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VEGETATION LINE DELINEATIONS USING NDVI TECHNIQUES IN THE GORI GANGA WATERSHED OF KUMAUN HIMALAYA, UTTARAKHAND

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ABSTRACT----------
Present research paper is an attempt to delineations the vegetation line by using Normalized Difference Vegetation Index (NDVI) in the Gori Ganga watershed, Kumaun Himalaya, Uttarakhand (India). The objective of the present study is delineation of vegetation lines of the Gori Ganga watershed in time space. For the study of detect vegetation line used of Landsat-5,8 and Cartosat-1 satellite imageries of three different time periods i.e., Landsat-5 Thematic Mapper (TM) of 1990, Landsat-5 (TM) of 1999 and Landsat-8 Operational Land Imager and Thermal Infrared Sensor (OLI and TIRS) of 2016. Geographical distribution of vegetation line average height reveals that in 1990 about 4294.97 m (± 307 m) which varies between 3035 m to 5057 m, in 1999 about 4394.51 m (± 325 m) which varies between 3165 m to 5655 m and in 2016 about 4758.55 m (± 533 m) which varies between 3144 m to 6339 m average height of the Gori Ganga watershed.
KEY WORDS: ***NDVI Techniques, Vegetation line, GIS and Remote Sensing----------***

INTRODUCTION

Vegetation is a very important component as it affects environmental activities and processes like air filtering, rainfall, drainage etc (Bolund and Hunhammar, 1999). In recent decades there has been increased in the effects of climatic changes on species distribution and ecosystem functions, following the recognition that global warming might have profound effects on future ecosystems (Chapin and Starfield 1997; Sturm et al., 2001; Callaghan et al., 2004; Kullman 2005; Kullman 2006; Truong et al., 2007). The study of vegetation responses to climate change in mountain areas might be complicated by human impact, since activities such as grazing by livestock or cutting trees for firewood or constructions in mountain areas are known to lower the forest limit (Hofgaard, 1997). Shukla and Ramakrishnan (1982), collect information on periodicities of different phonophases of subtropical humid forests in north-eastern India. Ralhan et al., 1985 studied in tree phenology in several forests lying within 350-2150 m elevation in Kumaun Himalaya and reported on the phenology of the shrub component of the same forests. Vegetation index is one of the most useful and used index to quickly identify vegetated areas with the use of multispectral remote sensing data (Pirottia et al., 2014).

Remote sensing analysis delivers synoptic information of land cover and land use at a particular time and location (Roy and Roy, 2012). The integrated geographical information system and remote system application found to be effective tools in understanding the rate of land use land cover change with time and space (Baidya et al., 2009). GIS and Remote Sensing can answer the various questions about Land Use Land Cover (LULC) and impact on animal kind, humankind, ecology and environment (Rindfuss et al., 2004). Normalized Difference Vegetation Index is a common and widely used index for extracting vegetation index in satellite images, widely applied in research on global climatic changes in environmental (Bhandari et al., 2012). Researchers have reported the use of NDVI for vegetation assessing the crop cover (Bechtel et al., 1997), drought monitoring (El-Shikha et al., 2007) and agricultural drought assessment at national (Demirel et al., 2010) and global level vegetation index is a simple and effective measurement parameter, which is used to indicate the earth surface vegetation covers and crops growth status in remote sensing field (Zhang et al., 2009).

