Research Report

On

"ANALYSIS OF MORPHOMETRY OF KANGSABATI RIVER BASIN: A GEOSPATIAL STUDY"

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Finally, I express my heartfelt gratitude to my family members. Without their unconditional support, love, and sacrifice, this journey would not have been possible. After all, I owe it all to Almighty for giving me the strength, wisdom, ability, and opportunity to undertake this research study, and enabling me to its completion.

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INTRODUCTION

1.1 Background

Morphometric characteristics are the dimension and mathematical evaluation of the configuration of the earth's surface. Moreover, the morphometric characteristics may control imperative information concerning its formation and growth due to all hydrologic and geomorphic processes that occur within the watershed. Morphometric techniques have been applied to a variety of earth surface features and have proven to be very effective in planning land surface processes. There have been few quantitative investigations of the Lateritic upland region of West Bengal. While more attention has been given to the morphometric and spatial distribution parameters of its surroundings. Furthermore, recognition of drainage networks within the watershed region can be obtained using conventional methods like field observations and topographic maps or instead with remote sensing and GIS technology. However, due to the absence of topographic maps in adequate scale, or the availability of data, it is difficult to observe all drainage networks from field observations by conventional methods in rough terrain and inaccessible areas.

In our study, we select the Kangsabati River for a brief. Kangsabati River is a small river that originated from the Eastern part of the Chatanagpur plateau and flows east-south direction in the district of Puruliya, Bankura, and undivided Midnapore. The river has a great impact on that region. Kharagpur Industrial belt, Kharagpur, Midnapore, Khatra, etc urban region develops on the bank of Kangsabati River bank.

The importance of Rivers in Human life and civilization is visual in spiritual, moral, as well as water transport, irrigation, and agriculture system. That is why; the great Greek Geographer Herodotus said that "Egypt is the gift of Nile". After the development of human civilization, the rivers were become threaten. Construction of Dams, mixing of industrial and urban liquid and solid garbage and other human activities collapsed the natural river eco-system. After the Earth Submit programme (1991-1992; Rio de Janeiro), the concept sustainable development has been brought up. Geographers and common people thought to rejuvenate the river ecosystem. For the rejuvenation of river ecosystem, we have to know each river individually, because of every river are individual and have some unique physical character.

Remote sensing and GIS technology are convenient method to study morphometric characteristics as the satellite images provide detailed information of earth's surface features with synoptic coverage, high receptivity, cost-effectiveness

Furthermore, Digital elevation models (DEMs) are progressively more used for visual and mathematical analysis of topography, landscapes, and landforms, as well as modeling the surface processes. Actually, the automatic generation of a DEM from remotely sensed data with sub-pixel precision is promising. The application of GIS to spatial data has proven to be instrumental in the analysis of complex problems in the earth and environmental sciences.

The varying nature of surface characteristics due to natural hazards (e.g., agricultural drought) is a persistent phenomenon in the western part of West Bengal during the last two-three

Due to the uneven distribution of the surface properties, soil moisture and inadequate rainfall played an important role for the growth of healthy crop and cause extreme crop stress and wilt. The study of morphometric characteristics of the lateritic upland area will reveal an apparent idea about the spatial distribution of relief and hydrological characteristics and will provide the knowledge to devise and accomplish an appropriate plan to progress agriculture and other allied activities. Hence, in the present study, we investigated the morphometric characteristics of the Kangsabati Interfluves Area using remote sensing and GIS technology.

1.2 Relevance of Remote Sensing and GIS

Satellite remote sensing (SRS) derived images provide synoptic views over large areas at frequent intervals and offer images of areas inaccessible to conventional surveying. The tool of remote sensing (RS) coupled with geographic information system (GIS) is a cost-effective, technologically sound, and increasingly used efficient tool in the assessment and modelling of river basins. The application of the RS-GIS tool during the last three decades has taken the extent and quality of research on morphometry analysis of kangsabati river basin. With the advancement in research, researchers have devised different robust indices and models integrated with RS-GIS for quantifying.

In the present study some physical Morphometric parameters include absolute relief, relative relief, contour spacing, and contour pattern. The hydrological analysis bifurcation ratio, stream ordering also drainage network.

1.3 Objectives:

The main objective of the study is to make a brief introduction to the Kangsabati River

- Studying spatial variation of absolute relief over Kangsabati river basin.
- Studying aspects of slope and average slope in the basin.
- Analysing stream order (Strahler Method) in the basin.
- Studying the flood-prone area in the basin using bifurcation ratio.

STUDY AREA

2.1 About Kangsabati River Basin:

Kangsabati River is also known as the Kasai and Cossye. The right-hand secondary tributary of Bhagirathi Hooghly River is generally a non-perennial river by nature. It originated from Ghoramara Hill (Jhalda - 23º32´30´´N and 85º56´30´´E) the Eastern Chotonagpur plateau. The Kangsabati meets with Rupnarayan River near Ghatal (Bandar). The combined flow of Rupnarayan and Kangsabati is known as Keleghai.

The Kangsabati River basin within the Lower Ganga or the Bhagirathi Hooghly basin is bounded by latitudes 21°45' N. to 23°30 ' N and longitudes 85°45' E. to 88°15' E., this includes the entire **Purulia** district, and major part of **Bankura** and **Midnapore** districts covering an area of about **9658** sq. km. The total length of the Kangsabati River is about 465.23 km (289.08 mi) and the valley with its high resource potential exhibits a great diversity in its polycyclic landscape development thus extending through a wide area in West Bengal.

