ISSN NO.2395-0692
IJAHMS International Journal of Arts, Humanities and Management Studies

Study of Drainage Frequency and Drainage Density of Somb drainage basin in lower Shiwalik hills, India

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ABSTRACT

The present paper deals with the analysis of drainage frequency and drainage density of Somb drainage basin as well as its sub-basins with the help of Horton's method, including identification of major categories and areas of high to low drainage frequency and density. Drainage density and drainage frequency are the most important factors that control the speed of runoff following a spell of heavy rain. Generally, the greater, the drainage density and stream frequency, the faster the runoff. In the present case, the drainage frequency and density seems to have been guided primarily by the existing lithologic, slope and climatic conditions as well as the anthropogenic factors producing a wide variety of both aspects mainly at sub-watershed level.

Key words- *Drainage frequency, Drainage density, Somb River*

INTRODUCTION

A drainage basin is an entire area drained by a river and its tributaries. It is a natural hydrological entity, which allows surface run-off to a defined channel, drains, streams or river at a particular point. It should be managed for various purposes depending upon local needs, including drinking water supply, capturing runoff, minimizing erosion, reducing pollution and many more. Drainage frequency and density are two most important aspects of a drainage basin, which affects the runoff capacity of a basin.

Drainage frequency is the number of streams in per unit area. It is associated with lithology, degree of slope, stages of fluvial cycle and amount of surface run-off. Investigations reveal that high frequency of stream is found in the areas of non-porous bedrocks, relatively high degree of slope, high rainfall, and thin vegetation cover. The high values of drainage frequency are represented by mature basins whereas; low range of drainage frequency indicates the youth stage of development. (Sidhu, et. al., 1974).

Drainage density is the length of stream channels per unit area. The value of Drainage density reflects the climate over the basin and the influence of other basin characteristics including rock type, soil, vegetation, land use, and topographic characteristics. (Goudie, et. al., 1985).

According to Nag (1988), low drainage density generally results in the areas of highly resistant or permeable subsoil material, dense vegetation and low relief and leads to coarse drainage texture. High drainage density is the resultant of weak or impermeable subsurface material, sparse vegetation, and mountainous relief and leads to fine drainage texture.

According to Rogers (1971), high drainage density is represented by metamorphic, whereas sedimentary exhibits low drainage values. The high drainage density indicates a large proportion

of precipitation run off and low drainage density indicates that, most rainfall infiltrates the ground and few channels are required to carry runoff. Drainage density can range from less than 5.00 km/km^2, when slope is gentle, rainfall is low, and bedrock is permeable (e.g. sandstone), much larger value of more than 5.00 km/km^2 in upland areas, where rocks are impermeable, slopes are steep and total rainfall is high (e.g. on un-vegetated clay 'badlands').

STUDY AREA

The Somb River is a tributary of Yamuna river, arise from the outer slope of the lower part of the Shiwaliks range in the Sirmaur district of Himachal Pradesh and takes a southerly course, which drains in the plain land of Yamunanagar district of Haryana. The Pathrala (also known as Palasi Khadi) and Boli River are two major tributaries of the Somb River. The Somb River combined with Pathrala and Boli River 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 $77^0 18'$E to $77^0 34'$E longitude and $30^0 9'$N to $30^0 29'$N latitude (Map-1 and 2). The total calculated area of Somb drainage basin is 492 kms^2. The basin is further divided in 14 sub-basins for extensive study (Map-3).

RELIEF AND GEOLOGY

The relief of the drainage basin is divided into three distinct types of terrain

1. The Shiwalik Hills 2. The Foothills and 3. The Plain

The Shiwalik Hills

The Shiwalik hills lies in the northern part of basin, which is the origin of Somb River and its tributaries. It is composed of sand, clay, silt and conglomerates. The elevation of hills varies ranging more than 400 meters above MSL. The slope is generally northwest to southeast, in which direction most of the terrain flow. A large numbers of rain-fed torrents flow down the outer slope of sub-mountain belt, which spread much gravels and pebbles in their beds. The Shiwaliks are characterised by extremely rugged and broken terrain with gentle to precipitous (steeper) slopes.

