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Evolution Analysis Of Structures And Landforms Of Thalisain Area, Garhwal Himalaya, Uttarakhand

TRIPTI JAYAL[1], D.D. CHUNIYAL[2]

[1]Environment Management Division, ICFRE, Dehradun, Uttarakhand
[2]Department of Geography, School of Earth Science, HNBGU, Srinagar, Garhwal, Uttarakhand

Abstract: **Evolution of landforms of any basin is due to its diversity in lithology, geological structures and their impact on drainage pattern. Thalisan area is combination of two basin (partially) Western and Eastern Nayar and Bino, the area has a distinctive landform-ecology. The landforms are severely deteriorated by geocatastrophic processes like landslide, rockfall, soil creep and debris flow.Impact of morphological characters on the terrain is reflected by drainagebasin of the area. The repetitive calculated values of all the morphometric parameters of different litho-tectonic zones were processed. The quantitative study of these morphometric parameters suggests that the basin shape, stream density, relief, ruggedness, stream frequency and circularity index are controlled by altitude and climateas well as nature of bed rocks. The morphometric parameters like absolute relief, relative relief, dissection index, drainage texture, drainage frequency and slope were analysised and superimposed to workout homogeneity in landforms units.**

Keywords: **Landform evolution, Watershed, Garhwal Himalaya, lithologyand tectonic zones.**

I. INTRODUCTION

The Western portion of Garhkum (Garhwal and Kumaon) Himalaya is known as 'Garhwal' with a total area of 30,000sq.km and this part of Himalaya consist of seven district- Uttarkashi, Chamoli, Rudrparyag, Haridwar, Tehri Garhwal, Pauri Garhwal and Dehradun which forms the administrative unit as 'Garhwal Region'.Thalisain area of Pauri district extends from 29°54'30" to 30°10'0" N and 78°54'0" to 79°13'30" E, measuring 35km in length and 49km in width. The area covers 584.km^2(Figure 1.).The Eastern part is delineated with an alpine pasture locally known as Bugyal is Dudhatoli ridge. The study area is drained by three rivers partially are Eastern and Western Nayar and Bino Nadi. Eastern-Western Nayar and Bino are the sixth order tributaries of Nayar and Ramganga river respectively.The lower area of Thalisain act as transitional location between Kumaoun and Garhwal. This area shows adequate variations of environment and level of development representing Himalayan heterogeneity.

Figure. 1. Location Map of Thalisan area

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II. GEOLOGY

The Lesser Himalaya is one of the most complex tectonic groups of Himalayan region. It is formed by sedimentary, igneous and low to high grade metamorphic rocks.These are as follows granite, grainodirite, basalt, augen gneiss, slate, mica schist, quartzite, sandstone, limestone, dolomite, conglomerate. The Thalisain Area is, located in the lesser Garhwal Himalaya south of the Dudhatoli range, exhibits a variety of meta-sediments that have suffered multiple phases of, deformation and metamorphism [1]. Middlemiss (1837) was the first to carry out investigations regarding the geology of the Dudhatoli range. The Dudhatoli crystallines as a thrust sheet [2]. Later (1949) he thought the Dudhatoli granites and schists to be occurring at the base of the Krol Nappe unit. The Dudhatoli granite massif is extended in the north west of Almora Crystalline Thrust sheet [3].The name Dudhatoli group was introduced by Mehdi et al (1972) for the rocks belonging to the Chandpur, Nagthat and Dudhatoli Almora crystalline formation exposed in the Pauri–Paithani–Thalisain sections of the inner lesser Himalaya. The metamorphism in the Dudhatoli are and has shown that the rocks of this area have been metamorphosed upto the sillimanite zone [4]. Das and Pande (1973) have delineated three metamorphic zones, i.e. (i) almandine zone (ii) stauratite-Kyanite zone-and (iii) felspar-muscovite-sillimanite zone. (Figure 2.)

In refrence to these three basins lineaments are Chhoya gad of western Nayar, Gwari gad and other tributaries of eastern Nayar in the lower part and Bhaneld and Basola gad of Bino basin follow the NW-SE trend. This trend represents the second phase of tectonic activities of upliftment. Chakhalghat Gad from source to confluence near Syoli talli , lower part of Khand gad and left flank of Dhijyuli gad of western Nayar; Singwar gad and Khirganga nala of Eastern Nayar follow the NE/SW trend. This is the youngest trend of lineaments in N/S direction which displaced all order trends of lineaments. Syoli gad and other tributaries of western Nayar follow the same trend and all are parallel to each other, the upper part of bino od ki gad, bagar gad and masangari nadi follows the N/S trend. Where ever NW/SE and NE/SW trends lineamentsdisplaced together the river flows in meanders.