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METHODOLOGY

The present study works out the analysis of vegetation index, vegetation line using remote sensing data. Remote sensing data are extremely valuable to examine the delineating of vegetation height and line in Gori Ganga watershed. To delineate vegetation lines Landsat-5 (TM) for the year 1990 and 1999, Landsat-8 (OLI and TIRS) for the year 2016 and Cartosat-1 Satellite images for the year 2008 were used from www.USGS.com, website and Global Land Cover Facility (GLCF). For all three years cloudless images were selected for the month of November. ERDAS software was used for apply geometric correction to re-project the original sinusoidal file to geometric lat-long projection. Figure 1 presents the flowchart which shows the steps of NDVI methodology adopted. The study area, i.e., Gori Ganga watershed was clipped using its shape file from satellite images and the image was given the base map coordinates, i.e., UTM projection, 44 N zone for the purpose to identify the study area in the images. For the NDVI raster data of the 1990, 1999, and 2016 was calculated in Arc GIS 10.2.2 software using the equation Normalized Difference Vegetation Index (NDVI) = NIR-Red/NIR + Red. Where NIR (Near Infrared) = Band 4 (Landsat-5) and Band 5 (Landsat-8), Red = Band 3 (Landsat-5) and Band 4 (Landsat-8) (Nouri et al., 2014):

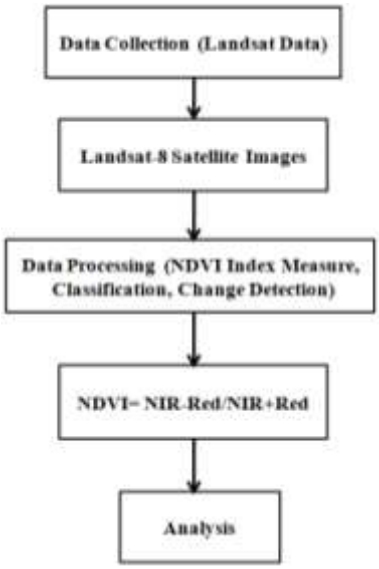

Figure 1: Flowchart of methodology (after Nouri et al., 2014).

LOCATION AND EXTENT

The study area, viz., the Gori Ganga watershed (Kumaun Himalaya) extends between $29^0$45'0''N to $30^0$35'47''N latitudes and $79^0$59'33''E to $80^0$29'25''E longitude, and encompasses an area of 2191.63 km^2. Figure 2 depicts the geographical distribution while Figure 3 depicts the altitude of the Gori Ganga watershed varies between 626m and 6639m. The Gori Ganga watershed has 168 villages and total population is about 40616 (Censes of India, 2011).

RESULT AND DISCUSSION

The results obtained through the analysis of NDVI imagery are diagrammatically illustrated in Figure 4. Figure 5 depicts vegetation line height frequency curve in 1990 to 2016 which is registered in Table 1. While Figure 6 depicts average altitude of vegetation line and Figure 7 depicts geographical distribution of average vegetation line heights in 1990, 1999 and 2016 in the Gori Ganga watershed which is registered in Table 2. Plates 1 and Plate 2 are presenting vegetation lines in the different alpine regions of the study area. A brief account of these results it's discussed in the following paragraphs.

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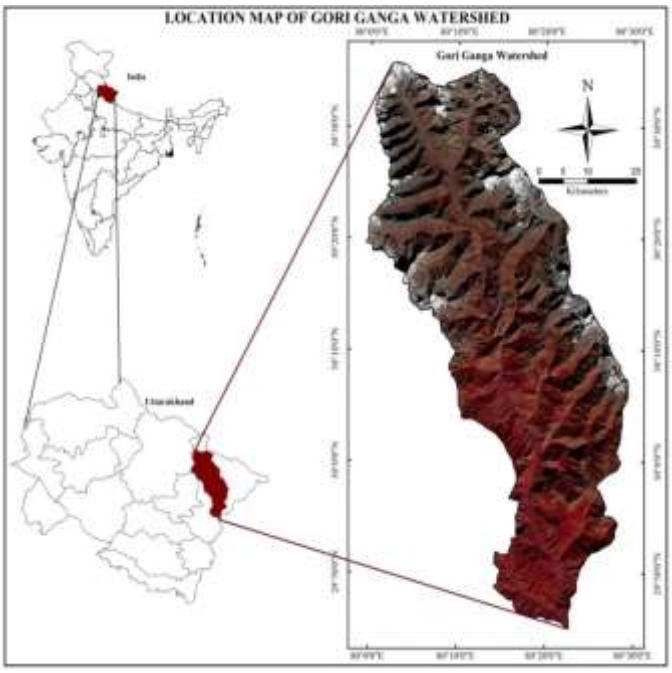

Figure 2: Geographical location and extension of the study area Viz. Gori Ganga watershed, Kumaun Himalaya, Uttarakhand.

