© 2017 IJSRSET | Volume 3 | Issue 5 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Slope Analysis and Slope Development of a Drainage Basin - A Case of Somb River in Lower Shiwalik Hills, India

Vipin Kumar
Department of Geography, Banasthali University, Banasthali, Rajasthan, India

ABSTRACT

Slope has been considered as a fundamental element of landscape feature, which prevails all over the earth's surface. As a result, it has received the utmost attention not only of geomorphologists but also for geologists, hydrologists and planners. It has rightly been marked that no other theme in geomorphology has been discussed, so exhaustively and deeply, as slope. In the present study, slope of the Somb river basin has been evaluated by Wentworth's method. Five major categories of slope viz. Level, Gentle, Moderate, Moderate steep and Steep have been identified in the area. The northern and eastern parts of the watershed have uneven slope, which show the altitudinal and structural variations of the area. The level slope has been observed in more than 60 per cent area of the watershed.

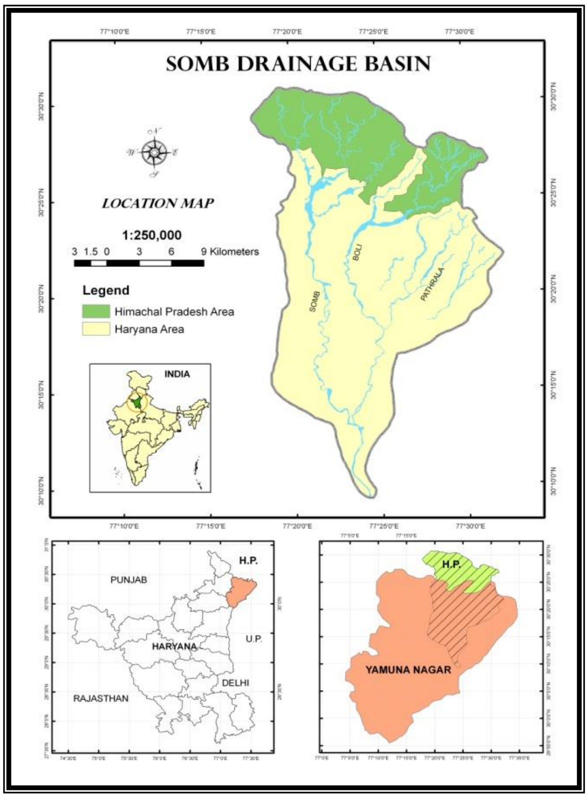
Keywords : Slope, Slope Development, Area Slope Curve, Slope Ogive, Altimetric Frequency Graph

I. INTRODUCTION

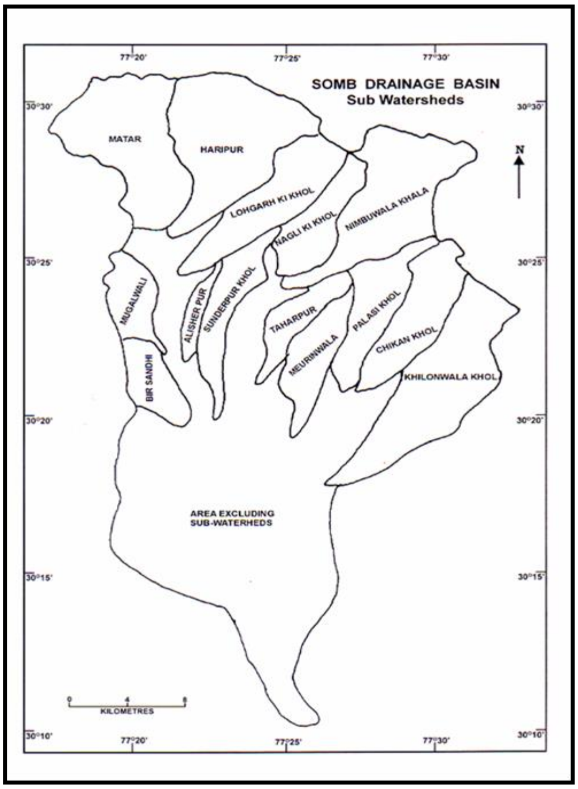
Slope is an important terrain aspect which is affected by tectonic activities, geological structure and climatic characteristics of the area and anthropogenetic factors. In watershed, slope analysis is an important step towards rationalisation of land use. It provides the basis for land capability classification, land use planning and soil conservation needs.

