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RESEARCH ARTICLE

RIVERINE MORPHOLOGY AND SOCIO-ECONOMIC ENVIRONMENT – A REVIEW

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ABSTRACT

The main objective of the present paper is to identify and fill up the voids in terms of concepts and methods of research work on 'Riverine Morphology and Socio-economic Environment in the southern part of Nadia District in West Bengal, India'. This work will make suggestion relating to the research work to be conducted by research scholars on almost similar type of problems and methods. For achieving the target, the authors have reviewed the previous literature thoroughly. The literature survey has been attempted on almost all the main aspects of the research topic. The previous works related to Riverine morphology, land use, land use model, socio-economic environment, regional development disparity *etc.* have enriched the present study.

INTRODUCTION

The challenge to resolve empirical issues on river and environment have motivated and inspired researchers to carry on investigations on the theoretical and applied aspects of riverine morphology and environment. Their research design and findings have stimulated academic and professional enquires for further research. For the present study, interaction with some of the authors through published books, journals and records have been conducted to get acquainted with the nature of work that has already been done. Decolonisation in Asia and Latin America ushered an era of researches in applied sciences. Scientists in the newly independent countries were requested to apply their scientific knowledge in the exploration of new resource horizons and to solve socio-economic problems by applying scientific knowledge. As a consequence, researches in applied sciences proliferated.

The Study Area

The spatial unit of the present investigation is the southern part of Nadia District, West Bengal. The study area extends from 22°47′33′′ to 23°20′ N latitudes and 87°19′32′′ and 88°45′27′′ E longitudes covering an area of 1132.30 km². The river Bhagirathi-Hooghly forms the western boundary which has separated the area from Burdwan and Hooghly districts. In the south and south-east the area is bounded by North 24-Parganas District, in the east by Bangladesh and in the north by Murshidabad District. The area consists of 5 Police Stations *viz.*, Santipur, Ranaghat, Chakdah, Kalyani and Haringhata and lies entirely within the Kalyani and Ranaghat Sub-divisions. There are 5 Community Development Blocks *viz.* Santipur, Ranaghat – I, Ranaghat – II, Chakdah and Haringhata. There are 491 villages in the study area (Fig. 1). The study area is flat and the general aspect is that of a vast level alluvial plain, dotted with villages and clusters of trees and intersected by numerous rivers, backwaters, minor streams and swamps. The average height of the study area is 9 metre above mean sea level. Geologically, the study area lies in the 'Rajmahal-Meghalaya Gap' and is composed of recent deposits. The soil is composed of recent alluvium and the surface consists of sandy clay and sand along the course of the rivers. Oppressive hot summer, high humidity and well distributed rainfall during the monsoon season are some of the characteristics of the climate in the area under study. At present all the rivers *viz.* Bhagirathi-Hooghly, Churni, Ichhamati, may be described as off-shoots of the Padma, or main channel of the Ganges. There are many lakes and marshes (locally known as *bils*) in the study area. Some are of small size, but others are practically inland lakes.

The study area has a total population of 14,28,992 (Census, 2001) with a population density of 1262 persons/km². The population is distributed unevenly because of surface configuration. The flood plains, levees and the river banks are highly populated while the lowlands liable to annual inundation and swampy and marshy areas are usually devoid of population. Given the natural endowments of the study area, agriculture dominates among all the economic activities.

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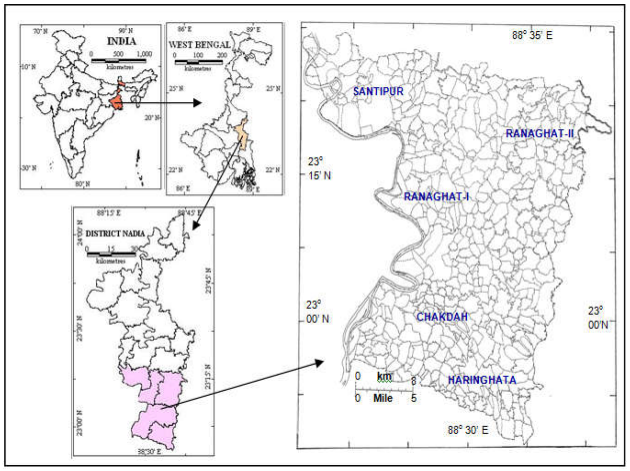