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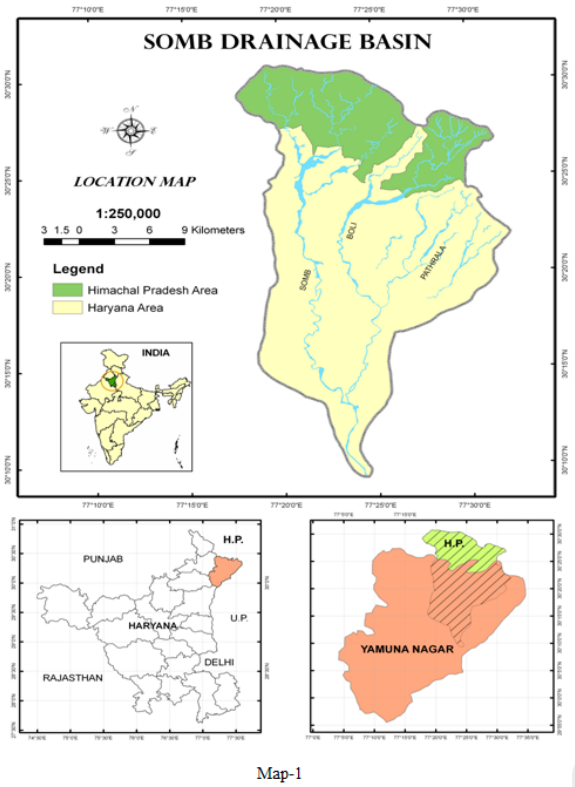
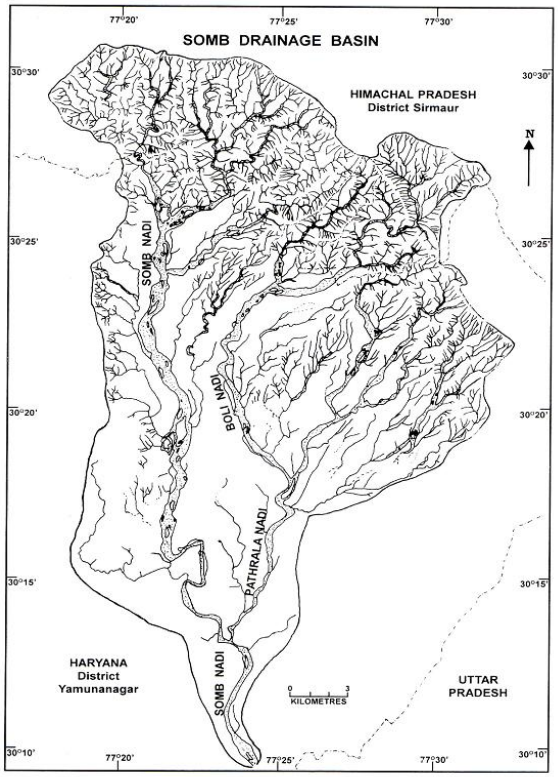
IJAHMS International Journal of Arts, Humanities and Management Studies



Map-1



Map-2

The Foothills

Topographically, the most significant and complex part of the basin, runs at the foot of the Shiwalik hills and extends outward in the form of elevated land. The elevated land of the foothills differs ranging between 300 meters to 400 meters above MSL. Basically, this part of the basin is an area of Bhabar tract, which is composed of unasserted debris from the upper part of the basin. Towards the south, the Shiwaliks present an almost abrupt front pierced by long gorges locally known as "KHOLS". The khols form the sand and boulder strewn beds of the torrents, which emerge from the Shiwaliks to the plain. These hills are mostly low with moderate slope, but the torrents' beds are locally known as "CHOS" cut up from the ground. These 'Chos' arise inside or in the vicinity of the hills and form a very striking features of the physical aspect.