Study Area

The Somb nadi is a tributary of Yamuna river, arise from the outer slope of the lower part of the Shiwaliks range in the district Sirmaur, Himachal Pradesh and takes a southerly course, which drains in the plain land of district Yamunanagar, Haryana. The Pathrala (also known as Palasi Khadi) and Boli nadi are two major tributaries of the Somb nadi. The Somb nadi combined with Pathrala and Boli nadi discharge its water into Yamuna River from western side near Meharmajara village of district Yamunanagar after about a course of 40 kms. from its origin. The extension of Somb drainage basin lies between 77018/E to 77034/E longitude and 3009/N to 30029/N latitude (Map-1). The total calculated area of Somb drainage basin is 492 kms2. The watershed is further divided in 14 sub-watersheds for extensive study (Map-2).



Map-1



Map-2

II. METHODS AND MATERIAL

Amongst the various methods for calculating slope, the contributions made by Stralher, Miller, Raisz and Henry, Smith and Wentworth are worth mentioning. The analysis of slope of the study area has been carried out by Wenthworth's method. He gave following formula for computation of average slope from contour map, using the British measures of Mile/Feet:

$$\text{Tan } \theta = \frac{\text{number of contours cutting per mile} \times \text{Contour interval (in feet)}}{3361}$$

The formula has been modified for the application of the metric system as follow:

$$\text{Tan } \theta = \frac{\text{numbers of contours cutting per km x Contour interval (in mts.)}}{636.66}$$

Where, 636.66 is a constant value for length in kms from the original Wentworth's formula.

The calculation of average slope has been based on the analysis of contour map represented on four topographical sheets (53F/6, 7, 8 and 11) on the scale of 1:50000. The contour map has been divided into 547 girds of one square kilometres each and average slope per unit area has calculated for each grid of the map. This has been later supplemented with field observations.

The slope values, thus obtained for each square grid, range from below 1^0 to slightly over 14^0 in the watershed. The average slope data and slope map (Table-1 & Map-3) explicitly reveal that about 64 percent of the total watershed area is comprised of level slope with an inclination of less then 3^0 as evidenced from the topographical maps and subsequent preparation of the slope map. It indicates that this part of the basin has mainly been leveled. It is observed that as much as 90 percent of the grid frequency lies in the level to moderate slope with an inclination of less than 9^0. Remaining 10 percent of the grid frequencies lie in the category of steep slope having more than 9^0 slopes.

Areal Distribution of Slope Categories

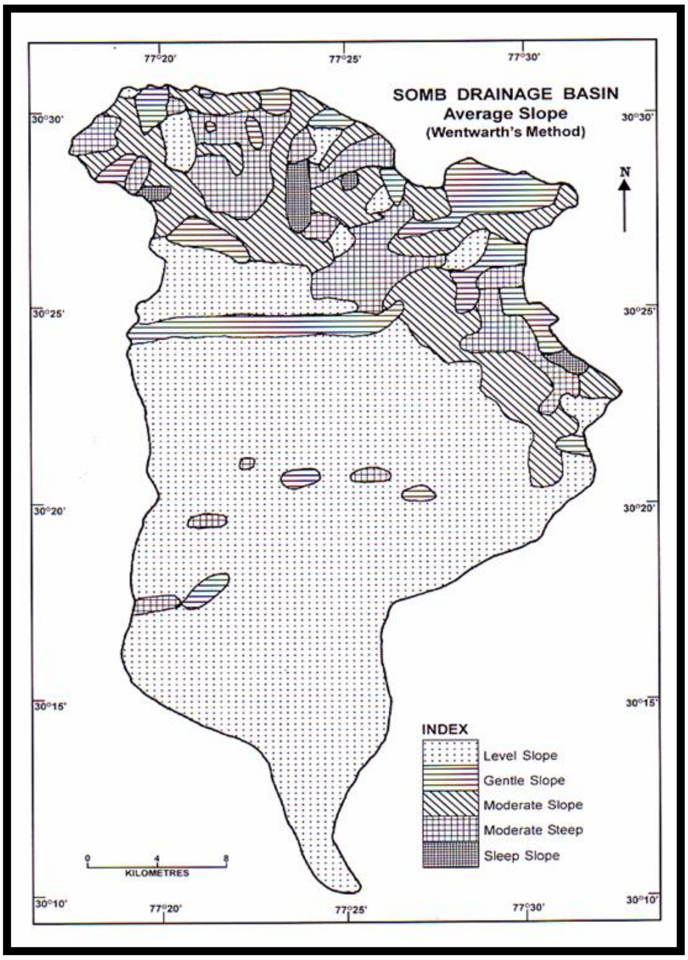
Slope of the present watershed has been divided into five classes, viz. level, gentle, moderate, moderate steep and steep. The table 1 shows that more than 60 percent area of watershed have level slope (below 30) and just 2.6 percent area have steep slope. The distribution pattern (Map-3) of these slope types is described as follow-

