The study of drainage patterns of Suketi River Basin for the proper environmental planning, Mandi District, Himachal Pradesh, India
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ABSTRACT
The Suketi River Basin is situated in lesser Himachal Himalaya, Mandi district H.P. In the study of proper environmental planning of rivers patterns play a dominant role due to its self sustained ecological cycles which make changes in landscapes morpho-units. The Suketi River Basin is drained by the Suketi River and its numerous tributaries, the main among these are Umli Khar Jatla Nallah, Bonyat Nallah, Gambhar Khad, Bhadyal Nallah, Gagal Nallah and Chadyam Nallah etc. The area up to Dhasni village south of the locality of Chela village the Suketi River flows in to a broad “U” shape valley from 400m to 600m wide with unsorted sediments of all the grades. To prepare base map from SOI Toposheets within 1:50000 scale. In drainage analysis the Strahler’s stream -segment method of stream order has been applied. To demarcate the Suketi River Basin prepared various thematic layers of river basin and its tributaries. The study objectives came into a final target that the nature and type of environmental resources depletion, hydrological planning and pinpoint the intensity and distribution of depleting factors to treat them with ecological measures and to develop a technique for finding out the suitability of landforms for varied uses in the context with environment development.

Keywords: River Basin, Geo-Morphology, Landscape, Valley

1. Introduction
Drainage analysis is the most important aspect in the study of landforms. The analysis of drainage basins has a particular relevance to geomorphology. Fluvial eroded landscapes are composed of drainage basins and these provide convenient units with the help of which an area may be sub-division. The development of landscape is equal to the sum total of the development of each individual drainage basin. The adjustment of stream lines to the landscape is rather and index of the landform evolution in a humid region in which water becomes the most important sculpturing agent. Rock is the base, drainage is the fast agent and climate characteristics make the suitable conditions for drainage to make the suitable conditions for drainage is the fast agent and climate characteristics make the suitable conditions for drainage to make needful morphology on rock. So the morphology of landscape may be explained after studying the nature and intensity of drainage activity. The analysis of drainage as an agent is very important aspect to work out its pattern, evolution and genesis which forecast the rational development of landscape. Now, it has become very clear by above discussions that the morphology of the landscape is greatly governed by the drainage activities of the area concerned. In the Basin, there are broad U-shaped valleys, in which some of the landforms like co leasing piedmont forms, fan cut terraces and sand bars have been clearly observed.
The tributaries (mostly seasonal) on either sides of the Suketi River are responsible for the development of fans at the point of their confluence. These later landforms are the outcome of the fluvial processes. The most of the tributaries of the Suketi Valley rises from the permanent glacier melt water and Perennial Spring of the Valley receives considerable amount of water throughout the year.

![Figure 1: Location Map of Suketi River Basin](image)

2. Study Area

The Suketi River Basin which lies in lesser Himachal Himalaya (Mandi district) extending from 76°48'30" to 77° longitudes and 31°29' north to 31°45' North latitudes. The Zoom Dhar Ranges are situated on the Right and left side of the Kansha Khad as we know that the Umli Khad and Khansa Khad Tributaries of Suketi River which makes a confluence on Dadour and after 16 kms flowing it makes a confluence on Beas River in Mandi Town in the North West the Valley is demarked by the Dhauladhar Ranges this Range is also makes a the Drainage line between the Beas River and Umli Khad and on the North East the Vally is demarked by
Kangni, Dudar and Baggi Ranges. the major tributaries of the Suketi River like Umli river and Kasha river are rising from melted ice of the glaciers. The Suketi River Basin encompasses an area of 1710 sq.km with an altitude ranging from 754 m (at Beas Suketi confluence) to 2052 m (the highest peak of Zoomdhar). Figure.1 represents the location map of Suketi River basin.

3. Methodology

The present study of the Suketi Valley has been carried out with the recent qualitative and quantitative research techniques of landform evaluation to find out the geocatastrophic factors of the Natural resources degradation and to suggest conservation measures for their rational use in view of the development of scenic landscapes for development in the region. In drainage analysis the Strahler's stream -segment method of stream order has been by allotting finger tipped stream the first order. For the detailed morphometry like number and length of streams, drainage density, stream frequency, texture ration, bifurcation ratio, circularity index and sinuosity index have been analyzed & categorize to present the information in the form of table and maps.

