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RELIEF ANALYSIS USING GIS AND REMOTE SENSING

Dr Watsen Bangsia

Associate Professor, Geography Department, Wangcha Rajkumar Government College, Deomali Arunachal Pradesh

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ABSTRACT

The knowledge of relief and forms is essential for understanding spatial arrangement of the landforms, which facilitate a better placing, and more rational use of particular area. The word relief is used to describe the broad features and relative heights of highland and lowland, which are characterize by its form as mountain, plateau, hills, plain, spur and Valley etc. The difference in relief features of the landscape is due to its geological history and structure. Landscape is dynamic and the change is caused either by endogenic or exogenic processes. Relief analysis is important for land-use planning, disaster management and development planning. Relief of Tarat River Basin has been analysed with the help of GIS and Remote Sensing where Relative relief, absolute relief, relief profile and hypsometric curve have been studied. Study area falls under the Vth Seismic Zone and reported tectonically very active. Though it is not possible to stop the occurrence of natural disasters but through proper knowledge based on scientific studies it can be managed.

KEYWORDS: *Relief, Profile, Landscape, Analyse, Dissection Index, Hypsometric, River Basin, ILWIS*

INTRODUCTION

The landscape of the earth surface is ever changing either by endogenic (internal) or exogenic (external) processes. The differences in the relief features of the landscape are largely due to its geological history and structure. The word relief is used to describe the broad features and relative heights of highland and lowland, which are characterize by its form as mountain, plateau, hills, plain, spur and valley etc. R.D Salisbury (1919) introduced the concept of hierarchy of relief features and subsequently divided the relief features of the earth into three major classes on the basis of their size. A.L. Bloom stated, "Earth successive level include feature of successive smaller size, greater unity of origin and move transistent durability."

Landforms are usually shown on maps by contours, which directly represent altitudes; yet this factor is little direct significance for soil, vegetation and animal life. Altitudes act indirectly through its effects on temperature and in a more complex manner on rainfall (Young, 1972). Relief can be analyzed in terms of absolute and relative or local elevation. The knowledge of relief and forms is essential for understanding spatial arrangement of the landforms, which facilitate a better placing, and more rational use of particular area. An attempt has been made to study the relief of Tarat River Basin with the help of relative relief, absolute relief, relief profile and hypsometric curve.

Data Base and Methodology

For the present study data were collected from both primary and secondary sources. Topographical sheets No. 83 M/8, 83 M/12, 83 N/5 and 83 N/9 (1:50,000) were used along with IRS LISS III imagery. A survey was carried out to acquire detail geographical knowledge of the study area. Various Journals and Literature related to the topic were referred. For identification of relief characteristics, relative relief and absolute relief analysis has been carried out using ILWIS GIS software. Dissection Index of the study area is found out with the help of ILWIS by using the formula i.e. Relative Relief/Absolute Relief. Relief profile is prepared from the topographical sheets to pick up knick points and slope breakage in profiles.

Study Area

The proposed study area covering an area of about 179.1 Km^2 lies in the north eastern part of Tirap District, Arunachal Pradesh. The proposed study area is located in between $95^{\circ}22'18''$ to $95^{\circ}32'45''$ East longitude and $26^{\circ}53'38''$to $27^{\circ}\ 8'37''$ North latitude. The study area is approach by road upto Sanliam via Tezpur, Dibrugarh, Tinsukia, Naharkatia, Pulung, Borduria and Khonsa (the headquater of the District) from Itanagar and Guwahati by the road with a distance of about 555km and 625km respectively. The area accommodates 20 major villages and one main town (Headquarter of Tirap District) with the population of 19,375 (according to 2001 census). The major settlements including town of the basin area are Khonsa village, Kaimai, SumsiPathar, Laptang, new Laptang, Pansumthong, Pullung ,Borduria, Paniduria, Noksa, old Tupi, new Tupi, Luthong, Lapnan, Kheti, Thinsa, Hukan, Dadam, Bogapani, Sanliam and Khonsa Town. Besides many small settlements has emerged in the area due to introduction of tea plantation and shifting from the main villages for better amenities like Lowangdong Tea Estate, Lowangcha Tea Estate, Tupi Tea Garden, Borduria range, new Paniduria etc.

RELIEF ANALYSIS

Absolute Relief

For the precise description of specific relief and for getting the direct or indirect evidences of the genesis and evolution of certain landform, absolute relief is an important tool (Satpathi, 1981). For the delineation of an absolute relief the whole study area has been divided into the grids of 1Km^2 and the highest point falling over each unit has been recorded with the help of contours and spot height and placed accordingly.

The absolute relief of the study basin ranges from 180m to 2280m. The whole basin had been divided into five categories on the basis of this range taking an interval of 300 m.

