



ISSN: 0975-833X

REVIEW ARTICLE

FLUVIAL MORPHOLOGY AND SOCIO-ECONOMIC ENVIRONMENT

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ARTICLE INFO

Article History:

Received 15th June, 2015
Received in revised form
23rd July, 2015
Accepted 10th August, 2015
Published online 30th September, 2015

Key words:

Fluvial Morphology, Moribund delta,
Floodplain, River Channel Shifting,
Land Utilisation.

ABSTRACT

The main objective of present paper is to identify and fill up the research gaps in terms of conceptual aspects and methods of research work on Fluvial Morphology and Socio-Economic Environment in the East-Central part of lower deltaic Bengal. This work will provide a proper idea to develop the method of study to the scholars studying on almost similar type of problems. For achieving the target the author has reviewed the previous literatures thoroughly. The literature survey has been attempted on all most all the main aspects of the research work. 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.

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Citation: Indrani Mukherjee, 2015. "Fluvial morphology and socio-economic environment", *International Journal of Current Research*, 7, (9), 20873-20878.

INTRODUCTION

The issues related with the rivers, particularly the deltaic rivers that used to shift their course frequently and its impact on socio-economic environment has motivated the researchers to conduct their investigations on fluvial morphology and environment. Their method of study and findings has opened academic and professional enquires for further research. The general ideas however, have been taken from the books, theses and research articles, records etc. to identify the nature of work have done so far on this topic. For proper and scientific 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 socio-economic parameters and riverine morphological characteristics can help in chalking out a better planning proposal for the area.

Conceptual aspects

The whole study area is a fluvial landscape, formed by the river Bhagirathi and its tributaries (Fig. 1). The oscillating tendency of the river Bhagirathi has produced many interesting fluviomorphic land forms. The whole study area represents a true form of 'hydraulic society' where each individual have the knowledge about the possible hazards related with the lower deltaic plain. The people here live with the benefits associated with the flood like fertile silt deposit, higher water table and the numerous advantages of river side location.

The Area under Study

Geomorp hic Unit	Topography	Geology	Climate	Soil	Vegetation
Flood plain (part of moribund Ganga delta)	Location: on the right bank of the river <i>Bhagirathi</i> .	Compos ed of recent deposits of the Pleistoc ene period.	Tropical monsoon climatic region ('Am' type).	Surface soil: recent alluvial formation. Underlying soil: older alluvium formed of different materials.	Tropical moist deciduous Mango, banana, coconut, palm <i>etc</i> are common.
	General elevation: ranges from 12 to 15 metres.			Nature: Soil is moderate to strongly alkaline	

Hydrology

Hydrology is the science of water. According to Webster, the definition of hydrology is, the science treating of water, its properties and distribution over the earth's surface.

Fluvial Morphology

The word 'fluvial' is a general term that refers to anything produced by the action of a river (Robart, A., p.1) and 'morphology' is the science of form (Stamp, D., Ed, p.327). The term fluvial morphology means the landforms or the features created by the action of river.