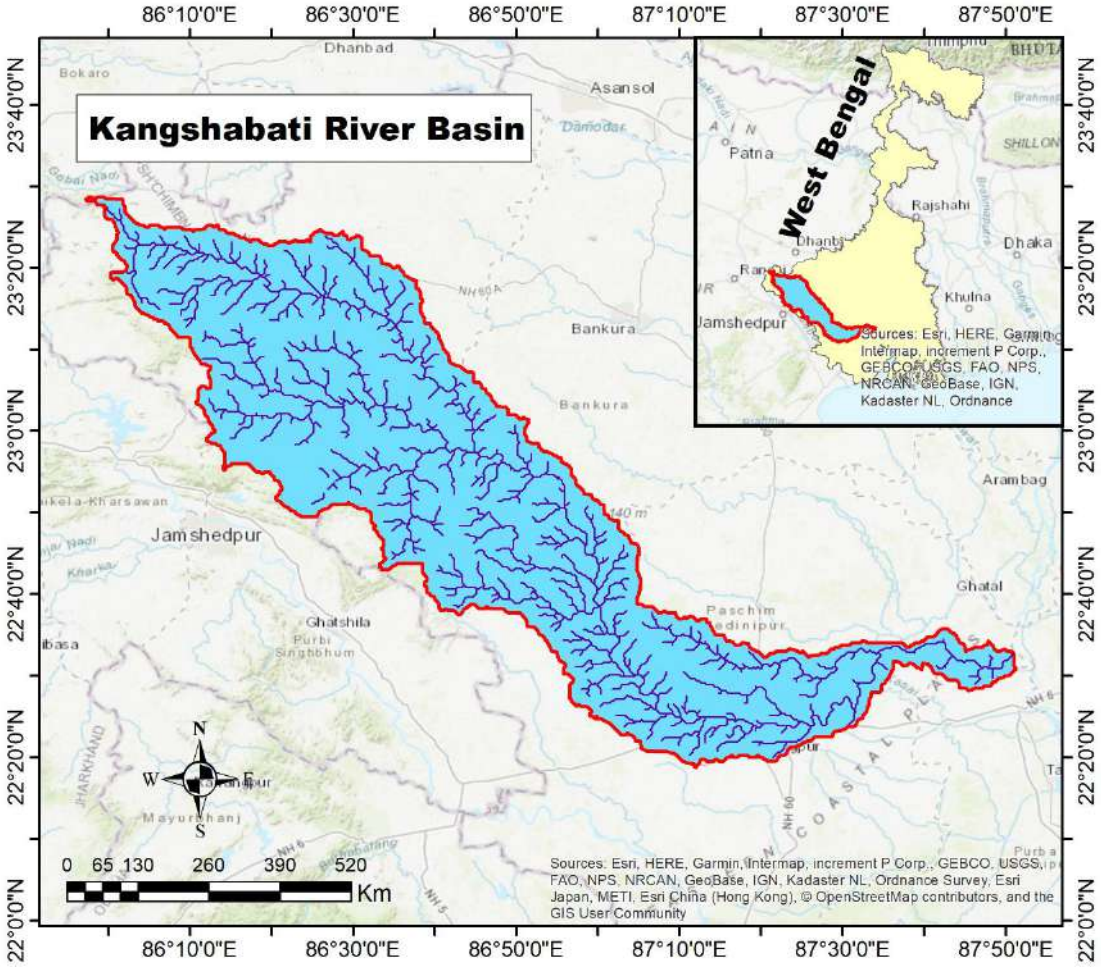

Fig. 2.1: Location map of the study area (Kangsabati River basin)

2.2 River Course:

The non-perennial Kangsabati has been divided into three major courses. Youth or upstream extended Jhalda to Sarenga, Middle course or mature stage extend up to Sarenga to Mohonpur. And the lower course or lower stream extant from Mohonpur to Ghatal (Bandar). The dendritic drainage pattern river basin covers 9658 sq. Km. ah the total mainstream length of 465.23 km. (289.08 mi).

River	Tributaries		Districts Covers (Location)
Kangsabati	Primary	Secondary	
	Saharjore, Bandhu, Patloi		Purulia
	Kumari	Hanumata, Kerro, Jore, Charan	Purulia
	Jam	Tatko	Purba Singbhum (JHARKHAND)
	Bhairabbanki	Jhinuk	Paschim Medinipur, Bankura
		Tarapheni	Paschim Medinipur (Now Jhargram Dist.)

2.3 Climatic Condition:

The climate of the river basin is generally semi-humid in nature. The Southwest Monsoon has the highest rainfall in June, July, and August, average rainfall of 150-175 cm. The highest temperature is found in April-May, the first period of summer, varied 40-42°c. the lowest temperature is found in December and January months, the mean temperature varied 8-12 °c. Deficiency of subsurface water availability is peek in the months of March, April and May. Bankura and Purulia districts are considered as drought prone areas in the state of West Bengal. Droughts are mostly caused by some geological and river hydrological factors.

2.4 Geology and Morphology of Kangsabati River Basin:

Geologically the river basin area is constituted of many geological units. That region was brought up through a long evolution from the oldest Arches (Pre-Chmbrian) to Tertiary-

Quaternary formation (Mukhopadhyay.1992). The river basin area is mainly formed with Granite, Gneiss, and mica schist. Upstream and middle streams mainly consist of igneous Granite and metamorphic Gneiss. Downstream mainly formed with alluvial deposition and fractured aquifer in upper basin granite gneiss. The Kangsabati River basin is mainly elongated in nature. Absolute and relative relief of the kangsabati river basin is 659 and 657 m correspondingly. The Dissection value of the Kangasabati River basin is 0.9.

3.1 LITERATURE REVIEW

Remote sensing and GIS application employed in the demarcation and modernize of the relief and drainage characteristics in the present study. The variation in drainage characteristics might be due to changes in slope and topography. It is contingent from the study that the streams have created a mature stage which is a sign of good geomorphic development. the complete analysis of drainage basin characteristics of Kangsabati area can be considered as an area with moderate to poor groundwater prospect as the area has less permeable subsurface and the conditions somewhat favourable for infiltration of surface water. However, it is also required to observe the other factors like, land use, climate, soil type, etc. which are identified to influence hydrologic processes to disentangle the multivariate nature of the predicament with the view to finding a holistic elucidation.

