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LULC CLASSIFICATIONS USING GIS AND REMOTE SENSING TECHNIQUES IN GORI GANGA WATERSHED OF KUMAUN HIMALAYA, UTTARAKHAND

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ABSTRACT
Present research paper is an attempt to classifications of the Land Use Land Cover (LULC) by using supervised classification in the Gori Ganga watershed of Kumaun Himalaya, Uttarakhand (India). Geographical distribution of LULC status of Gori Ganga watershed in 2018 about 26.50% (580.86 km^2) area was covered with snow, 3.85% (84.33 km^2) area was covered with glacier, 1.93% (42.39 km^2) area was covered with barren land, 5.63% (123.31 km^2) area was covered with Sand cover area, 10.02% (219.53 km^2) area was covered with water body, 50.39% (1104.49 km^2) area was covered with vegetation and 1.68% (36.72 km^2) area was covered with agriculture area. A brief account of these results it's discussed in the following paragraphs.

KEY WORD: ***LULC, Gori Ganga Watershed, Kumaun Himalaya, GIS and Remote Sensing***

1.0 INTRODUCTION

The most commonly terms used are basin, catchment and watershed. In the glossary of geographical terms, a basin is "the whole tract of a country drained by a river and its tributaries" (Stamp and Clark, 1981). Accurate delineation of a watershed plays an extremely important role in the management of the watershed. The delineated boundary helps in management efforts, analyzing and in drawn appropriate conclusions (Savant et al., 2002). GIS tools can be automated in implementation of various practical applications of watershed delineation (Fattah et al., 2015).

One concept that has much merit is that land use refers to, "man's activities on land which are directly related to the land" (Clawson, 1965). Land cover, on the other hand, describes, "The vegetation and artificial constructions covering the land surface" (Burley, 1961). LULC are important component for understanding the interactions of the human relationship with environment by using satellite data with supervised classification techniques (Prakasam, 2010). LULC of the Gori Ganga watershed was classified by using Landsat TM at a resolution of 30m data of 1990, 1999 and 2010 (Rawat et al., 2013). Image classification procedure was used to classify multispectral pixels into different LC classes and the maximum likelihood algorithm of supervised classification was used for pixel clustering. Identified three types of LULC were in the study area like vegetation, built-up land and others (Rawat et al., 2013).

2.0 METHODOLOGY

The present study works out classifications of the LULC by using remote sensing data with supervised classification in the Gori Ganga watershed of Kumaun Himalaya, Uttarakhand (India). To classification LULC, Santinal-2 of 2018 from www.USGS.com, website and Global Land Cover Facility (GLCF) and watershed, Cartosat-1 Satellite images for the year 2008 were used from Natural Resource Data Management System- NRDMS, Department of Geography, S.S.J. Campus, Almora Uttarakhand. For 2018 cloudless images of selected for the month of November. 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 LULC raster data of the 2018 was calculated in ERDAS IMAGINE and Arc GIS 10.2.2 software using the equation of supervised LULC classification.

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3.0 STUDY AREA

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 in Figure 1. The altitude of the Gori Ganga watershed varies between 626 m and 6639 m. The Gori Ganga watershed has 168 villages and total population is about 40616 (2011). Gori Ganga watershed is the part of Kumaun Himalaya (Indian central Himalaya) region, where Gori Ganga and its tributaries flow from north to south direction develop flat and narrow valley. There is 317 Gram Panchayat less than four administrative blocks (Munsyari 92, Dharchula 62, Kanalicheena 92, Didihat 71) as per Uttarakhand Gram Panchayat report as on 12/08/2016 and 168 villages under three Tehsil (Muansyari 120, Dharchula 08, Didihat 40) as per censes of India 2011. Gori Ganga watershed has total population 40616 (male 20249, female 20367). Female population is higher than the male population in the region and the sex ratio of male to female is 1000:1006. The total population of Scheduled Tribes (9840) and Scheduled Cast (6634) contribute 40.56% (16,474). Although the population is not distributed uniformly throughout the blocks, it is mainly distributed along the Gori Ganga watershed with the average density of 18.53 people per km^2 and population working density of the study area is 1104.62 people per km^2 (COI, 2011). Four types of tribes live in the study area which is Bhotiya Janjati, Rang Samuday, Barpatiya Samuday and Anuwal Samuday. Rang and Barpatiya Samuday is part of Bhotiya Janjati. Anuwal Samuday is part of other backward classes of the study area.

