NATIONAL SYMPOSIUM ON

REMOTE SENSING AND GIS FOR ENVIRONMENT WITH SPECIAL EMPHASIS ON MARINE AND COASTAL DYNAMICS

and

ANNUAL CONVENTIONS OF

INDIAN SOCIETY OF GEOMATICS & INDIAN SOCIETY OF REMOTE SENSING

December 4-6, 2013, Visakhapatnam

Full Papers

Organised by

Indian Society of Geomatics

&

Indian Society of Remote Sensing

ISRS

Hosted by

Department of Geo-Engineering & Centre for Remote Sensing

College of Engineering (A), Andhra University, Visakhapatnam

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Micro watershed management based on Morphometric parameters & societal prospective, through Remote Sensing & GIS techniques A case study of Kansachara sub-watershed

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Abstract: Professional prioritization needs characterization of watershed to optimize natural resources which is especially important in draught prone area like Bankura and Puruliya district. Morphometric analysis has been commonly applied to prioritization of watershed. In this study prioritization of watershed was carried out on the basis of morphometric parameters and the society affected by water scarcity, using Remote Sensing and GIS in Kansachara sub-watershed i.e right hand tributary of Dwarakeswar river in Bankura and Puruliya district of West Bengal. The morphometric parameters and field survey based investigation suggest the prioritization of the micro watershed. The study suggests that the sub-watershed has been categorized in to three stages based on the assigning weightage values of morphometric Parameters and scarcity period of water. First stage goes to 2A2C8F1a, 2A2C8F1b, 2A2C8F1e, 2A2C8F2b, 2A2C8F2e, 2A2C8F3d, 2A2C8F5c, 2A2C8F5e, 2A2C8F6b & 2A2C8F6d micro watershed and second stage goes to 2A2C8F1c, 2A2C8F1f, 2A2C8F2a, 2A2C8F2d, 2A2C8F3a, 2A2C8F3b, 2A2C8F3c and 2A2C8F4d microwatershed and other micro watershed in third stage respectively out of 33 micro watersheds. This priority class may be taken for conservation measures by engineers and decision makers for planning, developments and management of natural resource with fully considering the societal aspects.

Keywords: Prioritization, Watershed, Natural resources, Draught prone, Morphometric, Scarcity.

Introduction

Watershed prioritization is the scientific process of watershed delineation and monitoring (Bera-2013). The process was carried out on the basis of morphometric parameters using geoinformatics in Kansachara subwatershed, right hand side tributary of Dwarkeswar river in Bankura & Puruliya districts, West Bengal. Prioritization of watershed involves holistic integrated techniques of morphometric parameters. Morphomaric parameters are categories into three class i.e Linear, Relief and Arial. Many authors have been reported on morphometric analysis (Horton- 1945; Smith- 1950; Strahler-1957) and the use of remote sensing and GIS in morphometric analysis by other authors like, Krishnamurthy and Srinivas -1995; Srivastava and Mitra -1995; Agarwal- 1998; Biswas et al -1999; Chakraborty. et al - 2002, Rao et.al-2006; Thakkar. et al -2007; Christopher et al -2010; Rekha et al - 2011; Kumer et.al - 2011; Singh.V -2011; Pal. et.al- 2012). In the present study morphometric analysis and prioritization of micro watersheds are carried out for 29 micro watersheds of Kansachara sub watershed under Bankura and Puruliya districts of West Bengal, by using Remote Sensing and GIS Technology.

Location of the study area

Kanshchra watershed is left hand side tributary of Dwarakeswar River in Bankura and Purulia district, West Bengal. The extension of the study area is $23^{0}20'$N to $23^{0}30'$N latitude and $86^{0}45'$E to $86^{0}55'$E longitude. It is located between four blocks under Bankura and Purulia district of west Bengal. Upper part of Dwarakeswar river flow has several tributaries; one of them in left bank tributary is Kansachara. Kansachara has 33 Micro watersheds in 114.34 km^2. Study area is bounded by four blocks of Bankura and Purulia district (Fig: 01); i.e Chhatna, Indpur, Kashipur & Hura blocks.

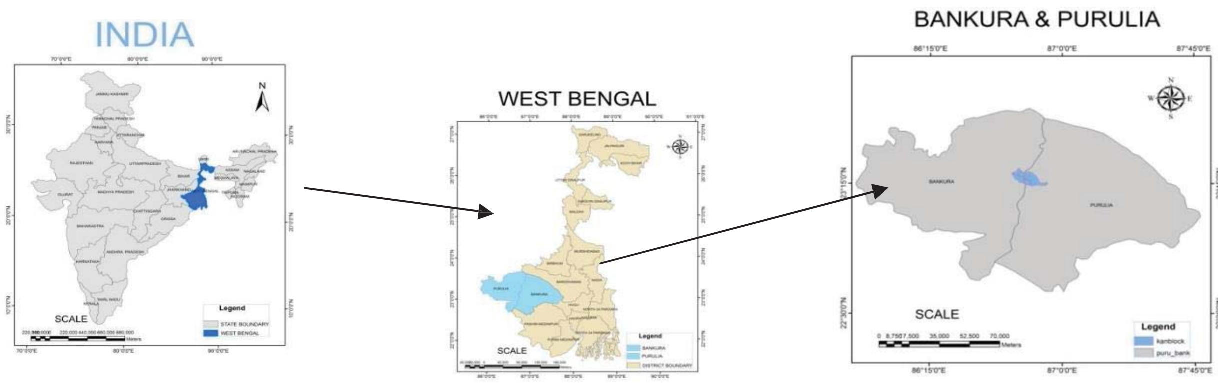


Fig.1: Study Area

General Aspect of Study Area

Drainage

The river Dwarakeswar originates from western upland of Chhotonagpur plateau region and flow almost parallel to each other carrying seasonal flow of water & meets Dwarakeswar (Bera Kartic-2013). The study area drainage pattern is dendritic and sub stream meet with mainstream at right angle (Fig: 02). All micro-watersheds are delineated after observing the flow pattern in the study area. The total length of all channels of river is around 209.1 KM.