- Very Low (<300m)
- Low (300m-600m)
- Moderately Low (600m-900m)
- Moderate (900m-1200m)
- Moderately High (1200m-1500m)
- High (1500m-1800m)
- Very High (>1800m)

The distribution pattern of Absolute relief shows that the height increases towards the southern part i.e. towards its source region from the mouth.

Table 1: Tarat River Basin: Absolute Relief

Absolute Relief (mtr)	Area in Km²	Area in %	Cumulative Area in %	Major Categories
<300	19	10.6	10.6	Very Low
300 – 600	60.9	34	44.6	Low
600 – 900	34.7	19.3	63.9	Moderately Low
900 – 1200	18.9	10.5	74.4	Moderate
1200 – 1500	19.8	11.1	85.5	Moderately High
1500 – 1800	16	9	94.5	High
>1800	9.8	5.5	100	Very High
Total	179.1	100	100	

Distribution of Absolute Relief

The lowest absolute relief is found near the mouth of the basin i.e. in the northern part. The total area coved under this category is 19Km² and accounts for 10.6% of the total area of the basin. The contour value ranges below 300m.

Maximum area of the basin falls under the low absolute relief where the height ranges from 300m to 600m. About 34% of the area comes under this category. The areal coverage of this category is 60Km². The height ranging from 600m to 900m had been categorized under moderately low category. The total area covered by this class is 34.7Km² accounting for 19.3% of the basin area.

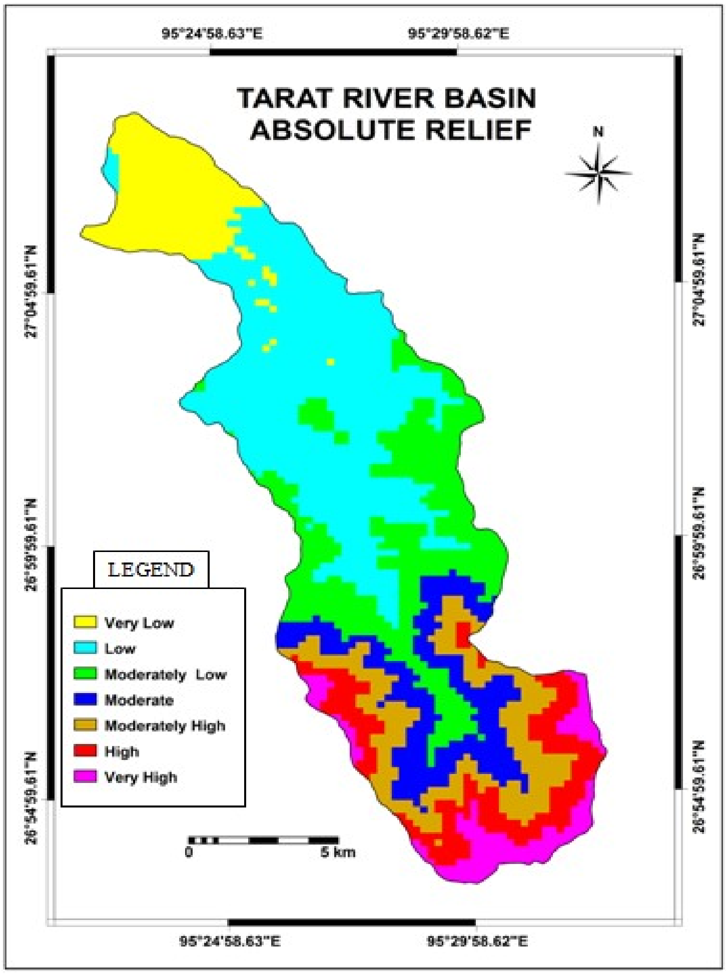


Figure 1: Absolute Relief

The Moderate class had been assigned to the height ranging from 900m to 1200m. This class had a percentage share of 10.5% of the total basin area and covers an area of 18.9 Km².

Altitude ranging from 1200m to 1500m had been kept under moderately high category. Total area covered by it is 19.9 Km² and accounts for 11.1% of the total Basin Area.

Under the category of High Absolute Relief the contour ranges from 1500m to 1800m. The areal extension of this category is 16 Km² and had a percentage share of 9% of the total basin area.

The southernmost part of the basin i.e. the source region has the highest Absolute Relief. It covers an area of 9.8 Km² that accounts for 5.5% of the total Basin Area.

RELATIVE RELIEF

The relative relief of the area expresses the amount of slope and nature of surface slope. It is obtained by computing the difference between the highest and lowest elevation within the unit grid. It is one of the best methods for the measurement of local roughness (Smith,G.H, 1935). According to Singh (1967) the term relative relief denotes actual variations of height in a unit area with respect to its actual base level. The concept of relative relief was first introduced by Partlich (1911) and later on different terminologies were used by different geomorphologists e.g. Drainage relief (Glocks, 1931), Topographical relief (Johnson, 1933), Amplitude of available relief or relative relief (Smith, 1935).