Kangsabati River is a small river originated from the Eastern part of Chatanagpur plateau and flow east-south direction in the district of Puruliya, Bankura, and undivided Midnapore. The river has a great impact on that region. **Kharagpur Industrial belt, Kharagpur, Midnapore, Khatra etc. urban region** develops on the bank of Kangsabati River bank.

The relief characteristics using Advance Space Thermal Emission and Radiometer (ASTER) data. Drainage networks were automatically extracted from digital aster elevation models. Second order local polynomial (LP) interpolation technique was used to estimate the surface characteristics of the study area using ArcGIS.

The result of the study highlights an about the spatial distribution of relief and hydrological characteristics which may provide the knowledge to devise and accomplish an appropriate plan to progress agriculture and others allied activities. Hence, from the study, it can be concluded that remote sensing data (ASTER –DEM) coupled with GIS techniques prove to be a competent tool in morphometric analysis and the data can be used for basin or interfluves area management and other hydrological studies in future.

DATABASE AND METHODOLOGY

4.1 Database:

The morphometric analysis of the study area was carried out using the Advance Space Thermal Emission and Radiometer (ASTER, Spatial resolution 30 m). ASTER GDEM data was downloaded from the ASTER GDEM Project of the Japan-US ASTER Science Team. The study of morphometric parameters of the basin is effectively done using modern RS and GIS techniques.

The following geospatial dataset has been used in the present study,

• Digital Elevation Model (DEM): JAXA released the "ALOS World 3D-30m" (AW3D30) dataset, the global digital surface model (DSM) dataset with a horizontal resolution of approximately 30-meter mesh.

• Global Human Settlement Layer (GHSL) provided by European Commission, Joint Research Committee

To fulfil the above-stated objective, 'SRTMGDEM' (30 m.) data has been used for river morphometric analysis, followed by the construction of a longitudinal profile.

The different basin morphometric parameters have been accessed and calculated through remote sensing and GIS techniques. Morphometric parameters include absolute relief, relative relief, contour spacing, and contour pattern. The hydrological analysis comprises flow direction, flow accumulation, identification of stream network, stream order, and bifurcation ratio.

4.2 Methodological Framework:

The morphometric analysis includes absolute relief, relative relief, and range of slope, contour spacing, and contour pattern.

Hydrological analysis identification of stream network, stream ordering, and bifurcation ratio in the Kangsabati river basin.

Second order local polynomial (LP) interpolation technique was used to estimate the surface characteristics of the study area using ArcGIS. The advantage of this technique is that it is a quite quick deterministic interpolator that is smooth and more flexible than the global polynomial method. As such, there is no measurement of prediction errors and this method does not let you to examine the autocorrelation of the data, making it less flexible and more automatic than Kriging techniques.

4.3 Software Used

- Google Earth Engine web portal for necessary data extraction
- ArcGIS 10.8 for thematic mapping and analysis
- MS Excel for statistical analysis