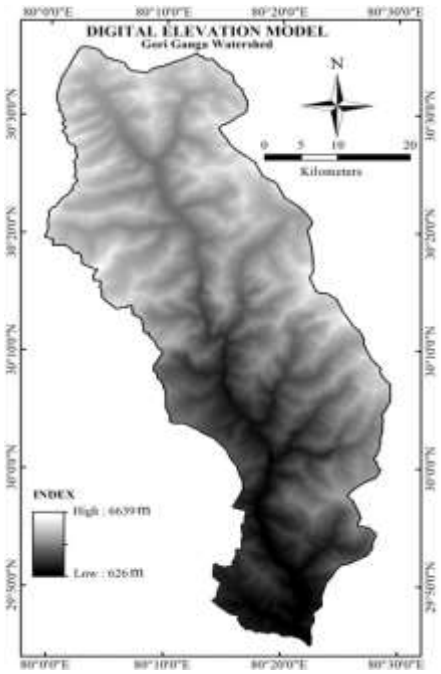

Figure 3: Digital Elevation Model (DEM) of the Gori Ganga watershed.

NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI)

Normalized difference vegetation index has found a wide application in vegetative studies as it has been used to estimate crop yields, pasture performance and rangeland carrying capacities among others. It is often directly related to other ground parameters such as percent of ground cover, photosynthetic activity of the plant, surface water, leaf area index and the amount of biomass. Since we know the behavior of plants across the electromagnetic spectrum, we can derive NDVI information by focusing on the satellite bands that are most sensitive to vegetation information (near-infrared and red). Theoretically, NDVI values are represented as a ratio ranging in value from -1 to 1 but in practice extreme negative values represent water, values around zero represent bare soil and values over 6 represent dense green vegetation. Figure 4 depicts geographical distribution of NDVI values (>0.2) in the Gori Ganga watershed in 1990, 1999 and 2016.

METHOD OF VEGETATION LINE HEIGHT DELINEATION

The methodology is as, the threshold value of NDVI range 0.2 for vegetation line map out, respectively (www.earthobservatory.nasa.gov). After displaying the NDVI imagery on the screen of Arc map, the lower limit of vegetation cover in the watershed area was digitized for all the three years. In order to draw vegetation line, a shape file was created in Arc GIS software in Arc-catalogue and vegetation line has been digitized for the year 1990, 1999, and 2016. To estimate vegetation line height, the vegetation line of both the years were overlaid on the DEM data and then a point shape file has been created in arc-catalogue and keeping the snapping mode on, the digitization was done, over the vegetation line of both year and then the digitized points were masked by the mask function from DEM data, so, that each point bear some height and then those points were exported into the Microsoft excel sheet and the average height have been estimated. Table 1 and Figure 4 depict the vegetation height frequency rate and curve in the Gori Ganga watershed. The methodology is as, firstly took Landsat-5 (TM) and 8 (OLI and TIRS) imageries 1990, 1999 and 2016 and demarcated the timber line on these images. Obtaining value from different elevation point for vegetation line average height of different years was worked out as presented in Table 2 and Figure 5, which special location is presented in Figure 7 of the Gori Ganga watershed in the year (A) 1990, (B) 1999 and (C) 2016.