Location map

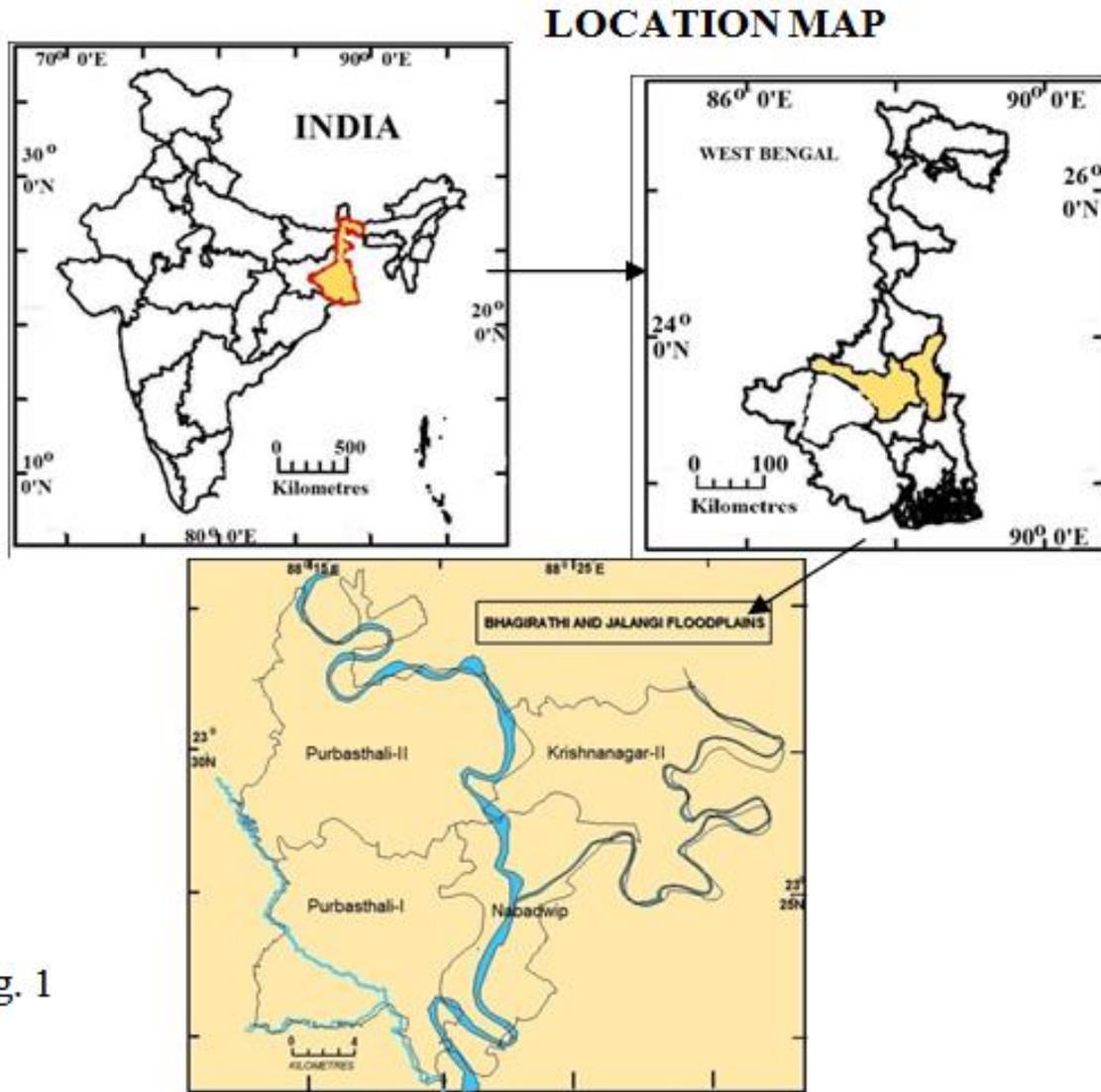
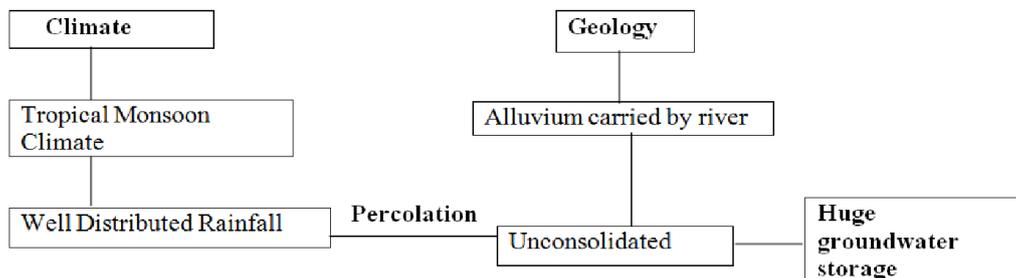


Fig. 1

Hydrology



Moribund delta

The *moribund* delta is characterised by the dead and decaying rivers which have lost their connection with the parent streams. The rivers having now no off-take from the main streams and cannot bring down enough water and silt even in flood. As a result, land building has ceased and delta has become *moribund*.

