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GIS BASED SEMI-QUANTITATIVE MORPHOLOGICAL ANALYSIS OF KANKURAM BASIN, GHATSILA

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ABSTRACT

The present research work embodies the application of GIS technique for the detail analysis of River basin morphology. Basically the study is concerned about the use of this recent GIS technique in basin analysis. Weight age have been given to the river morphology especially the morphometric parameters, slope analysis by DEM preparation and channel pattern quantification with its relevance of hydraulic knowledge. The Kankuram River is a small right-hand tributary of R. Subarnarekha of Jharkhand. This basin gives us an ample scope for studying and observing various morphological requirements from source to mouth. *Keywords: Rejuvenation, GIS technique,hydro-geomorphological parameters.*

Introduction: The present study is mainly concerned about the hydro geomorphological characteristics of Kankuram River Basin and it is a semi quantitave analysis of channel morphology of theBasin,Ghatsila in respect of its spatial temporal variable,WestBengal,India. The major aim of this research is to correlate various aspects of the hydrological and geomorphological with the components of channel morphological parameters. The basin is located in the Musabani CD Block, East Singhbhum district, Jharkhand, and is easily approachable from the town Ghatsila. It is an ample scope for studying the detailed landscape evolution which is the combined effect of structure, process and stage. Regarding the morphological scenario, Kankuram basin mainly deals with the magnificent account of geology, geomorphology, hydro-geomorphological attributes, as it is influenced by both endogenetic and exogenetic process in spatial and temporal scale. Regarding the dimension of scale variation, the Kankuram river basin considered under meso level basin analysis which is broadly under the

Subarnarekha river system of east Chhotonagpurplateau.The most significance feature of tecto-shearnesson the basin morphology is and channel pattern parameter has been taken under consideration for study.

Location of the study area: The Kankuram basin is a typical basin being structurally controlled have joined river Subarnarekha in its middle course, Moubhander, Ghatsila. It’s latitudinal extension is from 22°33’17” N to 22°34’1”N and longitudinal extension from 86°22’48” E to 86°25’58” E . The total basin area is about 22.90 sq km. (***Figure no.1***).Here the selected he Kankuram river is a rejuvenated right-hand side tributary of river Subarnarekha and from its origin flow on the hills of Singhbhum Shear Zone, a place of paleotectonic activities between Chotonagpur plate and Singhbhum Micro plate, which is responsible for evolution of the river by structural control and terrace formation which has a adverse impact on hydrogeomorphological prospects of the basin.

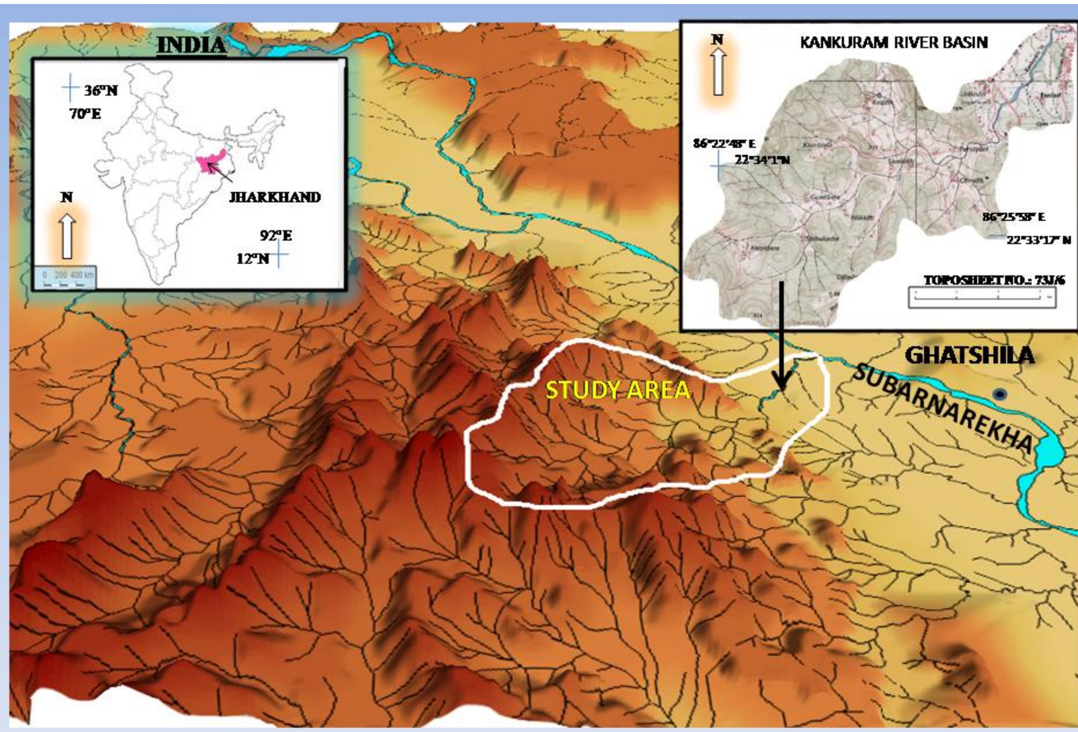


Figure No.1 Location of the study area

Objectives of the study area:

The main objectives of the study area are-

i) To evaluate the basic hydro - geomorphological parameters.

ii) Basin morphological analysis and terrain evolution by GIS techniques.

iii) Quantitative analysis of fluvial channel morphology by both GIS technique and field experiences.

Methodology:

The qualitative analysis of the morphometric characteristics of the basin includes stream order, stream length, bifurcation ratio, drainage density, drainage frequency, relief measurements etc. These parameters were estimated from digitized coverage of drainage network map in the GIS environment. Morphological characterization is the systematic description of watershed's geometry. Geometry of drainage basin and it''s stream channel system required the following drainage network: linear aspect of ratio, areal aspect of drainage basin, relief aspect of channel network and contributing ground slopes. Thus, it provides an effective comparison, regardless of scale. In the present study, for stream ordering Strahler (modified Horton's) method was adapted for quantitative analysis because of its simplicity and flexibility from subjective decisions.

Detail flow chart of methodology adopted for data capture to output generation is presented in Survey of India (SOI) toposheet (73J/6) of the year 1960 on 1: 50,000 scale was used for morphometric analysis. The map sheet covering the study area was scanned in ***tiff format***and translated to the ***pix format***(PCIDSK format) using utility option of the software and geo-referenced using Arc Gis 10.1. The input data information was used to geo-reference the toposheet as: 1) Projection- UTM, 2) Zone and Datum- D076 Indian (India, Nepal) and Resampling method- Nearest. Various thematic maps were geometrically registered with the base map and vector layers were generated. With the help of contour layer, ***Digital Elevation Model*** (DEM)has been prepared. These geo-reference maps were utilized to delineate the boundary of the watershed and drainage network with GIS environment of the SOI toposheet. We also used IRS LISS III Geo-coded data of 1: 50,000 scale for the year 2010, procured from **National Remote Sensing Centre** (NRSC), Hyderabad was also digitized in a GIS environment by visual interpretation.Thses advanced techniques have been formulated for the measurement of the aspect of the terrain evolution and basin morphology of Kankuram River basin, the entire work may be divided into 3 major parts-

Geological setup:

To understand the present day landform evolution and form processes we must consider studying the brief geology and tectonic history of the area. The area is a part of southeastern Chotonagpur terrain, a greater part of which consists of a very old continental block that was not submerged since early Paleozoic period. The Singhbhum area is similar to the various Precambrian shield area of the world. The major rock formations underwent different geological eras and prolonged periods of earth movements and the resultant igneous activity, and the predominance of igneous and metamorphic rocks. The middle Subarnarekha basin comprises of the undulating planes of tuff and quartzophylite, mica schist, and granite along with along with intervening Dalma range of basic lava. It also contains exclusive exposure of copper ore, with expensive exposure of iron ore series, with batholithic intrusion. It should be mentioned that the conspicuous Structural features of the basin is 200 km long., accurate thrust zone(copper belt thrust zone) which approximately separates the iron ore Group low grade meta sediments and meta volcanic from the mostly high grade meta sediments and basic rocks of the Dhalbhumgarh formation. In the north the former has been intruded by the batholithic mass of Singhbhum granite in the south. During deposition of the Dhalbhumgarh formation, the marine basin extended across the present site of the thrust zone. To the south west of Jadugora-Mosabani and south of latitude 22°15’ N, towards Simlipal region in Mayurbhanj, Orissa. These have been expressed in a series of residual hills of various origins, escarpments, basins and plateau surface, which actually truncates several geological formations. (***Figure no.2***)

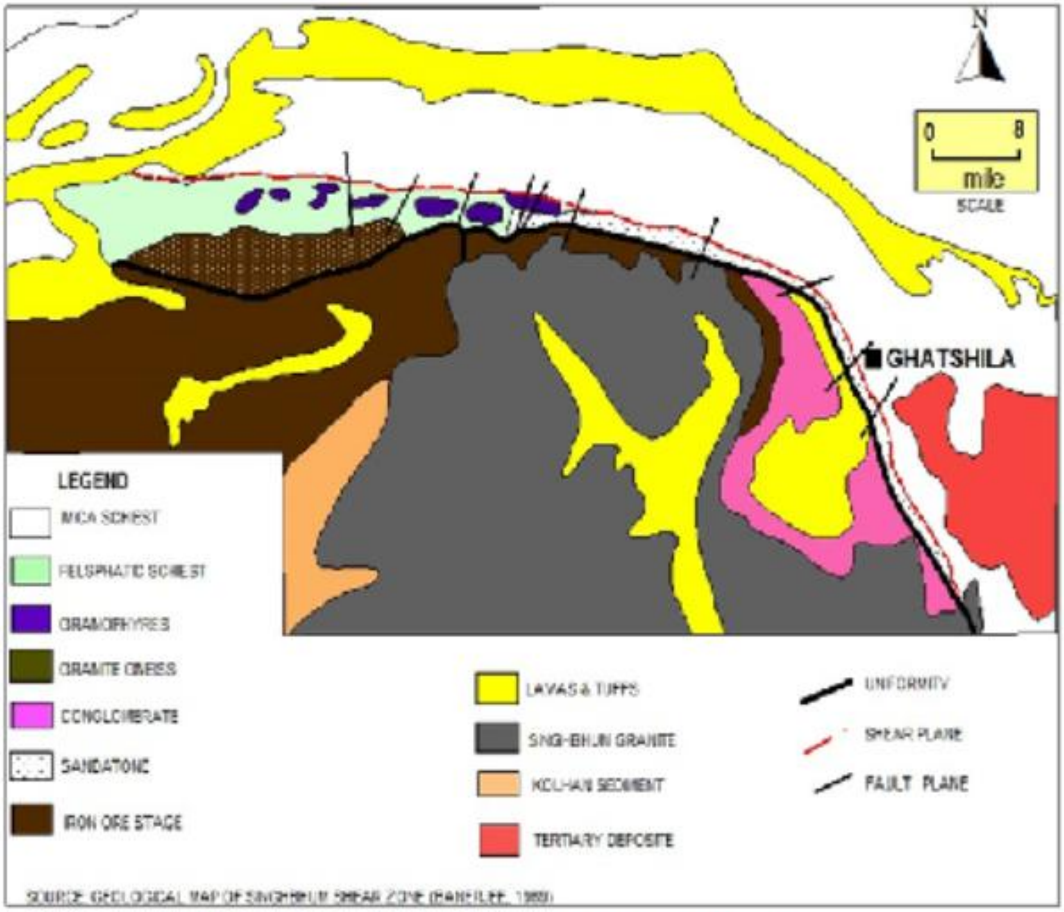


Figure no.2 Detail geological map of the entire area

Tectonic activity: Tectonically this area is a plate boundary between Singhbhum plate and Chotonagpur micro plate. The plate collision occurred about 3800 million years ago leading to the formation of singhbhum shear zone. Singhbhum shear zone is a unique fault line zone which leads to deposition of several Radioactive mineral deposition like uranium in Jadugoda and metallic ores of iron, copper,