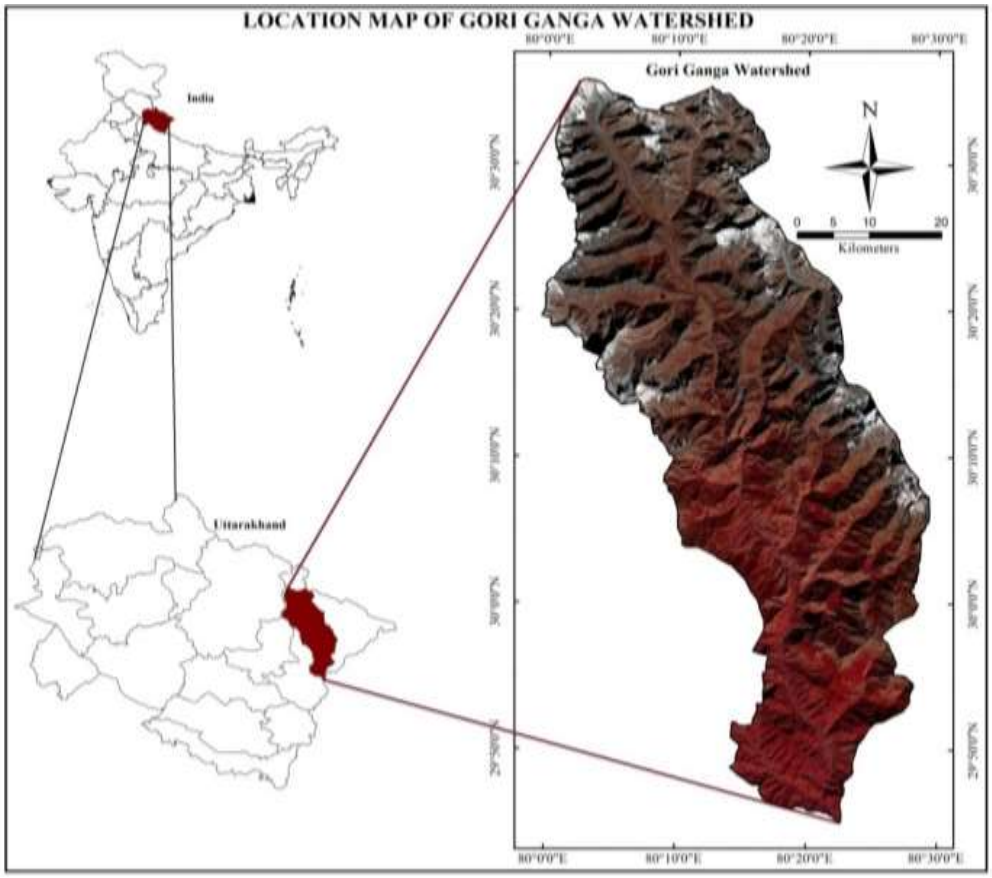

Figure 1: Geographical location and extension of the study area Viz. Gori Ganga watershed, Kumaun Higher Himalaya, Uttarakhand.

4.0 RESULT AND DISCUSSION

The Gori Ganga watershed is constructed of two physiographic regions (Great Himalayan region and Lesser Himalayan region) which are separated by the Main Central Thrust (MCT) where villages, road and drainage network distribution in the Gori Ganga watershed is presenting in Figure 2 and registered in Table- 1. The results LULC obtained through the analysis of supervised classification imagery are diagrammatically illustrated in Figure 3 and registered in Table- 2. A brief account of these results it's discussed in the following paragraphs.