Floodplain

According to Gilbert, 1877, the floodplain is the surface of deposit which is accumulated due to loss of momentum of the water current.

River Channel Shifting

River channel shifting is a part of nature's design in forming the delta lands. The height of the river rises with sedimentation

carried by river current. Gradually the delta becomes *moribund* and river flows toward more low-lying areas. It occurs mainly due to bank erosion by which the rivers dissipate their energy. The lateral erosion results increased sinuosity and lengthening of the stream.

Meander Belt

The meander belt is the zone along a valley floor that encloses a meandering river. The river is a living reality that needs its own space. Deltaic rivers shift constantly varying from an extreme right bank point to another on the left banks over centuries, over decades. These extremities are called the 'reach points' or 'meander belts' (Mukhopadhyay, S. Land Degradation and Desertification, p.371)

Survey of the Existing Literature

The researcher has tried to find out the impacts of Hydrological characteristics and fluvial morphology on land utilisation because both of them play very vital role in the life of the human beings. Surface waterbodies and ground water storage supply drinking water, irrigation water and provide cheap means of transport, on the other hand flow characteristics of rivers regulates the nature of landuse because the alteration or deterioration of the drainage courses will force man to discard his old ways of living and adopt new ones, followed by similar changes in the distributional pattern of population. In this way change in fluvial morphology of a particular area may lead to the economic change which ultimately gives rise to profound change in the landuse pattern. The work on this particular topic is very rare, the author have collected general ideas from the books, theses and research articles, *etc.* Some separate study on geology, lithology, hydrology, climatology, land use, soil, and land capability of BJK have already been done by different agencies such as Geological Survey of India (GSI), Topographical Maps by Survey of India (SOI), National Bureau of Soil Sample Survey (NBSS), Census of Burdwan and Nadia Districts (1971, 1981, 1991, and 2001). The total work has been divided into five major aspects viz. fluvial morphology and environment, a theoretical aspect, The Bhagirathi and the Jalangi floodplain-the study area, River bank erosion and its management, Surface waterbodies and socio-economic environment in the Bhagirathi-Jalangi riparian tract.

Fluvial Morphology and Environment, a theoretical aspect

Most of the books on fluvial morphology have been written by the physical scientists. The books have been consulted to have a comprehensive knowledge on the fluvial morphology. James Fergusson (1912) in his writing on 'Recent Changes in the Delta of the Ganges' has studied the oscillation of the rivers, elevation of the banks of rivers, mode in which deltas are elevated, physical changes in the valley of the Ganges and historical evidence of the changes in the delta of the Ganges. F.C Hirst (1916) in the writing 'Report on the Nadia Rivers' has broadly outlined the general description of the Hooghly river, formation of Bengal delta, major disturbing agents in the river system, evidences that the Bhagirathi was once the main channel of the Ganges and the impact of human beings on the Nadia rivers. D. Knighton (1998) in his book '*Fluvial Forms*

and Processes' has analysed the fluvial processes in detail and mechanism of channel changes over time. The study helps the researcher to understand the processes of river bank erosion and fluvial landforms in detail. A. Robert (2003) in his book '*River Processes*' has studied the fluvial dynamics of alluvial channels, bank erosion and its mechanism which has provided the researcher to make fundamental concept about the nature of alluvial channels such as Bhagirathi. A. Sarker (2004) in his article '*River Bank Erosion: Geomorphology and Environment*' has analysed the nature of alluvial channels, bank erosion and related environmental issues in four vulnerable stretches of West Bengal and the possible solutions by which it can be checked. This study helps the researcher to understand the bank erosion problem and the environmental issues in the Bhagirathi-Jalangi floodplains. The researcher has borrowed some methods from this study to assess the fluvial dynamics of the study area. M. Z. Islam (2009) in his article '*Indigenous Adaptation Strategies of the Riverbank Erosion Displacees in Bangladesh: A Study of Two Northwestern Riparian Villages*' has studied very successfully the multiple indigenous strategies the riverbank erosion displacees as none of them is adequate for their adaptation to the precarious riparian environment. He has also suggested some important policy measures for their future development. The researcher is highly impressed by his idea because most of the affected villages have got very little support from the Government and NGO's in our country also and compelled to adopt in their own way. The suggestions are very strong and fruitful to cope with this recurrent problem. S.R. Basu (2005) in his article '*Recent Findings on the River Dynamics of Bengal: Post Farakka Condition of the off-take and Bank Erosion of the River Bhagirathi-Hugli*' was concerned with the causative sequence of shifting of the off-takes as well as the bank erosion of the river Bhagirathi-Hugli quantitatively and suggests suitable measures for its prevention. The study helps researcher to point out that the causes of bank erosion throughout the whole year in the post Farakka situation and oscillation of river Bhagirathi in the deltaic Bengal.

