THE UNIVERSITY OF BURDWAN

SEMESTER V HONOURS (CBCS)

COURSE: - FIELD WORK (CC 11)

FIELD REPORT

ON

PROBLEM OF FLOOD IN KOPAI RIVER BASIN WITH SPECIAL REFERENCE TO SOCIO-ECONOMIC CONDITION OF PEOPLE: A CASE STUDY OF BIDYADHARPUR AND BANDHLODANGA MOUZA OF SRINIKETAN C.D. BLOCK IN BOLPUR

COLLEGE : KHALISANI MAHAVIDYALAYA (408)

KHALISANI, CHANDANNAGAR

HOOGHLY 712138

2022

CONTENT

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RE-ACCREDITED – B++, CGPA – 2.77

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Date: - 18.01.2023

To Whom It May Concern

This is to certify that Sri/Smt…… of 5th Semester Geography Honour of Khalisani Mahavidyalaya bearing Roll No…… has undertaken compulsory field work at Bidyadharpur and Bandhlodanga Mouza, District Birbhum, West Bengal on 10.11.2022 as a part of CC 11 (Research Methodology and Field Work) paper for the fulfilment of UG syllabus for B.A Honours course in Geography under CBCS of The University of Burdwan. He/She is submitting herewith, the report pertaining to the said field work.

…….

Dr. Kundan Kumar Das
Assistant Professor
HOD, Dept. of Geography
Khalisani Mahavidyalaya

PREFACE

A field study programme has been adopted by the Department of Geography, Khalisani Mahavidyalaya to prepare a Field Report on Flood Problem in Kopai River with both physical and cultural aspects as part of syllabus of B.A Honours course in Geography under CBCS of The University of Burdwan. For this we went to Bidyadharpur and Bandhlodanga Mouza of Sriniketan C.D. Block in Bolpur Sub-division of Bibhum district on 10.11.2022 and prepared the report entitled "PROBLEM OF FLOOD IN KOPAI RIVER BASIN WITH SPECIAL REFERENCE TO SOCIO-ECONOMIC CONDITION OF PEOPLE: A CASE STUDY OF BIDYADHARPUR AND BANDHLODANGA MOUZA OF SRINIKETAN C.D. BLOCK IN BOLPUR".

We prepared the report under the active supervision of our respected teacher Dr. Kundan Kumar Das. The report depicts the concise account of Flood problem in River Kopai of aforesaid mouzas and its socio-economic status with the help of primary and secondary collected from different sources and using maps, diagrams as well as several relevant photographs taken by us during our field survey.

ACKNOWLEDGEMENT

The completion of this work fills me with a sense of satisfaction and fulfilment and for that I am thankful to the Almighty. For completion of our field report on Bidyadharpur and Bandhlodanga mouzas, we are greatly indebted to our respected teacher Dr. Kundan Kumar Das for his careful guidance during our field survey and the preparation of field report later on. We would like to thank him for their unequivocal & intellectual guidance, invaluable & unconditional support, encouragement, creative suggestions and parental attitude throughout our work which enabled us to think in a proper direction and complete this work in a consolidated manner. We also expressed our gratitude to our Teacher-In-Charge for importing his kind permission to our field survey and allowing us to use Prismatic Compass, Dumpy Level instrument and GPS available in the Department of Geography.

Survey Team of 5th Semester Honours

INTRODUCTION:-

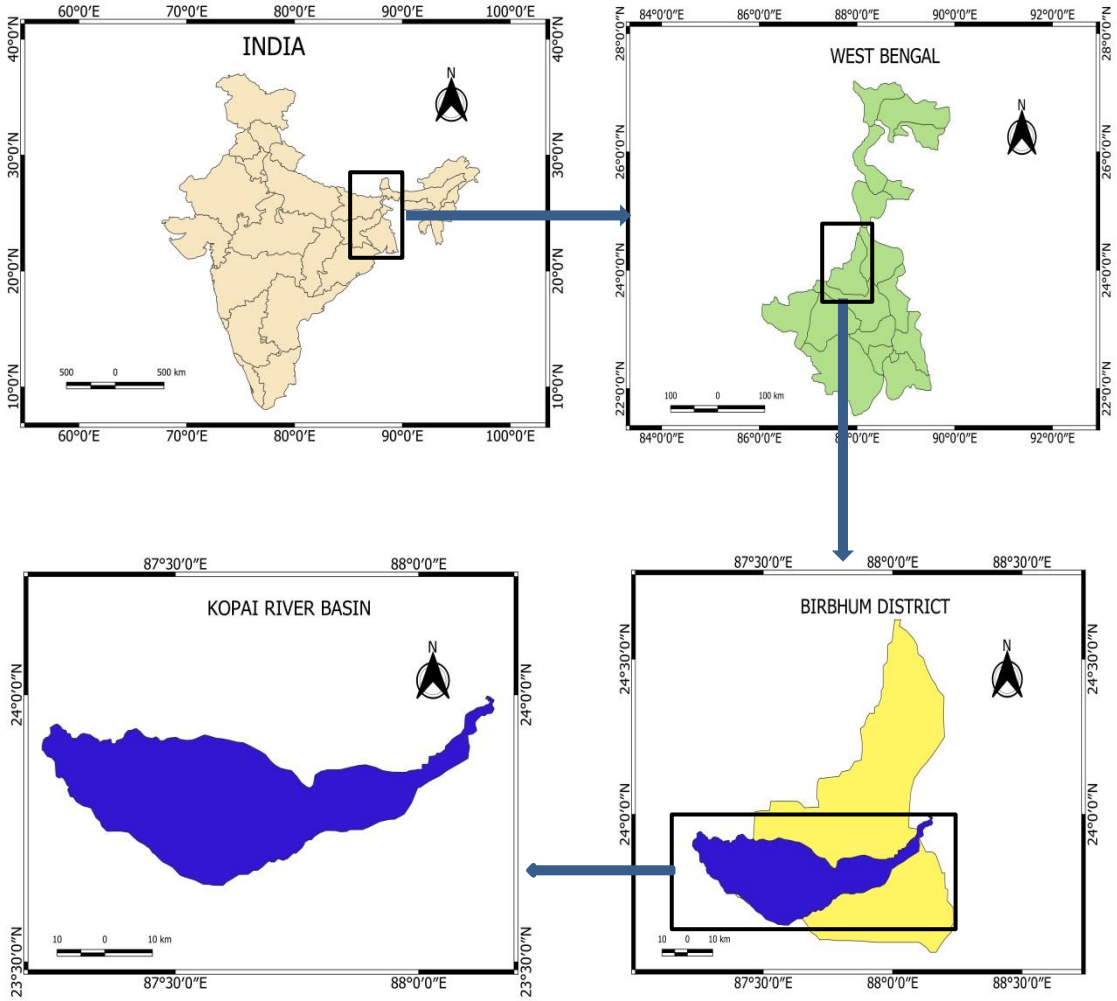
The current study has been designed for Kopai river basin, which mostly belongs to West Bengal and a little part of Jharkhand state of India. Kopai, as the main tributary of Mayurakshi river, originates in the Jamtara district of Jharkhand and flows toward south-east and joins with Bakreswar river in Labpur block of Birbhum district then flows toward east and joins with Mayurakshi river in Talgram village of Murshidabad district of West Bengal. Kopai river basin extends from 23° 37′ 55″ N to 23° 56′ 45″ N latitude and 87° 16′ 53″ E to 88° 4′ 42″ E longitude with 1714.099 sq. km. area. Total length of the river is 176.4 km.

LOCATION:-

Bidyadharpur and Bandhlodanga mouza are situated in Sriniketan C.D.Block, Bolpur –Shantiniketan in Birbhum district. River Kopai is flowing from west to east in the Southern boundary of Bidyadharpur mouza.

ACCESSIBILITY:-

Bidyadharpur and Bandhlodanga are accessible by road from Bolpur station. It is a journey of nearly 45 minutes from Bolpur railway station. One has to get down at Bolpur station and has to take shared toto to reach the destination



Location of Study Area

AIMS AND OBJECTIVES:-

1. To study the physical environment in study area with special reference to morphometric analysis of river Kopai.
2. To analyse the socio-economic condition of people living around river Kopai.
3. To examine the frequency of flood occurrence in Kopai river, its reasons and effects on local people.

METHODOLOGY:-

1. **Pre-Field Session**:- It was the period during which basic information on Kopai river, its basin and its surroundings have been collected e.g. Topographical map no $73\frac{M}{1}$, Cadastral map of Bidyadharpur and Bandhlodanga mouza (C.D Block:-Sriniketan, Dist: Birbhum, Scale – 16 inches to 1 mile, R.F. 1:3960), Google Earth,Reasearch papers, Journals, Articles, Books etc. have been procured and consulted. Two different sets of questionnaires have been prepared for physiographic survey and socio-economic survey. Worksheets for prismatic compass survey and Dumpy level survey have also been prepared beforehand.

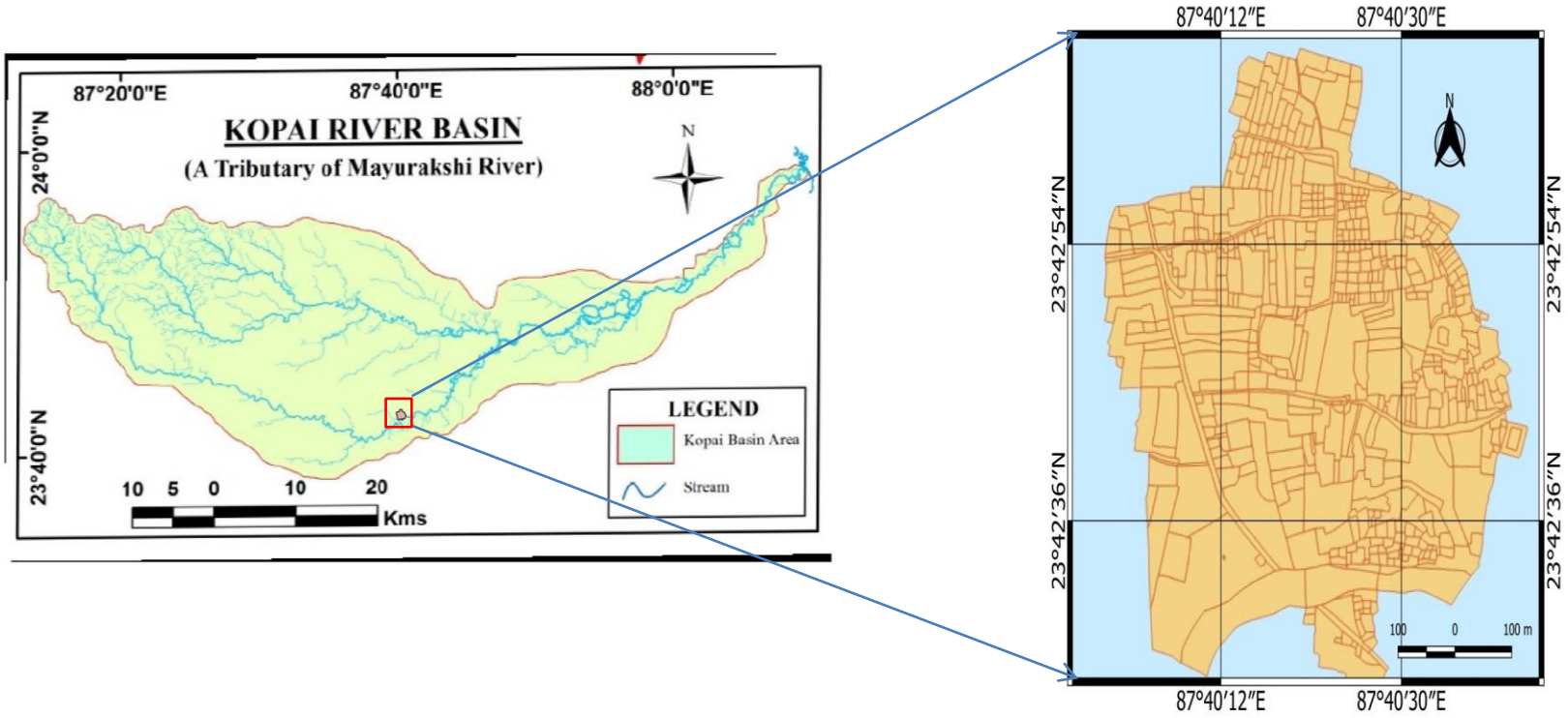
2. **Field Session: -** The field works of Kopai river basin at Bidyadharpur and Bandhlodanga was undertaken on 10.11.2022 and it was conducted taking all the precaution and safety measures due to the outbreak of Covid 19 pandemic. The field area was traversed on foot and different physiological survey was conducted using Prismatic compass, Dumpy level, GPS and other survey instruments. Soil sample has also been collected. Rough Land Use Land Cover map has been prepared using plot to plot survey. Primary data have been collected on the basis of questionnaires through door to door survey.

