Chapter 1

Conceptual Framework

**Major Themes:**

1.1 Introduction
1.2 Objectives
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1.1 Introduction

Hydro-morphological evolution is very normal and natural process in a river basin. In Kuya River basin, hydrological phenomena those are prominently influencing land use pattern are flood behavior, channel flow character, morphological characters of the channels, surface and subsurface water conditions etc. Change of these hydrological patterns with fast rate is bringing problem of land use restructurization. Peoples are yet not so equipped to accommodate with changing scenario of hydrological behavior. Strong interventions on river basin in terms of river flow modification, bridge and barrage or dam construction across river, embankment construction along river, brick factory construction just on the river bank and river bank erosion, wetland tampering within river basin, monotonization in crop culture, lifting of water from underground aquifer for cultivation etc. are again influencing hydrodynamics of the river and associated land use practices specially the agriculture & settlement pattern. More than 32 brick klin industries, Nil Nirjan dam across river
Brakeswar, Kultore barrage across river Kuya etc. are controlling the normal pattern of the channel and land use pattern of the canal command area.

This study has included physical background of the study area, hydro-morphological features of channel, morphometric aspects of the basin, surface hydrological aspects like runoff estimation, measurement of discharge, wetland hydrological status, pond and canal network and water diversion from river etc.; subsurface water availability; impact of all the mentioned issues on agriculture and settlement in regard to different hydro-geomorphological units.

1.2 Objectives

1. To find out hydrological evolution of the channels as well as basin as a whole.
2. To analyze the morphometric parameters in the basin in terms of their interrelationship, identification of principle determinant factors and influences of them on different aspects of human landscape.
3. To make a study on the formation processes of wetlands and palaeo channels on the flood plain
4. To detect the changing pattern of morphological parameters in river Kuya and indentify the trend of these parameters along river in respect of theoretical rules.
5. To explain the role of wetland, pond and canal irrigation system for agro-economic development of the basin.
6. To make a review on the impact of Kultore barrage on hydro-morphological modification of the rivers as well as on sedimentological situation.
7. To analyze the tendency of Spatio-temporal flood character of the basin and its impact on land use pattern specially on agricultural and settlement pattern.
8. To assess the emerging problems of ground water situation and associated ensuing risk on agricultural system and hydrological set up of the basin.
9. To assess the impact of hydro-geomorphic conditions on settlement and agricultural pattern.
10. To formulate some recommendations considering all these problems.
1.3 Database and Methodology

1.3.1 Database

Database is very important for conducting any type of research. In this study data have been from both primary and secondary sources.

1. Primary Sources of Data:

Primary data have been collected directly from the field through conducting field survey both during monsoon and post monsoon periods. Sand samples have been collected from different site to analyse sediment behaviour. Cross sections of the river at different sites have measured in field and temporal data regarding cross section change has collected from questionnaire survey, length and width of segments of embankments have been measured. Primary data also have been collected from questionnaire survey for perception study regarding different aspects of flood and effect of embankment, barrage etc.

2. Secondary Sources of Data:

Published data from various departments and authorities, like Directorate of River Research Institute, Govt. of West Bengal, Directorate of Irrigation and Waterways, Govt. of West Bengal, District Relief Department of Dumka, Birbhum and Murshidabad District, District Census Handbook of Dumka, Murshidabad and Birbhum, District Gazetteer of Dumka, Murshidabad and Birbhum, different blocks of Murshidabad and Birbhum district Geological Survey of India, etc. Ground water related information will be collected from Central Ground Water Board, State Water Investigation department etc.

1.3.2 Methodology

Bright methodological consequences certainly give a special tint to the standard of research work. To bring fulfillment along with traditional surveying method researcher would like to automation, i.e. some technological aids to make this work scientific and authentic. As per colloquial principal in spatio-temporal empirical research work, the researcher would also proceed over step by step, viz:-
A. Pre field work:

I. Previous literature and map consultation over related ground.

II. Delineation of basin area and base maps on different geo-environmental aspects on the basis of survey of India Toposheets and imageries.

III. Selection of objective oriented geo-environmental properties and socio-economic themes to be stressed on during course of field work.

B. Field Work:

I. Data collection from different offices regarding flood frequency, flood magnitude, flood stagnation period etc.

II. Cross profiles and velocity profiles have made in 24 sites from source to mouth of the river using Dumpy level and digital current meter. Along with profiles, measurement of some other morphological parameters like wetted width, wetted depth, wetted perimeters etc. have done.

III. Seasonal changing pattern of the hydrological characteristics of river has measured from field in different seasons.

IV. Perception study on the flood character, magnitude effect of existing flood abatement strategies, socio-economic loss etc. have been done with aid of scheduled questionnaire.

V. Sand Samples from different sites have collected to show the bed load types along this river.

VI. To measure suspended load, water have collected from different sites both during monsoon and post monsoon.

VII. To assess the temporal pattern of width and depth on spot survey has conducted to the bank dwellers and thereby measured the distance and depth.

