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Physiography and Geology of Gori Ganga Watershed, Kumaun Higher Himalaya

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Abstract: ***The present study is an attempt to examine the physiography and geology of Gori Ganga Watershed, Kumaun Himalaya, Uttarakhand (India). The study completed of physiography using after Pathak et al. 2015 and geology used natural resource data management system data from Department of Geography, S.S.J. Campus Almora, Uttarakhand (India) is using after Valdiya 1962, 1968, 1978, 1979, 1980 and 1981; Valdiya and Gupta 1972 and Bhatt et. al. 2018 studies. Gori Ganga watershed has two great physical diversities on the basis of physiographic features and six lithological formations under five geological groups and which includes in the present study. The geological study is most important for social problems, such as energy, water, mineral resources, environment, climate change and natural hazards like landslides, volcanoes, earthquakes and floods. The demand is growing at present for well-trained geoscientists with geological knowledge and remote sensing and geographic information system knowledge.***

Keywords: Physiography, Geological Groups, Lithological Formations

1. Introduction

Meaning of Physiographic is a description of the features and phenomena of nature. Physiographic is the subfield of geography which studies physical patterns and processes of the mother Earth. An aim of the physiographic study is to understand the forces that produce and change rocks, oceans, weather, and global flora and fauna patterns. Naturally Physiographic maps are represents of cartographic of the broad-scale physical regions of a study area, often based on relief, slope, aspect and geologic structure (Raiz, 1931).

Geology study is the science that studies the Earth's physical structure and substances, the history of rocks, the processes that act on them and the most economic way to use the world's resources. Geological study is involves many methods and knowledge's from biology, chemistry, physics and mathematical subjects. Geology is the basic various features and natural resource it like faults, folds and lithostratigraphy are responsible for creating variation in other resources (Bandooni, 2004). In subsequent papers, Valdiya (1962, 1978, 1979, 1980 and 1981) too modified his ideas about Uttarakhand Himalayan geology which are divided in many types of geological groups and geological formations with Kumaun and Garhwal Himalaya. Also the Auden (1937); Heim and Gansser (1939), studies in Garhwal Himalayan geology series of Chamoli-Tejam zone and studies by Bhattacharya 1981, in the Loharkhet area of the lesser Himalayan rocks between Berinag and Saling formations.

2. Methodology

For the present study geographic information system (GIS) of physiographic and geological map (Figure 3, 4, and 5) was prepared using Arc GIS Software. The Gori Ganga watershed basin was delineation using Digital Elevation Model (DEM) based on Cartosat-1 data (Figure 2). Basic data for physiographic using after Pathak et al. 2015 and geological study mapping data received from Natural Resources Data Management System (NRDMS) center, Department of Geography, S.S.J. Campus Almora (Uttarakhand) is using after Valdiya 1962, 1968, 1978, 1979, 1980 and 1981; Valdiya and Gupta 1972 and Bhatt et. al. 2018 studies.

3. Study Area

The study area, viz., the Gori Ganga watershed (Kumaun Himalaya) (Figure 2.1) 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 about 2191.63 km^2. The altitude of the Gori Ganga watershed varies between 626 m and 6639 m (Figure 2). The Gori Ganga watershed has 168 villages and total population is about 40616 as per 2011 censes.

4. Result and Discussion

For the present study physiographic and geological study of Gori Ganga watershed data collection from secondary and primary sources and used for mapping are registered in table. Physio-graphically, the Gori Ganga watershed lies in the major physiographic regions of the Himalaya. There are great Himalayan region and lesser Himalayan region (Figure 3). The spatial distribution of the above litho-logical formations of the study area depicts figure 4, 5 and table 1.

5. Physiography

The Gori Ganga watershed lies in the Great Himalayan range of the Kumaun Himalaya in the Uttarakhand state. Figure 2 is depicts the DEM of the Gori Ganga watershed varies in between 626 m (Jauljibi) to 6639 m (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 also found so many small natural lakes in Bugyals/grassland 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 come apart by perennial very small stream emerging through the forest covers of the river basin.