3. **Post-Field Session: -** The results of questionnaire survey were compiled, physical and socio-economic maps have been prepared using different cartographic methods. Excel is being used to prepare Diagrams and hand drawn maps have been prepared with suitable scale and latitude and longitude.

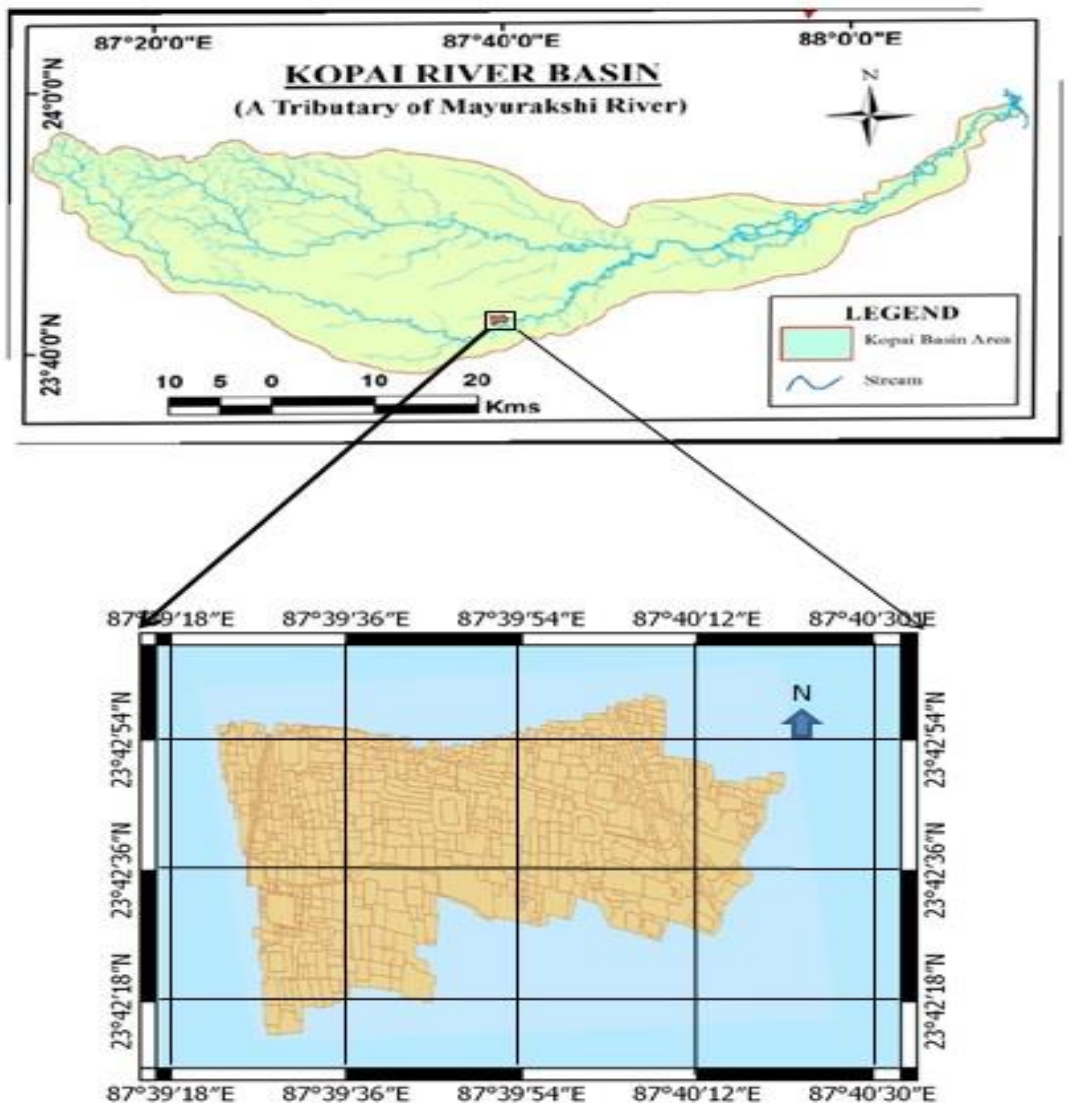
Data Base:-

1. **Primary Sources**:-
   a. Door to Door household survey
   b. Plot to plot landuse survey
   c. Survey using Dumpy and Prismatic Compass
2. **Secondary Sources**:-
   a. Topographical map no $73\frac{M}{1}$
   b. Cadastral map of Bidyadharpur and Bandhlodanga mouza (C.D Block:-Sriniketan, Dist: Birbhum, Scale – 16 inches to 1 mile, R.F. 1:3960)
   c. District Census Handbook, Birbhum, Census of India
   d. Satellite Images and Arial Photographs, Google Earth etc.

Type of Data	Publisher	Map no.	Spatial Coverage	Survey year	Scale
Topographical Maps	Survey of India	73M/1, 73M/5, 73M/6, 73M/9, 73M/10, 73M/13, 73M/14, & 79A/1	Kundahit, Birbhum, Burdwan and Murshidabad Districts	2005-06	1:50,000



BIDYDHARPUR MOUZA MAP



BANDHLODANGA MOUZA MAP

Physical Aspects:-

Relief Attributes-

Relief attributes of a drainage basin has three dimensional features involving area, volume and vertical dimension of landform, therefore different morphometric methods have been applied to analyze for understanding Kopai river basin relief features.

Absolute Relief

Absolute relief has been calculated by classifying the Digital Elevation Model (DEM) of Kopai river basin. The highest relief is identified in the north western part of the basin and it gradually decreases toward the north east corner of the basin area. The north western part of the basin belongs to the plateau region whereas the north eastern part is under the Ganges delta.

Relative Relief

Relative relief is the difference between the maximum and minimum elevation. It is the essential parameter to determine the denudation features of the drainage basin. A small division of north western part of the basin shows high relative relief, whereas the eastern part confirms the lowest relative relief. Thus, it is evident that the variation of denudational characteristics with the increasing relative relief and higher stream gradient decreases the time of concentration of runoff.

Average Relief

Average relief determines the grid-specific mean relief and therefore the average relief map of Kopai river basin has been prepared. The average relief is gradually decreasing toward east probably due to different tectonic activity, dissimilar formation and diverse erosional and depositional process of the river basin.

Dissection Index

It is the comparative ratio of relative relief to the absolute relief. It is an important morphometric parameter for the understanding of magnitude of the dissection of terrain. Dissection index is also useful to explain the stages of the cycle of erosion. The calculated value of dissection index of Kopai river basin shows that most part of the basin largely belongs in the matured stage.

Drainage Attributes-

Stream Order

Stream order refers to the determination of the hierarchical position of streams within a drainage basin. To find out the stream order, Strahler's method is applied in the present study and it is established that Kopai river basin has fifth order stream networks.

