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Appraisal of Deforestation and Forest Degradation in District Swat, Pakistan

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Abstract: Deforestation and forest degradation are not only a problem of north western mountainous region of Pakistan but it is one of the main global environmental issues. To find out deforestation rate and its extent in Swat, Khyber Pakhtunkhwa, Landsat 5 (October 2, 2011) and Landsat 8 OLI (October 15, 2016) data were processed in Carnegie Landsat Analysis System (CLASlite v3.3). Primary data related to deforestation in Swat were also obtained from local people through a structured questionnaire. Primary data were analyzed in Statistical Package for the Social Sciences (SPSS). Changes in land cover can be clearly identified during image analysis. The temporal analysis of forest cover between 2011 and 2016 showed a significant change in forest cover. About 11 km² area is converted from forest to barren land, while approximately 9,985 km² area of forest cover was degraded. The perceived causes of deforestation in the study area are unsustainable use and mismanagement of forest resources, population growth, plantation of eucalyptus and lack of basic facilities and awareness. However, community ignorance is the main factor responsible for deforestation and forest degradation. One of the major consequences of deforestation can be related to the total disappearance of Charchur waterfall in Talang Kota lower Swat in September 2016. Therefore, it is the right time to move toward sustainable management, detection and monitoring of national forest reserves by using geospatial tools, and by the involvement of local communities to participate in decision making about the conservation of forest resources.

Keywords: Deforestation, forest degradation, CLASlite, sustainability, Swat, Pakistan.

Introduction

The year 2011 was declared “the international year of forests” by the United Nations for sustainable forest management that resulted in a serious concern about forest cover globally (Chakravarty et al., 2012). Deforestation is the conversion of forest cover to another permanent non-forested land like urban areas, industry, agriculture and grazing land etc. (Van Kooten and Bulte, 2000). Approximately 3.9 billion hectares or 30 percent of the earth’s land area is under forest cover. However, it is also considered that real forest cover is almost 6 billion hectares (Bryant et al., 1997). Russia, China, Canada, Brazil and the United States of America were forest rich countries by contributing about 53 percent of the total forest cover of the world. Now, forest remain stable in North and Central America while expanded in Europe during the last decade. In Asia, China and India registered a net gain in forest cover due to a large number of afforestation projects. On the other side South America, Oceania and Africa registered a net annual loss of forest cover (FAO, 2010; 2011a). First comprehensive remote sensing-based study on national land cover assessment under the umbrella of Forestry Sector Master Plan. Forest cover in Pakistan is about 3.59 million hectare which is about 4.1% of the total land area. Out of total almost 67% (1.47 million hectare) of forest is located in western Himalayan region of Khyber Pakhtunkhwa (GOP, 1992). Due to increase in population the Himalayan mountain ecosystems are under stress. Large scale forest destruction started in this region during the early British period of colonization in 1850s, where forest wood used commercially and for infrastructure development like for railway tracks (Kapoor, 1994; Myers, 1988). According to Joshi et al. (2001) forest loss in the western Himalayas remain higher about 23 percent than the eastern region which is about 7 percent in the last 30 years. From 1981 to 1990 the deforestation rate in Pakistan was 0.6 percent while in the years 1990 to 2000 the rate of deforestation increased to 1.5 percent (ICIMOD and UNEP, 1998; Rao and Pant, 2001). Ali et al. (2006) observed a severe decrease in the forest cover of district Swat from 2000 to 2005. The annual deforestation rate of forest cover seems set to accelerate and could well double in another decade (Myers, 1992). Forests provide environmental benefits and play a major role in soil conservation, hydrological cycle, mitigate to climate change and conservation of biodiversity (Shehram, 1993). The whole earth is facing environmental problems like depletion of surface water, decrease in groundwater level, change in climatic condition, landslides, floods and loss of biodiversity, which are the consequences of heavy deforestation which also reduces water catchment potential and encourages landslides and siltation of water bodies. Deforestation is the root cause of land degradation (NEMA, 2001). It is the important determinant of forest degradation which ultimately leads to decrease in forest cover. Increase in greenhouse gases like carbon dioxide, nitrous oxide and methane welcome warming which is a current issue worldwide. Large amount of carbon dioxide released from burning of fossil fuels and only half is absorbed by the oceans, plants and trees and the rest is