Plateno.1: Mafic lava in Dalma hills.

manganese etc.This area is characterized by presence of ophiolite. Ophiolites are pieces of oceanic plate that have been thrusted (abducted) onto the edge of continental plates, which is evidenced by the presence of Dalma hills which is actually formed by mafic lava ***(Plate no.1)***of oceanic origin. The past undersea volcanoes are exposed out by erosional agents and present day they stand as small residual hills with flat top, the Fuldungri hill is a great example of such kind of erosional hill***(Plate no.2).*** A.N. Sarkar (1982) proposed a model of converging micro plates to interpret the tectonic evolution of the Singhbhum and Chhotanagpur plate. In this model the Chotonagpur block represents an overriding plate and the Singhbhummicroplate as the subducting plate. The collision of these continental micro plates took place around 1600 Ma ago. The model considers convergenceand collision of the Singhbhum micro plate against a stationary Chhotanagpur micro plate in three cycles. The first cycle (2000–1550 Ma) relates with the northward movement of the Singhbhum micro plate and its collision with the Chotonagpur micro plate. In this event it is believed that Dalma volcanic was emplacedas ophiolite in a flysch environment. In the second cycle (1550–1000 Ma) the Singhbhum plate is assumed to have rotated clockwise towards NE and generated folds, including the NW-SE trending fold of the Dhanjori rocks. The third cycle (1000–850 Ma) relates to the overriding of the Singhbhum plate onto the Chotonagpur plate in a NNW-SSE direction, abduction of the continental lithosphere in the southern part of the Singhbhum fold belt, and also deformation and metamorphism. At the close of the orogenic cycle the Singhbhum fold belt was uplifted and subjected to erosion. Whereas some scientists have opposed this model and accounted for the presence of a rift valley between Chotonagpur plate and Singhbhumplate.Rock formation belongs to Singhbhum shear zone. The area is occupied by Precambrian metamorphoses of Dhanjori group, represented by metabasics and its metamorphosed variants. The rock exposures in the block are quartz chlorite schist, mica schist,

Plate no.2: Fuldungri hill, Such kind of Erosional hill.

serichite schist/quartzite, biotite chlorite quartz schist and the Chaibasa quartzite. General strike of foliation is NNE – SSW with 40° – 50° south west dip. Host rock for mineralization is mainly quartz-chlorite-serichite schist and quartzite.

Climatic consequences:

The analysis of climatic condition in the field of geomorphologic studies is an important aspect. Apart from the lithological features like structure, types of rocks etc. climatic condition play an important role in fashioning the land surface. The geomorphologic process in a region varies with changes of climatic conditions. For example, fluvial processes are found to be dominated under humid climatic conditions Aeolian processes are found to be dominated in arid climatic conditions. The land forms developed by these processes are different in character. Hence the climatic condition of east Singbhum District is analyzed in this chapter in order to understand nature of land forms development under the processes are concerned in Middle Subarnarekha Basin. The Middle Subarnarekha Basin area i.e. south eastern part of Chotanagpure plateau is characterized by Monsoonal climate ,but according to Koppen's climatic classification it falls under the semi arid climate. The temperature and rainfall characteristic varies with change of season. There is a sharp increase in temperature found in the pre monsoon period that is months of March to April until May. The monthly mean temperature lies between…. The wind consequently blows from west with increasing velocity from 9.6 to14.4 km/hour (Sing). Norwester is another important climatic phenomenon in the month of May to June which brings heavy shower in short duration. During June and October the temperature begins to decrease with the temperature begins to decrease with the onset of South West monsoon. Most of the seasonal rain fall (above 75%) occurs in this time. July is the wettest month of this region. The total rainfalls during in the years 2008, 2009 are 1553mm, 1263mm respectively. The coldest season commences from November and last till the end of February. The January is the coolest month of this basin area. The normal mean temperature of January ranges from 16.4o to 17.8O. The main characteristic of climate of this region is the changes of climatic condition from arid to humid. The existing residual hills found at different parts of this region

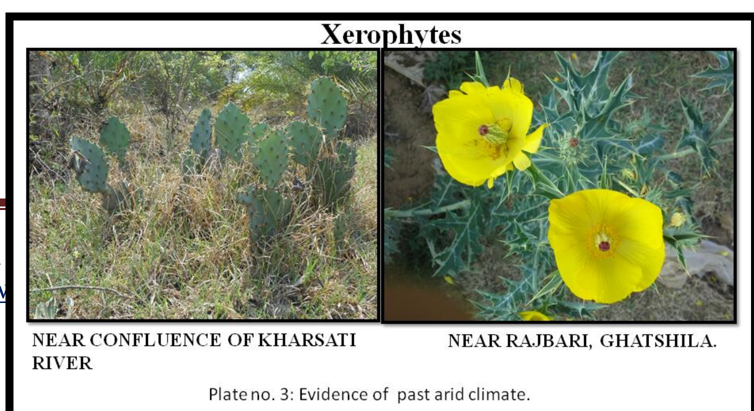


Plate no. 3: Evidence of past arid climate.

(for example Phooldungri) and some trees (like Cactus, which are found near Rajbari) are proved this type of climatic change.

Temporal changes of climate: In order to pursue the present day Geomorphological studies of the Kankuram basin, it is necessary to identify the evolution of the area under different climatic region. Climate plays a very important role in sculpting the landform through time. The climatic changes of the study are well demonstrated in the chart described below, after Mukhopadhyay, 1980. This chart***(Table no.1)*** describes the gradual change of the climate of this area keeping in pace with the geological history and tectonic activities. The gradual changes from hot and arid climate to cold climate in the recent Pleistocene Glaciations through time have dramatically influenced the landscape evolution.***Table no.1*** elaborates the change of climatic consequences through time. It can be seen from ***Table no.1*** that this area underwent a vast and prolonged change in terms of the climate from hot arid and semi arid conditions to recent semi arid under tropical monsoon condition, along with cold climate that was aided by periods of glaciations. The Climatic condition was dry and cold when this area came under the impact of glaciations, about 1500 million years ago (Precambrian) , and then it evolved from hot, dry, and arid conditions to humid condition in Carboniferous period, under which coal and iron depositions occurred. Then, again this area underwent glaciations in Permian period, which marks the end of Paleozoic Era. In Mesozoic era the climate becomes more variable in Cretaceous and Tertiary with fluctuating very warm – cold and semi arid to humid conditions. In Cenozoic era, the area experiences the last glaciations, which are the Pleistocene glaciations, which accounted for presence of cold climate over the area. Finally in the most recent period, the area goes through a final change in climate (up to recent), that is cold to semi arid and humid. In the study area there are ample evidence of climatic change in terms of the floras, the species of cactus that managed to prolong survive since Paleozoic era, are the examples of once presence of arid climate in the area (***plate no.3***).

Terrain evolution and profile analysis:

The worker has derived the DEM (Digital Elevation Model) surface of the study area based on contour value (***Figure no.4***) (Toposheet 73J/6, 1:50000 scale, contour interval-10m). ***Figure***

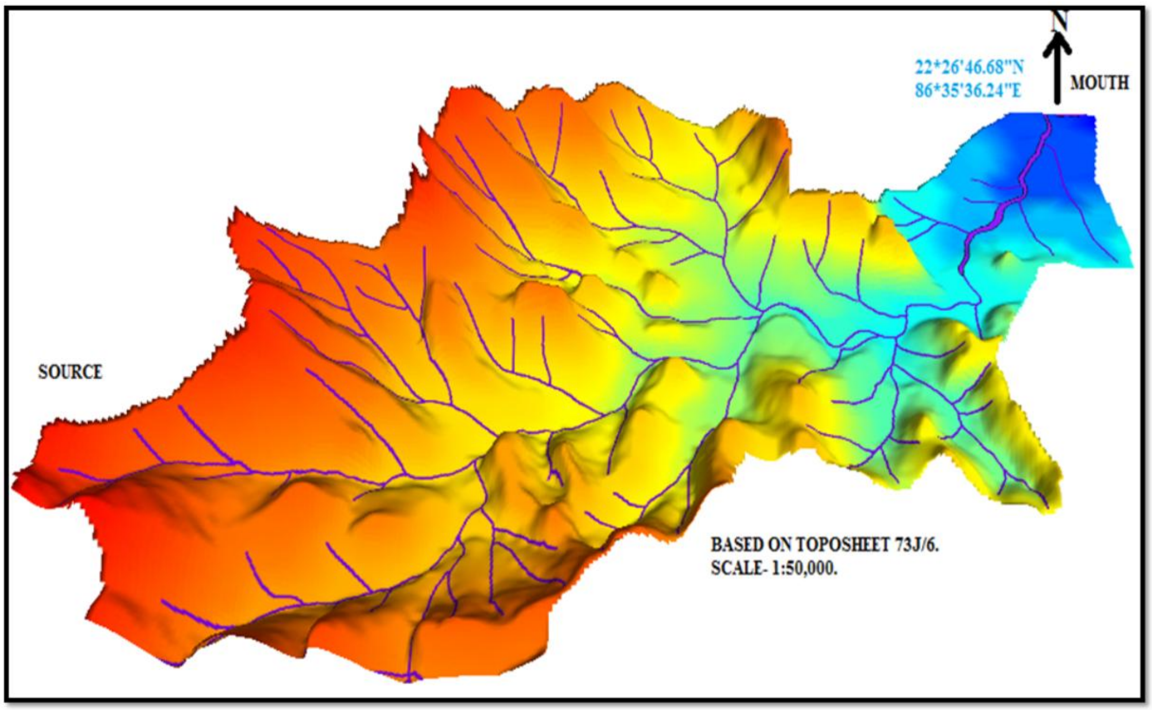


Figure no.3 3D DEM model of the Basin area

no.5 represents a general nature of terrain of this Basin. ***Figure-3***represents the 3D DEM surface of this area.He also derived some profiles like serial profile, superimposed profile, composite profile, and projected profile to understand the general nature of dissection, summit levels etc. There are 5 serial profiles which are draw 2km equal distance from mouth to source based on toposheet 73J/6 (scale- 1:50000).