VIII. Empirical survey has conducted to identify the Palaeo channels, moribund channels or ox bow lakes along the river.

IX. To assess the impact of irrigation and productivity in different catchments, from village level survey.

X. To assess the storage capacity and availability of Pond water survey has been conducted from monsoon to post monsoon season.
Plate 1.1: Resercher at the source of River Kopai

Plate 1.2: Resercher at the source of River Brakeswar

Plate 1.3 Researcher is busy to an interaction with crossing one of the village people

Plate 1.4 Researcher and her associates are anabranching channel of Kopai before Milanpur

Plate 1.5 Researcher’s associates are busy to measure water

Plate 1.6 Researcher and others are in the Velocity at Kopai Confluence way to Kopai Confluence
C. Post Field Work:

Analysis of Data

i. Different statistical techniques like correlation matrix, Regression, Principle Component Analysis (PCA) etc. have used to establish the nature of correlation among different physical and non physical parameters and to find out most important determinant factors for different results.

ii. Some indices like entropy index, Berry index for crop diversification, Weaver’s technique of crop combination, least square analysis for productivity trend etc. have used in agricultural analysis section. Allometric growth method using power regression and other statistical methods have used to explain the state of growth of agricultural components and degree of agricultural development.

iii. Different morphometric techniques have implied to assess linear, areal and relief parameters of the river basin.

iv. Weighted Composite indices have applied for measuring the integrated rate of flood intensity in different regions.

v. Spatial mean or gravity analysis method has used to assess the central tendency and temporal shift of central tendency of settlement concentration to determine the tendency of flood growth direction and settlement growth direction.

vi. Sand texture has analyzed with the help of sieving instrument, suspended sediment has extracted from collected turbid water samples.

vii. For land use land cover data analysis, Digital Elevation analysis, terrain modeling, relief zoning with the help of different remote sensing and GIS techniques 2D and 3D images have processed and presented.

viii. For vegetation and soil moisture mapping Normalized Differential Vegetation Index (NDVI), for the mapping of iron oxide content in soil, Index of iron oxide have properly utilized.

Presentation of Data

i. Analyzed data have been presented through different statistical technique by using SPSS software.
ii. For graphical presentation data modeling Arc GIS and Surfer 8 software have used. ERDAS imagine software has used to present remote sensing data.

It should also be mentioned that, the detailed methodology has included at appropriate places of each chapter.

1.4 Hypothesis

1. Human being has direct responsibilities to modify the hydrological and morphological scenario of the basin. Morphological dynamics controls the shift of land use and related instability.
2. Changing direction of different morphological parameters from source to mouth is not always in accordant with theoretical expectations.
3. Morphometric variables have significant impact on settlement pattern and agricultural pattern.
4. Hydro-morphological modification and canal network, wetland pattern have direct impact on agricultural pattern of the basin and other associated land use pattern.
5. Growing flood phenomena are directly and indirectly controlling the land use pattern specially agriculture and settlement. Arrangement pattern of settlement in the basin is not concomitant with flood intensity zones.

1.5 Location of the Study Area
Kuya River is a well known name in the riverine landscape of Eastern India. Taking start from a large pond of Khajuri village, Jharkhand and flowing S-E direction over Birbhum and Murshidabad districts of West Bengal it joins the Babla River near Sabitrinagar of Murshidabad district. Total length of the river is 176.4 km. The basin area can be delimited by 23°26′18″ North to 23°56′30″ North latitude and 87°13′ East to 88°09′30″ East longitudes covering an area of 1555.2 sq.km. (Fig. 1.1). Total length of the river is 176.4 km. About 24.64 km. is semi permanent. Total length of its main tributary- Brakeswar (Twin river of Kopai: Kopai and Brakeswar together have made Kuya river) is 82.98 km. out of which 10.57 km. is semi permanent and rest portion is semi permanent. The lower segment has embanked to restrict the over spilling tendency of the river.
Canal network in name of Kopai South Main Canal, Mayurakshi Canal System are existing in this basin. Tilpara barrage supplies water to this channel through these canal systems. Kultore barrage has built up over this river for irrigation purpose. It retains water except peak monsoon period. 27 brick kiln industries have found along this river.

Out of 15 blocks of this basin 13 blocks come under the Birbhum and Murshidabad district. Ketugram I block comes under Burdwan dist. and Kundahit block is under Jamtara district (Fig. 1.2).

Politically, two states (Jharkhand and West Bengal), three districts (Jamtara district of Jharkhand, Birbhum and Murshidabad districts of West Bengal) and 15 CD blocks like (Kundhahit, Rajnagar, Dubrajpur, Khoirasole, Suri II, Illambazar, Bolpur Srinikatan, Nanoor, Labpur, Burwan, Kandi, Bharatpur I, Bharatpur II, Ketugram I) are covering the entire basin.
1.6 Basis of Selection of the Study Area

1. Brakeswar and Kopai are Twin Rivers to create Kuya River. Brakeswar is considered as the tributary of Kuya river as per the length and base level conditions. But, the stature of the tributary is quite greater than Kopai before meeting with the tributary. Brakeswar is highly cultivated river in compare to Kopai river. Still migration of Kopai river channel and morphological modification of the river are running very fast. So, what are the impact of river migration, mechanism of palaeo channel development and their impact on hydrological and economic landscape etc. have inspired researcher to select this topic.

2. Interlinking of river through canal network bears important role to regenerate agricultural condition in the canal command area. So inquisitiveness has arisen on the kind of hydrological impact of this canal system which is one of the factor to select this basin as a study area.