4. Results & Discussions

A drainage map of a basin provides a reliable index of the permeability of the rocks and also gives an indication of the yield of the basin [Wisler and Brater 1959]. The stream order is a measure of its position in the hierarchy of a river. In the Suketi River Basin, the stream order network has been carried out to assume the smallest unit for the detailed Morph metric analysis of the valley. Thus the streams have been ordered according to the Stroller’s stream-segment allotting the finger toiled stream the first order. It is marked that the Suketi River Basin comprise of 5th stream order.

The total number of order streams in the Suketi Valley is 1238 which generates 250 second order streams forming 59 third order streams have been, marked to from three fifth orders streams shaping only fifth order in the whole Basin. Table.1 represents the streams order classification in the Suketi River Basin.

| Streams Order | Total Streams |
|---------------|---------------|
| 1st order     | 1238          |
| 2nd order     | 250           |
| 3rd order     | 59            |
| 4th order     | 01            |
| Total         | 1568          |

After having completed the network of stream ordering, the third order streams have been selected, which seems to be suitable smallest unit for the detailed Morph metric analysis of the Suketi Valley Basin. Thus there have been selected 16 intrabase in the area. The detailed Morph metric analyses of the selected 16 intra basins have been made on the following parameters.

1. Drainage Density
2. Texture Ratio
3. Drainage Frequency
4. Elongation Ratio
5. Bifurcation Index

The result of these parameters have been summarized and tabulated to correlate the parameters with each other to find out suitability to land use and its future planning for the economic development of the region.

4.1 Drainage Density of Study Area

Drainage density is an important geomorphic concept which means the relative spacing of drainage lines. It includes both drainage texture and drainage frequency. It may be defined as the ratio between the total lengths of streams in a given drainage basin divided by the area of the same drainage basin. The ratio between stream length and area has been calculated by taking third order intrabasins as the smallest unit.

\[
D = \frac{\sum L}{A}
\]

Drainage density = \frac{Total length of stream}{Area of the basin}

In the Suketi Valley Basin it has been recorded that if the density of the perennial stream in the given intrabase is maximum it reveals minimum areal coverage and the soil moisture remains more.

Thus, it concludes that the drainage density increase with the decrease in areal coverage and the soil moisture in the region remains more. Similarly, as the drainage density decrease the area of the intrabasin increase and soil moisture decreases and the area occurs and agriculture depends on rainfall. The drainage density of the present study area has been classified into seven groups ranging from .49 to 2.45 km. stream per Km² in the Jiwa nal and Jammu nal intrabasins respectively. Table 2 reveals the general distribution of drainage and its areal coverage.

Table 2: General Distribution of Drainage densities

| S. No | Drainage Density Class | Area in Km² | Area in % | Total Numbers of Intrabasins |
|-------|------------------------|-------------|-----------|-----------------------------|
| 1.    | 0.5-0.75               | 487         | 34.58     | 06                          |
| 2.    | .075-1.0               | 546         | 38.77     | 06                          |
| 3.    | 1.0                    | 375         | 26.63     | 04                          |

4.2 Distribution Pattern of Drainage Density

The above table no. and the distribution of drainage density map do not give a clear cut picture in the area because of its complexity. To avoid this complexity the drainage density is further categorized into three namely low, high and drainage density as given in the Table.3.

Table 3: Categorical Distribution of Drainage Density

| Drainage Density in Km/Km² | Area in Km² | Area in % | Total Nos. of Intrabasins | Remarks |
|----------------------------|-------------|-----------|--------------------------|---------|
| 0.5-0.75                   | 487         | 34.58     | 06                       | Low     |
4.2.1 Low Drainage Density

Generally, it has been marked that the intrabasins have more areal coverage with less drainage density which remains 0.5 to 0.75 Km streams per Km² 34.58 which includes the area of six intrabasins of the Suketi River. An extensive patch of low drainage density occurs in the catchments of Baryatral Goakhars Khad Sekli nal situated in the south Eastern portion of the basin. Other patches of this category are small and scattered throughout the valley.

The areas under low density category have very low soil moisture and land remains almost dry and infertile and there occurs problem of water for drinking and irrigation purpose. The dry farming wholly depends on rainwater otherwise the agricultural fields may go crop less.