climbed up to the atmosphere (Afzal and Akhtar, 2013). According to FAO (1996) the annual deforestation rate in Pakistan is about 77,000 hectares because of ruthless cutting going on since long. Climate change is a burning issue round the world, it is referred to any significant change in climate with the passage of time and it may be due to manmade or natural events (Woods and David, 2007). Annual deforestation rate in Pakistan is 4.6 percent which is the second highest in the world (Qasim et al., 2014). According to World Wide Fund for Nature (WWF), currently in Pakistan total forest is only 2.5 percent of its land area with annual deforestation rate of 2.1 percent, the highest rate in Asia. Tackling deforestation is important because forest not only reduces carbon but also defines long term climate stabilization (Okereke and Dooley, 2010). Swat was a princely state until 1969 then it joined with Pakistan in 1970. Before the management of forest resources, tenure system, rule and regulations all were different However, changes in the policies, formal and informal institutions resulted in a lasting impact on the mountain ecosystem of district Swat. A few investigations have been conducted so far and need more research work to expose the impacts of institutional changes in the valley of Swat (Khan and Khan, 2009; Khan et al., 2006; Shabaz and Ali, 2006; Tulachan, 2001; FAO, 2011a). This paper focuses on the recent approaches to detect and monitor deforestation and forest degradation hotspots and its consequences on the whole valley of Swat, especially in the lower Swat locally called Kuz Swat.

Study Area

District Swat is a part of Hindu Kush Himalayan region of Pakistan with an area of about 5,037 km². Geographically Swat district lies between 34º 30– 35º 50 N and 72º 05– 72º 50 E. The altitude of the district ranges from 721 m in the south to over 5821 m in the north (Fig. 1). Administratively, Swat is divided into 8 Tehsils namely Barikot, Babuzai, Charbagh, Bahrain, Kabal, Khwazakhela, Matta and Kalam with a total population of approximately 1.3 million (GOP, 1999). District Swat lies in the temperate zone. The hottest month is June with mean minimum and maximum temperature of 16 ºC and 33 ºC. The coldest month is January with mean minimum and maximum temperature of -2 ºC and 11 ºC. Annual precipitation ranges from 1000 mm to 1200 mm and relative humidity is 65.89 %. Summer season is short and it is warm in lower Swat and cool in upper Swat, while winter season is long and extends from November to March. Rain and snowfall occur during winter season (PPAF, 2015). Meteorological data are collected in nearby Dir due to no meteorological station in district Swat (CPPR, 2010). Majority of the population is rural with Mingora and Saidu Sharif, the main urban centers. Mostly Pashtuns of Yusafzai tribe, Kohistani, Gujars and Pirachas are living in the valley (Qasim et al., 2014).

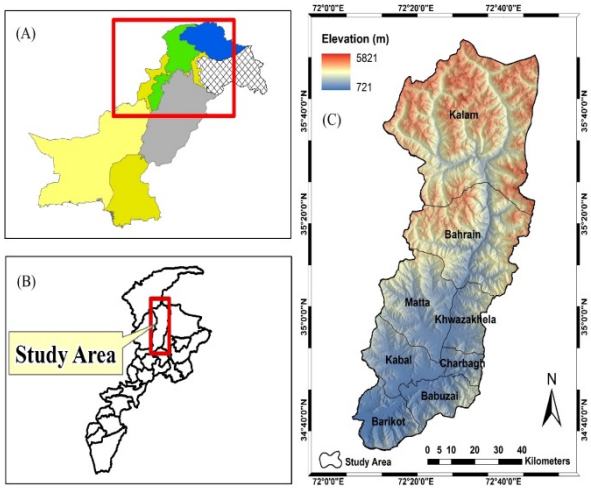

Fig. 1 (A) Showing location map of Khyber Pakhtunkhwa in Pakistan (B) Location map of Swat in Khyber Pakhtunkhwa (C) Map showing DEM (Digital Elevation Model) of district Swat.

Materials and Methods

Primary Data

Primary data were collected through a structured questionnaire, focus group discussion and interviews with the local communities, personnel observation of randomly selected different communities from lower Swat (i.e. village Talang, Kota, Spalbanday, Marghuzar, Totanu Banday, Madyan, Rodingar, Sulatanr) and upper Swat (Kalam), department of forestry and agriculture and University of Swat. The questionnaire was aimed at four main objectives including; perception, extent and causes of deforestation, socioeconomic benefits of deforestation, negative effects of deforestation and sustainable Forest Management. GPS points to identify the location of surveyed villages and field photos were also taken for the present study.