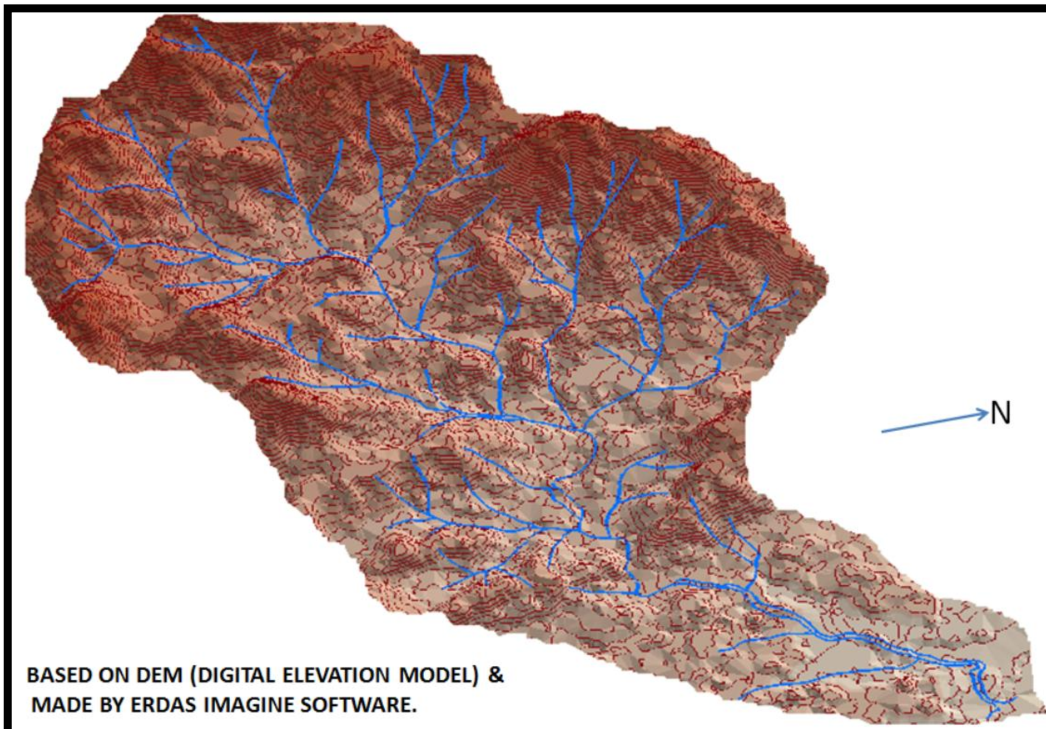


Figure no. 4 Contoure pattern of the Basin

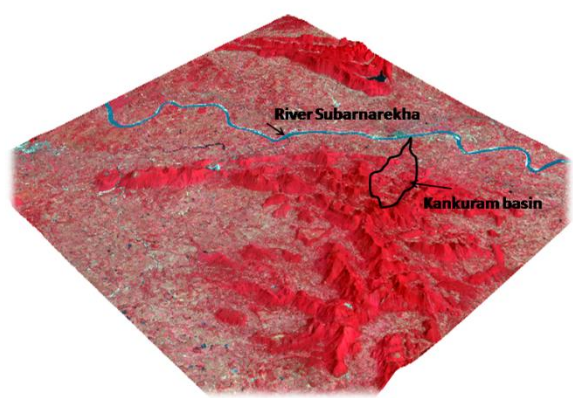


Figure No.5 Relief character of the surrounding area

Superimposed profile helps us to determining the different levels of ground surfaces. It is evident from ***figure-6a*** that there are five ground surfaces in the Kankuram basin.

Projected profiles (***figure-6b***) provide 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.

Composite profile (***figure-6c***) represents the highest parts of the summit levels as if seen from a distant place.

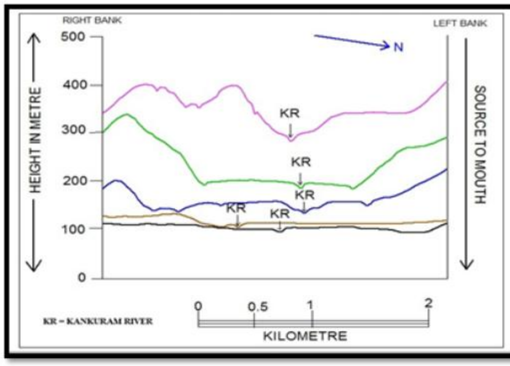


Figure No.6a Superimposed profile of the Basin

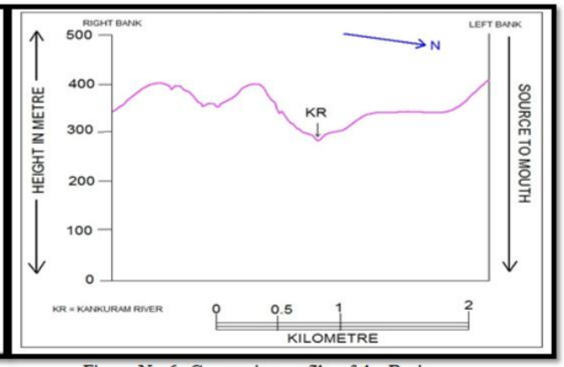


Figure No.6c Composite profile of the Basin

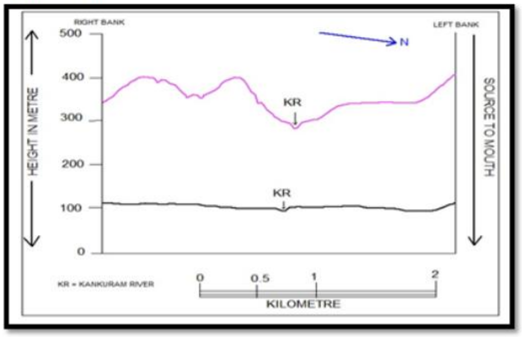


Figure No.6b Superimposed profile of the Basin

Morphometric analysis:

Linear aspects of the basin (Table no.2):

Stream Order (u): Stream order of drainage basin is the successive assimilation ofthe streams within a drainage basin. The term stream order was first introduced by Horton (1932, 1945) for the procedure of stream ordering. Later, Strahler modified the Horton's law of ordering. Here I have followed modified Horton's law of ordering. The smallest fingertip tributaries are designated as order 1st. where the two first-

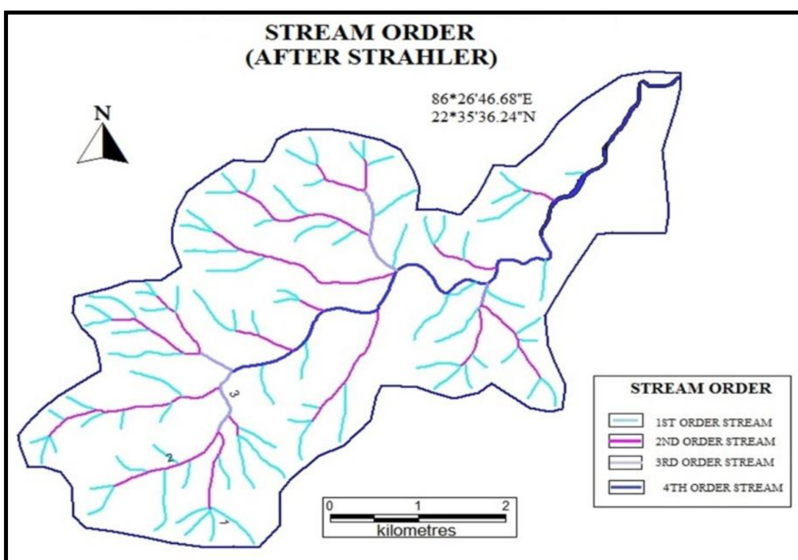


Figure No. 7: Stream Order of Kankuram River Basin.

order channels join, a channel segment of 2nd order is formed and so forth. The Kankuram River Basin is a 4th order river basin (***Figure no.7)*** which denotes the heterogeneous rock character of the area.

*Stream Length (Lu):*Stream length is measured from the farthest drainage divide to the mouth of a river, based on the law proposed by Horton (1945).Stream length of the basin indicates surface runoff characteristics. Streams of relatively smaller lengths indicate that the area is with high

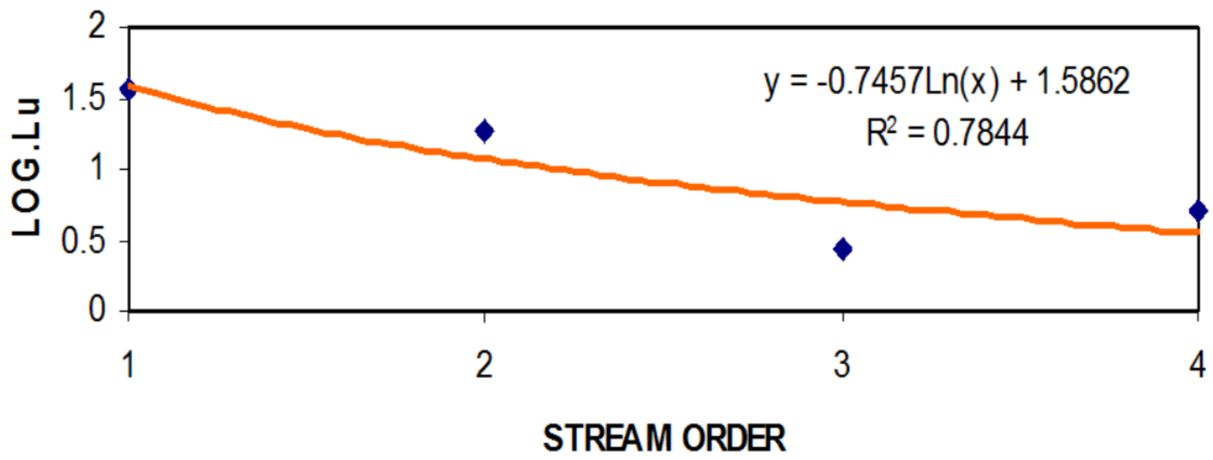


Figure No. 8. Relation between Stream Order (u) and Mean Stream Length (Nu)

slopes. Longer lengths are indicative of flatter gradient. Stream length of Kankuram River and its tributaries is measured with the help of Roto meter. The total stream length in Kankuram river basin is 62.225km.The logarithm of stream length of each order as a function of order is plotted and relation between stream order (u) and mean stream length yields a set of points lying generally along a straight line that indicates strong structural control in the area. (***Figure no.8***)