Table 1. Distribution of Slope Category

Slope Category	Description	Grid Frequency	Area (Km^2)	% of total area	Cumulative Frequency	C.f. (%)
Below 3^0	Level (S_L)	320	316.8	64.3	316.8	64.3
3^0 - 6^0	Gentle (S_G)	48	47.5	9.6	364.3	73.9
6^0 - 9^0	Moderate (S_M)	82	81.2	16.5	445.5	90.5
9^0 - 12^0	Moderately Steep (S_{MS})	34	33.6	6.8	479.1	97.3
12^0 & Above	Steep (S_S)	13	12.8	2.6	491.9	99.8
		497	491.9	99.8		

Level Slope -S_L (Less than 3^0)

This category of slope occupies the largest area accounting for as much as 316.8 km2 or 64.4 percent of the total watershed. It covers the area of plain tract in south and 80 percent of the foothills. The area of Bir-Sandhi, Alishpur, Meurinawala and Tharpur sub-watersheds lies in this category. More than 95 percent area of Sunderpur khol and Mugalwali sub-watersheds is a part of this category. It indicates that the lands of these sub-watersheds are generally flat. South of Logarh ki khol, Palasi khol, Chicken–Kansil, Khilonwala sub-watersheds also fall in this category. Some small patches are also seen in Matar, Haripur and Khilonwala sub-watersheds. Extremely low drainage frequency and density, coarse to intermediate texture, low relative relief and low dissection index are the characteristics associated with the area of this category.



Map-3

Gentle Slope- S_G (3^0-6^0)

Area 47.5 km^2 or 9.6 percent of the basin falls under this category. It is found largely in the north of Chikan-Kansil and Nimbuwala sub-watershed. About 11X1 kms long belt of this category spread in the south west of hilly tract. Some small areas also lie in Matar, Haripur, Lohgarh ki khol and Nagli ki khol sub-watershed. In these areas, low relative relief and low dissection indexes are observed.

Moderate Slope- S_M (6^0-9^0)

This is second largest slope category occupying an area of about 81.2 km^2 or 16.5 percent of the basin. It is found largely in the Matar, Haripur, North of Lohgarh ki khol sub-watersheds. Some patches also found in Khilonwala sub-watershed.

Moderate Steep Slope- S_{MS} (9^0-12^0)

The category occupies 33.6 km^2 about 6.8 percent area of total watershed, fall in north and northeast of the watershed. This high slope area is generally lies in Matar sub-watershed and largely in Haripur, Lohgarh ki khol sub-watersheds. It covers the north part of Palasi khol, Chikan-Kansil and Khilonwala sub-watersheds also.

Steep Slope- S_S (above 12^0)

This category has the smallest areal coverage of about 12.8 km^2 i.e. just 2.61 percent of whole watershed. This slope category is found in some patches. The major cluster of steep slope is in Haripur sub-watershed, and all the patches are in the hills area. High drainage density, high relative relief, and high dissection index, characterise the terrain of the area of this category.

Area Altitude Relationship

The terrain and the erosional morphology may be studied with the help of curves showing the area-altitude relationship. Area slope curve, Slope ogive and Altimetric frequency graph have been applied for the analysis of area altitude relationship of terrain of the Somb drainage basin.

The relationship between area and slope distribution is shown in Fig.-1. The area slope curve is rapidly skewed towards the right. The slope ogive (Fig.-2) indicates sudden rise of the curve after 3 degree. The rise is gradual increase to the slope at 12 degree.