Relative relief of the study area has been determined using the Smith's method where the whole area has been divided into the grids of 1km^2 and the difference between the highest and lowest elevation within grid limit has been calculated. After computation of the value it had been found that the Relative Relief of the Tarat river Basin ranges from 6m to 256m.

On the basis of this range the whole basin area had been divided into five classes

- Very Low (<50m)
- Low (50m-100m)
- Moderate (100m-150m)
- High (150m-200m)
- Very High (>200m)

It is clear from the Fig. n.3.2that the maximum area of the basin falls under low category covering a total area of 69.6Km² and sharing 38.86% of the total basin area. Moderate class occupies the second largest area accounting for 27.4% or 49.1 Km² of basin area. 31.7 Km² of the basin area falls under very low relative relief class accounting for 17.7% area. Very high relative relief class occupies about 20 Km² (11.1%) of the total area. The very high relative relief class, associated with steep gradient accounts for 4.9% of the basin area.

Table 2: Tarat River Basin: Relative Relief

Height (mtr)	Area in Km	Area (%)	Cumulative area (%)	Major categories
<50	31.7	17.7	17.7	Very Low
50 – 100	69.6	38.9	56.6	Low
100 – 150	49.1	27.4	84	Moderate
150 – 200	20	11.1	95.1	High
>200	8.7	4.9	100	Very High
Total	179.1	100		

Very Low Relative Relief (<50m)

The northern part of the basin mainly along the river valley falls under the low relative relief zone. The total area occupied by this class is 31.7 Km² and has a share of 17.7% of the total basin area. The border area of Assam and Tirap mainly falls under this category and the areas are marked under reserved Forest. Important places like Khonsa which is the headquarter of the Tirap District falls under this category along with places like Lakhaswang Ho and Famthang Ho.

Low Relative Relief (50m – 100m)

The total area occupied by moderate Relative Relief class is 69.6 Km² which is 38.86% of the total basin area. The maximum area of the basin (Table 3.2) falls under this category. Maximum settlement area of the basin has moderate relative relief that lies in the central part of the basin. Villages like Khonsa, Lapnan, Tapi, Noksa, Paniduria, Laptang and part of Borduria falls under this category.

Moderate Relative Relief (100m – 150m)

Moderately high relative relief accounts for 49.1 Km² (27.4%) of the total basin area. This category mainly can be seen in and around the moderate class. Some part of Borduria and Kaimai falls under this category.

High Relative Relief (150m – 200m)

To the south of the moderately High Relative Relief lies the High Relative Relief Zone. The total area occupied by this class is 20Km^2 which is 11.1% of the total basin area. This category can also be seen in the source region of the basin i.e. in the southernmost tip of the study area. Places like Hukan, Sanliam (some part) falls under this class.

Very High Relative Relief (>200m)

Very high relative relief zone is surrounded by the high relative relief category. It covers about 8.7 Km² or 4.9% of the total basin area. This category occupies the least area of the basin. Important places that come under this category are Thinsa, Dadam and some part of Saliam.

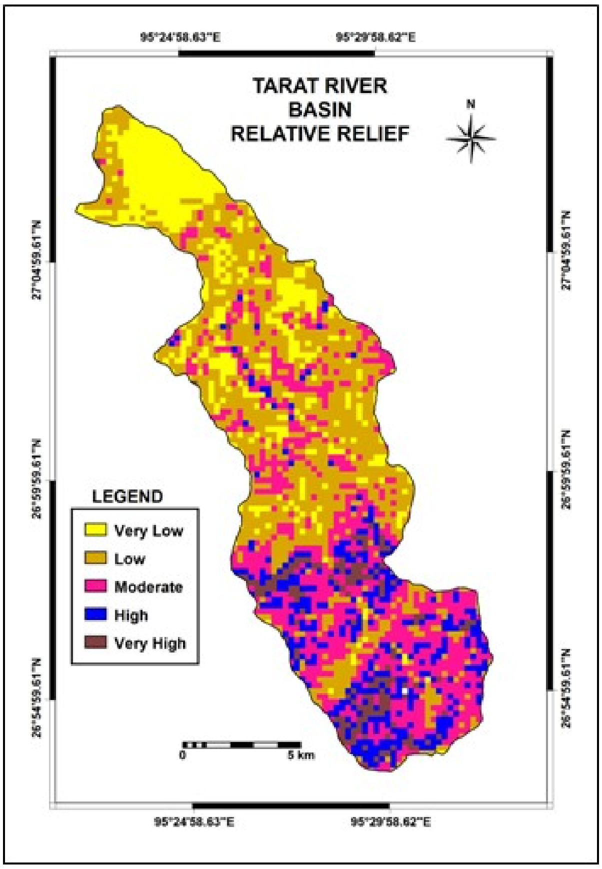


Figure 2: Relative Relief

It is clear from the figure- 3.2, that the northern part of the basin area falls under the low relative relief category. The central part falls under the moderately low and moderately high relative relief class. And the southern part of the basin comes under the high and very high relative relief category.

