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A Geomorphological Study of Hiyunl River Basin: A Tributary of Ganga River

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1. Introduction

Geography is the subject which describes the earth surface - its physical features, climate, vegetation, soils, peoples and their distribution. Geomorphology is one of many branches of geography which deals with the study of the land forms or physical features of the earth and the relationship between landforms and the geological structure beneath. In other words, the Geomorphology is a study of interrelationship of underlying structure and overlying processes. Thus, Geomorphology is the scientific study of origin of Land forms based on cause-and-effect relationship. Geomorphology is older subject, but had developed rapidly during 1940s. Geomorphology, in India started as physical-geography/ geology with the work done by early geologists. The Geological survey of India (GIS) did a pioneering work in describing the physical features of an areas as a prelude to its stratigraphy, lithology and tectonics. GSI brought the focus on mountains, plateaus, rivers, plains, lakes, volcanoes and other features. The analysis of these major features was analysed on the basis of facts known to human being till mid of 19th century. In India, foundation for the study of physical geography and geomorphology was laid with Major Rennel's account (1781) of the Ganges and the Burrrampooter (Brahmaputra), Buchanan's account (1807) of laterites of Malabar (now Kerala), Fergueson's early account of the river Ganga deltá (1863) by all standards good work of Geomorphology. In 19th Century the considerable workers were Burrard (1912) Oldhams (1917), Pascoe (1919), Pilgrim (1919) and Krishan (1940), all did work on Indo- Braham and Siwalik rivers. Around middle of century, seriously engaged scholars. Were H.L. Chibber, S.P. Chatterjee and S.C. Chatterjee, Kalyan Sundaram and Muthuswamy. At present geomorphic work has been done for various regions of India. A brief survey of literature concerning geomorphic studies is given below.

2. Previous Literature

Literature at international level on drainage basin morphometry is too voluminous to review it hear. The interest in drainage basin morphometry has grown since the publication of a pioneering work on drainage basin by R.E. Horton (1945). The work of Horton has been built upon and extended since the knowledge of the mathematical properties of drainage basins greatly extended. Horton was first who realised that dynamicity of drainage basin and its hydrological characteristics and closely related to their morphology. He analysed the interrelationship of the function of drainage basin to the numerical values.

Some notable contributions from international workers in the field of drainage morphomtry are by Dury (1952), Strahler (1952 & 1964). Schumm (1956), Melton (1958), Kesseli (1946), Miller (1953), Russel (1949), Simth (1958), Morisawa (1962), Schiedegger (1965), Shreve (1967).

In India also the literature on drainage basin morphometry is no less voluminous and all the studies deal with various drainage basins of different size from different physiographic, lithologic and climatic

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regions. Some of the noteworthy contributions are - Gupta, Ajit and Chakroborti (1965), Ghosh and Pandey (1963), Singh and Gheesa Lal (1965), Sharma (1968), Singh and Kumar (1969), Labh Singh (1970 & 1971), Kharkwal (1970 & 1971), Saroj K. Pal (1972), Verma and Tandon (1971& 1974), Agrawal, Meera (1972), Sidhu and Pandey (1974), Anil Kumar (1973), Sharma and Padmaja (1977 & 1978), Srivastava, Renu (1978), Singh (1978 & 1980), Subramanyam (1976) and R.L. Singh (1967). The data and results in all these papers satisfying the laws of morphometry of horton, strahler, chortey and shumm besides throwing **com correlations with lithology and climate.**

3. Study Significance of the Problem

Any earth science starts with observations of natural phenomena and geomorphological studies receive the upper hand in observation of these natural phenomena on the earth surface. Geomorphic studies are not only academic interest now, but occupied important place in applied field viz. terrain evaluation, watershade management, landuse planning, civil engineering, regional planning, defence arrangement and environmental planning. Earlier geomorphic studies were more quantitative in nature. Now days the recent scientific techniques are used in geomorphic studies which make it more applied. Drainage basin is the best geographical unit of geomorphological study in the Himalayan terrain. It is the unit which is basic to the transmission of energy from climate through geomorphological processes to give morphological landforms. Drainage basin unit is most useful where weathering, mass movement and water flow provide the basis of landscape morphogenesis. This deduction therefore produced the concept of the basin as an area of the land within which precipitation could generate stream flow. Studies of the morphometry **of stream networks were advocated by R.E. Horton in 1945 and 'laws'** of drainage composition were tested and eventually rejected as it was appreciated that they were the consequence of the statistics underlying the methods of ordering. Drainage basin characteristics of relief, soil, land use and rock type modify inputs of water and radiation by different processes. The other important aspects of the drainage basins are hydraulic geometry, river channel patterns, drainage basin dynamics and drainage discharge and sediment yield. Thus, the drainage basin has been selected for geomorphological study.

