The Himalayan Review
Nepal Geographical Society

Vol. XX-XXIII
1989 - 92

Morphometric Properties of the Drainage Basins in the Chure Range, Nepal

- *Narendra Raj Khanal**

INTRODUCTION

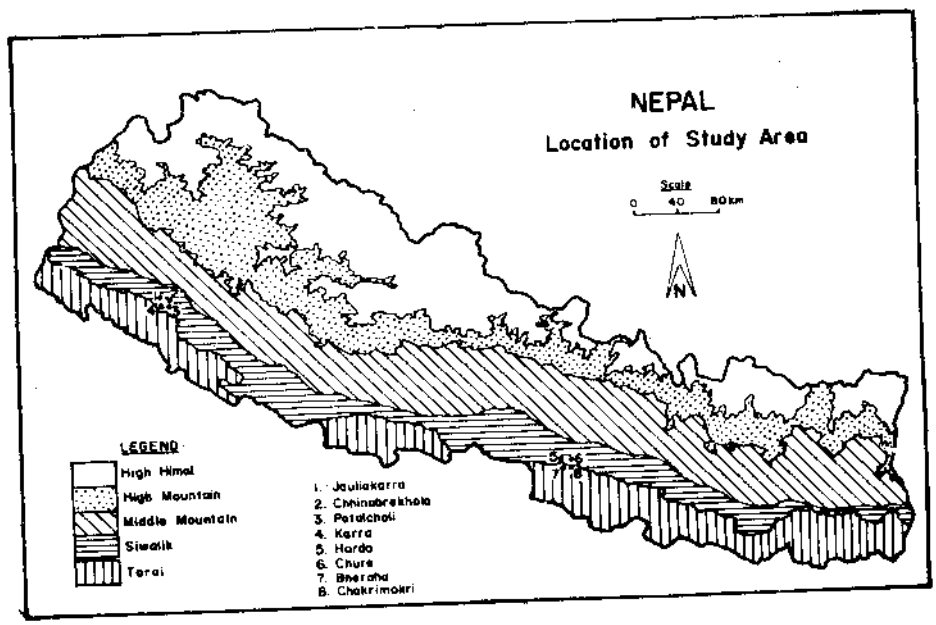
Drainage basin or watershed is that part of landscape which is drained by a main stream and its tributaries where the divide separates an unitary system from another. The flow of energy and mass of materials from the basin is directly related to the intensity of geomorphic forces derived from the sun, precipitation, atmosphere as well as tectonic activities and weathering processes (Chorley, et. al. 1984) Since, the degree and magnitude of geomorphic forces operating in one particular environment differ from another, the size and magnitude of the topographic features such as divide, hill slopes terraces, flood plains and stream channels also vary from one environment to the other.There is a complex relationship between geomorphic input which transforms the landscape and output which is influenced by the morphology of the basin itself. The study of morphological properties of drainage basin therefore, is not only important from a geomorphological point of view but also from a hydrological point of view since the discharge or output is the result of morphological features of the basin (US Department of the Interior 1977). Quantitative as well as comparative information obtained from the study of morphometric characterstics of the basins are useful to land use planners, engineers, agriculturalists, geologists, and foresters. Very few attempts have been made in the study of the drainage basins in our environment.

The present paper is a micro-level study of the drainage basins of the Chure (Siwalik) range. Some of the prominent characteristics of drainage basin of the Chure range are discussed. An attempt has also made to compare these properties both in terms of its regional location and slope orientation.