DISSECTION INDEX

Dissection Index is the ratio between absolute relief and relative relief. Dissection Index is an important morphometric indicator of the nature and magnitude of dissection of terrain. Dov Nir (1957) suggested the following formula for the derivation of dissection index:

$DI = R_R/A_A$

Where R_R is relative Relief and A_A is absolute Relief.

The values of dissection, derived generally vary between 0 and 1 and the value of ratio can never be more than 1 except in the case of vertical cliff, and similarly 0 values is possible only in theoretical framework. Dissection index is also used as morphometric determinant of the stage of cycle of erosion wherein old, mature and young stages are related to dissection indices of less than 0.1 (less than 10 percent), 0.1 – 0.3 (10 percent – 30 percent) and more than 0.3 (above 30 percent) respectively.

Dissection Index of the study area is found out with the help of ILWIS by using the formula i.e. Relative Relief/Absolute Relief.

The Dissection Index of the Tarat River Basin ranges from 0.02 to 0.32. On the basis of this range the basin area is divided into following classes.

- Very Low (<0.05)
- Low (0.05-0.1)
- Moderate (0.1-0.15)
- High (0.15-0.2)
- Very High (>0.2)

Table 3: Tarat River Basin: Dissection Index

Dissection Index	Area in Km²	Area in %	Cumulative area in %	Categories
<0.05	10.2	5.7	5.7	Very Low
0.05 – 0.1	55.9	31.2	36.9	Low
0.1 – 0.15	58.7	32.8	69.7	Moderate
0.15 – 0.2	31.6	17.6	87.3	High
>0.2	22.7	12.7	100	Very High
Total	179.1	100	100	

The Mean of Dissection Index is 0.13, Median is 0.12, Mode is 0.12 and the standard Deviation is 0.06.

Very Low Dissection Index (<0.05)

This category has a DI less than 0.05 and occupies an area of 10.2 Km² or 5.7% of the total Basin Area. It is mainly concentrated in the northern part of the basin in the flat valley region. Some traces can be seen in the source region and central part also. Some part of Borduria range has this type of dissection index.

Low Dissection Index (0.05 - 0.1)

DI ranging from 0.05 to 0.1 covers an area of 55.9 Km² or 31.2% of the basin area. This category is mainly identified in the source region i.e. towards the southern part of the basin. It is also found in the basin border in both right and left side towards the central part. In northern part it is found surrounding the very low dissection index. Areas like Sanliam, kheti, Thinsa and Dadam have low dissection index.

Moderate Dissection Index (0.1 - 0.15)

Maximum area of the drainage basin has DI ranging from 0.1 to 0.15. Total area covered by this category is 58.7 Km² or 32.8% of the basin area. This category is identified in the areas like Hunkan, some part of Khonsa town and Khonsa Village, Paniduria.

High Dissection Index (0.15-0.2)

This category covers an area of31.6 Km² or 17.6% of the basin area. Central part of the basin has high dissection index. Areas like Kaimai, Borduria have this category of dissection index.