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Table 1: Vegetation line height point frequency rate in the Gori Ganga watershed in (A) 1990, (B) 1999 and (C) 2016 *(based on Cartosat-1, Satellite image).*

S. N.	Height groups	Frequency of vegetation height point			S. N.	Height groups	Frequency of vegetation height point		
		1990	1999	2016			1990	1999	2016
1	3000-3500	147	42	104	5	5000-5500	15	74	6296
2	3500-4000	2102	396	1064	6	5500-6000	0	4	2870
3	4000-4500	7821	1978	2913	7	6000-6500	0	0	87
4	4500-5000	3407	1422	6636	Total		13492	3916	19970

Table 2: Average height of vegetation line in 1990, 1999 and 2016 in Gori Ganga watershed *(based on Cartosat-1, Satellite image).*

S.N.	Year	Average vegetation height	Standard deviation	Minimum height	Maximum height
1	1990	4294.97 m	± 307 m	3035 m	5075 m
2	1999	4394.51m	± 325 m	3165 m	5655 m
3	2016	4758.55 m	± 533 m	3144 m	6339 m

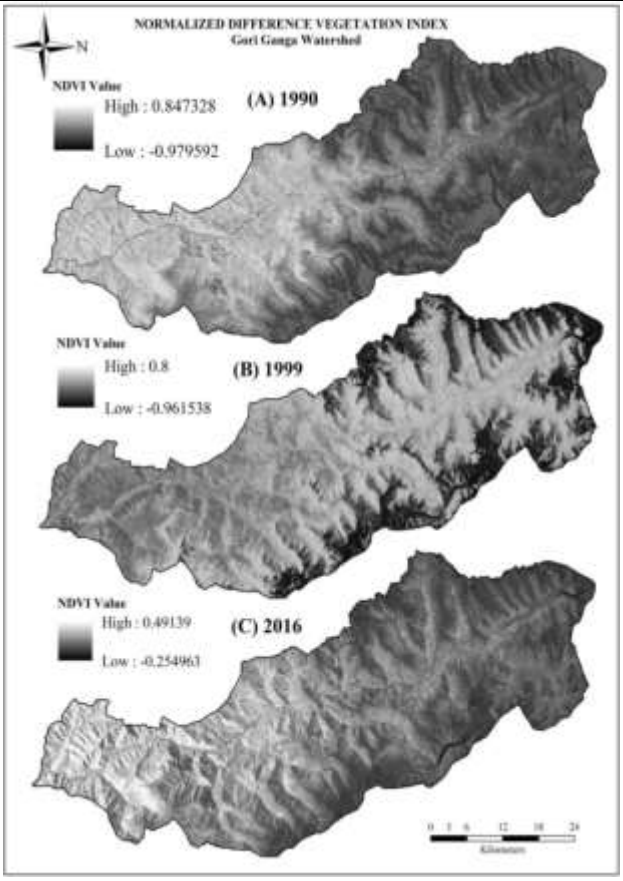

Figure 4: Geographical distribution NDVI values (>0.2) in different years in the Gori Ganga watershed in (A) 1990, (B) 1999 and (C) 2016 *(based on used NDVI techniques and Landsat-5 and 8, Satellite imageries).*