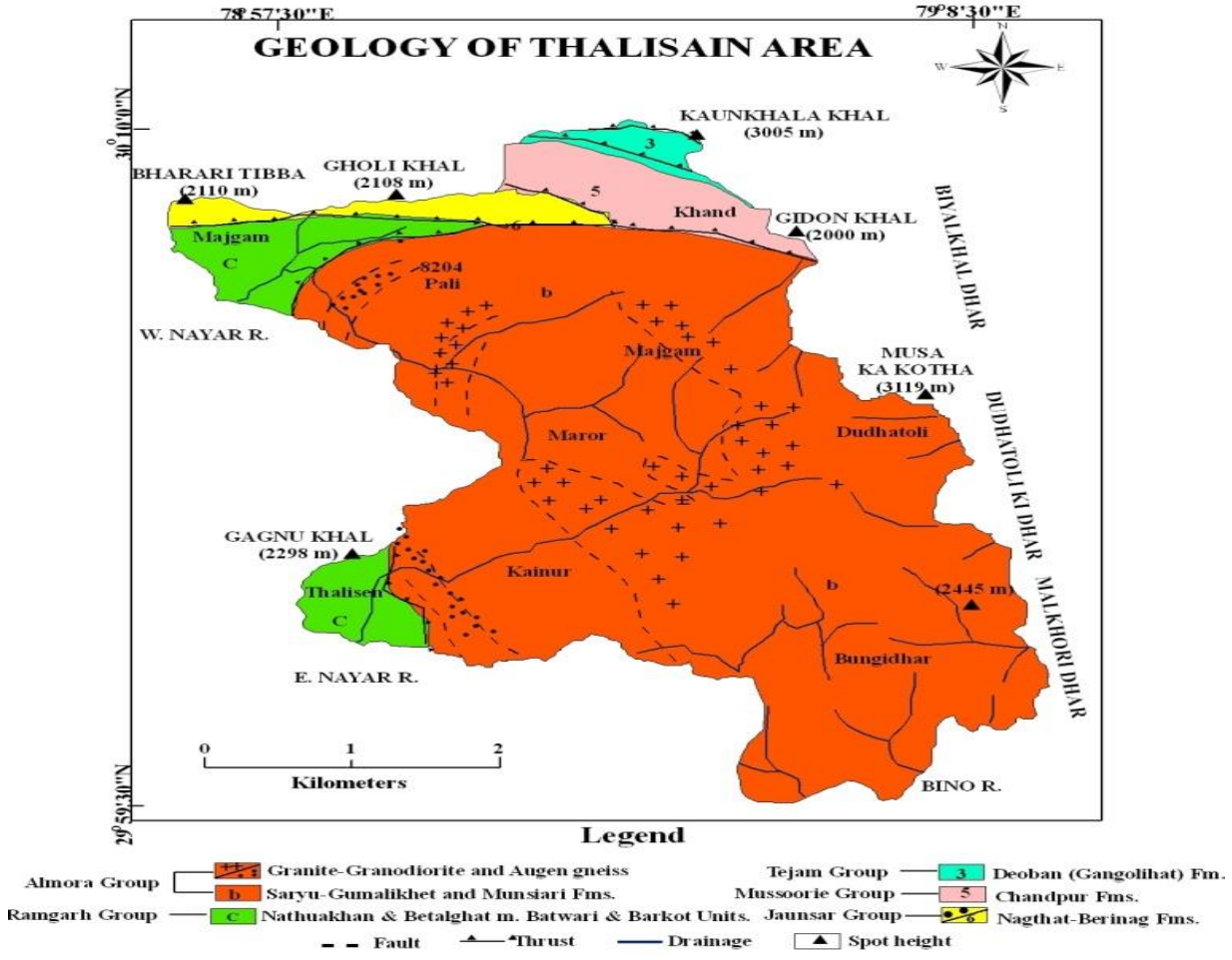

Figure 2. Geological map

A. *Correlation of morphogenetic system with landscape evolution:*

All the structural part present in this area are helping factors in the evolution of morphological features like stream courses, lineaments ridges etc as they follow these features for quite long distances. These thrust and faults are grouped as follows.