4.2.2 Medium Drainage Density

Medium drainage density in the region ranges from 0.75 to 1.0 Km² streams per Km² area. The drainage density, areal coverage and soil moisture conditions in the area remain medium thus the area occurs under medium drainage density category. The category occupies an area of 546 Km² that is 38.77 areas of the six intrabasins which stretches throughout the valley. A large patch of the catchments of Gambhbar Khad, Talhyar Khad and Jhankar nal occurs in the central part of the basin. Second large patch of this category covers the area of Umlli Khad, Gangli gad catchments in the Southwestern portion of the basin and third large patch of this category in the catchment of Kansa Khad in the western portion of the basin. Other patches of the medium drainage density are small and scattered throughout the valley. The area under medium drainage is also affected by the lack of moisture and agricultural practices and also depends on rainfall. Wet farming in the area is nor possible except the land lying along the perennial streams.

4.2.3 High Drainage Density

The high drainage density is the area range above >1.0 Km streams per Km² and covering an area of 375 Km² that is 26.63 areas. This category generally corresponds with the high to very high relative relief, high absolute relief and steep slope as particularly marked in the central Western and North-Western part of the study area. A large patch of high drainage density occurs in the catchments of Lol nal and Baggi nal. Second large patch covers the catchment of zoom, Nagin, Balahor nal and Sehli nal situated in the North western part of the basin. Other patches of this category of drainage density are comparatively small scattered throughout the basin. The area besides having high drainage density is also covered with thick vegetation which plays a vital role in retaining the soil moisture. Thus, there occurs no scarcity of water and wet farming may be practiced in the area under references.

4.3 Texture Ratio of River Basin

Texture ratio is obtained by dividing the number of streams of the given basin by the perimeter of the same basin and is measured in streams per Km. the texture ratio in the present area has been calculated by taking third order intrabasins as the smallest unit:
Texture Ratio: \( \frac{\text{Nu}}{\text{Pu}} \)

Where Nu is total number of streams and Pu is the perimeter of the same basin.

Generally the rock types, climatic conditions, capacity of water infiltration and presence of absence of vegetal cover in the area have a great effect in the drainage density and drainage texture ratio in the area. The texture ratio directly or indirectly reflects the drainage density. It has been generally marked that the texture ratio increases with the increase in the area of the intrabasins. The general distribution of drainage texture ratio has been classified into seven groups as given below Table.4.

**Table 4: General Distribution of Texture Ratio in Suketi River Basin**

| S.No. | Texture ratio streams per Km | Area in Km\(^2\) | Area in % | Total Intrabasins |
|-------|------------------------------|------------------|-----------|-------------------|
| 1.    | >25                          | 228              | 16.19     | 05                |
| 2.    | -2.5-5                       | 1005             | 71.37     | -01               |
| 3.    | >5                           | 175              | 12.42     | 01                |
| Total |                              | 1408             | 100.00    | 16                |

The above Table No. reveals that the maximum areal coverage that is 1408 Km\(^2\) Occurs in the 3\(^{rd}\) group of texture ratio >5 streams per km which occupies the area of nine intrabasins at the area. The large patches of this group occupy the area of Gambhar Khad and Gokhars Khad catchments. Other patches of this group are small and scattered in the Western part of the basin. The distribution map of texture ratio reveals that this group forms three major patches of texture ratio: first in the catchment of Gambhar Khad in southern part, second and third patches of Gagal Nal Chandiyal Na catchments respectively in the north-eastern.

On the whole the distribution map and table do not give a distinguishing feature of texture ratio in the basin. To avoid this complexity texture is further categorized into three as given in the Table.5.

**Table 5: Categorical Distribution of Texture Ratio in Suketi River Basin**

| Number of streams per Km | Area in Km\(^2\) | Area in % | Total basins | Intrabasins | Remarks Categories |
|--------------------------|------------------|-----------|--------------|-------------|--------------------|
| >25                      | 228              | 16.19     | 05           |             | Coarse             |
| 2.5-5                    | 1005             | 71.37     | 10           | 01          | Moderate           |
| >5                       | 175              | 12.42     | 01           |             | Fine               |
| Total                    | 1408             | 100.00    | 16           |             |                    |

