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CONTENTS

GEOGRAPHICAL CONTRIBUTIONS OF THE WORK OF PIERRE BOURDIEU

*Somnath Ghosal**

Abstract

Pierre Bourdieu is known as an important contributor in the field of social sciences in the twentieth century. He was an empiricist as well as a master theorist in his time. His extensive works in the arena of sociology and anthropology has given him a distinguished position among others. His power of methodical and systematic observation helped him decisively to work on the aspects of social phenomena upon a firm scientific base. The words 'habitus' or 'field', coined by him earned him a new identity by his artistic and pragmatic works. Bourdieu's theory on class, culture, education, gender, economics and politics inspired other social scientist of his time as well as the next generation thinkers to rethink over the subject areas from an empirical perspective point of view.

"One of my constant struggles, particularly through Actes de la rechercheen sciences sociales, has been to promote the development of a unified social science in which history would became a historical sociology of the past and sociology would became a social history of the present."

Pierre Bourdieu with Lutz Raphael

Introduction

Pierre Bourdieu was one of the leading intellectual social scientists of France in his time in the twentieth century like Foucault, Barthes and Lacan. The international Sociological Association has considered Bourdieu's as *'Distinction'* and the 6th among twenty most important social scientists of the twentieth century in the field of sociology. He was a thinker, a famous sociologist, educationist, researcher, as well as an anthropologist. The increasing importance of Bourdieu's social theory in the field of social sciences and humanities has been noted by a number of writers (Fowler, 1997, Shusterman, 1999, Painter, 2000).

Subsequent to the development of human geography, including human culture, economic status, political attitude, or gender study, as the important branches of social sciences Bourdieu's contribution in the development of modern human geographical thought come automatically. His works in the development of thought in the fields of economy, culture, ethnography and feminism are now considered important subject areas of present day human geography. Bourdieu was an economist, a human geographer, and above all a sociologist. With the increasing turn of the modern human geography towards the humanistic areas

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Bourdieu's contributions are becoming unavoidable to the scientist associated with the concerned field. At the present time without Bourdieu's modern thinking it becomes very difficult to study the philosophy of contemporary human geography.

Life and contributions of Pierre Bourdieu

Pierre Bourdieu was born on 1st August 1930 in a postman's family in Denguin of France. After the completion of education in Philosophy from Ecole Normale Superieure, Paris, he started his professional life as a teacher. During the Algerian War of Independence in 1958-62 he served in the French army. At that time Bourdieu had decided to work on ethnography, which was virtually the turning point of his life to become a famous sociologist. In 1964 he was posted as the professor of *Ecole des Hautes Etudes en Sciences Sociales* and in 1981 he joined at the *College de France*. In 1968 he founded the Centre *de Sociologie Europeenne,* of which he was the director until his death (23rd January 2002). He was honoured with the "*Midaille d'or du Centre National de la Recherche Scientifique*" (CNRS) in the year 1993.

Bourdieu and his anthropological works

Bourdieu, the most high-profile intellectual of France of the recent past, had done extensive theoretical works in the fields of sociology and anthropology. Since 1960s Bourdieu had published over twenty books on anthropology, cultural sociology, language and literature until his death. Besides, his contribution in the political field of France was also considered important. The art of thinking in social science stemmed in his mind from his very boyhood days as Bourdieu was born in a very middle class family and as such he had the opportunity to observe the socio-economic conditions of the middle class families of the then France from a very close position. From his observational experiences he got the main instruments for the study of anthropology. As a result his research work became so pragmatic and close to the reality. His works extended from marginalised social group to the homeless people and from unemployed people to illegal immigrants as well as the workers observing strikes in the industries.

From the early 1990s Bourdieu started taking part in several social activities outside his academic life. In 1995 Bourdieu's active participation in support of the strikes of students and workers of public sectors raised his political profile to a new level. Inspired with this political activity he had started editing the *'Raisons d'agir series'*, to present publicly the political and social problems of the present day France. Later, he considered that the struggle for social distinction is a fundamental subject area of all social life, from which the politics developed. And this politics control all the social phenomena of a modern society. In his *'social space'* model he presented graphically the space of social position and the space of lifestyle. In his *'Distinction'* he has shown using a diagram that the spatial distances are equivalent to social distance.

Actually, in his *'Distinction'* he tried to present the cause of distinct class differences that we usually see in our society, between different groups or communities. This class differences originated because of the socio-economic-cultural and political acts. In his whole life he had tried to do some constructive work on human culture and their society considering their surrounding socio-economic environments. The works on class-culture study and the study on feminism were only the part of that work.

Bourdieu as an empirical researcher

Bourdieu was an empiricist as well as classical sociologist. He believed only on observational phenomena. He used to describe all the sociological phenomena from a scientific point of view after observing and realising it in the real earth. The sociological phenomena, which are occurring in our daily life, were an interesting topic to him. Thus, his work was just like scientific descriptions. In short, he was a prolific thinker and scientific researcher. Bourdieu was a cultural sociologist. He was not only an empiricist but also was a master theorist.

He gave emphasis on two words, 'habitus' and 'field'. Field discovered by him as the 'system of social positions', which is formed based on power relationships. According to him one field can not be controlled by others or by outside forces, they are independent in terms of their cultural as well as social relations and the numbers of these independent or autonomous fields are increased in the case of more complex and developed society rather than the simple small classical one.

Bourdieu believed that each and every social phenomenon occurs in a place on the earth surface, 'a social arena'; where common people struggle continuously for survival in order to get their basic requirements. This struggle, according to him, can't be analysed following any particular model or theory or from any particular point of view such as economic conditions or policy of government. Like Weber, he used to follow some independent factors such as educational or cultural factors at the time of analysis of social phenomenon of any society. To Bourdieu, meta theory was a set of thinking tools for the guiding empirical research. That's why he used thinking tools for substantive investigation.

According to Bourdieu the term 'habitus' of a community can be determined by their standard of cultural activities and education systems. At the time of discussion about the term 'habitus' he considered individual as well as the group of people of the concerned society. The nature of an individual people is always affected by his or her surrounding environment where they are living and the status or condition in which they are living. Though, it is also true that every individual person has his or her own style of conception and perception. They also look over the same matter from different viewpoints and they analyse those incidents differently but even then there is a collective or social effect as well, which also have a direct impact on human habitus determination. In short, Bourdieu developed a new way for the study of literary as well as artistic works related with our

society considering the daily living of the common people. Later, Bourdieu discussed, based on his 'habitus' concept, the economic, social and cultural characteristics of the society.

Bourdieu with his theories on class, culture, and education

According to Bourdieu the culture and education are at the central position in affirmation of differences between social classes. So Bourdieu considered that nobody would be able to understand the importance of modern societies if they don't make out the importance of education. Based on education system and depending upon its success the advancement of modern society comes true. Bourdieu said that the sociology of education could never be a secondary discipline. It is the nucleus of the modern society. Education systems determine the standard of living by increasing the productive power and per capita income.

The structure of our society depends very intensely on the concerned society's educational development. So due to the differentiation of the development of education the advancement of society also varies throughout the world. He believed that in case of the development of any society the advanced education system always plays a crucial role. From the very first time of human civilisation there is a close relationship between them and with the passing of time the relation became only stronger. In his book *'La Reproduction' (1970),* he argued that the cultural division in France occurred due to its educational system only. The education system of any society can control the evil of social class system as well.

While defining culture he said that it helps to produce the dominant structure of our society. Culture is also a source of domination, in which intellectuals take the key role producing cultural products and symbolic power. Here mainly the educational capital gets priority. Bourdieu remarked that culture is the gift of 'nature' but he did not clarify if it was humanistic or inhuman. Although, from his further studies it can be said that, as he was much more interested in human culture, human mind and human taste so that his study on nature was humanistic. Culture, which is determined by the nature of human mind, individual as well as community, becomes complicated with the growing complications of our society. The relation between culture and education has got a new identity after Bourdieu. He remarked in his *'Distinction'* that all cultural practices are closely related with the educational level of the concerned society.

Bourdieu's discussion on class is also a great work of his time. As it is discussed earlier class system is determined mainly by the educational and cultural factors but at the same time the economic power and political environment also play decisive role in this regard. Though politics and economics come after education and culture, in case of the determination of class system in our society.

Bourdieu and feminism

Bourdieu's theory on social constructions, including the female study, was a great work in his time and after that. In case of study on feminism Bourdieu followed the radical feminists, particularly Catherine MacKinnon. In the present time, feminists tend to start their service following Bourdieu's works on feminism because of its scientific base. His contemporary theory on feminism is considered a truely helpful work to the present day feminist workers as it could avail some concepts on tension between structure and agency in regards of gender. His last publication was on masculine domination, where he discussed in detail about the rights of the female in society and how it varies from one society to another with the differentiation of other socio-cultural parameters.

His feminist study was mainly based on the differentiation of female positions in our society in respect of cast and gender. He has described how the daughters of lower-class communities or of backward families are compelled to leave schools and education earlier because of their poor economic base in the society. Bourdieu, following the idea of Sarah Thornton remarked that females of the backward society also get married at the very early age, which increases the teenage pregnancy in the concerned society. Thus the rights of female persons are ignored in lower class society, which are educationally as well as culturally backward (Elizabeth, 2005).

According to Bourdieu, the position of gender in our society is also determined by the characteristics of class and field of the concerned society (McLeod, 2005). It affects mostly in case of girls and women of socially marginalised families. So following Bourdieu's concept in this regard it can be stated that the positions of female of any particular society vary considerably with the variations of educational, social, cultural as well as economic background.

However, it is also true that the options that Bourdieu provided for the development of females are problematic. As the social features are determined by so many factors and it varies from one place to another, so we can't use a common theory or policy for the development of feminism or gender studies. His discussion about the female position in our society, based on class and culture, is also not an easy task for everybody to make-out at a glance as the feminists are also come out from different societies with different socio-economic background.

Bourdieu as an economist

In the case of sociological study Boudieu's key term was capital. He considered there to be two parameters based on which the distinctions between individuals, institutions and other agents can be found. These are economy and culture. Economy means the money, property or capital on which one commands. Bourdieu also considered the communal property at

the time of discussion on economy. As the economy of the individual persons has a great impact on the state economy at the same time the gross economy of the people of concerned area also plays an important part at the same time. Though, it is also true that the increase of total economy does not mean the increase of per capita income.

Presently the position and power of any people in our society is mainly determined by the economic conditions of that people. The economically stable people can control the political, cultural and social features of our society influencing others with their economic power. He, however, maintained a critical view in case of applying the neo-classical economic model of human action in all the social sciences.

At the time of discussion of economics he had used his cultural as well as symbolic power of concept. According to Bourdieu modern economics is totally culturalised. Consumers consume cultural goods increasingly. He had criticised the Marxist theory in this regard. According to him, Marx's theory had not considered cultural factors in the case of the study of economic phenomena of our society. It is, however, quite impossible to discuss the economic theory at present time without considering the cultural phenomena. The mode of production in our society is not only determined by the economic factors but also the cultural factors assume a crucial role. The relationships between culture and economy became inseparable. So, according to him most of the social phenomena related with either culture or economy are becoming hybridized.

Conclusion

Bourdieu was virtually a thinker in the international level. His phylosophy was not restricted within the boundary of France or in any particular society. The range of his working area made other sociologists in his time surprised. His discussion on ethnography, economics, politics and feminism has been followed by the next generation thinkers with great interest. He had not only discussed all the above mentioned subject areas specifically but showed with clarity how all are related with each other from the social aspect. Though these topics have separate identity and not dependent on each other completely, nobody can ignore one subject area at the time of studying others. The authors of the volume *'An Introduction to the work of Pierre Bourdiue'* (1990) have described Bourdieu as he "has been authoritatively placed in all major theoretical traditions, Marxist, Weberian, Durkheimian, even 'poststructuralist' or 'postmodernist'" (Harker et al.1990, p. 213). His discussion on all these social science topics, based on real experience, was scientific and pragmatic in his time and in some cases for future as well. He believed that it is not possible to make any social science theory permanently as the social structure is changing with the passage of time throughout the world. Human culture never terminates its movement; it continues to move as the river water. So he always tried to update himself and his thought. It is due to this fact that the importance of Bourdieu has got a new level to the contemporary sociologists.

Bourdieu's concepts emerged as tools for thinking about specific sociological problems. It is because of the updating of his thought on social problems. New problems are always emerging in the arena of our society considering our social life. The structure and the nature of our culture are changing with the changing of our economic-political-social features. So the old concepts are becoming useless for solving the related problems. Thus Bourdieu's empirical works became beneficial to his followers.

Though, Bourdieu had started producing his empirical works from the first half of 1960s his contribution appeared in the international arena with great importance in the year of 1993, with the publication of *'The weight of the world'* (La Misere du monde, 1993) under his editorship. The book clearly resonated with a broader sense of political, cultural, and social malaise in France.

It is true that Bourdieu can not be considered a geographer in true sense but his subject areas like the economics, politics or feminism contributed immensely to the contemporary human geography. At present, in the field of human geography the various social phenomena are studied, which Bourdieu, being an empirical sociologist, has discussed based on his practical experience. So in the discussion of components of contemporary human geography Pierre Bourdieu's contributions can never be ignored.

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CHARACTERISTICS AND PATTERN OF PARAGLACIAL LANDFORM FEATURES IN SOME RECENTLY DEGLACIATED PARTS OF THE INNER HIMALAYA

*Guru Prasad Chattopadhyay**

Abstract

Paraglacial slope development is a normal process that takes place in the Alpine environments during and subsequent to deglaciation. Paraglacial stress-release acting on glacially-steepened rock walls in parts of the western and eastern Himalaya during and after deglaciation has produced a wide variety of typical landform features of rock fall and talus slope types. These are associated with features of catastrophic slope failure, deep seated rock mass deformation, fan formation and progressive slope adjustment with intermittent rock fall activity. Development of avalanche tracks and melt-water channels also helped modification of mountain slopes in this area simultaneously. Typical features, developed under the above conditions and their evolution on the mountain slopes in these areas have been identified and interpreted from geomorphological point of view.

Introduction

Quaternary geomorpholigsts have identified four typical geomorphological processes in cold mountain environments, namely glacial, periglacial, paraglacial and nival. Thorough studies have already been done upon glacial, periglacial and nival processes and features in extensive areas in the Arctic and Alpine environments. Paraglacial processes and features have drawn attention of the Quaternary geomorphologists only recently, during the last few decades.

The term 'Paraglacial' was coined by Ryder (1971a, 1971b) to describe the reworking of potentially unstable glacial drift by rivers and debris flow after deglaciation in the Canadian Rockies in British Columbia. Paraglacial, as a distinct geomorphological process was later examined in detail by Church and Ryder (1972) who identified this typical landscape process as 'glacially conditioned fluvial process in the cold environments'. Afterwards the concept of paraglacial process and associated landscape modifications has been extensively applied to the reworking of glacigenetic sediments on hill slopes in the Arctic and Alpine environments (e.g., Owen, 1991; Ballantyne and Benn, 1994; Ballantyne, 1995, 2000, 2002, Watanabe et.al., 1998; Curry, 1999). Ballantyne (2000) is of the opinion that in many mountainous environments one of the most important geomorphological consequences of deglaciation tends to occur independently of sediment reworking in the form of the exposure and subsequent paraglacial adjustment of steep rock walls.

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Till now little attention has been paid to the paraglacial process and landforms in the recently deglaciated parts of the Inner Himalaya, and in several cases the fresh alluvial fans, occurring on the exposed foot slopes following recent retreat of glaciers, have mistakably been attributed to solely fluvial processes. This paper attempts to explore the pattern of unloading on the mountain slopes in the recently deglaciated Upper Bhagirathi and Upper Alakananda valleys in the Western (Garhwal) Himalaya and Rathang Valley in the Eastern (Sikkim) Himalaya and identify evidences of typical paraglacial landforms produced thereby.