Structurally, the study area which forms a part of the Dudhatoli Almora Thrust sheet, is very interesting where linear and planer structures and folds are very well developed[3].The area has suffered many phases of deformation. In the Thalisain area (North west of Dudalpli) polyphased deformation has also been reported. On the basis of broad stratigraphic setting, the Kumaon super group represents the following structural units: North Almora Thrust has NNN ESE trend with 45^{o}-70^{o} southerly dip and separates the litho units of the Kumaon super groups and Garhwal group [5].In the NW-SE direction there is a sheared zone in the western part, which separates the Dudhatoli granite Gneisses, and phyllites schist (Figure 2.). The dip of this sheard zone measures between 30^{O} 50^{O} in NW-SE direction. Dudhatoli Tectonic Unit shows effects of ¬at least three tectonic phases [6]. The first one is responsible for the development of the WNE ESE tending regional folds such as Dudhatoli syncline, and a number of strike slip faults. During the second phase, these structures were refolded along with the North Almora 'Thrust' into NE SW tending broad folds and faults. The last tectonic phase is superimposed over the earlier ones. Dudhatoli Syncline is an asymmetrical broad synclinal fold with a steeper northern limb. Dudhatoli Dhar Chopragarhi Dhar Kolani Dhar - Dharkot Dhar and Tama dhon Dhar in the Bino basin. The Massangarhi Nadi crosses this syncline at Deghat. The syncline is almost along the ridge. The axis of this syncline is NW SE direction.South Almora Thrust comprehends from south Almora, tending in NW SE direction with a variable amount of dips towards north or north cast. The major divisible as recognised by Kumar, Prakash and Singh (1974),separates the Dudhatoli, crystalline from the meta-sedimentary of lesser Himalaya. The Dudhatoli crystallines are equivalent to Ramgarh thrust, may be the extension of Chail thrust in this part of lesser Himalaya [7].

Nayar Fault is one of the major faults which is noticeable due to straight course of Nayar river from Marora to babina. Western Nayar fault also flows along a fault between Pabau and satpuli [8]. Another major fault is observed before Sanglakoti in Machhlad valley. Other lineament is the Eastern Nayar lineament extended 65 km in length passing through Thalisain, Baijro- Bironkhal and Dhumakot. Besides these major thrust and faults, there are number of faults observed in Nayar basin which are followed by small nalas and tributiries. Dudhatoli Crystelline fault separates the Dudhatoli crystalline zone and western meta sedimentary zone. The Bino river almost follows this fault line from Kedgr upto Deghat, and from Deghat to Dudhatoli, this fault line is follows by the Massangarhi Nadi. At Chhin Ghat, this fault crosses the Chuparagarhi Dhar and follows the southern limb of the Dudhatoli. From Ulmara to Dadholi, this fault makes a zig zig shape. This is because of the many phases of deformation. This fault line is clearly visible in the aerial photographs and had also been reported by Rupke and Sharma (1974) with the help of Remote Sensing techniques.

III. LANDFORM EVOLUTION

The Nayar and Bino Basin entirely lies within the Lesser Himalaya unveiling high altitudinal differences, numerous erosional and depositional landforms due to glacial, glacio-fluvial and fluvial processes. The hills in study area do not occur as a series of straight line and having conical and rounded ridges with their heights ranging from 2224m (Pithundikhal) to 3119m (Musa KaKotha). On the basis of altitude they are characterized as high to Low Mountain ranges. The valleys are the products of erosion of weak zones, like fold axes, fault-planes, features, joints and bedding-planes by the Eastern-Western Nayar River and its tributaries. Due to structural and lithological complexities, geomorphic features of the valleys are narrow and form deep gorges, while sporadically they suddenly become wide and shallow. This may be due to the intersection of faults or sudden changes in the lithology. Along the main central water divide where the lithologies are weaker (shale, phyllite etc.), the mass movement in the form of creep is dominant. In the dudhatoli area where metamorphic rocks are exposed, the physical weathering is dominant and detritus material is deposited along the middle part of slope. Along the valley regions and the upper slope areas where the lithology is hard, rockfallsand slide have helped in development of Escarpment or Cliffs. There are two types of escarpments identified in the study area; the first one is of tectonic origin and generated by faults while the second category of escarpment belongs to the differential erosion of compacted and friable sandstone bodies. Steep scarps are also found along the banks of drainage channels where the fluvial erosion had played a dominant role in carving such features. The main valley course of the Nayar reflects two distinct cycles of erosion and Nayar thus represents a two cyclic valley i.e. ‘V’ shaped in ‘U’ shaped valley.

In the study area, both paired and unpaired terraces are common. Unpaired terraces are more common in the upper reaches, while paired terraces are not uncommon and have been observed along the foothill and low-lying areas. Apart from the deeper valleys the whole area consists of highly dissected topography. The topography of the basin is highly rugged and differs with precipitous slope horn peaks, serrated crests of high ridges, cirques, hanging valley, torrential rapids and gigantic escarpments comprise gorgeous topography.

The western Nayar takes a straight course, while the Eastern Nayar flows in a semicircular course in an almost broad valley. The Eastern and Western NAYAR makes the confluence at Satpuli forming a broad valley up to Bilkhet- Marora, after which narrow passage of the Nayar is structurally controlled by the Nayar fault up to its confluence with Ganga River at Vyashghat.Other features are conical hills, rounded hills, planner surfaces, Khal (saddles) which has been marked in the map. Out of these features lakes and saddle features are locally known as Tal and 'Khal' respectively.