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 migrated 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/grasslands which 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. Physiographically, the Gori Ganga watershed lies in the major physiographic regions of the Himalaya. There are great Himalayan region and lesser Himalayan region (Figure 3). Physical study of the Gori Ganga watershed is based on After Pathak et al. 2015 which is finding two different physical divisions. A brief account of these physiographic regions is given in the following paragraphs.

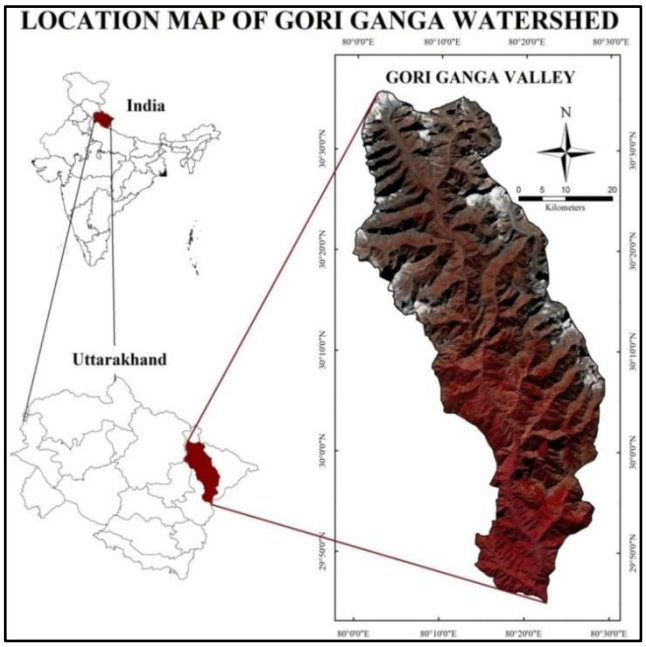

Figure 1: Location map of the study area viz. Gori Ganga watershed, higher Himalayan region Kumaun Himalaya

(i) Great Himalayan Region

The great Himalayan region is the bigger physical region of the Gori Ganga watershed includes area is that about 942.23 km^2 which accounts about 42.99% area of the total watershed area has great Himalayan region. About 7.74% villages (total 13 villages) are situated in the great Himalayan region of the Gori Ganga watershed (Figure 3). The villages which are located in this region are: Milam, Pachhu, Ganghar, Bilju, Mapa, Burphu, Mapa (paar), Martoli, Tola, Rilkote, Ralam, Khilach and Laspa.

(ii) Lesser Himalayan Region

The lesser Himalayan region is the bigger physical region of the Gori Ganga watershed includes area is that about 1249.4 km^2 which accounts about 57.01% area of the total watershed area has lesser Himalayan region. About 92.26% villages (total 155 villages) are situated in the lesser Himalayan region of the Gori Ganga watershed (Figure 3). Main Central Thrust (MCT) is an orogen-parallel ductile thrust fault which separates the greater and lesser Himalaya cross from Ranthi, Falanti, Darati, Ghorpatta Malla, Bunga, Namjala, Dummar Malla, Jaiti, Ghorpatta Talla, Diya Palla and Gopal Bara villages in the lesser Himalayan region of Gori Ganga watershed.

6. Geology

New stratigraphic framework of the inner as well as outer lesser Himalayan rocks of Kumaun, was suggested by Merh and his associates (Merh 1977; Shah and Merh 1978; Chamyal and Merh 1985; Chamyal et al. 1989). Geological study of the Gori Ganga watershed is based on After after Valdiya 1962, 1968, 1978, 1979, 1980 and 1981; Valdiya and Gupta 1972 and Bhatt et. al. 2018 which is finding six different rock formations under four geological groups, these are:

(i) Martoli Formation
(ii) Nahardevi Formation
(iii) Munsyari Formation
(iv) Sor/Thalkedar Formation
(v) Barinag/Nagthat Formation,
(vi) Jutogh Formation,