Mechanism of Paraglacial rock-slope modification in the tectonically active Himalaya

Tectonically active mountains like the Himalaya, Alps and others experience slope evolution under both geomorphological and geotectonic processes. The extent, to which either of these two processes dominates, depends upon the scale at which a process is dominant in the given part of the terrain. It is assumed that during the Pleistocene glaciation, i.e., when the valley glaciers were at maximum thickness the residual strain energy in the valley-wall rock mass was stored; and following deglaciation, at the time of down wastage of the valley glaciers the rock stress continued to get released deforming the slopes (*cf.* Ballantyne, 2000). The stress release, following deglaciation, often creates multiple effects on the rock body, giving rise to extensive fracturing and a large scale modification of the exposed slopes. The nature and extent of paraglacial response is largely determined by the varying lithology and structural characteristics. This part of the Inner Himalaya represents complex geological structure showing intense folding of gneissic and schistose rocks. Three types of paraglacial processes and landforms, observed in this part of the Himalaya, have been examined as follows:

1) Catastrophic rock-slope failure and associated landforms

Catastrophic rock-slope failure is a common phenomenon in all mountains. In the cold mountain environments, subsequent to glacier retreat, the exposed mountain slopes tend to exert outward pressure giving rise to shattering of rocks and thus catastrophic slope failure occurs. It is assumed from the evidences of fresh morainic deposits through the Upper Alakananda Valley beyond Mana village (about 4km upstream from Badrinath), that from the early Holocene, as the main Alakananda Glacier continued to retreat catastrophic rock-slope failures occurred extensively in the first phase causing initial modification of slopes. However, the huge volume of debris, covering the slopes on either side in the form of shattered blocks mixed with fines, raises question of the extent to which these are paraglacial product and how much the shattering effect due to tectonic (seismic) activity of the Himalaya. It seems probable that the debris comprising large blocks, accumulated at the base of the slopes, are by and large the product paraglacial activity subsequent to the withdrawal of the glacier from the valley, and those covering the upper part of the slopes

bear the evidence of the combined activity of paraglacial (due to stress release from the rock body), periglacial (due to frost wedging and frost shattering) and tectonic (due to crushing under compression and folding of rock strata) activities. Debris occurring in the upper slopes were found fresh in form and likely to be active in the present day contrasting to those on the foot slopes, which are by and large preserved in relict form as has been assumed from the spot marks of sizeable lichens on the boulders.

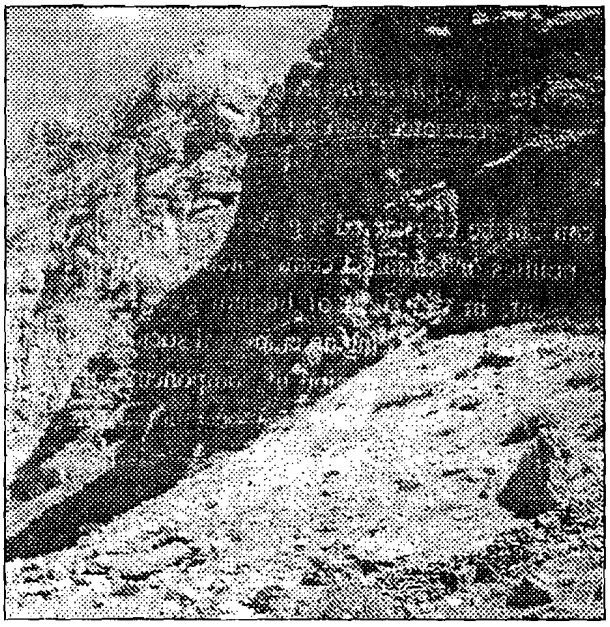

Plate 1: Modification of hill slope by catastrophic rock slope failure in the Upper Alakananda valley in the Garhwal Himalaya

2) Rock-slope deformation and associated landforms

Rock-slope deformation is a process of debuttressing of rock-slope during deglaciation. There is a certain relationship between this process and initiation of rock-mass creep. This process has been studied by several workers like Tabor (1971), Evens and Clague (1993) and Blair (1994). A thorough research on paraglacial rock-slope deformation has been done by Bovis (1990) in Affliction Glacier Valley in British Columbia. According to his observations the slopes were found to support typical features associated with rock-slope deformation, antiscarps, elongated graben and collapse pits. Stress-release under the process of deglacial unloading and debuttressing may give rise to slow rock-slope deformation which is often referred to as rock-mass creep. Such rock-slope deformation triggers large-scale failure of rock masses. Ridge-top trenches (grabens), crevasse-like tension cracks, upslope-facing scarps (antiscarps) and convex bulging slopes are the major types of landforms developed under the process of slow rock-slope deformation. Several instances crevasse-like tension cracks and upslope-facing scarps (antiscarps) are preserved on both sides of

the mountain wall through this valley.

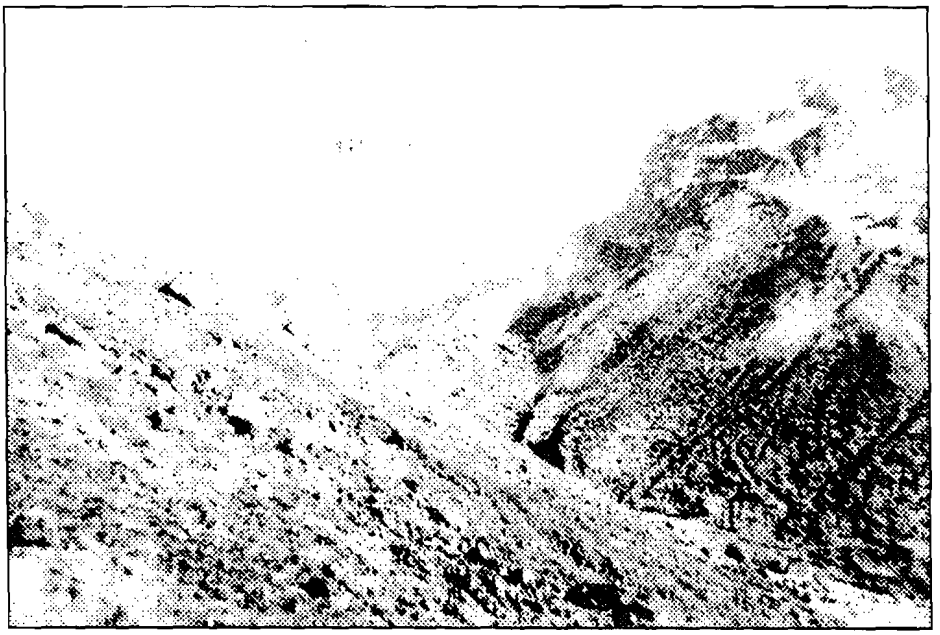

Plate 2: Antiscarp formation due to slope debuttressing at the margins of the retreating Rathang Glacier on the south-facing slope of the Kanchenjunga in the Sikkim Himalaya.

3) Paraglacial talus slope and fan formation

Paraglacial talus slopes and fan formations are the third possible response of glacially processed, as well as steepened slopes (e.g., Augustinus, 1995). Rapid rock-fall activity from the valley-side cliff-wall responses to the development of paraglacial talus accumulation. Geomorphologists working in the cold environments noticed that the huge volumes of talus deposited on the foot slope below the cliff-walls are not in conform with the rate of the present rock-fall activity. This helped them to assume that the rate of rock-fall in the past, subsequent to the withdrawal of the glacier from the valley, was much greater (e.g., Luckman; 1981, Gardnar, 1982; Marion et. al., 1995).

Debris cones and alluvial fans are unique paraglacial accumulation of the Late Pleistocene and Early Holocene age; there is however, limited information on the development of cones and fans on recently deglaciated forelands (*cf.* Ballantyne, 2002). Relict paraglacial debris cones and alluvial fans are of widespread occurrence throughout deglaciated mountain environments. In the Himalaya some paraglacial debris cones are assumed to be of Late Holocene origin. Glacier retreat in the Upper Bhagirathi Valley (Garhwal Himalaya) over the past 200 years has been followed by development of debris-flow dominated fans composed of reworked morainic debris (Owen and Sharma, 1998). In Langtang Himal of

Nepal Himalaya numerous cones formed after retreat of glacier-ice and the toes of some of these cones were subsequently truncated by later glacier advances (Watanabe, 1998; Watanabe, *et. al.*, 1998). Series of voluminous paraglacial fans occur through the study area of the Upper Alakananda Valley. These are largely of relict type and have often been deeply trenched by snow-avalanche tracks. Most fans in this area have now ceased to grow, and exhibit fan-head entrenchment and fluvial erosion.

Plate 3: Valley-side slopes on ground deglaciated with the retreat of Satlapanth glacier in the upper Alakananda valley showing the gullied upper slope zone and the lower zone of coalescing debris cones.

Plate 4: Development of melt-water channels on the mountain wall of the Upper Bhagirathi river valley

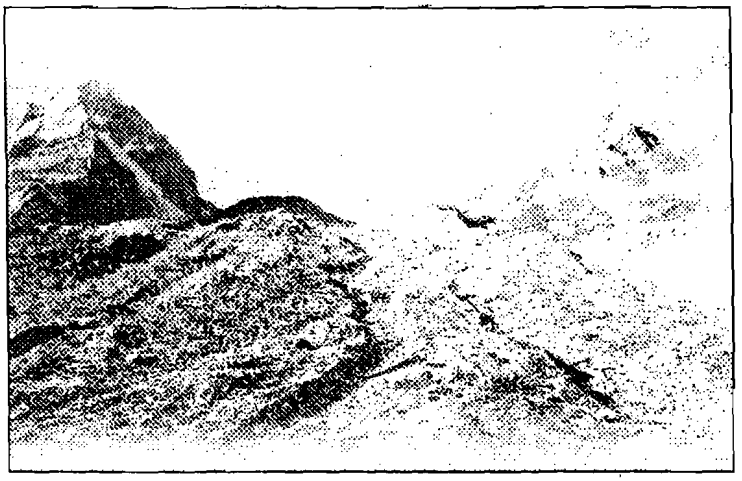

Plate 5: Scars formed by the Melt water Channels on the recently deglaciated mountain slope in the Upper Bhagirathi river valley in the Garhwal Himalaya

Plate 6: A large Snow-avalanche track on the mountain wall in the Upper Alakananda river valley in the Garhwal Himalaya

An overall assessment

Paraglacial slope evolution is a dominant geomorphological process over the recently deglaciated mountain region of the Upper Alakananda Valley. Stress release of the rock body during and immediately after the withdrawal of glacier from the main valley created triggering effect of this process within the rocky mountain walls overlooking the valley floor. Through the Upper Alakananda Valley upward from Mana village (beyond Badrinath pilgrimage) on the way to Satapanth, a wide variety of paraglacially developed landform features have been identified, namely talus accumulation, fan formation, antiscarps and convex bulging slopes. It is assumed that with the gradual cessation of paraglacial process since Late Pleistocene and Early Holocene, the features produced earlier became relict and subject to periglacial and fluvial processes. Hence a further modification process of slope evolution continued since then. The rock-fall features deposited at the bottom of the slopes, comprising large blocks and little amount of fines represent the features produced mainly by paraglacial process during deglaciation and the angular debris, mixed with finer material occurring on the upper slopes represent pariglacially and tectonically (seismically) produced slope deposits.

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DURGA PUJA : RITUALS AND ECOLOGY

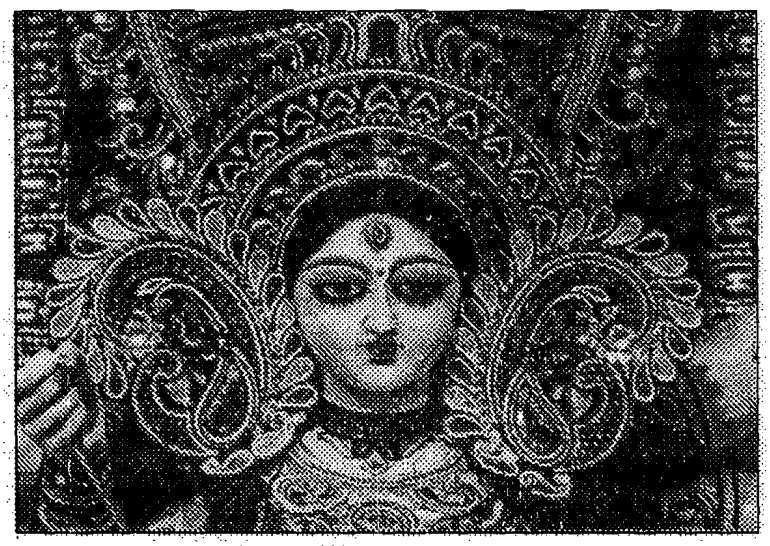
*R.K. Bhakat**

Abstract

Durga Puja is a popular socio-cultural festival in India. Despite it's mythological and religious significance, the worship of Durga has agrarian and ecological roots. This paper attempts to dissect the relationship between Durga puja, more specifically the worship of *nabapatrika* along with other plants and ecological sustainability. It thus illustrates how religion, environment and conservation are complementary to one another.

The goddess Durga, one of the most formidable yet popular personifications of the Hindu pantheon, is revered by innumerable Indians as the symbol of divine cosmic energy. The goddess is represented as Shakti whose foremost function is to maintain the balance of the cosmic order by vanquishing the demons who are considered antidivine forces. The Durga puja which falls in the autumn when the goddess is propitiated for nine days is one of the most popular festivals of India in general and Bengal in particular.

In the days of yore, Durga Puja was carried out by Hindu kings, Zamindars and well-to-do families. But gradually, this festival has evolved into a community festival organized by puja committees and temple trusts. And today, with an increased democratization, the puja far transcends it's Bengali roots, and is celebrated both in India and abroad by Hindus.



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The *Devi Mahatmya*, an authentic and most comprehensive account of the functional significance of the goddess, recounts that Durga was created at a time of critical cosmic crisis unleashed by the unrelenting *Mahisasura* – a demon who could transform himself into a buffalo. But according to another version of the myth following *Kritivasa Ramayana*, Rama solicited the goddess's favour to vanquish Ravana and free Sita. Yet, the third and most popular folk imagination of Bengal has given Durga another identity of a grace-bestowing mother who leads a family life on Mount Kailasha. She visits her mother every autumn during puja, coming down to the plains with her children for ten days. Her arrival begins with the new moon day of *Mahalaya* and her stay ends on *Dashami* (the tenth day). This period, popularly celebrated as *Nabaratri* (nine nights), heralds great rejoining in all mortal households. On *Dashami*, the idol of Durga is immersed in water to symbolise her return to husband's abode (Coburn, 1984; Kabiraj, 1991; Banerjee, 2006).

Notwithstanding all the narratives, it is generally believed that Durga puja is primarily performed to commemorate Durga's victory over Mahisasura to remind of the victory of good over evil and to respect the compassionate mother who bestows fortunes and prosperity, and also reorders and restores the balance of life.

During the autumn festival in Bengal, along with the earthen icons of Durga and her family members, nine plant incarnations of Durga referred to as *nabapatrika* representing nine aspects of the goddess are propitiated. The goddess is said to be one who resides in nine plants. These are : *Aegle marmelos* (*bel* or woodapple), *Alocasia indica* (*mankachu* or wild arum), *Clerodendrum phlomoides* (*jayanti*), *Colocasia antiquorum* (*kachu* or arum), *Curcuma longa* (*haridra* or turmeric), *Musa* sp. (*kala* or banana), *Oryza sativa* (*dhan* or paddy), *Punica granatum* (*dalim* or pomegranate) and *Saraca asoka* (*asoke*) representing Kalika, Brahmani, Camunda, Durga herself, Kartiki, Shakti/Uma, Raktadantika, Sokaharita and Lakshmi respectively (Pal, 1970; Khanna, 2000).

However, what is interesting and equally significant is the association of Durga with nature and ecology. Since the worship is performed on icons along with ceremonial pot (*mangala ghata*) holding cosmic waters of creation set on the freshly sprouted barley seedbed, it reveals its intimate connection with lands, fields, forests and groves. The three symbols of goddess – soil, water and vegetation – are the most fundamental elements of the nature which are in constant symbiotic relationship through the biogeochemical cycles that restore ecological balance on the earth. Even a closer and deeper look at the puja rituals and performances reveals that the roots of Durga Puja lie in the larger context of nature-based pro-ecological rural agricultural traditions of India which have a bearing on the seasonal rhythms and crop cycles. This is the original motive and intent behind the worship.

Madhu Kanna (2000), in an essay in the book *Hinduism* and *Ecology* says, "For millions in India, the goddess Durga lives in freshly sprung paddy saplings or in the tender shoots

of barley; in golden spikelets of harvest grains; in deep forest groves hidden among clusters of green shrubs, trees, and creepers; in the spices and roots used in the daily diet; in the *bilva*, or wood apple tree, and its fortune-bestowing fruit, *sriphala*; and in the rich produce of the harvest season. These nature personifications of the goddess represent the fecund power of the earth with which the goddess Durga is identified. The unity of agricultural productivity and festive activity is integral to all the traditional societies, and Durga worship presents but one 'ecocosmic' model of this worship". But over a period of history, the primal link between seasonal celebration and ecology has been superimposed and blurred by the mythification of Durga. Today, we recognise Durga as a demon slayer, but not as one who is responsible for preserving the natural balance of our environment. This write-up, therefore, attempts to dissect the relationship between Durga puja, more specifically the worship of *nabapatrika*, and ecological sustainability. In doing so, it then illustrates how religion, environment and conservation are complementary to one another.