IV. RELIEF ANALYSIS

The eastern part of the Nayar basin having its steeper side to the east and gentler part in the south. The area shows altitudinal variation from 1180m at Somaya is in South-East to 3119meters at Musa Ka Kotha with a relative relief of 1939m. It characterizes the highest ranges of Dudhatoliki Dhar and Biyalkhal Dhar mountainous ranges and Isolated peaks like Musa Ka Kotha (3119m), Kodiyabagar (3098m), Diwali Khal (2609m), Binsar Devta(2570m), Chaterasin (2518m) in the eastern , north eastern and some western part of the study area. Binsar and its environs represent high relative relief. In north eastern part Biyalkikhal and in the mid of the study area Bindinikhal ki dhar has highest relative relief.

- **The 'relief ratio'** varies from 0.31 from Bagrugad to 1.14 for Khand Mallagad. A direct relationship between relief ratio and channel gradient has been noted, i.e. lower the relief ratio, lower the mean channel gradient of the main valley and vice-versa. This is because the area of strong relief and steep slopes are characterized by high relief ratio. It is noted that the relief ratio 11 tributary basins vary from 0.31 to 0.49. These basins are composed of resistant rocks. For example Bagrugad and Singwargad 0.31 and 0.35 flows with local occurrence of gnessis, quartzites, schist.

- **The roughness index** is an important parameter to represent relief. Here moderate roughness index is from (12-18) covers maximum area (262 km^2.) and this is transportation zone of Eastern and Western Nayar. High Roughness Index has (18-24 and above 24) covers second largest area 220km^2.or (37.67%) the center, north and south western part of the study area. The places covered by large patches are Sauntkhal, Bhararikantha, Chaurakhaldhar, Bagru gad (Eastern Nayar) and Bagar gad, Od ki gad (Binonadi). The increased intensity of erosion, highly precipitous gradient and geological characteristics of area affect the relative relief are responsible for high roughness index. The dissection index, for the study area, varies from (0.71 to 0.86). Area of 141.55 km^2 (24.24%) has moderate dissection index (.0.76-0.81).

- **Relief Profiles** indicate the nature of surface configuration as well as degree of dissection to terrain. Serial profiles 7N-S(figure 3.) and 3E-W (figure 4.)have been drawn to obtain a clear picture of the morphology of the study area. The northern and central part of the study area is characterized by maximum absolute relief which decreases towards the south. The lowest values of absolute relief, relative relief and dissection index are found at the southern and south eastern margin of study area. The highly dissected nature of terrain in the northern, central and Eastern parts. Very steep, 'V' shaped or deep valleys are in this area Khand, Chakhalghat, Dhijyuli gad (western Nayar); Singwargad, Khirganganala (eastern Nayar) and Basola gad (Bino River).Occurrence of few conical hills like Jayapani Ki Dhar, Bharari Tibba. Occurrence of rounded crests of mountain ranges such as: - Dhangi Ki Dhar, Dudhatoliki Dhar in south eastern, ChauriKhal in south western, Chaya choti on the upper part of Bino basin and Ramwala kiSain on Eastern part of the block. Wide valleys of Massangarinadi (W6-E6), Purvi nayar (W5-E5) and Dhijyuli gad (W3-E3).In the superimposed profiles, trends of the mountain ranges, deep valleys and other topographical features are well noted.The projected profiles present a panoramic view of the whole area. The high ranges of the area which is marked as a single line from projected profile are well preserved on composite profiles. Thus all the relief profile represents character of ruggedness of the landform by denudational processes (perennial and non-perennial streams) and superimposed profiles record high conical summits with deep valleys and severe gully erosion forming deep channels, rills, gullies and escarpments.