The Plain

The foothills gradually merge into plains, which is mostly a flat terrain. These plains form the tract through which numerous streams emanating from the Shiwaliks pass. Towards the west of Somb River many scattered small clay like plateaus are present, which are highly ravined (narrow valley with steep sides) and locally known as "DARRARS". The southern parts of the tract are the fertile level lands with a gentle slope through which sluggish sandy seasonal streams flow at intervals. These areas abound in some fine mango grooves and agricultural activities. The Southeast region of the plain is a low-lying tract with abundant tree growth. The elevation of this plain land is less than 300 meters from MSL. The flood plain of the Somb River is also narrow but very well defined, especially along its western margin.

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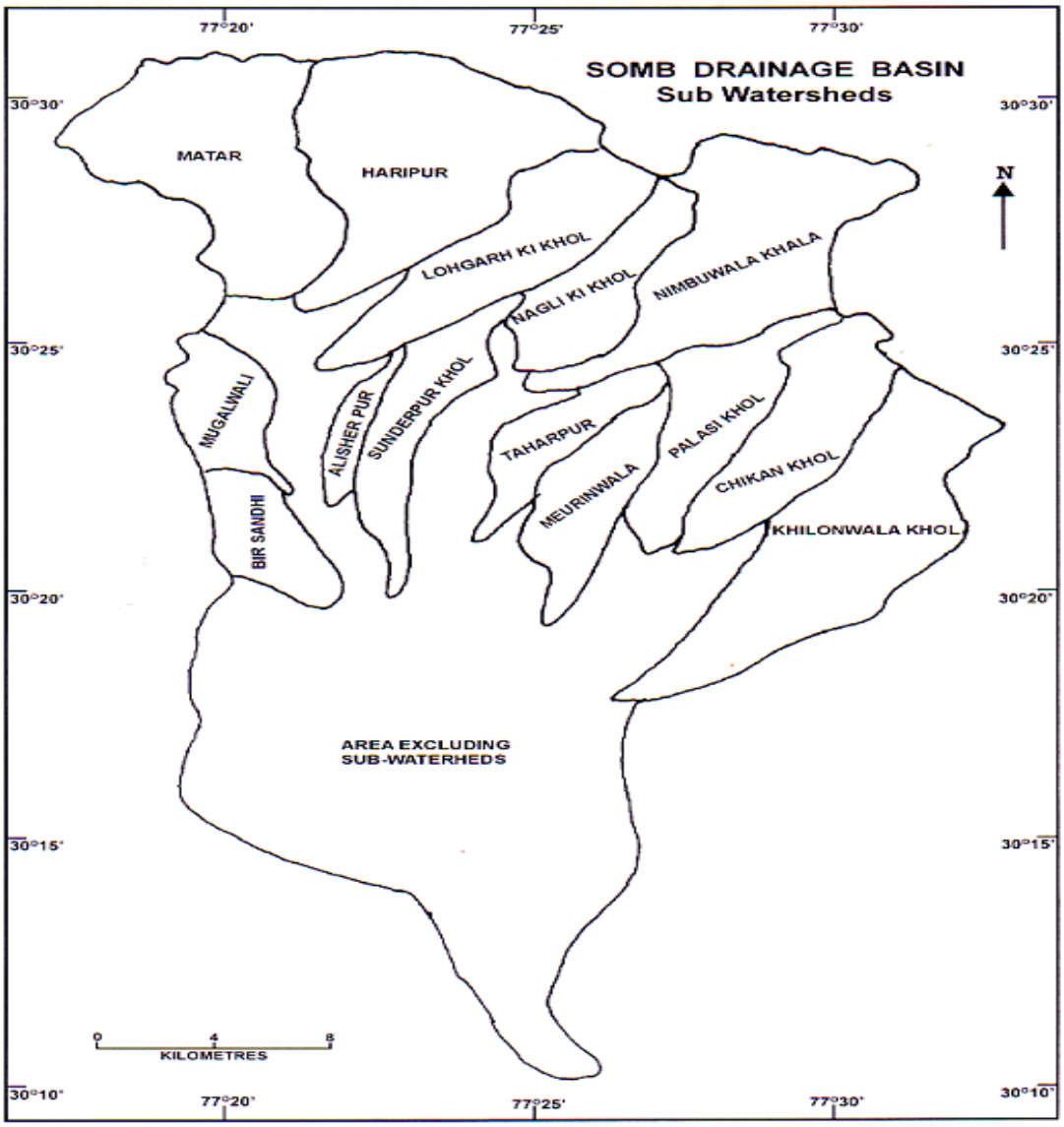