Though the goddess is synonymous with the cosmic energy, she is vitalised through her natural symbols or *swambhu murtis*, such as the sacred waters of *mangala-ghata*, the wood apple tree and the *nabapatrika*. Before the commencement of the main puja on the sixth day (*sasthi*), the goddess is aroused (*bodhana*) and welcomed in the wood apple tree. On the seventh day (*saptami*) and thereafter, the *nabapatrika* is purified and anointed by invoking sacred waters of oceans, rivers, streams and lakes. Besides this, almost all the bounties from nature – plants, plant parts, soils etc. enter into the ritual cycle of Durga worship. And this affirms that the goddess's association with plants, trees, groves, soils and waters is perennial. The Durga-stava in *Mahabharata* also states that the Durga's abodes can be found on the mountain peaks, by the rivers and in caves, forests and groves. Her association with trees and forests may have been the very basis of the goddess's survival as sacred tree or grove based folk deity *Bana Durga* or *Bana Devi* in rural areas of Bangladesh and India, particularly in Sundarbans and South West Bengal forest belts. Among the folk and tribal cultures of Bengal, trees and forests are worshiped as *Bana Devatas*, or deities of the forests (Mitra, 1922; Kamilya, 2002). A parallel of this belief is also found in *Devi Mahatmya* in which the earth mother proclaims that she will slay the *asura* (demon) that personify drought, and sustain the whole world with the life-giving vegetables that grow from her body (Shiva, 1989).

A direct relationship of the worship with ecology is evident in the selection of plant varieties (including *nabapatrika*) for the rituals. The large number of plants, plant parts/organs and products (Table 1) used during puja as puja ingredients and for making idols to immersion have a sustenance value, and are therefore significant in terms of ecology, environment, economy and health. Making these species available along with other earth-borne resources like different kinds of holy waters, soils etc. year after year in the age of environmental destruction is the easiest, safest and surest way of natural resource management in general and biodiversity conservation in particular. The innumerable rituals of Durga puja, the

bodhana for example, where plants are awakened, preserve a norm for the ecological ethics. They unambiguously show and record the ethos and sensibility of the people who care for the nature. Therefore, the ritual of Durga puja and similar other religious beliefs and ethics as they exist today have the potential to inspire people to use symbols rooted in the earth for environmental activism and ecological preservation. In fact, this kind of religious and sacred tags on the environment has been one of the many arguments put forwarded by the rural communities in India to protect and preserve ecosystems. In the tribal-dominated village of Chilkigarh (near Jhargram) in West Midnapore district of West Bengal, villagers have formed a committee to protect a 60-acre forest patch which houses the holy temple of Kanak Durga (a lesser known local forest deity). This sacred grove, a piece of uncut original forest vegetation, typical of the South Bengal, harbours around 400 species of plant populations (Table - 1). It acts as a last sanctuary for more than 100 different kinds of regional ethnomedicinal plants which are fast becoming rare in the rural hinterlands (Bhakat, 2003; Bhakat and Pandit, 2006). And the method of degraded forest revival, protection and conservation due primarily on socio-religious grounds by the adivasis in India in general and Bengal, Bihar, Jharkhand and Madhyapradesh in particular through the network of sacred groves variously known as *sarna*, *jahirthan*, *deovan* etc. is an eye-opener in this respect. This network of sacred groves that covers India so impressed Sir Dietrich Brandis, the first inspector general of forests in colonial India, that he urged a system of forest reserves and preserves modelled upon it. Therefore, there is an urgent need to respect, revive and reinvent these traditional ecological attitudes. And also, these strategies should be given a new-found significance in modern discourses on environmental conservation.

Table 1: Ingredients used for Durga Puja (modified after Pal, 1970 and Khanna, 2000).

A. PLANT-DERIVED ITEMS:

I. *Pratima prastuti* (Idol preparation)

1. *Aeschynomene aspara (Sola)*
2. *Bambusa aurandinacea (Bans)*
3. *Gossypium herbaceum (Karpas)*
4. *Oryza sativa (Dhan)*
5. *Saccharum spontaneum (Keshay)*

II. *Nabapatrika* (Nine plant-forms of Durga)

1. *Aegle marmelos (Bel)*
2. *Alocasia indica (Mankachu)*
3. *Clerodendrum phlomoides (Jayanti)*
4. *Colocasia antiquorum (Kachu)*
5. *Curcuma longa (Haridra)*
6. *Musa sp. (Kala)*
7. *Oryza sativa (Dhan)*
8. *Punica granatum (Dalim)*
9. *Saraca asoka (Asoke)*

III. *Homagni* (Fire oblation/sacred fire)

1. *Aegle marmelos (Bel)*
2. *Areca catechu (Supari)*
3. *Ficus sp. (Dumur)*
5. *Ocimum sanctum (Tulsi)*
6. *Piper betle (Pan)*

IV. *Pancha pallava* (Five types of twigs)

1. *Mangifera indica (Am)*
2. *Ficus bengalensis (Bat)*
3. *Ficus infectoria (Pakur)*
4. *Ficus raccmosa (Jagna-dumur)*
5. *Ficus religiosa (Aswatha)*

V. *Pancha Kasaya* (Five types of barks)

1. *Mimusop elengi (Bakul)*
2. *Salmalia malabarica (Shimul)*
3. *Sida rhombifolia (Berela)*
4. *Syzygium cumini (Jam)*
5. *Zyzyphus jujuba (Kul)*

VI. *Pancha sarsa* (Five types of seeds)

1. *Brassica hirta (Sweta sarsa)*
2. *Hordeum vulgare (Jav)*
3. *Oryza sativa (Dhan)*
4. *Phaseolus mungo (Mung)*
5. *Sesamum indicum (Til)*

VII. *Pancha guri* (Five types of powders)

1. *Aegle marmelos (Bel leaf)*
2. *Carthamus tinctorius (Kusum phal)*
3. *Curcuma longa (Rhizome)*
4. *Oryza sativa (Burnt paddy)*
5. *Triticum aestivum (Wheat grain)*

VIII. *Sarbaaushad* (Medicinal plants)

1. *Barberis aristata (Darhaldi)*
2. *Curcuma longa (Haldi)*
3. *Curcuma zedoaria (Sati)*
4. *Cyperus rotundus (Mutha)*
5. *Michelia champaca (Champa)*
6. *Nardostachys jatamansi (Jatamansi)*
7. *Saussurea lappa (Brahmakamal)*
8. *Zingiber zerumbet (Bach)*

IX. *Mahaausadhi (Medicinal Plants)*

1. *Asparagus racemosus (Satamuli)*
2. *Eclipta alba (Bhringaraj)*
3. *Ichnocarpus frutescens (Shyamalata)*
4. *Sida rhombifolia (Swet berela)*
5. *Tinospora cordifolia (Gulancha)*

X. *Prasada* (Holly food)

1. *Carica papaya (Pepe)*
2. *Cocos nucifera (Narikel)*
3. *Cicer arietinum (Chhola)*
4. *Citrus maxima (Batabilebu)*
5. *Citrus reticulata (Kamal lebu)*
6. *Cucumis sativa (Sasa)*
7. *Mangifera indica (Am)*
8. *Musa paradisiaca (Kala)*
9. *Phaseolus aureus (Mash-kalai)*
10. *Phaseeolus mungo (Mung)*
11. *Phoenix sylvestris (Khejur)*
12. *Pisidium guajava (Peyara)*
13. *Pisum sativum (Matar)*
14. *Trapa bisponosa (Paniphal)*

XI. *Siddhi* (Tonic with hemp)

1. *Amomum zeylanicum (Dalchini)*
2. *Cannabis sativa (Sidhi)*
3. *Cinnamomum tamala (Tejpata)*
4. *Cocos nucifera (Narkel jaal)*
5. *Crocus sativa (Kesar/Saffron)*
6. *Syzygium aromaticum (Lavanga)*
7. *Zingiber officinalis (Ada)*

B. MISCELLANEOUS ITEMS

I. Different types of waters

1. Pure water
2. Conch water
3. Ganges water
4. Metal-bathed waters
5. Honey water
6. Kush grass water
7. Lotus water
8. Green coconut water
9. Honey water
10. Milk water
11. Coconut water
12. Curd water
13. Water from holy places, etc.

II. Different types of soils

1. Soil from king's door
2. Soil from cowshed
3. Soil from sacred hill
4. Soil from meeting points of sacred rivers
5. Soil from the Ganges
6. Soil from different pilgrimages
7. Soil from courtesan's door, etc.

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JURIDICAL INTERVENTION FOR A GENDER-JUST SOCIETY : A REFLECTION THROUGH CULTURAL DIAMOND

*Soumyajit Patra**

The penetration of judiciary even into the minor contexts of our day to day life, having a concern for the subjugation of the so called 'fair sex', has stormed a debate – how far can judicial intervention ensure gender equality in real life. It is true that the legal safeguards have been visibly helpful for the women of a particular section and invisibly conducive for the conscientisation of the people as a whole. So, no one denies the role of judiciary in extending the horizon of justice to include the women. But the question is how many women are directly benefited by these legal measures or, at least how many of them are aware of these? Gender divide is present in every aspect of life without exception in our society. If we consider women not in 'absolutist' terms but in terms of positional differences, which ultimately lead to psychological differences, the answer becomes clear. And the advocates of women liberation movements 'now realize the limits of speaking of women's identity in singular' (Giri, 2001). Naturally the legal support is not a much effective instrument for the women who belong to the lower socio-economic strata for obvious reasons.

Even among the women of higher socio-economic group a negative attitude to resort to legal procedure is evident. This is not only because the women do not employ instrumental or calculative rationality in case of husband-wife relationship, considering it a 'commodity relations', but also because they simply obey the custom of what Visvanathan (2001) has rightly referred to as 'honour society'. In such a society the women simply tolerate patriarchal exploitation and avoid exposition of their personal life to the public. So except some extreme cases the women themselves do not consider legal battles for their freedom as right and desirable and hence the effectiveness of judicial safeguards for them is reduced. The paradox lies in the peculiar value system of Indian society which demands submissiveness from the women, at the same time orients them towards a world marked by equality and individuality following the western model. Chitnis (1988) has found a 'cultural emphasis on *sublimating* the ego' (emphasis mine) in Indian tradition.

This emphasis has a deep rooted and long term impact on the total process of women empowerment. In fact it is a conflict between long cherished emotions underlying the general behaviour pattern and the growing rationality. Legal measures, which aim at the harmonisation of gender relations, must be examined from this angle.

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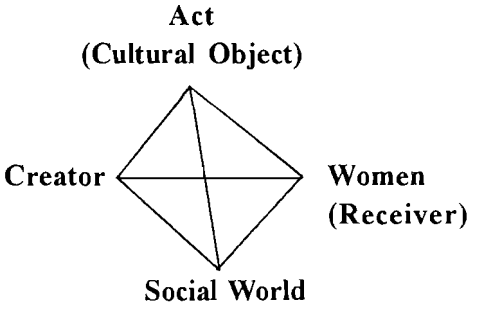
Need for Contextualisation

Wendy Griswold (2004) has devised a tool for understanding the effectiveness of what she calls 'cultural object' in a particular social context. In fact any legal measure, a cultural object in a wider sense, is bound to fail if it contradicts the basic values of a society. In a country like India where traditionalism is persisting in varying degrees among different sections of population, the problem becomes more evident. Take the example of child marriage which is not only legally banned but also there is a growing awareness among the people of its fatal impacts particularly at the individual and family levels. The present socio-economic structure of our country is also not conducive to child marriage as such. But till now, as per 2001 census, there are 15 lakh married girls, in our country, who are under 15 years of age (The Times of India, May 13, 2005). It would be an oversimplification if we analyse it as a consequence of bad governance. The reason lies in the fact that to many the girl children are liabilities or what Sharma (2000) calls *'parayadhan'*.

Similarly in their work in Rohtak district of Haryana, Sabu M George and Ranbir S Dahiya (1998) have analysed the context in which the national law (1994) against Sex Determination Test (SDT) is working. I would like to quote a few lines from their article:

Thus it is the cultural peculiarities which are responsible for the failure of a legal measure to be a real threat to an age old practice. But the 'social world' is only one point of the 'cultural diamond' as has been envisaged by Grisdwold (Griswold 2004). The other three points – the creator, the receiver and the cultural object itself – are also essential for a clear understanding of the causes of success and failure of a legal measure. The following diagram shows it.



Cultural Diamond

Contemporary sociologists often point out that the problem of women empowerment lies, to a great extent, in the psychological set up of the women themselves, who are often regarded as the *conserver* of tradition. The contradiction becomes evident when the women deny to label their male counterparts 'as the principal oppressors' (Chitnis, 1988). Therefore the root of 'pervasive gender inequalities lies in the fact that the normative structure of

society not only deliberately inspired gender discrimination, in almost every sphere of life, was reinforced by the actions of the women' (Manna and Patra, 2001). So the effectiveness of a legal measure should be analysed from the receiver's points of view also. However, for obvious reasons, it depends on the nature of the act itself. If it attacks a traditional value or a belief directly, it hardly satisfies the people in general.

The effectiveness of a legal measure, thus, depends on many factors, but its importance lies in the fact that it helps to reorganise the existing value system by defining justice in different spheres of life. If, conscientisation of the people is the only remedy to eradicate gender bias, a legal measure definitely sets up an ideal for at least a section of population. As human behaviour is a reflection of what Sharma (2000) calls 'cultural psyche', we have to wait further for a radical change to occur there to have a gender-just society.

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HUMAN ECOSYSTEM: A FRAMEWORK FOR EMPIRICAL STUDY

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Abstract

The study deals with the theoretical considerations of the broad subject matter of human ecology. Principally, it attempts to review the rationale of the application of the ecological principles in understanding the dynamics of the resource process of the human society at large.

1.0 Introduction

An ecosystem may be defined as an orderly network of linkages and inter-linkages of various components, superposed on each other. The linkages are maintained through a unidirectional transfer of energy and matter. Therefore, any physical or notional plane where such transfers occur can be analyzed through the ecosystem, be it in the plant, animal or human world.

2.0 Framework of a Natural Ecosystem

Ecosystem is defined as the patterns of functional relations and interactions between and within organisms and their environment, interaction between organisms take place in a horizontal plane and within organism it occurs in the vertical plane i.e. in the hierarchical organization of species. The functional link is maintained through the transfer of matter and energy.

- The trophic structure framework
- The food chain framework
- Levels of organisation

In the trophic (nourishment) structure framework, the components of study are the autotrophic and heterotrophic layers. The functional relationship between the two layers is studied through production, consumption and decompositon of matter and energy. The framework of food chain in akin to and indeed a part of the trophic structure but is restricted to the heterotrophic layer alone.

Within the framework of the levels of organization, the components are studied at the populations, community and ecosystem level. In ecology, a population is defined as a group

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of individuals of any one kind of organism, while a community is defined as a collection of population in a given area. An ecosystem is defined as the combination of a community and its functional link with the environment.

3.0 Framework of a Human Ecosystem

Perfect equivalents of the framework of a natural ecosystem may be difficult to find and define in a human ecosystem. Nevertheless analogous situation can be found with certain reservations and limitations in view of the fundamental difference of the factors involved.

The trophic layers analogous to autotrophs and heterotrophs of a natural ecosystem can be found in the human ecosystem too, precisely, in the hierarchical organization of rural society.

The autotrophs of natural ecosystem are the plant world who fix solar energy to produce food and is the support system of the higher trophic levels i.e. herbivores and carnivores. Likewise, the autotrophs of a human ecosystem are represented by the persons engaged in agricultural activities (mainly field production) who are mostly the tribals and other low caste people. Like their counter parts in the natural ecosystem, they also form the base of the human ecological pyramid, because the rest of the society comprising the upper caste people depends for their food supply on this layer alone.

The population level may find its equivalent in the castes groups like the scheduled tribes, scheduled castes, general castes etc. The community level may be identified with an administrative unit like the mouza (revenue unit) and in the present case where several settlement clusters each with its own social composition exists. The ecosystem level may be identified in the resource process through which the population groups of a particular area interact with their immediate environment to eke out a living.

4.0 Differences between a natural and human ecosystem.

The essential difference between the two ecosystem lies in the nature of the matter and energy together with the processes involved in their transduction from one level to the other. In a natural ecosystem matter is produced through natural process while in a human ecosystem it is produced through technological processes. Therefore, the nature and processes involved in their fixation, production, consumption distribution and decomposition are inherently different from each other.

In a natural ecosystem, energy occurs primarily in the form of electromagnetic spectrum and secondarily in the form of metabolic and other involuntary chemical processes within living things and living beings while in a human ecosystem, apart from the involuntary metabolic energy derived externally from food, most of the energy occur in the form of monetary profits obtained from economic activities. In other words, energy dynamics in

human ecosystem manifests itself through the resource process which is defined as the activities which are required to be performed in the process of making the energy matter available to people in the form of energy including wastage, recycling and final disappearance of the energy matter outside the ecosystem boundary.