Fig. 1. Location map of the study area

Conceptual Aspects

Since times immemorial, human civilization of our globe has chiefly centred on rivers and river basins. The early growth of settled human life in river basins is ascribed with the fact that rivers supplied the largest amount of needs of early societies which were mainly agricultural. The river is not simply a flowing mass of water. Besides water, river carries varieties of products including sediments and nutrients besides water, and builds up a vast stretch of alluvial tract of varying morphological characteristics. River has innumerable importance in civilization. The assessment of the rivers thus depends upon the potentiality of the varieties of use of its water and material it carried in. Therefore, the river has to be understood thoroughly to carry on this work. The term 'environment' etymologically means 'surrounding'. It represents the surrounding conditions and/or forces that influence or modify. It can broadly be divided into two groups:

(a) Physical Environment: The whole complex of climatic, edaphic and biotic factors that act upon an organism or an ecological community and ultimately determines its form and survival constitutes the physical environment.
(b) Social Environment: The aggregate of social and cultural conditions (as customs, laws, language, religion, economic and political organizations) that influence the life of a community is referred to as the social environment.

Land is the container of all the physical, biological and cultural components of the environment. Land use is the universal instrument of modification of the environment. Environmental impact is the response of environment to this modification. Ecologically, it can be said that environment is of two types:

(a) *Inherently stable/ Resilient Environment*: It has an ability to revert its original form after stress from a given land use regime is discontinued.
(b) *Fragile Environment*: This environment is susceptible to change.

The study area is undergoing changes due to anthropogenic activities which are affecting both the physical and socio-economic environment of the area. Thus, the study area can be categorized under fragile environment and thus requires special attention.

Survey of Existing Literature

Virtually no work on this particular topic has been made previously. However, the authors have been benefitted by getting various details published in books, reports, journals *etc.* related to the topic. The total work has been divided into five major aspects *viz.* Riverine morphology and environment, a theoretical aspect; southern part of Nadia District, the study area; surface water management; human interference in surface water bodies and studies related to socio-economic environment

Riverine Morphology and Environment, a theoretical aspect

Most of the books on *riverine morphology* have been written by physical scientists. These books have been consulted to have a comprehensive knowledge on the general processes of riverine morphology. Crickmay (1974) has discussed on fluvial dynamics, channel equilibrium relationships and the secular work of rivers. Gregory's (1977) book is a collection of papers in the context of mechanics and sedimentology of rivers and changes in channel geometry and channel pattern. Knighton (1984) has dealt with drainage networks, fluvial processes, and the adjustment of channel form and channel changes through time. Morisawa (1985) has dealt with stream denudation, hydraulics of stream flow, entrainment and transport, mechanics and landforms of fluvial erosion and deposition, river morphology (the channel and channel pattern), quantitative basin analysis, structural and lithological controls and finally the impact of man on rivers. Bridge (2003) has put forward an overview of river systems and discussed in detail on the fundamentals of water flow and sediment transport, alluvial channels and bars, geometry of floodplains, nature of floodplain deposits, along-valley variations in channels and floodplains and channel-belt movements across floodplains.

Environment is a comprehensive term and it includes both physical and social environment. The general concepts on environment have been gathered from the writings of Aaradhana P S (1998), Prasad and Basu (2000), Biswas and Dasgupta (2000), Singh (2003) and Saxena (2007). All of them have discussed in detail about the various aspects of environment and has put forward their views regarding man-environment relationships, environmental degradation, risk assessment, environmental impact assessment and finally the strategies for environmental management. Rao (2006) gives a clear idea of social structure, social process, social inequality, social mobility, social change, social institutions and the role of individual in society and forms a basis of analyzing the socio-economic environment.