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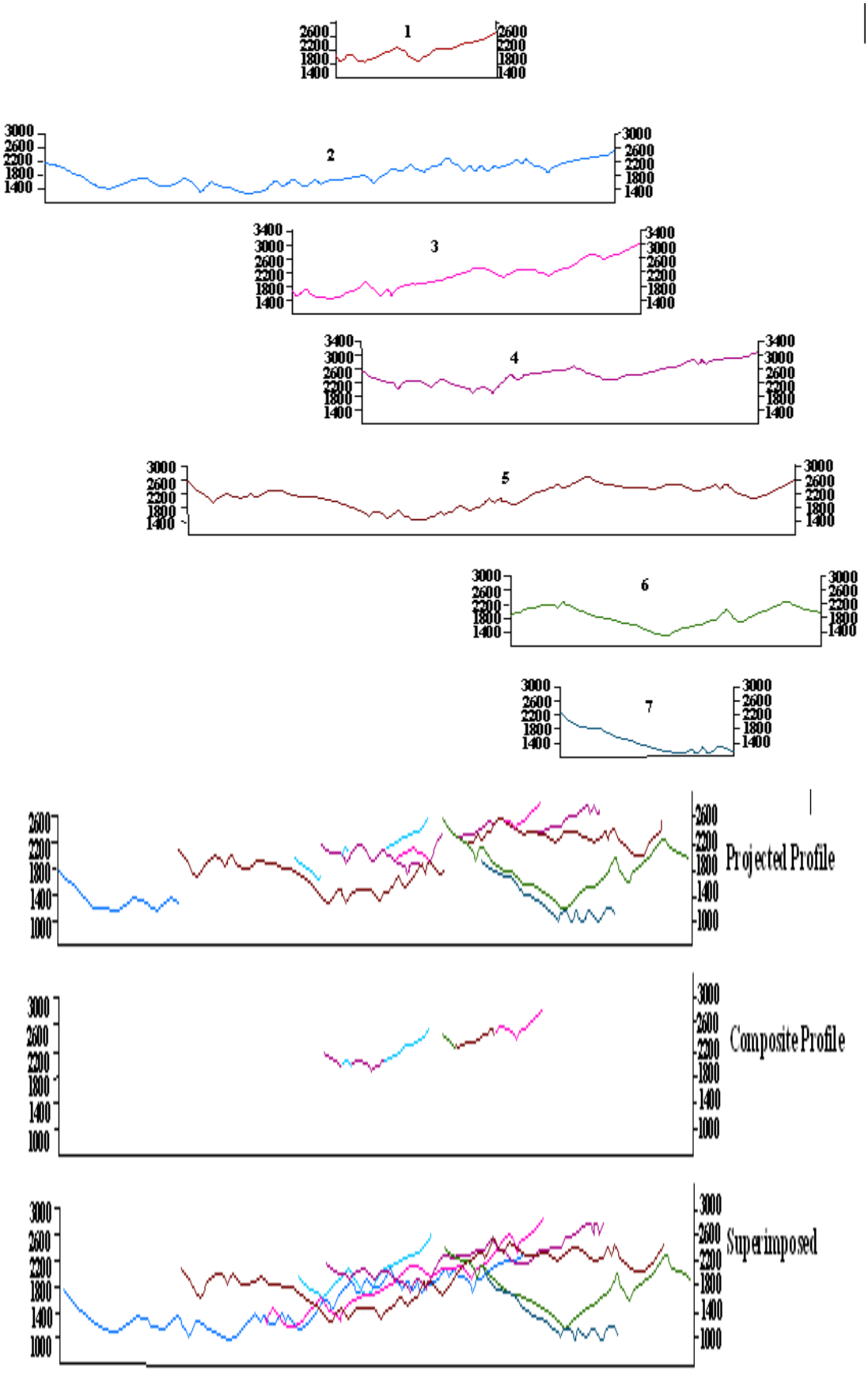

Figure 3.Serial, Projected, Composite and Superimposed Profile of North-South of Thalisain Area

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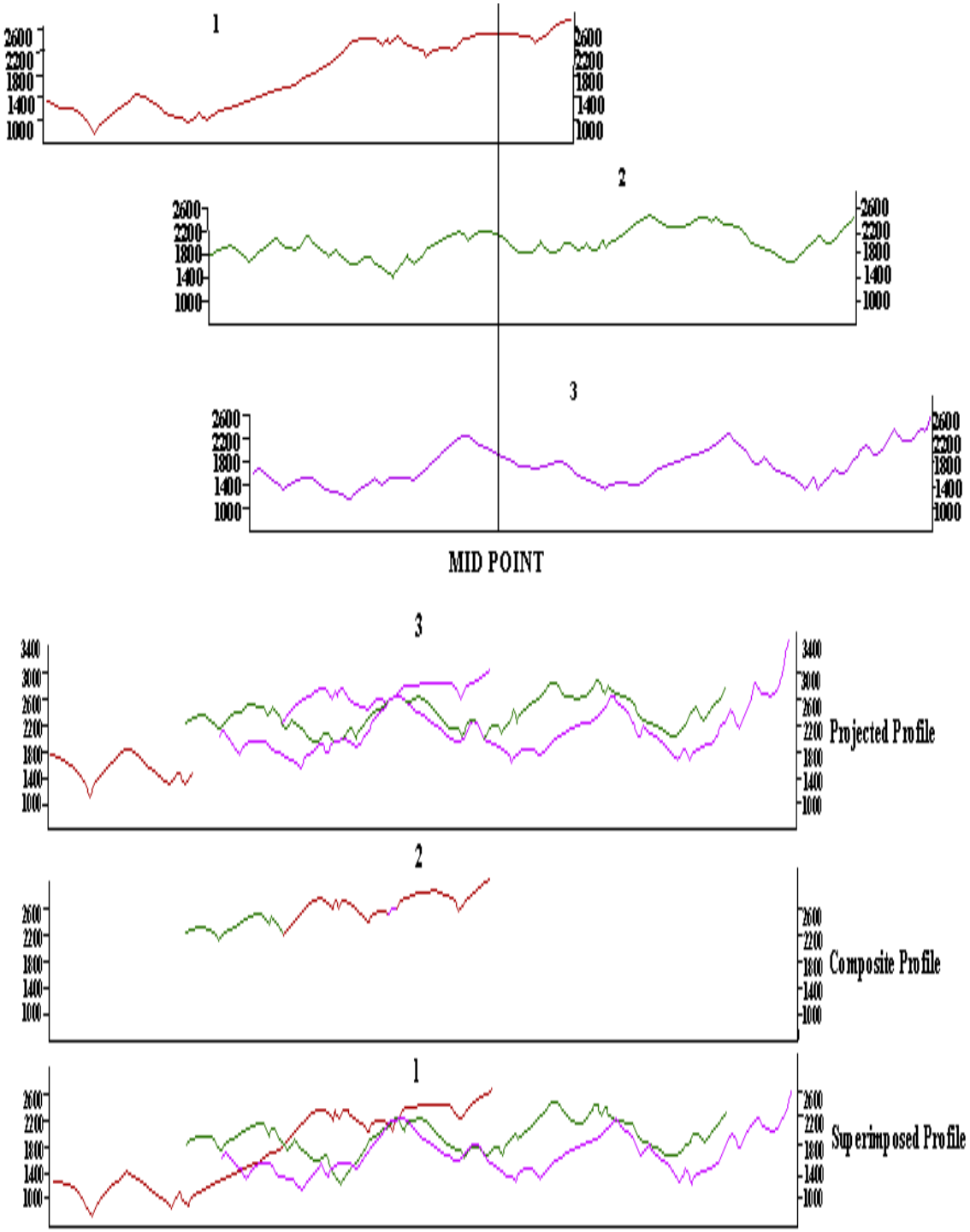