The naturally occurring energy of a natural ecosystem "flow" i.e. it is unidirectional, while matter circulates through the process of decomposition and its consumption by the saprophages. In sharp contrast to this, in a human ecosystem, the energy component (money) circulates but all matter doesn't, as judged by the nonrenewability of many of the resources we use to-day. Besides, natural ecosystem has natural attributes alone while a human ecosystem has cultural attributes too. The interaction of the 'natural' and 'cultural' attributes of man, the unique ability to control his immediate surroundings which has no parallels in the other spheres of the living world.

Furthermore, in the case of a natural ecosystem, the energy and matter are identical in nature and hence amenable to measurements in the same units or in comparable units. In contrast to this, energy and matter of a human ecosystem are inherently different in nature and hence their measurements and paths of transduction cannot be measured in the same unit or comparable units.

Because of these fundamental differences among the two ecosystems the traditional input - output analysis of a closed natural ecosystem cannot be applied in a human ecosystem. In other words the energy circuit of a natural ecosystem has only limited applicability in a human ecosystem. It is largely notional in nature, bearing no scope for drawing direct analogy of factors and processes. Attempts to do so, may end up in elaborate arithmetic exercises resulting in far-fetched imaginary result detached form reality. The objective to understand and unravel the intricacies of ecology-economy relationship will be defeated.

5.0 Suggested methods for the study of Human ecosystems

A tentative method for the study of a Human ecosystem can be suggested here on the basis of the analogies described above.

5.1. The trophic structure of the rural society

The vertical cross-section of the society, i.e. the caste hierarchy is analogous to the trophic structure .Therefore, it can serve as the framework for identification of the pattern of transduction of matter and energy in the human ecosystem .For the present study, an example has been taken from the Ballavpur Mouza (a revenue unit) of the Birbhum District of West Bengal.

Table 1: Position of households in caste hierarchy

Village	No. of households			Place in trophic Structure
	GEN.	SC.	ST.	
Ballavpurdanga	4	3	74	Autotrophs
Sarkardanga	-	1	16	Autotrophs
Kheledanga	1	-	42	Autotrophs
Khejurdanga	-	3	23	Autotrophs
Ballavpurpara	86	87	-	Heterotrophs
Amarkutir	4	2	-	Heterotrophs
Deerpark				

Source: Census of India, 2001

5.2 Energy and matter transduction in a human ecosystem

Transduction of energy and matter in an ecosystem takes place through the processes of production, consumption and decomposition at various levels.

5.2.1 Production process in a human ecosystem

Production process in a human ecosystem involves activities like agriculture, manufacturing, service etc. Therefore, an analysis of the occupation structure of a human ecosystem provides the framework to study its production process. Accordingly, the occupational structure of the Ballavpur Mouza has been analysed (Fig - 1).

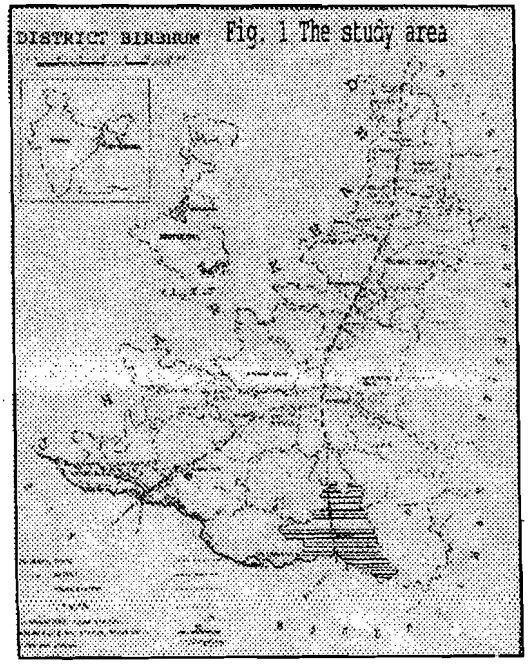

Table 2

Occupational Structure at the trophic levels

Population / Occupation	Autotrophs		Heterotrophs	
	A	B	A	B
Total adult population	256		190	
Total main workers	219		126	
% of T.M.W. to T.A.P.	85.55		66.32	
Total population in :				
Agriculture	153	718.73	14	89.17
% to T.M.W.	69.86		11.11	
Construction	16	177.93	-	
% to T.M.W.	7.31		-	
Brick making	14	106.69	-	
% to T.M.W.	6.39		-	
Dairy	-		-	60.24
% to T.M.W.	-		-	
Others	13	22.36	6	
% to T.M.W.	5.94		4.76	
Service	23	384.36	106	2403.66
% to T.M.W.	10.50		84.13	
Total Energy Input into Primary Occupation		256856.0		28389.6
Per Capita Energy Input into Primary Occupation		1003.34		149.42
Total Energy Input into Secondary Occupation		5723.0		-
Per Capita Energy Input into Secondary Occupation		22.6		-
Total Energy Input into Tertiary Occupation		98396.0		456695.6
Per Capita Energy Input into Tertiary Occupation		384.36		2403.66

Source : *Primary Survey, TMW :Total main workers, TAP : Total Adult Population*
A= Percentage of Population, B= per capita energy input (MJ); Energy Calculations as per Binning et.al. (1983) and Fluck (1992).

It is evident from the table that the villages of the autotrophic layer are indeed engaged in primary economic activities while the villages in the heterotrophic layer are engaged in the non primary economic activities thereby proving the hypothesis.

Not only this, it is also noted that the human energy input (estimated in terms of human-energy expended of the social autotrophs in primary occupation is significantly greater than those of the social heterotrophs the corresponding per capita figures being 1003.34 MJ and 149.42 MJ respectively. These observation imply that the social autotrophs are the greatest energy fixers like their counter parts in a natural ecosystem. They are therefore the principal producers while the general caste people and the scheduled castes representing the higher and middle rungs of the society become the consumers.

5.2.2 Consumption process in a human ecosystem

The consumption process in a human ecosystem can be analysed in terms of the content and nature (nutritional value) of food and fuel used.

A. Food Energy

Table 2 shows total food energy intake by the two trophic levels. It is evident that food energy consumption is less among social autotrophs than among heterotrophs the corresponding per capita energy intake being 42.24 MJ and 78.22 MJ respectively.

Table 3 :Food Energy Intake

Energy Intake / Trophic Level / Villages	Total Population	Total Energy (MJ)	Energy Value per Capita at the Village Level (MJ)	Per Capita Energy Intake at the Trophic Level (MJ)
Autotrophs				
Ballavpurdanga	181	6473.48	35.77	
Sarkardanga	93	6382.39	68.63	
Kheledanga	114	3404.55	29.90	
Khejurdanga	62	2746.16	44.29	
Total	**450**	**19006.58**	-	**42.24**
Heterotrophs				
Ballavpurpara	245	20862.0	85.15	
Deerpark	10	544. 04	18.75	
Amarkutir	29	945.54	94.90	
Total	**274**	**22355.58**	-	**78.22**

Source : Primary Survey

B. Food Energy Constituents

Rice, vegetable and pulses are consumed by all households being the staple cereal of the region. However, wheat is rarely taken. Major differences are noted in percentage of households consuming animal products. They are discussed below.

C. Distribution of Energy Derived from animal product consumption

Table 4: Pattern of consumption of Animal Products

Villages / Trophic levels	Milk		Egg		Fish		Meat	
	A	B	A	B	A	B	A	B
Autotrophs		0.01	51.95	0.14	44.20	32.59	7.79	0.15
Ballavpurdanga	-	-	54.54	0.13	24.24	25.65	6.10	0.12
Sarkaradanga	-	-	25.00	0.08	91.67	59.32	25.00	0.47
Kheledanga	5	0.03	45.00	0.15	45.00	2.16	5.00	0.02
Khejurdanga	8.33	0.02	83.33	0.26	66.70	35.59	-	-
Heterotrophs		0.18	83.93	0.47	39.30	74.16	48.21	1.01
Ballavpurpara	32	0.15	82.00	0.48	84.00	78.06	54.00	1.13
Deerapark	100	0.40	100.00	0.30	66.70	45.97	-	-
Amarkutir	100	0.29	100.00	0.28	100.00	25.36	-	-

Source : Primary Survey

Note:Figures in column A is % of households; in B is per capita energy value in (MJ.) after Binning et.al. (1983) and Fluck (1992).

From the distribution of energy value obtained from different animal products among the two trophic layers it is evident that it is lower among the autotrophs and higher among the heterotrophs. Besides even the coefficients of variation of the intake of animal products by the autotrophs and heterotrophs reveals very high variations in frequency and amount of intake of food from animal products in both categories of population under study.

However, the variations are more in case of autotrophs indicating greater inconsistencies in amount and frequency of intake of food items of higher nutritional value .

D. Fuel Energy

Pattern of fuel energy consumption has been analysed on the basis of the content and method of procuring. Accordingly, fuel procured through collection is termed non commercial, that which is partly purchased and partly collected is semi commercial, and

that which is purchased is termed commercial fuel. The following table shows the nature and pattern of its distribution.

Table 5 : Distribution of fuel types among the trophic levels

Villages/Trophic Levels	Non commercial (Leaves, dry twigs etc.)		Semi commercial (wood)		Semi Commercial (Cowdung Cake)		Commercial (Coal briquette)	
	A	B	A	B	A	B	A	B
Autotrophs								
Ballavpurdanga	33	13.01	100	14.84	3.03	0:09	-	-
Sarkardanga	12	14.19	100	13.55	100	4.13	-	-
Khejurdanga	20	12.16	100	14.24	5.00	0.42	-	-
Kheledanga	12	9.47	100	19.91	100	5.32	-	-
Heterotrophs								
Ballavpurpara	1	0.54	52	7.81	96.0	8.37	74.0	10.10
Deer Park	-	-	-	-	-	-	-	-
Amar Kutir	-	-	-	-	66.66	0.96	66.66	44.67

Source : Primary Survey.

A – Percentage of house holds using the fuel type

B – Per capital Energy input (MJ) after Binning et.al. (1983) and Fluck (1992).

It is evident from the table that the use of the non-commercial fuel is restricted within the autotrophs alone.Among the heterotrophs it is used by a negligible number of households in Ballavpurpara. The semi commercial variety is used by both the trophic levels but predominantly by the heterotrophs,while the commercial variety is used by the heterotrophs alone.

E. Monetary and material possessions

Monetary and material possessions are also important indicators because they indirectly indicate the level of energy consumption through the upstream and downstream linkages, besides determining their nature and level of accessibility to general comforts of life which ascertains their levels of energy consumption. Indicators of matter which can be taken into consideration are the material possessions like land, household belongings, monetary possessions etc. They can be used to empirically test the hypothesis of an inverse relationship between production and consumption of energy and matter among the 'social autotrophs' and social heterotrophs.

Table 6 : Quality of Habitat

Name of the village	Do	Sali	Suna	Danga	Total
Tribal Villages					
Ballavpurdanga	2.22	18.63	70.31	8.74	100.00
Sarkardanga	14.18	2.08	65.03	17.32	98.61
Kheledanga	1.06	31.74	57.99	8.94	99.73
Khejurdanga	4.33	67.66	25.41	1.48	98.88
NonTribal Villages					
Ballavpurpara	2.45	41.72	50.16	5.90	100.13
Amarkutir				100.00	
Deerpark			100		

Note: 1. Figures in the table are in percentage to the total area of the village. 2.Danga plots include Bastu plots.

Source : *District land and Land Record office, Siuri, Birbhum, West Bengal; Analysis of the data in the above table disproves the hypothesis of the study because it shows that the habitat of the tribes are not restricted to inferior quality of land. The data shows that the percentage area of the good quality land to the total area is more or less equally distributed in the tribal and non tribal villages. However an analysis of the ownership pattern of the landholdings reveals otherwise.*

Table – 7 : Ownership Pattern of Landholdings

LAND CATEGORIES / TROPHIC LEVELS/ VILLAGES	CASTE	DO		SALI		SUNA		DANGA		BASTU	
Tribal Villages											
		A	B	A	B	A	B	A	B	A	B
	NT	1	7.69	24	44.44	42	35.29	10	47.62	4	7.02
Ballavpurdanga	SC	6	46.15	26	48.15	37	31.09	7	33.33	3	5.26
	ST	6	46.15	4	7.14	40	33.61	4	19.05	50	87.72
	Total	**13**		**54**		**119**		**21**		**57**	
	NT	3	75	3	50.0	14	48.28	10	50.00	-	-
Sarkardanga	SC	1	25	-	-	8	27.59	5	25.00	1	16.66
	ST	-	-	3	50.0	7	24.14	5	25	5	83.33
	Total	**4**		**6**		**29**		**20**		**6**	
	NT	4	57.14	55	58.0	78	25.57	3	17.65	1	3.23
Kheledanga	SC	2	28.57	40	42.11	120	39.34	4	23.53	-	-
	ST	1	14.23	-		107	35.08	10	58.82	30	96.22
	Total	**7**		**95**		**305**		**17**		**31**	
	NT	2	37.03	12	10.08	7	9.46	4	36.36	-	-
Khejurdanga	SC	33	61.11	74	62.18	44	59.46	2	18.18	3	16.67
	ST	19	35.19	33	27.73	23	31.08	5	45.45	15	83.33
	Total	**54**		**119**		**74**		**11**		**18**	
Non-Tribal villages											
	NT	27	57.45	165	69.92	258	67.19	15	62.5	91	49.20
Ballavpurpara	SC	7	14.89	61	25.85	111	28.91	9	37.5	94	50.81
	ST	13	27.66	10	4.24	15	3.91	-	-	-	-
	Total	**47**		**236**		**384**		**24**		**185**	
	NT										
Deerpark	SC										
	ST										
	Total										
	NT										
Amar Kutir	SC										
	ST										
	Total										

Source : *District Land and Land Records office, Siuri, Birbhum* ***Note : 1:*** *Figures is column A indicate number of plots in each category and figures in column B indicate the percentage of plots of each category of land to total plots of the same category at the village level. 2: NT =Non Tribals; SC =Scheduled Tribes; ST= Scheduled Caste.*

It is seen that the largest share of the superior quality of landholdings are in the possession of the non tribals followed by the Scheduled Castes and Scheduled tribes even in tribal dominated villages. Similar trends are noticed among non tribal villages too except in case of 'DO' category of land.

These observations suggest that non tribals are the possessors of superior quality of land even in tribal habitats despite being non residents (as is evident from the distribution of the proportion of bastu lands among the two categories of population) here. They cultivate these lands by hiring agricultural labourers from the local area. It further implies that homogeneity of habitat qualities is only apparent and rather superfluous because the benefit of the quality of the habitats does not accrue to the tribals. The whole of it is garnered by non tribals who are the de-facto owner of productive agricultural land.

6.0 Conclusion

The inverse relation between production and consumption of energy among social autotrophs and heterotrophs is undesirable in many other ways if it exceeds a certain given limit. This is because the base of the ecological pyramid both in natural and human ecosystem alike is formed by the autotrophs, it is imperative in either case to sustain it with full vigour failing which the ecosystem will collapse resulting in ecological chaos. The social connotations of such a situation are negative in nature. It manifest itself in the form of social unrest, famine like situation due to instability in the food supply situation, economic depressions, political upheavals and the like.

Such undesirable situation in a human society should be attended to and steps shall have to be taken to ensure proper nourishment of the autotrophic layer through assured food supply and other survival inputs to maintain the production base of the socio-ecological pyramid. It is imperative to keep in mind that the autotrophic layer is endowed with a self-sustaining mechanism which is commensurate with the local ecological milieu. Any outside interference with its working or energy subsidy into the system has always resulted in inefficiency and instability because it increases dependence on supply of outside energy which is difficult to ensure or maintain. When steps are taken to maintain the self- sustaining mechanism of an ecosystem, care has to be taken to ensure the judicious and optimum utilization of local ecological factors. In other words one should put greater emphasis on grass roots level planning which should be based on environmental resources rather than on laboratory resources. This is indeed the essence of sustainable development.

The study has shown how the ecosystem framework can be used to study the structure of the society and the nature of distribution of resources among the different social groups together with their social and economic implications. Such studies can be consulted for resource planning by different interest groups.

Acknowledgement

We express our sincere gratitude for the Late Professor Arabinda Biswas for introducing us to this line of enquiry in geographical studies.