Stream Number (Nu): Whole Kankuram River basin has 104 streams, of which 78.85% are the first order streams having 82 segments. The second order stream segments are 17 and account for

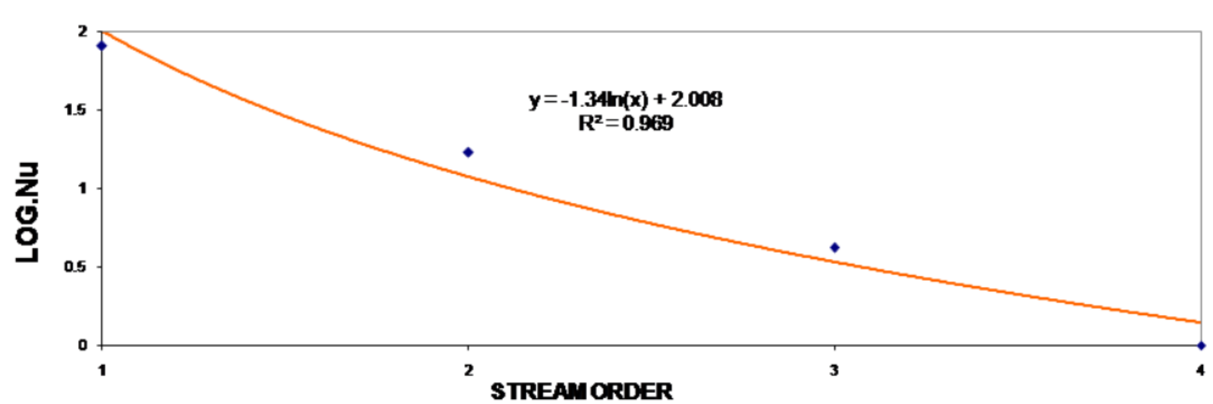


Figure no.9 Relation between Stream Order (u) and Stream Numbers (Nu)

16.35%, third order stream segments are 4 and accounted 3.85%, fourth order stream segments are 1 and account for 0.96%.The logarithm of stream length of each order as a function of order is plotted and yields a set of points lying generally along a straight line. Relation between stream order (u) and stream numbers (Nu) shows the straight line which indicates area with structural disturbance. (***Figure no.9***)

Mean Stream Length (Lsm):

Mean stream length (Lsm) is a characteristic property related to the drainage network components and its associated basin surfaces (Strahler, 1964). This has been calculated by dividing the total stream length of order (u) by the number of streams of segments in that order. It is seen that Lsm values exhibit variation from 0.44 to 5.15. This deviation might be due to change in topographic elevation and slope of the basin.

Stream Length Ratio (Rl):

The ratio in between the average lengths of successive orders is stream length ratio. Total stream length of a given order is inversely related to stream order, i.e., total stream length decreases from the lower order to the successively higher orders. This change might be attributed to variation in slope and topography, indicating the youth stage of geomorphic development in the streams of the study area (Singh and Singh, 1997 and Vittala et al., 2004).Stream Length Ratio of Kankuram River basin is given in ***Table-2.***

Bifurcation Ratio (Rb):

According to Schumm (1956), the term bifurcation ratio may be defined as the ratio of the number of the stream segments of given order to the number of segments of the next higher orders. Bifurcation ratio shows a small range of variation for different regions or for different environments except where the powerful geological control dominates (Strahler, 1957). The higher values of Rb indicate a strong structural control in the drainage development whereas the lower values indicate less affected by structural disturbances (Stahler, 1964). The Rb values in the study area range from 1.00 to 5.80 indicating that the basin is largely controlled by structure (Strahler, 1957). In the study area, mean bifurcation ratio***(Table no.3)*** value is 4.358 which indicate this region has largely controlled by structure.

Areal aspect of the basin (Table no.4):In Quantitative Geomorphology, Area of basin (A) and Perimeter (P) are the important parameter. The area of the basin is defined as the total area projected upon a horizontal plane and Perimeter is length of the boundary of the basin. Different parameters of areal aspect arecalculated.

Drainage Density (Dd):Drainage density is defined as a ratio of total length of all streams to the total area of the basin (Horton, 1932). Where, Drainage Density (Dd) = Total Length of the stream of all segments / Total Area of the basin. High Drainage Density value indicates the region having impermeable subsurface or moutainous relief. In Kankuram River basin, the Drainage Density value is 2.70 km/sq.km.

Stream Frequency (Sf):The total number of stream segments of all orders per unit area is known as stream frequency (Horton, 1932).It is a good indicator of drainage pattern. The value of stream frequency of Kankuram River basin is 4.52. High drainage density and high stream frequency in Kankuram River basin indicate larger runoff from the basin.

Shape of Basin:The shape of basin is determined on the basis of computation of parameters such as form factor, circulatory ratio and elongation ratio.

*Form Factor (Rf):*Horton in 1932 assigned Form Factor as one of the significant index for presenting the hydrological characteristics of the basin. The higher value represent the shape of the basin is circular and the lower value represents the linear shape of the basin. The form factor value of Kankuram basin is 0.28. Which indicates the shape of the basin is elongated, because the value is within the 0.1-0.5 range, which denotes the shape of basin is elongated.

*Circulatory Ratio (Rc):*Miller (1953) defined a dimensionless circulatory ratio (Rc) as the ratio of basin area to the area of circle having the same perimeter as the basin. He described that the circularity ratios range from 0.4 to 0.5 which indicates strongly elongated and permeable homogenous geologic materials. Circulatory ratio (Rc) is mainly concerned with the length and frequency of streams, geological structures, land use/land cover, climate, relief and slope of the basin. In the study area, the Rc value is 0.42, indicating that the basin is elongated in shape having low discharge of runoff and highly permeability of sub soil conditions.

Elongation Ratio (Re): This is also a significant parameter as suggested by Schumm (1956).This helps to give idea about the hydrological character of a drainage basin. Elongation ratio (Re) is the ratio between the diameter of the circle of the same area as the drainage basin and the maximum length of the basin. The value of elongation ratio (Re) can be grouped into three categories, namely circular (>0.9), oval (0.9-0.8) and elongated (< 0.7).The Elongation ratio of the Kankuram river basin is 0.6 which indicate basin is elongated.

Lemniscates Ratio: this index extracted from basin, specially designed by Chorley in 1957 is called Lemniscates Ratio and he suggested the K value on higher limit represents circular shape. The value of Lemniscates Ratio is 0.88 which indicates nearly elongated.

Length of Overland Flow (Lg):The length of overland flow (Lg) approximately equals to half of reciprocal of drainage density (Horton, 1945). It is the length of water over the ground before it gets concentrated into definite stream channels. The length of overland flow (Lg values) of the study area is 1.35, indicating nearly mature topography.

Texture Ratio (Rt):It is the ratio of total stream numbers to the total perimeter of the basin (Horton, 1945). Texture ratio is an important factor in the drainage morphometric analysis which is depending up on the underlying lithology, infiltration capacity and relief aspect of the terrain (Nageswara, 2010). Smith (1950) has classified drainage density into five different texture i.e. very coarse (<2), Coarse (2-4), moderate (4-6), fine (6-8) and very fine (>8). In the present study texture ratio of the Kankuram river basin is 3.14, which indicate coarse texture.

Relief aspects of drainage basin (Table no.5):

Relief Ratio (Rh): Schumm (1956) defined Relief Ratio as basin relief (H) is divided by maximum basin length (Lb). The relief ratio of Kankuram basin is 53.25, which indicate that the basin has mountains relief and steep slope.

Relative Relief (Rr): Relative relief is defined as the difference between maximum elevation and minimum elevation in a unit area. Relative relief is classified into 3 categories viz. low relative relief = 0meter to 100meter, moderate relative relief = 100meter to 300meter, high relative relief = above 300meter. In the study area, relative relief value is 480m, which indicate the region has high relative relief ***(Figure no. 10b)***.

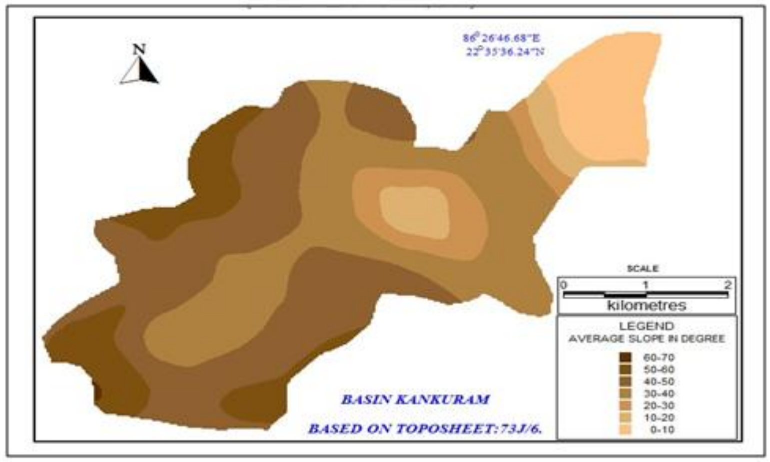


Figure No. 10a Average slope map of the Basin

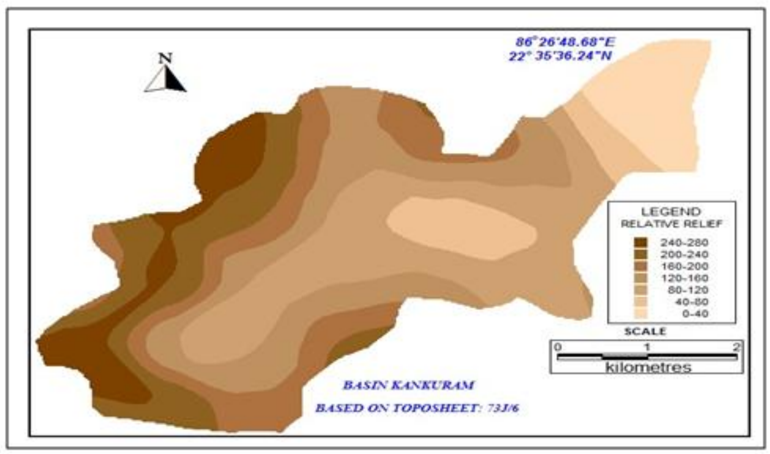


Figure No. 10b Relative Relief map of the Basin

Average Slope (As): Using the following formula, as suggested by Wentworth to calculate the average slope of the study area ***(Figure no. 10a).*** $\tan\varphi = (N \times I)/636.6$. Where, N = Number of contour crossing per kilometer length, I = contour interval, 636.6 = constant value. The values of slope angels derived for each grid square of the drainage basin are tabulated and classified into convenient slope categories, e.g. i) level slope category = 0^{O}-2^{O}, gentle slope = 2^{O}-5^{O}, moderate slope = 5^{O}-15^{O}, steep slope = 15^{O}-30^{O}, and very steep slope = above 30^{O}. The average slope map of the Kankuram basin has been constructed and it represents that nearly 80% of the study area is under the very steep slope and other part of the area is under the steep, moderate, gentle and level slope.