Table 1: Distribution of area under different geological group of the Gori Ganga watershed (*after Valdiya 1962, 1968, 1978, 1979, 1980 and 1981; Valdiya and Gupta 1972 and Bhatt et. al. 2018*)

S.N.	Geological group	Geological formation	Area (in km^2)
1	Tethyan sequence	Martoli	360.12
2	Vaikrita	Nahardevi Granite	1034.5
		Munsyari	469.61
3	Tejam	Sor/Thalkedar	289.61
4	Jaunsar	Barinag/Nagthat	21.03
5	Almora	Jutogh	16.73
Total area			2191.63

The spatial distribution of the above litho-logical formations of the study area depicts Figure 4, 5 and Table 1. A brief account of each rock formations is presented in the following paragraphs.

(i) Martoli Formation

This zone stretches from village Martoli to the origin of river at Milam glacier. The Martoli formation are finding in the study area under the Tethyan sequence group. Total area

covered by this group is 360.12 km^2. Tethyan sedimentary zone is the most degraded part of the Gori Ganga watershed. Moraine deposits are a common feature find on either bank of river Gori Ganga. Lithology succession of Tethyan sequence findings are basal conglomerates, phyllities and quartzites (Bhatt et. al., 2018).

(ii) Nahardevi Granite Formation

Nahardevi Granite Formation observed near village Leelam and around Kalamuni Pass, Munsyari and Dummar a type section in Gori Ganga basin. From Leelam village to further north, high grade metamorphic minerals are noticed up to village Martoli. Like; Garnet quartz schist, Migmatoid gneiss with intrusion of tourmaline Granite and Pegmatite, Inter-bedded staurolite schist, kynite gneiss and quartize etc. (Bhatt et. al., 2018). The Nahardevi Granite formation of rocks occupy total area is 1034.5 km^2 in the Gori Ganga watershed.

(iii) Munsari Formation

Munsari formation observed around Kalamuni pass, Munsyari and Dummar a type section in Gori Ganga basin. The lithology and grade of metamorphism found in the study area is greenschist, Amphiboliteand gneisses and this formation corresponding to the lower Crystallines unit and the Vaikrita group to the upper Crystalling (Valdiya, K. S., 1980). The Munsari formation of rocks occupy total area is 469.61 km^2 in the Gori Ganga watershed.

(iv) Sor/Thalkedar Formation

Sor/Thalkedar formation observed near Madkote and Umargarha village under the Tejam group in Gori Ganga basin. Some metamorphic minerals are noticed in present groups are Quartzite, white crystalline limestone with talk pockets, Granite/Gneissose granite with occasional bands of mylonite, Limestone inter-bedded with grey slates and black phyllites. The sedimentary sequence rocks are exposed between Balmara and Jauljibi. Total area under this group is 289.61 km^2. This region has so many thermal water springs between Devibagar and Badeli (Bhatt et. al., 2018).

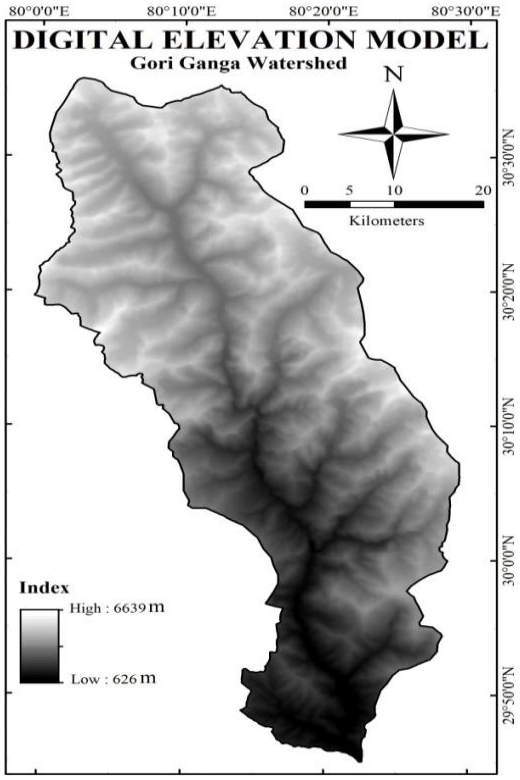

Figure 2: Digital elevation model of the Gori Ganga watershed (*based on Cartosat-1 satellite, data*)