The Bhagirathi and the Jalangi Floodplain-the study area

Information on the various aspects of the study area has been collected from different sources; the important among them are given in brief in the following paragraphs.

General Information: Hunter (1877) provides information on history and revenue account of the Nadia rivers, Garrett (1910) supplies basic information of Nadia district before the partition of 1947. Peterson also supplies information of Burdwan district. Both of the books convey the information regarding the physical aspects, history, people, agriculture, irrigation, industries, communications, administration, education, health, culture, public life as well as places of interest. Historical evolution of socio-cultural and economic base of the districts has also been described in detail. Thus the books give a detailed past record on all geographical aspects of both the districts. Hirst (1915) in the book '*Nadia Rivers*' has broadly outlined the general description of the Hooghly river, formation of Bengal delta, major disturbing agents in the river system, evidences that the Bhagirathi was once the main channel of the Ganges and the impact of human beings on the Nadia rivers. Mukherjee (1938) in his book '*The Changing*

Face of Bengal has studied the agriculture, economy and health of the people as related to riverine activities. The book describes the gift of the Ganges in the region in making the old and new delta in the last three centuries, agricultural decadence and public health in the early twentieth century. Changes in the river courses and formation of ports in the sixteenth and seventeenth centuries have also been studied. Majumdar (1941) in his book *Rivers of Bengal Delta* has mentioned the decaying nature of the rivers of Bengal, the reasons for which he ascribed to human interferences in the past and lack of initiative in the present. He has also considered that the spill area is essential for maintenance of rivers in deltaic area and established various evidences in support that the Bhagirathi was the original course of the Ganges. Bagchi (1943) in his book *Ganges Delta* has contributed a valuable research on the stages in which the Ganges delta came to be formed and the hydrographic characteristics in the different portions in order to bring out in details the nature of distribution of population in different parts of the deltaic region. Bhattacharya (1959) in his book *Bangladesher Nad-Nadi o Parikalpana* has discussed in detail the general description of the rivers of Bengal, changes in the river course in different decades, description of delta, the rivers of active, mature and moribund delta etc. He also described the farakka barrage project and necessity of flood for maintaining the navigability of the rivers. The study helps to arrange the chronology of past courses in the lower deltaic Bengal in various decades. Bagchi and Mukherjee (1983) in their book *Diagnostic Survey of Deltaic Bengal* has made a comprehensive study of the agricultural land capability and market accessibility of West Bengal on a regional basis. M. Mondal (1998) in his book *Brihattara Purbasthalir Itibritta* has attempted a thorough study of Purbasthali police station. He has studied analytically the old history of Purbasthali, its geographical location, distribution of rivers in past and their relationship with present waterbodies, distribution of settlements, society and culture, festivals and significance of place names etc.

Geology: Chakraborty (1969) in his article *Some Consideration of the Physiographic Evolution of Bengal* has discussed much about the geological and tectonic framework of West Bengal. This study has also covered the geological uniqueness of the Bengal basin. The study provides the fundamental information regarding geology and lithology of BGF. Sengupta (1972) in his article *Geological Framework of Bhagirathi-Hooghly Basin* has made an in-depth study about the geological history of the Bhagirathi-Hooghly basin which covers the study area and helps to understand the geological evolution in a systematic order. The detail of geological study by R.C. Mehdiratta (1985) in the book namely *The Geology of India, Pakistan, Bangladesh and Burma* has provided information about the Archean gneissic complex i.e. the basement complex below the thick layer of alluvium. To understand the old geological set-up of the study area, this discussion is indispensable. Sinha *et al.* (2005) in their article *Late Quaternary geology and alluvial stratigraphy of the Ganga basin* have studied in detail reviews the available information on the near-surface Late Quaternary stratigraphy of the upper, middle and lower Ganga basin, and reports new results based on studies of river cliff sections and shallow

boreholes down to -50 m depth. Their work gives a clear view about the recent geological history of the Bengal.

