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Analysis of Forest Cover Change and its Environmental Impact in Kupwara Region of Jammu and Kashmir Through Remote Sensing

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ABSTRACT

Forests play a pivotal role in human life by providing, directly and indirectly, a wide range of resources. During the last two decades, due to climate change and anthropogenic activities, the forest cover has been adversely affected. In the present study, the analysis of forest cover change between 2003 and 2019 was conducted in Kupwara district of Jammu and Kashmir, India, using remote sensing (RS) and geographic information system (GIS) supported with field investigation. Data was extracted from different digital maps and various satellite images. ArcGIS software was used to classify the different cover type of the study area. In addition, different impacts of the changes occurred in the study area were explained through socioeconomic data. The result acquired during the period 2003 to 2019 showed a decline in forest cover by 173.83 km^2. The annual rate of change recorded in forest cover from 2003 to 2019, was 10.23 km^2. Loss of forest cover has substantial socioeconomic effects such as climate change, loss of water and forest resources, loss of wildlife habitat, drought conditions, soil erosion, and air pollution. To minimize the forest cover change, the awareness about importance of forest and their sustainable use is seriously and urgently needed. Moreover, to reduce the negative impacts of forest cover change, curative actions are also recommended.

Keywords Forest cover change, Remote sensing, Geographic information system, Climate change, Phytogeography.

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INTRODUCTION

Forest cover change is a dynamic, accelerating, and widespread process in which natural events and anthropogenic activities like agricultural expansion into the forest land, timber logging, firewood harvesting and charcoal production are the major drivers of deforestation, resulting in changes that have an impact on natural ecosystems (Declee *et al*. 2014, Muhati *et al.* 2018). Forest is the most threatened by anthropogenic driven deforestation from the existing land use land cover class (Fokeng *et al.* 2019). At global level, forest area in 1990 is declined from 4128 million hectare to 3999 million hectare in 2015 (Keenan *et al.* 2015). It is predicted that forest area are projected to continue to decline at alarming rates in most regions (d'Annunzioin *et al.* 2015). Understanding forest patterns, its changes and natural phenomenon are essential for appropriate forest management, to investigate the extent of land use land cover change (LULCC) substantial research conducted in several countries at various times (Deng *et al.* 2013, Geng *et al*. 2015, Lark *et al.* 2017, Gibson *et al.* 2018, Ru-Mucova *et al.* 2018, Lei and Zhu 2018). Today, data from satellites RS and GIS tools has now facilitated the processing (digitizing) of historical maps and assessment of the forest cover changes of vast areas over long periods of time (Zgłobicki *et al.* 2016). In various forest structural and biophysical characteristics deforestation and forest degradation should be monitored regularly in order to gain an accurate picture of the forest. ecosystem's numerous functions and implement early conservation interventions (Fawzi *et al*. 2019). The monitoring of forest cover change is one of the most well-known applications of remote sensing-based change detection (Abyot *et al.* 2014). A major cause of global environmental change in the past three decades has been found due to rapid and extensive modification of forest cover (Khan *et al*. 2022). Deforestation and forest degradation should be monitored on a regular basis in order to develop and implement early conservation actions. Conservation relies on monitoring data to support strategy, decisions and to evaluate the effectiveness of methods (Rasmussen and Jepsen 2018). For several planning and management activities concerned with the surface of the earth, land use and land cover information is important because it constitutes key environmental information for many scientific resource management and policy purposes (Mir *et al.* 2016).The loss of vegetation cover in turn leads to many other hazardous effects on the environment (Khan *et al*. 2022). The issue of forest cover change is a very serious frightening environmental concern in the research area, with vast areas of forest cover, including deforested open forest land. The ecosystem's delicate character makes it vulnerable to the harmful effects of this transformation. RS and GIS technologies provide a flexible and pleasant environment for entering, analysing, and displaying digital data from a variety of sources, which is required for feature recognition, change detection, and database creation (Weng 2001).