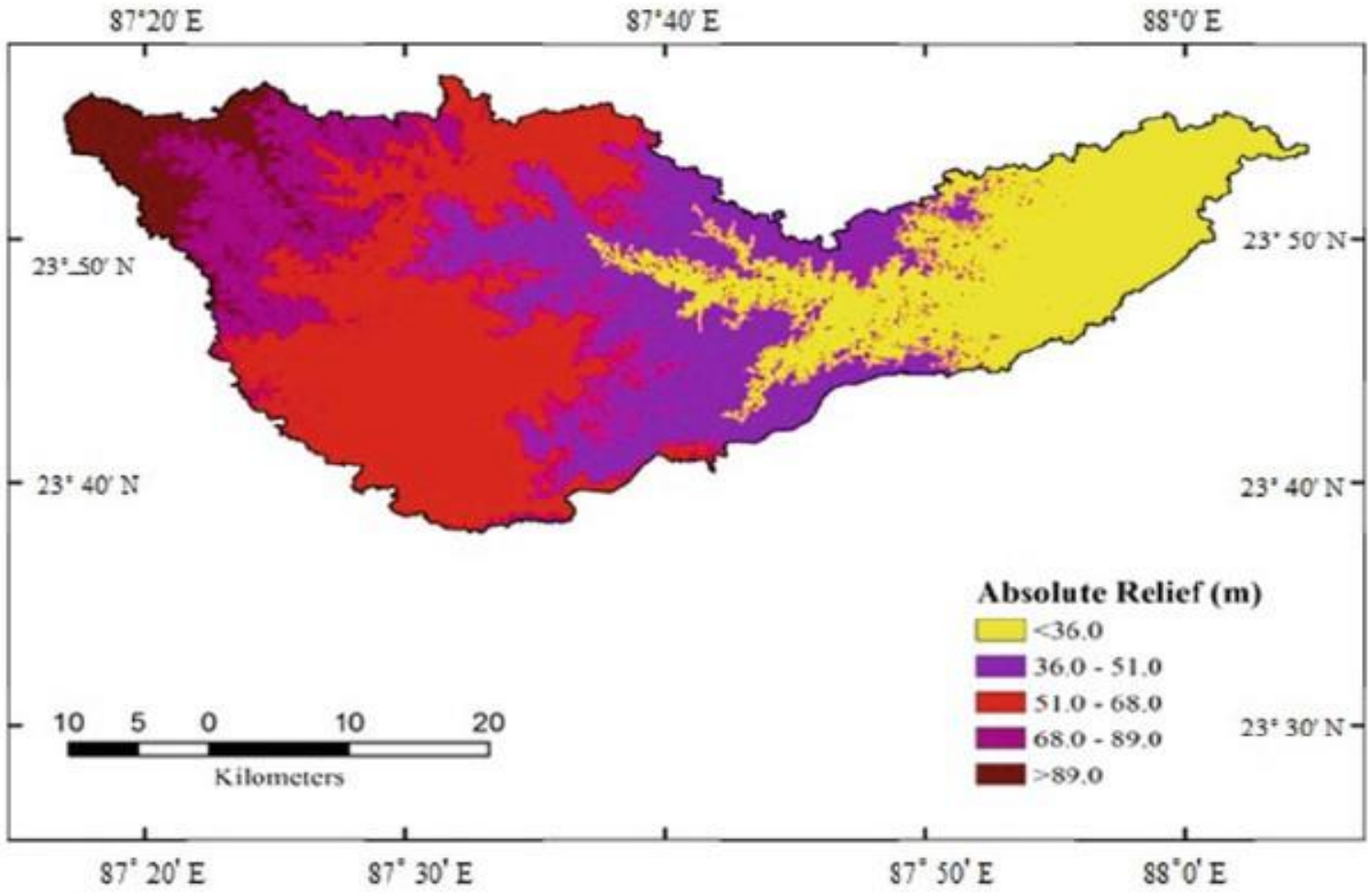


Fig. 11.1 Absolute relief map of Kopai river basin

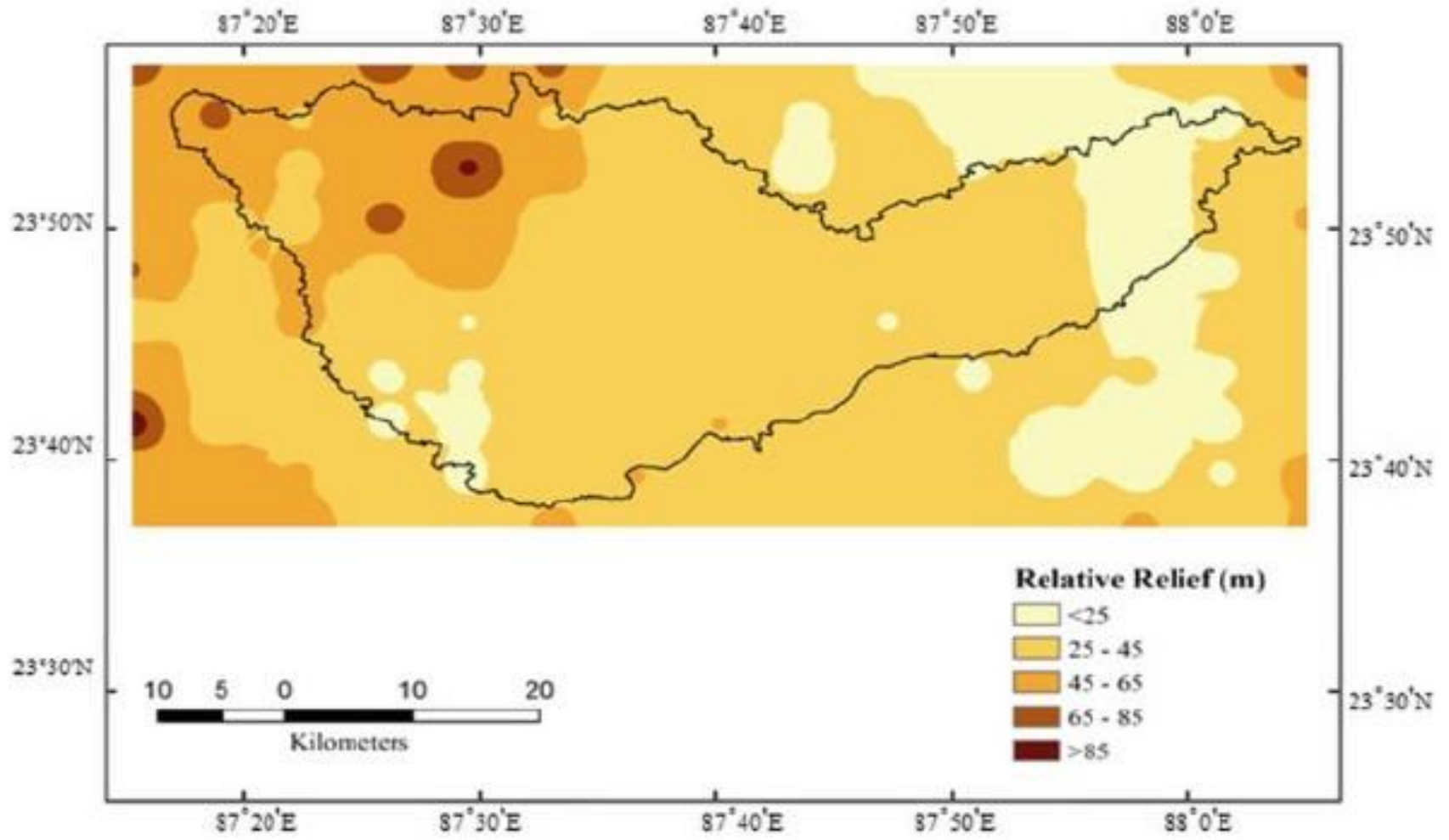


Fig. 11.2 Relative relief map of Kopai river basin

Stream Number

The total number of streams of each order in the basin is called stream number and as per the calculation, Kopai river basin has a total of 938 stream segments of which 472 are 1st order, 225 are 2nd order, 119 are 3rd order, 95 are 4th order and 27 are 5th order streams. This huge figure of different streams has a tremendous influence in shaping the morphometry and geo-hydrological personality of the basin area.

Stream Length

The total stream length of Kopai river basin has been calculated and categorized according to the stream orders. Total stream length and mean stream length of Kopai river basin are 1423.0812 km and 1.5171 km, respectively. In particular, first order stream has larger length with 758.452 km, followed by 349.473 km 2^{nd} order, 165.861 km 3rd order,113.850 km 4^{th} order and 35.4452 km 5th order stream length. These small streams exert a critical influence on downstream portions of the drainage network of the study basin.

Bifurcation Ratio

It is the ratio between the number of streams of one order and the number of streams of the next higher order (Horton 1945; Strahler 1952). Thus the bifurcation ratio is an index of relief and dissection and is often considered as a measure of the level of the upshot of drainage system, which has a strong control above the runoff (Chorley 1969; Chorley et al. 1957; Mesa 2006). Therefore, the bifurcation ratio of Kopai river basin has been calculated and the value ranges from 1.25 to 3.51 with mean bifurcation ratio 2.19. Moreover, the highest bifurcation ratio is found in between 4th and 5th order stream and lowest bifurcation ratio is found in between 3^{rd} and 4th order stream. The study also reveals that Kopai river basin is principally near elongated in shape which indicates moderate probability of flood considering its circular shape in the upper basin and lower basin area is elongated shape.

Drainage Density

Drainage density is the ratio of total length of all streams and area of the basin and it has a very significant role on surface runoff, influencing the intensity of torrential floods. Therefore, in the current study, actual drainage density and grid specific drainage density (mean drainage density) are taken into consideration to explain the drainage basin. The middle and eastern portion of the basin demonstrates high drainage density and some parts of western and northern portion confirm lowest drainage density values due to physical properties of underlying rock, vegetation envelop and variable relief assets.

Ruggedness Index

Ruggedness index indicates surface roughness and unevenness of a region and expansively high ruggedness indicates elevated relief with high stream density (Melton 1965). Therefore, to analyze the morphometry of the study area, actual ruggedness index and mean ruggedness index have been calculated and mapped. The present study basin indicates comparatively lower relief, subsequently it denotes less surface roughness in general. In the mean ruggedness index map, the western part of the basin demonstrates comparatively high ruggedness index, which confirms the comparatively high relief and steep slope while the eastern part of the basin point toward low ruggedness index which indicates low relief, depositional surface and gentle slope.

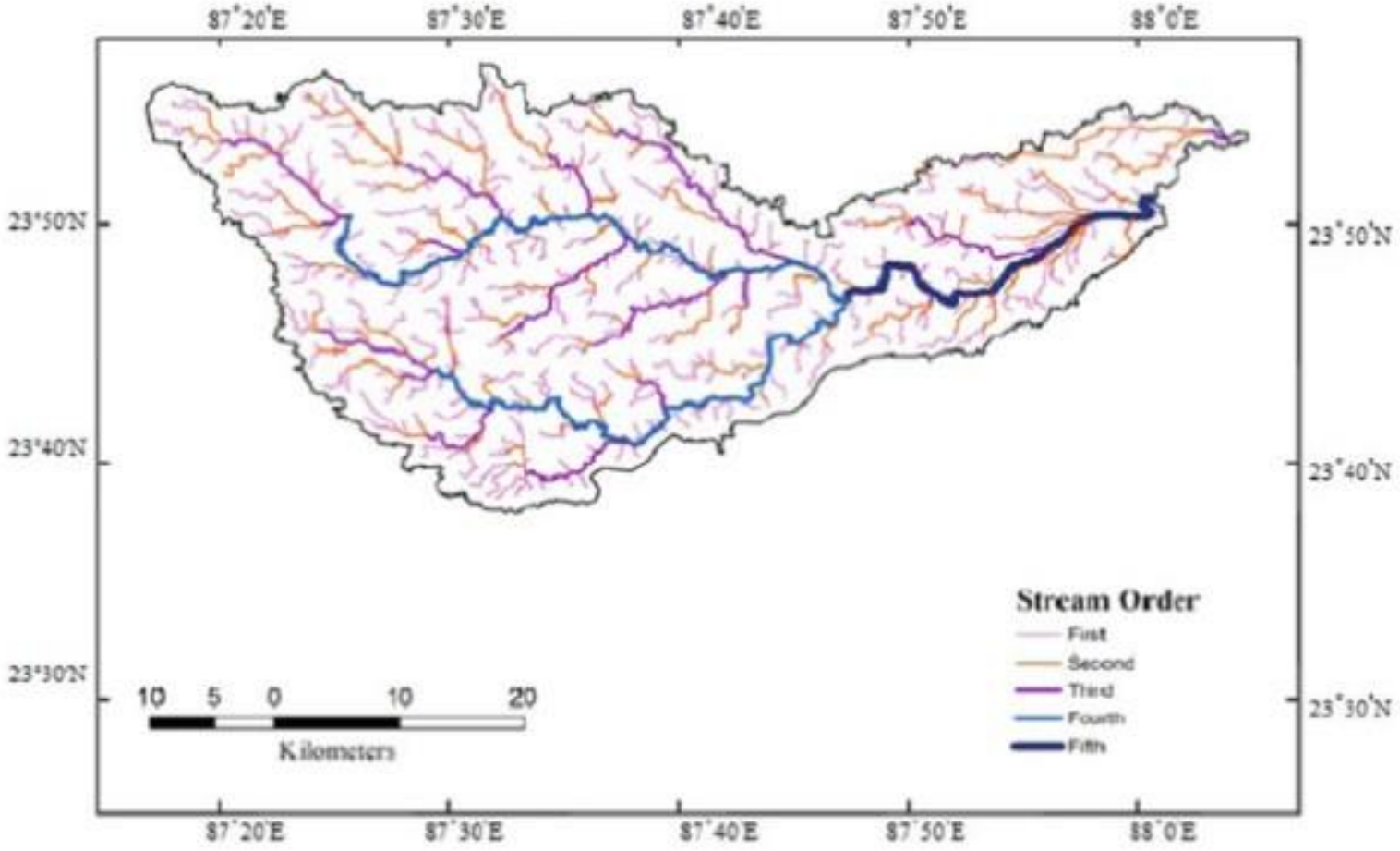


Fig. 11.8 Stream ordermapof Kopai river basin

Slope Attributes:-

Actual and Average Slope

To determine the slope characteristics, actual slope of the particular pixels of Kopai river basin has been calculated using the method of Wentworth. Moreover, the average slope of Kopai river basin has also been calculated by Wentworth's method. It is observed that the basin is mostly influenced by the erodibility therefore it is large slopping from north western to south eastern direction. Geologic upliftment, rock structure, erosional rate of fluvial process and valley deposition is the major causes of slope variation of Kopai river basin.