3. Wetland modification in relation to irrigation and shifting of land use pattern is significantly prominent in this basin. So, phase wise analysis of surface storage evolution vis-à-vis land use change may help to find out hydrological conditions. This kind of tentative answer has encouraged to select this topic.
4. The cognitive master stream of this river system is river Mayurakshi. Master River is highly flood prone and intensity of flood has been inflating over period of time. What is flood situation and its trend of intensity etc. and how it exerts impact on human landscape is one of the major areas of interest.

1.7 Review of the previous Researches Related to the Present Context of the Thesis

The main aim of the literature review is to get an idea about different observation and findings in other scholar's work that will be necessary in substantiating the agreement put forward in the present study. It is also necessary because it helps to understand the magnitude of the problem.

Literature review related to flood:

During the end of 1950 and early 1960 US senate selected a committee on national resources and published many reports on Water resource activities in the monograph U.S: Future needs for navigation (from 1956 to 1960) U.S govt. printing office, Washington DC. Discussions on the various multipurpose river valley projects of US were made in the proceeding of the WMO/TJNRSCO symposium on Hydrological Forecasting (1967), World Metrological Organization. Research article on the various flood problems of US including the effects of urbanization, Changing land use problems, dearth of hydrological knowledge etc. were published by the University of Chicago (1961).

G. Petts and I. Foster, (1985) stated that a river Channel represents water course of a river confined within the limits of valley walls on both the sides. It is in fact a three dimensional form defined by its slope, cross section and patterns. While, channel morphology is the analysis of shape or form of a river channel. A river channel morphology broadly includes the consideration of (i) Channel geometry or channel cross sectional characteristics (ii) Channel fluid dynamics (iii) Channel hydraulic geometry (iv) Channel bed topography (v) Channel load (vi) Channel types (vii) Channel pattern etc. All these parameters in the one hand help to understand the channel dynamics and on the other hand flow dynamics of the channel and flood behaviour of the same.
Flood zoning based on geographic areas have been successfully completed in a wide range of environments around the world. So many parameters can be applied for micro level flood zoning. According to Magura and Wood (1980) hazardous flood event may be judged by characteristics such as magnitude, frequency, velocity, affected area, speed of onset, and duration.

Petts & Foster (1985), pointed out that normally size of sand particles gradually decreases downstream because of the loss of carrying capacity and competencies of the river. So granulometric analysis expressed the flood magnitude.

After 1980 various research papers on flood warning systems and methods of hydrological forecasting were published by the World Metrological Organization. The Inter-Agency Flood plain Management Committee was established in 1994 and formulated some post flood policies after a prolonged and huge flood of Mississippi in 1993.

Risk assessment for flood and drought have studied by Zongxue Xu, Kazmasa and Jingyuli (2001) who have given stress on Integrated Water Resources Management. According to them intensive study must be done on risk and uncertainty in hydrological processes.

Najing Hydraulic Research Institute of China has suggested (2004) some measures as flood management programmes for a country like China where the densely inhabitation in limited flood prone areas develop social conflicts. Participatory planning approach in flood mitigation has been proposed by Zang Hailun and Weng Kang. The new fund raising system has been approached by encouraging the investment from the enterprises, private sectors, foreign investors and the peasants in the form of labour contribution.

Md. Khalequzzaman (1994) stated that the magnitude, intensity, and duration of floods have increased in Bangladesh during the last few decades. It also appears that most of the flood control embankments experienced breaching since their completion, and are not very effective.

The World Commission on Dam (WCD) was born from the debate of the impacts of dam on local people and environment under the chairmanship of Professor Kader Asmal (1998, February). The major objectives were to review the development
effectiveness of large dams and to assess alternatives for water resources and energy development. The report (London&Sterling 2000) has given stress on the decommissioning of large dams for river restoration, especially in the United State where the decommissioning rate for large dams has overtaken the rate of construction. The United Nation’s World Water Development report (2003) shows 60% of the world’s 227 largest rivers are severely fragmented by dams.

Dr. Sutardi in his paper (2005) analyzed the causes of increasingly intensive Flood, challenges and constraints in the overcoming flood management. In this paper he stated that recent govt. in its comprehensive policies of flood management try to address mitigation of floods in comprehensive way, i.e., synergizing spatial planning, integrated water resource management, providing better management of drainage system and garbage disposal and controlling of development of new settlement and improving preparedness of community. All these are the effective and efficient approach to mitigate floods with also be reported.

Famous scientist Marlene Attz and Marcel Marchand (2003) have explained about sustainable flood defense scheme. ‘WWF’ (2004) also argued about the Integrated River Basin Management (IRBM) and Ecologically Sustainable flood Management.

J. Marlowe (1966) has stated the benefits of floods on the life and prosperity of the Nile river valley. Maria-Carmen Llasat, Mariano Barriendos, Antonio Barrera, Tomeu Rigo (2005) pointed out that Floods are the complex hydro-meteorological hazard. Both hydrology and meteorology play a major role. They analyzed the temporal evolution of floods in NE Spain since the 14th century.

Along with the published books since 1970 so many research articles on the causes and effects of floods of different small and large basins have published in different journals of Hydrology, Meteorology, Water Engineers, Institute of Civil Engineers, Geography etc. Ward R.C. (1978) has identified the various causes of floods and the nature of flood processes that vary spatially and temporally within a drainage basin with their locations and magnitudes.