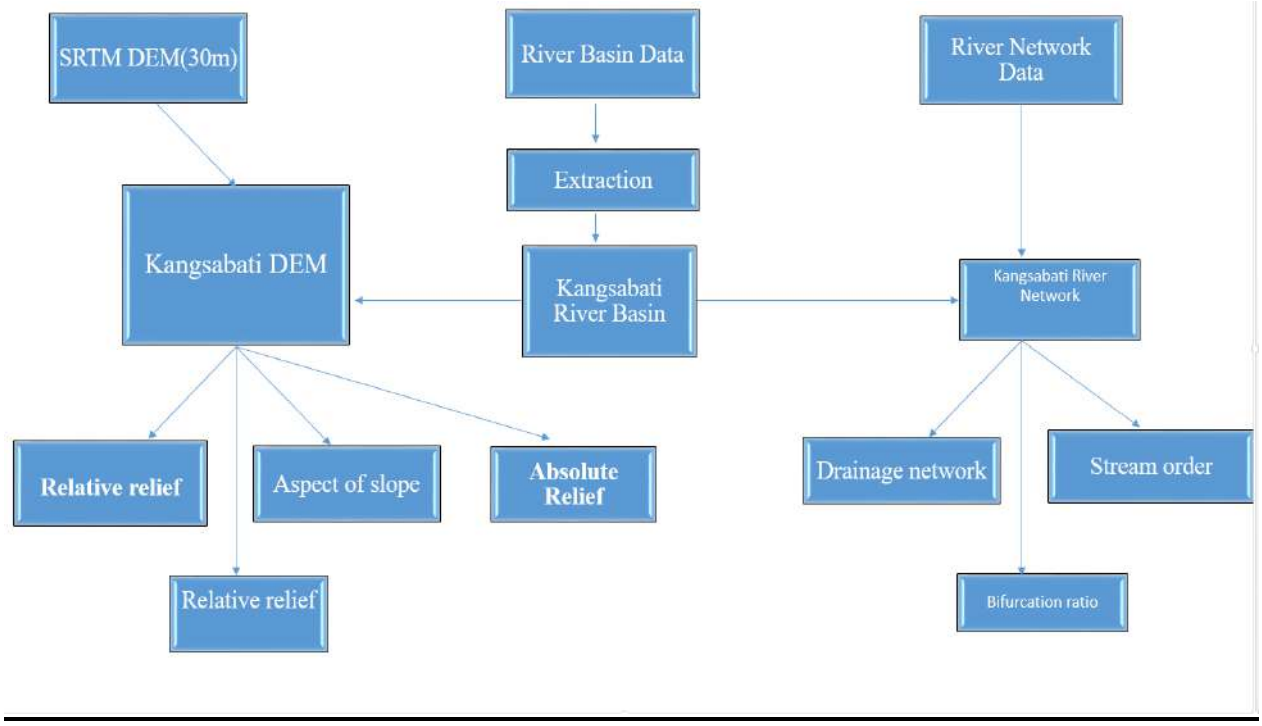

Fig. Methodological flowchart

5.1 Absolute Relief:

Absolute relief refers to the maximum elevation in a regional unit. The map reflects absolute relief with five categories of elevation. Absolute relief (R) are important parameters to understand the evolutionary characteristics of the Kangsabati River basin. The map reflects a relatively lower elevation with less than 87 meters in the south-eastern part and the north-western part of the map reflects a higher elevation which is about 368 meters. Central and Eastern parts moderate elevation ranging between 169-236m. Height is found to be decreasing from the north western part to southeastern. The absolute elevation of the study region is between87.0 to 368 meter.

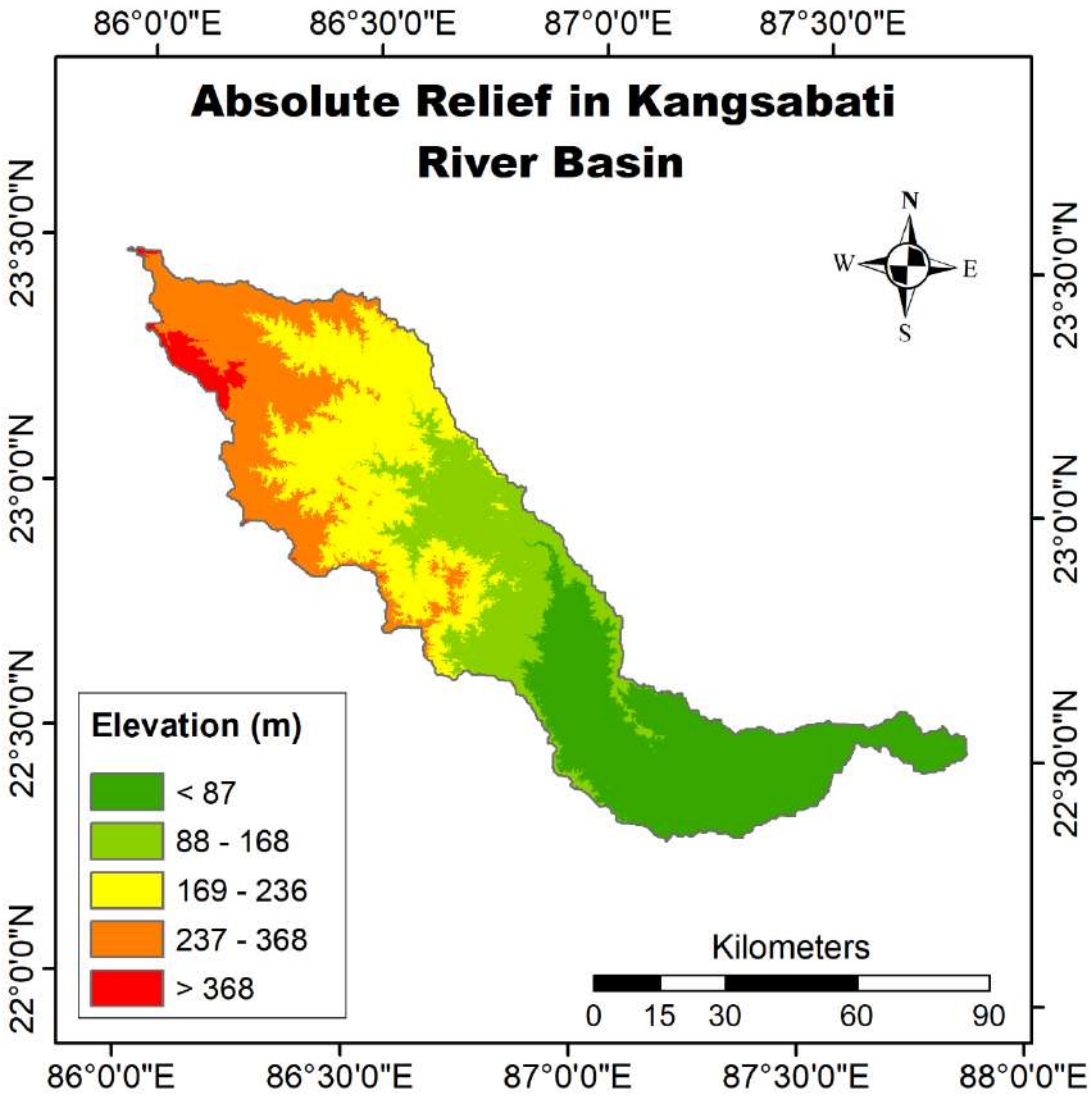

Fig. 5.1: Absolute Relief in Kangsabati River Basin

5.2 Relative Relief:

Relative relief is an important morphometric variable used for the overall assessment of morphological characteristics of terrain is 208m where the lowest value is recorded as 36m.The low relative relied demonstrated that the region is almost flat and appears like mature stage of geomorphic evolution. The region could be used for agricultural purpose for its flat nature depending on water accessibility.