Slope Variability Index

Slope variability index shows the variability and stability of slope in each grid of the Kopai basin. As the basin is belonged to lower plateau and plain land region, consequently the region has less slope variability. Comparatively higher slope variability is observed in the eastern and middle part and lower value is perceived in the west middle part of the region. From the field visit and observations, it can be stated that this particular pattern of slope variability has probably come about due to dissimilar geologic rock formation, unlike rate of erosion and some anthropogenic gesture like deforestation, over-grazing, etc.

Slope Aspect

Slope aspect refers to the direction of slope to geographical north. This aspect analysis is an important parameter as it can easily influence the direction of river or stream and thereafter, it is taken into consideration to identify Kopai river basin morphometry. The aspect map affirms that the northern part of the basin confirms south direction of slope which compelled most of the streams of this region to flow toward south.

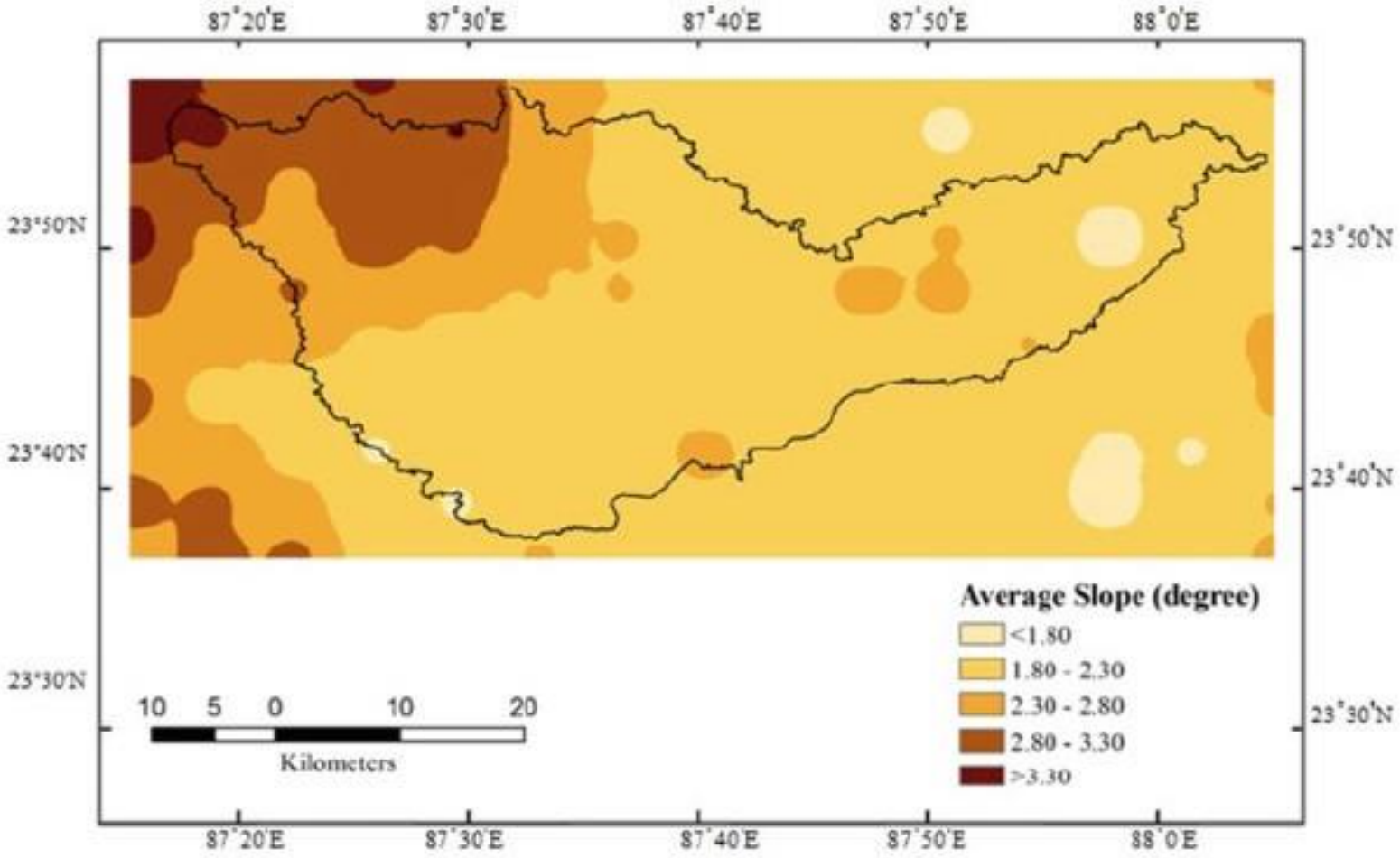


Fig. 11.5 Average slope map of Kopai river basin

Climate-

The climate of Shantiniketan is moderately warm, with summer temperatures at around 35-42 °C (maximum) and winter at 10-15 °C (minimum). Summer is felt for three months, March, April and May. December, January and February are the winter months. June, July, August and September see heavy rainfall, these four months are known as monsoon (rainy season).

Climate Type	Months
Scorching	April
Muggy	August, September, October
Transitional between Scorching & Muggy	May, June, July
Transitional between Scorching & Keen	January, February, March

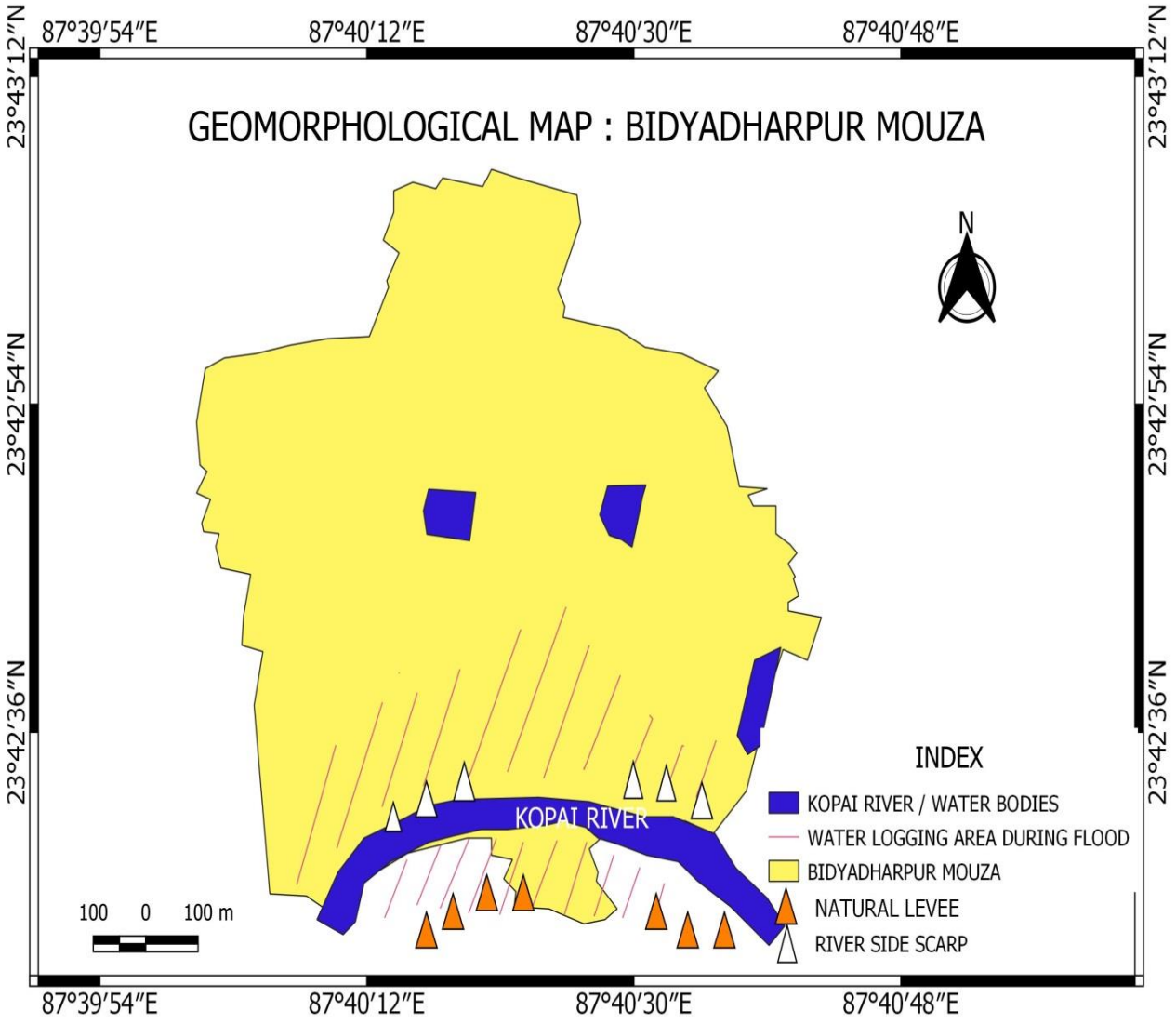
Topography:-

Prismatic and Dumpy level survey have been carried out on the right bank of river Kopai. The surveyed area comes under Bidyadharpur mouza. Dumpy level survey helps us to understand the topography of the surveyed area and helps to prepare contour map to measure the undulation of land surface.

Dumpy Level Survey on Right Bank of River 'Kopai'

Dumpy Level Survey on Right Bank of River ‘Kopai’

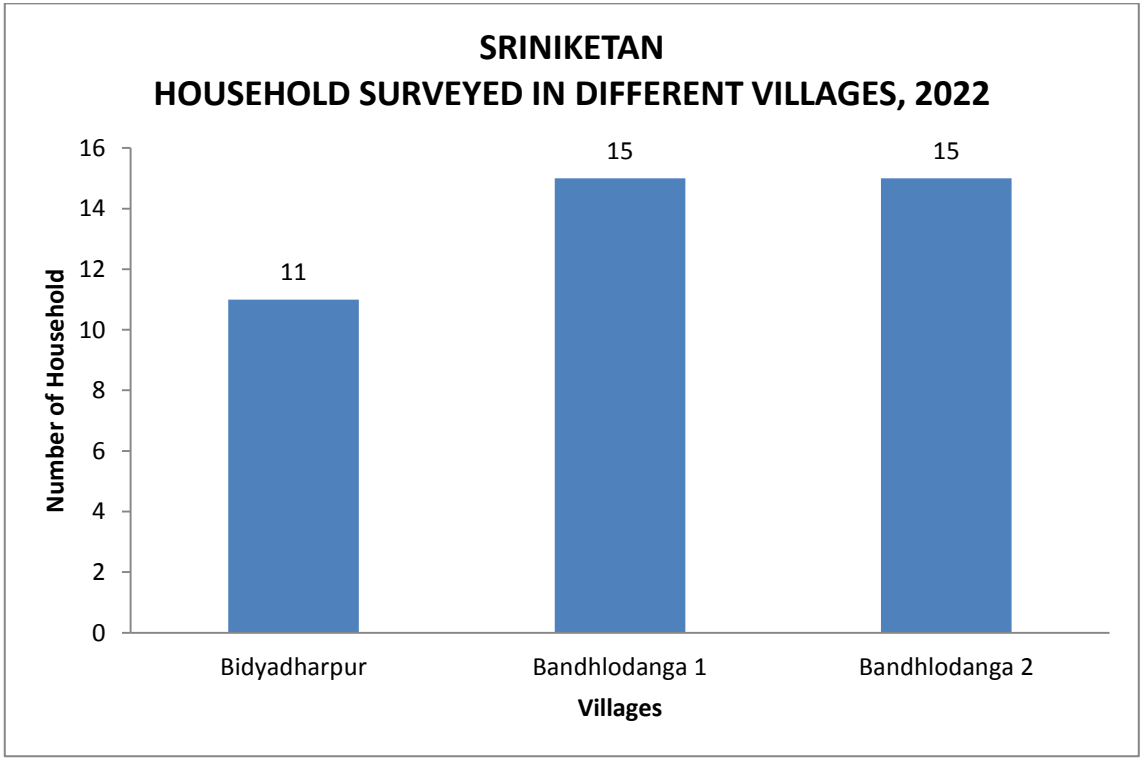
Prismatic Compass Survey on Right Bank of River ‘Kopai’