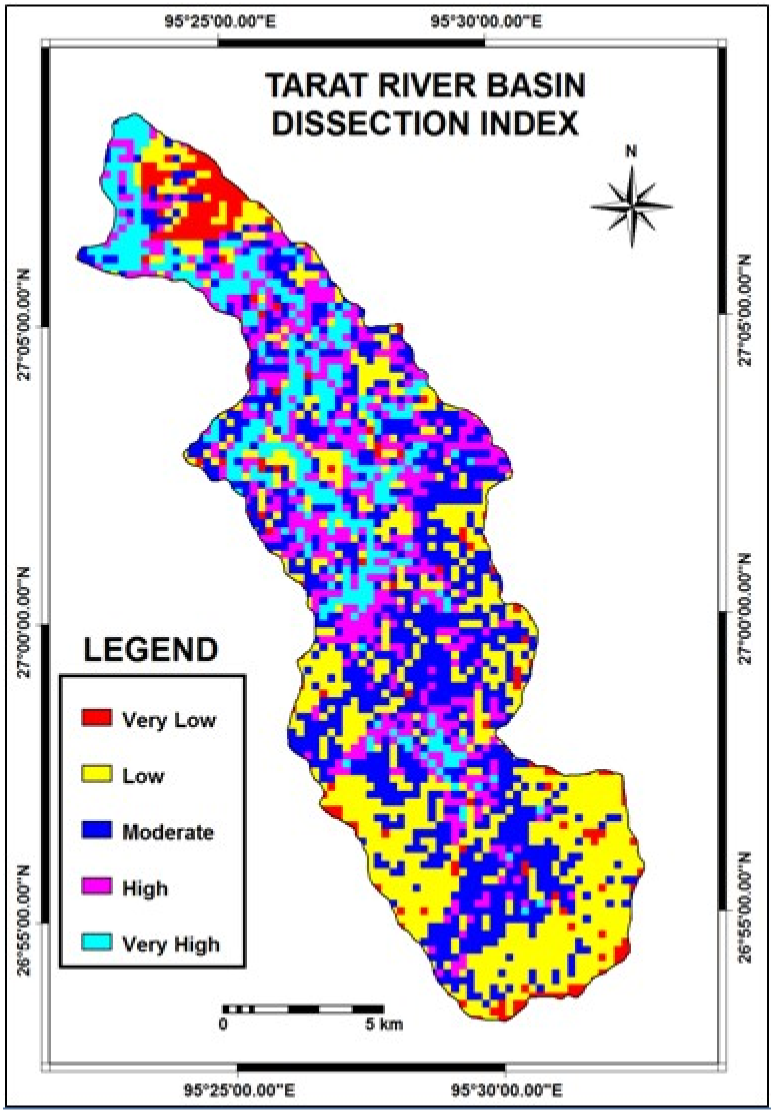


Figure 3: Dissection Index.

Very High Dissection Index (>0.2)

Dissection Index ranging above 0.2 covers 12.7% or 22.7 Km² of the total basin area. This category is found mainly towards the extream north and the central part of the basin. Settlement like Pullung, Pullung camp, Laptang have very high dissection index.

HYPSOMETRIC ANALYSIS

Hypsometry involves the measurement and analysis of relationships between altitude and basin area to understand the degree of dissection and stage of cycle of erosion. Area - height curves, hypsometric curves and percentage hypsometric curves are generally used to show the relationship between altitude and area of the basin. The basic data which required for its preparation are area between successive contours and their respective heights.

A Hypsometric curve indicates the proportion of area of the surface at different elevation above or below a datum (Monkhouse and Wilkinson, 1967). The values of area are plotted as ratios of the total area of the basin against the corresponding heights of the contours and hence the area is represented by cumulative percentage. Hypsometric curve present a generalization of the surface character along with the areas incorporated in different height groups (Singh, R.L., 1980). The hypsometric analysis has been used to differentiate between erosional landmass at different stages during their evolution (Strahler, 1952).

Hypsometric analysis of the study basin area has been carried out to analyze the relationship between altitude and basin area to understand the degree of dissection and stage of cycle of erosion. The hypsometric curve generally shows the proportion of area of the surface at various elevations. Tarat River Basin hypsometric curve revels that the highest proportion of the area has the height below 1000m above mean sea level. Area having very high altitude (more than 2000m) has a very less proportion of area under it. The area having the height of 2000m to 1200 has a very steep slope which indicates a high rate of erosion.

Table 4: Tarat River Basin: Height and Cumulative Area (%)

Height in metre	Area in %	Cumulative Area in %
>2000	1.09	1.09
1750-2000	4.13	5.22
1500-1750	6.65	11.87
1250-1500	8.74	20.61
1000-1250	9.35	29.96
750-1000	9.73	39.68
500-750	22.38	62.06
250-500	29.25	91.31
<250	8.68	100

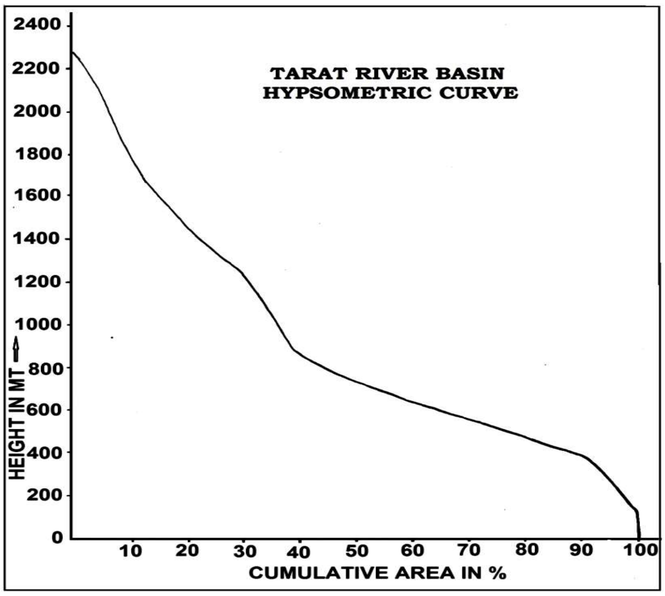


Figure 4: Hypsometric Curve.

AREA-HEIGHT CURVE

Area-Height curves generally indicate the actual areas between two successive contours and hence horizontal axis represents area in terms of percentage of total area and the vertical axis shows height.

Area-Height curve of Tarat Basin was prepared with the help of contours identified from the toposheets of the study area with their corresponding areas. The Area-Height curve of the study basin indicates that the highest percentage of area comes between the contour values to 250m to 500m.