Table No-1(Land Use & Land Cover)

LU/LC cover	Area in Km^2	Area in %
1.Water body	17.9794	15.72
2.Sand	1.4603	1.28
3. Wet valley	0.0112	0.01
4.Agricultural land	20.5160	17.94
5.Settlement	0.7207	0.63
6.Dense Forest	19.4320	16.99
7.Medium Forest	25.8575	22.61
8. Open Forest	0.2468	0.22
9.Scurb land	26.9941	23.61
Total area □114.34 km^2		

Slope

The slope map shows that in some part slope is high where as form upper to lower part slope is moderate and in other area slope is level plane. In the high slope area runoff is high, so ground water availability is low. In study area the slope is varying from 96.31M to 184.09 M (Fig: 02).

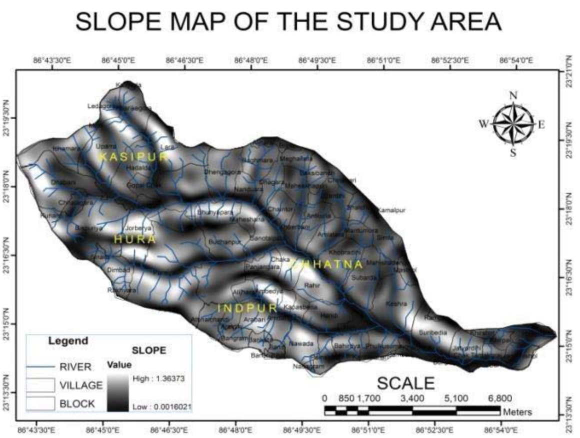


Fig: 02

Relief

The value of relative relief is calculated from contour and DEM data using range analysis in Arc GIS software. The relief map of the study area shows that it is a plateau region. In the north east part of the study area height is 188m where as in the south western part relief is low, with a gentle gradient from east to west. The relief undulation of the area is varied between 99m to 188m with a gentle gradient from east to west.

Soil

The soil of the study area shows that a major portion is covered with red and yellow soil; the rest part is composed of red gravel soil on the central part of the basin. Mostly the soil is infertile in type; mostly covering either forest or scrub land. Others land is cultivated for practice. (Bera- 2013) The reddish yellow soil is not very fertile due to less availability of water productivity.

Land Use & Land Cover

The most part of land use under agricultural fallow whereas some part of area is covered by the forest mainly in the middle part of watershed (Fig: 03). Land Use/ Land cover is one principal tool. The land use / Land cover data sets are generated from the digital image classification of LISS-III satellite images. The land use study was made in close connection with water resource management and irrigation utilities. This classification is performed nine classes within the study area, namely water body, sand, wet ally, agricultural land, settlement, dense forest, medium forest, open forest, scrub land (Table: 01). Overland accuracy achieved is 89%, after carrying out an accuracy assessment using ground truth data sets.

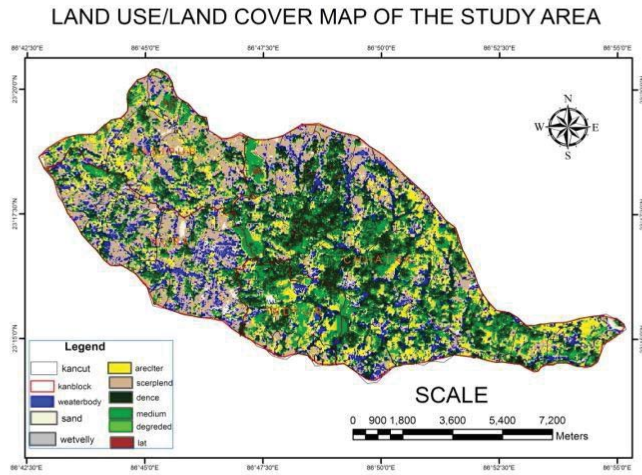


Fig: 03

Geology

The geological formation of the study area comprises Archaean rocks and is an extension of peninsular mass of Chhotanagpur plateau (Visual interpretation of Resource Map, Geological Survey of India, 2001).The Dwarkeswar consist of quartzite Slates, and chloride schist. The geology map shows that in upper most area granite granodiorite pegmatite igneous sandstone shale& conglomerate schist are present. The most part of the study area covered by gneisses rocks. On this region of low permeability through gneissic rocks and reddish soil the intensity of surface cannel is high and thus tendency of branching of streams are also high which facilitates easy drainage of water. Thus the availability of water is quite less on the surface as well as at sub subsurface.

Climate

Climate of the area is of tropical dry sub humid with normal annual rainfall ranging from 1100 mm to (in the western part) 1400 mm (in the eastern part) .The mean daily temperature ranges from 12^0C (Winter) to the maximum 46^0C (Summer). Dwarakeswar River and its all tributary dry up during cold and dry seasons. The variations in the number of rainy days & soil moisture limitations are common. Severe drought periods lasting for weeks adversely affect the crop growth & yields during main cropping i.e., Kharif season.

Aim

Watershed management based on Morphometric & Socio economic parameters Using Remote Sensing and GIS.

Objectives

The following specific objectives will be purposed in order to achieve the aim above -

- The present study is to analyze the morphometry of the basin using GIS techniques.
- To delineate micro-watershed boundary.
- To prepare drainage network map.
- To prepare land use & land cover classify map of watershed.
- To adjust political and physical boundary.

Methodology

The purpose of watershed prioritization of Kanschra micro watershed under study, a drainage map was prepared with the help of LISS-III image and SRTM database. The flow accumulation from the SRTM Dem of drainage network was carried out using Arc GIS (9.3) software and overlay analysis on Erdas Imagine (9.0) software. Erdas Imagine 9.0 and Arc GIS 9.3 were used for digital image processing and generating thematic maps. Boundaries of micro-watershed, blocks, villages and drainage were digitized and in the attribute table. Soil map was taken from NBSS & LUB, Geology from GSI. Rainfall data were obtained from IMD Kolkata. Political boundary collected from District Statistical Hand book. The details information of morphmetric parameter in watershed is measured with the help of Arc GIS software up to micro level. Then details information (Table: 03) of drainage was calculated in Arc GIS (9.3) and Microsoft excels based on formula (Tabel: 02).