The RS technique for detecting changes in forest cover and monitoring over two or more time periods has been used to examine the differences in forest cover induced by human actions and other factors (Kaliraj *et al*. (2012). Remote sensing (RS) is a recent technique for mapping the earth's surface without the need for human interaction (Roy *et al.* 2017). It works by capturing (EMR) electromagnetic radiation reflected or back scattered off the earth's surface characteristics. According to the World Bank (2017), between 1990 and 2015, East Africa's forest cover declined by 1% annually, while the human population increased by 2% annually. Thus, it is likely to correlate the change in forest cover with increasing population. The sustainability of agricultural production systems is affected by forest depletion and forest degradation and hence endangers the economy of the country (Duguma *et al*. 2019). Using remote sensing techniques is the best option because it is time- and cost-effective and can capture long-term changes (Grecchi *et al.* 2017, Langner *et al.* 2012; Wang *et al*. 2010). However, till date the rate and areal extent of forest cover change is not well studied, thus on large spatial and temporal scales, it is essential to estimate forest cover change for a sustainable forest resource management (Suleiman and Wasonga 2017). The general objective of this research was detect forest cover change for the years 2003, 2009, 2013, 2017 and 2019, its causes and impact.

MATERIALS AND METHODS

Description of the area under study

The union territory of Jammu and Kashmir is situated in the western Himalaya. It is divided into two parts i.e., Jammu and Kashmir. Geographic area of 42,241 sq. kms. The state is divided into three geographic regions viz., Kashmir valley, Leh-Ladakh and Jammu. The important river systems of the state are the Chenab, the Tawi and the Jhelum. The higher regions are covered by Pir Panjal, Karakoram and inner Himalayan ranges of mountains. Jammu and Kashmir have 20 districts among them Kupwara district falls in the north of the Kashmir which lies between lat-

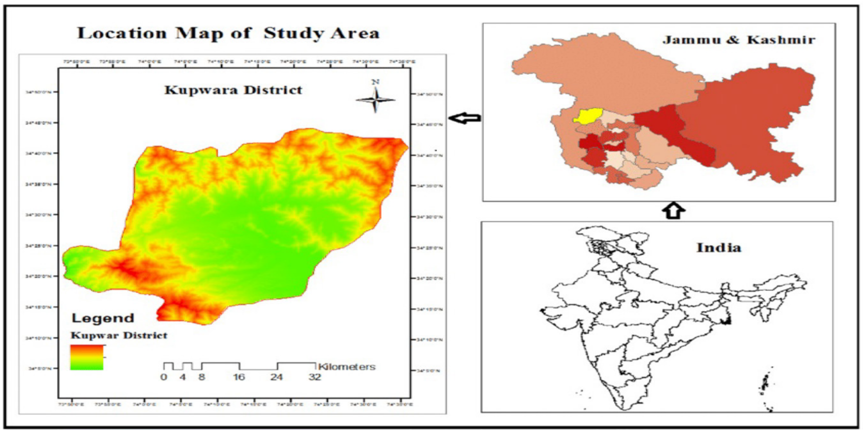

Fig. 1. Study area.

itude 32^{0}17'N and 37^{0}05'N and longitude 72^{0}31'E and 80^{0}20'E and elevation are 1629m / 5344 feet and barometric pressure are 83kpa (Fig. 1).

The district covers a total area of 2,379 km^2 and is home to 368 settlements. According to 2011 census data, there are 870,354 people living in the city, with a population density of 366 people per square kilometer. The research region is around 5300 feet above sea level, with an annual rainfall of 869 mm and the climate in the research area is moderately hot and humid. The average yearly temperature is around 17.5 degrees celsius, with maximum and minimum temperatures of 20 and 15 degrees celsius, respectively.