Figure 4. Serial, Projected, Composite and Superimposed Profile of East-West of Thalisain Area

- **The altitudinal zones** was grouped into five on the basis of relief. The first zone (below 1400m) mainly occurs in river valleys. Some part of lower valley bottom of tributaries like Basola and Bharnaun Gad of Bino valley and Chhoya Gad of Western Nayar occur in this zone. Areal coverage of the zone is (32.45 m) of total area. The second altitudinal zone (1400-1800m) forms the backbone of the area Valley spurs and middle part of the tributary valley falls under this zone. This zone covers relatively larger expanse in the north as comparatively to South and South East. The area covered by this zone is (134.5 km^2.) of the total area The third zone comes under (1800-2200 m) which covers the maximum area of the block (250.5 km2).Though the area of this zone is large by comparison to second zone but habitat and agricultural land is less. Thickly forested area is (131.74 km^2) which is 52.59% of this zone. The fourth zone under (2200-2600m)

covers an area of 131.km^2. Cultivated land (2.46.km^2) is very less in this zone almost with correspondence with 1400-1800m which comes under inhabited zone, but the forest area is the second largest in this zone. According to habitation there are limited settlements compare to inhabited zone. The zone shows varieties of landscape and is highly dissected by numerous stream head. Mountain spurs primary and secondary water divides, Cliffs, landslide, rock falls etc are the main feature developed here. Fifth zone of this block comes under 2200-2600 and covers an area of (31.05 km^2) which is 5.32% of the total area. Totally the area is covered by forest but slowly density of forest is decreasing compared to other zones. This sixth zone covers only 0.77% of the total area in this block and is claded by forest land.

- **Slope** defines as angular inclinations of terrain between hilltops (crests) and valley bottoms, resulting from the combination of many causative factors like geological structure, climate, vegetation cover, drainage etc. The Nayar valley comprises multicyclic slopes. Generally slope varies from 15^o to 40^o[9].Five categories were developed for analysis: Very Steep slope, Steep slope, Moderately Steep slope, Moderate slope and Gentle slope.