The report on Risk Management Solution (1947), it has been discussed that climatic change was mainly responsible for catastrophic river flood of U.K. The flooding was triggered by the rapid thaw of deep snow that covered much of the country after one
of the coldest and snowiest winters on record. The thaw was triggered by the arrival of a succession of southwesterly depressions, each bringing significant additional rainfall.

Currently it is proved by the river geomorphologists that encroachment of the human beings on flood plain and different land use activities have significantly disturbed the ecosystem of the flood plains. E.E. Wool (2000) has given stress on the anthropogenic alterations of river regime and morphology. According to him flood - mitigating measures must have interconnections between floods, river channels and riparian corridors.

Some noted Govt documents on the floods and river systems of West Bengal are very relevant in the present context. W.A Ingles (1909), Chief Engineer, public works Dept has vividly described the conditions of the then existing various schemes of canals at Bihar, Bengal and Orissa. He made a discussion on the embankment of Damodar citing the views of Lieutanant Beadle, Secretary to the Military Board, Mr. E Drummond, Collector of Burdwan on the removal of right embankment of the river.

In the writings of James Fergusson(1912) a picture of the changing courses of the Ganges delta and the report of some old floods have unveiled. Human intervention in the river valley have changed the hydrological regime of the rivers of South Bengal and may be considered as the principle causes of the flood hazard of Bengal. Sir William Wilcox (1930) while dealing the flood problem of lower Damodar accused the river side embankments as the ‘Satanic chains’ in his article ‘Ancient System of Irrigation in Bengal’, pub. by University of Calcutta, and proposed the canals for draining out the flood water. Prof. M.N.Saha (1935) was also concerned about the obnoxious effect of dams and embankments on the hydrological character of the rivers while explaining the causes of the flood problems of Bengal (Collected Works of M.N.Saha Vol I).

Flood is undoubtedly the most dreadful natural calamity in India, specially in Eastern India. In order to ensure sustainable development of national economy a nationwide flood control management as well as flood disaster reduction system must be introduced. From the early ages large numbers of academic articles have published in renowned books, scientific as well as popular journals on the hydrological; problems
of the rivers, pattern of regional variability, review of the existing management programmes, future needs of flood management etc.

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The classic work of S. Kale provides a striking milestone in the study of flood hydrology. According to him, though all the floods are primarily meteorological in origin, geomorphic, geologic and anthropogenic factors also intensify floods. Geomorphic processes such as avulsion, channel migration, rise in the channel bed due to aggradations, etc. affect the water levels during large floods. Such processes are common in the Indus-Ganga-Brahmaputra plains (Kale, 2003a). In the Gangapains, the dynamic behaviour of river channels and frequent avulsions often divert the flow into a newly formed channel with low bank full capacity causing extensive flooding (Sinha, 2005). Some of the most devastating floods in the Indian subcontinent have been produced from failure or breaching of natural or man-made dams (Kale, 2004). In the 20th Century there have been more than a dozen floods in India that were related to failure of man-made dams (Kale, 2003a; Cenderelli and Wohl, 2003).

According to the Information Bulletin of International Federation of Red cross and Red crescent Societies, heavy monsoon rains have caused a second wave of floods that have swept across a vast and densely populated area of the Indian state of West Bengal on 29th September 2000.

Bandyopadhyay (1992) stated that as soil remains already saturated with moisture before peak monsoon, any additional input of heavy rain is enough to create a devastating flood.

The important works of Mahammad Muzzamil and Javed Alam (2010) reveals that investigation on the flood magnitude and their frequency are required for the design
of the various types of hydraulic structures and also in planning and management of watershed and river basins.

Anil K. Gupta and Sreeja S. Nair (2010) discussed flood risk reduction and management strategies in urban context with example of the Chennai city and draws attention of land-use planners and disaster management experts to integrate their efforts for better and sustainable results. According to them there are four interrelated but separable effects of land-use changes on the hydrology of an area: changes in peak flow characteristics, changes in total runoff, changes in quality of water, and changes in the hydrologic amenities (Leopold, 1968).

In this context it can be stated finally there is an urgent need to store systematically the available flood related data through computerization and also to make updating of the data. Some flood related studies on the neighboring river basins like Damodar river, Ajoy river of Rarh Bengal have done but no such in depth study on the hydrological characters of the river Dwarka has yet been done. Some scholarly works by Mukherjee, 2002; Mitra, 1998; Mukhopadhyay, 1995; Mukhopadhyay, 1992, Mukhopadhyay and Pal, 2007 are well known.

Ghosh and Dutta(2011) has to assessed the possible future changes in the flood characteristics and flood vulnerability of the Brahmaputra basin, India, due to climate and land use changes. Future projected metrological data from a regional climate model(RCM) simulation and the ‘Best Guess’ land use change scenarios have used to show the changes in spatio-temporal distribution of flood generation and its tributaries. These spato-temporal distributaries of flood regime changes have been analyzed to assess the flood vulnerability of the Brahmaputra basin.