Research methods and design

This study used the collaboration of GIS and Remote Sensing (RS) technologies to detect a Spatio-temporal dynamics of forest cover in Kupwara region of Jammu and Kashmir. Change detection techniques of forest cover for landsat imagery preprocessing and supervised classification methods were performed as per (Wu *et al*. 2017), which involves the use of multi-temporal datasets to distinguish areas of land cover change between various dates of imaging (Garai and Narayana 2018). The primary data product of the different satellite sensor with special resolution of 23.5m on scale of 1:50,000 have provided with the longest time series satellite imagery from 2003–2019 and sequential coverage of the same area at high spatial resolution much appropriate for monitoring changes in the forest cover. Based on variation in tone and Normalized Difference Vegetation Index (NDVI) values, the images shows five classes viz., very dense forest (found in the core and greener pixels), moderate dense forest (found in the core and light green pixels), open forest (less dense found in the periphery of the forest and in yellow pixels) and non-forest (found in core as well on periphery and white pixels) using an image classification technique (Table 1 and Fig. 2).

Forest cover change detection technique

The change detection involves the formulation of multi-temporal datasets to distinguish areas of land cover changes from the dates of imaging. It is extensively used in the application of remote sensing (RS) that examines multi-temporal datasets (Stehman and Foody 2019, Dalmiya *et al.* 2019). Table 1 comprises the attributes of every forest type for the years 2003,

Table 1. Land cover type with its location and pixel colors.

Land cover type	Location on map	Pixels on map
1 Very dense forest	Core and periphery	Green pixels
2 Moderate dense forest	Core and periphery	Light green
3 Open forest	Core	Yellow
4 Scrubs	Periphery	Red
5 Non forest	Core	White

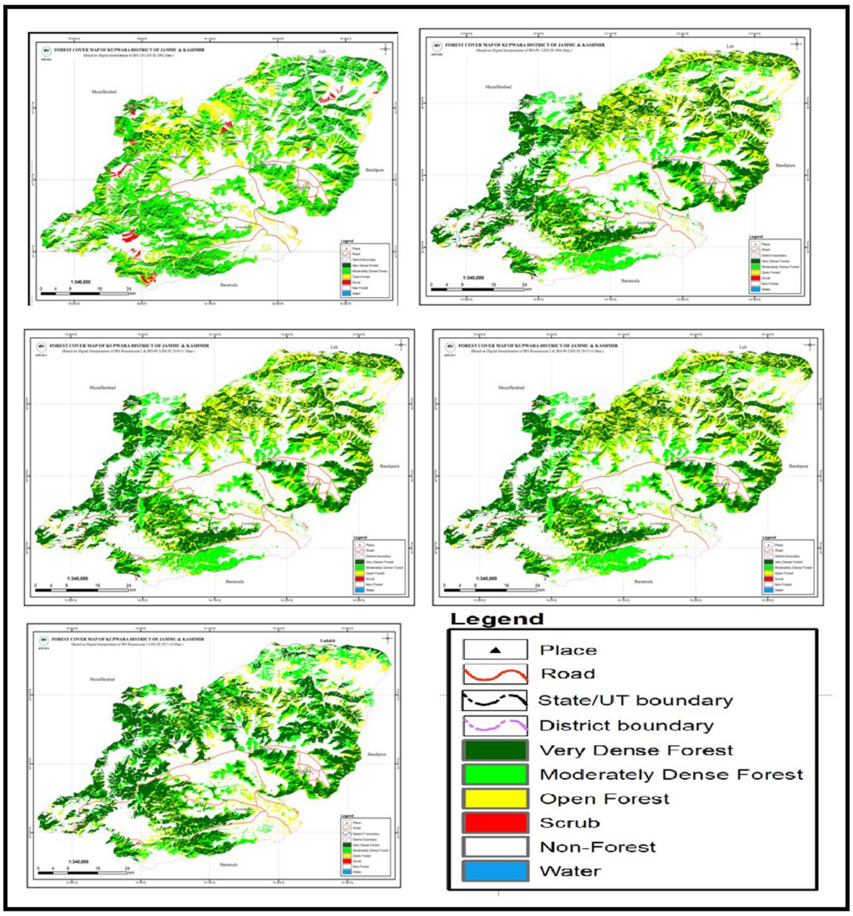

Fig. 2. Forest cover type of the years 2003, 2007, 2013, 2017 and 2019.