The slope values, thus obtain for each facet of the study area, range from below 11^o to above 26^o. Maximum of 37.85% of its area is characterized by slope values of 16^{o}21^o is under the moderately steep slope. This is associated with mountainous uplands, crests of ranges, low elevation spurs, intermediate parts of mountain ranges and outer margins of uplands in the North of Sauntkhal mountainous range, upper part of Khand gad, confluence point of Singwargad and KhirgangaNala with Eastern Nayar. The slope category of below 11^o and above 26^o occur in 5.11% and 14.22% which are under gentle and very steep slope respectively. Gentle slope characterizes the alpine pasture, lower and mid valley of Bino River, and Eastern –Western like in origin of Khirganganala and Chhoya gad and Bino River tributary (Masangari River) and very steep slope are located in the sharp edges of water divides where altitude is very high as observed in the ridges of Jayapani Dhar, KaunkhalaKhal (3005) and Sauntkhal in the North, North Eastern and South parts of area. It is noted that about 20.14% of the study area has moderate slope which comprises mid and lower valley almost all the tributary basin found in South, South West and South East portion of the area as compared to North East and North West and Steep slope characterizes about 22.68%represents the first and second order water divides of the basin. The category comprises the maximum area of Dhaijyuli gad, middle part of Purvi Nayar, upper part of Bhanelu gad and maximum patch can be observed in the North, South and North- western part of the study area. The terrain is highly dissected and uneven. In general, area of steep slopes exhibit high relative relief, high dissection index and medium to high drainage density. The distribution of slope in Eastern and Western Nayar basins reflect the control of geology and cycle of erosion. The declivity of slopes over different bedrock depends on the rock characters and on the rate at which the material is denuded. The less resistance rocks like schist and weathered metabasics have given rise to depressions, whereas the spurs, ridges, crests and projection are found on more resistant rocks like quartzite and gneisses. Frequent mass wasting and tectonic disturbances cause the development of steep to very steep slope and also indicate the rejuvenation of the area. Entrenched gorges, V, U, L and S-shaped entrenched meanders, colluvial fans, fossil valleys, knick point in the slope profile, faulting etc. all indicate rejuvenation of this area, which supports the concept of Neotectonism [10]; [7].

- The Slope aspect factor affects the moisture and temperature. A major portion of the study region occurs under forest management. The northern aspect is identified with forest cover in north, north-east and eastern parts of the study area. While the southern aspect is identified with cultivation and grass land cover in south-south west and western parts of the study area.

V. DRAINAGE MORPHOMETRY

Drainage is the most important aspect in the study of landforms which reflect the recent diastrophism and geologic and geomorphic history of the basin concerned and the erosion characteristics such as size, shape pattern and drainage density are controlled by the factors which influence the denudation, i.e. initial slope, structure and stratigraphy of the rocks and climatic and biotic factors (Singh, 1977). Rock is the base, drainage is the fast agent and climatic characteristics make the suit¬able 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 activities.

The Eastern /Western Nayar and Bino River are of sixth order. The total number of first order streams in the study area is 2698 which generates 613 second order streams forming 133 third order streams have been marked to form 33 fourth order streams shaping out 8 fifth order tributary basin. Then there are 3 sixth order of the study area.

- **Drainage Density** reveals that areas of fine drainage density correspond to areas of high dissection index. Occurrence of faults and thrust zones has produced a highly dissected topography particularly south western and eastern part of the study area about 56.33% of the study area has moderate to high drainage density. Very High drainage density characterizes about 14.55% of the total study area. Low to very low drainage density characterizes 14.21% and 14.90% of the study area respectively.

- **Drainage Texture** means closeness in the spacing of stream channels. The concept introduced by [12] and [13]. It is defined as the ratio between channel length and the area of the grid in the same planimetric surface [14].

Very fine drainage textures covers 3.60% of the total study area with lower valley of the study area which shows that the area is passing through the early maturity stage of geomorphic development. Fine drainage texture categories consist of outer crystalline rock and covers maximum area of 54.97% Dhaijuligad, Syoligad and Khand Mallagad in Western Nayar, Singwargad, lower part of Purvi Nayar Nadi and Chhaya Chaunrigad in Eastern Nayar basin and last Bino valley has very less area of this category Panyalyun gad and Bharnaun gad. Mostly valley bottom are under fine drainage texture. Moderate drainage texture covers 3.77% of total study area which is similar as the area of Very Fine Drainage Texture. The category has dissected terrain, faulted scarp, thrusted zones, highly jointed rocks and on waste land zones. The coarse drainage texture covers Chakhalaghatgad, Khandgad, Pajiyanagad, Chopragad, Choyagadin Western Nayar, in Eastern Nayar Khirganganala and Purvi Nayar Nadi, Bhanelugad, Upper part of Masangarinadi Bino valley. The first and second order drainage is observed either on the high alpine pasture or dense forest water divide from higher ranges. It is assumed that during topographical survey the drainage line were not clear, visible and well defined under the dense forest cover. The very coarse drainage texture is mainly confine to the flat hill tops, rounder ridge and river terrace. It covers 6.16 % area. The main area are the Gidonkhal (2100m) north east, Bharari Tibba (2110m north west); Gagnukhal (2298m southwest). This category is mainly found in Southern part of study area near Basolagad, Bagargad, gad, in western and southwestern part in Gwarigad, in North Chakhalghat gad and Khand gad. The mountainous range and hill tops are under high absolute relief and low dissection index which tells to lesser development of streams. In the upper ridges the area is underlined by massive crystalline rock beds with higher vegetal cover on gentle sloppy terrain, which enjoys the characteristics very coarse drainage texture.