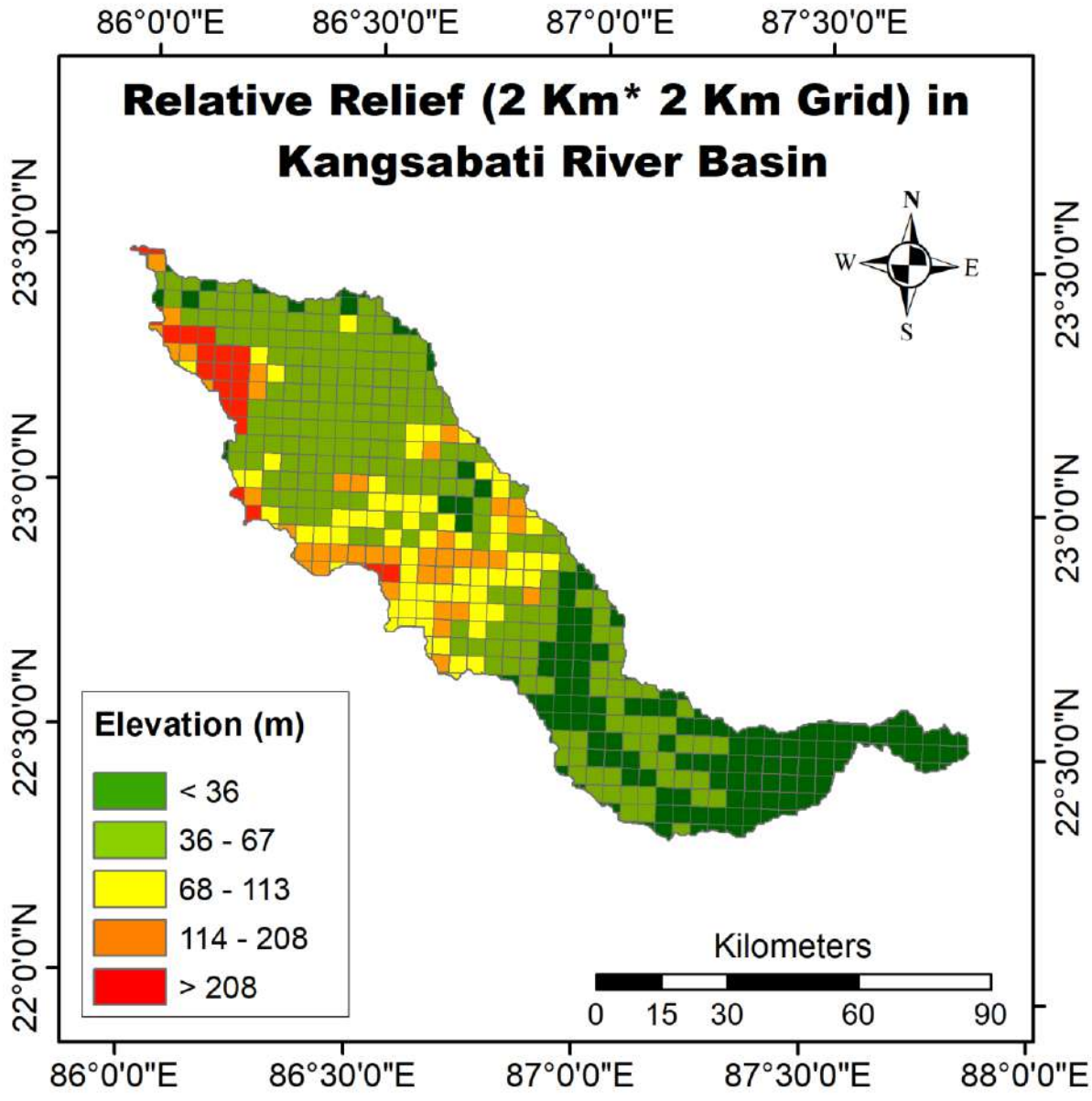

Fig. 5.2: Relative Relief in Kangsabati River Basin

5.3 Slope and its spatial variation:

The slope of a terrain refers to the amount of inclination of physical features, topographic landform to the horizontal surface. Slope analysis is an important parameter in morphometric studies. The slope elements, in turn, are controlled by climatic-morphogenic processes in areas having rocks of varying resistance. Identifies the slope (gradient or steepness) from each cell of a raster. The output slope raster can be calculated in two types of units, degrees or percent (percent rise). The percent rise can be better understood if you consider it as the rise divided by the run, multiplied by 100. When the angle is 45 degrees, the rise is equal to the run, and the percent rise is 100 percent. As the slope angle approaches vertical (90 degrees), as in triangle C, the percent rise begins to approach infinity.

In this river basin slope ranges between 0◦ and 18.31◦. A higher Magnitude of the slope is found in the north-western and central parts of the river basin.