Table No – 2		
Morphmetric Parameters	Methods	References
Stream Order (U)	Hierarchical Order	Strahler, 1964
Stream Length (Lu)	Length of the Stream	Horton, 1945
Mean Stream Length (Lsm)	Lsm=Lu/Nu where, Lu= Stream length of order 'U' Nu=Total number of stream segments of order 'U'	Horton, 1945
Stream Length Ratio(RL)	RL= Lu/Lu-1; where Lu= Total Stream length of order 'U', Lu-1=Stream length of next lower order	Horton, 1945
Bifurcation Ratio (Rb)	Rb=Nu/Nu+1; where, Nu=Total no of stream segment of order 'U', Nu+1=Number of segment of next higher order	Schumn, 1956
Basin Relief (Bh)	Vertical distance between the lowest and highest points of watershed	Schumn, 1956
Relief Ratio (Rh)	Rh=Bh/Lb; where Bh=Basin relief; Lb=Basin length($1.312*Area^{.568}$)	Schumn, 1956
Ruggedness number (Rn)	Rn=Bh×Dd; where, Bh=Basin relief, Dd=Drainage density	Schumn, 1956
Drainage Density (Dd)	Dd=L/A; where, L=Total length of the streams; A=Area of watershed(m^2)	Horton, 1945
Stream Frequency (Fs)	Fs=N/A; where, N=Total no of streams; A= Area of watershed(m^2)	Horton, 1945
Texture Ratio (Rt)	Rt=NI/P; where, NI=Total no of first order streams; P=Perimeter of watershed(m)	Horton, 1945
Form Factor (Rf)	Ff= $A/(Lb)^2$; where, A= Area of watershed(m^2); Lb=Basin length($1.312*Area^{.568}$)	Horton, 1932
Circulatory Ratio (Rc)	Rc=4πA/P2; where, A=Area of watershed(m2); π=3.14, P=Perimeter of watershed	Miller, 1953
Elongation Ratio (Re)	Re=2√(A/π)/Lb; where, A=Area of watershed(m2); π=3.14, Lb=Basin length(1.312*Area.568)	Schumn, 1956
Length of overland flow (Lof)	Lof=1/2Dd; where, Dd=Drainage density	Horton, 1945
Constant channel maintenance (C)	C=1/Dd; where, Dd=Drainage density	Horton, 1945

Table: Formula for the computation of morphometric parameters

Socio-economic information

A standardized questionnaire was prepared to collect Socio-economic information for the watershed management in Kansachara River by using matrix based sampling. The village were selected based required information in each village i.e. river distribution. Every care was taken to give proper representation in the sample by making use of B.D.O office. After the data collections all the data generated from the field and sorted by data entry process in the software. Finally prioritized the villages for tacking action compare with micro watershed boundary (Table: 5).

2.0 Result and Discussion:

Morphometry analysis

Morphometry is the measurement and mathematical analysis of the configuration of the earth surface, shape and dimension of landform (Clarke, 1966). A major emphasis in geomorphology over the past several decades has been on the development of quantitative physiographic methods to describe the evolution and behavior of surface drainage network (Horton, 1945). Different morphmetric techniques are considered for quantitative analysis of different attribute of watershed. In the present study, the morphmetric analysis for the parameters namely stream order, stream length, bifurcation ratio, mean stream length, stream length ratio, basin relief, relief ratio, ruggedness no, drainage density, stream frequency, texture ratio, form factor, circulatory ratio, elongation ratio, length of overland flow constant channel maintenance has been carried out using the mathematical formula.

Stream order (U)

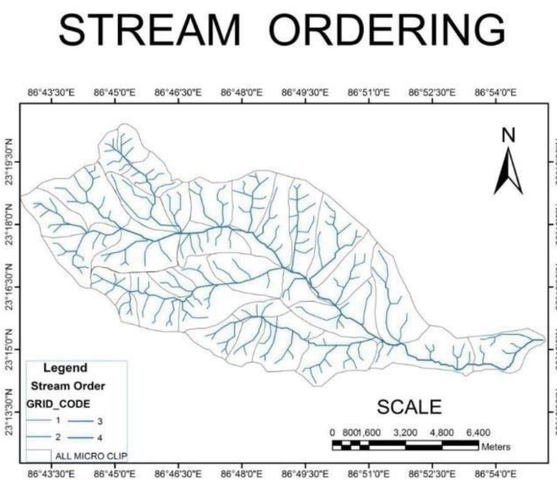


Fig: 04

The study area is a forth drainage basin. The total no of stream 235 were identified (Fig: 04) which are 1st order streams, are 2nd order, are 3rd order and in 4th order streams. It is observed that there is a decrease in stream frequency as the stream order increases (Vittala S.et.al) Drainage patterns of stream network from the basin have been observed as mainly dendritic pattern. This pattern is characterized by a tree like pattern. While in some part of the basin represent parallel and radial pattern type indicating that the topographical features are dipping folded and highly joined in the hilly terrains (Jenson, 2006). The properties of the stream networks are very important to study the landform making process.

Stream length (Lu)

The numbers of streams of various orders in a micro watershed are counted and their lengths from mouth to drainage divide are measured with help of GIS software. The stream length (Lu) has been computed based the law proposed by Horton (1945) for all the 33 micro-watershed. Generally the total length of the stream segments is Maximum in first order streams and decreases as the stream order increases. This change may indicate flowing of streams from high altitude, litho logical variation and moderately steep slopes (Singh and Singh, 1997).

Bifurcation ratio (Rb)

The term bifurcation ratio (Rb) is used to express the ratio of the number of streams of any given order to the number of streams in next higher order (Schumn, 1956). Strahler (1957) demonstrated that bifurcation ratio shows a small range of variation for different regions or for different environment except where the powerful geological control dominates. The lower value of Rb are characteristics of the micro-watershed which have suffered less structural disturbances (Strahler, 1964) and the drainage patterns has not been distorted because of the structural disturbances (Nag, 1998). In the present study, the higher value of Rb indicates strong structural control on the drainage pattern while the lower values indicative of micro-watershed that are not affected by structural disturbances.

Mean stream length (Lsm)

According to Strahler(1964), the mean stream length is a characteristic property related to the drainage network and its associated surfaces. The mean stream length (Lsm) has been calculated by dividing the total stream length of order (u) and no of streams of segment of order (u). Lsm of any given order is greater than that of lower order and less than that of its next higher order in all micro-watersheds which might be due variations in slope and topography. Mean stream length (Lsm) is calculated according to Strahler(1964) formula.