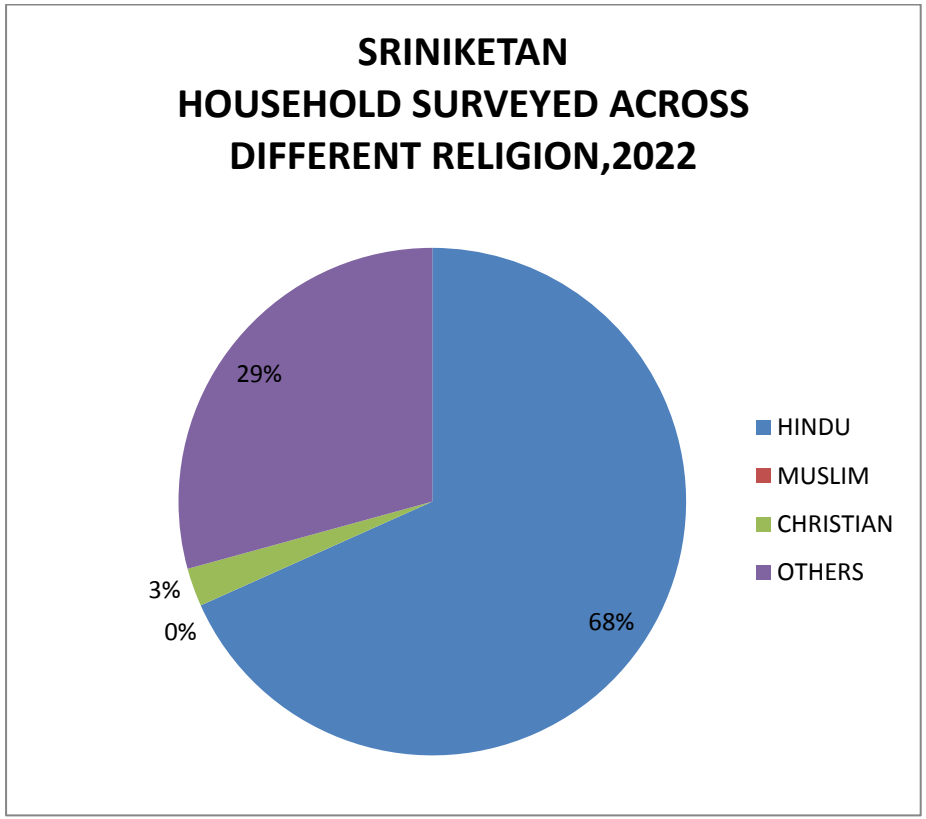

GEOMORPHOLOGICAL MAP : BIDYADHARPUR MOUZA
87°39′54″E
87°40′12″E
87°40′30″E
87°40′48″E
23°43′12″N
23°42′54″N
23°42′36″N
N
KOPAI RIVER
INDEX
KOPAI RIVER / WATER BODIES
WATER LOGGING AREA DURING FLOOD
BIDYADHARPUR MOUZA
NATURAL LEVEE
RIVER SIDE SCARP
100 0 100 m

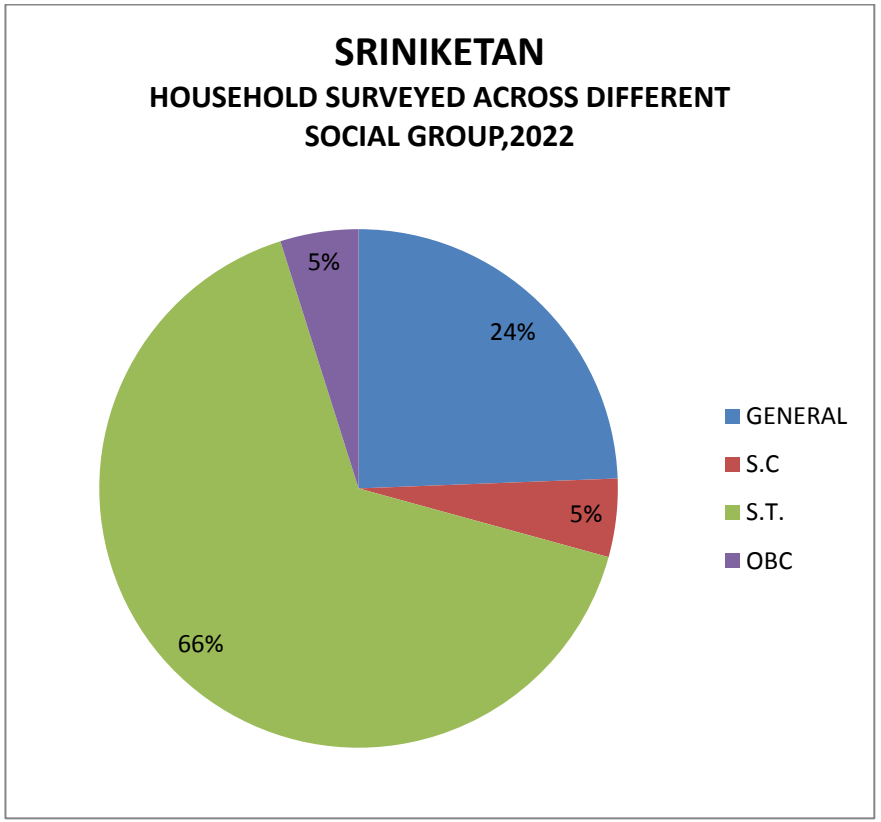
Socio-Economic Aspects:-

Household Survey-

Total 41 number of Households have been surveyed across three different villages which are Bidyadharpur, Bandhlodanga 1 and Bandhlodanga 2. Hindus (68%) are in majority followed by others (29%) and Christian (3%) across different households surveyed. Whereas according to our survey majority of population are S.Ts (66%) followed by General (24%), S.Cs and OBCs (both 5%).