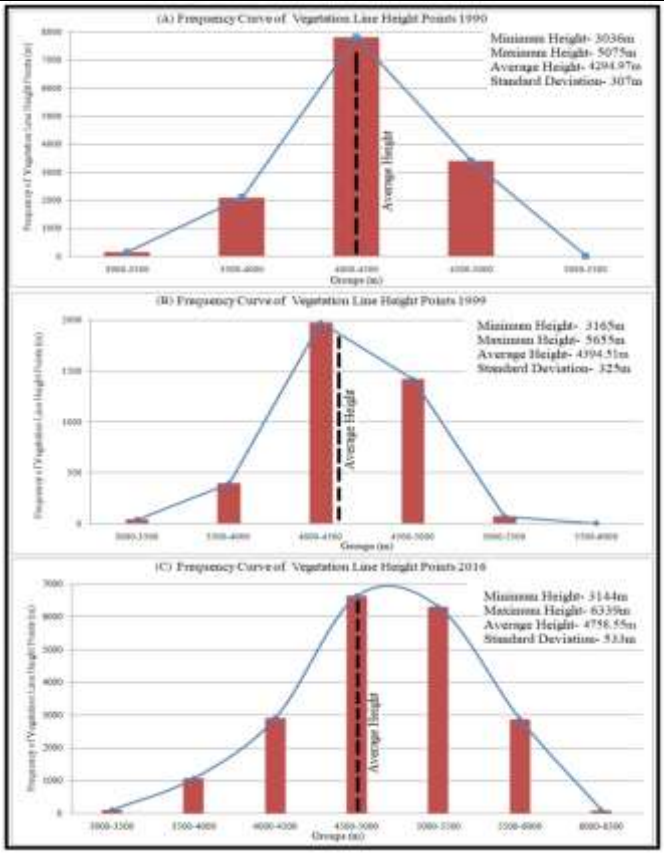

Figure 5: Vegetation line height frequency curve in the Gori Ganga watershed in (A) 1990, (B) 1999 and (C) 2016 *(based on Cartosat-1, Satellite image).*

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Vegetation Line 1990

To determine the average height of the vegetation line for the year 1990. 13492 height points were taken from DEM and they were summarized and present in Table 1 and Figure 5 (A). The frequency curve of these height points reveals that the average height of vegetation line in 1990 was about 4294.97 m (sd ± 307 m) in 1990 which varies between 3035 m to 5057 m in the Gori Ganga Watershed present in Table 2 and Figure 6. Figure 7 (A) depicts the special location of vegetation line in the Gori Ganga watershed in 1990.

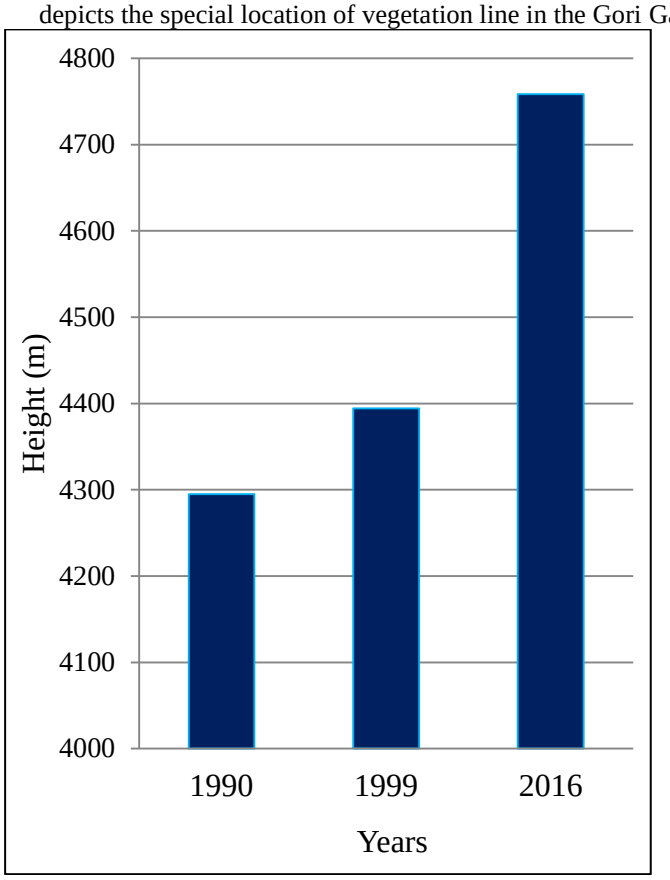

Figure 6: Average vegetation line altitude for the year 1990, 1999 and 2016 *(based on Cartosat-1, Satellite image).*