Map-3

Climate

The basin has a sub-tropical continental monsoon climate, where we find great variation in climatic elements. Normally, the period from November to February is cold; this is followed by the summer season from March to the end of June. The south-west monsoon mostly breaks in the last week of June or first week of July and continues up to about the middle of September. The period from mid September to the mid of November is the post monsoon or transition season. In winters, frost sometimes occurs during December and January. The basin also gets occasional winter rains from cyclones or western disturbances. The rainfall is mostly restricted to rainy season. The study area is characterised by the high velocity of hot winds and dust storms during the summer months of May to June. The temperature for the last ten years varies from 3^0C in January to 36^0C in June.

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OBJECTIVES

There are following objectives of present study-

1. Study and mapping of drainage frequency
2. Study and mapping of drainage density
3. Study the correlation between drainage frequency and drainage density

DATA SOURCE AND METHODOLOGY

The present study is carried out basically with the help of topographical sheets no. 53 F/6, F/7, F/8 and F/11 on 1:50,000 scale, obtained from Survey of India. The topographical sheets and field investigation are the basic source of information. The area of basin has been delineated on the bases of topographical sheets. The streams of all orders are marked to generate a drainage map. The map is further divided into fourteen sub-watersheds. The drainage frequency and density both have been analyzed with the help of Horton's method (1932). For drainage frequency (D_F), Horton suggested that it is derived by dividing the number of streams (NU) with the area of drainage basin or the per unit area (A)- Drainage Frequency (D_F) = NU/A
Horton defined drainage density as the total number of stream lengths in the basin (LU) divided by the area of basin (A)- Drainage Density (D_D) = LU/A

The length of each stream is measured with the help of rotameter. A correlation between drainage frequency and density has been measured with the help of Karl Pearson method. Finally, all the data have been arranged and represents by appropriate maps to show the variations in drainage frequency and density.

RESULTS AND DISCUSSIONS

Drainage (Stream) Frequency (D_F)

The drainage frequency of whole drainage basin is poor (i.e. 3.57) due to poor stream network of the basin. It is noticed in every case that there is a decrease in stream frequency as the stream order increases. The sub-basins Haripur, Nagli ki khol, Nimbuwala khol, Matar, Lohgarh ki khol and Mugalwali have the higher value of stream frequency, which lie between 7.83 – 5.06. The higher values, indicating denser network, found along the hilly regions, where the first order and second order streams are well-developed with large in number of streams. The sub-basins Taharpur, Alisherpur, Sunderpur khol, and Meurinawala have comparatively low drainage frequency. The drainage frequency of sub-basins is shown in table 1.