Climate: Chatterjee (1969) in his article *The Climate of West Bengal: A Genetic Approach* has made an in-depth study to divide West Bengal into climatic zones. This study helps the researcher to identify the nature of micro-climate of the study area.

Irrigation: Willcocks (1930) in his book *Ancient System of Irrigation in Bengal* has analysed the effects of drainage decay and suggested reactivation of drainage channels at a reasonable cost and effort. He was convinced of the artificial nature of most of the water ways of Bengal which are now called dead rivers because of their decaying state. He has mentioned that these streams had been laid down to carry flood water of the Ganges. He has pointed out that an elaborate system of over-flow irrigation that flushes the country with silt water from the rivers regulate the prosperity of people in deltaic region and help to activate the rivers in this region. N. Prasad and P. Mukherjee (1984) in their article *Irrigation in the Indian Context* have clearly identified the importance of irrigation mainly for the production of winter crops and six-fold increase of the productivity of land when water is added to it. The study helps researcher to find out the impact of irrigation on agricultural productivity in a spatio-temporal scale in the BGF.

River bank erosion and its Management

River bank erosion is a dynamic natural process in the deltaic landscape. The river is a living reality that needs space. Deltaic rivers shift constantly; varying from an extreme right bank point to another on the left banks may be over centuries, perhaps over decades. Bhattacharya (1959) in his book *Bangladesher Nad-Nadi o Parikalpana* has discussed in detail the general description of the rivers of Bengal, changes in the river course in different decades, description of delta, the rivers of active, mature and moribund delta etc. He also described the farakka barrage project and necessity of flood for maintaining the navigability of the rivers. The study helps to arrange the chronology of past courses in the lower deltaic Bengal in various decades. Rudra (2008) in his book *Banglar Nadikatha* has described the history of sedimentation in the Ganges-Brahmaputra delta, disputes related to the old course of Ganges, changes in the course of Ganga and Bhagirathi, floods in West Bengal etc. It especially helps to study the history of Bengal delta, river channel changes and their consequences. Sarker (2004) in his article *River Bank Erosion: Geomorphology and Environment* has analysed the nature of alluvial channels, bank erosion and related environmental issues in four vulnerable stretches of West Bengal and the possible solutions by which it can be checked. This study helps the researcher to understand the bank erosion problem and the environmental issues in the Bhagirathi-Jalangi floodplains. The researcher has borrowed some methods from this study to assess the fluvial dynamics of the study area. Islam (2009) in his article *Indigenous Adaptation Strategies of the Riverbank Erosion Displacees in Bangladesh: A Study of Two Northwestern Riparian Villages* has studied very successfully the multiple indigenous strategies the riverbank

erosion displacees as none of them is adequate for their adaptation to the precarious riparian environment. He has also suggested some important policy measures for their future development. The researcher is highly impressed by his idea because most of the affected villages have got very little support from the Government and NGO's in our country also and compelled to adopt in their own way. The suggestions are very strong and fruitful to cope with this recurrent problem. Basu (2005) in his article '*Recent Findings on the River Dynamics of Bengal: Post Farakka Condition of the off-take and Bank Erosion of the River Bhagirathi-Hugli*' was concerned with the causative sequence of shifting of the off-takes as well as the bank erosion of the river Bhagirathi-Hugli quantitatively and suggests suitable measures for its prevention. The study helps researcher to point out that the causes of bank erosion throughout the whole year in the post Farakka situation and oscillation of river Bhagirathi in the deltaic Bengal.