Southern part of Nadia District, the study area

Information on the various aspects of the study area has been gathered from various sources, the principal among them are cited in the following paragraphs.
General information: Hunter (1877) provides information on the history and revenue account of the Nadia rivers, the

Census of 1872, population characteristics including immigration and emigration data, land tenures, rates of rent, educational statistics and also the fiscal divisions of the undivided district. The data available are of ten years (1860-61 to 1870-71). Garrett (1910) supplies basic information of Nadia district before the partition of 1947 and Majumdar (1978) does the same but to the truncated district with an eye to the progress and achievements of the people since Independence. Both of them convey information regarding the physical aspects (*i.e.*, climate, soil, vegetation and river system), history, people, agriculture and irrigation, industries, communications, administration, education, health, culture, public life as well as places of interest, the former prior to independence and the latter after independence. Historical evolution of socio-cultural and economic base of the district has been described in detail in both of their writings. Thus, it gives a well furnished past record on all geographical aspects of the district and is very much helpful in the analysis of present scenario of the study area. Mitra (1953) has put forward an account of land management in the state of West Bengal from the year 1870 to 1950. Detailed climatic data, geological description, soil analysis, regional classification of land, account of land employment, crop statistics, settlement reports, chronological record of natural calamities have also been put forward by him. Bagchi and Mukherjee (1978) have carried out a Diagnostic Survey of Deltaic West Bengal and have brought into light the ecological conditions (morphology, drainage, seasons, ground water and soil) and economic conditions of the delta as well as the land use, input-output structure, rural industries of the delta.

Geology: Pascoe (1962) and Mathur (2003) have discussed the geology of the Indo-Gangetic Plain in detail. The Geological Survey of India (1999) has provided information on the geology and physiography of the alluvial and deltaic plains of the study area. These records have been treated as fundamentals of geological description for the present research work. Sengupta (1972) has thrown some light on the Geological Framework of the Bhagirathi-Hooghly Basin. He has classified the basin into subsurface structural units. It has been suggested that the easterly shift of the main flow of the Ganga is due to the blocking of Hooghly estuary by tidal sands. The geological processes seem to be in favour of revival of the main flow of the Ganga through the Bhagirathi channel.

Soil: Maji (1993) has identified different soil associations of the district of Nadia, analyzed their evolution as well as physical and chemical properties and also put forward the types of crops best suited to the different soil types of the area. He has also determined the block-wise land use orientation and irrigation orientation of the district. Nayak, Sarkar and Velayutham (2001) have prepared Soil Series information of each physiographic region of West Bengal which describes their location, classification, associated soils, their extent, important morphological, physical and chemical properties, potential and constraints for crop management along with vegetation and climatic resources.

Riverine Conditions and Irrigation: Inglis (1909) has written an article on the Nadia Rivers in which he states that these channels are effluents or flood spill channels from the Ganges. He has described the state of these channels in 1881, revenue administration of the Nadia Rivers and has enquired into the possibility to open a channel by dredging. Fergusson (1912) has brought to light the changes in the delta of the Ganges. Hirst (1915) has written a detailed report on the Nadia Rivers. It consists of a general description of the Hooghly river, the general formation of the Bengal Delta, major disturbing agents in the river system of Bengal, the effect of old alluvium on the fresh water-supply of the Hooghly, the effect of other river changes on the fresh-water-supply of the Hooghly, interference with the Nadia Rivers by human agency, shoals in the Nadia Rivers, discharge observations, *etc.* The text is well supported by maps. Reaks (1919) in his report on the physical and hydraulic characteristics of the rivers of the delta has given a description of the development of the delta and of the Nadia Rivers; physical conditions prevalent in the Nadia Rivers and tributaries, alleged deterioration of the Nadia Rivers and suggested remedies. Addama-Williams (1919) has analysed the history of the rivers in the Gangetic Delta from the year 1750 to 1918.

Mukherjee (1938) has analyzed the changing face of Bengal with particular reference to riverine economics. He has stated that the hydraulic dynamics of the delta were the product of the inextricable mixture of ecological and human factors in the colonial era. He has focused on the naturally shifting courses of rivers on the one hand and the short-sightedness of the colonial water and land management policies on the other. He has also discussed about the silting up of Nadia Rivers, artificial interferences in the river and man's disregard of the natural balance of a river system. He has also raised some of the intricate questions on the use of water and irrigation for ecological, demographic, economic, social and cultural points of view which were definitely coloured by the rudimentary views of political ecology, paving the way for cultural politics of natural resources in the process.

Willcocks (1930) has analysed the ancient system of irrigation in Bengal and its application to modern problems. Majumdar (1941) has described the nature of the rivers of the Bengal Delta, floods and river management strategies. Basu and Chakravorty (1972) have investigated into decay of the Bhagirathi drainage system. Chatterjee and Majumder (1972) have discussed the drainage problems of the Bhagirathi basin. Chakrabarti and Sen (1972) have discussed the flow condition and sediment transport characteristicts in the Hooghly and the effects of upland discharge.