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5.0 PHYSIOGRAPHIC BACKGROUND

The Gori Ganga watershed lies in the Great Himalayan range of the Kumaun Himalaya in the Uttarakhand state. The relief of this watershed varies in between 626 m at Jauljibi to 6639 m in the snow capped mountains. The upper part of the Gori Ganga watershed contains huge alpine and sub-alpine zones locally called Bugyals by the local inhabitants. Those alpine zones extent till the lofty snow covered peaks and so many small natural lakes are also found near Bugyals locally known as 'Kund'. Between the vegetation cover of dense forest at the height of 3000 m to reach down tills the river basin. Gori Ganga valley and slope of mountains are cover unevenly distributed population with rural and traditional settlements far and wide in small clusters between mountain remotes. Most small villages are situated away from the road heads. The valleys are mostly steep down merging the river Gori Ganga.

The valley falls on the tracking routes to some of India's and Uttarakhand's most peaks and trails- Chhipla Kedar, Panchachuli, Trishul peak and seven tributary of Milam glacier with Johar valley, Nanda Devi base camp and Ralam glacier. Traders who are caravans crossed from India into Tibet by the high passes of Unta Dhura and Kungribhingri La trail. Once the trading season was over the entire population of Milam and the surrounding areas migrate to Munsyari or lower during winter. Trade stopped with the Indo-China conflict of 1962 and these once prosperous villages are now deserted. However the trail still exists, linking the villages and beckoning trekkers. Bugyals of this region are used for extracting herbs and as a source of cash income. There are 19 bugyals their names are Chhipla Kedar Bugyal, Thalba Bugyal, Charthi Bugyal, Khamba Bagar, Satper Bugyal, Kolgu Bugyal, Jimba Bugyal, Panchachuli Bugya, Nagini Dhoora Bugyal, Ralam Bugyal, Milam Bugyal, Sumatu Dhoora Bhugyal, Tola Dhoora Bugyal, Burphu Dhoora Bugyal, Bilju Bugyal, Laspa Bugyal, Martoli Bugyal, Bhadeli Bugyal and Kauguri Bugyal. Out of total 168 villages about 50.60% (85) villages are directly and indirectly depended and connected with trade of herbs. The 85 Yarsa-Gambu collecting villages are depended on 19 Bugyals which names are Baram, Kulthum, Bindi, Phapa, Kanar, Buinee, Bona, Dhuratoli, Metali, Paton, Tomik, Lari Pyankti, Chami, Lang, Nirtoli, Quiry, Lumti, Dadabisa, Walthi, Jimia, Jara Jibli, Darati, Madkote, Sain, Bangapani, Darkote, Dunamani, Polo, Mavani, Dummar, Josha, Milam, Darma, Talla Dummar, Gandhi Nagar, Ralam, Seeling, Dhapa, Imla, Panchhu, Khartoli, Synnar, Golma, Ghanghar, Sera, Suring, Chona, Bilju, Sirtola, Ranth, Narki, Burphu, Alam, Dolma, Dobri, Martoli, Sera Ghat, Timphu, Waiga, Tola, Lodi, Dharikhet, Sana, Old Rilkot, Bata, Gaila, Chulkote, Rilkote, Tanga, Basantkote, Wadni, Sumatu, Mulyan Pani, Bhatkura, Okhali, Laspa, Bali Bagar, Uchhaiti, Bhikuriya, Syalthing, Ringu, Bogdyar, Golpha, Dhaula Dhunga and Dheelam.

5.1 Physiographical Regions

Physiographically, the Gori Ganga watershed is constructed of two physiographic regions. There are Great Himalayan region and Lesser Himalayan region separated by the Main Central Thrust (MCT). The MCT passing through the middle part of the watershed which saperate the Great Himalayan rock from the underlying younger rocks of the Lesser Himalayan region. Main Central Thrust (MCT) cross between villages Laspa, Khilanch, Rilkote, Ralam in the Great Himalayan region and Zimiya, Quiri, Leelam, Paton and Bunie villages in the lesser Himalayan region. Physiographic study of the Gori Ganga watershed is based on after Pathak et al. 2015. A brief account of these physiographic regions is given in the following paragraphs.