Stream length ratio (Rl)

Stream length ratio (RL) may be defined as the ratio of mean length of the one order to the next lower order of stream segment. Horton's law (1945) of stream length states mean stream length segment of each of the successive orders of a basin tends to approximate a direct geometric series with streams length increasing towards higher order of streams. The RL between streams of different order in the study area reveals that there is a variation in RL in each micro-watershed. There is a change from one order to another order indicating their late youth stage of geographic development (Singh and Singh, 1997).

Basin relief (Bh)

To show spatial variation from one place to another calculation of basin relief (Rao, 2011) is paramount. The value of relative relief is calculated from contour and DEM data using range analysis in Arc GIS software. According to Schumn (1956), basin relief is the vertical distance between the lowest and highest point of watershed. Maximum relative relief value is 188 and minimum relative relief value is 99 in Kanschara watershed.

Relief Ratio (Rh)

The elevation difference between the highest and lowest point of micro- watershed. The relief ratio (Rh) of maximum relief to horizontal distance along the longest dimension of the basin parallel to the principal drainage line is termed as relief ratio(Schumm,1956). There is also a correlation between hydrological characteristics and relief ratio of a drainage basin. The Rh normally increases with decreasing drainage area and size of micro-watershed of a given drainage basin (Gottschalk, 1964). The high values of Rh indicate steep slope and lower values indicate the presence of basement rocks that are exposed in the form of small ridges and mouth with lower degree of slope (GSI, 1981).

Ruggedness number (Rn)

The values of ruggedness coincide with other morph metric values. Ruggedness no of the area varied from 0.184743471 to 0.797936229.

Drainage density (Dd)

The drainage density of the study area is 0.023371414m/sq m including high drainage density. High drainage density is the resultant of weak or impermeable subsurface material, sparse vegetation and mountainous relief. The drainage density of the study area is 0.001731034m/sq m including low drainage density. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture (Strahaler, 1964).

Stream frequency (Fs)

Stream frequency is the total no of stream segments of all order per unit area. Hypothetically, it is possible to have the basin of same drainage density differing in stream frequency and basins of same stream frequency differing in drainage density. The Fs exhibits positive correlation with the drainage density values of the micro-watershed indicating the increase in stream population with respect to increase in drainage density.

Texture ratio (Rt)

Texture ratio is an important factor in the drainage morph metric analysis which is depending on the underlying litho logy, infiltration capacity and relief aspect of the terrain. According to Horton (1945), Rt is the total no of stream segments of all order per perimeter of that area.

Form factor (Ff)

The Ff varies between 0.07170112 and 0.121682971 and indicates higher value of Ff of micro-watershed is circular in shape whereas the remaining micro-watersheds are elongated with lower value of form factor.

Circulatory ratio (Rc)

The circulatory ratio (Rc) is influenced by the length and frequency of streams, geological structures, land use / land cover, climate, relief and slope of the basin. In the present study, the Rc ranges from 0.039963995 to 0.078160564 which indicates strongly elongated and highly permeable homogenous geologic materials.

Elongation ratio (Re)

Schumm (1956) defined elongation ratio (Re) as the ratio between the diameter of the circle of the same area as the drainage basin and maximum length of the basin. It is a very significant index in the analysis of basin shape which helps to give an idea about the hydrological character of a drainage basin. In the study area Re value is varying between 0.113493892to0.49900871.

Length of overland flow (Lof)

It is the length of water over the ground before it concentrated into definite stream channels (Horton, 1954). The length of overland flow (Lof) equals to half of the reciprocal of drainage density (Horton, 1945). This factor relates inversely to the average slope of the channel. The computed value of Lof for all micro-watershed varies from 21.39365637 t0 40.59683518.

Constant channel maintenace (C)

A constant channel maintenance method follows, Horton (1945). The 'C' values ranges between 44.5013607to78.70577483 (Table: 03).

Table No-3 (Stream Analysis)

Micro WC	Parameter	I Order	II Order	III Order	Iv Order
	Stream Order (U)	5	1		1
	Stream Length (Lu)	3065	1629		3554
2A2C8F1a	Bifurcation Ratio (Rb)	5	1		

	Mean Stream Length (Lsm)	613	1629		3554
	Stream Length Ratio (RL)	0.531484502	2.181706568		
2A2C8F1b	Stream Order (U)	8	2		1
	Stream Length (Lu)	4804	911		4265
	Bifurcation Ratio (Rb)	4	2		
	Mean Stream Length (Lsm)	600.5	455.5		4265
	Stream Length Ratio (RL)	0.189633638	4.681668496		
2A2C8F1c	Stream Order (U)	4	1		
	Stream Length (Lu)	4410	3006		
	Bifurcation Ratio (Rb)	4			
	Mean Stream Length (Lsm)	1102.5	3006		
	Stream Length Ratio (RL)	0.681632653			
2A2C8F1d	Stream Order (U)	7	1		1
	Stream Length (Lu)	5835	283		2690
	Bifurcation Ratio (Rb)	7	1		
	Mean Stream Length (Lsm)	833.57	283		2690
	Stream Length Ratio (RL)	0.048500428	9.505300353		
2A2C8F1e	Stream Order (U)	4	1		1
	Stream Length (Lu)	2399	1940		1296
	Bifurcation Ratio (Rb)	4	1		
	Mean Stream Length (Lsm)	599.75	1940		1296
	Stream Length Ratio (RL)	0.808670279	0.668041237		
2A2C8F1f	Stream Order (U)	7	3	1	1
	Stream Length (Lu)	4445	2435	2206	413
	Bifurcation Ratio (Rb)	2.33	3		
	Mean Stream Length (Lsm)	635	811.66	2206	413
	Stream Length Ratio (RL)	0.547806524	0.905954825	0.18721668	
2A2C8F1g	Stream Order (U)	10	1		1
	Stream Length (Lu)	5659	3728		279
	Bifurcation Ratio (Rb)	10	1		
	Mean Stream Length (Lsm)	565.9	3728		279
	Stream Length Ratio (RL)	0.658773634	0.074839055		
2A2C8F1h	Stream Order (U)	2	1		1
	Stream Length (Lu)	984	958		738
	Bifurcation Ratio (Rb)	2	1		
	Mean Stream Length (Lsm)	492	958		738
	Stream Length Ratio (RL)	0.973577235	0.770354906		
2A2C8F2a	Stream Order (U)	8	2	1	
	Stream Length (Lu)	4332	2172	2673	
	Bifurcation Ratio (Rb)	4	2		
	Mean Stream Length (Lsm)	541.5	1086	2673	
	Stream Length Ratio (RL)	0.501385041	1.230662983		
2A2C8F2b	Stream Order (U)	7	2	1	
	Stream Length (Lu)	3920	2239	2144	
	Bifurcation Ratio (Rb)	3.5	2		
	Mean Stream Length (Lsm)	560	1119.5	2144	
	Stream Length Ratio (RL)	0.571173469	0.957570343		
2A2C8F2c	Stream Order (U)	3	1		
	Stream Length (Lu)	1875	852		
	Bifurcation Ratio (Rb)	3			
	Mean Stream Length (Lsm)	625	852		
	Stream Length Ratio (RL)	0.4544			
2A2C8F2d	Stream Order (U)	2	1	1	
	Stream Length (Lu)	1014	1562	176	
	Bifurcation Ratio (Rb)	2	1		
	Mean Stream Length (Lsm)	507	1562	176	
	Stream Length Ratio (RL)	1.540433925	0.112676056		
2A2C8F2e	Stream Order (U)	5	2	1	
	Stream Length (Lu)	1817	2276	185	
	Bifurcation Ratio (Rb)	2.5	2		