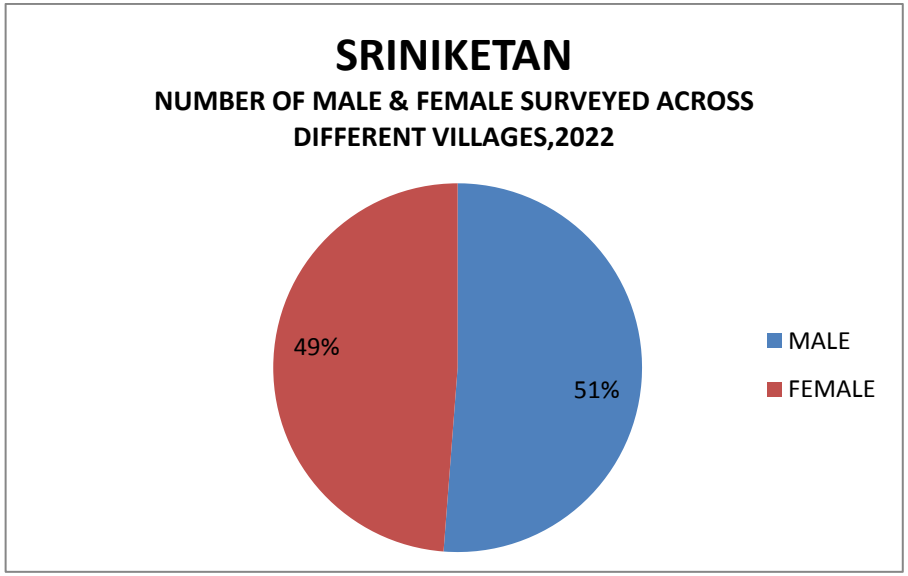


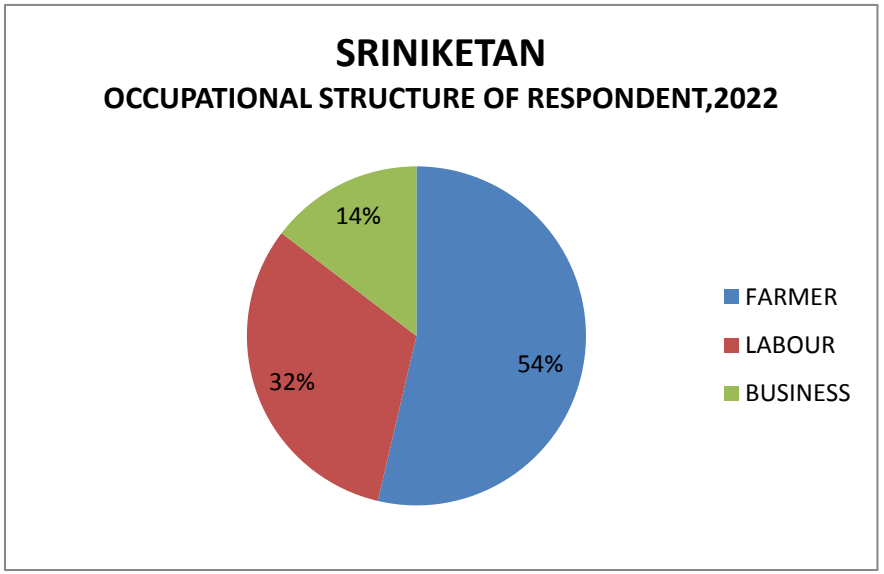

SRINIKETAN
HOUSEHOLD SURVEYED ACROSS DIFFERENT RELIGION,2022
29%
3%
0%
68%
HINDU
MUSLIM
CHRISTIAN
OTHERS


SRINIKETAN
HOUSEHOLD SURVEYED ACROSS DIFFERENT SOCIAL GROUP,2022
5%
24%
5%
66%
GENERAL
S.C
S.T.
OBC

Male Female Population-

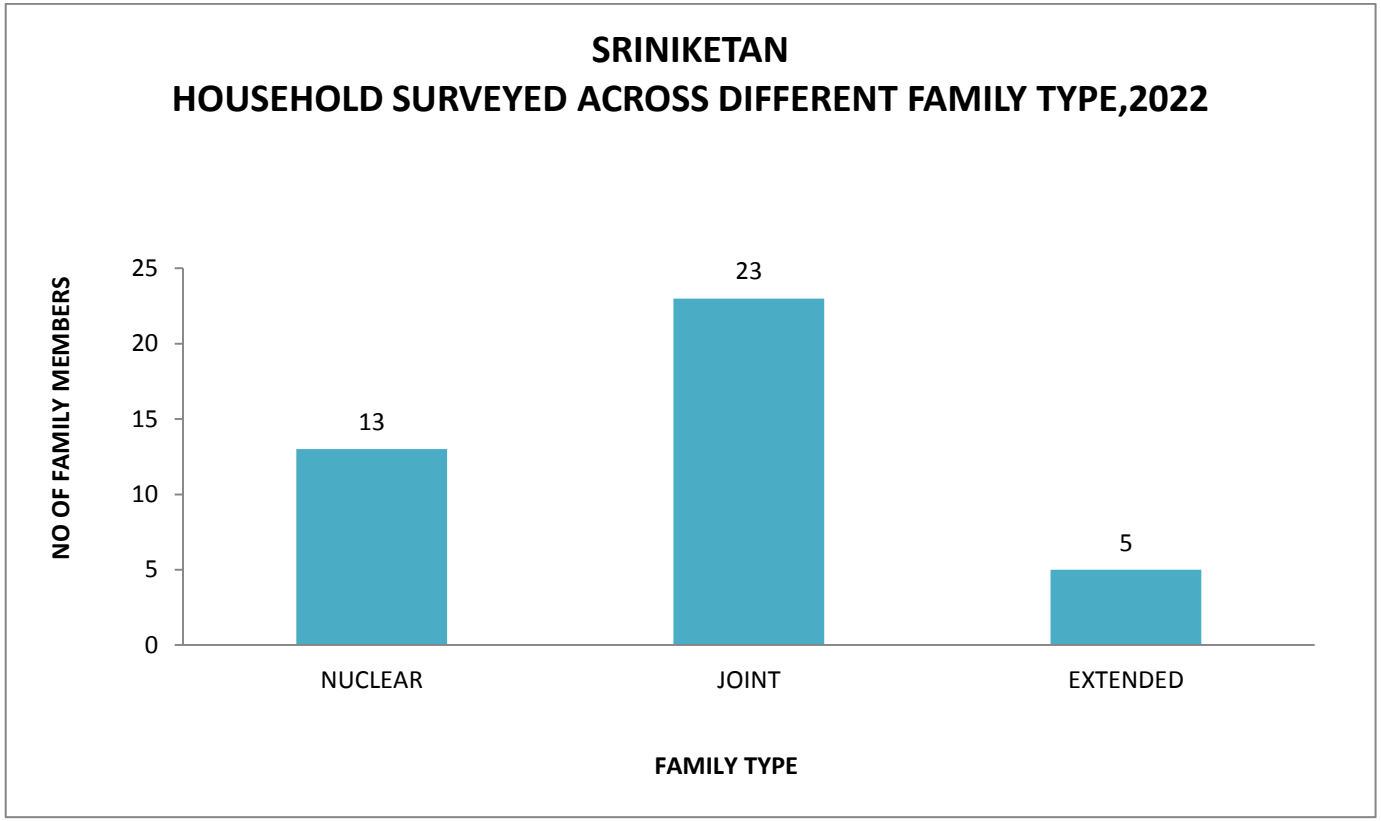
Among total 41 households surveyed, 21 respondents are male and rest 20 respondents are female.



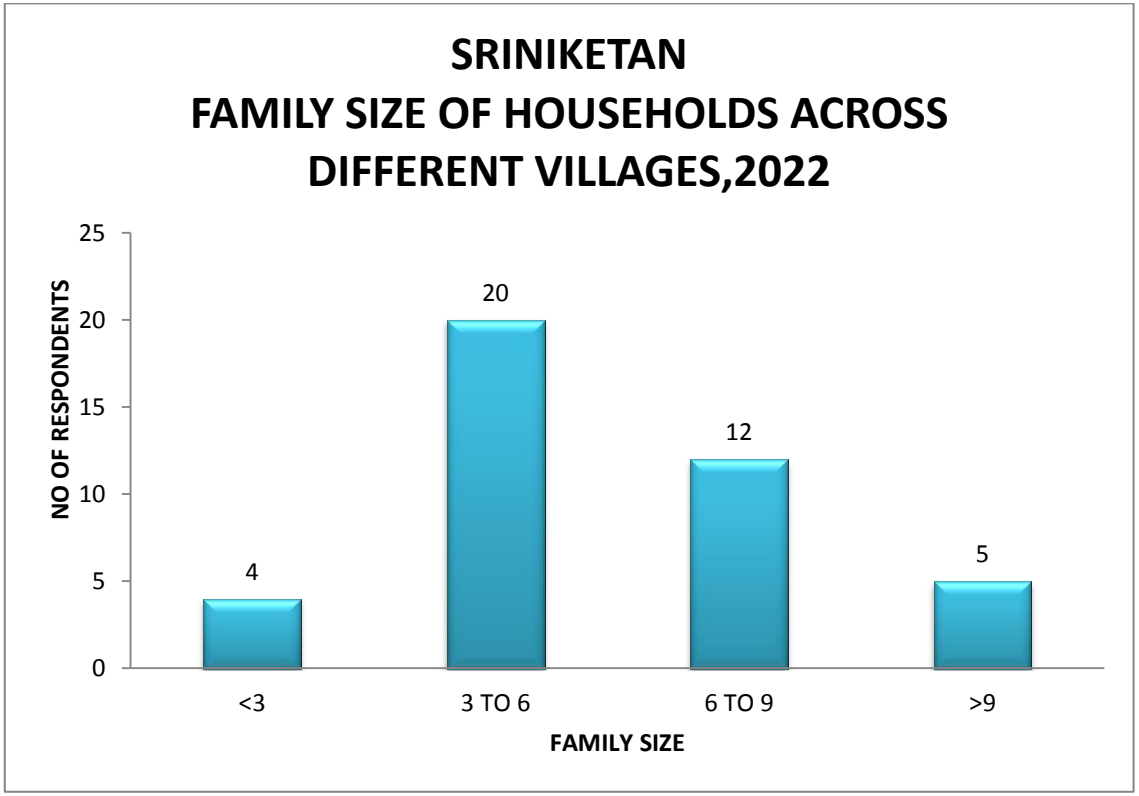


Occupation:- According to our survey most of the respondents are farmers (54%) followed by labourers (32%) and business person (14%) in three villages of Sriniketan taluk.

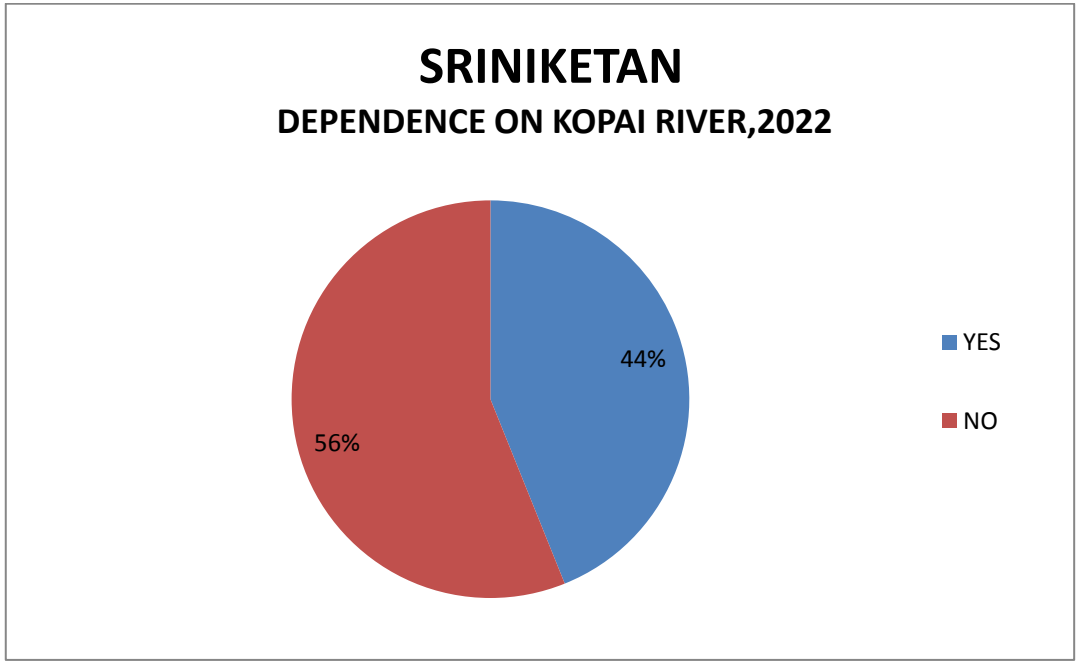
Family Type:- According to our survey more than 50% of households in Sriniketan having joint family. 13 households are recorded to have nuclear family and very less number of households is having extended family.



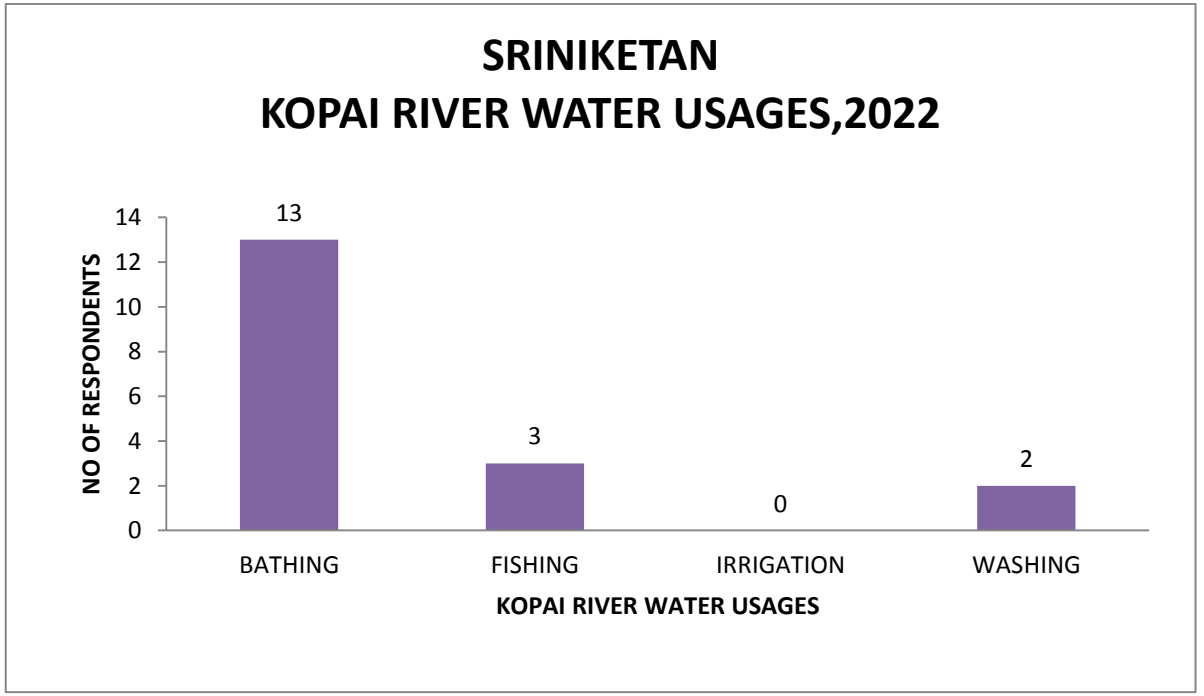
Family Size:- Most of the households (20 households) having family size 3 to 6 persons , 12 households having family size 6 to 9 persons, 5 households having famiy size more than 9 persons and only 4 households having family size less than 3 persons.