4. Selection of the area

Geomorphologically the Hiyunl river basin forms a diversified morpho-unit an account of varied changes in geological structure, tectonic sequence and landforms. Basically, it is a structural valley. Hiyunl river flows along the fault line which accross the Ganga River near Shivpuri. In the opposite side the eastern Hiyunl river flows along the same fault line in the NE io SW direction. Out of the major fault there are large numbers of local faults which controlled the landform pattern. The basin terrain is under many geological sequences. Large are in under limestone topography. The existing landforms of the basin are severally depleted by the geo-catastratic processes i.e. landslide, rockfall, soil creeping, debries flow, erosional, depositions etc. which are also stimulated by the anthropoganic activities i.e. deforestation, construction of roads, canals and settlements and other activities. The valley terraces are intersively cultivated and densely populated while the mid-slopes are moderately cultivated and moderately populated. Besides these the upper reaches are 'spassely populated and dense forested. Anthropogenic activities are degrading the basin topography by construction of roads on hills slopes, canals in the lower valley bottoms, limestones quarries, stone mines, deforestation etc. All jointly are increasing the soil. erosion, upgraded valley bottoms and siltation load on the river channels.

The proposed study envisages to conduct an intensive geomorphological study of the basin of so that physical environmental planning might be suggested.

5. Objectives of the study

1.The following were the main objectives of the present study:

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2. To evaluate the terrain through geological character and morphometric attributes i.e. slope, relief and drainage.
3. To assess the natural hazards, intensity and their mapping.
4. To classify the entire basin into different land systems after comprehensive geomorphological mapping.
5. To assess the anthropogenic activities in the basin and their effects on environmental degradation.

6. Hypotheses

The following hypothesis can be made for the present study:

1. That landforms of the basins are structurally controlled and produced by different processes in different time.
2. That the natural hazards are the results of slope, lithology and rainfall.
3. That the anthropogenic activities in the study area are the responsible factors for environmental hazards.

7. Research Anthropology

The study requires wide range of geomorphological data. The following research techniques were applied for the completion of scientific study:

7.1 Topographical Interpretation

The base map was prepared on the basis of large-scale topographical sheets. Other topographical details i.e. drainage contour, altitude, general landuse etc. was dispicted by the use of topographical sheets.

7.2 Morphometric Analysis

The morphometric analysis of drainage, slope and relief was analysed by the use of traditional methods and recent techniques. Geomorphological and Hazard Mapping: The geomorphological map was prepared on large scale topographical map (1 : 25000) and comprehensive field study. Hazard mapping was completed on five times enlarged large scale maps. The field study visual interpretation and local knowledge regarding hazards was the basic techniques of hazard mapping.

7.3 Field study

The field study and ground truth traverses were conducted by longitudinal and transverse field traverses along the valley, tributaries, mountain ranges and across the valleys and ridges.

7.4 Data Analysis

Resource use data was collected by primary and secondary sources. The spatial interpretation of the data requires preparation of maps and diagrams. Cartographical representation to be helpful in the geomorphological evaluation and analysis of the data of the Hiyunl river basin.

8. Location

The present study area is the basin of the Hiyunl river, a tributary of the Ganga River which drains the North-Western part of Tehri Garhwal (Fig. 2.1). encompassing an area of 252.74 km2. It extends from 78°17' E to 78° 25' E longitude and 30° 08' N to 30° 26' N. latitude. The Hiyunl river originates from the south & south eastern slopes of the Surkunda mountain range at a height of 2770 m and joins Ganga at Shivpuri at a height of 375 m. The basin has been delineated with the help of water partings of the Bhagirathi River in the east and the Tons (Yammuna) river in the west. The northern boundary of the basin is demarcated by Uttarkashi district. The Eastern part is demarcated by Dehradun.

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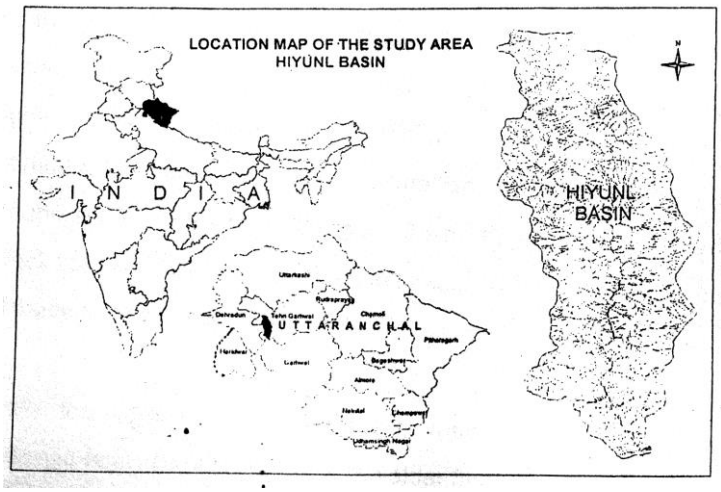

9. Showing location of study area

The Hiyunl river valley has the charm of Tehri Garhwal region. Verdent mountain ranges, garlands of peaks, valleys, high peak, steepest scarp, deepest gorges, water falls, river terraces and plain staking cultivation by the simple people combine to crete a delightful landscape. The 2011 census enumerated 618,931 persons in the District Tehri Garhwal.