	Mean Stream Length (Lsm)	363.4	1138	185	
	Stream Length Ratio (RL)	1.252614199	0.081282952		
	Stream Order (U)	5	1		
2A2C8F3a	Stream Length (Lu)	2559	1219		
	Bifurcation Ratio (Rb)	5			
	Mean Stream Length (Lsm)	511.8	1219		
	Stream Length Ratio (RL)	0.476357952			
2A2C8F3b	Stream Order (U)	3	2	1	
	Stream Length (Lu)	1349	813	44	
	Bifurcation Ratio (Rb)	1.5	2		
	Mean Stream Length (Lsm)	449.66	406.5	44	
	Stream Length Ratio (RL)	0.602668643	0.054120541		
2A2C8F3c	Stream Order (U)	6	1	1	
	Stream Length (Lu)	3974	1175	2169	
	Bifurcation Ratio (Rb)	6	1		
	Mean Stream Length (Lsm)	662.33	1175	2169	
	Stream Length Ratio (RL)	0.295671867	1.845957447		
2A2C8F3d	Stream Order (U)	6	2	1	
	Stream Length (Lu)	3393	1273	2208	
	Bifurcation Ratio (Rb)	3	2		
	Mean Stream Length (Lsm)	565.5	636.5	2208	
	Stream Length Ratio (RL)	0.375184202	1.734485467		
2A2C8F3e	Stream Order (U)	2	1		
	Stream Length (Lu)	1804	571		
	Bifurcation Ratio (Rb)	2			
	Mean Stream Length (Lsm)	902	571		
	Stream Length Ratio (RL)	0.316518847			
2A2C8F3f	Stream Order (U)	2	1		
	Stream Length (Lu)	934	961		
	Bifurcation Ratio (Rb)	2			
	Mean Stream Length (Lsm)	467	961		
	Stream Length Ratio (RL)	1.028907923			
2A2C8F3g	Stream Order (U)	3		1	
	Stream Length (Lu)	3379		2496	
	Bifurcation Ratio (Rb)	3			
	Mean Stream Length (Lsm)	1126.33		2496	
	Stream Length Ratio (RL)	0.738680082			
2A2C8F4a	Stream Order (U)	6	2	1	1
	Stream Length (Lu)	3607	1207	1071	2608
	Bifurcation Ratio (Rb)	3	2		
	Mean Stream Length (Lsm)	601.16	603.5	1071	2608
	Stream Length Ratio (RL)	0.334627113	0.887323943	2.43510738	
2A2C8F4b	Stream Order (U)	8	2	1	
	Stream Length (Lu)	4575	1852	1938	
	Bifurcation Ratio (Rb)	4	1		
	Mean Stream Length (Lsm)	571.87	926	969	
	Stream Length Ratio (RL)	0.404808743	1.046436285		
2A2C8F4c	Stream Order (U)	7	2	1	
	Stream Length (Lu)	3772	2233	1494	
	Bifurcation Ratio (Rb)	3.5	2		
	Mean Stream Length (Lsm)	538.85	1116.5	1494	
	Stream Length Ratio (RL)	0.591993637	0.669055082		
2A2C8F4d	Stream Order (U)	6	2	1	
	Stream Length (Lu)	3005	1924	811	
	Bifurcation Ratio (Rb)	3	2		
	Mean Stream Length (Lsm)	500.83	962	811	
	Stream Length Ratio (RL)	0.640266223	0.421517671		
2A2C8F5a	Stream Order (U)	2	1	1	
	Stream Length (Lu)	2321	486	551	
	Bifurcation Ratio (Rb)	2	1		

	Mean Stream Length (Lsm)	1160.5	486	551	
	Stream Length Ratio (RL)	0.209392503	1.133744856		
2A2C8F5b	Stream Order (U)	2		1	
	Stream Length (Lu)	4638		2009	
	Bifurcation Ratio (Rb)	2			
	Mean Stream Length (Lsm)	2319		2009	
	Stream Length Ratio (RL)	0.433160845			
2A2C8F5c	Stream Order (U)	5	1		
	Stream Length (Lu)	3373	1746		
	Bifurcation Ratio (Rb)	5			
	Mean Stream Length (Lsm)	674.6	1746		

Socio economic survey

The standard questionnaires was prepared and used to collect socio-economic information for the watershed management in Kansachara River. Random sampling design was adopted. The list of respondents was prepared by backward class village and villagers of Kansachara Sub-Watershed. This list of respondents was prepared by selecting 25 tubes well from 20 villages (Table: 04) of Kansachara watershed. The villages were selected on the basis of Watershed distribution and also on the socio-economic condition. Every care was taken to give proper representation in the sample by making use of B.D.O office. Finally the collected information was compared with different data set.

Sources of Drinking Water

"Water is life" – this language is very popular to us. But importance of water is any place how would be premendous, cannot be possible image without the realization of this tropical dry sub humid region (kansachara basin).