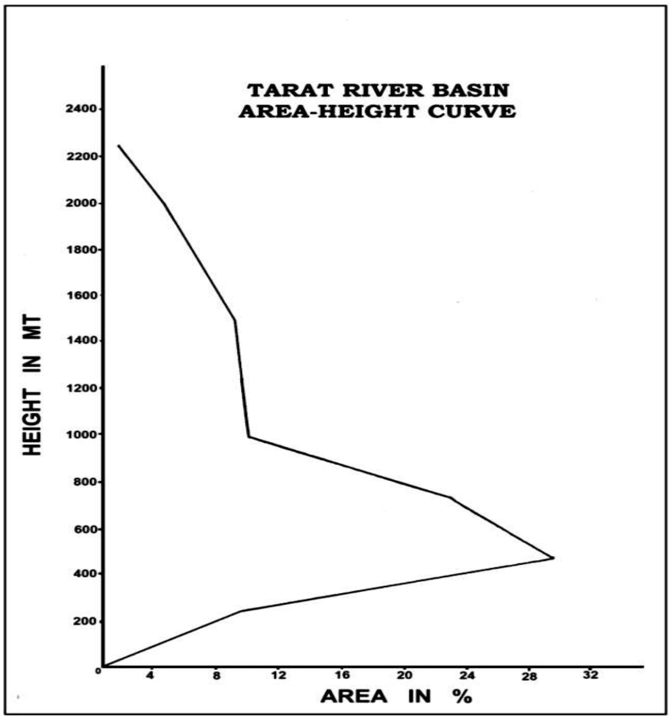


Figure 5: Area- Height Curve.

ALTIMETRIC FREQUENCY HISTOGRAM

Altimetric frequency graph involves the computation of frequency of occurance of height above sea level and plotting it on the graph paper. Either spot height all over the map of an area may be counted, or the map may be covered up by a grid of small squares and the highest point in each square be noted, percentage of the frequency should be graphed along the vertical scale and the actual elevation along the horizontal scale.

The Altimetric frequency histogram of the Tarat River Basin shows that the height between 2000m-2500m has less than 2% of the basin area. This shows that the river is actively involved in the erosion work towards this region. The area having the height of 1750m-2000m has the percentage of 4.12% area of the basin.

Table 5: Tarat River Basin: Height and area in Percent

Height in metre.	Area in %
<250	8.68
250-500	29.25
500-750	22.38
750-1000	9.73
1000-1250	9.35
1250-1500	8.74
1500-1750	6.65
1750-2000	4.13
>2000	1.09
Total	100

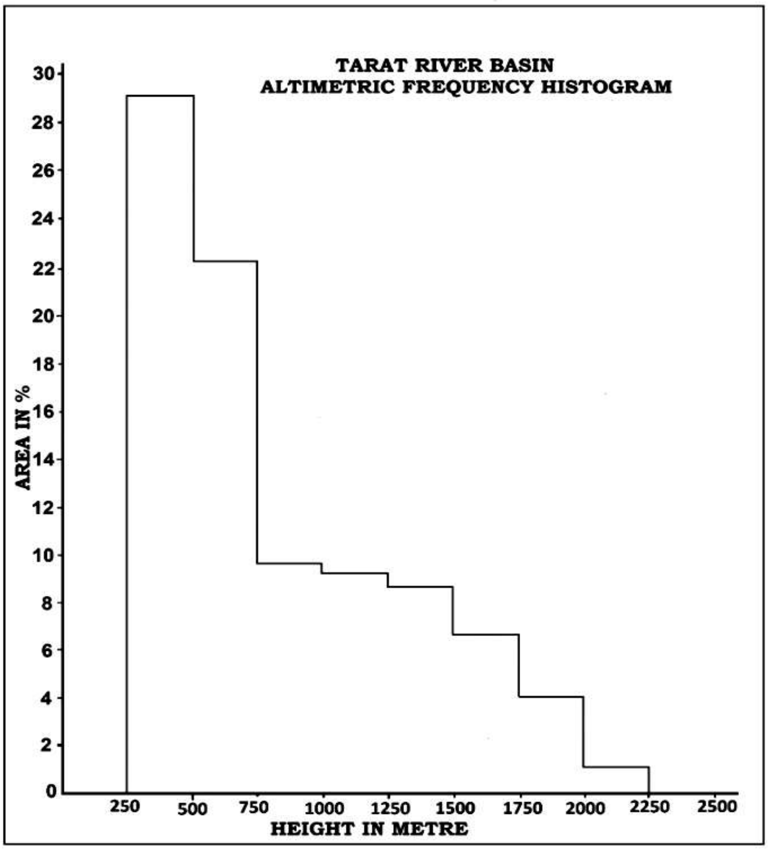


Figure 6: Altimetric Frequency Histogramshare.