2009, 2013, 2017, 2019.

The supervised classification techniques from the multispectral imagery (23.5m) based on spectral signature characteristics classify the different types of forest covers (Fig. 3). The spectral signature file was created from the imagery by using classification tool in Earth Resources Data Analysis System (ERDAS) Imagine 9.1, with the ratio of 1:10 that signify each 100 pixels of feature classes participate to prepare 10 pixels spectral signature file. To recognize different types of forest covers, the number of signature files were inputted to classify the imagery. By using ESRI ArcGIS 9.3.1 geo-processing tool the raster feature classes were transformed into polygon vector, and they have verified geometrically by removing overlapped adjacent layers and tiny polygons. The area of each feature class was anticipated and tabulated. The temporal changes of forest cover types between different periods of time were considered the digital number values of image differencing.

To calculate the percentage (percent) of Land Cover Land Change (LULC), the initial and final LULC area coverage was compared following Garai and Narayana (2018) as shown in Eq. (1).

$$\text{Change percentage} = \frac{\text{Present LULC area} - \text{Previous LULC area}}{\text{Previous LULC area}} \times 100$$

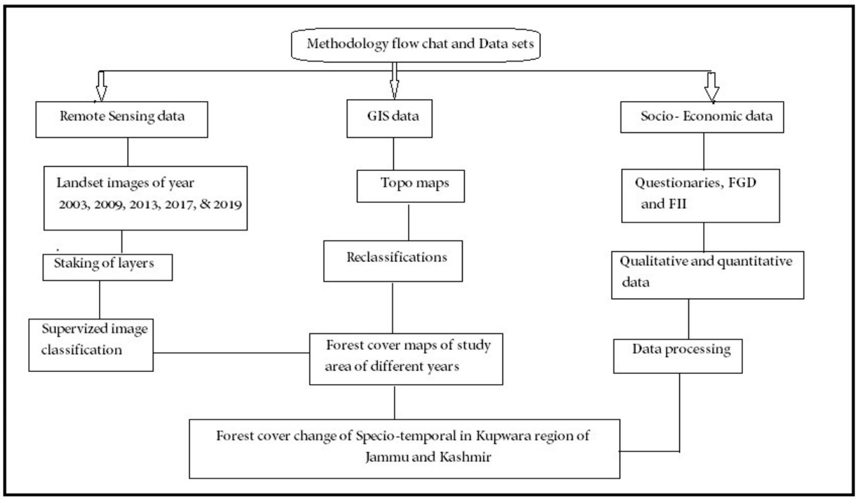

Fig. 3. Flow chat of data processing and supervision of images.

In the meantime, circumstances of forest cover change detection characteristics such as identifying the nature of the change, detecting the changes that have occurred, the areal extent measurement of the change, and assessing spatial pattern of the change are explored. Moreover, the change detection matrix has been formed to explore the patterns and trends of forest cover change as well. The rate of forest cover change for the current study over the time period was also calculated using the following formula (Eq. 2).

$$r = \frac{a-b}{t} \qquad \text{Eq. 2}$$

r = Rate of change
a = Recent year forest covers in hectare
b = Initial year forest covers in hectare
t = Number of years between a and b

Field investigation

For qualitative information about the land use change and its environmental effects on the study area, field investigation was carried out where focused group discussions (FGD), key informant interviews (KII) and household questionnaire survey were used. Later on, this data was integrated with the results from GIS and RS for spatio-temporal forest cover change analysis and its negative impacts on human beings in the study area. Accordingly, different village surveys and three spatially unambiguous datasets were used to discover the role of forests to maintain regularity in sustainable environment. On the possible relationships, we test seven hypotheses between the local environment and villager perceptions.

RESULTS AND DISCUSSION

For analysis of forest cover changes in the study area, multi spectral images from landsat images of 2003, 2009, 2013, 2017 and 2019 were used. The images were classified into 5 LULC viz., very dense forest, moderate dense forest, open forest, scrub and non-forest area (Minta *et al.* 2018, Tolera *et al.* 2008, Feyissa and Gebremariam 2018).