5.1.1 Great Himalayan Region: In the northern region of the watershed about 942.23 km^2 which accounts for 42.99% of the total watershed is constituted of the regions of the Great Himalaya region. About 7.74% villages (total 13 villages) are situated in the great Himalayan region of the Gori Ganga watershed (Figure 2). The villages which are located in this region are: Milam, Pachhu, Ganghar, Bilju, Mapa, Burphu, Mapa (paar), Martoli, Tola, Rilkote, Ralam, Khilach and Laspa.

5.1.2 Lesser Himalayan Region: In the southern part of the watershed about 1249.4 km^2 which accounts for about 57.01% area of the total watershed is constituted of the regions of the Lesser Himalaya region. About 92.26% villages (total 155 villages) are situated in the Lesser Himalayan region of the Gori Ganga watershed (Figure 2).

5.2 Road Network

The transportation system is a critical component of rural infrastructure and life line of the region. It plays a key role in the economic growth of the study area. It also displays region's economic condition as well as planners' dedication for this region. Transport is an indicator of development and developing transport in the higher mountains regions can be done with many difficulties. The Gori Ganga watershed is very well connected with other part of district Pithoragarh. There are Public Works Department (PWD) and borders road organization (BRO) takes care of maintenance of the roads. There are as many as long and short 30 roads in the Gori

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Ganga watershed and spatial distribution of these roads is presented in Figure 2 while the length is recorded in Table 1. The longest road of the watershed is Munsyari to Jauljibi which passes through Madkote, Seraghat, Bangapani, Baram and its total length is about 76.52 km. This is the very important road for connecting Gori Ganga watershed to Dharchula, Pithoragarh, Didihar etc. and this road is only one road which has metalled.

Table 1: Road network distribution in the Gori Ganga watershed *(based on field visit)*.

S. N.	Road Name	Length (in km)	S. N.	Road Name	Length (in km)
1	Munsyari to Jauljibi	76.52	16	Tanga Road	2.34
2	Balibagar to Farvekote	1.09	17	Bindi Road	2.68
3	Chhori Bagar to Jarajibili	15.71	18	Suring Ghat	3.94
4	Madkote to Doonamani	8.16	19	Phalyati	5.23
5	Josha to Gandhi Nagar	3.62	20	Sarmoli Road	1.08
6	Chouna to Dana Dhar	5.58	21	Milam Road	15.94
7	Sera Pul to Dana Dhar	7.38	22	Sera to Sirtola	1.87
8	Darati pul to Darkote	5.26	23	Baram to Goge	4.45
9	Bunga to Minal Gaon	4.3	24	Baram to Kanar	10.71
10	Munsyari-Danadhar	5.47	25	Imla to Chouna	3.56
11	Dharchula Jauljibi	1.32	26	Madkote to Paton	17.39
12	Madkote to Chulkote	7.9	27	Seraghat to Lodi	4.78
13	Basantkote to Chukotedhar	8.09	28	Sera to Sirtola	1.85
14	Walthi to Gaila	6.04	29	Chami to Metali	5.62
15	Munsyari by Pass	3.06	30	Walthi Bona	25.21
Total					189.63

5.3 Drainage Network

Gori Ganga is the largest tributary of Kali River which receives water from Trans, greater and lesser Himalaya region. Figure 2 depicts the spatial distribution of drainage network of the Gori Ganga Watershed based on DEM by using Arc GIS software. The total length of rivers in Gori Ganga watershed is about 263.05 km having density of 0.120 km/km^2. Gori River originates from Milam glacier at about 3600 m and merging point in Kali River near Jauljibi 600 m from mean sea level. A brief account of the river names, origin place, types, length and confluence geographical point with Gori Ganga is presented in the following paragraph.

5.3.1 Gori Gad: The Gori Gad originates from Milam glacier at 80°22'40.14" E longitude and 29°44'59.64" N latitude. The total length of Gori Gad from Milam to Jauljibi is about 97.97 km from its origin. After origin it flows towards east passing through Madkote, Bangapani, Baram and then finally meets with Kali river at Jauljibi at 80° 7' 13.27" E longitude and 30° 27' 7.61" N latitude.