From the ground truth verification and also information, there is observed the acute scarcity in the villages of kansachara basin. Sources of drinking water of this area are given below.

Table No-4 (Sources of Drinking water)

ID NO	Location(J.L no)	Block	Village Name	Latitude	Longitude
1				23□20' 18.8"	86□44' 40.2"
2	*201*	Kashipur	Uparra	23□20' 37.1"	86□43' 56.7"
3				23□20' 38.0"	86 □45' 52.5"
4	200		Ichamara	23□20' 18.8"	86 □45' 16.0"
5	199	*Kashipur*	Mehi	23 □20' 21.4"	86 □45' 13.6"
6	206	Kashipur	Lara	23□19' 21.0"	86□44' 40.0"
7				23 □18' 03.7"	86□50' 48.4"
8	139	Chhatna	Kamalpur	23□18' 03.8"	86□50' 47.3"
9	213	Chhatna	Simla	23 □17' 35.4"	86□50' 53.1"
10	219		Subarda	23□18' 19.0"	86 □49' 57"
11	241	Chhatna	Subarda	23□16' 40.4"	86□50' 50.6"
12			Metyala	23□17' 19.0"	86□47' 41.3"
13	245	Chhatna		23□17' 21.7"	86 □47' 39.9"
14	211	Kashipur	Jambadh	23□16' 57"	86 □46' 08.1"
15	232	Hura	Jorbariya	23□16' 51.1"	86□45' 42.3"
16	509		Sinara	23□16' 53.9"	86□46' 06.5"
17	501			23□16' 59.1"	86□44'23.0"
18	792	Hura	Bispuriya	23□16' 54.2"	86□44' 22.1"
19	3		Ambedya	23□15' 29.8"	86 □52' 47.2"
20	230	Indpur	Kapasberia	23□37' 00"	86 □25' 00"
21	356	Indpur	Bangram	23□15' 29.6"	86 □52' 47.1"
22	239	Chhatna	Keshra	23 □15' 16.2"	86 □52' 57.8"
23	227		Humulia	23□15' 9.6"	86□15' 4.6"
24	228	Chhatna	Laxmishale	23□15' 07.7"	86 □54' 12.5"
25	230		Khirpai	23 □14' 56.8"	86 □53' 49.4"

The villages were selected on the basis of Watershed distribution to collect water availability condition for the watershed management. This list of respondents was prepared by selecting 25 tubes well from 20 villages of Kansachara watershed. From the ground truth verification and also information, there is observed the acute scarcity in the villages of Kansachara basin.

Settlement

Details of settlement are collected from Google earth. Settlement of this region indicates typical rural structure with scattered small settlements all over the region due to hilly region in continence of the Chhotanagpur plateau. The villages were selected on the basis of Watershed distribution to collect water availability condition for the watershed management

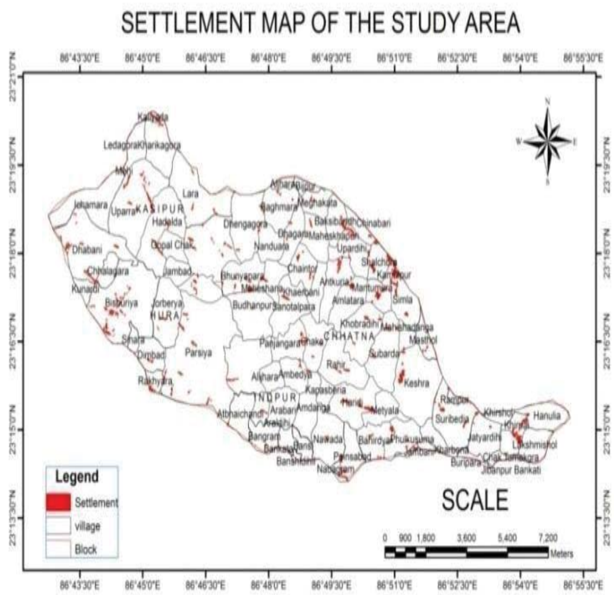


Fig: 05

Water availability and settlement condition

The standard questionnaires was prepared and used to collect socio-economic information for the watershed management in Kansachara River. Random sampling design was adopted. The list of respondents was prepared by backward class village and villagers of Kansachara Sub-Watershed. Details of settlement are collected from Google earth. This list of respondents was prepared by selecting 25 tubes well from 20 villages of Kansachara watershed. The villages were selected on the basis of Watershed distribution. Water is available from 1 month to months. It shows that the socio economic parameters categories based on the MWC for management in a table.

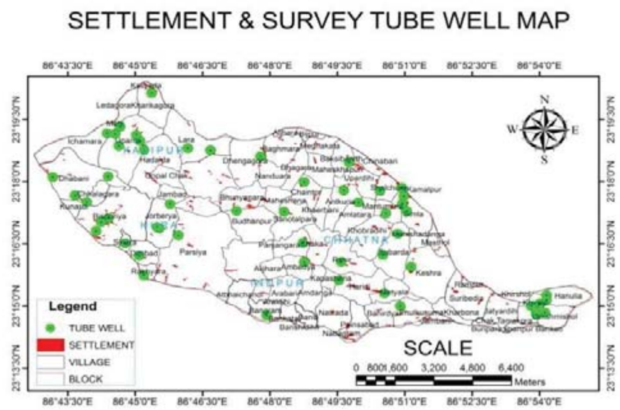


Fig: 06

Table No-5 (Micro Watershed & Political boundary)

Micro W.C	**Block**	**Village**	**Water Scarcity Condition**	**Volume of Population**	**Prioritization**
		Khirpai	2months	3	5
		Hanulia	2months	1	3
2A2C8F1a	CHHATNA	Laxmishol	2months	2	4
		Jayardihi		2	2
		Suribedia		2	2
2A2C8F1b	CHHATNA	Kharbona	1months	1	2
		Rampur		2	2
		Keshra	2months	4	6
2A2C8F1c	CHHATNA	Masthol		3	3
		Mahisdanga	3months	2	5
		Simla		2	2
		Metyala	2months	1	3
		Haridi		1	1
		Rahir	2months	2	4
2A2C8F1d	CHHATNA	subarda	2months	1	3
		Khobradihi		6	6
2A2C8F1e	CHHATNA	Mantumura	3months	8	11
		Amlatara	2months	2	4
		Kamalpur	3months	2	5
		Chinabari		1	1
2A2C8F1f	CHHATNA	Upardihi		3	3
		Antkuri	1months	2	3
2A2C8F1g	CHHATNA	Maheshapuri	2months	1	3
		Chaka	_	7	7
2A2C8F1h	CHHATNA	*Rahir*	_	8	8