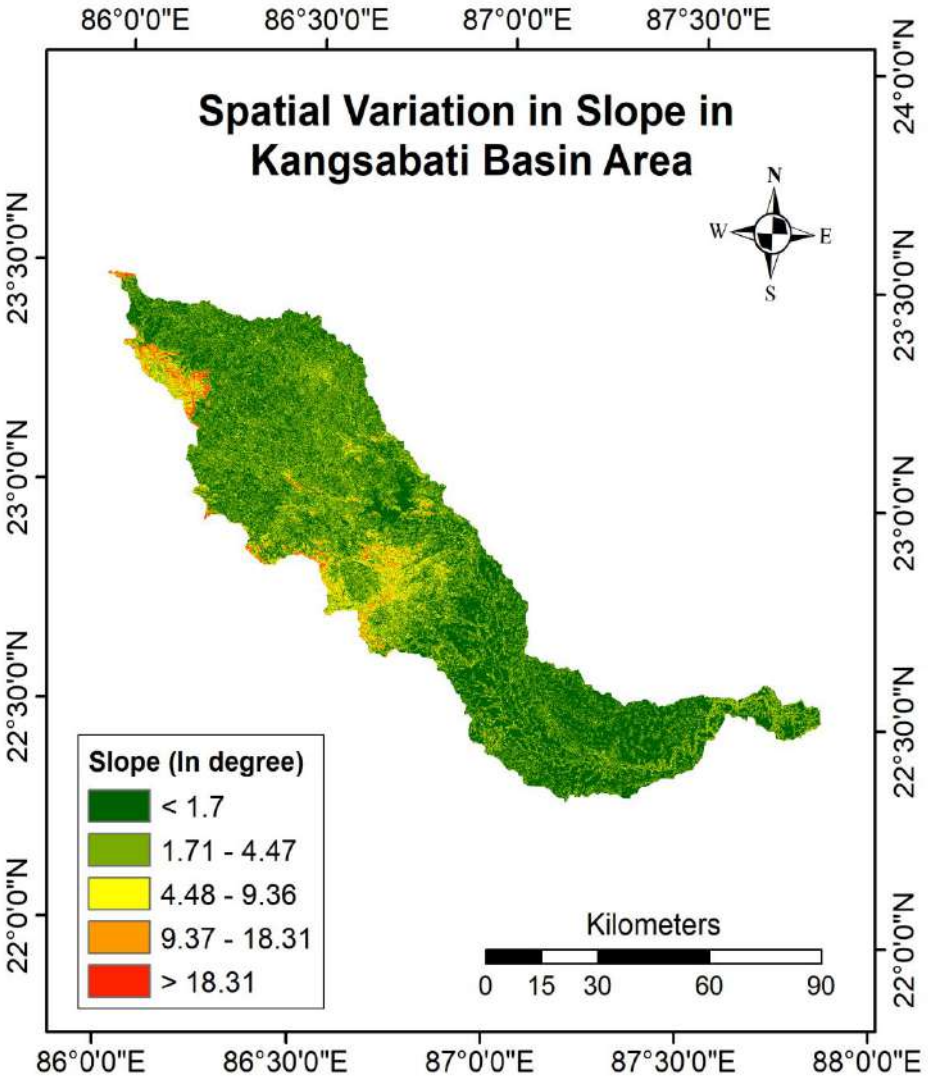

Fig. 5.3: Spatial variation of slope in Kangsabati River Basin

5.4 Contour and contour-based altitudinal zonation:

Contours are drawn in ArcGIS with an interval of 100 m. A number of contour are less in south east direction. Contours are closely spaced in the north western part of Kangsabati River. Therefore, the gradient is very high towards the north-western. Based on the number of contours and contour interval an isopleth-cum-choropleth map has been prepared as presented above. The map reflects six zone and in this river basin highest elevation more than 500m in north-western part. The lowest elevation zone cover maximum in this river basin.

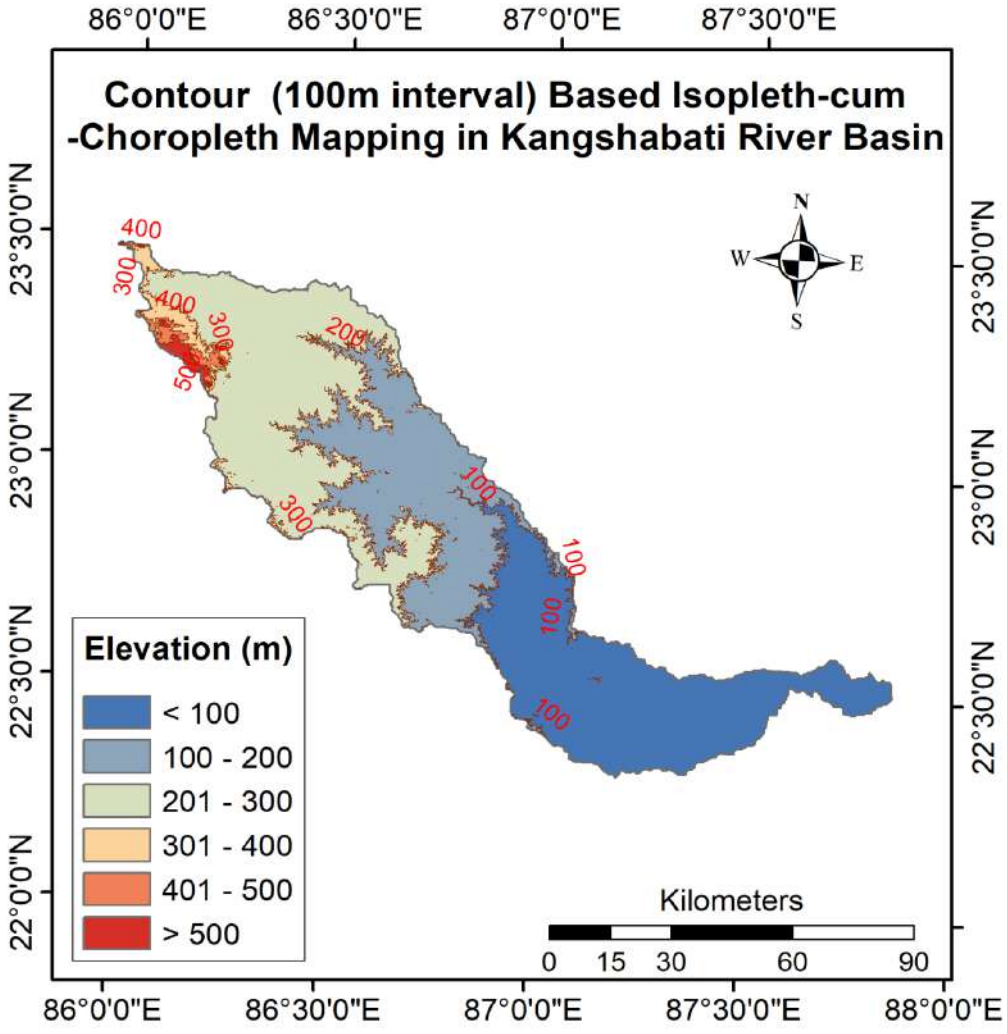

Fig. 5.4: Contour and contour-based altitudinal zonation in Kangsabati River Basin

6.1 Drainage Network:

The stream order or water body order is a positive whole number used in geomorphology and hydrology to indicate the level of branching in a river system. There are various types of stream ordering techniques (Horton 1945), (Strahler 1952). Strahler's system which is slightly modified the Horton's method was used to analyse the stream order in this study. The smallest (un-branched) streams are first order and where the two first-order streams join together, they form second-order, and two second-order streams come together to change to third order and so on, whereas two different levels of streams come together; they will remain as the highest one.