5.3.2 Goukha Gad: The Goukha Gad originates from Gaukha glacier at 80° 9' 10.23" E longitude and 30° 25' 38.73" N latitude. The total length of Gaukha Gad from Gaukha glacier to Milam village is about 20.39 km from its origin. After origin it flows towards east passing then meets with Gori River at Milam village at 80° 11' 45.24" E longitude and 30° 34' 6.94" N latitude.

5.3.3 Lwan Gad: The Lwan Gad originates from Shalang glacier at 80° 4' 43.04" E longitude and 30° 20' 14.68" N latitude. The total length of Lwan Gad from Shalang glacier to Lwan village is about 12.24 km from its origin. After origin it flows towards east passing then meets with Gori River at Lwan village at 80° 11' 35.25" E longitude and 30° 21' 8.54" N latitude.

5.3.4 Sain Gad: The Sain Gad originates from Khaliya Dhura at 80° 9' 53.58" E longitude and 30° 8' 29.42" N latitude. The total length of Sain Gad from Khaliya Dhura to Jimighat village is about 9.9 km from its origin. After origin it flows towards east passing then meets with Gori River at Jimighat village at 80° 15' 7.56" E longitude and 30° 8' 2.90" N latitude.

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5.3.5 Ralam Gad: The Ralam Gad originates from Ralam glacier at 80° 15' 16.11" E longitude and 30° 10' 49.60" N latitude. The total length of Ralam Gad from Ralam Glacier to Near Paton Village is about 22.99 km from its origin. After origin it flows towards east passing then meets with Gori River at Near Paton Village at 80° 19' 43.53" E longitude and 30° 20' 34.37" N latitude.

5.3.6 Poting Gad: The Poting Gad originates from Poting glacier at 80° 9' 38.37" E longitude and 30° 12' 42.15" N latitude. The total length of Poting Gad from Poting Glacier to Bogdiyar is about 16.67 km from its origin. After origin it flows towards east passing then meets with Gori River at Bogdiyar at 80° 13' 23.98" E longitude and 30° 12' 52.06" N latitude.

5.3.7 Mandakini Gad: The Mandakini Gad originates from Panchachuli glacier at 80° 17' 46.52" E longitude and 30° 03' 8.32" N latitude. The total length of Mandakini Gad from Poting Glacier to Bogdiyar is about 27.95 km from its origin. After origin it flows towards east passing then meets with Gori River at Bogdiyar at 80° 25' 3.52" E longitude and 30° 14' 6.71" N latitude.

5.3.8 Bona Gad: The Bona Gad originates from Jimba glacier at 80° 19' 12.50" E longitude and 30° 0' 32.53" N latitude. The total length of Bona Gad from Jimba Glacier to Seraghat is about 22.69 km from its origin. After origin it flows towards east passing then meets with Gori River at Seraghat at 80° 27' 32.50" E longitude and 30° 8' 46.33" N latitude.

5.3.9 Baram Gad: The Baram Gad originates from Chhipla Dhura at 80° 21' 10.15" E longitude and 29° 50' 56.68" N latitude. The total length of Baram Gad from Chhipla Dhura to Baram is about 15.28 km from its origin. After origin it flows towards east passing then meets with Gori River at Baram at 80° 25' 16.07" E longitude and 29° 56' 58.36" N latitude.

5.3.10 Rauntis Gad: The Rauntis Gad originates from Ghanghura Dhura at 80° 16' 13.36" E longitude and 29° 52' 11.57" N latitude. The total length of Rauntis Gad from Ghanghura Dhura to Garjiya is about 16.97 km from its origin. After origin it flows towards east passing then meets with Gori River at Garjiya at 80° 21' 20.74" E longitude and 29° 46' 35.26" N latitude.