**4.4 Drainage Frequency of River Basin**

Drainage frequency deals with the number of streams per Km\(^2\) . It gives an idea of the distributional pattern of river with its tributaries per Km\(^2\) . In the Suketi basin, the number of streams has been counted in the selected intrabasins to find out the frequency of drainage in the valley. In the basin it has been recorded that the frequency of drainage counted through above method varies <.75 to 1.0 streams per Km\(^2\). It has been also recorded that the drainage frequency decreases with the increase in the area of the intrabasins. General distribution of
the drainage frequency in the area under reference has been grouped into eight classes in Table.6.

| S.No. | Number of streams per Km | Area in Km² | Area in % | Total intrabasins |
|-------|-------------------------|-------------|-----------|------------------|
| 1.    | >.75                    | 436         | 30.9      | 05               |
| 2.    | .75.1.0                 | 533         | 37.8      | 07               |
| 3.    | >1.0                    | 439         | 31.17     | 04               |
| 4.    | Total                   | 1408        | 100.00    | 16               |

The table and distribution map of drainage frequency does not give a clear cut picture of the drainage frequency in the valley. Therefore, to avoid this complexity these classes have been further categorized and expressed as low, medium and high drainage frequency in the basin as given in the below Table.7.

| S.No. | Number of streams per Km² | Area in Km² | Area in % | Total intrabasins | Category |
|-------|---------------------------|-------------|-----------|--------------------|----------|
| 1.    | >.75                      | 436         | 30.9      | 05                 | Low      |
| 2.    | .75.1.0                   | 533         | 37.8      | 07                 | Medium   |
| 3.    | >1.0                      | 439         | 31.17     | 04                 | High     |
| 4.    | Total                     | 1408        | 100.00    | 16                 |          |

Now the table given above reveals the distinguishing features of the drainage frequency in the basin. The map of drainage frequency categories are in the Suketi Basin. The area stretches from central part to Southern-Eastern part of the study area which occupied the catchment of Jatla nal, Baryat, Nalson, Khad and Suketi Khad, show comparatively poor frequency where as the northern part and central southern part of the basin exhibit higher frequency. It has also been marked that if the maps of drainage frequency categories and drainage density categories are overlapped, the patches of low, medium and high drainage frequency would ultimately more or less coincide respectively with the low, medium and high drainage density categories of the study area.

4.4 .1 Low Drainage Frequency

Low Drainage Frequency is marked below 0.75 streams per Km² in the region and covers an area of 436 Km² 30.9 of five intrabasins, which form only big patch of Jatla Barat Nal and Gokhars Khad catchments which is situated in the Western eastern portion of the Suketi Basin. It has been marked that these intrabasins of low drainage density category.

Thus the drainage density and drainage frequency are marked high correlated in the area. Resultantly, the moisture retaining capacity in the soil is very low and the agriculture is fully dependent on rain water.

4.4 .2 Medium Drainage Frequency

Medium Drainage Frequency in the basin ranges from 0.75 to 1.0 streams per Km² and the area of the intrabasins. On the whole the medium drainage frequency cover the maximum area i.e. 2303.59 area i.e. 233.59 Km² 37.85 which contribute the area of ten intrabasins of the study area. First large patch of medium drainage frequency occupies the area of Kamsha
Khad and Suketi Khad catchments situated in the extreme North western portion of the Valley. Second large patch covers the area of lot had and Ropru Khad catchments situated in the western portion of the area. Third patch of this category occupies the area of Taryasal Nals and Baryat Nalah catchments which is situated in the Easter part of the stud area. Remaining four patches of medium drainage frequency are small and scattered in the region.

It has been recorded that the drainage density of the perennial streams in this category is medium; resultantly the availability of water and soil moisture in the area is also medium. Thus, the agriculture basically depends upon rain fall except the low lying lands along the perennial streams where the irrigation is possible through Kuhal system in the basin.

### 4.4.3 High Drainage Frequency

High Drainage Frequency in the basin ranges from above 1.0 streams per Km\(^2\) and covers an area of 439 Km\(^2\) which contributes the area of four intrabasins of the area under reference. The drainage Frequency categories map shows that the maximum area of the high drainage frequency occurs in the northern half of the valley. A large patch of this category includes the central Western part of the study area. Second large patch occupies the area of Bhadyal catchment situated in the South Eastern part. Third patch occupies the area of Joka Rana, Khani Ra nal.

The area under high drainage frequency category is marked maximum under dense vegetal cover and the density of perennial stream is marked very high. Resultantly the moisture retaining capacity in the soil is recorded high which is suitable for agriculture, forest growth and fruit gardening in the region. In low lands the area under this category has been marked under rice cultivation.