The classifications of the Lansat images for the year 2003, 2009, 2013, 2017 and 2019 revealed that the Kupwara forest area of the Jammu and Kashmir has been experiencing decline path over the time by observing the net gain of non-forest area. The dynamic of cover types such as very thick forest, moderate dense forest, open forest scrub, and non-forest can be shown as a result of change detection analysis. The coverage of non-forest types has increased, while all other types, such as very dense, moderate thick, and scrub forest types, have decreased. Firewood harvesting, forest logging, and increased built-up areas like

Table 2. Index of different forest cover area and non forest cover area in km^2.

Sl. No.	Cover type	2003	2009	2013	2017	2019	Change detection (2003-2019)
1	Very dense forest	90	479	472	468	468.48	+378.48
2	Moderate dense forest	793	358	366	369	358.34	-434.66
3	Open forest	387	323	322	313	273.19	-113.81
4	Scrub	5	5	3	3	1.22	-3.78
5	Total forest type	1275	1165	1163	1153	1101.23	-173.77
6	Non forest	1104	1216	1216	1226	1277.77	+173.77

towns, agricultural land expansions, are contributing to the degradation of forest resources in Jammu and Kashmir's Kupwara region.

It was emphasized that through time sequence analysis, there has been an important change in forest cover, especially the expense of forest land conversion to agricultural land and settlements in Kupwara region. Fig. 4 shows a great variation of forest cover over the estimated period. Very thick forest, open forest, and scrub cover types all declined, but intermediate forest cover first declined and then increased for a time. The study area's non-forest cover has increased dramatically from 2003 to 2019, owing to the reduction of other cover categories, particularly open forest cover (Table 2).

Special distribution and change detection

By using Eq. (1) the percentage calculation was done according to total geographical area 2,379 km^2, in 2003 the total forest cover extend of study area was 1270 km^2 (53.38 %) covered by very dense forest with 90 km^2 (3.78%) while moderate dense forest of 793 km^2 (33.33%), the open forest with 387 km^2 (16.26%) and scrub 5 km^2 (0.21%) and the non-forest area with 1104 km^2 (46.40%). In 2009, the total forest cover extend of study area was 1160 km^2 (48.75%) in which very dense forest with 479 km^2 (20.13%) while moderate dense forest of 358 km^2 (15.04%), the open forest with 323 km^2 (13.57%) and scrub 5 km^2 (0.21%). In year 2013, the total forest cover extend of study area was 1163 km^2 in which very dense forest with 472 km^2 (19.84%), while moderate dense forest of 366 km^2 (15.38%), the open forest with 322 km^2 (13.53%) and scrub 3 km^2 (0.12%), the non-forest area with 1216 km^2 (51.11%). In year 2017, the total forest cover extend of study area was 1153 km^2 in which very dense forest with 468 km^2 (19.67%) while moderate dense forest of 369 km^2 (15.51%), the open forest with 313 km^2 (13.15%) and scrub 3 km^2 (0.12%), the non-forest area with 1226 km^2 (51.53%). In year 2019, the total forest cover extend of study area was 1101.23 km^2 in which very dense forest with 468.48 km^2 (19.69%) while moderate dense forest of 358.34 km^2 (15.06%), the open forest with 273.19 km^2 (11.48%) and scrub 1.22 km^2

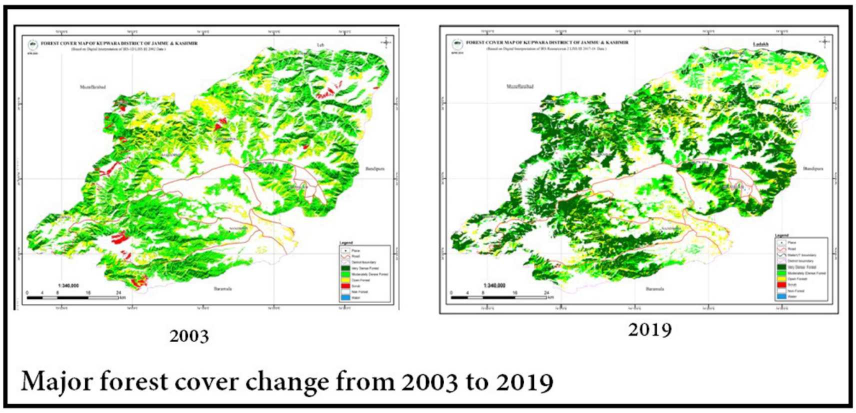

Fig. 4. Major forest cover change from 2003 to 2019.