Methodology

About 30 basins in the Central (Makawanpur-Chitwan-Parsa) and 35 basins in the Western Nepal (Surkhet-Bara-Kailali) have been selected to discuss some of the prominent

* Mr. Khanal is Lecturer in Central Department of Gegraphy, Tribhuvan University, Kirtipur.



features such as the texture and the magnitude of geomorphic processes (Fig. 1). Four drainage basins (Harda, Chure, Bheraha and Chakrimakri) in the eastern part and four drainage basins (Jaulia Karra, Karra, Potalcholi and Chhinabre Khola) in the western part of the Chure range have been selected for the study of other major physical attributes of the drainage basins. Four drainage basins (Bheraha, Chakri makri, Karra and Potalcholi) from the south facing slope and four drainage basins (Harda, Chure, Jaulia Karra and Chhinabre Khola) from the north facing slope have been selected to examine the differences in the value of major physical attributes between eastern and western part and southern and northern side of the Chure area. Topographic maps prepared by survey of India in 1953/54 at the scale of 1:63,360 have been used to measure the value of each attribute. The technique applied by Strahler (Strahler 1964) in classifying stream order has been adopted in this study. Most of the information on the eastern part of the Chure area has been derived from previous work (Gurung and Khanal 1987). The topographical and drainage network measurements of the eight basins studied are given in Table 1.

The Chure Range

The present day Chure ranges are the result of thrusting up of the deposited erosional debris of molasse brought from the Himalaya since mid-miocene times some 18 million years ago. The continued penetration of the northern edge of Indian plate into Asian plate resulted in the uplift of the Himalayas forming the broad shallow sea in the south (Molnar 1986) As the elevation of the main Himalayas increased, the erosional processes therein began to operate with greater intensity. As a result, lots of sediments were deposited in the shallow basin. As the Indian plate moved northward, the fine grained sediments of the Siwalik group were thrusted up for some 4 km. Their overall width is 0 at Dharan (Eastern Nepal) and 34.18 miles in Chitwan (Central Nepal). The elevation of the ridges ranges from 2,597-4,870 ft. with a maximum of 6,078 ft, north and north west of Dhangadhi (Kenting Earth Sciences 1986) The dip slope of the Chure is mainly to the north.

There are three distinct formations within Chure range - the upper, the middle and the lower Siwalik. The upper Siwalik mainly consists of fine to coarse unconsolidated materials. The middle and lower Siwalik is composed of soft sandstones and fine grained grey coloured sandstone and siltstone respectively.

The temperature fluctuates from 39° F to 104° F in the eastern part and from 42°F to 113°F in the western part of the Siwalik. The average annual precipitation ranges from 584 inches in the northern side of the Siwalik in the western part and 889 inches in eastern part.

Most of the streams are seasonal. The flow remains only for a few hours in the rainy period. The river system originating from the southern side of the Chure range debouch in the foothills of Bhabar and the Tarai, whereas rivers on the north side debouch in the main longitudinal rivers flowing in the eastern or western direction between the Mahabharat and the Chure range itself.

Sal (Shorea robusta) is by far the dominant species in the Chure area. Other major species are pine (Pinus roxburghii), Saj (Terminalia tenentosa) and Sisoo (Dalbergia sisoo). Sal is more prominent in the eastern Chure area whereas Pinus roxburghii is more common in the western part.

Basin Size and Shape

The size of the drainage basin in the selected 8 localities ranges from 4 sq mile to 22 sq mile. The average size of third order basin is less then 5 sq mile, whereas it is 5.5 sq mile, to 10.04 sq mile, in fourth order drainage basins. It is more than 22 sq mile, in the fifth order basin. The order of the drainage basins in the study area ranges from the third order to fifth order. Out of 30 studied drainage basins in eastern part (15 on the south side and 15 on the north side), more than 60% of the drainage basins belong to the fourth order. But in the