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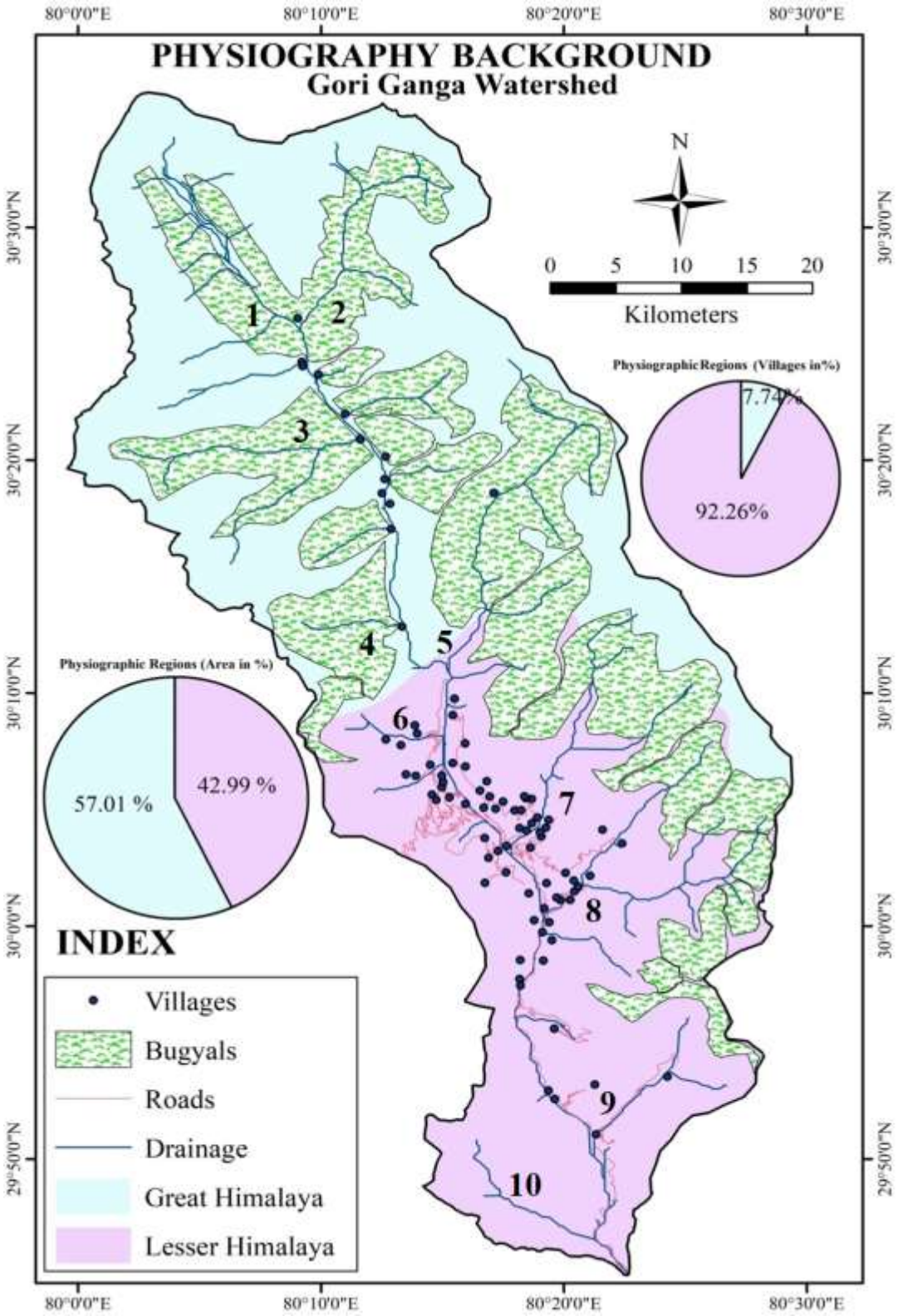

Figure 2: Geographical location of Physiographic regions and distribution villages in the Gori Ganga watershed *(after Pathak et al. 2015).*