Table 3. Percentage of forest cover classes and non forest class with respect to its geographical area.

Sl. No	Cover type	2003	2009	2013	2017	2019
1	Very dense forest	3.78	20.13	19.84	19.69	19.69
2	Moderate dense forest	33.33	15.04	15.38	15.51	15.06
3	Open forest	16.26	13.57	13.53	13.15	11.48
4	Scrub	0.21	0.21	0.12	0.12	0.05
5	Total forest type percentage	53.58	48.95	48.96	48.56	46.28
6	Non forest	46.40	51.11	51.11	51.53	53.71

(0.05%) and the non-forest area with 1277.77 km^2 (53.71%) (Tables 2-3).

Statistical data shows that the percentage increase of non-forest cover area over the time in study area is inversely proportion to decline of other cover areas of study area. Fig. 5 shows the decline of forest cover as in 2003 the total forest cover area with 53.58% declined to 46.28% in 2019 i.e., 7.3% of cover has been decreased while the percentages of non-forest cover type in 2003 was 46.61% but it was recorded 53.71% in 2019 i.e., 7.10% of the non-forest area was increased from 2003 to 2019 (Table 3).

Rate of forest cover change

Analysis of forest cover change was done using geo-special technologies after calculations by using Equation (2) indicates the rapid decline of open forest cover and rapid incline of non-forest cover type because of high demand from the increasing population and household numbers for the logging and timber for development purpose (Table 3). Total forest cover area in 2003 was 1275 km^2 while as in 2019 it was 1101.23 km^2 i.e., 173.77 km^2 area of forest is reduced from 2003 till 2019 (Table 2), the rate of forest cover change over the period of 2003 to 2019 was 10.23 km^2 (Fig. 6) i.e., 10.23 km^2 area of forest cover is converted into non forest cover area per year.

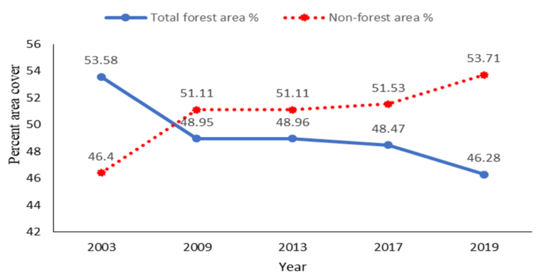

Fig. 5. Percentage increase of non forest cover and decrease of Open forest cover.

The socio-economic results

This section of survey helps to recognize respondent's observation about the impacts of forest cover change on their locality. Three range types of villages were selected to get responses; 19 villages within the 10 km near to forest land, 8 villages within 20km from the forest land and 7 villages were selected having above 20km rage from forest land. The most common response by 82% of respondents from 34 villages who answered the open-ended question was that forests keep the environment steady. In the aggregated village-level responses, over 26% of the responses mention the importance of water resource regulating services while 31% of the responses mention the importance of regular rain and moderate temperatures (climate change). The response for the importance of forest resources and the importance of wildlife habitat was 30% and 13% respectively.

In 19 villages, residing near to 10km of forest, 28% of respondents mentioned forest loss results in the climate change of the study area and the subsequent non-periodic rain fall. 7% of respondents noted the loss of water resources, 21% listed the loss of forest vegetation, 10% cited water deficit risk

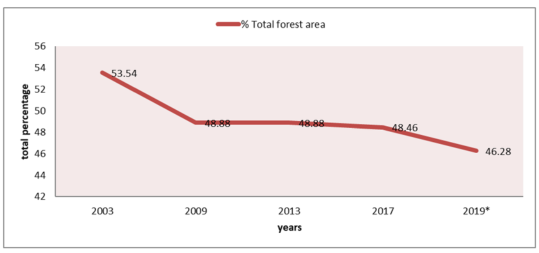

Fig.SSS 6. Decline of total forest area in Kupwara area.