The derived drainage network was used to derive stream order in the Kangsabati River basin following Strahler's method.

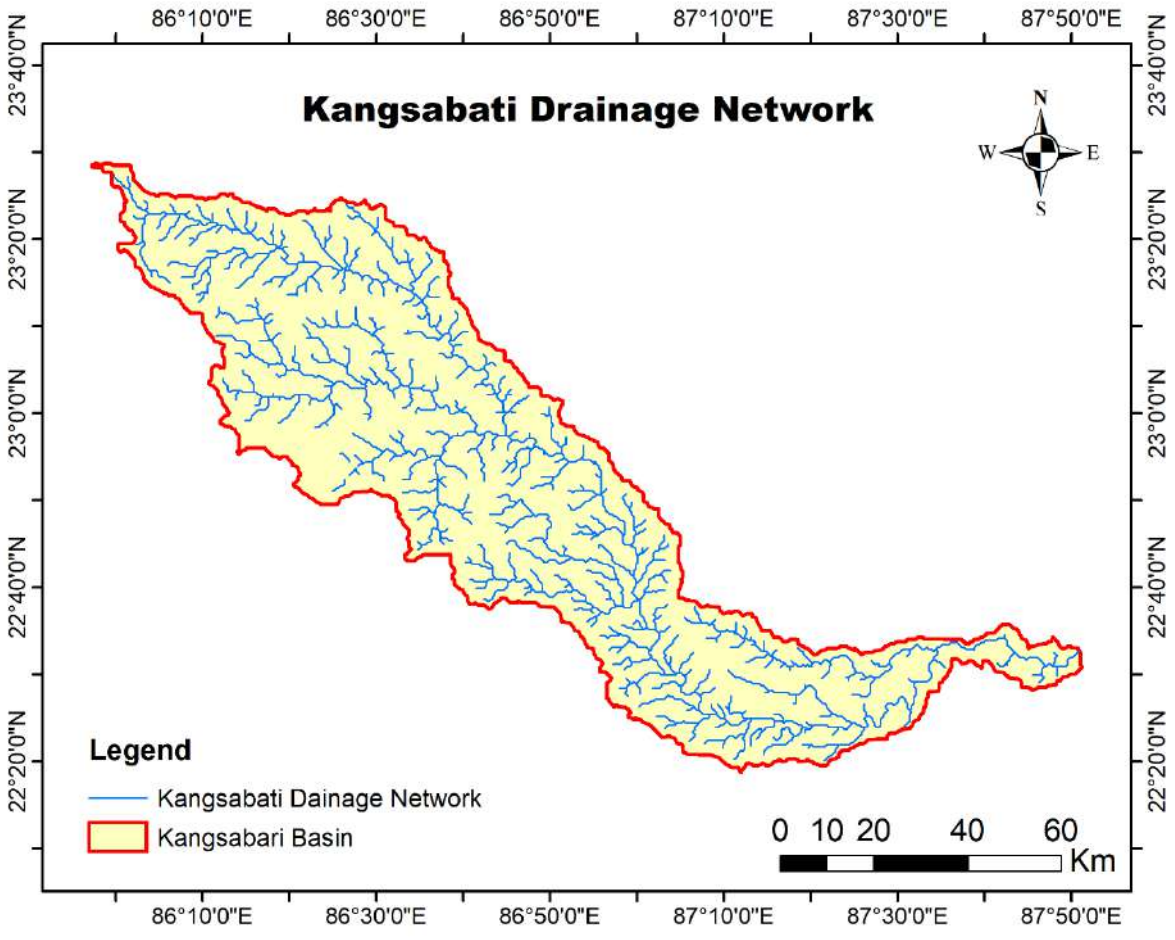

Fig. 6.1: Drainage network in Kangsabati River Basin

6.2 Stream Order (Nμ):

Stream order (Nμ) treated as the first step of drainage analysis based on the hierarchical ranking of streams. Strahler (1964) invented ordering method has been selected for the present study. According to Strahler (1964), the smallest fingerprint tributaries numbered as 1st order. The 2nd order of stream forms where two 1st-order streams join. A 3rd-order stream forms when two 2nd-order streams join and so on. The main channel through which most of water discharged marked as highest order stream of any particular drainage basin.