Secondary Data

For monitoring and detection of the most recent forest cover change in part of North Western Himalayan region of Pakistan we used CLASlite v 3.3. The Carnegie Landsat Analysis System – Lite (CLASlite, 2012) is a forest monitoring technology developed by Carnegie Institute for Science, Department of Global Ecology Stanford University, California, USA. It is highly automated computer-based software for the identification of deforestation and forest degradation from remotely sensed satellite imagery like Landsat 4-5, Advanced Land Imager, OLI, Spot 4-5, Moderate Resolution Imaging Spectroradiometer (MODIS). For this study we analyzed Landsat 5 Thematic Mapper (TM) of October 2, 2011 and Landsat 8 Operational Land Imager (OLI) of October 15, 2016 raw imagery, acquired from Earth Explorer USGS and then stacked and calibrated to apparent surface reflectance. Reflected images are then MOSAIC in ERDAS IMAGINE 14. CLASlite take raw satellite imagery and applies established data gains and offsets to produce

exo-atmospheric radiance for each image band. The radiance data is then forward to a fully automated 6S atmospheric radiative transfer mode (Anser et al., 2009). CLASlite uses the latest version of 6S (http://6s.ltdri.org/). Water masking is done by detecting the unique reflectance properties of water that is decreasing from blue to near infrared portion of the spectrum. Cloud shadow and those pixels that do not receive direct sunlight are also masked out. The main process within CLASlite is a sub model called Auto MCU (Automated Monte Carlo Unmixing) which provides quantitative analysis of the fractional cover of live and dead vegetation, bare substrate within each pixel in a Landsat image. Technically live vegetation is called photosynthetic vegetation, dead vegetation is referred as non-photosynthetic vegetation. Bare substrate is often dominated by exposed mineral soil and rocks (Robert et al., 1993; Kokaly et al., 2009). We performed classification of fractional cover data into a map of forest cover, and change detection with multi-temporal fractional cover data to map deforestation and forest disturbance. These functions are reflected in CLASlite's User Interface (Fig. 2).

Fig. 2 CLASlite user interface (CLASlite, 2012).

Results and Discussion

Landsat images of the year 2011 and 2016 were analyzed by using CLASlite software. The results clearly show a drastic decrease in vegetation cover mostly in lower Swat of tehsil Babuzai, Matta, Khwazakhela, Kabal and Madyan areas and mostly closed to the roads and river valleys. About 11 km² area is converted from forest to barren land, while approximately 9,985 km² area of forest cover was degraded in district Swat which ultimately results in depletion of water resources especially in lower Swat, where most of the streams and also a waterfall disappears. There was also a rapid increase in the settlement which was observed in the areas around Mingora and Saidu Sharif which are the main urban centers of the district Swat.

Reflectance Cover Analysis of Swat

CLASlite automatically converts raw satellite imagery into reflectance cover by removing all the atmospheric anomalies like water vapor, dust particles, effects of clouds and shadow of a steep slope formed in the imagery of mountainous region and masked out in black color along with water bodies. The output image is in six different bands. We selected the band combination of 4, 3 and 2 representing near-infrared, red and green respectively because the reflectance of vegetation is high in the near-infrared band (Fig. 3). In upper Swat most of the pixels (shown in black color) represent glaciers, water bodies and shadow of solar elevation. The dark red pixels are representing the forest cover, while the light red color is agricultural land. The results are not very clear because of a steep slope and unexpected weather conditions. However, in Kalam region the buildup area is increased and therefore in southern portion of upper Swat forest cover is decreased. In lower Swat, a rapid change in live vegetation is observed due to the prevailing rate of deforestation and forest degradation. In the southern part of the study area especially in tehsil Babuzai, Kabal, Matta, Khwazakhela and Madyan. The built-up area of the twin cities (Mingora and Saidu Sharif) is expanding with a high-rate replacing rich fertile soil that is present close to Swat river.

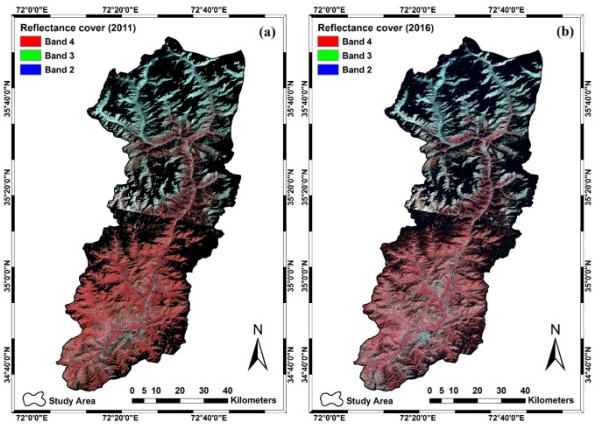

Fig. 3: Reflectance image of Swat (a) October 2, 2011 and (b) October 15, 2016 with a color composite of band combination 4, 3, 2 representing near infrared, red and green respectively where red color represents vegetation cover, grey color represent substrate, while the dark pixels were the shadow effect of solar angle and water bodies.