Common people’s active participation in flood management is highly accepted by all the countries of south-east Asia. In addition to the above mentioned studies and management programmes the present geo-economic approach will lead us to a syngerrgism system of management programme through people participation. This study will enhance the self-confidence and the admiration on the indigenous environment of the bank dwellers.

Kalyan Rudra (2006) stated A catastrophic flood ravaged nine districts of West Bengal during late September –early October’ 2000. The disaster’ may be a weak
phenomenon which reportedly submerged 23756 sq. km. area and marooned 2.21 crores of population. The total loss due to this flood is estimated to be Rs. 41 crores, which is six times higher than the damage caused by the super cyclone (October, 1999) of Orissa. The loss revenue due to the suspension of service was estimated to be Rs. 11 crores.

Chandan Roy, chief engineer (2001) pointed that at present 42.3% of total area of the state is susceptible to flood spread over 110 blocks in 18 districts. The highest affected area of flood as recorded in 1978 is about 30,607 sq. km. About 23,970 sq. kms of area were devastated by flood in 2000. After last 1978 major flood, the state suffered consecutively in 1998, 1999 and 2000. In terms of loss of life and property the 2000 flood was almost comparable to 1978 flood.

Mr. S.C. Majumdar (1942), the eminent engineer, warned about the long term effect of embankment and he stated “….construction of flood embankment as a flood control measure would be like mortgaging the future generations to derive some temporary benefits for the present generation”. He also asserted that no river can be permanently maintained by dredging especially the tropical rivers with high ranges of flood discharge.

An is made by Suvarna Shah and J.N. Patel (2010) to discuss the system for survival – Flood Management to prevent flooding disasters, to minimize flood damages and to promote sustainable development. Decisions for flood management system are multidimensional and involve a set of environmental, social, economical and engineering aspects.

Common people’s active participation in flood management is highly accepted by all the countries of south - East Asia. Prof. M. Mukhopadhyay (2005) has given much stress on the perception study for mitigating the disasters and perception of the basin dwellers should be implied to chalk out the management strategies.

The new evolving concept of living with floods represents a holistic, locally based, participatory and integrated approach that recognizes the importance of flood in maintaining ecosystem and their role in human society.
H.M. Raghunath (1985) calculate return period and percent of probability i.e. frequency of flood with the help of the Weibull’s method and E.J. Gumbel’s by using peak discharge period.

Flood often cause sand deposition in the depressed areas within basin specially in wetland and river bed which encourage accretion of flood level. Since 2006 S. Pal has been working on wetlands in Hizole bill areas of lower Mayurakshi river basin. He has executed pegging operation in different wetlands to detect the rate of wetland deposition for each and every individual wetland (2010).

At present, with the aid of GIS and Remote Sensing techniques flood hazard mapping, sedimentation study of the reservoirs, flood morphological studies with its changing hydro-morphological patterns have been going on for creating long term data base on flood proneness, risk assessment and relief management. Various private and Govt. organizations are involved in such work sporadically. A study on the floods of 2000 on West Bengal using Remote sensing satellite data was done by S.K Bhan & the team (2000).

**Literature review related to morphometric analysis of the river basin:**

The history of morphometric analysis of river basin vigorously started since the period of Horton (1930 onward). A series of works on morphometric issues have done by the geomorphologists emphasizing a particular or a set of morphometric parameters. So precursors in this field are Horton, Strahler, Schumm etc. R.E. Horton (1932) in his work *Drainage Basin Characteristics* introduced several morphometric techniques like stream ordering, bifurcation ratio etc. A.N. Strahler in 1957 and 1964 consecutively published his two well recognized research article (*Quantitative Analysis of Watershed Geomorphology*) and research oriented chapter (*Quantitative Geomorphology of Drainage Basins and Channel Networks.*) of the *Hand book of Applied Hydrology* edited by V.T. Chow. In these work he systematically organize different dimensions of morphometric aspects and established different morphometric laws. S. Singh & M.C. Singh in 1997 published their article on *Morphometric Analysis of Khanar River Basin* in National Geographical Journal of India properly applying and illustrating different morphometric aspects of Khanar river basin. Application of remote sensing for morphometric study have brought new dimension in Geomorphology. S.K. Nag, in 1998, analyzed morphometric characters in the
Chaka sub-basin, Purulia Dist., West Bengal using remote sensing techniques and published his work in the Journal of Indian Societies of Remote Sensing. V.C. Miller, in 1953, has published his research project on Drainage Basin Characteristics in Clinch Mountain area, Virginia and Tennessee emphasizing morphometric characters of the mountain areas.

P. M. Mather and J. C. Doornkamp in 2008 published their work on Multivariate Analysis in Geography with Particular Reference to Drainage-Basin Morphometry. In their work, they applied different multivariate techniques like PCA, Cluster analysis, Multiple correlation analysis, partial correlation etc. and interpreted how one morphometric parameter is affected by another.

In braided streams, channel change occurs due to sediment transport and the motion of barforms through the channel (Leopold, and Wolman, 1957). Reservoir like dam, barrage and sudden flow from those storages often causes the shifting of channel at faster rate.