Area Slope Curve

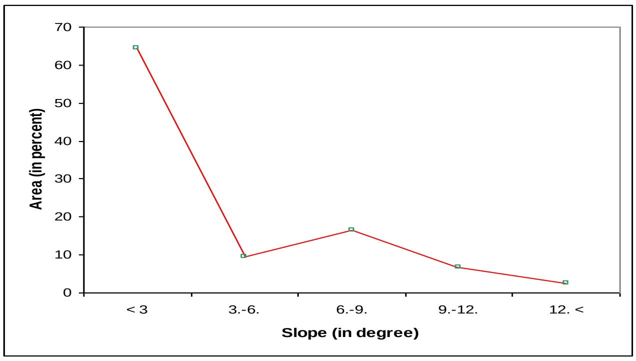


Figure 1

Slope Ogive

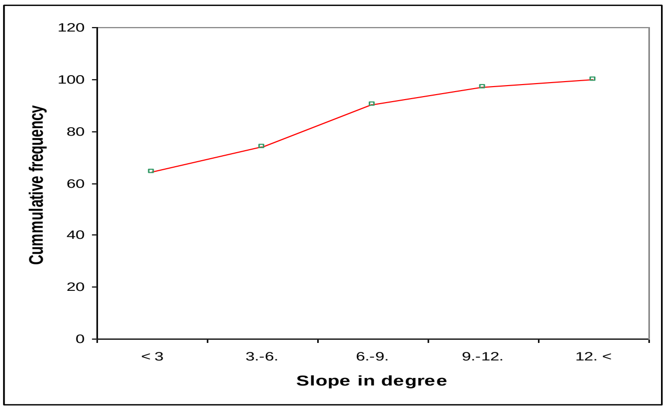


Figure 2

The Altimetric frequency graph involves numerical frequency of occurrences of land surface including summits or flat surface at various elevations by either a spot height, a contour or a bench mark and helps in identifying the erosion surfaces. The maximum frequency of an elevation or elevation-class indicates its dominance in the basin and leads to infer about the existence of a planar surface (Gujjar, 2001).

In present case, the entire study region has been divided into grids of 1x1 sq. km. and the maximum elevation in each grid has been estimated. After arranging these grid values in different groups, the frequency histogram has been plotted. Table- 2 & Fig.- 3 reveal that the elevation between 350-300 mts. has the maximum frequency. The proportion of these frequencies of the total elevation frequency is 30.68 percent. Such a high value indicates predominance of 350-300 mts. height in the watershed area. The next dominant elevation is 300-250 mts. This frequency also covers about 30 percent area of watershed. The above two elevation classes collectively consists more than 60 percent area of watershed, which represent almost plain feature of basin terrain.

Table 2 : Height Frequency Data

Elevation (meters)	Grid Frequency	Percentage	Covered Surface Area (sq Km.)	Percentage
700-650	7	1.40	6.92	1.40
650-600	27	5.43	26.72	5.43
600-550	58	11.67	57.41	11.60
550-500	35	7.04	34.64	7.04
500-450	38	7.72	37.61	7.72
450-400	14	2.81	13.85	2.81
400-350	17	3.42	16.82	3.42
350-300	152	30.58	150.47	30.58
300-250	149	29.97	147.50	29.47
Total	**497**	**100.04**	**491.94 (492)**	**99.47 (100)**

Slope Development

Development of slope, relates to the change in slope form with the passage of time. It is a function of three factors viz. structure, process and stage. In general, development of slope is affected by climatic factors, nature of weathered waste mantle, vegetation, soil, rock types and transport of land waste. Slope evolution in any area can be analysed with respect to its type, weather gentle, moderate or steep, weather even or uneven, nature of the breaks, profile characteristics weather concave, convex or straight or complex and the nature of slope elements. (Sinha et. al., 1994)