Bandopadhyay (2007) has given a detailed description of all the rivers of the area *viz.* Churni, Ichhamati, Jamuna, Marali and Bidyadhari. He has discussed in detail the evolution of the Churni river which is actually a dug canal. He has also provided information on the large lakes (locally called bils) of the area. Rudra (2008) has put forward a detailed account on the Bhagirathi-Mathabhanga-Churni-Ichhamati river system of the area. He has discussed the characteristics of these rivers from 1779 to 2008. In his analysis he has taken Rennel's map (1779) as reference. From his study it has been found that there has been considerable shifting in the river channels. Abandonment of former courses by the rivers have led to the formation of ox-bow lakes, cut-offs and marshes. The Jamuna, Bidyadhari and Marali rivers once connected to the Bhagirathi at present have lost their connections with it and have deteriorated to a large extent.

Underground Water: Sarkar (1981) in his article 'On the fluctuation of water table surface in the district of Nadia, West Bengal' analysed the water table situation of the district of Nadia in terms of its seasonal fluctuation and variability. The water table has got the property of spatial as well as seasonal variability. Pre-monsoon and post-monsoon variability as well as inter-monsoon fluctuation of water table has been computed. Sikdar (2008) has stated that groundwater occurs in the subsurface sediments under unconfined condition. The huge thickness of the alluvium with good aquifer materials and effective recharge prospects makes the area one of the most developed well fields in the state.

Management, **Environmental Assessment and Impact of human interference in Surface Water Resources**

Basu (1973) has thrown light on the decay and the associated problems of river dynamics of the Bhagirathi valley. The decay of the Nadia rivers in the 17^{th} and 18^{th} cenuries, the continual flight of the principal flow of the river Ganga along its easterly distributaries, the rapid silting in the lower section of the Bhagirathi-Hooghly channel, etc., are some of the more salient expressions of this decay. The fertility of the land is on the decrease with the diminishing rate of water supply from the river throughout the year and as such the crop failure is usual. The regular influx of refugees from Bangladesh has added gravity to the existing problems. His study reveals that with the increase of population and the decrease of resources, the future economy of the region is in great peril. Conway (1990) has discussed the basic concepts and issues of water resources development and the environment. Water is a part of the environment and managing or exploiting water resources has an impact on the environment. He has suggested the categorization of the major forms of water exploitation before analyzing the consequences of water resource development. Frequently major environmental impacts arise because an activity such as discharge of pollutant sets in motion a chain of events with far reaching consequences. He has regarded the water resource system as a complex agro-industrial-socio-economic-ecologic-hydrological system and has conceptualized a hierarchy of such systems, extending from the individual irrigated field through the command area to the impoundment project to the river basin and the national water system. According to him, the water resource systems are characterized by four interconnected system properties – productivity, stability, sustainability and equitability. Together they provide a measure of the "value" of a water resource system which has a present as well as a future dimension and may be related to the human population that benefits from the system. He has also stressed the need for policy research, practical analytical tools and development packages aimed at increasing the sustainability and rectifying undesirable inequities in the water resource system. Huq (1990) has stated that there are intricate relationships between flowing water, static water and rainfall patterns. The surface water system follows a natural pattern and any human interference that interferes this natural pattern creates ecological imbalance. Thus, it becomes essential to ensure minimum disturbance to the surface water system while undertaking development plans in the water sector. According to him, zoning is necessary to ensure that water development activities will cause minimum disturbance to the environment. Zoning has to be done by considering several elements like river system, static water bodies, rainfall, drainage pattern, flooding characteristics, temperature, aquifer conditions, soil characteristics, crops and cropping patterns.

Chowdhury and Bhuiya (1990) have tried to enhance the general understanding of the surface water system and its linkages with the landforming processes. They have attempted to examine the state of our understanding of the physical impacts of flooding, erosion, transportation and deposition of sediments on the environmental processes. Rahman and Bisset (1990) has discussed, though in most general terms, some of the methodologies of baseline, environmental assessments and environmental impact assessments of surface water systems. They have put forward a conceptual framework for addressing the assessment of surface water systems. Description of water quality and quantity conditions is fundamental to baseline information provision. Softestad (1990) has considered time allocation studies as a methodology to aid in planning, implementation and impact analysis of interventions in surface water systems. He has also given due consideration to the local population living, as well as making a living, in surface water systems. Their behaviour has been specially taken into account for time allocation studies. The aforementioned five studies are written by keeping Bangladesh in the background. But these studies are very well relevant in the present study area as both the areas are part of the Ganga–Brahmaputra delta and bear wide resemblances of physical and socio-economic environment. These basic ideas will be of great help in the present research work and shall be immensely beneficial during the field work.