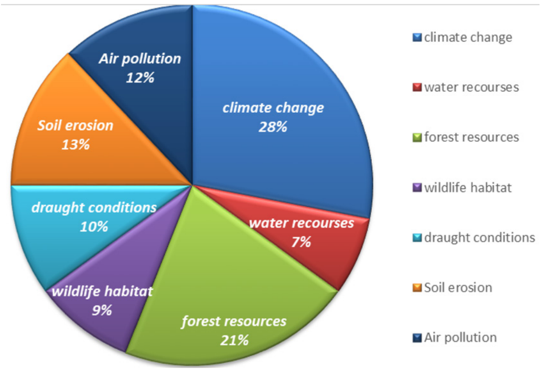

Fig. 7. The total percentage of responses about various impact.

and vulnerability, 13% mentioned soil erosion, 12% mentioned air pollution brought on by the removal of forest cover, and 9% mentioned the loss of wildlife habitat, which prompts wild animals to move into human communities in search of food and shelter. In 8 villages located 20 km from the forest, 29% of respondents stated that forest loss causes draught conditions, which results in a net loss of the agricultural economy, 19% mentioned the loss of water resources, 11% mentioned soil erosion, 10% mentioned the loss of valuable forest resources, 10% mentioned air pollution caused by the destruction of forest cover and 10% mentioned the loss of wildlife habitat. In seven villages located more than 20 kilometer from a forest, 19% of respondents stated that the loss of the forest causes water scarcity (both for drinking and for aggregation purposes), 13% noted that the study area's climate has changed as a result of the loss of the forest, 29% mentioned that the loss of the forest has caused air pollution, 12% noted the loss of valuable forest resources, and 10 % or more noted the loss of the forest. The total responses from the respondents about the effects of the forest destruction is shown in (Fig. 7) while the total percentage of responses about the specific impact of forest destruction is given in (Table 4). Regarding the solution of the forest destruction, 41% of the respondents suggested the strong law and penalties against the responsible for the forest loss. However, 25% suggested to start the awareness program about the environmental health and its benefits to the society. 21% of respondents suggested finding alternative uses for forest products to preserve the resources, and the remaining 13% suggested planting trees as a solution.

CONCLUSION

The primary environmental issue in the Kupwara district is the shift in forest cover brought on by deforestation. In the district, forest cover change has been decreased between 2003 to 2019. Open forest cover type was decreased while increasing trend of non-forest cover type from 2003 to 2019 was recorded. This change in in the forest cover by different anthropogenic activities results in the climate change, change in different plant species diversity and the topography of the land. Moreover, the main effects of the research area's socioeconomic data analysis were soil erosion, water scarcity, drought conditions, climate change, and loss of forest resources due to forest encroachment. Therefore, in order to prevent additional deforestation and use forest resources sustainably, residents should be instructed and motivated to plant quickly growing trees on bare fields, degraded lands, and high sloppy lands as well as to minimize the deforestation for different purposes. By raising public

Table 4. Percentage of responses with respect to the specific impact.

Sl. No.	No. of villages range from forest	19 10km	8 20km	7 above 20km	Total
		Percentage of respondents			
1	Climate change	28%	11%	13%	52%
2	Water recourses	7%	19%	19%	45%
3	Forest resources	21%	10%	12%	43%
4	Wildlife habitat	9%	10%	9%	28%
5	Draught conditions	10%	29%	10%	49%
6	Soil erosion	13%	11%	8%	32%
7	Air pollution	12%	10%	29%	51%

awareness about importance of forests, and conservation efforts and strategies as well as reducing the consumption of forest resources, the environmental deterioration can be minimized.

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