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Table-1

Drainage Frequency of Somb Drainage Basin and Sub-basins

Sr. No	Sub-basins	D_F	Sr. No.	Sub-basin	D_F
1	Matar	7.17	8	Khilonwala	4.0
2	Haripur	7.83	9	Meurinawala	3.80
3	Lohgarh ki khol	5.63	10	Taharpur	2.22
4	Nagli ki khol	7.75	11	Sunderpur khol	3.37
5	Nimbuwala khala	7.16	12	Alisherpur	2.44
6	Palasi khol	4.23	13	Mugalwali	5.06
7	Chikan Kansil khol	4.40	14	Bir Sandhai	3.91
Somb Drainage Basin		**3.57**			

Table- 2

Somb Drainage Basin

Distribution of Drainage Frequency (streams / km^2)

D_F	Description	Grid Frequenc	Area (Km^2)	Cumulative frequency	% of total	% of c.f.
Below – 3	Very low	238	235.60	235.60	47.90	47.90
3 – 6	Low	101	99.90	335.50	20.30	68.20
6 – 9	Medium	107	106.50	442.00	21.60	89.80
9 – 12	High	51	50.48	492.48	10.20	100.00
Total		497	492.48		100.00	

For micro study and to find out the regional variation, the drainage frequency has been analysed on one square kilometre grid and further categorised into four groups (Table-2). The area 235.6 km^2 have very low drainage frequency, which indicates that 47.9% area of the drainage basin have 0-3 streams per sq. km grid, this is found in the plain land of the basin. The maximum area of this category lies below 340 meters from MSL. The area of low drainage frequency is spread in the foothills and some patches are seen in the hilly area of the basin. It covers approximately 20 percent area of basin. Medium drainage frequency is found in the northern hills with an area of 106.5 km^2, whereas high drainage frequency spreads over in some patches, situated in the extreme northern hilly area of basin. It covers little part of basin with an area of 50.48 km^2 (Map-4).

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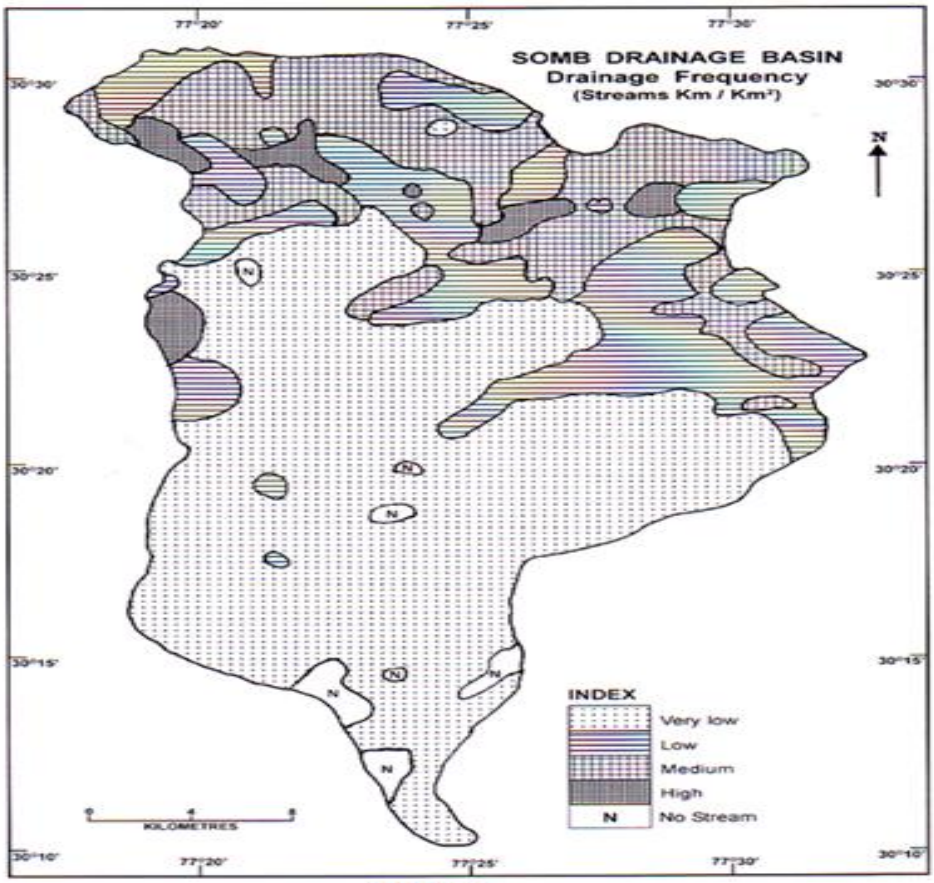
IJAHMS International Journal of Arts, Humanities and Management Studies