Table 1 : Topographic and Drainage Network Measurements

	Harda	Churc	Bhera	Chakri Makri	Jaulia Karra	Karra	Potalcholi	Chhinabre
a) Topographic Measures								
1. Order of the Trunk river	5	4	4	3	3	3	4	4
2. Area in mile^2	22.27	10.04	7.96	4.76	9.68	4.06	5.54	5.87
3. Basin Length (mile)	9.28	3.88	5.27	2.47	5.20	3.40	3.45	4.70
4. Basin Perimeter (mile)	2.40	2.59	1.51	1.93	1.56	1.23	1.62	1.25
5. Basin Perimeter (mile)	25.63	14.65	14.60	8.40	14.60	9.10	9.50	13.00
6. Basin Elevation (ft)								
Mean	1451	1961	1734	1446	2331	2392	2218	2071
Maximum	2387	2660	2750	2350	4940	4940	4600	4600
Minimum	721	1450	1090	900	890	980	850	1030
Differences	1166	1255	1660	1450	4050	3960	3750	3570
7. Relief Ratio	.03	.06	.06	.11	.15	.22	.21	.14
8. Average Slope (degree)	12.20	11.43	22.57	22.35	22.20	27.46	26.4	19.20
9. Basin Shape (Dimensionless)	.26	.67	.29	.78	.36	.35	.47	.26
b) Drainage Network								
1. Steam number and order								
First order	312	69	107	24	47	17	46	67
Second order	69	16	21	4	8	5	9	16
Third order	16	3	4	1	1	1	2	4
Fourth order	4	1	1	-	-	-	1	1
Fifth order	1	-	-	-	-	-	-	-
2. Mean stream length (mile)								
First order	.24	.37	.17	.35	.47	.50	.34	.34
Second order	.34	.63	.33	.59	.89	.31	.62	.43
Third order	.86	1.84	2.43	3.53	1.02	2.80	2.45	.73
3. Total stream length (mile)	127.82	42.14	37.62	14.33	34.06	12.9	26.33	34.73
4. Drainage Density (mile/mile^2)	5.74	4.20	4.73	3.01	3.52	3.18	4.75	5.92
5. Drainage Frequency	18.05	8.86	16.71	6.09	6.10	5.67	10.47	14.99

Source : Calculated from Topographic Maps.

western part, majority of drainage basins are of the third order. The size of the drainage basin in the study area is very small. It is slightly larger in the eastern part in comparision to the western part of the Siwalik. Similarly, the size of the basins, located in the northern side is comparatively larger than in the sourthern side. The size of the basins indicates that the denudation rate is comparatively higher in the western part and southern side of the Siwalik than in the eastern part and northern side. There is a direct relationship between basin area and geomorphic output. If the basin area is larger, the potentiality of sediment accumulation within the system will be greater.

The shape of the basins in dimensionless unit ranges from 0.26 to 0.78. Chhinabre (0.26), Harda (0.26) and Bheraha (0.29) are more elongated whereas Chure (0.67) and Chakrimakri (0. 78) in the eastern part are more circular in shape. This has implication on the discharge of water as well as sediments from the system. The circularity of the basin contributes to sharp peak flows whereas elongated basin contributes to low but extended peak flow (Ruhe, 1975).

Relief and Slope

The differences in elevation between the lowest point and the highest peak of the drainage basin ranges from 1,166 ft. to 4,050 ft. The basin diameter ranges from 50,688 ft. to 2,392 ft. The average elevation of the drainage basin is comparatively higher in the western part than in the eastern part. Hence, the relief ratio is also comparatively higher in the western part than in the eastern part. The relief ratio is also found to be higher in the southern side than in the northern side. The average slope of the basin ranges from 11° to 27° (tan). The slope is comparatively higher in the western part than in the eastern part. Also, slope on the southern side is more conspicuous than on the northern side. This indicates that the potential energy for the geomorphic processes is comparatively higher in the western part than in the eastern and in the southern side than on the northern.

A larger proportion of the area of the Siwalik range has an elevation of less then 2,500 ft. The area above 2,500 ft. is very limited specifically in the eastern Siwalik. The hypsometric curve of the study area indicates that the area with the higher altitude is greater specifically in the western part. The curve of north facing slope is more convex than the southern side of the Siwalik. This has implication for the history of the intensity of erosional process. The larger area with higher altitude in the western part indicates that there is still a very high proportion of unconsumed materials and the high rate of erosional processes has the potentiality to continue in the future.