Lateral migration rates often increase with flow energy, which includes the kinetic energy of the water discharge and the potential energy measured by either the valley or channel slope. Hooke (1979), Nanson and Hickin (1986), MacDonald (1991), and Lawler et al. (1999) found that lateral migration rates increase with flow energy in meandering rivers. Bledsoe and Watson (2001) found that measures of stream power were significantly correlated with the degree of lateral stability in river channels measured by the transition to braiding. Along those same lines, Knighton and Nanson (1993) proposed that high flow energy was necessary for planform shifts from meandering to braided. However, Brice (1982) showed that both braided and meandering streams exhibited either high or low lateral mobility, depending on other factors. He suggested that the lateral mobility of meandering rivers is a function of downstream variability in width. For braided rivers, if the braidplain is sinuous and point bars are visible, the rivers tend to be highly mobile; but if a braided river is straight and wide, it tends to be more stable. These wide, straight, braided rivers are typically adjusted to a very large discharge, i.e., flow energy.

The planform geometry of channels also relates to lateral migration rates. Several studies found that there is a maximum erosion rate for meandering rivers corresponding to an $Rc/W$ somewhere between two and three (Hickin and Nanson, 1975, 1984; Nanson and Hickin, 1983; Biedenharn et al., 1989). The correlation
between radius of curvature and migration rate suggests that there is also a value for
sinuosity that would correlate to maximum lateral migration rates.

The channel width has been noted to be important in association with lateral
migration (Brice, 1982; Nanson and Hickin, 1986). Channel width has also been used
to scale for flow energy and for river size (Brice, 1982; Nanson and Hickin, 1986) and
as such could be a useful variable for correlation with lateral movement. The
relationship between bed material size and migration rate varies. A fine bed material
(noncohesive) is easier to transport and erode. As Nanson and Hickin (1986) showed,
the bed material size at the toe of the slope can be a good indication of the resistance
of the bank. At the other extreme, for instance downstream from a dam, armored beds
are no longer mobile and the flow often scours the banks. Additionally, incision
associated with armoring results in high, often unstable banks. The result is that high
lateral migration rates can be associated with both small and large bed material size.
However, it would be expected that the highest rates would be associated with smaller
sized material in a wandering/braided river.

Sediment supply also impacts the rate of lateral migration. Carson (1984) suggested
that a high sediment supply is an important factor for the development of braiding and
that the banks are often a source of sediment. High rates of sediment transport can
result in aggradation and avulsion, whereas extremely low sediment supply
encourages bed and bank erosion. Bledsoe (1999) suggests that sediment supply and
bank resistance determine whether instability in a channel is manifested laterally
(braiding) or vertically (incision). The sediment transport balance between the
transport capacity of the channel and the sediment supply from upstream sources is
also very important. Channels will aggrade and possibly avulse when sediment
transport is capacity limited (i.e., the supply exceeds the transport rate). On the other
hand, channel incision and potential bank erosion result when the reach is supply
limited. The state of equilibrium occurs when the sediment transport capacity of a
reach equals the sediment supply (Julien, 2002).

Rivers reach a state of quasi-equilibrium after decades to centuries of adjustment.
This quasi-equilibrium state is defined as having no net accumulation or depletion of
sediment in the bed, banks, or floodplain and nearly constant average hydraulic
characteristics (width, depth, velocity, roughness, slope, and channel pattern) through
a reach of channel at a given discharge (Andrews, 1986). Modifications in the natural
flow regime can drive morphological changes in channel form, disrupting the existing quasi-equilibrium state (Petts and Gurnell, 2005).

**Literature related to the impact of dam:**

Downstream geomorphic and hydrological impacts of dams vary with the operational strategies of dams and the characteristics of downstream river channels. Studies of regulated rivers have revealed varying responses including narrowing of channel, channel widening, degradations or aggradations of river bed occurring at different temporal scale (William and Wolman, 1984; Collier, et.al., 1996; Friedman, et.al., 1998; Xu, 1997). Friedman et.al. (1998) found from the study of 35 dams on large rivers in the Western US that rivers with braided patterns tended to narrow following dam construction and meandering rivers experienced reduction in channel migration rate. Dewey et.al., 1979; Richard, 2001; Leon, 1998; Bauer, 1999; Lagasse, 1980 etc. some scholars asserted that dam traps virtually all the upstream sediments as well as controls the water discharge and resulted channel degradation, channel bed coarsening etc.

Given the complexity of hydrological and geomorphic response of rivers to dam and reservoir construction, case studies of rivers for which both pre and post dam data are valuable. Understanding the river’s dynamics prior to dam construction can enhance our understanding of the impacts of a dam on the downstream river reach. Quantifying the historical water and sediment inputs to a river reach and identifying the resulting responses can aid in understanding the changes induced by dam construction. William and Wolman (1984) highlighted the necessity of understanding the unregulated water and sediment regime as well as change caused by flow regulation. Such understanding can provide opportunities to differentiate between natural and induced changes.

S. Pal(2012) in his paper has revealed that damming alters flow level status, sediment availability, up and down stream variability of different morphological parameters like total width, depth, wetted depth, wetted width, erosion character, micro level variation of long profile etc.

The construction of more than 8,00000 dams all over the world including 5,100 big dams and reservoirs (9% to world total) on the rivers of India, 6500 big dams (15% to world total) and total 75000 including all on the rivers of United States (Graf, 1999),
on the rivers of China (46% to world total) etc. has resulted in alteration of the hydrology, geometry, and sediment flow in many of the river channels down streams of dams. A regulated river is caught between the conflicting goals of maintaining the virginity of channel flow, channel morphology and human uses (Richard, 2001). Kuya river of Eastern India is no more exceptional in this regard after damming on it.