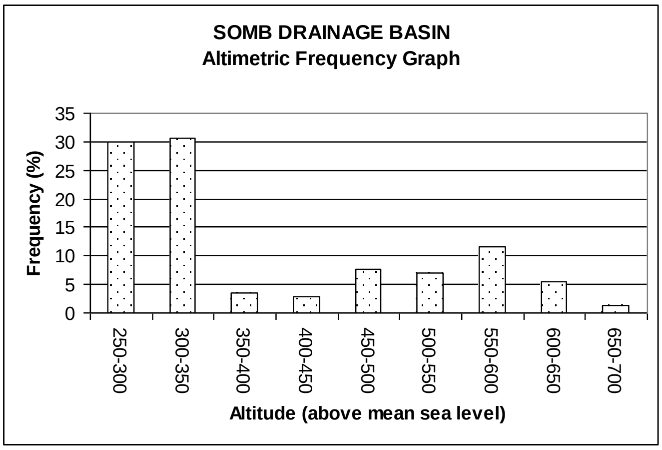


Figure 3. (Table-2)

The processes of denudation, geological complications, or structure and stage of landscape evolution have produced large variations in slope, which provides significant clues in the study of Geomorphological evolution. The process of denudational activities are mainly the action of rainfall and running water during the monsoon, when the seasonal torrents extend their beds, changing their course and accelerate soil erosion. Human interference with terrain such as deforestation and grazing, ploughing up and down on slope, mining and constructional activities including quarrying, laying of roads, canal and building of dams and reservoir etc. are significant factors in the evolution of slope in a watershed.

Level to moderate slope is concentrated mainly in the southern and middle part of watershed up to 340 mts. above msl. It is dominated by mixed sediments like multi-cyclic sequence of brown to grey silt, clay with kankar and radish brown to grey micaceous sand with pebbles, which are mostly found in deep alluvial plain. Sediments are deposited in level slope by the rivers during rainy season. Human interferences affect the area widely because the area is used for agriculture and grazing. Highly populated villages are also situated in that part.

Moderate to steep slope is mainly concerned in northern hilly areas of structural hills and Mesa/ Butte type denudational hills, over 340 mts. to 660 mts. above msl. Grey micaceous sandstone, gravel beds, shale, and clay are observed in the upper part while brownish grey clay, sand, and gravels with boulders are found in the lower area. Escarpments are main feature in this area. During field survey, it is observed that the area is covered with forests, but human interference like grazing, desertification, constructional activities and denudation process, which are more active during rainy season, and are important factors to generate changes in slope of Somb drainage basin.

Figure 4. Soil degradation through bank erosion in Boli nadi, near Goharbani village, District Yamunanagra (Haryana, India)

Figure 5. A view of erosion through livestocks in Boli nadi, near Jatipur village, District Yamunanagar in Haryana

III. CONCLUSION

It is concluded that the slope form in the drainage basin is the result of both physical factors like erosion and anthropogenesis factors like forest cutting and over grazing. The study area lies in the lower foothills of Shiwalik hills where stream erosion play significant role as exogenetic process in the slope evolution. The study reveals that the area, in general, possesses low slope gradient with the exception of a few areas (north of watershed) like hill ranges, valley side and the like. In general, the inclination of the slope increases from south to north. The area of sub watersheds of Matar, Haripur, Lohgarh ki Khol and Nimbuwala khala are deeply dissected by erosion due to steep slope, lack of vegetation and over grazing. Hence, these watersheds has considered as priority for the management of soil, water and vegetation and required controlling the problems. We can also conclude that in case of non-availability of maps like soil map, vegetation map etc, this type of study could be of use in prioritising areas of soil conservation measures in the basin areas.

IV. REFERENCES

[1]. Gupta, V.S. (2003): 'Water Conservation Through Watershed Management', Kurukshetra, Ministry of Rural Development, Vol. 51, No.12, pp. 66-69.

[2]. Gurjar, R.D. (2000): 'Slope Profile Analysis: Methodology and Tools', Transaction Institute of Indian Geographers, Vol. 22, No. 2, pp 63-76.

[3]. Gurjar, R.D. (2001): 'Relief Morphometry of Shibi River Basin (A Case Study of An Inland Drainage Basin in North East Rajasthan)', Indian Journal of Geomorphology, Vol. 6, No. 1&2, pp. 45-58.

[4]. Mangat, H.S. (1988): 'Slope Map: A Modification to Wentworth's Method', Indian Geographical Journal, Vol. 63, No. 2, pp 133-141.

[5]. Sinha, N.K.P. and Singh, C.P. (1994): 'Slope Categories and Slope Development in South Mirzapur Region, U.P.', Geographical Review of India, Vol.56, No.4, pp.1-13.