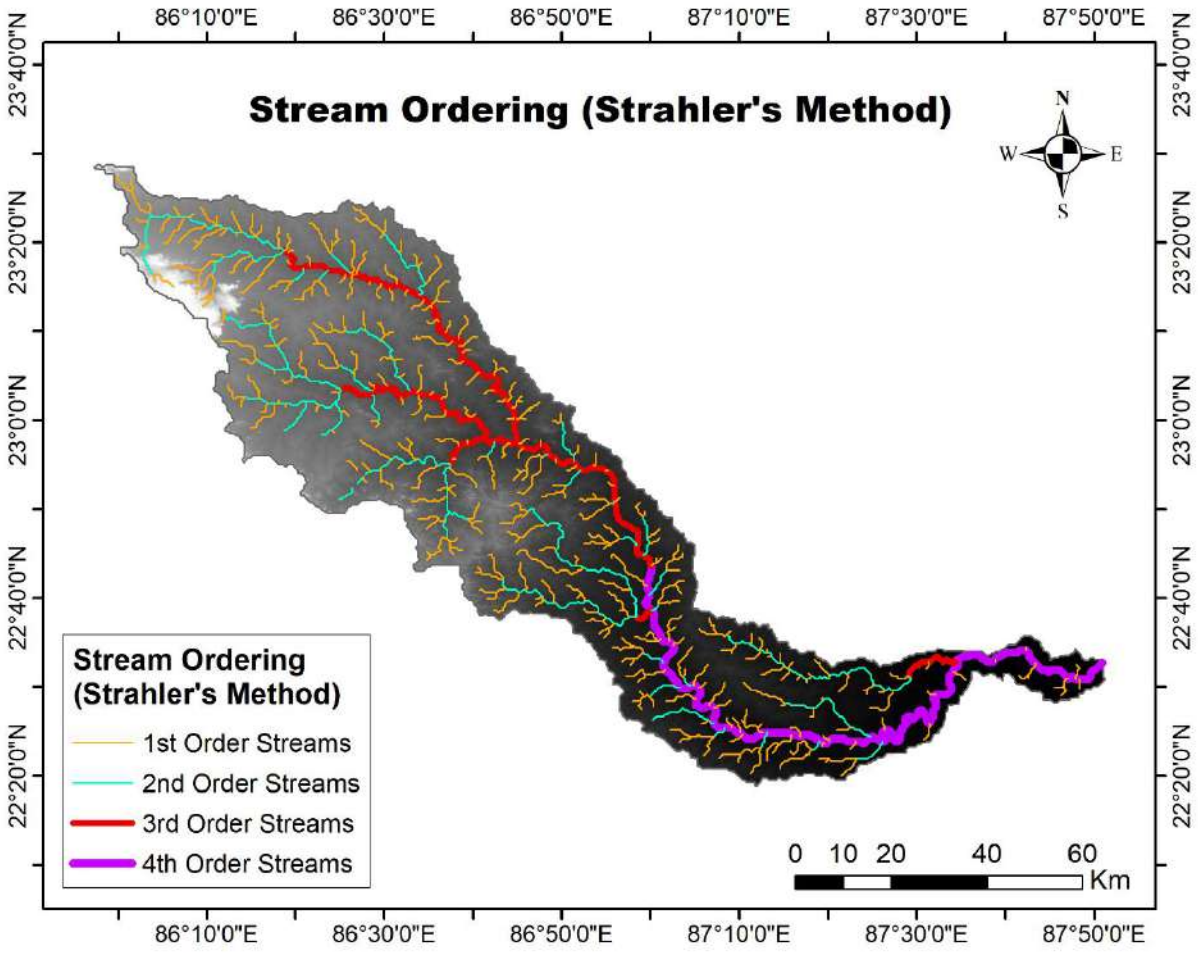

Fig. 6.2: Stream ordering in Kangsabati River Basin (Strahler's method)

The Kangsabati basin has a total 639 number of streams of which 382, 141, 74, number of streams belongs to 1st, 2nd, 3rd and 4th order respectively.

The consistent decrease in number of streams in relation to stream order throughout the basin indicates the dominance of erosional landform throughout the basin. The lower number of streams in 1st, 2nd and 3rd order indicates its mature topography adjacent to the stream concerned. Higher order streams (4th) are less in number due to their alluvial deposited plain course. The lower number of streams in the upper reaches and a consistent number of streams throughout the basin indicates its lower water regimes and water stress condition.

6.3 Bifurcation ratio (Rb):

The bifurcation ratio (Rb) expresses the ratio of the number of streams of a given order (u) to its next higher order (u+1) (Horton 1945). Strahler (1952) indicates that without strong controls of geological formation, the Rb shows only small variation in different regions. It is considered an important parameter, denoting the water-carrying capacity and related food potentiality of any basin. The value normally ranges from 2 to 5.Studies identified high Rb values in the mountain–plain areas than plateau–plain fringe areas of tropical environments due to their young morphological adjustment and high water pressure.

The Rb values ofthe Kangsabati river basin are 2.71 for 1st to 2nd, 1.90 for 2nd to 3rd, and 1.76 for 3rd to 4^{th}.The consistency of Rb values throughout the basin and the low average bifurcation ratio are indicative of mature geomorphological adjustment. Low mean Rb is also indicative of water stress conditions for river basins. A constant decrease of Rb throughout the different stream order as well as a low mean Rb 2.12 indicates low food potentiality for the basin.

CONCLUSION AND MAJOR FINDINGS

In the present study, some morphometric, hydrological, and anthropogenic parameters have been studied in the KangsabatiRiver basin. Morphometric parameters include absolute relief, relative relief, contour spacing, and contour pattern. The hydrological analysis comprises flow direction, flow accumulation, identification of stream network, stream order, and bifurcation ratio.

- The north-western part of the river basin has a higher altitude in comparison to the central and southeastern parts of the river basin.
- The absolute elevation of the study region is between 87.0 to 368 meters.The elevation of less than 87 meters in the south-eastern part and the north-western part of the map reflects a higher elevation which is about more than 368 meters. Central and Eastern parts reflect moderate elevation ranging between 169-236m. Height is found to be decreasing from the northwestern part to the southeastern.

- Contour analysis with 100m intervals reveals. A number of contours are less in a southeast direction. Contours are closely spaced in the northwestern part of the Kangsabati River. Therefore, the gradient is very high towards the north-western. Based on the number of contours and contour interval an isopleth-cum-choropleth map has been prepared as presented above. The map reflects six zones and in this river basin highest elevation is more than 500m in the north-western part.

- In the basin up to 4^{th}order streams are found. The Kangsabati basin has a total 639 number of streams. The 382 is the first order stream, 141 is the 2^{nd} order stream and 74 is the 3^{rd} order stream and 4^{th} order stream respectively.

- The Rb value of the Kangsabati River basin is 2.12 which indicate low flood potentiality for the basin.

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