- **Drainage Pattern** refers to the layout of the stream lines on the surface. In other words, surface geometry of the drainage line is known as drainage pattern. Each river system has its own plan or morphology guided by so many factors as initial slope, nature of rocks, structural control, recent diastrophism and recent geological and geomorphic history of the basin (Thornbury, 1954). Dendritic pattern of the drainage is the most common pattern, observed mostly in Dhijyuli gad and its tributaries (western nayar), masangarinadi tributary of bino and tributary of eastern nayar like bagru gad. Faulted drainage pattern developed on Soyli gad, Chakhalghat gad and Khand gad (Western nayar); Bagru and Gwari gad (Eastern nayar) and Massangarhinadi (Bino basin). The radial drainage pattern is observed mostly in the north (Sountkhaldhar), south (Bangarsain, Kalijabar and Ranotdhar) and east (Malkhari, Dudhatoli and Biyakhaldhar) and localities of Eastern-Western and Bino basin. The other drainage patterns are Parallel and Trellis.

- **Bifurcation Ratio** is generally influenced by variations in the physiographic, lithologic and climatic conditions prevailing in individual basins. Thus basin with similar rock group composition and tectonic history, uniform climate conditions and in similar stage of development is characterized by more or less similar values of bifurcation ratio. In general, the bifurcation ratio ranges from 2 to 5 but higher values are noted in a few basins, namely the Singwargad and Musetigad (8.00), Chakhalghatgad (7.00), ChhayaChaunrigad (6.50), Sauntgad (6.11), Rikholigad, Kaphaldgad and Khandgad (6.00). In the area, the bifurcation ratio tends closely to equal 3.00 and in the tributary, the ratio ranges from 2.00 (between third and fourth order tributary streams of the Pajiyanagad, Chuthanigad, Rikholigad, Syoligad, Chakhalghatgad, KhandMallagad, Gidongad, KhandTallagad, Khandgad, Banasgad, Manjohligad, Krisalgad, Simargadhera, Raukharagad, Koramgad, Rishtigad, ChhayaChaunrigad, Musetigad, Kaphaldgad, Bhanelugad, Bagarki gad, Bharnaungad, Kimojgad, between second and third order tributary streams are Krishalgad and Odiki gad to 8.00 (between third and fourth order tributary streams of the Singwargad and between second and third order stream is Musetigad. High bifurcation ratio of 8-7 (between second and third order streams), 7-6 (first and second order streams and second and third order streams), 6-5 (first and second order streams) and 5 (second and third order streams and third and fourth order streams) are also noted in the case of Syoligad, Chakhalgahtgad, Khandgad, Sauntgad, Rikholigad, Kaphaldgad, Simargadhera, Koramgad, Rishtigad, Singwargad, ChhayaChaunrigad, Panyalyungad. These are the

indicative of lower degree of stream integration. Large variations in stream frequency between successively higher order streams result in high bifurcation ratio. The lower number of streams of sixth order may be probably due to development of more mature topography in the lower reaches where these streams meet Western/Eastern Nayar and Bino River.

- **Sinuosity Index**, measures the deviation of drainage lines from their geometric paths. Thus 9 basins have early mature stage while the remaining 2 are youthful stage.

- **The elongated ratio** varies between 0.4 to 0.9 in fourth order basins. The basin of watershed 10 is more elongation comparatively than other basins. Watershed 4 is having circular basin.

- **The circularity index** varies from 0.2 to 1. This indicates only a moderate circular shape for the basin. Among the drainage basin the Watershed 10 and 8 has a low circulatory ratio and Watershed 4 has the highest circulatory.

VI. CONCLUSION

The terrain of the Thalisain area presents a numerous landforms of great interest. Agriculture, methods of cultivation, irrigation and means of communication within the hilly terrain has greatly influenced by the topography. The structure of the basin has been studied with the help of Satellite imageries and aerial photographs to highlight lineaments of neotectonic activities which have been further diagnosed for ecological treatment to cure landform alignments. Relief has been analyzed with the help of contour map after drawing the cross sections of various relief profiles like serial, Superimposed and composite profiles.

The morphometry analysis indicates high bifurcation ratio for lower order basins stream shows high erosion activity. High drainage density and drainage texture observed in the middle and western part of the Nayar basin while upper and lower part of the basin has relatively low drainage density and drainage texture. The drainage frequency is basically controlled by the lithology in the area. High and medium drainage frequency observed in the western and southern part of basin which indicates lithological control in the study area. It is also observed that the maximum intrabasins are elongated in nature.

The study of sediments of terraces suggests that terrace T1 is of glacial origin, whereas terrace T2 appears to be fluvio-glacial. Terrace T3show fluvio-glacial and climatic fluctuations during its deposition. Terrace T6 is flat floored with alluvial deposits on its bottom.

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