### 4.5 Elongation Ratio of River Basin

Basin elongation is the ratio between the diameter of the area occupied by the basin and the maximum length measured for the same basin. In other words elongation ratio is the representative of the shape of the basin. Smaller the fraction more elongated is the shape of the basin, and larger the fraction the more circular is the shape of the basin.

The elongation ratio is also governed by the geological structure, relief and slope of the area. In the intrabasins which have soft rocks like phyllite, dolomite schists, slate and clay, low relief and slope the elongation ratio is marked low. It is generally marked that the elongation ratio remains high where rock strata is hard and slope remains high where rock strata is hard and slope remains steep. Table 8 represents elongation ratio of the Suketi River Basin.

| S. No. | Class  | Total Intrabasins | Area in Km\(^2\) | Area in % |
|--------|--------|-------------------|-----------------|----------|
| 1.     | >0.2   | 03                | 310             | 22.0     |
| 2.     | 0.2 to 0.4 | 12              | 933             | 66.2     |
| 3.     | >0.4   | 01                | 165             | 11.7     |
| Total  |        | 16                | 1408            | 100.00   |

The elongation ratio in the Suketi Basin ranges from 0.2 in the Gangle gad to 0.4 in the Ropru Nalla. The Table No. reveals that the first group of elongation ratio covers an area of 310 Km\(^2\) that is 22.0 areas of the intrabasins. Only one large patch of this group of elongation ratio occupies the area of Bhadyal nal, Chandyal nal, Vehra nal, Jatla nal and Bayat nal.
catchments situated in the central northern part of the study area. Other patches of this group are small and scattered in the area. Second group of elongation ratio covers the maximum area of the twelve intrabasins i.e. 933 Km² and is just half of the total area of the intrabasins. The map of elongation ratio reveals three major patches of this group of elongation ratio. First patch occupies the area of Gangli Khad and Knnsa Khad catchments situated in the South Eastern part of the basin. Other patches of this group of elongation ratio covers a 164 i.e. 11.7 area of the ten intrabasins of the study area.

4.5 Bifurcation Ratio of Suketi River Basin

Horton has introduced this parameter which indicated the property of streams to develop tributaries as well as frequency with which the stream of a given order inter the stream of next higher order. Bifurcation is the ratio between the numbers of streams in successive order, is the bifurcation ratio and this is simply a measure of the amount of branching of the drainage lines.

Thus bifurcation is one of the contributing factors of the drainage density, texture ratio and the value measures of property of the distributaries. To analysis the bifurcation ratio the number of streams of lower order is divided by the number of streams of next higher order\(^1\). Thus the bifurcation ratio ranges from 2 to 5 the study area. Table 9 represents elongation ratio of the Suketi River Basin.

| S. No. | Total Intrabasins | Area in Km\(^2\) | Area in % |
|--------|-------------------|-----------------|----------|
| 1.     | 03                | 232             | 16.47    |
| 2.     | 05                | 341             | 24.21    |
| 3.     | 08                | 835             | 59.30    |
| 4.     | 16                | 1408            | 100.00   |

The proceeding table and distribution map of bifurcation ratio reveals the three distinguish group of bifurcation ratio. The first group <4 covers minimum area that is recorded only 232 Km\(^2\) 16.47 of three intrabasins scattered throughout the basin. Second group 4-5 covers 341 Km\(^2\) that is 24.21 of the five intrabasins and area also scattered in the basin. Third group >5 occupies 835 Km\(^2\) that is 59.30 area of the basin which encompasses the area of Jatla nal in eastern and Sehli nal, Talhyar nal and Boryat nal intrabasins in the north. The bifurcation ratio reveals the conditions of surface run off of the basin. As the bifurcation ratio increase the run off may also increase in the basin, geology and climatic condition of the area has its influence on the bifurcation ratio.

5. Conclusion

This small study is observed that drainage study has several advantages. It will be of great use to hydrological planning, watershed management, EIA (environment impact analysis) proper management, policy makers, rural planners, in preparing proper village plans, slope stability plan, disaster management plan and prevention, for drainage designers to layout drains conforming to the contours of the area, as well as creation of other infrastructure facilities like hydro projects (dams), check dam and water supply network. So, Drainage pattern Study recommendations will helpful to the planners and decision makers to find the real solution for the problem chosen.
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