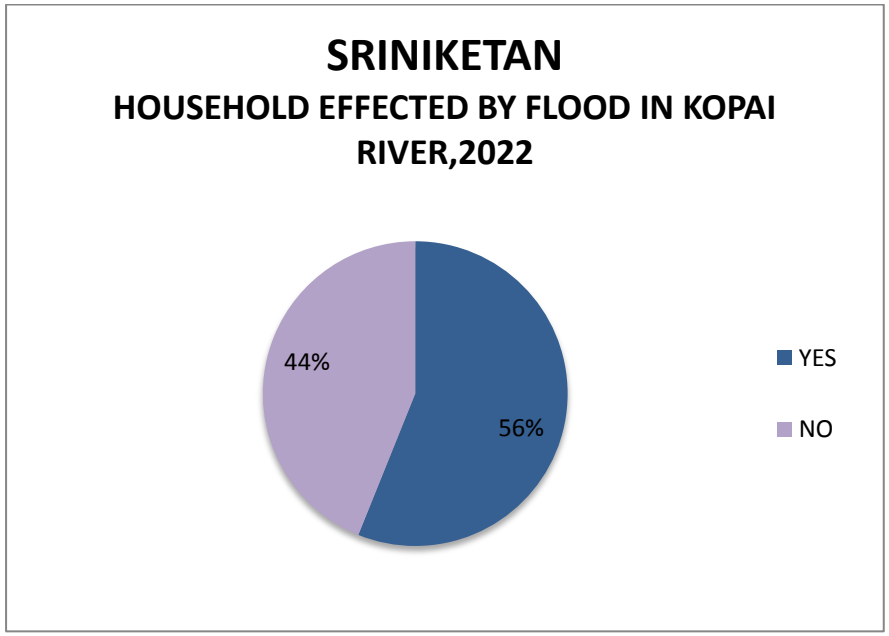
Dependency on Kopai River: - 44 % of surveyed households are depended on river Kopai to meet the requirement of water to use for their daily life. Whereas, 56% of surveyed households do not depend on river Kopai to meet the daily requirement of water.

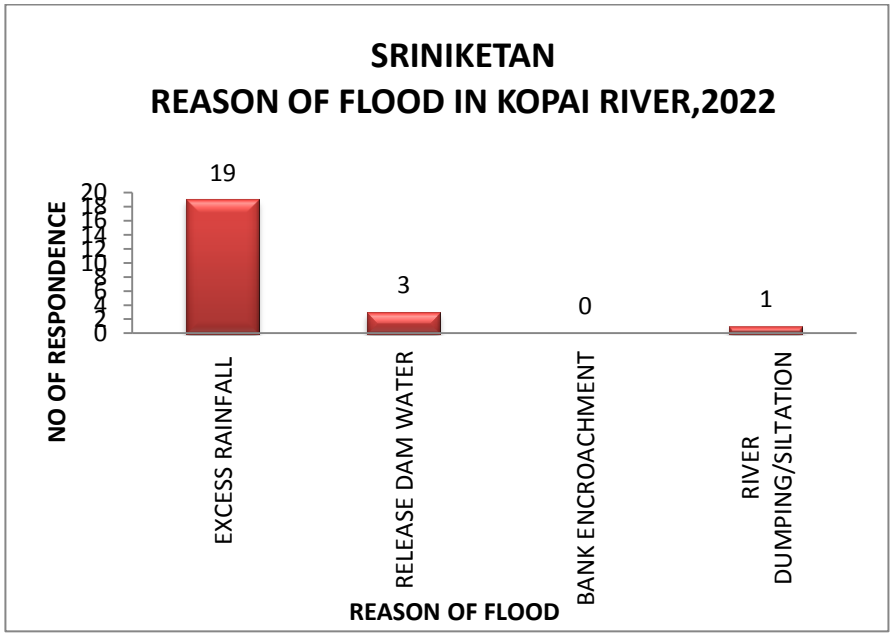


Water usages of river Koapi: - Out of 18 households which are dependent on river Kopai, 13 households use the water of river Kopai for the bathing purpose, 3 households use the water of Kopai for fishing and rest of 2 households use water of Kopai for washing purpose.



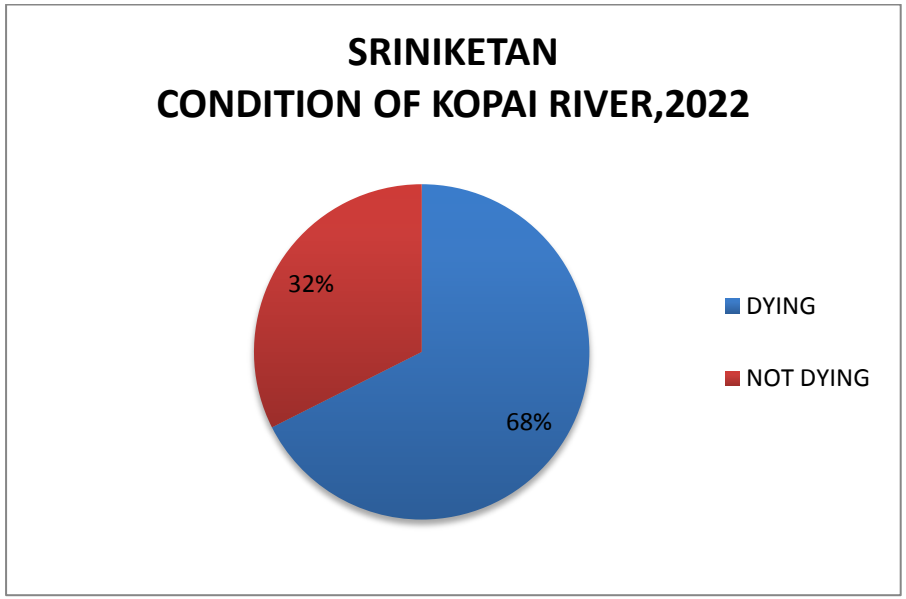
Flood in Kopai: - 56% of surveyed households are affected by recent flood happened in river Kopai. Rest 44% households are not directly affected by the recent flood happened in river Kopai.

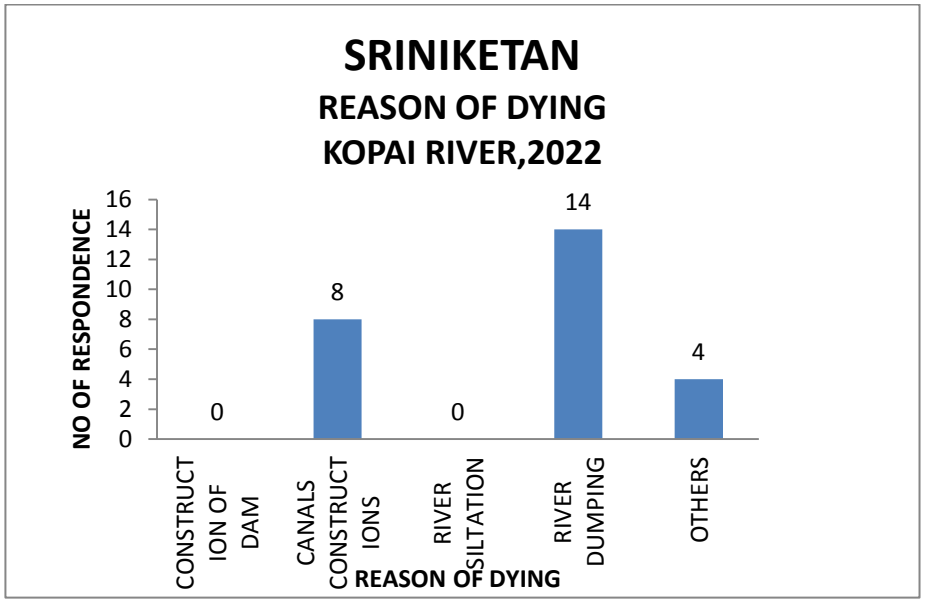




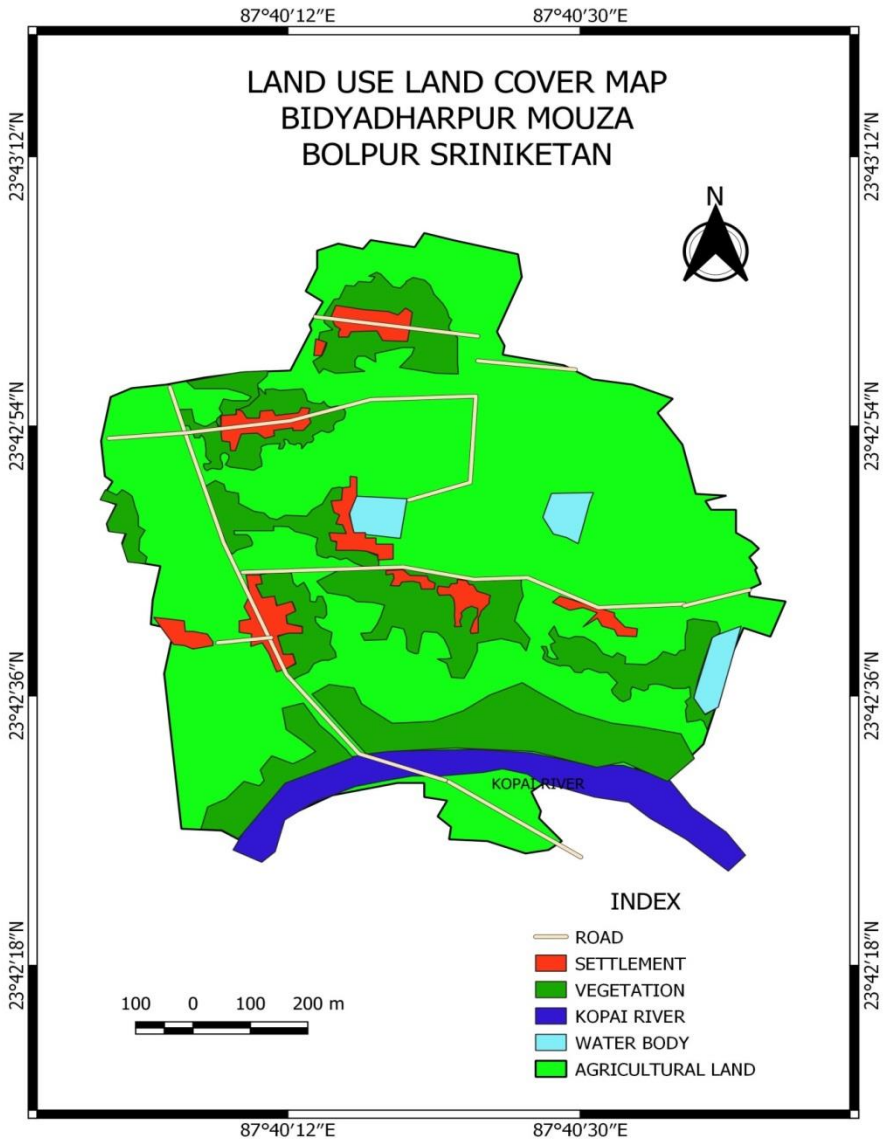
Reason of recent Flood in Kopai:- Most of the respondents answered that the excess rainfall in the upper catchment area is the main reason of recent flood happened in Kopai. Release of Dam water and Dumping in the river or Siltation are the other two associate reasons that could have caused the recent flood in river Kopai as per the survey carried out in the Bidhyadharpur and Bandhlodanga villages.

