjected to accuracy assessment the overall classification accuracy was 82.6 % and the Kappa accuracy was estimated at 0.8081 % similar accuracies were obtained by Popal and Satachi (2018); Othow *et al*. (2017); Rawanga and Ndambuki (2017); Kara (2017); Okoro *et al*. (2016); Wani *et al*. (2013); Dewidar (2004).

CONCLUSION

Estimation of different LULC classes of any area has been always a great demand by various organizations like policymakers, the local population, and environmentalists. The forest around the world is confronting colossal pressure and the forest of Afghanistan, which has a long deforestation background needs accurate and up-to-date information for better management. In the current investigation, different forest cover classes of Paktia province have been mapped for the first time based on forest cover density classes, using remote sensing and GIS. The result of the study revealed that there were some positive changes in different forest classes during the two decades. the conversion of open forest to the closed forest (2562.44 ha) forest scrub to open forest (7046.71 ha), conversion of grassland to forest scrub (1634.66 ha). These positive Qualitative and Quantitative changes might be due to political stabilization post year 2000 and due to administrative control of Forest land by Govt. and the Tribal community.

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