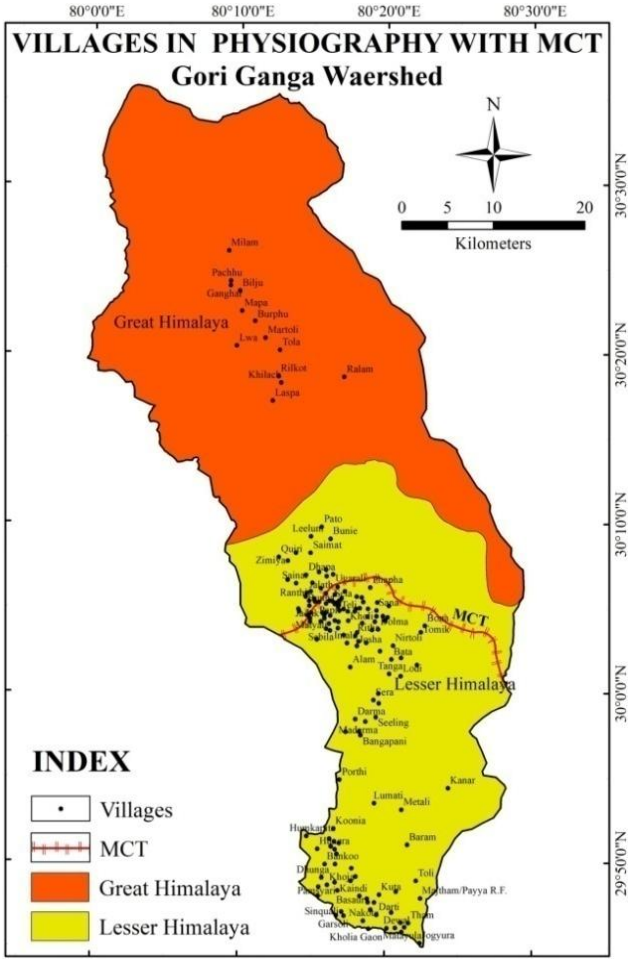

Figure 3: Villages on physiographic map of the Gori Ganga watershed *(after Pathak et al. 2015)*

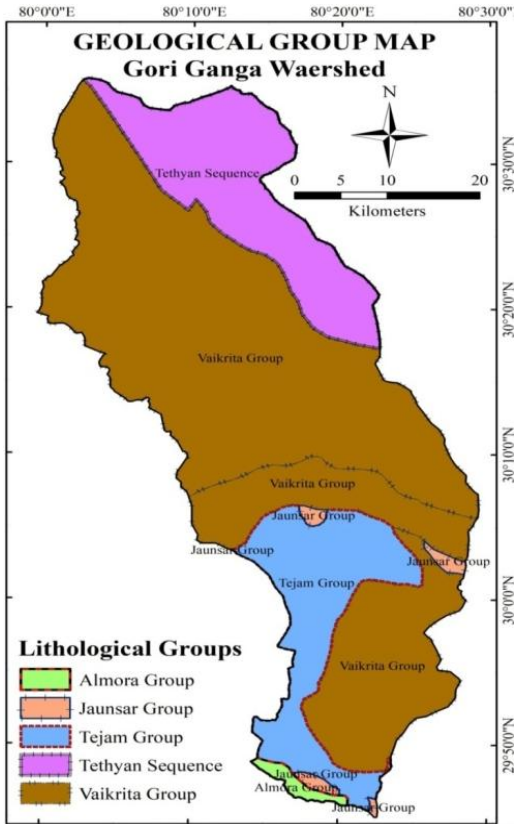

Figure 4: Geological group map of the Gori Ganga watershed *(after Valdiya 1962, 1968, 1978, 1979, 1980 and 1981; Valdiya and Gupta 1972 and Bhatt et. al. 2018)*