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IRS-LISS-IV DATA FOR CADASTRAL LEVEL INFRASTRUCTURE MAPPING AND LAND DEGRADATION STUDY AT PPSP PROJECT SITE – AJODHYA HILLS, PURULIA

Abhisek Chakrabarty and Dr. Soumendu Chatterjee***

Abstract

The Purulia Pumped Storage Project (PPSP) on Kistobazar Nala of Ajodhya Hills is proposed to improve the peaking power scenario of West Bengal in India. The project involves construction of two reservoirs with rock-fill dams comprising central clay core, rock crushing ground, cement mixing plant, staff quarters, service roads and disposal area which in turn claimed a huge amount of forest and agricultural land. On the other hand stream impoundment for filling the reservoirs created water scarcity in the canal fed agricultural land of the downstream villages. IRS-P6, LISS-4 MX (5.8m) standard scene 23.5 x 23.5 km (11'x11') of The LISS-IV data with 5.8 m spatial resolution in multi-spectral mode, is helpful in improving the large scale mapping of natural resources at cadastral level including infrastructure mapping. This study attempts to map out the infrastructure developed during the gestation period of the project (1998 to 2007) and consequent land degradation took place all over the study area. To accomplish this target a multi-temporal image analysis has been made with a LISS-III data (23.5m) of 1999 and a LISS-4 MX data (5.8m) of 2005 and a change detection map is prepared. This study reveals that alteration of natural forest and agricultural land to built-up area and permanent fallow was the most remarkable happenings to this area. Cadastral map overlay on the change detection map clearly visualizes the private ownership lands which have been acquired by this project and those which have been simply damaged. Field survey and photographs of the areas surrounding the dams and the service roads speak about the truth of deforestation and man induced gully erosion. SCS (NRCS) Curve Number method and Modified Universal soil loss Equation (MUSLE) are used to get a quantitative assessment of increase in runoff and soil erosion respectively. Interviewing the common people it has been found that they do not rely on the temporary job opportunities as an unskilled labour in this project. They are scared of loosing their traditional source of income from the forest and agricultural land.

Among few of the limitations of this study, non-availability of high-resolution data of 1999, thus multi temporal analysis with images of different spatial resolution is significant one. The accuracy of socio-economic impact evaluation is faded somewhere because no reliable secondary data were available and the analysis is based on primary survey and reviews of other scholars. Still updated and accurate spatial information from high resolution remote sensing and huge database handling capacity of GIS has proven these a successful means of change detection and land use mapping. Finally the flaws of PPSP, which came out from this research, will enable the project authority to rectify in future projects, on adjoining Turga and Kathlajal river. Thus environmental sustainability can be maintained.

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Introduction :

Purulia is the western most district of West Bengal. The Purulia upland includes the Baghmundi plateau, which is an extension of the Ranchi plateau of Chotanagpur Region and constituted of the granite-gneiss of oldest Precambrian or Archean formations. The residual hills of Ayodhya are situated in Baghmundi Block, at the southwestern part of the district with an average elevation of 600m. These hills are bordered by steep escarpment and acts as a watershed divide between Kangsabati watershed in the north and Subarnarekha watershed in the south. Among the left bank tributaries of Subarnarekha river the most important descending from the Ayadhya hills are Kestobazar nala, Turga nala, Sobha nala, Sapahi nala, Salda nala and Sanka nala. They have formed waterfalls and gorges for long stretches, and have potentiality for hydropower generation. This region is one of the most backward part of the district, covered by thick forest and is sparsely inhabitated by tribal population (Bhattacharya. 1985). Though the climate of this region is not very harsh [annual average rain fall is 1186 mm and average annual range of temperature is 11°- 43°C] but high evaporation and infiltration losses cause agricultural drought, which accumulated over years and had weakened the economy of the area.

In mid nineties the Government of West Bengal along with the Major Japanese Corporate such as Mitsubishi Heavy Industries Ltd, Taisei Corporation, Toshiba and Mitsui etc. as well as Bharat Heavy Electricals Ltd. initiated the construction work for a pumped storage project on the Kistobazar Nala, a tributary of Sobha Nala, in the southern slope of Ayodhya hills (23°11′27″N, 86°05′29″E). It is still under construction and expected to be operational from March 2008. A pumped storage project utilizes the off-peak surplus thermal power to pump up water, which is stored and released during the peak period to generate power. This project has four units of 225 MW each and it would require 1,000 MW daily for generation of its capacity of 900 MW (WBSEB).

Study area :

Seventy-nine Mauzas (villages) and four protected forest patches of the Baghmundi and Balarampur blocks consisting of fourteen micro-watersheds have been considered as the study area (23°05′58″N-23°15′01″N, 85°58′11″E-86°12′22″E) for this research (fig-1A). Among these, six mauzas namely Ranga, Hatinada, Ajodhya, Baghmundi, Kuchrirekha and Kudna fall in the catchment of the Kestobazar nala. Bareriya (fig-1B & 1C) is the worst affected mauza where the project has been developed and maximum land use alterations have taken place. And nine mauzas, Gosaidi, Sakardi, Patardi, Pratappur, Chano, Gobindapur, Madla, Matiala and Kudlung are situated in the down stream canal fed areas of Kestobazar irrigation project and suffering from paucity of irrigation water, after the closing (June,2005) of the gates of lower reservoir. Other mauzas are under the impact zone of two future projects, namely Turga Pumped Storage Project (TPSP) and Kathlajal Pumped Storage

Project (KPSP) will be constructed on either side of Purulia Pumped Storage Project (PPSP).

Objectives and methodology :

The Basic objective of this study is mapping land use, land cover changes and land degradation as a result of infrastructure development (from 1995 to 2005) in the study area.

Acquisition of multi temporal satellite imageries [IRS, LISS-3 (23.5m) of Dec-1999 and IRS, P6 (Resource Sat 5.8m) of Jan 2005], their supervised classification by ERDAS Imagine-8.6 software and comparative analysis of individual classes by RSI ENVI–4.3 software that helped in assessing the aerial extent of degradation. The whole area has been divided into fourteen micro watersheds and quantitative assessment of change in runoff and soil erosion has been made to fortify our findings.

Detailed on the NRCS Runoff Curve Number (CN) method is described in NEH-4 (SCS 1985). The equation modified for Indian condition is:

$$Q=(P-0.3S)^2/(P+0.7S)$$

Q is the daily runoff, P is daily rainfall, S is potential maximum retention after runoff begins that is (1000 / CN) – 10, where CN refers to the runoff curve number of hydrologic soil cover complex which is a function of soil type land cover and antecedent moisture condition. I_a denotes initial abstraction before runoff begins, that can also be substituted by 0.3S. These all values are expressed in inch (USDA, 1986).

The Modified Universal Soil Loss Equation (MUSLE) follows the structure of the Universal Soil Loss Equation (USLE), with the exception that the rainfall factor is replaced with the runoff factor. The equation calculates sediment yield for a storm within a watershed that does not exceed 8 square miles. The structure of the MUSLE is :

$$SY = b\ (Q_v * q_p)^{0.56} * K * LS * C * P.$$

SY is the sediment yield per calculation unit (watershed) in tons, *b* is a constant, Q_v is the volume of runoff in acre-feet, and q_p is the peak flow rate in cubic feet per second. The other factors are precisely the same as the Revised Universal Soil Loss Equation (RUSLE) factors and include *K*, which is the soil erodibility factor—the soil loss rate per erosion index unit for a specified soil, as measured on a unit plot, which is defined as a 72.6 feet length of uniform 9% slope continuously in clean, tilled fallow; *L* is the slope-length factor—the ratio of soil loss from the field slope length to that of a 72.6 feet length under identical conditions; *S* is the slope gradient factor—the ratio of soil loss from the field slope gradient to that from a 9% slope under otherwise identical conditions; *C* is the cover and management factor—the ratio of soil loss from an area with specified cover and management to that of

an identical area in tilled continuous fallow; and *P* is the support practice factor—the ratio of soil loss with a support practice like contouring, strip-cropping, or terracing to that with straight-row farming up and down the slope (Balaszczynski, 2003).

Assessment of the impact of this project on the society and the economy of that area is another objective of our study. Primary household survey with Check Lists and Matrices and studying reviews of other scholars are the basis for appraisal of those impacts.

Results and Discussion :

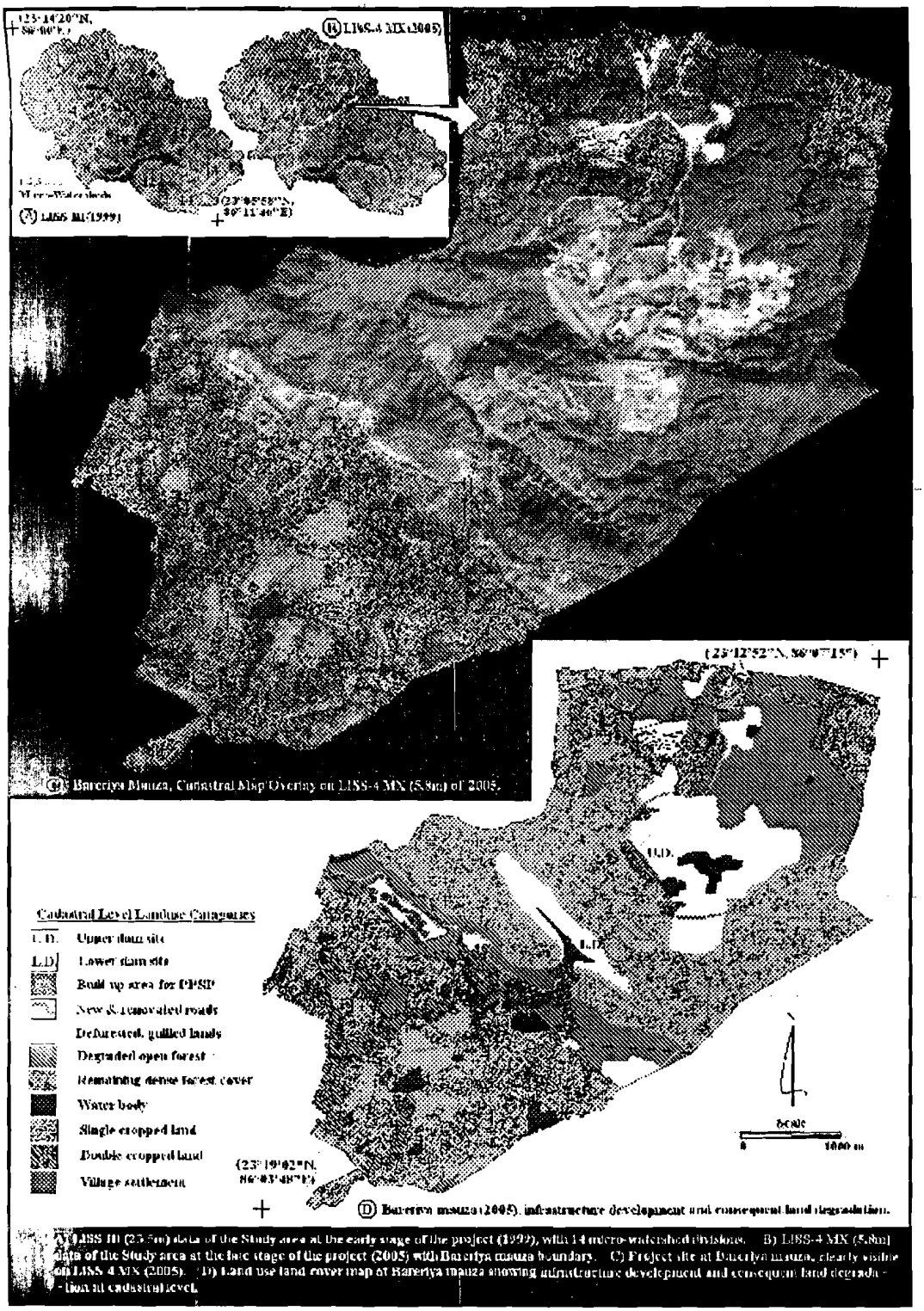
Satellite remote sensing images and primary survey reveal that during 1995 to 2005 huge infrastructure development has taken place in the study area (fig-1C & 1D). Two reservoirs with rock-fill dam, one power station, one cement mixing plant, three land bridge, 7 km long service roads surrounding upper & lower dam and & 20 Km of repaired and widened roads from Balarampur to Baghmundi, one twelve bedded hospital, one fire station, two office buildings and fifty staff quarters are constructed on an around the project site. Most of these are developed at the cost of forest and agricultural land of the area.

Land Use (Area sqkm)	Natural Forest	Dry Fallow	Wet Fallow	Agricultural Land	Water Body	Built-up Area	Total Area
1999	93.80268	8.10667	10.654	67.20754	1.11114	5.793453	186.6755
2005	85.81141	11.56563	12.01329	70.28964	1.006494	6.063343	186.6755
Total Change	-7.99127	+3.45896	+1.35929	+3.0821	-0.10465	+0.26989	--

(Area FROM sqkm) TO	Natural Forest	Dry Fallow	Wet Fallow	Agricultural Land	Water Body	Built-up Area	AREA GAINED
Natural Forest	X	--	--	--	--	--	--
Dry Fallow	**1.112487**	X		**2.346473**	--	--	**3.45896**
Wet Fallow	**0.410723**	--	X	**0.843917**	**0.10465**	--	**1.35929**
Agricultural Land	**6.268155**	--	--	X	--	--	**6.26816**
Water Body	--	--	--	--	X	--	--
Built-up area	**0.199905**	--	--	**0.069985**	--	X	**0.26989**
AREA LOST	**7.99127**	--	--	**3.260375**	**0.10465**	--	

Table-1. Land use Land cover statistics (1999 & 2005) and change detection metrics of the study area.

From the raster attributes of the classified images, areas under the six main categories of land use classes for 1999 and 2005 are obtained (Table-1). Before the commencement of the project (forest clearance and dam construction started in the year 2001) there were *93.8 sq.km. of dense forest which is reduced to 85.8 Sq.Km. within Jan, 2005.* Forest clearance in the project site is primarily responsible for this, where forestlands are altered to dry fallow, wet fallow and in some cases built-up area. Conversion of forest to agricultural land is also responsible for forest cover contraction, and it has taken place all over the



A) LISS III (23.5m) data of the Study area at the early stage of the project (1999), with 14 micro-watershed divisions. B) LISS-4 MX (5.8m) data of the Study area at the late stage of the project (2005) with Baneriya mauza boundary. C) Project site at Baneriya mauza, clearly visible on LISS 4 MX (2005). D) Land use land cover map at Baneriya mauza showing infrastructure development and consequent land degradation at cadastral level.

study area. Another significant change that is the alteration of agricultural land to dry fallow and built-up area in the project site and in down stream areas agricultural lands are altered to fallow by stream impoundment. Intense use of surface water in the construction site and agricultural land caused the alteration of surface water body to wet fallow. It signifies that not only the forests are cleared but also private agricultural lands and surface water bodies have been destroyed during the gestation period of the project. The Proposed surface area of 1.04 sq.km and shallow water level of 15m (PPSP) of upper dam is another fearsome factor of future land use change. In such a drought prone region of Purulia, high evaporation loss from this reservoir is going to prove very expensive to the project authority.

Runoff Estimation From SCS -CN			Soil Loss Estimation of a Design 24hr Storm (4.15 inch) By MUSLE								
	1999	Runoff Q (in)	1999	Rainfall P (in)	Runoff Volume Qv (Acre_ft)	Peak discharge q_p (cfs)	LS Factor	C factor	P factor	K factor	Soil loss SY (ton's/acre)
Total Rainfall of the Year 1999 is 40.543 inch	MW1	8.3318	MW1	4.15	636.0838	1110.248955	1.58239	0.193578	0.373303	0.236966	7.58
	MW 2	12.884	MW 2	4.15	456.5391	1042.625391	0.25409	0.259197	0.275388	0.23	0.93
	MW 3	2.9275	MW 3	4.15	236.3288	339.2513236	3.257547	0.096644	0.653803	0.375267	6.39
	MW 4	6.5543	MW 4	4.15	507.9225	740.5540794	3.390123	0.169221	0.397485	0.240018	10.76
	MW 5	9.4708	MW 5	4.15	466.08	471.3835454	0.247039	0.227325	0.32743	0.237347	0.63
	MW 6	3.5291	MW 6	4.15	447.6593	805.7899305	3.596541	0.114158	0.582765	0.32847	15.09
	MW 7	8.3334	MW 7	4.15	473.0917	1057.807822	1.287339	0.209583	0.41161	0.242313	6.21
	MW 8	7.3468	MW 8	4.15	446.5608	1027.12203	3.480952	0.202807	0.442718	0.25	17.17
	MW 9	1.6645	MW 9	4.15	101.9922	141.5147167	4.123673	0.027151	0.795437	0.391992	1.10
	MW 10	3.3043	MW 10	4.15	357.8819	624.0590656	3.61858	0.089069	0.668187	0.310402	9.81
	MW 11	2.0976	MW 11	4.15	249.9759	257.7886478	3.247368	0.05814	0.717485	0.388256	3.85
	MW 12	3.8842	MW 12	4.15	246.6489	536.4635461	3.708229	0.132005	0.578601	0.347904	10.79
	MW 13	4.2968	MW 13	4.15	585.987	1044.452831	3.728114	0.170711	0.516405	0.336382	28.55
	MW 14	5.8976	MW 14	4.15	487.7993	1419.501854	10.99119	0.234981	0.418405	0.320374	95.82
	2005	Runoff Q (in)	2005	Rainfall P (in)	Runoff Volume Qv (Acre ft)	Peak discharge (cfs)	LS factor	C factor	P factor	K factor	Soil loss (ton's/acre)
Total Rainfall of the Year 2005 is 41.637 inch	MW1	14.081	MW1	4.15	663.5956	1201.569082	1.58239	0.229763	0.404696	0.236966	10.44
	MW 2	19.894	MW 2	4.15	473.5597	1151.021092	0.25409	0.36151	0.343787	0.23	1.75
	MW 3	7.5283	MW 3	4.15	219.8983	304.9039722	3.257547	0.071821	0.642581	0.375267	4.22
	MW 4	13.036	MW 4	4.15	557.0106	1081.266428	3.390123	0.261692	0.436262	0.240018	23.78
	MW 5	16.616	MW 5	4.15	524.9447	582.2973113	0.247039	0.363259	0.411088	0.237347	1.53
	MW 6	9.2165	MW 6	4.15	505.2811	909.7938606	3.596541	0.139615	0.54008	0.32847	19.60
	MW 7	14.081	MW 7	4.15	493.5538	1320.385231	1.287339	0.250164	0.419567	0.242313	8.75
	MW 8	13.123	MW 8	4.15	466.8394	1142.302309	3.480952	0.26074	0.507589	0.25	27.54
	MW 9	5.9838	MW 9	4.15	113.7616	159.9778909	4.123673	0.025864	0.776197	0.391992	1.170
	MW 10	8.7354	MW 10	4.15	381.5054	659.1723958	3.61858	0.09586	0.657809	0.310402	11.11
	MW 11	6.5421	MW 11	4.15	249.9759	250.0549883	3.247368	0.052376	0.677596	0.388256	3.22
	MW 12	9.7082	MW 12	4.15	277.2488	634.2093182	3.708229	0.104259	0.524586	0.347904	9.06
	MW 13	10.273	MW 13	4.15	653.8067	1212.898094	3.728114	0.160008	0.463191	0.336382	27.75
	MW 14	12.271	MW 14	4.15	536.2558	1648.289523	10.99119	0.210686	0.377482	0.320374	88.87

Table-2. Runoff and soil loss (1999 & 2005) from fourteen micro-watersheds of the study area.