Conversion of Reflectance Cover to Fractional Cover

While converting reflectance cover image to fractional cover image, Automated Monte Carlo Unmixing Algorithm (AutoMCU) was applied to the input imagery and the output imagery consists of 7 bands. The land cover is classified into three main classes including band 1 that represent substrate, band 2 showing live vegetation in green color, and the blue color indicates dead vegetation in band 3. While the other bands calculated the estimated uncertainty and root mean square error for each cover pixel in the image (Fig. 4).

In upper Swat, most of the pixels of the image are in white color, showing glaciers and shadow effects of

the steep slope. The results of this stage reveal that there is a gentle increase in the substrate (settlement, soil, and rocks) and a decrease in live vegetation (in green color) towards southern regions along the road and main tributaries of river Swat in Kalam and Bahrain tehsils.

Fractional Cover Analysis of Lower Swat

In lower Swat, there is a rapid decrease in live vegetation (green pixels) and agriculture (yellow pixels) mostly in the western region of the study area that is Tehsil Kabal and Matta, as well as in eastern regions i.e. Khwazakhela and Charbagh. This stress on natural vegetation and agriculture is mainly due to continuous and large-scale deforestation, population growth and tourism.

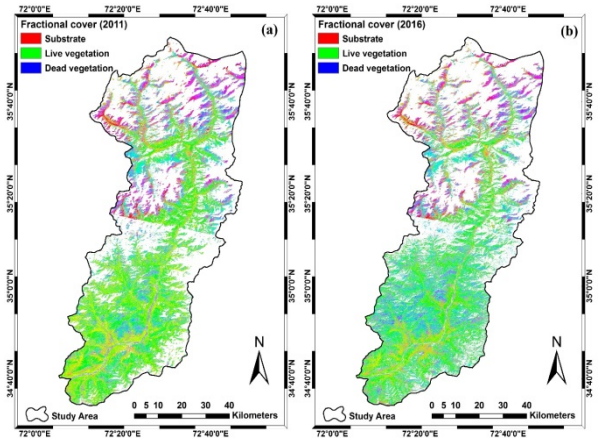

Fig. 4 Fractional cover image of Swat (a) October 2, 2011 and (b) October 15, 2016 with a color composite of red, green and blue where red color show non-photosynthetic vegetation, green color indicates photosynthetic vegetation, while blue color is showing soil, settlements and rocks.

Conversion of Fractional Cover into Forest Cover

The function of CLASlite is that it can convert the fractional cover image into a single image of forest cover in the third step and their spatial pattern of forest and non-forest land use images sometimes reveal all those areas which faced clear-cutting of forest cover and distribution in that area, which is under investigation. Natural non-forested areas such as grassland and shrub lands are also included in the output images (Fig. 5).

Forest Cover Analysis of Swat

In upper Swat there is a gentle decrease in forest cover and grasslands. The trend of increasing deforestation is from north to south.

In lower Swat the distribution of vegetation cover is decreased dramatically in 2016, as most of the population is present in this region and it is easily accessible because of good means of transportation. There is no monitoring and accountability of the people who are disturbing the natural ecosystem by cutting this precious resource of the country.

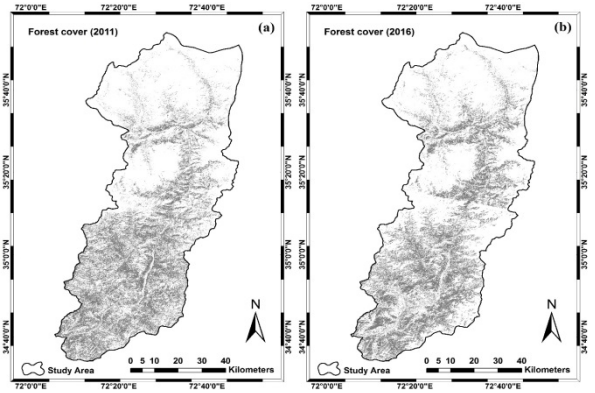

Fig. 5 Forest cover image of district Swat showing photosynthetic vegetation in grey and black color (a) October 2, 2011 and (b) October 15, 2016.

Normalized Difference Vegetation Index (NDVI)

Swat is a mountainous region therefore we have done NDVI also to check the health of vegetation cover and its spatial distribution. The values close to 1 show vigor of vegetation while the values close to zero means no vegetation which is represented in red color. In both upper and lower Swat there is a dramatic change in natural vegetation (Figure 6).

NDVI Analysis of Swat

Figure 6 shows that as we move towards north vegetation is decreasing due to harsh climatic condition because these areas are mostly covered with snow and glaciers having high gradient. However, Kalam and Madyan region can be detected very clearly, where the green color is showing the presence of vegetation, while the red color is showing no vegetation.