Rudra (2008) has discussed in detail the nature of human interference in surface water bodies of the study area. All the rivers are subjected to pollution, encroachment, obstruction, eutrophication, siltation, weed infestation and elimination of aquatic flora and fauna and this has led to the overall degradation of the aquatic ecosystem of the area. Chatterjee (2009) has delved into the problems and management of natural riverine wetlands in six districts of West Bengal. The district of Nadia is also included in his article. The wetlands of this district are facing the problems of siltation, encroachment, pollution, weed infestation and unscientific agricultural and aquaculture practices. He has suggested building a database of wetlands for proper management and monitoring of the wetlands. Rudra (2010) has made a comparative assessment of the conditions of the Bhagirathi-Hooghly river and its tributaries in the past with that of the present. The study has revealed that the condition of the rivers have degraded to a great extent mainly due to anthropogenic activities. Increase in the number of factories and settlements alongside the rivers have intensified the pollution problem of the rivers in the area. Sewage pollution has also increased the concentration of *coliform* bacteria manifold. He has also stated that despite the initiation of the Ganga Action Plan the problem of pollution has not been solved due to lack of monitoring and proper implementation. He has also suggested reviving the wetlands and draining the waste water into them as a measure to control river pollution. Roy (2010) has pointed out a massive elimination of aquatic flora and fauna in the rivers of the area. Indigenous varieties have almost disappeared and have been replaced by exotic species. Mukhopadhyay (2010) has stressed upon the importance of mass awareness and the proper

implementation of the 'Nirmal Nadi Abhiyan' for controlling the degradation of the water bodies of the area.

Studies related to socio-economic environment

Applied researches have been carried on different subjects to implement the theoretical knowledge in the real field of human benefit and to explore new resources within the country. In geography, L. D. Stamp first used the term 'applied geography' and he gave emphasis on the use of geographical information to address socio-economic problems. A discussion on some empirical studies related to the research topic both within and outside the present study area has been portrayed in the following paragraphs. Bose and Banerjee (1972) have focused on the economic activities related to the Bhagirathi-Hooghly river system and how they are being affected due to the continuing decline in the headwater supply in the river. Dutta (1972) has analysed the progress and prospects of agriculture in the Bhagirathi-Hooghly Basin. Chakrabarti (1972) has attempted a landuse survey with particular reference to the fluvial ecology in the Bhagirathi-Jalangi riparian tract. Basu (1977) has analysed the decadal trends in urban growth in Nadia, West Bengal from 1901 to 1961. His study reveals that there was a setback in urban growth during 1901-31 but after the partition of India there has been a marked increase in the growth of urban population. To face the sudden heavy tide of refugees, the Government opened Refugee Transit camps and colonies which have ultimately evolved as urban centres of the district at present. Sen and Sen (1990) analyses the growth and decay of settlements in the moribund Ganga delta of West Bengal which experienced depopulation following mortality from malarial fever in the past. The settlements are affected by riverine action as well as their location in the *char* area. They have classified the settlements of this area into 16 types and their study gives an idea of the human occupance of settlements in the moribund deltaic part of West Bengal between 1921 and 1971. Dasgupta (1983) has analyzed the processes of evolution of rural settlements in the moribund Ganges delta in two different time frames – pre-independence (1860-1947) and post-independence (1947-1981). The rivers played a greater role in population distribution during the pre-independence period. The settlements were built along the embankments of the rivers. With the gradual silting up of the rivers and the advent of railways the concentration of settlements increased along the railway lines rather than the rivers. But in the post-independence period influx of population especially from Bangladesh led to tremendous settlement growth. Dasgupta points out in his work that settlements developed on the riverine levee tract, intervening plains and even by filling up portions of wetlands. This has led to a haphazard growth of settlements in the area and has degraded the physical and socio-economic environment of the area. Bhattacharyya (1984) has put forward her ideas on the population geography of Nadia district. She has systematically examined the three components of population *viz.* fertility, mortality and migration in her thesis. The different compositions of population in terms of age, sex and religion have been distinguished. The variations in population distribution caused by the changes in the course of the main streams particularly the Hooghly have been carefully dealt. The transfer of *mouzas* between the districts of Hooghly and Nadia have also been pointed out ion her work. She has emphasized on river dynamics and population distribution and has also stressed upon the nature of population in the *char* settlements.