Hypsometric Analysis:Hypsometry involves the measurement and analysis of relationship between altitude and basin area to understand the degree of dissection and stage of cycle of erosion. Hypsometric curve is generally used to show the proportion of area of the surface at various elevations above or below a datum (F.J. Monkhouse and H.R. Wilkinson, 1967) and thus the values of area are plotted as ratios of the total area of the basin against the corresponding heights of the contours. The hypsometric curve ***(figure no.11, Table no.7)*** of Kankuram river basin represents that the basin area is under the equilibrium stage and the study area is under the mature stage according to W.M. Davis.

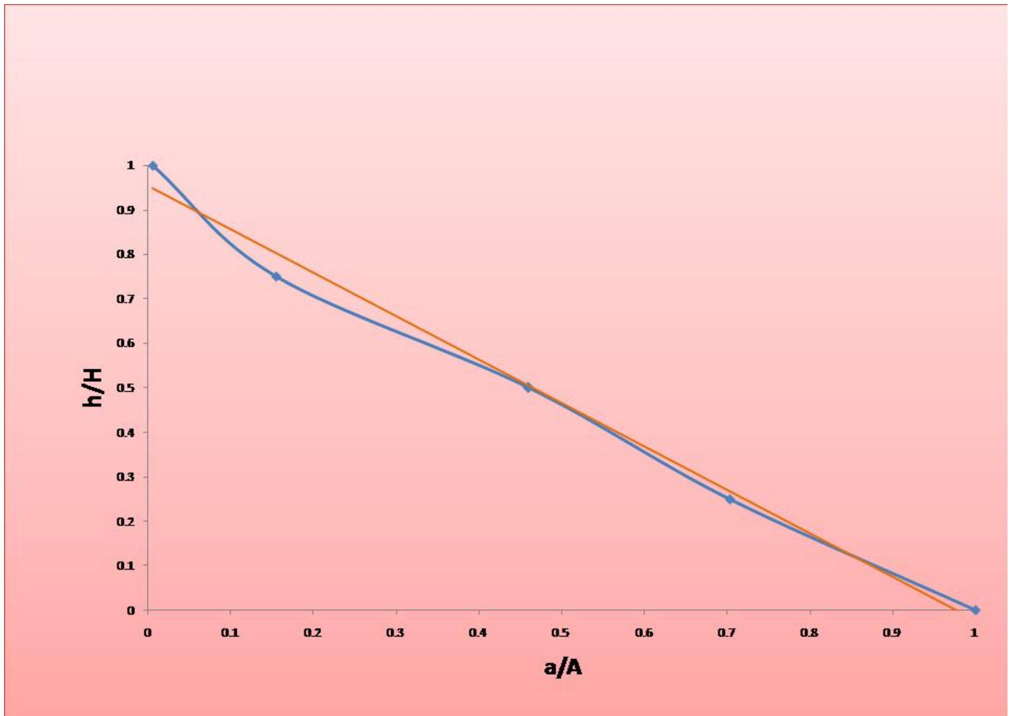


Figure No. 11 : Hypsometric Curve

Ruggedness Number (Rn):Ruggedness number is the relation between relief of basin (H) and drainage density (Dd). The ruggedness number of Kankuram river basin is 1296.0 which indicate both relief and drainage density are high. Such higher values are expected in a mountainous region of tropical and sub-tropical climate with higher rainfall (Schumm, 1956). So, the value indicates the study area is under the mountainous sub-tropical climate with higher rainfall.

Dissection Index:Dissection index is a ratio of the maximum relative relief to the maximum absolute relief, which is an important morphometric indicator of the magnitude of dissection of terrain. DI = RR/Hx, where RR = Relative Relief of the square area, Hx = Highest Altitude of the

Square area (Miller, 1949). The figure- shows the dissection index map of the study area, which represents that the some part of the area is highly dissected and others part of the area is normally or low dissected.

Rejuvenation and river terraces evolution:The entire area of the middle Subarnarekha river area including the Kankuram basin is characterized by the several tectonic activities (Plate no.) and the presence of Singhum Shear Zone enhanced the river cycle as the Kankuram in now flowing in its third cycle. When a channel being in a state of equilibrium or progressive sedimentation changes the rejuvenation (***figure no.12a)*** occurs. The main causes of rejuvenation are uplift of the ground, decrease of sediment load and increase of discharge due to climate change, etc. Various landforms are formed by reactivated channel process.

When rejuvenationoccurs then a channel begins to deepen and a new gorge is formed in an alluvial plain. As a result, the surface of the former alluvial plain becomes higher than the river bed, and river water ceases to overflow onto it. The former alluvial plain then becomes a river terrace. ***Figure no.12b***shows the stages of development of terrace formation.

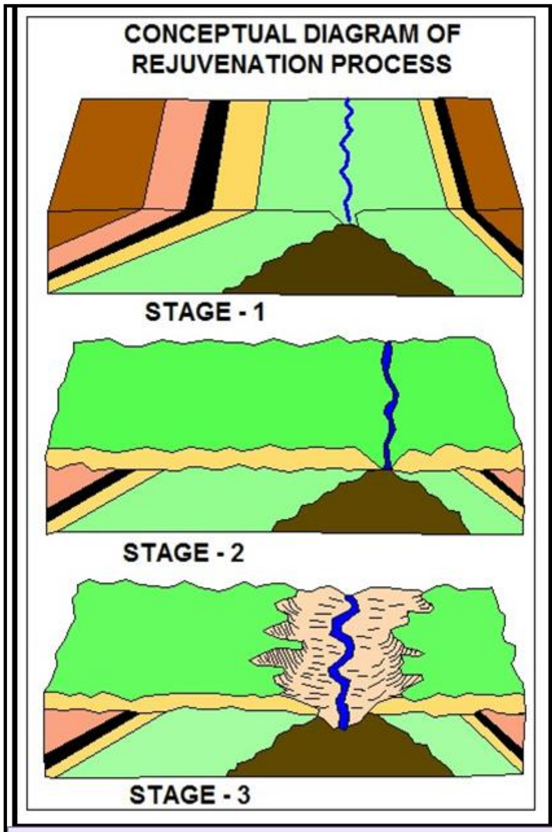


Figure No. 12a Conceptual diagram of rejuvenation process

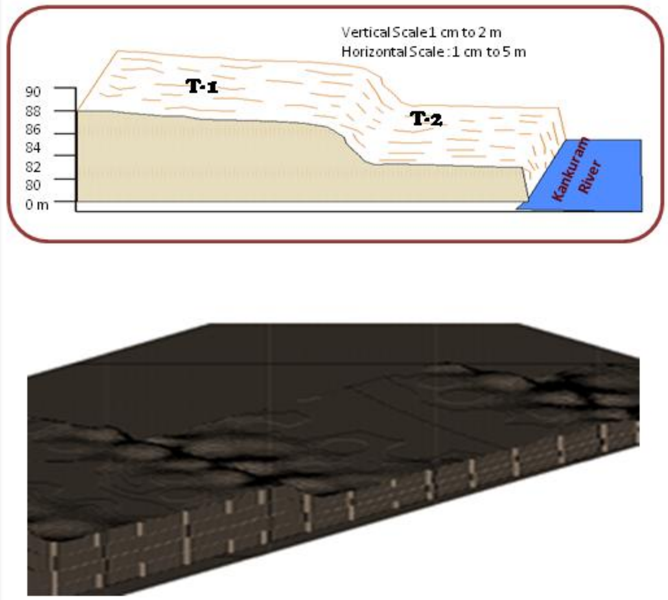


Figure No. 12**b** measurement of river terraces in field with its 3D view

In Kankuram River basin, the terraces are formed. Physical weathering predominated in this area, due to climatic change the terraces are formed on this river. Terraces are mainly two types e.g. - *Paired terrace,* formed due to alluvium soil which is rare to topography and *Unpaired terrace*, formed due to structural setup of this area which have been seen in this area. Three numbers of terraces ***(Plate no.4)*** has been seen in this area, which proved that the study area is 2 times rejuvenate and under the 3 times normal cycle of erosion (W.M. Davis).

Plate no.4: Three numbers of terrace has been seen in Kankuram River basin.