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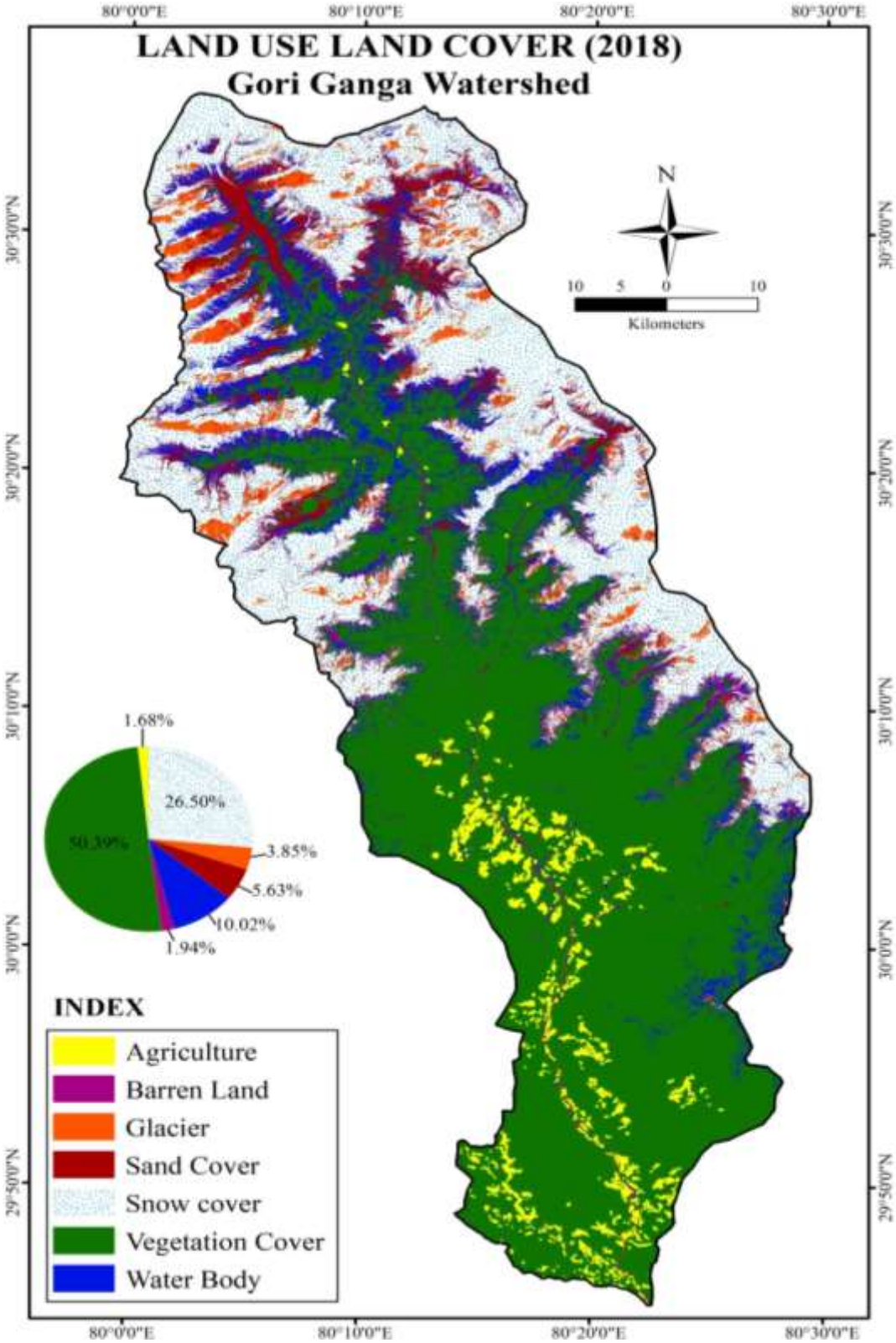

Figure 2: Geographical distribution of Land Use Land Cover (LULC) classification in the Gori Ganga watershed *(based on Sentinel-2, October 2018).*

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6.0 LULC IN GORI GANGA WATERSHED

The remote sensing technology is currently being offered a wide variety of digital imagery that covers most of the earth's surface. This up-to-date image data is a promising tool for producing accurate land cover maps. Although the terms "Land Use (LU)" and "Land Cover (LC)" are sometimes used interchangeably, they are actually different. Simply put, land uses describe how the land is used and land cover is what covers the surface of the earth like land use example includes: Agriculture land, settlement etc. and land cover classes includes: snow, glaciers, grassland, vegetation, water etc.