Das (1988) has analyzed the industrial potential of Nadia district. For the study, she has identified the physical and human resources, infrastructural facilities available in the district for aiding the development of industries in the area. She has specially stressed upon the importance of cottage and small scale industries in the economy of the district. Mondal (2007) has stated that the issue of social change is organically connected with the question of agricultural development in the district of Nadia. He has envisaged that agricultural development can bring about a change in the hegemonic structure of the society. Asthana and Dey (2008) have made an assessment of the agricultural conditions of Nadia district. They have studied the nature of crops grown, made crop ranking, crop association and calculated agricultural efficiency of the blocks of this district. Their study reveals that the present study area has a high level of agricultural efficiency due to better irrigation facilities from surface and underground water resources, fertile soil and better farm infrastructure. Mondal (2009) has highlighted on the decadal change (1990-91 to 1999-2000) of the agricultural development and social change of six villages in Nadia District. An attempt has also been made to find out the interaction between the agricultural development and social change in these villages. Social changes of the villagers are associated with the agricultural development but it is not completely controlled by it. Asthana and Dey (2009) have analyzed the socio-economic infrastructure of Nadia District in terms of education, healthcare, transportation, traffic flow, accessibility, communication, markets, electrification, and industries. The study has revealed that although the area enjoys adequate physico-cultural infrastructural base but due to their uneven distribution, unscientific use and lack of management, they are unable to satisfy the growing needs of local population. Thus, from the survey of available literature it is very much clear that practically no research on this topic has been done in the southern part of Nadia district.

Research Voids

The literature review has been done on different aspects of the topic at national and international level. Each of these parts has its own importance and weightage which may improve the total research work and can give a proper idea to develop the method of study. The main objective of literature survey is to identify the research voids and to make the research framework. The authors have identified some methodological, technical as well as spatial gap of analysis. The major gaps along with better approaches and techniques have been highlighted as follows:

- All work done so far have been carried out taking into consideration only one or two aspects. So, there is a lack of holistic approach in the studies conducted so far in the present study area. An appraisal of the Riverine environment and society needs to be done in a comprehensive manner to facilitate proper planning and management of resources and for using them in a sustainable manner.
- The literature survey reveals that most of the work is based on parametric method. Satellite images and aerial photographs have not been used. Remote Sensing (RS) and Geographical Information System (GIS) needs to be

applied in the present research for better interpretation and analysis.

- Regional development disparity at village level has not yet been attempted in the study area. Village Development Index (VDI) can be calculated by using PCA for each village of the area. On the basis of socio-economic variables, PCA can be done. This technique can give satisfactory result as it is able to identify which factor is lagging behind within a group of factors. For planning, we must know which sector of society is suffering due to lack of social amenities; only then we can develop that particular sector. Therefore combination of VDI and Riverine morphological units' characteristics can help in chalking out a better planning proposal for the area.
- The land use of the study area is highly susceptible to changes owing to the frequent changes in the Riverine morphology. So, land use change study and its cause-effect relations are very much important. Land use model represents the cause-effect relations in a single frame. But, no such work has been done on land use model. Therefore, development of land use model for the study area can help to make effective planning proposals.
- The impacts of river on man and *vice-versa* have been stated in simple terms so far. This calls for the need of Environmental Impact Assessment (EIA) which takes into consideration variables both from the physical and socio-economic environment in qualitative as well as quantitative terms and helps to identify the principal causes and impacts by the application of scoring techniques and PCA.

The present study may be considered as a new and an honest contribution to the sphere of current research in physico-socio-economic study of rural area all over India as well as a new venture for the authors. An attempt to assess the impacts of riverine morphology and socio-economic environment in the sphere of rural life with the help of EIA and also to conclude the result in comprehensive manner with the aid of RS and GIS as well as statistical techniques like PCA shall be done for the first time in this area.

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