Land excavation and deforestation for road construction and rock crushing surrounding the upper dam are accelerating gully erosion at an alarming rate and siltation is taking place in the lower dam. Deforested hill slopes near the water surface of the reservoir are somewhere left exposed and somewhere concealed by cement. Though Honorable C.M. two years ago assured a massive re-plantation program, -[*Saturday,July 02,2005 PURULIA (PTI): " Chief Minister Buddhadev Bhattacharjee set the ball rolling for the Rs 3,198-crore Purulia Pumped Storage project - - - - - - - - The Chief Minister, however, said that in view of the large scale deforestation of Ayodhya Hills due to the project, the state government would take up a massive replantation program and a tourist spot centering the project"* (Outlook)] but no effort has been taken to reforest those slopes till date. Therefore slope instability and chances of landslide are in its peak and threatening the life span of the project.

To assess the changes in surface runoff and soil erosion before and after the development of the project, we have divided the whole region into fourteen micro-watersheds (fig-1A) and applied SCS/NRCS Curve Number method for annual runoff estimation and Modified Universal Soil Loss Equation (MUSLE) for soil loss estimation (from a 24hr design storm) for each micro-watersheds (Table-2). It has been found that in micro-watershed 3, 6, 9, 10, 11, 12, 13 and 14 increase in runoff is very high (>100%) where as increase in soil loss is in its peak (>30%) in micro-watershed 2, 4, 5, 6, 7 and 8. The project area in Bareriya mauza, is located over micro-watershed No.6 and 7. The increase in runoff and soil loss in other micro-watersheds may be explained as indirect effect land acquisition in Bareriya. Loosing hold on forest and agricultural land of bareriya, village peoples are now destroying the adjoining forests to make out their livelihood.

Large number of tribal people (Santal, Munda, Bhumij) living in the Bagmundi Police Station are below poverty line. About 2000 people (70% women and 10% children) are dependent on the forest resources for their survival (NRCS). Collection of fuel wood from the jungle is sometimes the primary source of income of many forest dependent tribals as well as others. Clearance of 200 ha of forest by PPSP has increased illegal deforestation in surrounding forests of Baghmundi, Kuchrirekha, Kudna and Goberia (Plate-1). Forest dwellers are also worried that they will not be able to collect the Lac, *tussar*, *kendu* leaf, *sal* leaf, and other fruits (Minor Forest Produce). In a review by S.Bhattacharyya (2005) it is written that - "According to Sibcharan Mahato, aged 45, a villager of Bareria, the jungle which was full of *sal*, *kendu*, *piyal*, *mohul*, *ashon*, *dha*, *parurh*, *dumur* trees were chopped off for the project. According to him in the stone crushing area (30 acres) alone there were 2000 *palash* trees. Moreover, due to excessive mass of suspended particles in the air lac culture is adversely affected. Villagers of Bareria are losing 10-15 mounds of lac per year which they used to collect from the forest (selling price is Rs 50-150 per kg. More profitable is the egg of the lac, the price of which varies from Rs 200-500 /kg)".

At present Kestobazar nala is draining its entire water to fill-up the upper reservoir of PPSP. No water flows to the irrigation dam of Kestobazar Irrigation Project (KIP). PPSP is already having serious adverse impacts on the agricultural community of nine villages (2250 families) dependent on KIP. The 19 km long Kestobazar nala, just down stream of the PPSP lower dam site KIP, has been used to irrigate 678.981 ha *Kharif* and 70.72 ha *Robi* crop each year and it supplied 15-28 cusecs of water for *Kharif* and 10-12 cusecs of water for *Robi* cultivation. But now most of them are not getting water properly from KIP. It is claimed that after 2007 Kestobazar nala will flow normally, but huge evaporation losses from the reservoirs may shorten its life up to 2009. For the mean time the farmers are left to suffer.

S. Bhattacharyya also wrote that sound of heavy vehicles and stone blasting is creating a lot of noise in this relatively noise free zone of Purulia. Dry dust of the roads and crushing stone are creating smog. Entire region is now under thick dark dust cloud. Though water is sprinkled through machines some times but it is unlikely to be sufficient in the dry and arid climatic conditions of Purulia. Cement mixing plant near the Lower dam is also polluting the water of KIP reservoir.

A recent newspaper report has highlighted the growing aggression of migratory elephants in Ajodhya hills. [*24th Dec, 2006. Prasanta Pal, Kotsila, Purulia: "Three people were killed and eleven hurt by a stray tusker at Kariam village in Ajodhya Hills on Sunday morning. The tusker killed Sumitra Kundu (55) of Parua Village, Maheswar Mahata (45) and Bucharam Mahata (65) of Kariam village. The injured persons are admitted in Purulia State Hospital and four of them are in critical condition"* (Anandabazar Patrika, 2006)]. According to elephant experts migratory elephants that were trying to migrate from the Saranda to Ayodhya Hills were stopped due to the PPSP project activities. The vast land of 602 ha which the elephants used to migrate have been acquired for the project. Migration is an essential need for the elephants. If they cannot migrate, they will obviously face the threat of extinction and become aggressive (Bhattacharya, 2005).

Conclusion :

It is difficult to project benefits that may come from the project in improving the level of peaking power scenario of West Bengal, but from the above study it is obvious that PPSP has caused a great damage to the environment and economy of these villages. Therefore immediate mitigation measures are required to restore environmental stability and ensure economic prosperity of this region. Only intimate interaction, consultation, and co-ordination, of government officials with local inhabitants can help to achieve this goal. Otherwise the entire project will pass through a great phase of uncertainty.

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CREATION OF GIS DATABASE FOR UPDATING INFRASTRUCTURE AND SOCIO-ECONOMIC PLANNING IN PASCHIM MEDINIPUR DISTRICT

Sujoy Jana and Professor D. K. Pal***

Abstract

The paper concentrates on how locale specific development based on the physical resources is critical for the well-being of the grass root communities who do not have any skill / expertise to eke out living from other means. It also embarks on a plethora of social analyses in a GIS platform to show what consequences and how such situation could be improved towards sustainable development and localized poverty alleviation. GIS has been used as a tool to the maximum extent possible to generate these inputs that can be used towards sustainable development of Paschim Medinipur district, West Bengal, India. Paschim Medinipur District was chosen as study area, which is located between 21° 46" N and 22° 57"N; between 86°33" E and 87°44" E.

The query shells developed (in GIS platform) in this study offer a distinct possibility to locate the trailing socio-economic / natural resources endowment with a view to generating sustainable action plan for all round uplift of the geographic entity. This facility serves as a boon to the planners/managers who are responsible for launching development programmes.

The backwardness ranking of the block by 'level of development' has given enough indication to the planners for prioritizing development goals for a particular block. The gaps in facilities and services could be mt and disparities in levels of development among the blocks could be reduced if appropriate action programmes of development are taken up in the priority blocks. This will, however, need prioritization of actions since financial resources for developing the blocks are limited. This will, however, call for framing suitable guidelines depending on the levels of the particular socio-economic variables.

The work has been a humble effort of generating database for action plan towards the uplift of the rural mass of the district of Paschim Medinipur.

Introduction :

About 32.88% of its families are living below the poverty line (BPL). Of these, the majorities belong to Schedule Caste (SC), Schedule Tribe (ST) communities and other backward classes (OBC). They largely depend on these forest resources for their livelihood. Thus, in order to ameliorate the socio economic condition of these downtrodden lots, it is paramount

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to formulate a well-designed development programme. Thus the development policies and their implementation are vital for overall development domain of a Blocks. The role of the Government has been however, is expected to uplift the lot dependent on forests based on a suitable action plan generated from a scientific analyses of resources inventory. Unfortunately the efforts to this direction are not up to the expectations and as a result these sectors of the society are becoming poorer day by day. Lack of development has ostensibly brought about social strife that evinces law and order problems especially within the forest and fringe areas where often the unemployed youths resort to subversive activities (eg. The stretch of Nayagram – Gopiballavpur road is a stark example).

In the district of Paschim Medinipur there are many indigenous/ aboriginal communities like Santals, Sabar/Lodha, Sarder and others living in and around the forest area of Paschim Medinipur. In the recent years some cases of hunger deaths from sabar households received wide publicity in the media. Despite huge tracts of forests and the practice of joint forest management, the situation has remained pretty grim as far as poor landless households are concerned. The present work also emphasizes how forests are critical for such poor communities to survive. The work contain a social analysis to show what resources the poor people have, which group of people use forests, when and how and with what consequences such situation could be improved towards sustainable development and localized poverty alleviation.

Location :

The entire district of Paschim medinipur in the state of West Bengal, India forms the study area, which is located between 21° 46" N and 22° 57"N latitudes and also between 86°33" E and 87°44" E longitudes (Fig: 2.1). The district is bounded on the north by Bankura and Purulia districts, on east by Purba Midnapore district, on the south by Purba Midnapore district and Balasore district of Orissa and on the west by Mayurbhanj district of orissa and Singbhum districts of Jharkhand. The total geographical area of Paschim Medinipur district is about 9081.13 km^2. and the total population is about 460095 in paschim medinipore district as per (census 2001). There are 29 Blocks and 4 Sub-Divisions in Paschim Medinipore. The credit of highest population density goes to Daspur-II Block located in north-eastern part of districts while the lowest density is recorded in Nayagram Block located in the south western part of the district.

Block Backwardness study :

Table-1: Socio-economic backwardness -A ranking system :

PARAMETER	TOTAL SCORES	DISTRIBUTION		SCORES	
01. Concentration of SC Population	25	< 25 %		25	
		25-50 %		18	
		50-75 %		12	
		>75 %		6	
02. Concentration of ST Population	25	< 25 %		25	
		25-50 %		18	
		50-75 %		12	
		>75 %		6	
03. Literacy	25	< 25 %		6	
		25-50 %		12	
		50-75 %		18	
		>75 %		25	
04. Dominance of Occupation	50	Non worker (In %)	<50	5	5
			50-60		3
			>60		1
		Other Worker (In %)	<20	10	3
			20-30		6
			>30		10
		Marginal Worker (In %)	<10	15	5
			10-20		10
			>20		15
		Agricultural Worker (In %)	<40	25	7
			40-50		15
			>50		25
		Cultivators Workers (In %)	<20	35	10
			20-30		20
			>30		35
		Household Worker (In %)	<5	40	10
			5-10		20
			>10		40
		Main Worker (In %)	<25	50	10
			25-30		30
			>30		50

PARAMETER	TOTAL SCORES	DISTRIBUTION		SCORES	
05. Educational Facilities	50	Primary School (Nos.)	<100		4
			100-200	10	6
			>200		10
		Jr. High School (Nos.)	<10		8
			10-20	20	12
			>20		20
		High School (Nos.)	<10		12
			10-20	30	18
			>20		30
		High Sec. School (Nos.)	<5		16
			5-10	40	24
			>10		40
		College			50
06. Health facilities	25	Hospitals			25
		Health Center			20
		Clinics	<20		5
			20-40		10
			>40		15
		Dispensary			10
		Other			5
07. Infra-structure and Economic services	50	Commercial Bank	<10	50	15
			10-15		30
			>15		50
		Gramin Bank			35
		Co-Operative Society	<50	20	10
			50-100		15
			>100		20
		Post Office	<20	10	3
			20-40		5
			>40		10

Table-1 shows the socio-economic status of the study area on the basis of which a ranking system had been parameterized on which socio- economic status normally depends. The responsible parameters considered in the present study are concentration of SC & ST population, literacy, and level of occupation, educational facilities, health facilities infrastructure & economic services of the study area.

The blocks where concentration of SC & ST population is less than 25%, these blocks

achieved highest score & where concentration is in form 25- 50%, they have moderate score (18) & where these concentration is >50% , these block are socio-economically backward blocks having lower score(12,6).

Literacy rate plays an important role on socio-economic condition of any area. The blocks where literacy is >75%, these blocks achieved highest score(25) & these blocks can be designated as socio-economically developed ones but where these percentage is<75% & in between 50-75%, these blocks achieve moderate score (18) & where <50%, those blocks will be designated as socio-economically backward ones scoring lower marks(12,6) from ranking system.

Nature of occupation is another important parameter from socio-economic view point. In this study area people belonging to different occupations received varied marks. If the percentage of people holding service (government or non-government) in the study area is >30%, the block receives the highest score (50) & those are in between 25-30% have moderate score (30) & where these percentage < 25% have lowest score (10). There are several people who are engaged in house hold working system. Those block where concentration of this type of work is >10% achieved highest score (40) & where < 5% achieved lowest score (10) in the study area. Cultivation is the main occupation of the study area. Blocks where percentage of cultivator-workers are >50% achieved score of (35), where this percentage is less than 20% achieved score (10). There are people who are agricultural workers, blocks where percentage of these occupation is > 50% have highest score (25) & where these percentage is less than 40% have lowest score (7). Marginal workers are also there in the study area. Blocks where occupation of this people is > 20% has highest score (15) & where it is less than 10% score marks (5). Other workers & non-workers are also there in different percentage in the study area.

Socio-economic status also depends heavily on educational facility of any area. If number of primary school is > 200, then the area will be developed area with highest score(10) & when number of primary school is in between 100-200, then scoring is also moderate (6) & if below 100 then scoring is (4), i.e., the area is backward. When the block is endowed with >20 junior high schools if gets then highest score (20), but if this number is in between 10-20 then a moderate score is given (12) & ones having < 10 then the lowest score is given (8). Similar ranking criteria have been followed for presence of the number of high schools in the study area. If the block belong one college then that area will be educationally upgraded area with highest score (50).

Health facilities also have another important implication on socio -economy on any area. If one hospital belongs to this study area then according to the ranking system it will score highest marks (25) & in stead of hospital if there is one health centre then it scores 20. If presence of number of clinics are > 40, in the study area then it scores (15) & in case

fewer lower than 40 and in between 20-40, then its score is (10) and if below 20 then the score will be (5). When their occurs one dispensary then its score will be 10 which evinces that the area is socio-economically backward one.

Infrastructure & economic services facility is also important for socio-economy of any area. If number of commercial bank is >15 in the area then its score will be highest (50) & if number of commercial bank is less than 10 than its score will be 15. Otherwise, there may occur co-operative society or post-office. If no. of co-operative society is > 100 then scoring will be 20 & if below 50 then scoring will be 10 when no. of post-office is > 40 on the area then scoring is 10 & < 20 then scoring is 3, which tells that the block is a socio-economically backward area.