In this work a LULC classification scheme of Gori Ganga watershed area is generated on the basis of United State Geological Survey (USGS) classification system, concerning the existing LULC features of that area. For the study of existing land cover classification of the study area, satellite data of Santinal-2 of 2018 was used. The results obtained through the analysis of satellite imageries are diagrammatically illustrated in Figure 3 and data are registered in Table- 2. Total LULC status of Gori Ganga watershed reveals that in 2018 about 26.50% (580.86 km^2) area was covered with snow, 3.85% (84.33 km^2) area was covered with glacier, 1.93% (42.39 km^2) area was covered with barren land, 5.63% (123.31 km^2) area was covered with Sand cover area, 10.02% (219.53 km^2) area was covered with water body, 50.39% (1104.49 km^2) area was covered with vegetation and 1.68% (36.72 km^2) area was covered with agriculture area in Gori Ganga watershed.

Table 2: LULC categories in Gori Ganga watershed in 2018 *(based on Sentinel-2, October 2018)*.

S. N.	LULC Categories	Area		Cumulative Area	
		in km^2	in %	in km^2	In %
1	Snow Cover	580.86	26.50	580.86	26.50
2	Glacier	84.33	3.85	665.19	30.35
3	Sand Cover	123.31	5.63	788.50	35.98
4	Water Body	219.53	10.02	1008.03	46
5	Barren Land	42.39	1.93	1050.42	47.93
6	Vegetation Cover	1104.49	50.39	2154.91	98.32
7	Agriculture	36.72	1.68	2191.63	100

7.0 CONCLUSION

The fundamental objectives of this chapter is to classifications of the LULC by using supervised classification using remote sensing and GIS techniques in the Gori Ganga watershed of Kumaun Himalaya, Uttarakhand (India). Based on the previous study following can be concluded.

I. The Gori Ganga watershed is constructed of two physiographic regions. There is northern part Great Himalayan region about 942.23 km^2 which accounts for 42.99% where 7.74% villages (total 13 villages) are situated and southern part is Lesser Himalayan region about 1249.4 km^2 which accounts for 57.01% area where 92.26% villages (total 155 villages) are situated in the watershed.

II. Gori Ganga watershed has many as long and short 30 roads. Where longest road of the watershed is is Munsyari to Jauljibi which passes through Madkote, Seraghat, Bangapani, Baram towns and its total length is about 76.52 km. This road found very important for connecting enterer villages and towns of Gori Ganga watershed to Dharchula, Jauljibi, Pithoragarh and Didihar etc.

III. Gori Ganga River is receives water from Trans, greater and lesser Himalaya region where 10 major tributaries rivers accounts total length about 263.05 km having density of 0.120 km/km^2. All 7 tributary rivers are glacial fed river and only three tributaries Raunits, Baram and Sain Gad is non-glacier fed river. Gori River originates from Milam glacier at about 3600 m and Confluence point in Kali River near Jauljibi 600 m from mean sea level.

IV. LULC of Gori Ganga watershed in 2018 about 26.50% (580.86 km^2) area was covered with snow, 3.85% (84.33 km^2) area was covered with glacier, 1.93% (42.39 km^2) area was covered with barren land, 5.63% (123.31 km^2) area was covered with Sand cover area, 10.02% (219.53 km^2) area was covered with water body, 50.39% (1104.49 km^2) area was covered with vegetation and 1.68% (36.72 km^2) area was covered with agriculture area in Gori Ganga watershed.

V. Remote sensing and GIS are very useful techniques for Land Use Land Cover classify in the Gori Ganga watershed.

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