The percentage of basin area under the height of 1500m-1750m, 1250m-1500m, 1000m -1250m, 750m-1000m, 500m-750m and 250m-500m are 6.65%,8.74%,9.35%, 9.73%,22.38% and 29.25% respectively. It is clear from this observation that there exist a negative relationship between the height and the percentage of area i.e. the percentage of area increase with the decrease in height. This indicates that river is actively involved in vertical erosion towards the higher altitude and the rate of it decreases with decrease in height.

PROFILES

A profile on relief features is a visual aid in its description and interpretation; hence, it is of particular interest for geomorphologists. Broadly speaking, a profile means an outline of relief (elevation) of depression (along a selected line), for example, the profile of a river valley. Since contour maps which is an indispensable and to geomorphologists is incomplete in its indication (Wooldridge and Morgan, 1946) the terrain profile provides a better knowledge of the absolute relief. Serial, superimposed, projected and composite profiles are frequently used in the geomorphological interpretation of the terrain as they are useful in depicting the nature of the general relief and different surface. In the study area these profile shows the visual picture of surface configuration.

Generally profiles are of two types viz.

- River profile
- Terrain profile

River profile is further divided into:

- Longitudinal profile
- Transverse profile

Terrain profile is further divided into

- Serial Profile
- Super imposed Profile
- Projected Profile
- Composite Profile

Serial Profile

In the serial profile a number of parallel lines should be drawn on the map. Important features should not remain untouched by the lines. A series of profiles one along every line should be drawn.

The diversification of undulating topography is easily marked by serial profiles. The eroded dissected and flat characteristics of the terrain are noticeable near the excavated river valley areas. In profiles drawing it become necessary to exaggerate the vertical scale in order to give prominence to the relief features, which would otherwise remain unrecognized. The exaggeration depends on the map scale and the relative altitude. Serial profile of the present study basin is shown in the fig. no. 3.5. Tarat basin has a rugged profile with deep central portion towards its source and more or less uniform and plain profile towards the mouth. This indicates that there is more vertical erosion towards the source and more of lateral erosion towards the mouth.

Super-Imposed Profile

When all the profiles of the series of profiles are traced on a single frame, these are called super-imposed profiles, because it illustrate the super imposition o profiles one over the other. It is drawn with the help of serial profiles starting from east towards west. The high ridges and deep valley are well marked in superimposed profiles; the clustering form of hilltops can be represented in the profiles.

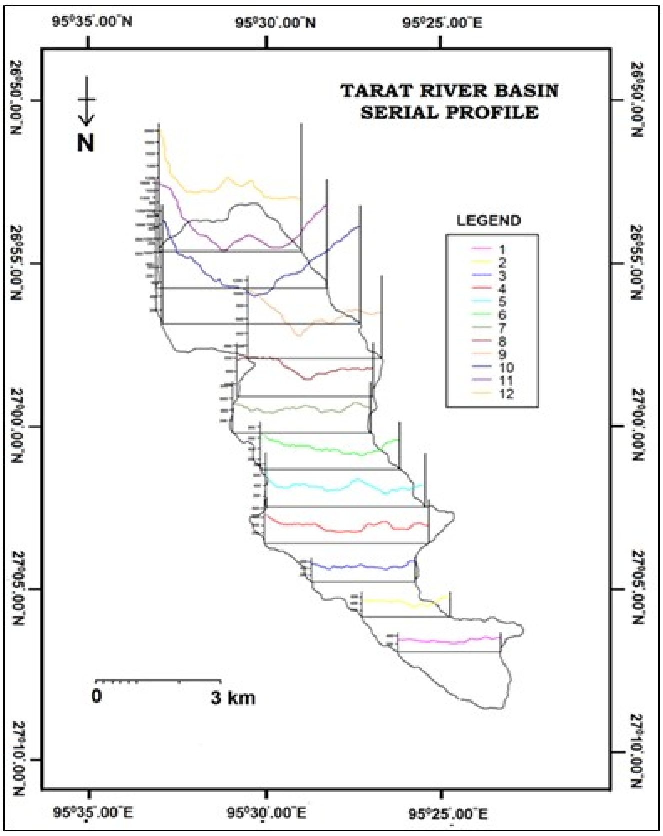


Figure 7: Serial Profile.

Projected Profile

It is a careful super imposition of a series of profiles one over other but those parts of the profiles from the super imposed profiles which show the relief hidden behind higher elevation. A projected profile gives a panoramic view of the whole landscape of the region as if seen from above and they also present a vivid picture of the magnitude of relief and general nature of dissection of the region (Savindra, 1999). Projected profile of the study basin is shown in the figure 3.6.

Composite Profile

When the highest parts of the profiles are shown to represent relief as viewed in horizontal plane of the summit levels from an infinite distance. It can be called as composite profile. It shows the ruggedness of the skyline.