Map-4

Drainage (Stream) Density (D_D)

In present study, drainage density of the sub-watershed of Somb drainage basin is less than 4.00 and varies between 3.49 to 1.90 (table 3.15 & fig.3.8**)**, which indicate the low drainage density that the nature of sub-surface strata is permeable and a characteristic feature of coarse drainage.

The drainage density of Somb basin is 1.93 km/km^2. The basic factor of low drainage density is low rainfall and high slope in northern hilly area. The drainage density is measured on one square kilometer grid for the whole basin (table 4). Map-6 shows the spatial variation in drainage density of basin area.

Table-3

Drainage Density of Somb Drainage Basin and Sub-basins

Sr. No	Sub-basins	D_F (km/ sq.km)	Sr. No.	Sub-basin	D_F (km/ sq.km)
1	Matar	3.47	8	Khilonwala	3.49
2	Haripur	2.87	9	Meurinawala	2.56

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3	Lohgarh ki khol	2.91	10	Taharpur	2.22
4	Nagli ki khol	2.75	11	Sunderpur khol	2.15
5	Nimbuwala khala	3.43	12	Alisherpur	1.94
6	Palasi khol	2.24	13	Mugalwali	2.33
7	Chikan Kansil khol	2.40	14	Bir Sandhai	1.86
Somb Drainage Basin		**1.93**			

Table-4

Somb Drainage Basin

Distribution of Drainage Density (km/km^2)

Dd Km/Km^2	Description	Grid Frequency	Area (Km^2)	% of total area	Cumulative frequency (Cf)	% of Cf
Below - 1	Extremely Low	89	88.1	17.9	88.1	17.9
1 – 2	Low	153	151.4	30.7	239.5	48.6
2 – 3	Moderate	97	96.0	19.5	335.5	68.1
3 – 4	High	99	98.0	19.9	433.5	88.0
4 & above	Very High	59	58.4	11.8	491.9	99.8
Total		497	491.9			

The high drainage density is found in the hilly area and decrease rapidly towards plain area. The maximum area of very high drainage density is found in the northern part of the basin with a height of 400 meter above MSL. This covers an area of 58.4 km^2, including middle Matar, Lohgarh ki khol and Nagli ki khol, north of Nimbuwala, Chikan-Kansil, and Khilonwala sub-watersheds, Whereas high drainage density constitutes 98 km^2 of the total basin area. Its major concentration is found in the north of Matar, Haripur, Lohgarh ki khol, Sunderpur, eastern and middle part of Nimbuwala and middle part of Nagli ki khol. Some little patches are also seen in the other parts of basin. The moderate drainage density, where 2-3km/km^2 length of streams is calculated has occupied about 96 km^2 area of the basin. It spreads in the northern part of Matar, northern and middle part of Lohgarh ki Khol, south part of Nagli ki khol and middle part of Nimbuwala sub-basins and some small patches are spread all over in the basin area.