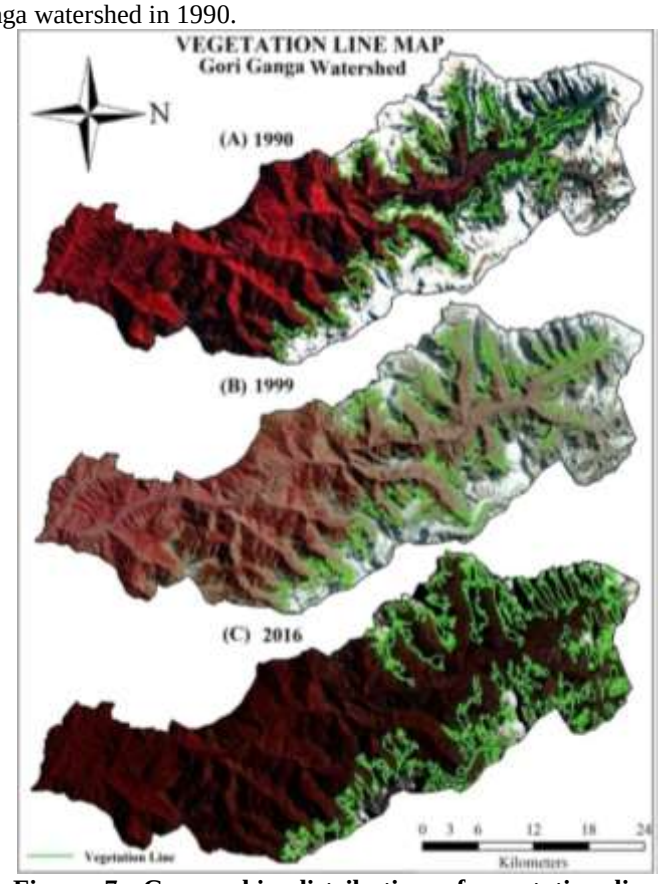

Figure 7: Geographic distribution of vegetation line based on NDVI values (>0.2) in different years in the Gori Ganga watershed, (A) 1990, (B) 1999 and (C) 2016 *(based on Landsat-5 and 8, Satellite imageries).*

Plate 1: Vegetation line in Ralam Bugyal and Ralam Glacier (July 2018) of the Gori Ganga Watershed.

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Plate 2: Vegetation line in Hansling Peak (December, 2019) of the Gori Ganga Watershed.

Vegetation Line 1999

To determine the average height of the vegetation line for the year 1999. 3916 height points were taken from DEM and they were summarized and present in Table 1 and Figure 5 (B). The frequency curve of these height points reveals that the average height of vegetation line in 1999 was about 4394.51 m (sd ± 325 m) in 1999 which varies between 3165 m to 5655 m in the Gori Ganga Watershed present in Table 2 and Figure 6. Figure 7 (B) depicts the special location of vegetation line in the Gori Ganga watershed in 1999.

Vegetation Line 2016

To determine the average height of the vegetation line for the year 2016. 19970 height points were taken from DEM and they were summarized and present in Table 1 and Figure 5 (C). The frequency curve of these height points reveals that the average height of vegetation line in 2016 was about 4758.55 m (sd ± 533 m) in 2016 which varies between 3144 m to 6339 m in the Gori Ganga Watershed present in Table 2 and Figure 6 while Figure 7 (C) depicts the special location of vegetation line in the Gori Ganga watershed in 2016.

CONCLUSION

The Fundamental objective of this chapter is to determine the vegetation lines by using remote sensing and GIS techniques. For this study Landsat-5 (TM), Landsat-8 (OLI and TIRS) and Cartosat-1 satellite images of the years 1990, 1999 and 2016 were used. Based on this study the following may be concluded:

I. In 1990 the average height of vegetation line in the Gori Ganga watershed was about 4294.97 m sd ± 307 m which is varies between 3035 m to 5057 m.
II. In 1999 the average height of vegetation line in the Gori Ganga watershed was about 4394.51 m sd ± 325 m in 1999 which varies between 3165 m to 5655 m.
III. In 2016 the average height of vegetation line in the Gori Ganga watershed was about 4758.55 m sd ± 533 m in 2016 which varies between 3144 m to 6339 m.
IV. This study has clearly determined that remote sensing and GIS application is determining the average height of vegetation lines.

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