NDVI Analysis of Lower Swat

Figure 6b indicate that there is a rapid decrease in vegetation in the year 2016. It is because of high human pressure, demand of more food and space along with the impacts of natural hazards and climate change. The stress on natural resources increases with the passage of time.

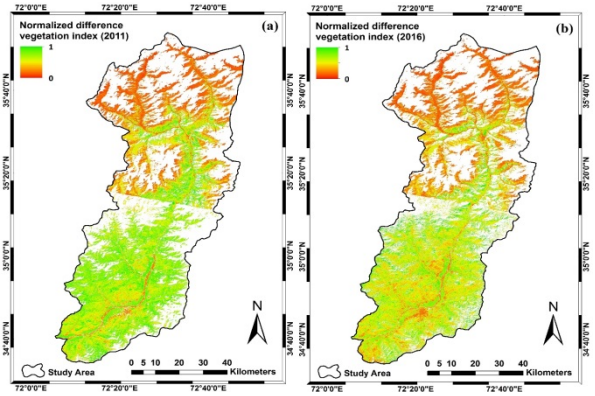

Fig. 6 NDVI image of district Swat (a) October 2, 2011 and (b) October 15, 2016 showing presence of vegetation in green and no vegetation in red color.

Forest Change Detection

The forest changes were automatically detected in forest cover between a time series data from October 2011 to October 2016 taken from the same geographical area, because a multi-image analysis is a more authentic approach for the monitoring and detection of deforestation and forest degradation. A spatial filter of 3x3 kernel pixel is applied to the output image to eliminate isolated pixels values. All those pixels values which cannot process through 3x3 kernel filter is moved forward to another spatial filter of a 7x7 kernel to the output image of raw degradation to remove separated pixels during the detection of the orientation results from forest disturbance.

Deforestation and Forest Degradation in District Swat

The pattern and orientation of disturbance pixels indicate that forest degradation is getting high in this region and it may be predicted that the rate of deforestation will be increased in the region, if suitable measures is not taken timely (Fig. 7). In upper Swat rate of deforestation and forest degradation is very low, only a small area is affected in tehsil Kalam and Bahrain.

In lower Swat rapid rate of forest depletion is observed mainly very close to streams, which is clearly shown in red pixels. Tehsil Babuzai, Kabal, Charbagh, Khwazakhela and Matta experienced a dramatic rate of deforestation in a short period of time (2011-2016) in the recent past which ultimately results, the loss of biodiversity, loss of timber forest products (TFPs) and non-timber forest products (NTFPs) and natural ecosystem of the study area.

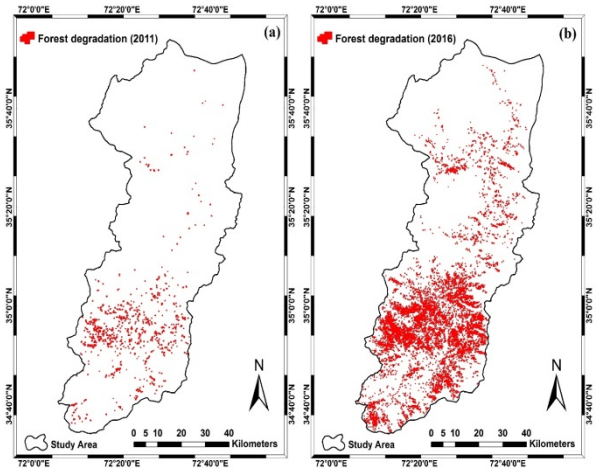

Fig. 7 Deforestation and forest degradation map of district Swat (a) October 2, 2011 and (b) October 15, 2016. The red dots represent those areas where forest disturbance takes place. The disturbance is low in upper Swat because of inaccessible steep slopes and less population. However, Babuzai, Kabal, Charbagh, Khwazakhela, Matta, and Bahrain areas in southern Swat are more affected because these areas have high population and most of the people are involved in exploiting natural ecosystem, increase in settlements and commercial areas, unawareness about environmental and climate change.

Natives Perception about Deforestation in District Swat

Native's perception of local issues plays a vital role in making public decisions for their wellbeing. For monitoring and controlling deforestation, the public opinion is an essential factor in planning and implementation of suitable preventive measures. After getting insight to the district deforestation and forest degradation through remote sensing analysis, a questionnaire regarding people perception about deforestation was made. The questionnaire mainly contains the demographic characteristics of the respondents following questions related to perception, causes and extent of deforestation; socioeconomic benefits of deforestation; negative impacts of deforestation and sustainable forest management. Primary data were collected by the researcher from the randomly selected sites (e.g. Talang, Peranu Kalay, Spalbanday, Totanu Bandai, Madyan, Ghwaleray, Sulatanr and the University of Swat). Interview with the native local elders, youth, educationists and officials from the forest department of Swat were conducted. The field survey was conducted during 2016 and 2017 by arranging different field trips of one day to one week. Ninety questionnaires were distributed among the respondents in different sites and from each site 5 to 10 questionnaires were filled by the respondents. The researcher also explained the meaning of different terminologies of forest and other difficult terms were included in the questionnaire in the Pashto language.