Incised River: If a meandering channel has been rejuvenated, a channel begins to under-cut a river bed while keeping a meandering course. As a result, a meandering valley is formed, and the river running in the valley is called an incised river.In the Kankuram River basin, the area is under the mountain region of Chotonagpur plate and this part is highly controlled by the lithological structure. So, the meander of Kankuram River has controlled by structure also. The river Kankuram

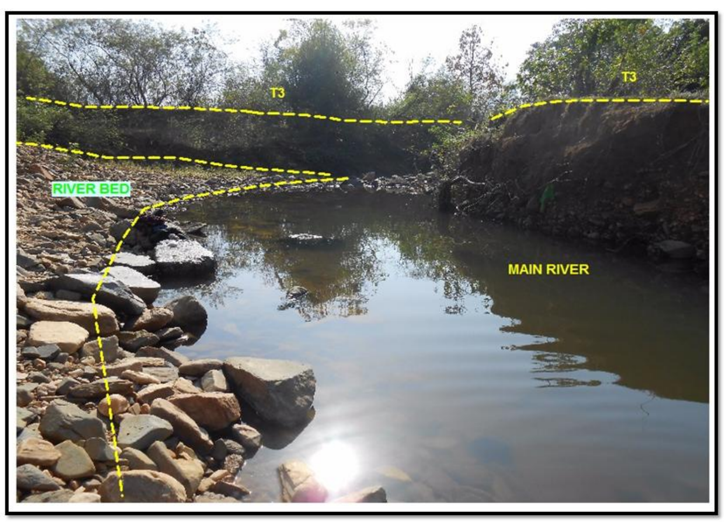
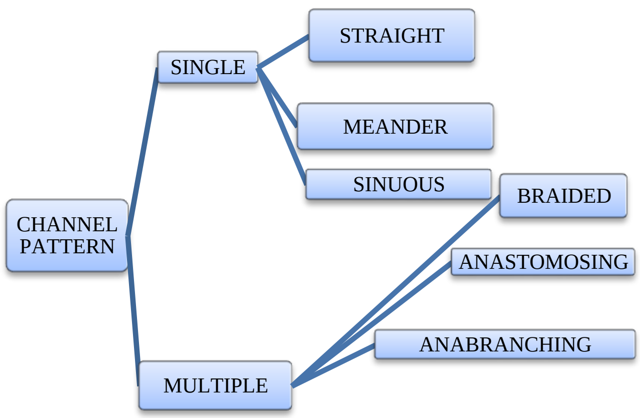


Plate no.5: Incised river.

has created terrace due to rejuvenation, in this circumstances it may be say that the river has been under-cut the river bed and formed incised river ***(Plate no.5).***

Channel pattern: We are all known that the channel pattern of a river is mainly 2 types. This is ***Single channel***and ***multiplechannels***. These two types of channel pattern further sub-divided.Single channel means one river and Multiple channel means including bar, two or more channel. So, the river Kankuram is a Single channel. Sinuosity index are two types, which are i) CSI (Channel Sinuosity Index) which calculate by Actual length of channel reach/same channel straight length of channel reach. And other one is ii) VSI (Valley Sinuosity Index) which calculated by Actual length of valley of channel/same channel straight length of channel reach. I considered CSI value to find the channel pattern. If CSI value is 1-1.10 or less than 1 then it becomes straight channel. When CSI value 1.10-1.5, it becomes sinuous channel, 1.5-2.5 represents meandering channel, and more than 2.5 values, and it becomes tortuous channel (Channel length considered



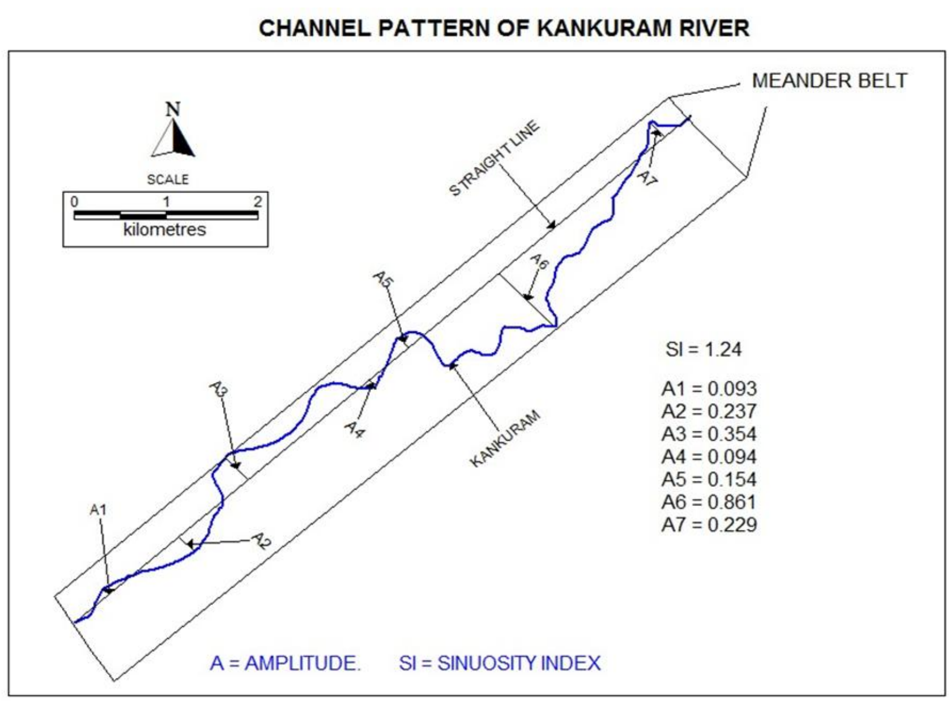


Figure No.13 Channel Pattern of Kankuram basin.

minimum 5km). The Kankuram River's CSI value is 1.24 which indicates this river is a sinuous channel. The ***figure-13*** shows that the channel pattern of Kankuram River. It also shows the amplitude value of various point and meander belt. Amplitude means the amount of displacement of the channel from straight line drawn through the bends (MBA = Meander Belt Axis.) and Meander belts mean the zone obtained by joining the crests of the meander or either side which basically shows the extent to which the river has shifted historically. High value of Amplitude indicates that the amount of displacement of channel is high and it indicates that the channel has more meander or value of sinuosity index is high. The above figure no. shows the middle-lower portion of the river, Amplitude value is high than other point and it also indicates that here the river is more meander than other portion. Wehave divided the channel into 3 segments based on break-of-slope (150meter, 250meter contour) which are upper, middle and lower segment for better understanding of meander pattern of a river.

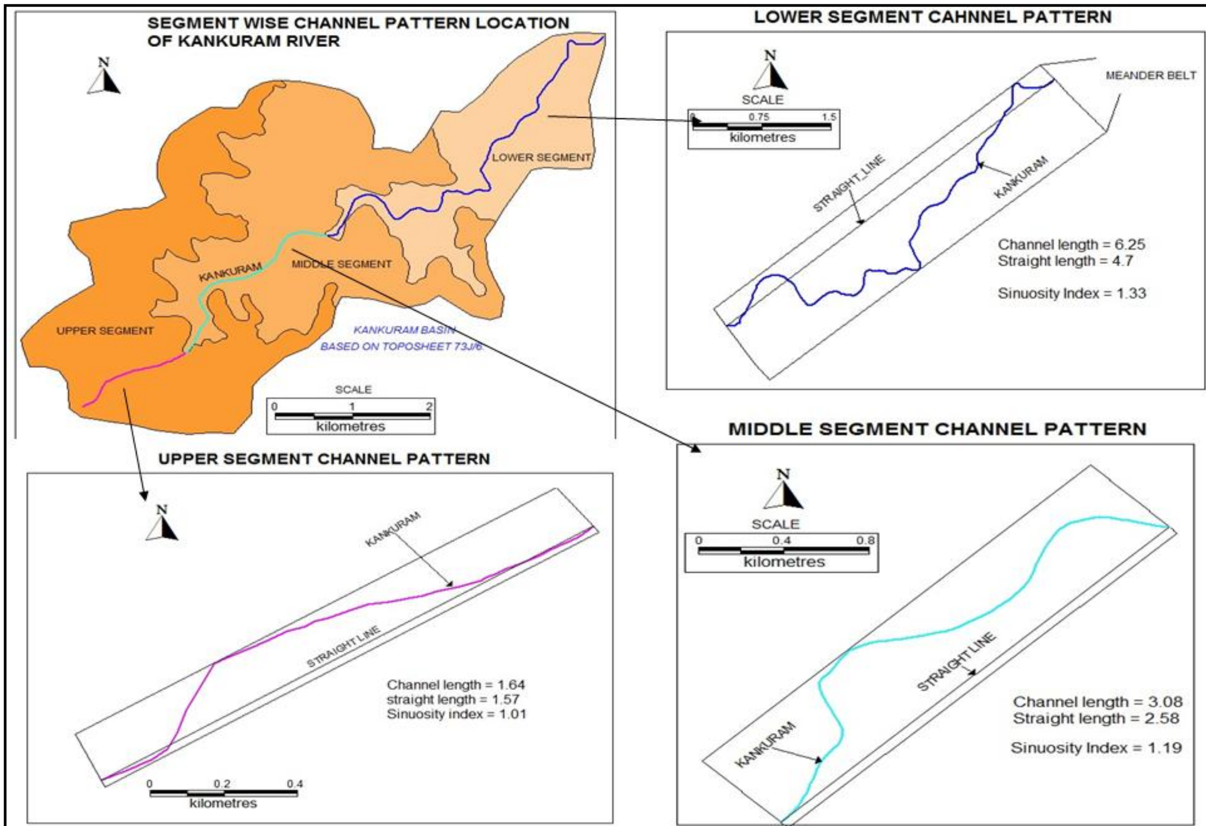


Figure No. 14 Shows the channel pattern of various segments of the Kankuram River.

Upper segment: If we are considered upper segment river then the channel length is 1.64 kilometer and straight length of channel is 1.57 kilometer. So, sinuosity index value of the upper segment river is 1.01 which indicates that the upper part of the river is a straight channel river.

Middle segment: In middle segment, the channel length is 3.08 kilometer and straight length is 2.58 km. The Sinuosity index value is 1.19 which indicates the channel is a sinuous.

Lower segment: In lower segment, the channel length is 6.25 kilometerand the straight length is 4.71 km. The Sinuosity Index value of lower segment channel is 1.33. It also indicates that the channel pattern of lower segment is Sinuous. In overall view of 3 segments, it represents that the upper segment channel is straight, middle and lower segment is sinuous. Because the middle and lower part of the river is alluvial part also than upper part. And the upper is largely controlled by structure than middle and lower. The ***figure-14*** shows the channel pattern of various segments. A micro level study was conducted to understand the meandering pattern of

Kankuram River. Here the channel length is 61.7meter and straight distance is 48.5m, the sinuosity index is 1.27 and amplitude value is 21.15. The SI value indicates that the study area of channel is sinuous. A conceptual diagram represents here to show the micro meander feature in ***figure-15***.