Drainage Network

There are altogether more than 881 streams within the 8 selected drainage basins.

Of these, 689 streams belong to the first order. The bifurcation ratio between first and second order streams ranges from 4.75 to 5.91. This ratio is comparatively higher in north facing slope than in southern side and higher in the eastern part than in the western part.The larger number of first order streams in the Churc range indicates a very high energy environment in terms of geomorphic processes.

The mean length of the first order streams ranges from 0.24 miles to 0.50 miles with an average of 0.35 miles and the standard deviation of the length of first order streams ranges from 0.12 to 0.27 miles with an average of 0.19 miles. Similarly, the mean length of the second order stream ranges from 0.31 miles to 0.89 miles with an average of 0.52 miles. The mean length of the second order stream is higher than in first order stream except in the Karra drainage basin. The ratio of the mean length between the second and the first order stream ranges from 1.25 to 1.94 except in the Karra basin. The mean length of the third order and the fourth order stream is 2.78 and 3.15 miles respectively. The length of the fifth order stream is 8.22 miles.

Drainage density of the area ranges from 3.18 mile/sq mile to 5.92 mile/sq mile. with an average of 4.28 mile/sq mile. This value is comparatively higher in the northern side than in the southern side. Drainage frequency ranges from 6.09/sq mile to 18.05 /sq mile with an average of 10.86/sq mile. Drainage frequency is higher in the eastern part (12.42/sq mile) than in the western part (9.30/sq mile). The value of channel ruggdness ranges from 0.82 to 4.00. This value is higher in the western part than in the eastern part.

The very high number of the first order streams, high bifurcation ratio, very short channel length, and high drainage density indicates that the Churc range is very weak in terms of its formation and the erosional activities therein is very high.

Since the Churc range (Siwalik) is very high energy environment duc to its very weak geological conditions, steep slopes and high drainage density, human disturbance in this area would further intensify the geomorphic processes which may cause the destructions of fertile land in the Tarai and the Inner Tarai belts. Though parts of the Churc and theBhabar belts have been proposed to be protected areas in the Eighth plan of Nepal, human activities even on the very steep slopes have been increasing in may parts of this range. Unless effectively protected these lands are bound to degrade rapidly. Any development work in these areas should be carefully planned so that such interferences do not lead to further instability of these mountain slopes.

Conclusion

The Churc (Siwalik) range is composed of unconsolidated materials. Majority of the basins fall under the third and the fourth order and their size is comparatively small. The number of first order streams is very high with very short channel length. Drainage density

is also very high. On the basis of basin size, shape, relief and slope, the rate of erosion is expected to be very high in the western part and the southern part than in the eastern and northern part of the Chure area. However, the actual erosion rate in the area is also controlled by the intensity and the volume of precipitation and the vegetative cover which are not dealt in this paper. Further investigation into these aspects in essential. The physical properties of the Chure range discussed in this paper have a number of implications for the development and ecological stability of the Chure range.

Reference

Gurung, Harka and Narendra Khanal (1987) . Landscape Processes in the Chure Range, Central Nepal Kathmandu. (A report submitted to Nepal National Committee for Man and The Biosphere) .

Kenting Earth Sciences (1986) Land Resouce Mapping Project Kathmandu : LRMP .

Molnar Peter (1986) "The Geologic History and Structure of the Himalaya" American Scientist, Volume 74, pp 144-154.

Chorley, Richard J., S.A. Schumm, D.E. Sugden (1984) Geomorphology. London : Methuen,

Ruhe Robert, V.(1975) Geomophology Processes and Surfacial Geology "Boston: Houghton Miffin Company.

Strahler A.N. (1964)"Quantitative Geomorphology of Drainage Basins And Channel Net Works" in Chow V. ed. Handbook of Applied Hydrology, New York: Mc Graw-Hill Book Company, pp 4-II 39-75 .

U.S. Department of the Interior (1977) National Handbook of Recommeded Methods for Water Data Acquisition. Reston : USDI (Chapter 7).