		Bahirdya	3months	4	7
2A2C8F2a	CHHATNA	Ranisabad		4	4
		Nawada		2	2
2A2C8F2b	CHHATNA,INDPUR	Haridi	2months	2	4
2A2C8F2c	INDPUR	Ambedya	3months	2	5
2A2C8F2d	INDPUR	Bangram	4months	11	15
2A2C8F2e	INDPUR	Arabari		9	9
2A2C8F3a	HURA	Sinara	3months	1	4
		Rakhayara	2months	1	3
2A2C8F3b	HURA	Dimbad	2months	1	3
2A2C8F3c	HURA	Parsiya	3months	8	11
2A2C8F3d	CHHATNA, INDPUR, HURA	Alijhara		9	9
2A2C8F3e	HURA	Parsiya	3months	12	15
2A2C8F3f	CHHATNA, HURA	Parsiya		11	11
		Panjanagar	3months	4	7
	CHHATNA, HURA	Budhanpur		3	3
2A2C8F3g		Sanotalpara	3months	2	5
		Jorberya	3months	6	9
2A2C8F4a	HURA,KASHIPUR	Jambad	2months	8	10
		Uparra	2months	2	4
	HURA,KASHIPUR	Mehi	4months	1	5
2A2C8F4b		Hadalda		2	2
		Chhalagara	2months	3	5
2A2C8F4c	HURA	Bispuriya	3months	9	12
2A2C8F4d	HURA	Dhabani	3months	12	15
2A2C8F5a	KASHIPUR	Lara	3months	4	7
		Dhengagora	3months	11	14
		Uparra	3months	4	7
	KASHIPUR	Hadalda		4	4
2A2C8F5b		Gopalchak		5	5
2A2C8F5c	KASHIPUR	Lara	2months	1	3
		Kaliyadah	4months	6	10
2A2C8F5d	KASHIPUR	Kharikagora		5	5
2A2C8F5e	KASHIPUR	Ledagora		3	3
		Maheshkhapuri		10	10
2A2C8F6a	CHHATNA	Meghakata		5	5
		Dhangra		1	1
2A2C8F6b	CHHATNA	Baghmara	2months	2	4
2A2C8F6c	CHHATNA, KASHIPUR	Dhengagora	3months	13	16
2A2C8F6d	CHHATNA, KASHIPUR	Bhunyapara	2months	2	4

Table No - 06		**ACTION PLAN**		
Micro WC	Prioritization of Morphometric Parameters	Prioritization of Socio-economic Parameters	Final Prioritization	Action Plan
2A2C8F1a	11	1	12	1
2A2C8F1b	1	8	9	6
2A2C8F1c	30	31	61	33
2A2C8F1d	19	14	33	17
2A2C8F1e	26	29	55	30
2A2C8F1f	14	18	32	16
2A2C8F1g	4	9	13	7
2A2C8F1h	24	19	43	19
2A2C8F2a	12	15	27	12
2A2C8F2b	8	10	18	10
2A2C8F2c	9	6	15	9
2A2C8F2d	33	20	53	24
2A2C8F2e	15	12	27	13

2A2C8F3a	2	4	6	2
2A2C8F3b	10	11	21	11
2A2C8F3c	13	16	29	14
2A2C8F3d	17	13	30	15
2A2C8F3e	32	21	53	25
2A2C8F3f	25	26	51	23
2A2C8F3g	31	22	53	26
2A2C8F4a	21	32	53	27
2A2C8F4b	18	17	35	18
2A2C8F4c	16	30	46	21
2A2C8F4d	20	23	43	20
2A2C8F5a	23	33	56	31
2A2C8F5b	27	27	54	28
2A2C8F5c	6	2	8	3
2A2C8F5d	22	24	46	22
2A2C8F5e	5	3	8	4
2A2C8F6a	29	25	54	29
2A2C8F6b	7	7	14	8
2A2C8F6c	28	28	56	32
2A2C8F6d	3	5	8	5