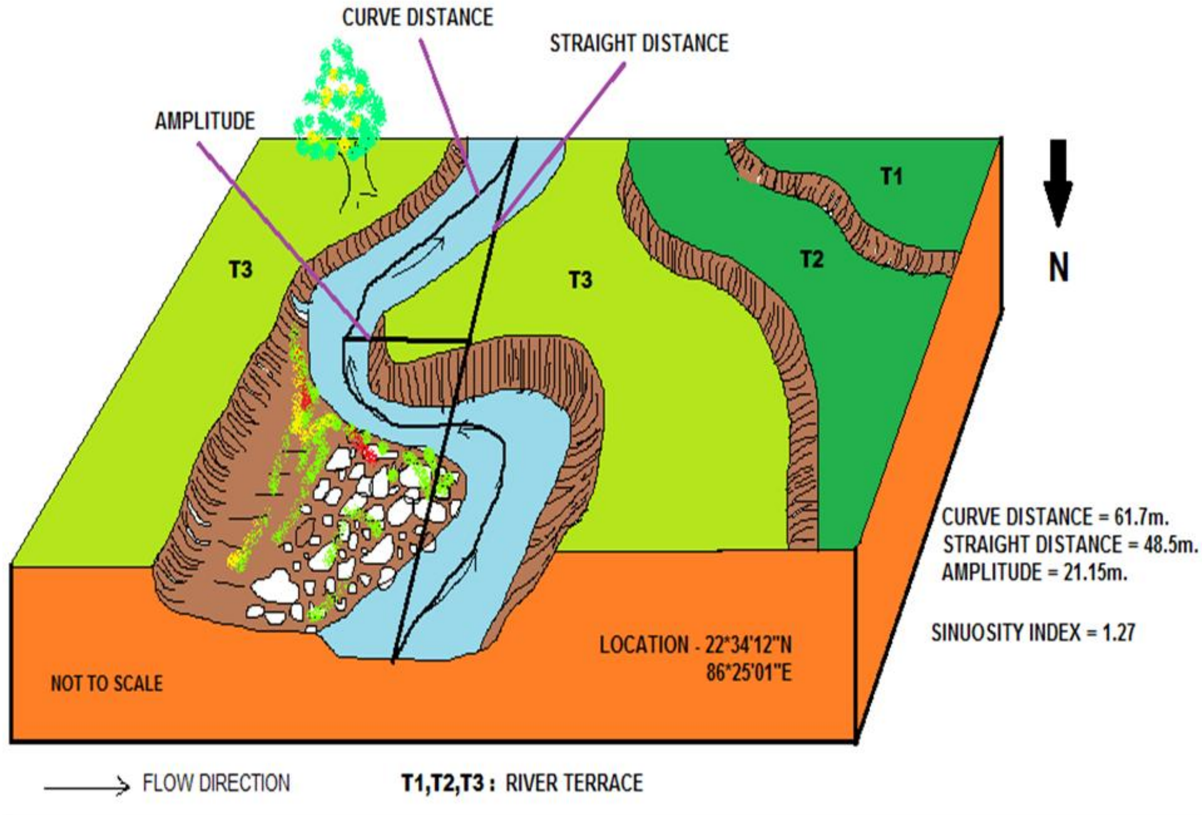


Figure No. 15 Conceptual diagram of micro-level meandering features.

Drainagepattern and profile analysis: The effects of lithology and rock structure are most evident in the drainage pattern of well-developed drainage basins. Local ground slope and local variation in geology exert an influence on flow direction and drainage-pattern development. (M. Morisawa). The drainage patterns are Dendritic, Rectangular, and Trellised etc. The Kankuram River basin is a dendritic drainage pattern. Dendritic drainage pattern are developed in this area, because the area is fully structurally controlled.

Long profile analysis: Profiles, drawn from the contour map, are of the great assistance to the geo-morphologists who are primarily concerned with the analysis of relief and surfaces of terrain because profiles provide a visual perception of the actual nature of terrain (S. Singh). Long profile gives a vivid picture of breaks in longitudinal profile and these breaks help in examining the polycyclic nature of landform development.

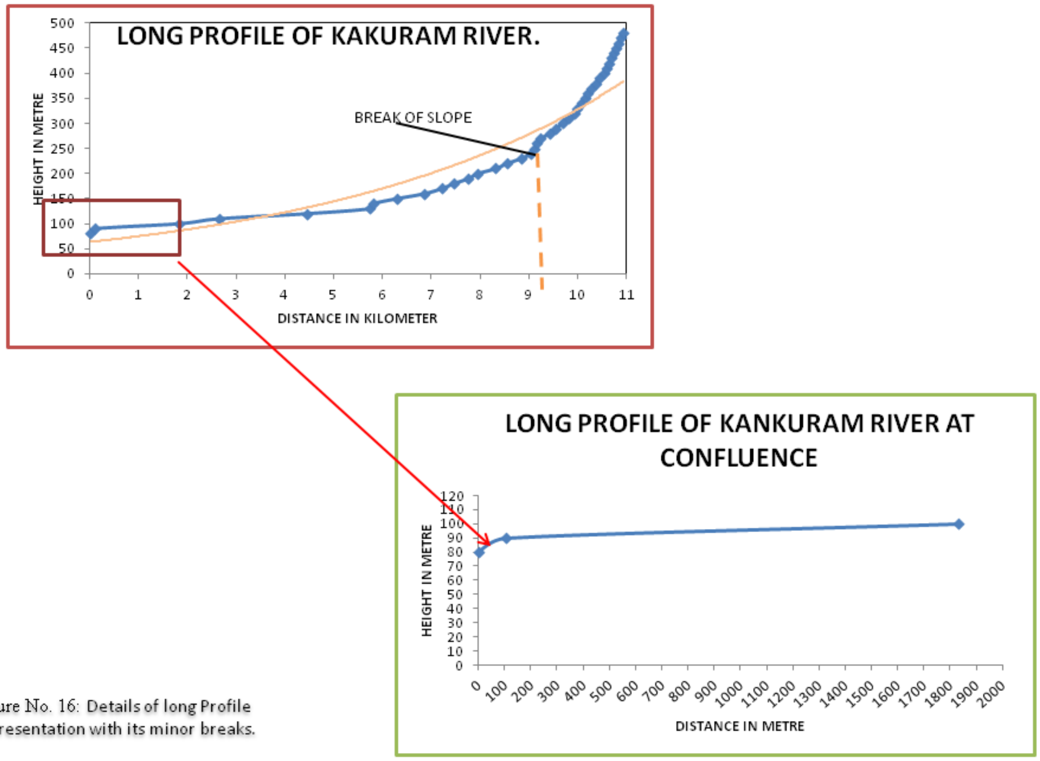


Figure No. 16: Details of long Profile representation with its minor breaks.

Plate no.6: 7m height at break-of-slope near confluence of kankuram River & Formed a waterfalls.

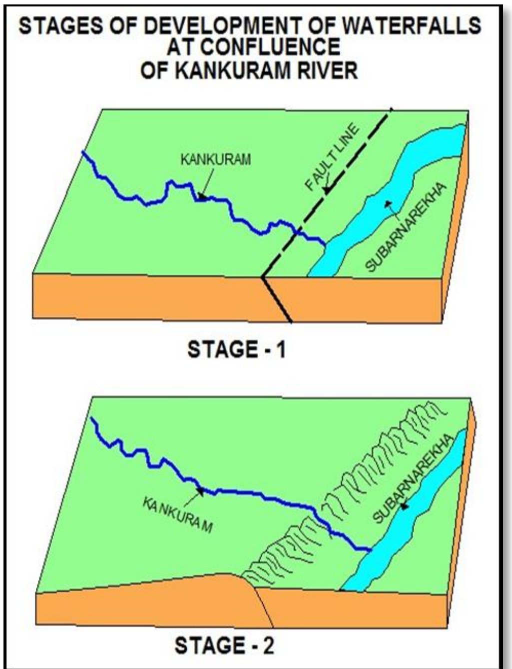


Figure No. 17 Conceptual Diagram presenting the process of break near confluence

After draw long profile of Kankuram River ***(figure no.16),*** we have find the 2 break-of-slope on 150m contour and 250meter contour, which indicate the 3 segment of the river. In confluence we have also be seen that suddenly contour interval decrease here, normally it not be seen.

A fault line is present at confluence of Kankuram River between two micro plates. Due to endogenetic force the fault has been formed here, and due to formed fault at confluence the waterfalls ***(Plate no.6)*** has formed at confluence of Kankuram River. The ***figure-17*** shows the stages of development of waterfalls at confluence.

Cross profile analysis: Cross profile represents a general view of terrain development of an area. I have presented here some cross profile of Kankuram River basin***(Figure no.18)*** to show a general view of terrain and valley shape changes over the area. I divided the whole study area in 3 segments on the basis of break-of-slope (150meter, 250meter contour) to carefully understand the changes of valley shape, weighted perimeter, hydraulic radius and thalweg***(Table no.6).***

Regarding the detail cross profile analysis we have considered 11 cross section points and they have selected on the basis of its hydrological units, two from upper part, three from middle and

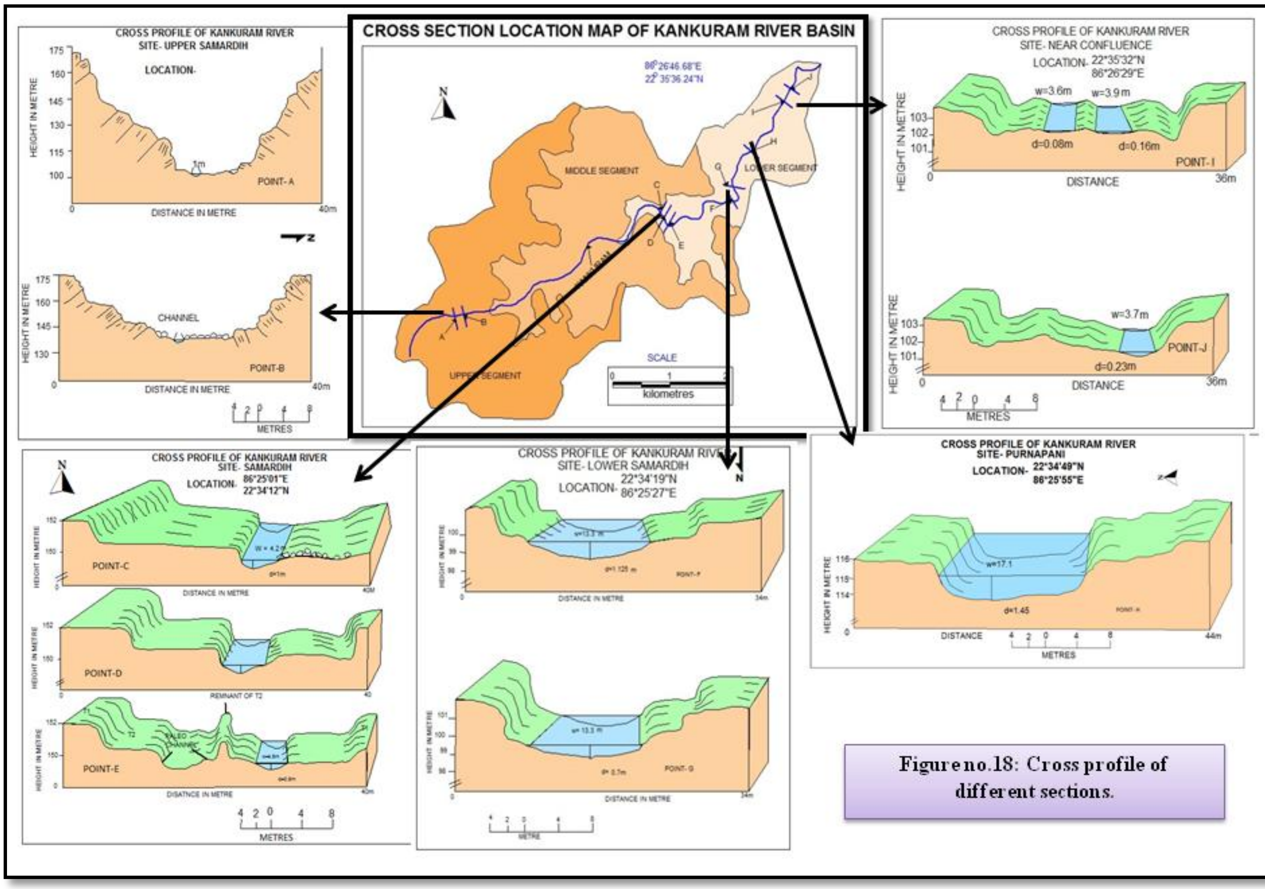


Figure no.18: Cross profile of different sections.

six from lower part of the basin.