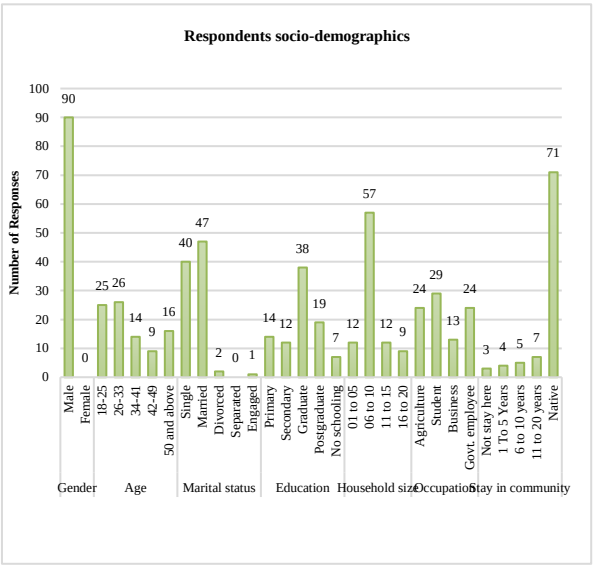

Fig. 8 Graph showing frequency distribution of respondent's socio-demographics.

All of the respondents were male, mostly ranging in the age group of 18-33 years. Teachers of government schools and students of Forestry and Agriculture Department, University of Swat were also included in the survey. Among interrogated respondents mostly were educated. Household size of most of the respondents consists of 6 to 10 persons. The

occupations of respondents were several, including education, agriculture, business and doing Government jobs etc. Most of the respondents (71) were native to the area (Fig. 8).

Majority of the respondents (more than 90 percent) were agreed that deforestation has taken place in district Swat instead of completely ban by the government. The main causes of deforestation are rapid growth in population, increase in settlements and development of more commercial areas. High rate of unemployment and poverty are also considered as a main factor of decrease in vegetation cover. Furthermore, due to absence of alternative use for the source of energy, the forest is under stress resulting in high annual rate of deforestation in the region since long. Due to socio-economic condition of the people, they still used fuelwood for cooking, heating and building shelters etc. Agriculture expansion which is a primary source of livelihood, corruption and mismanagement of forest are also some of the other causes of deforestation (Fig. 9 and Fig. 10).

Due to unsustainable use of Timber Forest Products (TFP) and Non-timber Forest Products (NTFP), some of the medicinal species are now endangered due to their commercial exploitation and because of high price in the local markets. Most of the people are unaware about the sustainable use of forest, they don't think that cutting forest can harm the environment in which we are living (Fig. 11). The major causes of extensive deforestation were ignorance of local population, lack of environmental awareness, lack of rule and regulation enforcement by forest department, the natural hazards like land sliding and floods. Majority of the local people have the opinion that due to the loss of vegetation; unique biodiversity of upper Swat is disappearing and also affects temperature and the amount of snowfall (Fig. 10).

The major impact of deforestation and forest degradation is climate change and this has been experienced by the local people. Most of the respondents have the opinion that there is a fluctuation in precipitation, which mostly affects the agriculture sector in the form of low productivity. The temperature also increases with the passage of time and this increase is noticeably experienced in the summer season. One of the mountain peaks beyond Sulatanr village named SPEN SAR (means white peak) remains under snow throughout the year. However, it was observed without snow for more than the usual time in the year 2017 due to less snowfall. Deforestation also caused soil erosion and degradation due to which the fertility and yield of crops reduced. Due to shortage of timber forest products and non-timber forest products in the study area the people fulfill their respective need with difficulty because of high prices. Loss of biodiversity has also occurred because of large-scale deforestation. A number of species especially birds and monkeys are become endangered in district Swat (Fig. 12).