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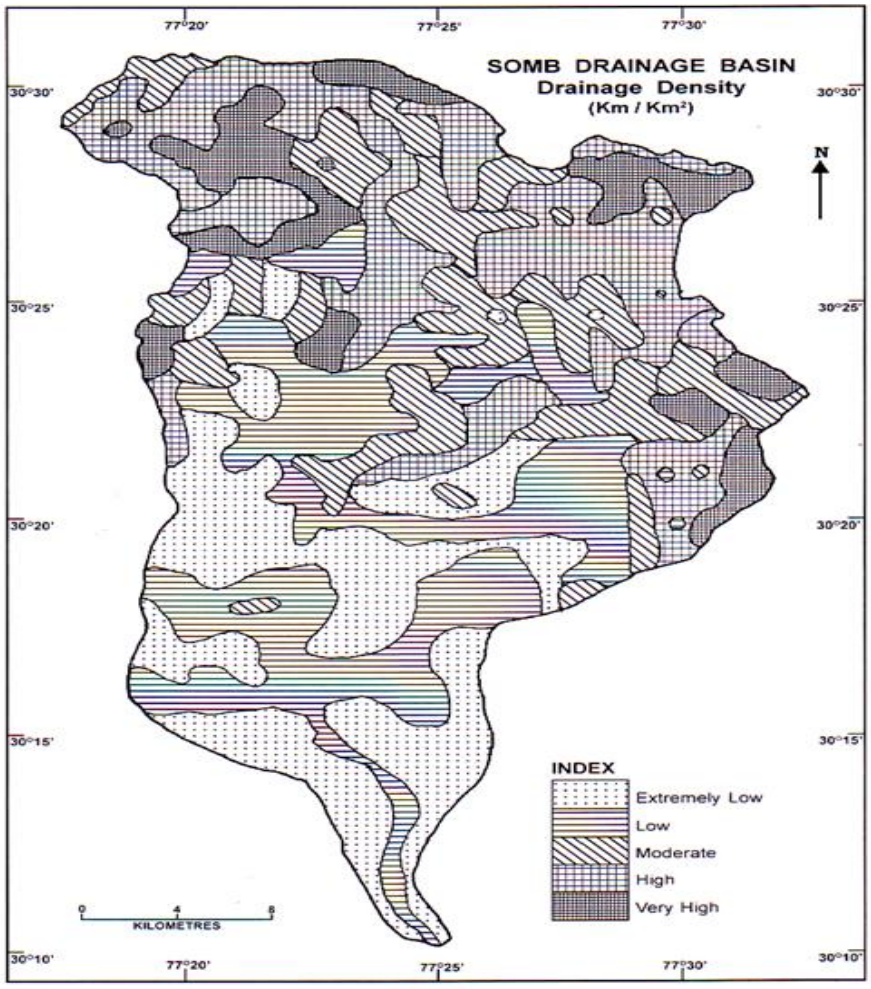
IJAHMS International Journal of Arts, Humanities and Management Studies



Map-5

The low drainage density is found in 151.4 km^2 area of the basin. The maximum area of low drainage density falls below 340 meters. altitude from MSL., which includes the area of Sunderpur, Tharpur, Alishpur, south of Khilonwala, Chikan-Kansil and Meurinawala sub-watershed have also low drainage density, beside this some small patches also spread in other part of the basin. About 88.1 km^2 areas in the basin have very low drainage density, which takes less than 1km/km^2 stream length. Maximum area of this category lies in the plain land of basin. Here, the gentle slope and a configuration of hard rocks like quartzite with sand stones are responsible for very low drainage density. The other reason of low density is due to presence of permeable rocks, most of the rainwater infiltrate in to ground. Hence, very little rainwater is available on the surface.

The relationship between drainage frequency and density of fourteen sub-watersheds has been measured with the Karl Pearson's method and it is found the value of correlation between both variables is +0.65, indicates a high relation between drainage frequency and drainage density in other words as stream frequency increase the drainage density also increase a sub watershed level.

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IJAHMS International Journal of Arts, Humanities and Management Studies

CONCLUSION

The drainage frequency and drainage density of whole Somb drainage basin is 3.57 and 1.93 km/km^2, respectively, which indicates porous rock structure, permeable subsoil, low rainfall, and low degree of slope. More than 47 % of the total are have very low drainage frequency and more than 30 per cent have very low drainage density. Only three sub-watersheds have high value of drainage frequency, lies between 5.06-7.83, which indicates dense stream network in hilly area and other have low drainage frequency. Similarly, all sub-watersheds have low value of drainage density. High correlation is found between drainage frequency and drainage density. The low range of drainage frequency and density indicates the youth stage of basin.

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