10. Physical background

Although the area enjoys sub-tropical and temperate types of climates, there is much diversification in the climatic conditions. Three climatic seasons experienced over here are summer season, the rainy season and cold weather season. Generally, it enjoys the typical monsoonal character with the seasonal variability of rainfall being greater than the annual one. The soil types are associated with terrain characteristics, variations in vegetation and climatic aspects. Four soil types such as Loam to Loamy Clay, Alluvim Forest soil to clay Loam have been categorised here. The topography, rock types, climate, soil and drainage combinedly produce a variety of natural vegetation such as Sal, Chir, Deodar and Sub-Tropical decides forest.

11. Geological Structure of Hiyunl River Basin

Devoted to the general geology and structural setting of the area. The study region witnessed severe phases of structural and tectonic disturbances; hence, the geology is highly complex. These elements also contributed greatly to the evolution of the present natural landscape. Two main structural features i.e.(i) Garhwal Groups (ii) Shimla Groups, are well marked in the region. The north-eastern part is, however, occupied by rocks of the Krol series, ascribed to the Lesser Himalayan system. The formations of these two systems are separated from each other by Shimla group of rocks.

Structurally, the area is complicated due to repeated folding, faulting and thrusting. The thrust-faults have brought out the older formations over the younger formations. In the west of Nagni, due to the existence of a major anticline, the rocks exhibit easterly as well as westerly dips facing each other with the regional axis trending NW-SE. The trend of this axis indicates that probably the line of action of the tectonic forces was in a NE-SW direction. Faults in the area can be traced along the axial plane of these folds. These faults are generally striking in NW-SE direction.

In the area under investigation, there seems to be a close relationship between the present-day landforms and the structural and tectonic feature i.e., folds, faults, thrusts etc. The course of present-day drainage pattern also follows the trend of weak zones i.e. faults. The varying lithology of the rock formations and the Lith tectonic boundary of the area also guide the course of drainage patterns.

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12. Relief analysis

The analysis of absolute and relative reliefs along with the dissection index to explain the nature of topography. The relief analysis of the area brings out certain interesting facts about the Hiyunl river Basin. It has been depicted with the aid of the analysis of absolute height, relative relief, dissection index, area, height breakup and profiles (superimposed, composite and projected with NS and WE base lines). The area-height breakup clearly indicates that a large proportion of the area (18.11 percent) falls in the altitudinal zone of below 1000 metres followed by 1000 - 2000 (75.79 percent). Beyond these height-groups the areal shares of the altitudinal zones decreases so much so that it is only -76.09 percent for above 2000 metres. The chirographic curve follows trend of hypsometric curve: The higher altitudinal zones of Bandla and Naina Devi present submits of continuous land surfaces.

The relative relief explains the total morphological character of the landforms more explicitly than absolute relief. The five categories of relative relief sharing uneven distribution, are 3.37% (below 450), 7.70% (450 - 600), 50.30% (600 - 750), 33.97% (750 - 900) and 4.67% (above 900). The study of relative relief reveals that denudational work is still under its process of eroding the higher slopes and no erosional surfaces could be developed.

The area is passing through young to early region. The following conclusion

The area is passing through young to early region. The following conclusion have been drawn from the relative relief analyses:

- Low relative relief zones are mainly confined to area near sabli village.
- Moderate relative relief zones are situated contiguous to the low relative relief zones.
- Moderately high relative relief regions are confined to all valley flat areas and lower slopes of study area mainly on tal and Shimla formations.
- High relative relief areas and found where mountain ranges have been cut into deep valley and minor divides. The existences of very high relative relief concides with the still standing high crestal tops of the mountain ranges mainly on Krol formations.

13. Slope analysis

The slope morphology of the present terrain may be explained as an outcome of combined control of structure, endogenetic forces, intensive weathering and combined processes of erosion and transportation of detrital matter. Latest computer software has been used for analysing the area into slope categories. The average slope values have been grouped into six classes ranging from below 3° to above 55°. The gentle moderate, moderately steep and steep slope categories cover 18.46, 23.71, 33.26, 24.56 and 0.31 percent of the area respectively. The slope development in the area is primarily guided by the lithology and tectonics. For the support of the slope evolution of the region, slope profiles have been discussed.