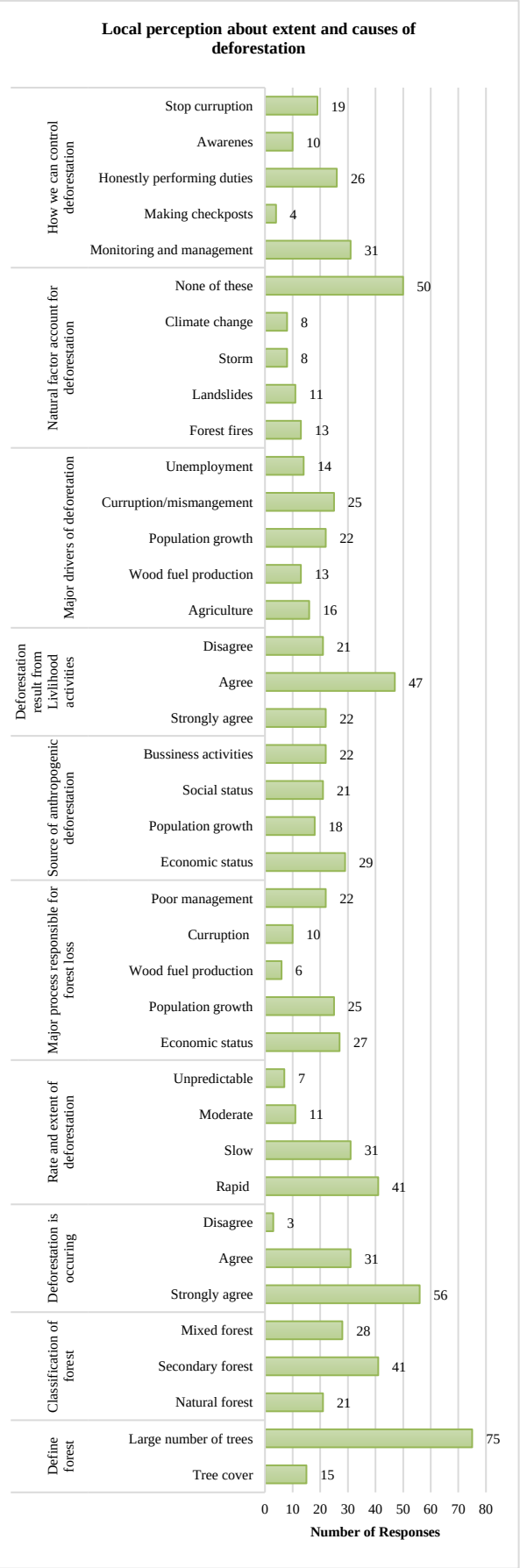

Fig. 9 Graph showing frequency distribution of responses related to local perception about extent and causes of deforestation.

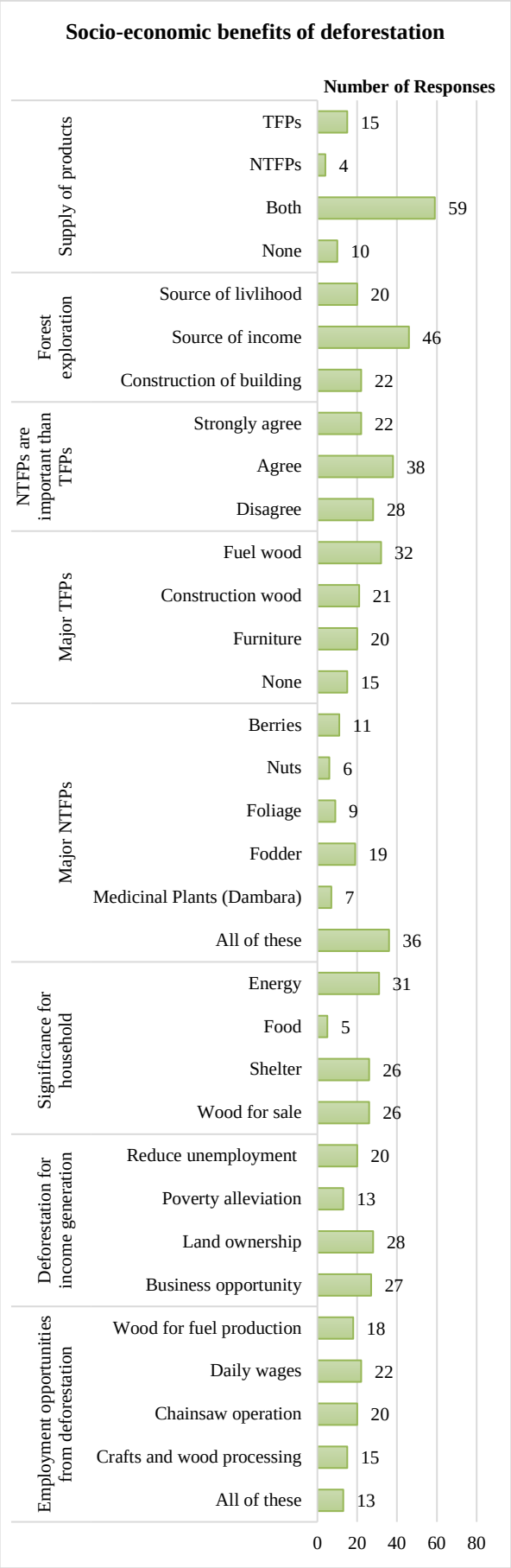

Fig. 10 Graph showing frequency distribution of responses related to local perception about socio-economic benefits of deforestation.