Action plan

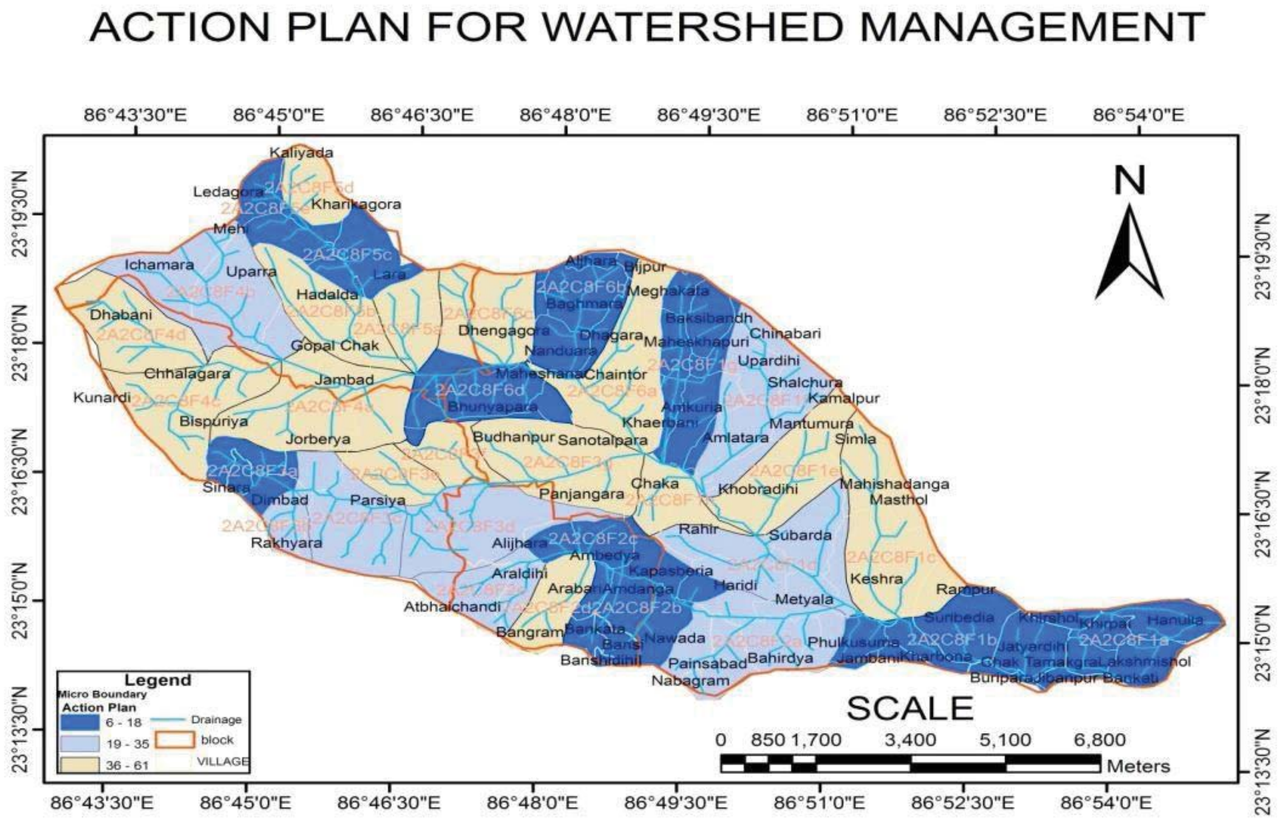
Micro watershed wise value of Morphometric parameters are calculated by priority (Table: 06). Then prioritized of Morphometric parameters of micro-watersheds calculated sum for Prioritization and also weighted value of socio economic parameters calculated for Prioritization. Then Prioritization of morphometric and socio economic parameters calculated sum for final prioritization and Action Plan. Finally the Action Planning Map is classified into three classes i.e. high, medium and low. The Action Planning zone is scattered around the study area. It is observed that 1st planning zone includes maximum part of Kashipur and Hura and upper part of Chhatna and some part of Indpur. Whereas 2nd planning and 3rd Planning zone includes some part of Chhatna, Indpur, Kashipur, Hura (Table: 07). It is necessary for watershed management in micro level. Remote sensing and GIS has provided to be efficient tool in drainage delineation and updating in the present study and updated drainage have been used for morphmetric analysis. The quantitative analysis of morph metric parameters is found to be of immense utility in river basin evolution, watershed management at micro level. The morphmetric analysis carried out in the lower river basin shows that the basin is having low relief of the terrain. The morphmetric analysis of drainage network of all micro-watershed exhibits dendritic drainage pattern which indicates homogeneity in texture and lack of structural control. In some part of basin, the dipping and joint of the topography reveals parallel and radial pattern and stream length ratio might be due to changes in slope and topography. The variation in value of bifurcation ratio among the micro-watersheds is ascribed to the difference in topography and geometric development. The stream frequency for all micro-watershed of the study exhibits positive correlation with the drainage density values aspect to increase in drainage density.

Table No – 07 (Management Plan)

Action Plan	Micro Watershed	Block	Village
1st Plan	2A2C8F4a,2A2C8F5a,2A2C8F5b, 2A2C8F5d	Kashipur	Kharikagora, Kaliyadah, Hadalda, Lara, Dengora, gopalchak, Jambad
	2A2C8F3e,2A2C8F3f,2A2C8F4a, 2A2C8F4c,2A2C8F4d	Hura	Dhabani, Chhalagara, Bishpriya, Jorberya, Parsiya
	2A2C8F2d	Indpur	Bangram, Arabari
	2A2C8F1c,2A2C8F1e,2A2C8F1h, 2A2C8F3g,2A2C8F6a,2A2C8F6c,	Chhatna	Rampur, keshra, Masthol, Mahishdanga, Simla, Kamalpur, Mantumura, Khobradihi, Chaka, Panjangara, Budhanpur, Sanotalpara, Rahir, Bijpur, Meghakata, Maheshkhapuri, Chaintor,
2nd Plan	2A2C8F4b	Kashipur	Ichamara, Uparra, Mehi
	2A2C8F3b,2A2C8F3c,2A2C8F3d	Hura	Parsiya, Rakhyara, Dimbad, Alijhara
	2A2C8F2e, 2A2C8F3d	Indpur	Alijhara, Araldihi, Atbhaichandi
	2A2C8F1d,2A2C8F1f, 2A2C8F2a	Chhatna	Uparadihi, Chainabari, Shalchuri, Amlatara
	2A2C8F5c,2A2C8F5d	Kashipur	Ledagora, Uparra, Lara
	2A2C8F3a	Hura	Sinara, Dimbad

3rd Plan	2A2C8F2b,2A2C8F2c	Indpur	Ambedya, Kapasberiya, Amdanga, Bankata, Bansi, Basidihi
	2A2C8F1a,2A2C8F1b,2A2C8F1g, 2A2C8F2b,2A2C8F6b,2A2C8F6d	Chhatna	Hanulia, Lakshmishol, Jibanpur, Bankati, Tamakgra, Khirpai, Khirshol, Jatyardihi, Chak, Buripara, Kharbona, Jambani, Suribedia, Haradi, Nawada, phulkusuma, Baksibandh, antkuri, Aljhara,

Drainage density is very coarse to coarse texture. Elongation ratio shows that the morphmetric parameters evaluated using GIS helped us to understand various terrain parameters such as nature of the bedrock, infiltration capacity, run-off etc. The Action Plan Map (Fig: 07) is prepared for the entire Kansachara watershed management. The Action Planning Map is classified into three classes i.e. high, medium and low.1st planning zone includes maximum part of Kashipur and Hura and upper part of Chhatna and some part of Indpur. Whereas 3rd Planning zone includes some part of Chhatna, Indpur, Kashipur, Hura.Similar studies in conjunction with high resolution satellite data help in better understanding the landforms and their processes and drainage pattern demarcations for basin area planning and management.



Acknowledgements

A number of people have assisted us, directly or indirectly, in the preparation of research. Namely Dr. Parthasarathi Chakrabarti (Former Chief Scientist-DST Kolkata Govt. of West Bengal). I offer apologies & request that all of you provide corrections to me by email at 1kbrsgis@gmail.com .

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