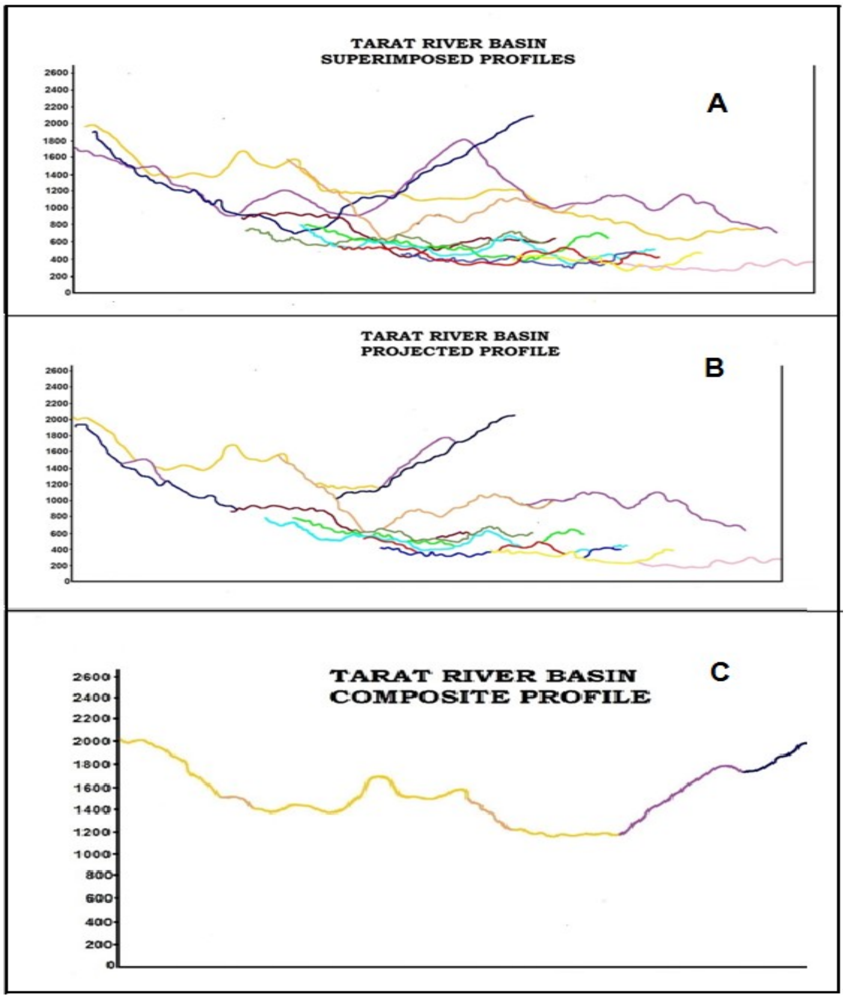


Figure 8: Profile: A. Superimposed B. Projected C. Composite.

CONCLUDING REMARK

The distribution pattern of Absolute relief shows that the height increases towards the southern part i.e. towards its source region from the mouth. The absolute relief of the study basin ranges from 180m to 2280m and the Relative Relief of the Tarat river Basin ranges from 6m to 256m. The Dissection Index of the Tarat River Basin ranges from 0.02 to 0.32 having maximum area coming under the range of 0.1 to 0.15. This indicates the basin in its moderate stage of terrain evolution and erosion intensity. Tarat River Basin hypsometric curve revels that the highest proportion of the area has the height below 1000m above mean sea level. The Area-Height curve of the study basin indicates that the highest percentage of area comes between the contour values to 250m to 500m. Tarat basin has a rugged profile with deep central portion towards its source and more or less uniform and plain profile towards the mouth. This indicates that there is more vertical erosion towards the source and more of lateral erosion towards the mouth.

From the above analysis it is relevant that the study area is characterized by rugged, mountainous and highly dissected terrain with high relief. Soil is not fertile and most of the area has mountain soil. Due to this the life of the people is not easy. There is very limited area for wet cultivation and the people are mostly engaged in shifting cultivation and terrace cultivation where the input is more than the output. The drainage of the study area have a high capacity to carve deep valleys, gorges and canyon due to deep vertical drop which accelerates surface runoff and river flow thereby indicating strong hydro- geomorphic activities. The region has rich and diverse microclimates supporting multiple ecological zones making it home for rich flora and fauna.

Tarat River

Shifting cultivation

Exposed Rocks

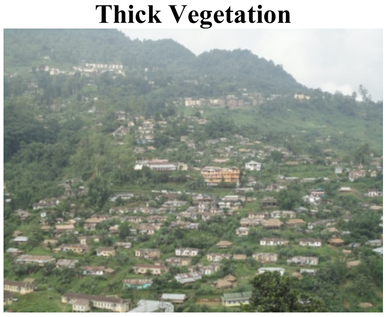
Exposed Mountian Soil

Landslide

Thick Vegetation

Profile

Settlement (Rural)



Settlement (Urban)

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