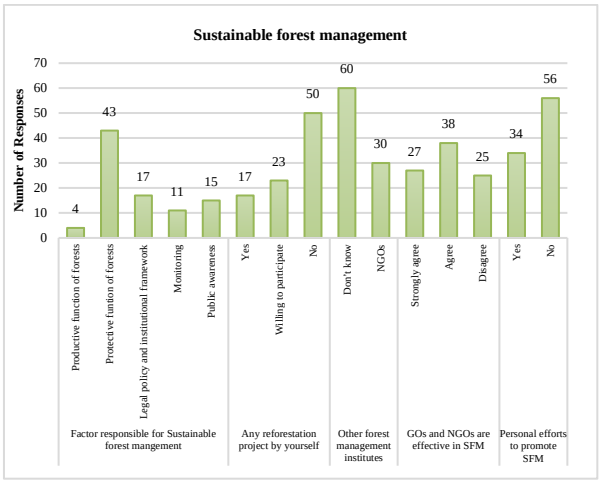

Fig. 11 Graph showing frequency distribution of responses related to local perception about sustainable forest management.

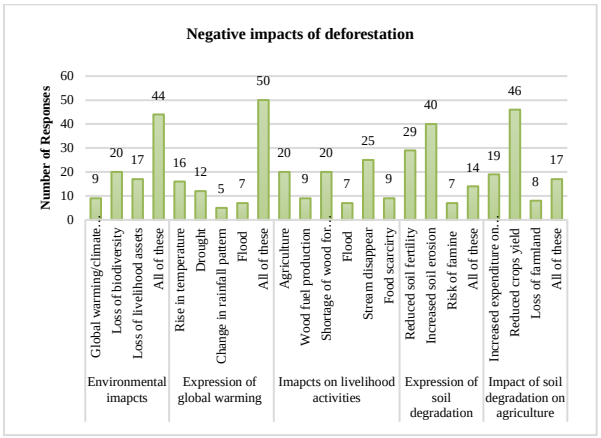

Fig. 12 Graph showing frequency distribution of responses related to local perception about negative impacts of deforestation

Conclusion

The study has attempted to find out recent deforestation and forest degradation in District Swat from 2011 to 2016 by using Landsat image data and ground truthing information. To reduce the different error effects on image data, the ground truth survey was held in the study area and useful information is collected from this survey. The forest is only survived where there is a security check post or in that places which is far away from the settlements. The area around the settlement is mostly covered with different types of crops like Maize and vegetables such as potatoes in the upper Swat while in lower Swat apple, plum, apricot, peaches, Rice, and vegetables are grown. A billion trees afforestation project was completed in Khyber Pakhtunkhwa and it was very good initiatives for sustainable forest management but there is a serious issue that is the plantation of ever thirsty Eucalyptus in the mountainous region, which affects the local environmental and climatic conditions like depletion of water resources especially in lower Swat where most of the perennial streams and waterfall disappear. In Babuzai and Barikot tehsils most of the mountain ranges are completely covered

with Eucalyptus. During field survey, most of the respondent agrees that deforestation has been witnessed in Swat and its history goes back to the accession of the Princely State to Pakistan in 1969. The people of Swat after accession with Pakistan came out from home with a slogan, "Da Wali pa Sat Ghuzar koom pa Wanna Na" Pashto language term which means I made a cut in the head of Wali, not on the tree. The local community believes that deforestation is linked with the lack of basic facilities, poverty, unemployment, subsistence agriculture, logging, corruption, unawareness, agriculture activities, and forest wood for sale to earn money. Timber forest products and non-timber forests were reduced and biodiversity is disappeared because of forest degradation. In the last 5 years that is from Oct. 2, 2011 to Oct. 15, 2016 approximately 11 square kilometers area of photosynthetic vegetation was converted to barren land and about 985 square Km area was disturbed and degraded which ultimately results depletion of water resources. Most of the deforestation and forest degradation hotspot is detected in Kabal, Khwazakhela, Matta, Charbagh, Babozai, Bahrain, and Barikot tehsils of Swat. Deforestation and forest disturbance not only impact climate but also a large number of people are at great risk due to surface and underground water depletion, loss of biodiversity, land sliding, reduced agriculture productivity, flash floods, less rain and decreased snowfall etc. Because of freely available satellite imagery it is possible to monitor, detect and identify the endangered ecosystem anywhere in the country.

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