Socio-economic backwardness ranking data analysis :

Name of the	Block	Value From Param-eter 01	Value From Param-eter 02	Value From Param-eter 03	Value From Param-eter 04	Value From Param-eter 05	Value From Param-eter 06	Value From Param-eter 07	Toat Value
Jhargram	01.	25	25	18	91	104	60	88	411
Binpur-I	02.	25	18	18	116	42	50	68	337
Binpur-II	03.	25	18	18	116	104	35	48	364
Jamboni	04.	25	18	18	116	104	35	67	383
Nayagram	05.	25	18	18	140	42	35	33	311
Sankrail	06.	25	25	18	116	42	35	67	328
Gopi-I	07.	25	18	18	101	92	30	68	352
Gopi-II	08.	18	25	18	126	42	35	33	297
Salboni	09.	25	25	18	116	56	35	83	358
Keshpur	10.	18	25	18	91	130	65	85	432
Garhbeta-I	11.	25	25	18	111	106	65	73	423
Garhbeta-II	12.	25	25	18	128	106	25	68	395
Garhbeta-III	13.	25	25	18	120	42	50	67	347
Midnapore	14.	25	25	18	102	100	60	82	412
Debra	15.	25	25	18	94	72	60	90	384
Pingla	16.	25	25	25	123	106	35	68	407
Keshiary	17.	25	18	18	101	50	35	33	280
Dantan-I	18.	25	25	18	91	98	35	68	360
Dantan-II	19.	25	25	18	79	48	25	68	288
Narayangarh	20.	25	25	18	99	122	60	70	419
Mohanpur	21.	25	25	25	71	40	35	67	288
Sabong	22.	25	25	25	150	122	60	88	495
Kgp-I	23.	25	25	18	73	120	60	67	388
Kgp-II	24.	25	18	18	94	98	35	68	356
Chandrakona-I	25.	18	25	18	96	122	35	63	377

Name of the	Block	Value From Param-eter 01	Value From Param-eter 02	Value From Param-eter 03	Value From Param-eter 04	Value From Param-eter 05	Value From Param-eter 06	Value From Param-eter 07	Toat Value
Chandrakona-II	26.	18	25	18	91	46	50	63	311
Ghatal	27.	18	25	18	124	110	60	68	423
Daspur-I	28.	25	25	18	130	56	60	63	377
Daspur-II	29.	25	25	25	104	60	25	63	327

Study of centrality and centers of growth :

Thee settlements plan programme at micro level aims at coordinating various economic and social activities over space. It takes care of integration of inter-dependent aspects of development and lays down conscious location of the services and facilities in relation to human habitation. The location of facilities and services depends upon the manner in which they are specially related to one another and the hierarchical order of settlement are differentiated by the population size and concomitant functional cross examinations. The location of certain services and facilities in a settlement increases its centrality to which people of other settlement are attached. The centrality is determined in terms of functions and it could be measured by putting relative weight ages to different functions and their components.

The examination of the spatial distribution of the facilities and services in the Blocks of Paschim Medinipur by their order shows eastern part of Blocks i, e., Daspur –I & II, Ghatal, Sabong, Pingla, Mohanpur, Dantan and Kharagpur have attained maximum concentration. These blocks could be identified as important growth centers.

Identification of priority areas for welfare programmes implementation :

The decentralized planning in our country has gained momentum particularly after the 73rd & 74 rd constitutional amendments. The local self-government particularly at a block level enjoys lot of freedom now for making their own plans. Financial resources are available from different sources such as: DPAP (Drought Prone Area Programme), EAS, JRY (Jowahar Rojana Yojana), etc. Therefore there is a need to identify the backward regions on the basic of socio – economic information. In this study, the cited data is analysed for prioritizing the most needy blocks.

It is sought to identify socially and economically backwards regions on the basis of literacy, tribal population concentration, and dominance of occupation.

Identification of blocks lacking in the basic amenities and economic infrastructure and services such as heath, education, drinking water, communication facilities, commercial banks

Co-operative society etc is of prime significance in the present study.

For the purpose a ranking system based on marks has been adopted for each blocks of Paschim Medinipur in the manner described above. The higher marks a particular block receives, the more developed is the particular block. Again, each item under category is allotted equal marks. The scheme of marking is described in this note. However, it may be noted that, the data collected is not sufficient for the purpose and here an attempt has been made from the available data to identify backward areas for prioritization and implementation of social welfare programmes. The ranking system adopted here is basically the similar to that of scalogram analysis adopted in convention planning. In scalogram analysis, the facilities are awarded equal marks. Here, instead of equal marks, a weighted marking system has been adopted as an innovative proposition.

In this ranking system the block with less mark indicate lower development. The prioritization of these blocks is obtained on the basis and the classification of Block is provided in map form. However, finally the prioritization may be done from this ranking and population density. By means of density slicing five significant priority classes have been shown as a choropleth map in GIS based platform (Fig:1).

The total backwardness rank range 288 to 495, here 495 occur in Sabong Block and 280 lower value shows in the block of Keshiary. To show the Backwardness rank on map have been standardized and classified into 5 Categories as :

(i) Below 300 -Gopiballavpur-II, Keshiary, Dantan-II, Mohanpur

(ii) 300-350 - Binpur-I, Nayagram, Sankrail, Garhbeta-III, Chandrakona –II, Daspur-II

(iii) 350-400 – Jambani, Binpur-II, Gopiballavpur -I, Salboni, Garhbeta-II, Debra, Dantan-I, Kharagpur-I & II, Chandrakona -II, Daspur-II

(iv) 400-450 – Jhargram, Keshpur, Garhbeta-I, Pingla, Narayangarh, Ghatal, Midnapore

(v) Above 450 – Sabong

Of the 29 block, just one (1) falls under rank 1. Sabong block is the most developed one due to its high score in socio-economic attainments. They have also good score in Occupation, Education and Infrastructure facilities. About 7-blocks lies in the 2nd rank with their good score in Socio-economic attributes such as Education and Infrastructure and also Community services etc. 11 Blocks get into the 3rd rank such as Jambani, Binpur-II, Gopiballavpur -I, Salboni, Garhbeta-II, Debra, Dantan-I, Kharagpur-I & II, Chandrakona -II, Daspur-II. Those blocks show moderate to high scores in socio-economic components. About 6 Blocks i. e., Binpur-I, Nayagram, Sankrail, Garhbeta-III, Chandrakona –II, Daspur-II in rank 4. This group represents the moderate level of development with moderate scores

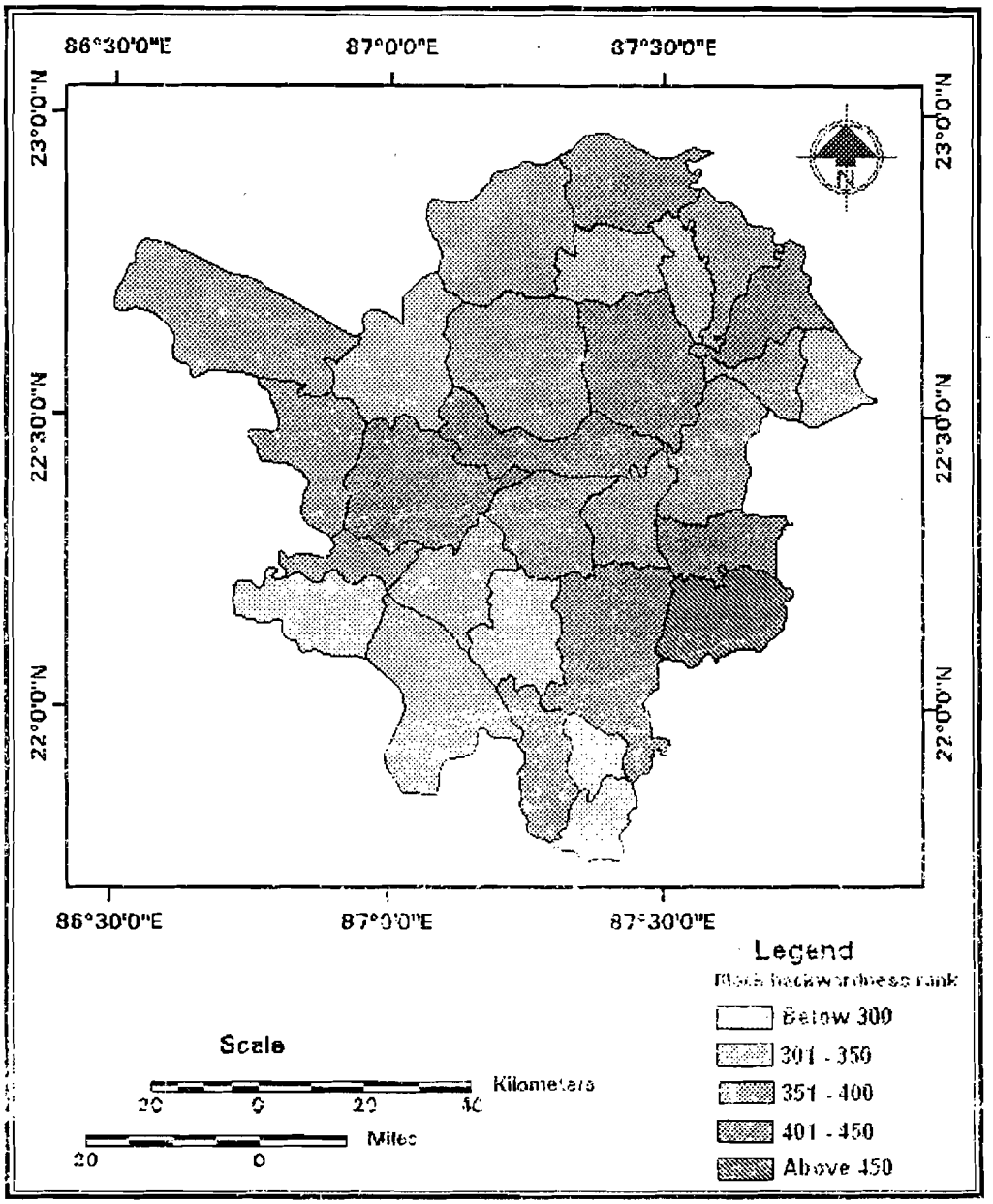
in Socio-economic opportunities, community facilities as well as infrastructural builds-up. But in the case of Daspur – II block, the Health facilities is very poor and education is much inferior in magnitude. 5th ranking blocks are Gopiballavpur-II, Keshiary, Dantan-II, and Mohanpur. Usually these blocks depict low level of development with low scores against almost all the indicators.

The blocks are well distributed over the ranks of development with distribution varying parameter wise, the most developed i.e., the 1st rank block are normally situated Eastern part of the district. This block where soil is more productive and in some cases lands are irrigated by Kelaghai-kapalaswari river, agriculture is advanced due to recent soil deposited by recurrence of flooding and availability of irrigation facilities. The 2nd rank blocks are too endowed with fertile lands. Education level is high, community service is better, in some of the blocks viz. Jhargram, Midnapore, Garhbeta-I have dense forests. This group is well developed in agriculture system, irrigation facility is developed. The moderate development in the falling 3rd rank are covered by good forest wealth in the block of Binpur-II, Western part of Keshpur, Salboni, Portion of Narayangarh and Medinipur. And some blocks are also good in education and health facilities. These 4th and 5th rank blocks and their economy is principally dependent on agriculture. However, the lands have low productivity and lack in irrigation facilities, overall productivity is generally very low. In most of Binpur-II, Jambani, Salboni, Garhbeta-II, Kharagpur- I & II Gopiballavpur-II and Keshiary, good chunk of the lands are barren and remain uncultivated throughout the year and in some cases the land is covered by degraded forest. In spite of the fact that some of these blocks have some community facilities and are endowed with infrastructures, their rank could not be higher due to other socio-economic conditions and poor productivity of soil.

The above ranking of the block by level of development has given enough indication to the planners for development of the blocks. The gaps in facilities and services could be met and disparities in levels of development among the blocks could be reduced if appropriate action programmes of development are taken up. This will, however, need prioritization of actions since financial resources for developing the blocks are limited. This will, however, call for framing suitable guidelines depending on the levels of the particular socio-economic variables.

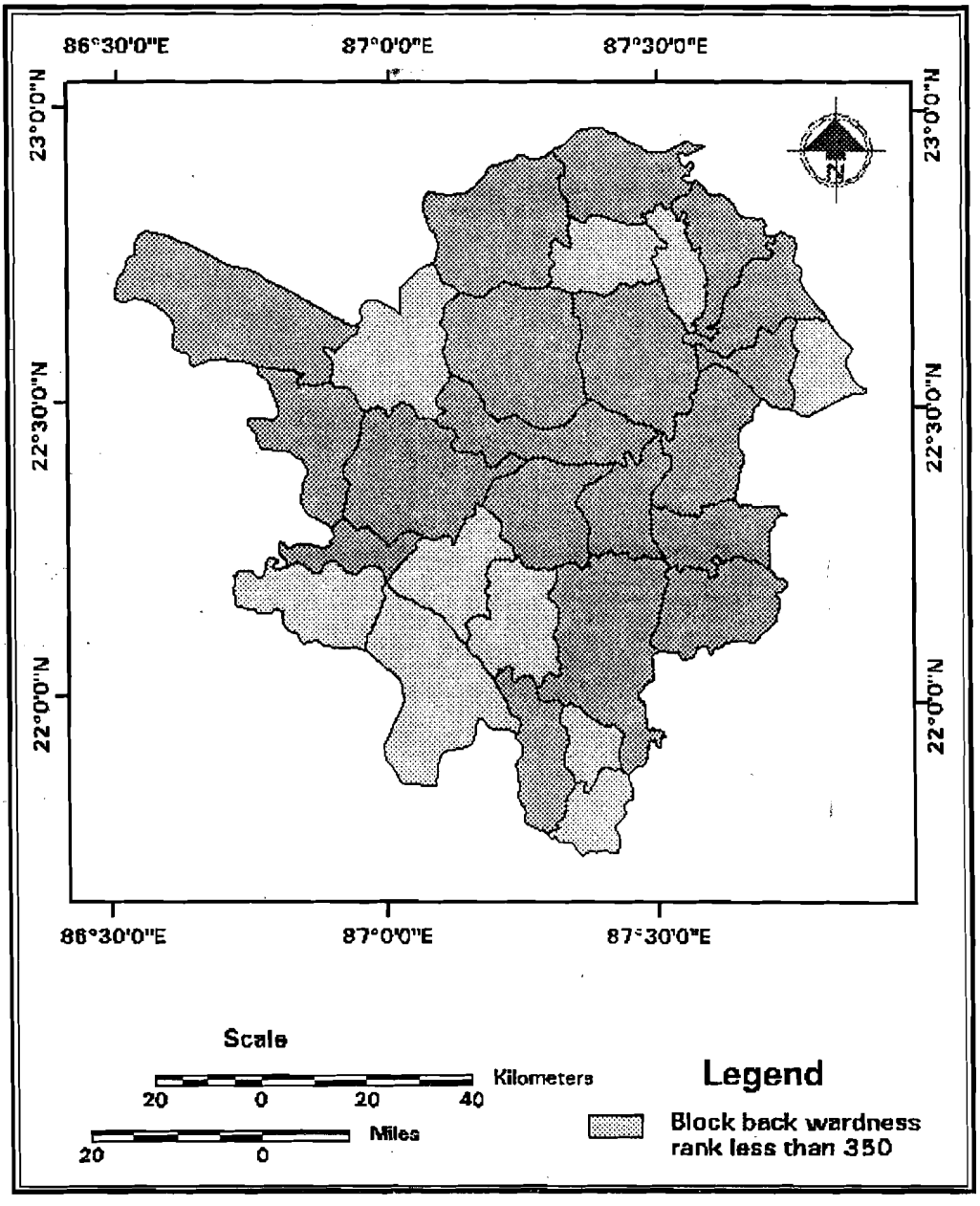
Answers in form of maps according to query development of Secondary data from GIS database :