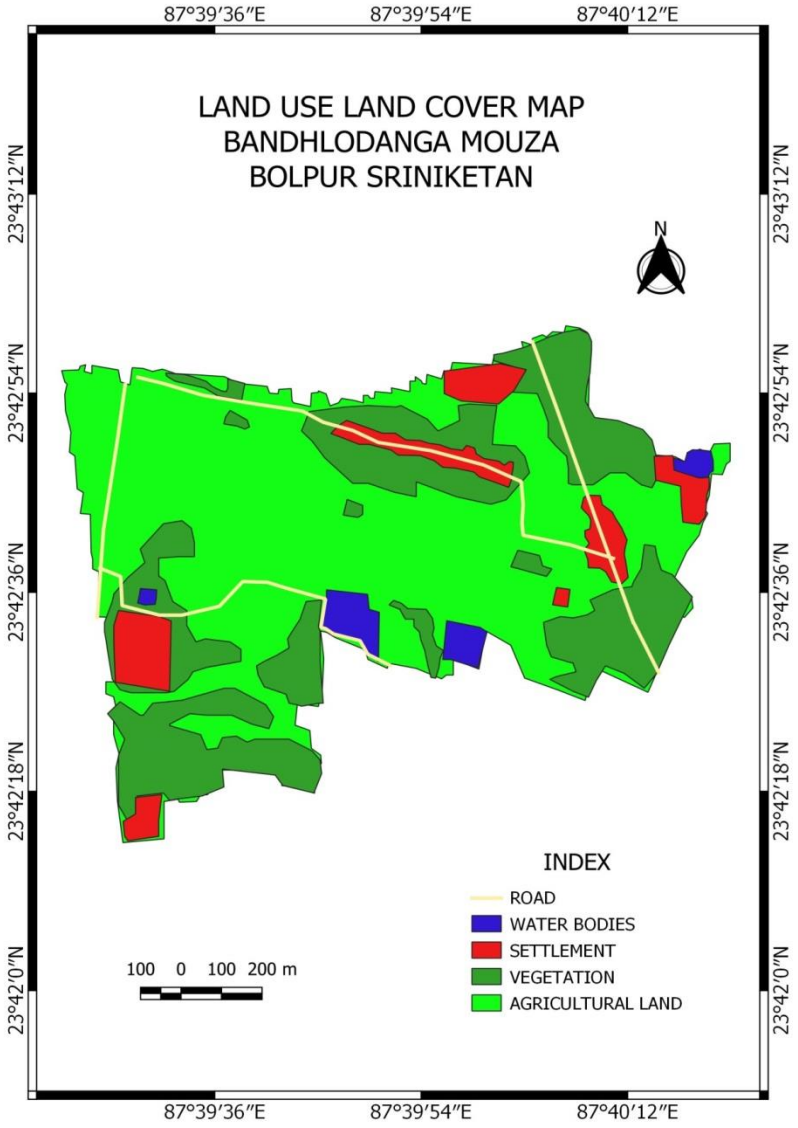
Condition of river Kopai during survey: - During Survey River Kopai is seen as a stream of water flowing in narrow channel and having very less water in the channel. 68% of surveyed households responded that the river Kopai is dying and rest of 32% households opposed this.





Reasons of Kopai River dying: - River dumping is seen as the main reason of dying of river Kopai followed by canal construction on the upper reach of river and other reason. Uncontrolled river dumping and continues siltation chock the river flow to a great extent and the river may siege to exist in near future if no proper plans are to be adopted to revive the dying Kopai.


LAND USE LAND COVER MAP
BIDYADHARPUR MOUZA
BOLPUR SRINIKETAN
N
87°40′12″E
87°40′30″E
23°43′12″N
23°42′54″N
23°42′36″N
23°42′18″N
KOPAI RIVER
INDEX
ROAD
SETTLEMENT
VEGETATION
KOPAI RIVER
WATER BODY
AGRICULTURAL LAND
100 0 100 200 m


LAND USE LAND COVER MAP
BANDHLODANGA MOUZA
BOLPUR SRINIKETAN
N
87°39′36″E
87°39′54″E
87°40′12″E
23°43′12″N
23°42′54″N
23°42′36″N
23°42′18″N
23°42′0″N
INDEX
ROAD
WATER BODIES
SETTLEMENT
VEGETATION
AGRICULTURAL LAND
100 0 100 200 m

Problems:-

1. Farm sector happens to be overburdened.
2. Apart from farming, other economic activities can only generate employment not development.
3. A few workers are employed in tertiary sector.
4. Roads are narrow though mostly metalled.
5. Irrigation facilities are limited.
6. Flood problem during monsoon specially along the Kopai river bank
7. The supply of potable drinking water is not sufficient.
8. There is problem of sanitation, sewerage and open defecation.
9. Absence of Primary School and Primary Health Centre in the both the villages.

Prospects:-

1. Tertiary sector should be promoted.
2. Primary education and primary health services are to be enhanced.
3. Irrigation facilities to extend for crop marketing.
4. Betterment of road condition.
5. Farmers should be trained in modern techniques related to the development of agriculture.
6. Some job opportunities must be created for female workers.
7. Cooperative society must be encouraged for agro-product marketing.
8. Aware and Educate local people not to defecate openly.
9. Flood Management along the Kopai river bank.

References

Abrahams AD (1984) Channel networks: a geomorphological perspective. Water Resour 20:161–168

Agrawal CS (1998) Study of drainage pattern through aerial data in Navgarh area of Varanasi district, U. P. J Indian Soc Remote Sens 26:169–175

Chorley RJ, Donald Malm EG, Pogorzelski HA (1957) A new standard for estimating drainage basin shape.Am J Sci 255(2):138–141. https://doi.org/10.2475/ajs. 255.2.138

Chorley RJ (1969) Introduction to fluvial processes. Methuen and Co Ltd., Routledge, London, Bungay, UK

Clarke JI (1973) Morphometry from maps. Essays in geomorphology. Elsevier Publication Corporation, India, Delhi

Doornkamp JC, CuChlaine AMK (1971) Numerical analysis in geomorphology: an introduction. Published by Edward Arnold, London

Esper AMY (2008) Morphometric analysis of Colanguil River Basin and Flash Flood Hazard, San Juan. Argent Environ Geol 55:107–111. https://doi.org/10.1007/ s00254-007-0969-2

Frissel CA, Liss WJ, Warren CE, Hurley MD (1986) A hierarchical framework for stream habitat classification-viewing streams in a watershed context. Environ Manag 10:199–214

Garde RJ (2005) River morphology. New Age International (Pvt) Ltd. Publishers, New Delhi

Gardiner V (1995) Channel networks: progress in the study of spatial and temporal variations of drainage density. In: Gornell A, Petts GE (eds) Change in river channels. Wiley, New York, pp 65–85

Giamboni M, Carretier S, Niviere B, Winter T (2005) Do river profiles record along stream variations of low uplift rate? J Geophys Res 111(F02024). https://doi. org/10.1029/2005JF000419

Gregory KJ, Walling DE (1985) Drainage basin form and process: a geomorphological approach. Published by Edward Arnold, London. https://doi.org/10.1080/ 02626666809493583

Grohmann CH (2004) Morphometric analysis in geographic information systems: applications of free software GRASS and R. Comput Geosci 30:1055– 1067. https://doi.org/10.1016/j.cageo.2004.08.002

Grohmann CH, Riccomini C, Alves FM (2007) SRTM – based morphotectonic analysis of the Pocos de caldas alkaline massif Southeastern Brazil. Comput Geosci 33:10–19. https://doi.org/10.1016/j.cageo.2006.05.002

Hadley R, Schumm S (1961) Sediment sources and drainage basin characteristics in Upper Cheyenne River Basin. US Geological Survey Water-Supply Paper 1531-B, Washington DC, 198

Horton RE (1932) Drainage basin characteristics. Trans Am Geophys Union 13:350–361

Horton RE (1945) Erosional development of stream and their drainage basin−hydrogeological approach to quantitative morphology. Bull Geolog Soc Am 56 (3):275–370

Huang XL, Niemann JO (2006) An evaluation of the geomorphically effective event for fluvial processes over long periods. J Geophys Res 111:1–17

Kessali JE (1941) Concept of the graded river. J Geol 49:561–588

Leopold LB, Maddock T (1953) The hydraulic geometry of stream channels and some physiographic implications. USGS Prof Paper 252:1–57

Magesh NS, Jitheshlal KV, Chandrasekar N, Jini KV (2013) Geographical information system based morphometric analysis of Bharathapuzha River Basin, Kerala, India. Appl Water Sci 3:467–477

Magesh NS, Chandrasekar N (2012) GIS model-based morphometric evaluation of Tamiraparani subbasin, Tirunelveli district, Tamil Nadu India. Arab J Geosci 7 (1):131–141

Melton MA (1965) The geomorphic and paleoclimatic significance of alluvial deposits in Southern Arizona. J Geol 73:1–38. https://doi.org/10.1086/627044

Mesa LM (2006) Morphometric Analysis of a Subtropical Andean basin (Tucuman, Argentina). Environ Geol 50:1235–1242

Miller VC (1953) A quantitative geomorphic study of drainage basin characteristics in the Clinch Mountain area Varginia and Tennessee. J Geol 65(1):112–120

Moglen GE, Bras RL (1995) The importance of spatially heterogeneous erosivity and the cumulative area distribution. Geomorphology 12(3):173–185. Elsevier

Mohd I, Haroon S, Bhat FA (2013) Morphometric analysis of Shaliganga sub-catchment, Kashmir Valley, India using geographical information system. Int J Eng Trends Technol 4(1):10–21

Morisawa M (1985) Rivers-forms and process. Longman Group, London, pp 54–56, pp 70–73

Nag SK (1998) Morphometric analysis using remote sensing techniques in the Chaka sub basin, Purulia District, West Bengal. J Indian Soc Remote Sens 26(1 & 2):69–76

Nag SK, Chakraborty S (2003) Influence of rock types and structures in the development of drainage network in the hard rock area. J Indian Soc Remote Sens 31 (1):25–35

Pareta K, Pareta U (2011) Quantitative morphometric analysis of a watershed of Yamuna Basin, India using ASTER (DEM) data and GIS. Int J Geomat Geosci 2 (1):248–269

Rhea S (1993) Geomorphic observations of rivers in the Oregon Coast Range from a regional reconnaissance perspective. Geomorphology 6(2):135–150. Elsevier

Sarita G (2015) Morphometric analysis of a Shakkar river catchment using RS and GIS. Int J u- and e- Serv Sci Technol 8(2):11–24

Schumm SA (1956) The evolution of drainage system and slopes in Badlands at Perth Amboy New Jersey. Bull Geolog Soc Am 67:214–236

Sen PK (1993) Geomorphological analysis of drainage basins. The University of Burdwan, Burdwan Sharma SK, Gajbhiye S, Tignath S (2014) Application of principal component analysis in grouping geomorphic parameters of a watershed for hydrological modeling. Appl Water Sci 5:89–96

Singh DS, Awasthi A (2011) Implication of drainage basin parameters of Chhoti, Gandak River, Ganga plain, India. J Geol Soc India 78:370–378

Singh S, Singh MC (1997) Morphometric analysis of Kanhar river basin. Natl Geograph J India 43:31–43

Smith GK (1950) Standards for grading texture of erosional topography. Am J Sci 248:655–668

Strahler AN (1952) Hypsometric (area-attitude) analysis of erosional topography. Geol Soc Am Bull 63:1117– 1142

Strahler AN (1964) Quantitative geomorphology of drainage basins and channel networks. In: Chow VT (ed) Handbook of applied hydrology. McGraw Hill Book Company, New York, Section 4–76

Vikhe SD, Patil KA (2016) Morphometric analysis of a basin using remote sensing and GIS−a review. Int J Innov Res Sci Eng Technol 5(5):7029–7034

Wentworth CK (1930) A simplified method of determining the average slope of land surfaces. American J Sci 5–20(117):184–194

Willgoose GR, Hancock G (1998) Revisiting the hypsometric curve as an indicator of form and process in transport limited catchment. Earth Surf Proc Land 23:611–623