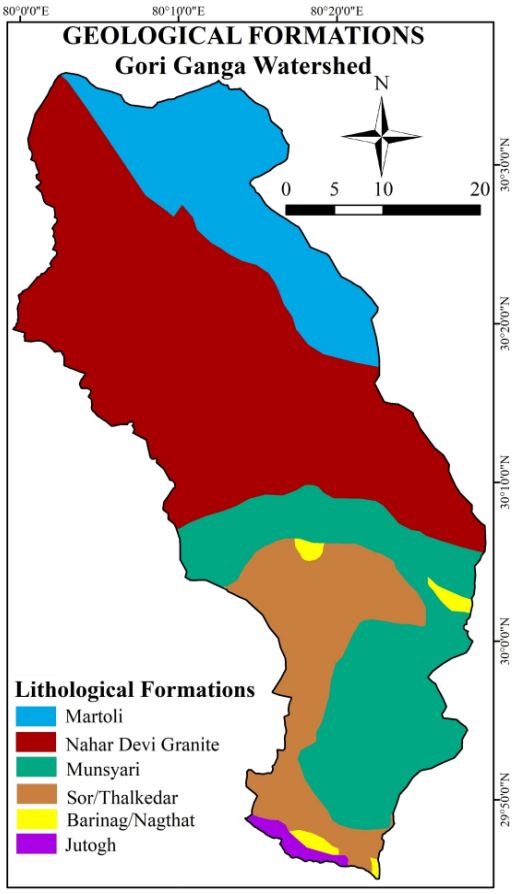

Figure 5: Geological formation map of the Gori Ganga watershed *(after Valdiya 1962, 1968, 1978, 1979, 1980 and 1981; Valdiya and Gupta 1972 and Bhatt et. al. 2018)*

(v) Barinag/Nagthat Formation

Barinag/Nagthat formation of rocks is observed near Munsyari and near Sera Gad. This group has two types of formation Berinag formation and Nagthat formation. Near the Pithoragarh Berinag is similar to the Nagthat (Valdiya, 1968). After study by Valdiya 1962, Berinag formation covering a large part in the inner lesser Himalaya the Berinag quartzites are in all likelihood of the Nagthat. Berinag forms has locally minerals are dynamo thermal metamorphism, comprising sericitic quartzite, sericite-quartz schist, schistose amphibolites and chlorite schist. Total area covered by this group is second smallest 21.03 km^2 which found in middle and southern part of the watershed. Talc deposits are notable near Painya-Pauri and Imkhola west of Balwakot in the Gogi Ganga Basin. Those are very high economic value and are being exploited profitably for resident of near villages. Those talc are very high quality and suitable for using in preparation of cosmetics (Valdiya 1980).

(vi) Jutogh Formation

Jutogh formation of rocks is observed near Askote in the Gori Ganga watershed. This is known as the crystalline zones of Nandprayag, Baijnath, Dharamghar, Askote and Chhiplakote (Valdiya and Gupta 1972). This is smallest group at Gori Ganga basin; covered total area is 16.73 km^2. There are four major types of schist's are identified; chlorite schist, sericite-chlorite schist, biotitesericite schist and graphic schist. First three schist are constituting the lower part of Munsyari formation (Valdiya 1980).

7. Conclusion

The Present study was carried out in a Kumaun Himalayan Watershed, viz., the Gori Ganga Watershed. The study based on physiographic and geological study. The Gori Ganga watershed has two parts of phisiography and one Main Central Thrust is a major geological fault cross the study area. According to geologist the Indian plate has pushed under the Eurasian Plate along the Himalaya. It is evident for the study area is lies in a geologically active area which is cause for the major earthquake. The Gori Ganga watershed has five geological groups and six lithological formations.

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