In India, there are still diversified outlooks in favour or against the construction of dam. Man-made barriers like dams and storage reservoirs, leads to excessive deposition upstream and erosion in the downstream below the structure, and consequent increase of flood levels and extent (Kale, 1998). Sir William Wilcox (1930), Prof M.N.Saha (1935), Mr. S.C. Majumdar (1945) etc. have warned against construction of dam across river and embankment along river in aim to control flood, detain sediment etc. S.C. Mazumdar stated that construction of dam, embankment as flood controlling measures would be like mortgaging the future generations to derive some temporary benefits for the present generation.

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Sand splay is one of the newly emerged but crucial anthropo-geomorphic hazards after the passing of flood. It is the deep sheet of sand deposited at the back swamp areas due to sudden break of river embankment and ejection of sand from the riverbed all of a sudden. The rate sand splay formation has been hastened many times due to significant growth of manmade flash flood (Mukherjee, 2000). S. Mukhopadhyay, & M. Mukherjee in 2005 emphasized the role of dam and barrage for flood intensification and sand splay extension. Ajoy river basin is heavily exploited by human being in many ways. Therefore, flood propensity is very high, and as the long
stretches of the river made up of earthen embankment, phenomena of embankment breaching is common which directly leads to the formation of sand splay. Progress in coupled hydrological/erosion modelling is more evident at the field scale or in small homogeneous basins, for which a number of models are available: (a) empirical models (USLE, RUSLE), (b) those that are largely based on mathematical descriptions of physical processes (WEPP, EUROSEM), and (c) intermediate models combining some mathematical process description with empirical relationships (GLEAMS, EPIC, ANSWERS, AGNPS) (see the overview in Favis-Mortlock et al., 1996). The availability of GIS tools and more powerful computing facilities makes it possible to overcome many difficulties and limitations and to develop distributed continuous time basin-scale models, based on available regional information. Recent developments provide a few models which allow evaluation of erosion processes at the basin scale, among them SWRRB (Arnold et al, 1990), SWAT (Arnold et al, 1993), and SWIM (Krysanova et al, 1996a,b). Usually, the basin-scale model includes a version of a field-scale model as a module, plus a parameterization of the routing processes. Thus, a simplified version of EPIC (Williams et al, 1984) is included in SWAT and SWIM for simulation of crop growth and sediment yield processes.

**Literature review related to changing form of surface and subsurface hydrological phenomena & its impact:**

Intensification of agriculture after Green Revolution era in India (after 1968-69) has exaggerated ground water deterioration with rapid rate. Boro paddy in Indian agricultural atlas has got significant place only after this period. The worst affected states of India in this connection are Punjab and Haryana which has been mentioned by P. Singh and I. Singh (1996) in their article on Ground Water Depletion in Haryana and Punjab.

West Bengal also gravely affected by agricultural intensification induced ground water depletion. S. Pal (2008) also clearly indicated the steady depletion of ground water with increasing agricultural intensity.

S. Pal and O.C. Akoma (2009), in another article warned that unscientific and misfit agricultural practices in relation to geophysical environment may bring mishap like water scarcity in the wetland area.
Report of Ground Water Estimation Committee by Ministry of Irrigation, (June 1997) mentioned that ground water depletion is not any regional problem, by and large this problem infested entire ground water and surface water atlas. Excessive consumption of water in agricultural sector and allied sector are some well recognized cause for such trend of depletion.

Artificial groundwater recharge is a process by which the groundwater reservoir is augmented at a rate exceeding the augmentation rate under natural conditions of replenishment. In some parts of India, due to over-exploitation of groundwater, decline in groundwater levels resulting in shortage of supply of water, and intrusion of saline water in coastal areas have been observed. In such areas, there is need for artificial recharge of groundwater by augmenting the natural infiltration of precipitation or surface-water into underground formations by methods such as water spreading, recharge through pits, shafts, wells et cetera (Amartya Kumar Bhattacharya, 2010; IJRRAS 4 (2)).

Siltation related retention capacity loss, damming, bridging, construction of road, spread of agriculture, urbanization, spread of rural settlement, contamination of wetland water through solid, liquid waste etc. collectively have confronted wetland in great crises. So many works with greater concentration by different scholars have been forwarded.

The Bureau of the Convention on Wetlands in 1998 had forwarded an article on *The Key Role of Wetlands in Addressing the Global Water Crisis* in the International Conference in Paris on Water and Sustainable Development where this society clearly expounded that almost 50% wetland areas of India, Australia, New Zealand, Tanzania etc. have converted into other traditional land use practices like agriculturization, urbanization etc. Here warning has been ringed that if immediate checklist is not possible to prepare and implement, very near future wetland communities will be obliterated completely but their economic potentialities and ecological diversity should not be overlooked.

Liu, H. et al. (2004) in his article *Impacts of Wetland of Large Scale Land use Changes by Agricultural Development* have shown that wetland are losing their character with massive intervention of human being. As a result large amount of land is getting exposed is favourable for agriculture. Such exposures again responsible for
large scale change of land use pattern i.e. agriculture is getting much openings for spread.