Upper segment:

Two cross profile (point- A and B) draw in this segment, which represents the valley shape is nearly 'V' shaped valley ***(Plate no.7).*** And the channel width and depth is very narrow. This type of feature formed due to structurally controlled.

Middle-lower segment:


Plate no.7: V- Shaped valley in the upper part of Kankuram Basin.

Near the 250meter contour or upper break-of-slope, three cross profile (point- C, D, and E) has been drawn. These cross profile also represent that the terraces are formed here, and slope is moderate, channel depth and width is increased, hydraulic radius and weighted perimeter also increased and one paleo-channel ***(Plate no.8)*** is formed here.

Plate no.8: Paleo-Channel.

Generally in middle part of the basin have more number of 1st order streams with rills and gullies and also have huge water volume capacity than upper part of the basin. And also volume of discharge of water is high than upper part. In this cause, here the channel width and depth is increase than upper part of the basin.

Lower segment:

In lower segment, five cross profile (point- F, G, H, I and J) has been drawn at various points to study the nature of terrain of lower segment of the basin. In middle part of lower segment (point-H, near Purnapani), there have very wide and very depth of the channel and it is the deepest part of the channel ***(Plate no.9)*** in respect to the total Kankuram River. The upper portion of the lower

Plate no.9: Deepest part of Kankuram River at Purnapani.

segment (point-F) have width & depth is also high than middle and upper segment. But the lower part of the lower segment (near confluence), there have very low depth of water and channel width is very high and it is the widest part of the channel in respect to the whole Kankuram River. The channel has divided into two parts at lower portion of the lower segment (near confluence) and it cover some distance and go through the direction of mouth and then it is meet together once.

Concluding remarks:

The afforest research represent the detail study of fluvial channel morphology with its surrounding terrain evolution of the Kankuram River basin. It is very significant to find that the value of hydraulic radius is considerable changes with its terrain character not in normal way but it represents complex channel variability from source to mouth. This channel morphology has influenced the land use pattern in applied sense. The changing nature of land use shows the development of agricultural land over those areas. Where the water is available for irrigation, i.e. Purnapani area but the lower & upper part shows the opposite view due to the minimization water availability as the lowest value of wetted perimeter, it is also viewed that near Purnapani the slope value is low but near mouth the sudden change of break-of –slope in 12m has made the area bowel shaped, because of which all the seepage water is concentrated which leads to the proper development of agricultural area.

Acknowledgement

We bend over in adoration in Almighty God whose kind blessing gave me the required enthusiasm for completion of this work. We do not find pertinent words to articulate my thoughtful gratitude and indebtness to our guide Prof.S.C. Mukhopadhyay,MSc.Ph.d,DSc.(Cal)(rtd),of Calcutta University for her outstanding guidance, well-timed criticism, suggestions and all the assists in carrying out the study, nevertheless for which this work would not have been accomplished.We are thankful to all the respondents of Ghatsila and its surrounding areas who co-operated with me during the collection of information related to my field work. Wish to extend my thankfulness to Mr. AbhijitKundu, Mr. RakeshChoudhury and Sutapa Bhattacharya for their tireless help in carrying out the entire work.

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Table Number.1 Geological time scale with stratification of rocks and succession of Climate

(After S.C Mukhopadhyay,1980)

ERA	PERIOD	EPOCH	AGE (million years ago)	CLIMATE	EARTH MOVEMENT
Cenozoic	Quaternary	Recent Pleistocene Pliocene	1 to 10	Continued cooling	Tertiary earth movements (Epeirogenetic)
	Tertiary	Miocene Oligocene Eocene	25 40 60	Cold+Semi-arid Warm+Humid Cold+Warm	
		Pliocene	70	Humid + Semi arid Fluctuating, Very warm	Epeirogenic Triassic Uplift
Mesozoic	Cretaceous	Upper Lower	125		
	Jurassic	Upper Middle Lower	150	Warm	
	Triassic	Upper Middle Lower	180	Warm + Semi arid	
Paleozoic	Permian (Glaciation)	Upper Lower	205	Dry	Harcynian Earth Movement (Faulted Damodar Epeirogenetic)
	Carboniferous (Coal- age)	Upper Lower	255	Hot + Humid	

	Devonian	Upper Middle Lower	315	Arid + Semi arid	
	Silurian	Upper Middle Lower	350	Arid + Semi arid	
	Ordovician	Upper Middle Lower	430	Dry	
	Cambrian	Upper Middle Lower	510	Warm temperate	
Archeozoic	Precambrian (Glaciation)	Upper Middle Lower	700 1100 1500	Dry + cold	Archean Earth Movements
	Earth's Crust		3000 to 4000		

Table Number.2 Linear Aspects of the Kankuram basin.

Stream order (u)	No. of streams (Nu)	Total length of streams in km (Lu)	Mean Streams length	Stream length ratio (Rl)	Log. Nu	Log. Lu
1	82	36.06	0.44	-	1.914	1.557

2	17	18.2276	1.07	2.43	1.230	1.261
3	4	2.7927	0.70	0.65	0.602	0.4460
4	1	5.1449	5.15	7.36	0	0.711

Table Number.3 Bifurcation ratio o of the Kankuram basin.

Order	Bifurcation Ratio (Rb)	Mean Bifurcation Ratio
1st order / 2nd order	4.824	4.358
2nd order / 3rd order	4.25	
3rd order / 4th order	4	

Table Number.4 Areal Aspects of the Kankuram basin

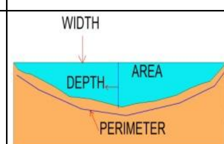
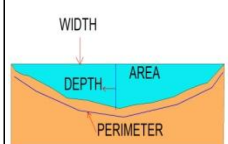
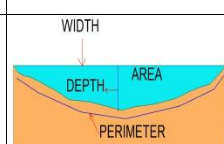
SL. No.	Morphometric Parameters	Symbol / Formula	Calculated value	Remarks
1	Area (sq. km)	A	23.0086	-
2	Perimeter (km)	P	26.149	-
3	Basin Length (Lb)	Lb	9.014	-
4	Drainage Density (Dd)	Dd = Lu/A	2.70	-
5	Stream Frequency (Sf)	Sf = Nu/A	4.52	-
6	Texture Ratio (Rt)	Rt = N1/P	3.14	-
7	Elongation Ratio (Re)	$Re = (2\sqrt{A/\pi})/Lb$	0.601	Elongated
8	Circulatory Ratio (Rc)	$Rc = 4\pi A/P^2$	0.423	Elongated
9	Form Factor Ratio (Rf)	$Rf = A/Lb^2$	0.283	Elongated
10	Length of Overland Flow	Dd/2	1.35	-

11	Lemniscate Ratio	$Lb^2/4A$	0.883	Sub-circular

Table Number.5 Relief Aspects of the Kankuram basin.

SL. No.	Morphometric Parameters	Symbol / Formula	Calculated value
1	Basin Relief in metre (RR)	Max. elevation- Min. elevation	570-90 = 480
2	Relief Ratio (Rh)	Rh = RR/ Lb	53.25
3	Ruggedness Number (Rn)	Rn = RR×Dd	1296.0

Table Number. 6: Weighted perimeter and hydraulic radius of Kankuram River.

Observation point	Wetted perimeter			Hydraulic radius				
	Width (w) In metre	Depth (d) In metre	Calculated value Sq. metre	Area (A) Sq. metre	Perimeter (P) In metre	Applicable types	Applicable formula	Calculated value
A	1.0	0.1	0.1	0.1	1.3		A/P	0.077
B	1.25	0.3	0.375	0.375	1.5		A/P	0.250
C	4.2	1.0	4.2	4.2	4.6		A/P	0.913

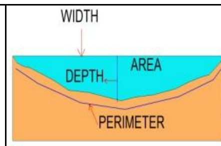
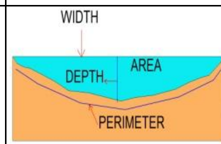
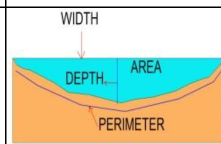
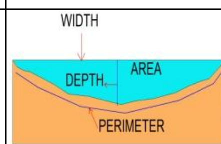
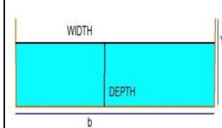
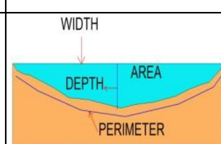
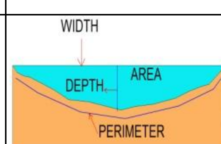
D	5	1.2	6	6	5.45		A/P	1.101
E	4.5	0.5	2.25	2.25	4.720		A/P	0.477
F	13.3	1.125	14.963	14.963	15.2		A/P	0.984
G	13.3	0.7	9.31	9.31	14.8		A/P	0.629
H	17.1	1.45	24.795	24.795	20		A/P=b.y/b +2.y	1.240
I	3.9	0.16	0.624	0.624	4.2		A/P	0.149
J	3.7	0.23	0.851	0.851	3.9		A/P	0.218

Table Number.7 hypsometric curve.

ELEVATION IN (m)	h/H	AREA IN (sq. km.)	a/A
100	0	9.636	1
200	0.25	6.777	0.703300125
300	0.5	4.433	0.460045662
400	0.75	1.493	0.154939809
500	1	0.059	0.006122873

LIST OF FIGURES

Figure no.13: Channel pattern of Kankuram Basin.

Figure no.14: Shows the channel pattern of various segments of the Kankuram River.

Figure no.15: Conceptual diagram of Micro-level meandering feature.

Figure no.16: Details of Long profile representation with its minor breaks.

Figure no.17: Conceptual diagram presenting the process of break near confluence.

Figure no.18: Cross profile of different sections.

LIST OF PLATES

LIST OF TABLES