14. Drainage Morphometry

The analyse the drainage morphometry which is one of the most important elements of landform study. Drainage analysis early reveals the impact of varying nature of lithology of the rock formation and the lithotectonic boundary of their area on the distribution of streams and their characteristics. The region with moderately steep slope and moderate drainage frequency has, in general, moderate drainage density. The Hiyunl river with its major tributaries is, apparently, more significant in carving out predominantly 'V' shaped valley indicates towards down-cutting, everywhere, simultaneously adjusting to the upheaval of the Himalayas interrupted by tectonic movements. The morphometric measures have been applied to assess the form of selected sub-drainage basins. This analysis is also an attempt to find out the stages in the geomorphic developments of Hiyunl river basin with the help of morphometric attributes, namely, stream order, stream number, bifurcation ratio, relief ratio, circularity ratio, sinuosity index and drainage density.

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15. Morphological Mapping and Terrain Classifications

Morphology of landforms is discussed. The stratigraphy and diastrophic history of the area contribute greatly to explain the evolution of the present natural land scape alongwith drainage, relief, climate and geomorphic processes. There are evident in the ferm of narrow v-shaped valley, breaks in longitudinal profies, interlocking spurs, boulders, cobbles and pebbles of various rocks. Land forms of Hiyunl river basin are classified and grouped according to structure, hieght and processes, Structurally, there are two main groups-garhwal and Shimla groups of rocks.

16. Environmental Hazards

Hiyunl river basin is a part of highly un-stable region of world popularly known as Himalayan region. Un-scientific and un-planned land use increased the risk of hazards both natural and created by human beings Earthquaes, heavy rain, snow fall, weathering and landslides are common hazards of Hiyunl river basin. More recently rapid increase of construction work and construction of new roads also increase the toll of hazards. Consequences of these hazards are discussed in this chaper-VIII and researcher trying to give remedial measures to check the hazards in same chapter.

17. Conclusion

The Hiyunl river, a right bank tributary of the river Ganga, flowing through the young and lofty ranges of Himalaya which is composed of various geological formations. The region is known for their erosional as well as flood havocs. The catchment of this river has mostly been clearing for extension of agriculture, roads, settlements, water pipe lines, drugging for tele communication cables network and most recently construction of poles power lines from Tehri Hydro project, discrupting the overall ecological balance. As a result, during monsoon season, the soil and debris slips in, the form castastrophic landslides involving millions of cubic metres of debris. Being in effective disposing of such huge load deposit on beds of small stream and main channel, forming several sand bars and debris bar in the lower reaches where water velocity falls due to the lessening in gradient obstructed by several such bars, the flow of the river temperarty blocked or divided the river channel into multi-chennels, often forming a braided pattern. Moreover, during heavy rain, the river water rushing the low level tarraces which are the main and fertile land available for cultivation in Hiyunl river basin.

Immediate steps have, therefore, been proposed for suitable afforestation on valnerable slopes, restriction of road and houses construction on stable geological formations only, and the propogation of scientific knowledge for the peoples of Hiyunl river basin will promote the ecological balance. Moreover, the supply of an alternative source of energy in the form of LPG, solar energy or mini-Hydro project will contribute to incease the vegetation cover of Hiyunl river basin.

As a result, the afforested slope in the near future, will not yield soil and debris under heavy rain and a large amount of the rain water will be stored in the sub soil. This will keep the water for dry season and supply sufficient water to streams and also check the flood. This will also help to strengthening of local economy and ecological balance of strategically important part of Hiyunl river basin of the Himalaya. Thus, the following hypothesis have been proved in present study :

- That landforms of the basins are structurally controlled and produced by different processes in different time.
- That the natural hazards are the results of slope, lithology and rainfall.
- That the anthropogenic activities in the study area are the responsible factors for environmental hazards.

18. Suggestions

- More geomorphological researches should be conducted in the field of Environmental management for better recreational planning.

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- Before any human use of Natural resources geomorphologist should be consulted.
- A data base should be prepared for proper use of water resources/ water management
- Social forestry should be promoted with the help of local village communities.
- Reserve forests should be protected from fire. Forest exploitation should also be banned in ecologically sensitive and geologically unstable areas.
- Landslide prove area should be identified in advance and check walls must be constructed in Landslide prove areas.
- Disaster management schemes should be selected according to ground realities. Participation of common people be increased in area planning.
- At last, geomorphologists views must be considered for land use planning and management while working on highly un-stable terrains like Himalayas.