Surface Waterbodies

Mukherjee (2008) in her article '*Economic Valuation of a Wetland in West Bengal, India*' has successfully established that in the Gangetic flood plain of West Bengal, wetlands are used for multiple purposes, and have significant role in the livelihoods of the local people. Over the years, these Multiple Use Systems (MUSs) are getting converted to single use systems due to economic and social pressure from dominant stakeholders, which are higher than that in single use systems. Economic and ecological functions of MUS changes over time and space. These dynamic aspects of MUS are often not fully appreciated. She has selected a wetland in Burdwan district of West Bengal to evaluate the economic benefits from multiple uses namely, wetland cultivation, irrigation, fisheries, jute retting, and fodder collection. The study shows that the major economic benefits that people living in the surrounding area of wetland derive are from wetland cultivation; direct irrigation; jute retting; and fisheries. The most important benefit was from fisheries, followed by wetland cultivation and jute retting. The irrigation benefits were found to be low due to larger distance of the land from the wetland, and the easy access to shallow groundwater in the region. It helps the researcher to assess the importance of wetlands with their multiple functions during the time of field investigation. Das (2010) in his article '*Seasonal Wetlands: A Unique Ecosystem for Regeneration of Wild Fish Diversity*' has studied that the Seasonal wetlands occupy considerable areas of eastern India during rainy season, spread over mainly three states such as Bihar (40,000ha), West Bengal (46,000ha), and Assam (1, 00, 000ha). Due to submergence, water retention period of such wetlands extends up to next 5-7 months with depth ranging from 0.5-1.0 metre. Importantly, existence of these wetlands has become phenomenal from the biodiversity point of view. These wetlands can generate huge fish resource for several months of the year, which help to open the income opportunity to the rural poor. The study helps the researcher to point out that if the local people properly utilise the wetlands it will open a new source of income, instead of age old agricultural practice.

Socio-Economic Environment in the Bhagirathi-Jalangi Riparian Tract

K. Chatterjee (1972) in her writing '*Land-Use in Relation to Fluvial Ecology in the Bhagirathi-Jalangi Riparian Tract:*

Nadia district' has focused on the adaptability of human beings to the changing physical and socio-economic conditions. The study helps to identify how the nature of soil, position of land regulates the cropping pattern and land-use of a particular area. S. Barman (1982) in her thesis '*Spatio-Temporal Aspects of Agriculture in Burdwan District*' has made an in-depth study on the agriculture of Burdwan district, the spatio-temporal variation within the district with numerous maps and diagrams. The study helps to understand the agricultural characteristics of the Purbasthali from 1951 to 1971. P. Bhattacharya (1983) in her thesis namely '*Population Geography of the Nadia District*' has studied the population characteristics of Nadia district elaborately. The changes in population pattern with the changing physical aspects help to establish the relationship between the river dynamics and settlement evolution. S. Sen and J. Sen in their book '*Evolution of rural settlements in West Bengal, 1850-1985: a case study*' have focused the settlement changes, spatial pattern and internal structure of the settlements, their change with changing physical conditions. The study has inspired the researcher to find and establish such relationship among dynamic fluvial condition and evolution of new settlements and the obliteration of some settlements due to bank erosion. The study of R.K. Banerjee on '*Study of The Levee Settlement System of Nadia District of West Bengal With the Help of Air Photographs and Satellite Imagery and Its Mapping*' regarding the positions and patterns of settlement has inspired the researcher for intensive field study to assess the causes of distribution of settlements on a particular location. Thus, from the survey of available literature it is very much clear that no research on this particular topic has been done in the east-central part of West Bengal.

Research Gaps

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 gaps and to make the research framework. The author has identified some methodological, technical as well as spatial research gap of analysis. The major gaps along with better approaches and techniques have been highlighted as follows:

All the 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 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. Disparity in the regional development at village level has not yet been attempted for the concerned study area. 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 socio-economic parameters and riverine morphological 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 present study may be considered as a new and an honest contribution to the sphere of current research in physico-socioeconomic study of rural area all over India. An attempt to assess the impacts of riverine morphology and socio-economic environment in the sphere of rural life with the help of RS and GIS as well as statistical techniques shall be done for the present study.

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