Waterloo University of Canada has completed a long term project about the implication of wetland in human life and effect of agriculture and urbanization on wetland since 1970 to 1997. It is obviously a mile stone work in this ground.

In U.K intensive research work is still going on about *Wetland of Coastal Region* emphasizing wetland bird survey, international collaboration, species turnover, non-native water bird species, water bird an climate change, water bird and habitat change etc. As per their findings due to climate change non-native birds have become highly irregular in their movement.

Massive changes of wetland system in terms of hydrological and ecological perspective is an emerging issue since 1965, so a galaxy of scholars, institutions and organizations have made fruitful attempt to detect the change in wetland. Time series satellite imageries analysis by NRSA have clearly proceeded some points that wetland area has been getting squeezed, wetland status gradually getting deteriorated, hydrological irregularities have been increasing. Some important articles in this regard streamed out from Journal of Indian Society of Remote Sensing are *Landscape Dynamics in Hokersar Wetland, Jammu & Kashmir-An Application of Geospatial Approach* by Joshi, P.K., Humayan, R., Roy, P.S. during 2002, *Loktak Notified Wetland Ecosystem and its Catchment* by Singh, Randhir, Singh, N.S., Garg, J.K., & Murthy, T.V.R. during 2000, *Delineation of Surface Water logged areas in Parts of Bihar using IRS-IC, LISS-III data* by Chatterjee, C., Kumar, R., Mani, P. by 2003 etc are important. All such articles strongly shown those wetlands have been squeezing in faster rate in recent times.

Ahamed, S.I., Tiwana, A.S. (2005) in their article *Disappearing Wetlands: A Threats to Biodiversity* published in Geographical Review of India argued that wetland is geo environmentally precious but our indifference over looking and desperate tapping, profit making wetland areas have been gradually but devastatingly losing their existence.

Mistch and Gossilink (2000) have also suggested that in regard to wetland values, 3% to 7% of temperate land should be in wetland to provide adequate flood control and water quality values for the landscape.

Mukhopadhyay, S. (1987), Khotari, A. (2001), Ahamed, S.I., Tiwana, A.S. (2005) etc. some Indian scholar have also preached in their articles that wetland character its land use etc. has been changing at a very faster rate.

Ahamed, S.I., Tiwana, A.S. (2005) have argued that wetland is geo environmentally precious but our indifference over looking and desperate tapping for profit making wetland areas have been gradually devastatingly losing their existence.

**Literatures Related to the Regional Basin**

A little works have done regarding hydrological shift and land use pattern of Kopai River Basin. Some concerned works are-

S. Basu(1972) in his article mentioned the influence of lateritic region on fast rate shoal deposition in the river. Anthropogenic activities encourage the erosion rate and how it is related with spreading of this deposition has explained in his article.

S. Bandhopadhyay, in 1987, in his article has clearly defined the strong rate horizontal, vertical gully formations. The head ward, vertical and lateral extension of gullies produce huge amount of geo materials which again increases the sedimentation level of in the river. According to him fast rate gully formation mainly responsible for diversification in badland topography in Santiniketan area. S. Mukhopadhyay and S. Pal,( 2007) extend the previous work in same trend line. Their results speak that the of erosion in this area is fastly increasing over time.

S. Mukhopadhyay, (in 1991), in her article describes the spatial pattern of waste land character and causes of waste land formation. She established the fact that existing land use pattern and deforestation and man initiated gullies are encouraging the formation of wasteland in Kopai River basin. Her remarkable work on soil Erosion in Kopai River Basin, has explained the spatial pattern of soil erosion and the factors related for such spatial diversity of erosion rate. She also emphasized on the influences of growing erosion in river channel.
M. Mukhopadhyay’s edited “Kopai Nadir Kada Paye” (trekking report in regional language) explains the traditional knowhow and strategies of the bank dwellers on the use of river for their daily life at different parts of the reach.

Some Observations from Literature Review

- Hydrological evolution of any river basin is a natural process but human interaction and shifting nature of land use make it over dynamic and arrhythmic.
- Flood is a common hydrological event but the effect of urbanization; changing land use pattern, dearth of hydrological knowledge etc. are responsible for flood intensification.
- Large scale agricultural practices in relation to geophysical environment causes the depletion of ground water.
- Wetlands are in great crises for siltation related retention capacity loss, damming, construction of road, spread of agriculture, urbanization, spread of rural settlement etc.
- Construction of dam on river channels controls the hydrological character of downstream in varying response including less water flow, channel narrowing or widening, degradation or aggradations of river bed.

1.8 Importance of the present study

This work will add new dimension to the academic encyclopedia of research work. The changing hydrological situation and its impact and justification will give a basic frame work to the planner and policy makers when plan regarding drainage hydrology, wetland hydrology, canal plan and agro-economic development is going to be adopted. Moreover, the suggestions of this work to manage hydro-agrological resources also will help them to tally during decision making. Common people will get real idea what is the present scenario of the water use status as irrigation, pattern of land use change which they are performing, its positive and negative impacts etc. It will also guide them how shifting of river, spread of canal, wetland etc. are influencing the land use evolution and how land use pattern should be linked with hydrological evolution. All these will again help them to take decision how to behave with hydrological system dynamics.