Choropleth map showing the block backwardness rank of Paschim Medinipur District



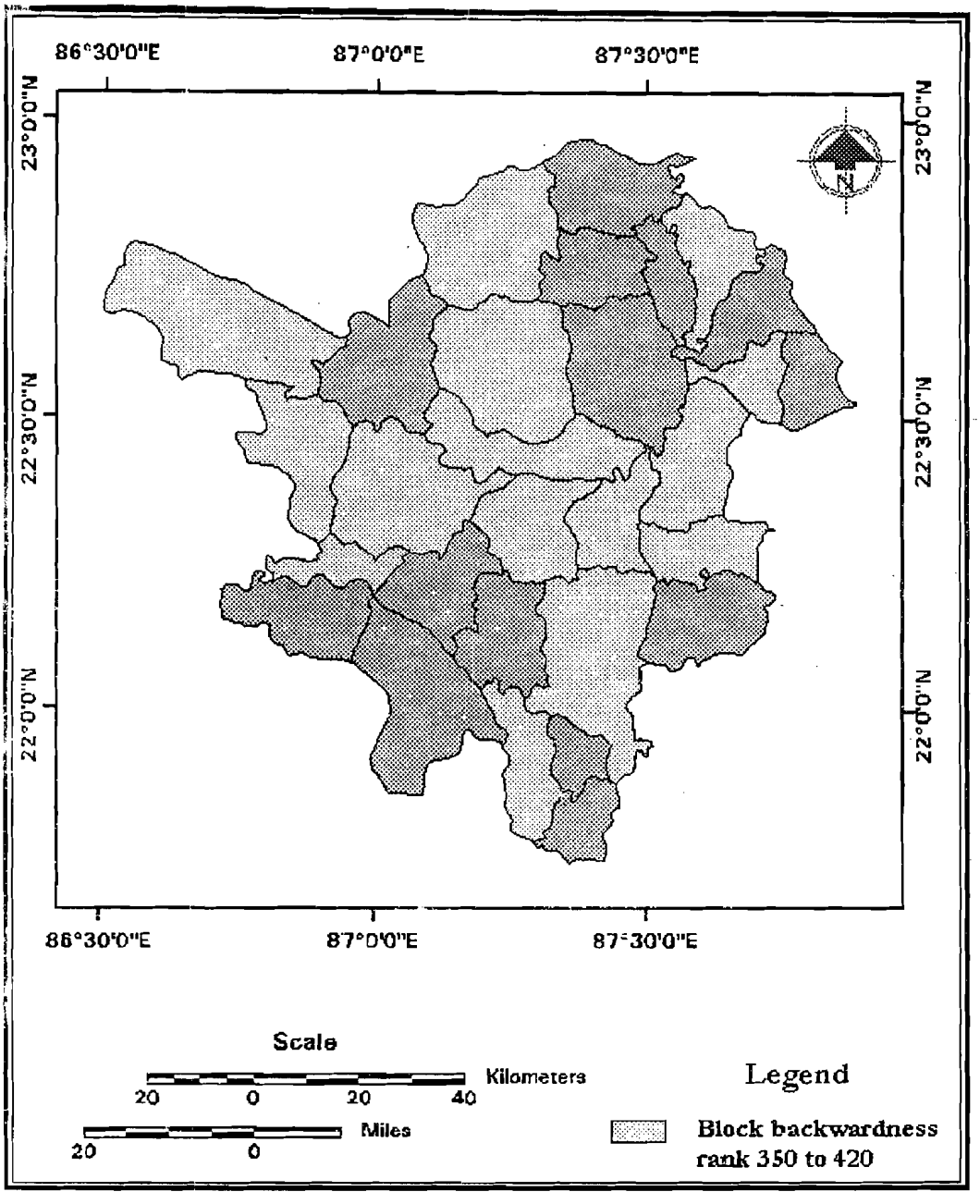
- Find out the blocks backwardness rank of less than 350.

Block back wardness ranking map of Paschim Medinipur district



➢ Find out the blocks backwardness rank of 350 - 420

Block back wardness ranking map of Paschim Medinipur district



And a lot of query generate in ERDAS IMAGINE platform and system will answered in GIS development platform.

Major findings of the study are :

1. The blocks at the western portions containing more than 30 % of their area as forest covered and the presence of a large chunk of unproductive and barren lands do not aptly support the livelihood of the human population. The eastern portion of the district is simply holding a large volume of population due to the presence of fertile and high yielding lands, absence of barren land and forest coverage, facility of irrigation, health and developed infrastructure.

2. The overall literacy rate of the district of Paschim Medinipur is 60.7% as per Census 2001 where the literacy rate of male and females are 70.13% and 50.90% respectively. Individually the overall literacy rate is found maximum at Daspur II block (79.7%) where the male and female literacy rate is maximum at Sabang (89.3%) and Daspur (70.7%) block respectively. On the other hand, individually the overall literacy rate is found minimum at Nayagram block (55.7 %) where the male and female literacy rate is minimum at Gopiballavpur I (70.5%) and Nayagram (40.6%) block respectively. The block of Sabang is in the developed condition due to the availability of the education facility but the stunning feature is present at Daspur II where educational facility is inadequate (appendix, table:3) but the consciousness of people of these blocks has lead to reach at such a high level of literacy. In Binpur II, Nayagram and Gopiballavpur I the literacy figure is very poor for the dominance of the poor tribal population (specially Sabar, Santal, Gand etc) marked by a fragile financial base, lack of banking facility, predominance of low yielding agriculture and forest resource collection. The block of Keshpur enjoys the most intensive educational facility but could not come at the top according to the literacy rate (only 67%, although above the average level but lagged behind by 12.7% from the highest rate of literacy observed at Daspur-II.) which indicates the less-than-optimum utilization of resources and a not-so-successful planning consequence of the district

3. The landuse pattern of different blocks of the district Medinipore avail the maximum % of land under net shown area is found at the block of pingla (84%). Where the Nayagram block has the highest proportion of land (47.4%) under forest, the minimum forest covered block with respect to the area is at Chandrakona II (5.01%). The twelve blocks of eastern most portion of the district has no forest coverage at all and even no barren land, permanent pasture, except some current fallows. Maximum percentage of multi-cropped area is present in the eastern blocks.

4. The distributional pattern of persons related to agricultural activity. According to the data, the patta holders and the marginal farmers (in percent%) are the maximum portion of these sectors. The maximum percentage of patta holders are in the block of Narayangarh (31.93%) and the maximum percentage of marginal workers are at

Garhbeta-1 block (16.97%). The dominance of patta holders are due to the government acquisition of land from the Zamindar in 1980s. But there are a huge amount of uncultivable land that is shown at the western part of the district but no step is taken from the Govt. of West Bengal to convert than to useful purposes. Though it is hopeful that the Social and Regional Planning Department has taken the strong steps for utilizing the uncultivable lands. As for example a waste land at Dohijuri in Jhargram block a grapes producing firm is projected over an uncultivable land and at Gopali a tea firm has been established by the help of Agriculture & Food Engineering Department of IIT, Kharagpur with the cooperation of Goodrick Tea Company. Other findings are given below:

- Agricultural labour (wage) is the main livelihood.
- Number of the occupational variability is low – very limited choice for the inhabitants
- Most livelihoods – related activities are highly seasonal in nature and thus entails an induced vulnerability in poor households mainly in terms of food insecurity and health care.
- In rain fed farming areas, migration in search of livelihood is a pronounced strategy in the lean seasons.
- The agricultural dependent livelihoods are vulnerable, which are solely dependent on aman paddy (Rice cultivation during monsoon), whose price is unstable and unremunerative.
- The query shells developed (in GIS platform) in this study offer a distinct possibility to locate the trailing socio-economic / natural resources endowment with a view to generating sustainable action plan for all round uplift of the geographic entity.

CONCLUSION AND RECOMMENDATION

The entire paper has been undertaken with a view to exploring the milieu emanating from a socio-economic parameters. However, the study is intended to address the following topics:

- Promoting income generation from forest goods and services
- Enhancing capacity and skill of people to meaningfully use of natural resources
- Educating people about the potential value of forest/ natural resources
- Organizing villagers for setting up their own business and marketing forest products
- Organizing people's institutions like co-operative or producer associations

- Providing complimentary activities like tree nurseries and eco-tourism to people for making additional income
- Improving forest management and conservation by giving access and ownership rights to the communities
- Reducing people's vulnerability not only through secure forest resources but also political empowerment and improved governance through development of local mechanisms
- Increasing livelihood related activities using forest resources through people-centered approaches to combat poverty
- Enhancing knowledge base (including recognition of traditional / indigenous knowledge) and sharing locally relevant livelihood-oriented resource management practices, through emerging technology like REMOTE SENSING & GIS.

Recommendation

Some recommendations emanated from the study.

- GIS must be used for holistic management of land and water resources, as the technology generates unbiased information which can be suitably processed in GIS platform towards desired decision making.
- For better management of the institution to be stewarded by the panchayet authority, which is the direct beneficiary of the improved physical/social environment and thus can work with the right passion.

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RILL MORPHOLOGY IN RELATION TO TOPOGRAPHIC PEDOLOGIC AND HYDROLOGIC ATTRIBUTES - A CASE STUDY AT RANGAMATI, PASCHIM MEDINIPUR, W.B.

*Pravat Kumar Shit and Dr. Ramkrishna Maiti**

Abstract

The development of channel network in relation to the topographic, Pedologic and hydrological attributes and their spatial distribution in the basin is analyzed in a small (244.503sq.m) rill-basin at Rangamati. The rills and branches are developed due to concentration of Hortonian overland flow and this is conspicuous at the upper catchments with more than 45° steepness. The valley side slopes observed more branching particularly of Cis type due to concentration of flow from right hand slope and thus the valley widening and shifting of divide are uniclinal in type directed toward west. The valley lengthening is favoured by development of knick point, basal sapping and toppling of overhanging slopes. The greater rate of valley lengthening of VU & TS links sets the possibility of abstraction of the upper part of PQ. The association between channel gradient and valley depth and that between gradient & valley width is very low. The exceptional relation between channel gradient and depth of channel deposit is also common. The development of drainage network is at its primary stages indicating less adjustment with topographical factors and thus showing the possibility of more dynamism.

Keywords; Valley lengthening, widening, deepening, abstraction, shear strength, gradient, branching, regression.

Introduction :

Land degradation through rill-gully erosion is studied with increasing attention from geographers specially geomorphologists and soil scientists in India as well as in abroad in a situation where 53% (175 M.ha.) of India's geographical area is subjected to environmental degradation, of which, 150 M.ha. is experiencing soil erosion by either water or wind (Ministry of Agriculture, Govt. of India, 1980, Vohra, 1985).Gullies have attracted considerable scientific attention from geomorpholgists, because they provide the most ideal geomorphic situation for understanding the evolution of landforms and drainage, for three reasons (Bryan and Yair, 1982) :

a) The gullies and the associated badlands develop rapidly, facilitating monitoring.

b) The gullies are analogous to the large river systems except in scale; and represent the river system in the juvenile stage, and

c) The geomorphic processes are relatively simple and thus easy to understand.

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The integrated network of irregularly spaced minor channels (rills) and somewhat larger and deeper channels (gully), developed as a result of either enlargement or coalescence of rills, invites concentrated flow of water and thus causing huge soil erosion. The inter-rill tracts are subjected to sheet wash and raindrops splash (Wild, 1996, Singh and Phadek, 2004). Overland flow is usually analyzed as a broad sheet flow, erosion processes on inter-rill areas are primarily detached by raindrop impact and lateral transport of detached particles to the rills by their overland flow plus particle entertainment by raindrop impact. Transport by direct splash to the rills is minimal (Young, 1973). Water tends to accumulate in depressions and begins to flow, taking the path of least resistance. Essentially, flow hydraulic in the terrain, the susceptibility of the soil to detachment by flow and the transportability of the detached sediment decide the process of detachment and transport in rills. Flow in rills detach soil particles when the flow's transport capacity is more than its sediment load. Sheer stress of the flow detaches the soil particles. The process includes head cutting, undercutting, soughing off the sidewalls, cleanout of the slumped material, scour and transport of detached particles etc.

The present study concentrates on geomorphic attributes of the gully basins, distance and area wise distribution of depth and width of the channels, gradient of gully wall and gully floor, the relation between the important gully network variables, soil resistance etc. to understand the temporal change of the gully system at Rangamati, Medinipur; on the bank of river Kossi (22°24'42. 0"N to 22°24'43. 2"N and 87°17'48. 1" E to 87°17'48. 9" E).

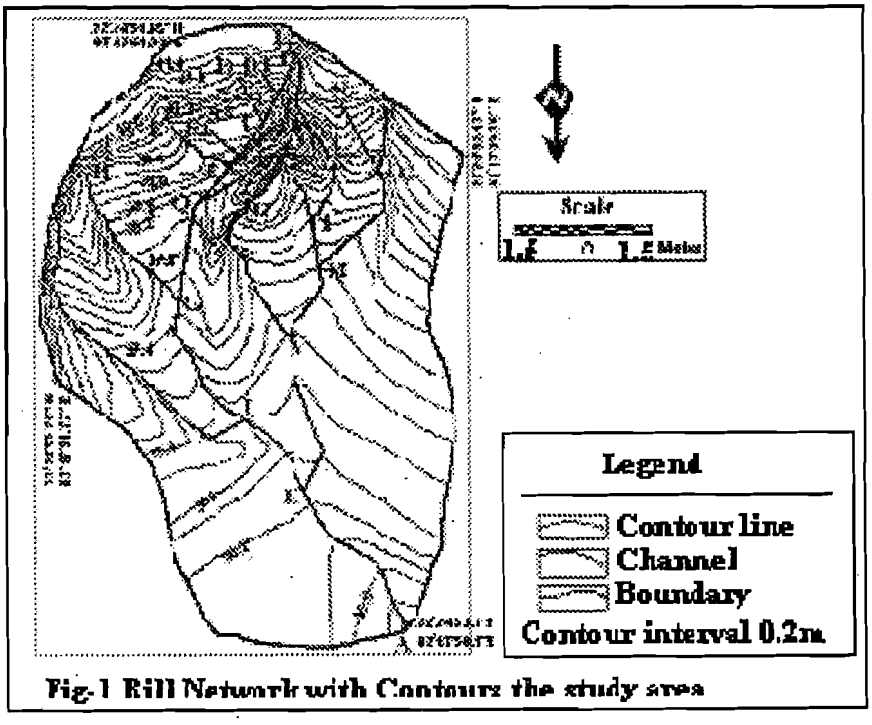

Fig. 1 Rill Network with Contours the study area

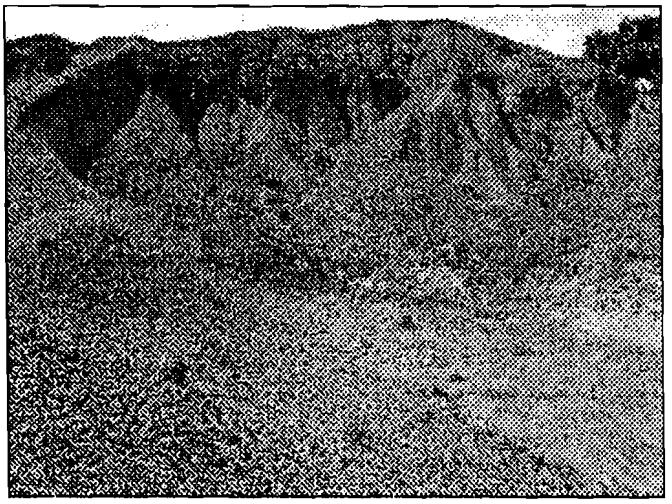

Plate-1 Showing the orientation of channel

Objective of the study :

1. Measurement of length, depth and width & gradient of channels and the rate of valley lengthening, valley widening and valley deepening
2. To calculate the co-relation among different attributes namely gradient vs. Sediment deposit, gradient vs. Channel depth and gradient vs. Channel width.
3. To assess the order-specific distribution of catchment area and analysis of the channel attributes.
4. To measure the hydrological attributes namely infiltration.
5. To assess the soil resistance in the form of cohesion (C) and angle of internal friction (ø).
6. To asses the development of branch in relation to topographic and pedological attributes.

Methodology :

The mapping of the rill system and the measurement of length, depth, width and gradient of the channels are done through field work with appropriate instrument following proper methodology. The rate of valley lengthening, valley widening and valley deepening are measured by the field study during pre-monsoon, monsoon and post-monsoon of 2006 - 2007 with pegging techniques. The study of discontinuous rill system is made following Schumm and Hadley (1953). The study of rill morphology, channel elongation and elaboration in one hand and compensation by loss of channel length in the system is made following Glock (1931) and Morisawa (1964). The study of Links is made following James & Krumbein (1969). The correlation among different attributes of rill system is made following

Morisawa (1962). The hydrological attributes are measured and analysed after Goudie (1990). The measurement of Cohesion (C) and internal friction (Ø) is made by Tri-Axial Compression Test from Geotechnical Laboratory, GSI, Kolkata.

Result :

The channels of the present rill system is grouped into five orders following Strahler (1957) and the result is shown in the Table-1. The corresponding contributing area of each channel is measured and correlated with length and gradient. The numbers of 1st, 2nd, 3rd, 4th and 5th order streams are 37, 10, 4, 2 and 1 respectively (Fig-2 & Table-1).

The successive field studies on 07-09-2006, 09-03-2007 and 03-09-2007 revealed that 13 channels registered headward erosion (Table-2). The valley lengthening is considerable during this short span due to high intensity of energy available from intensive rain in acting on steep slope. The rate of increase in length is not same every where, which varies according to the variation of upslope contributing area, gradient, length, texture etc. The headward erosion is an important process in valley lengthening and which contributes towards channel abstraction. The rate of headward increment in length is high for both VU & TS links where as that along OP is less (Table-2). The ridge separating KL subsystem and KB subsystem is fast shifting away from KL subsystem as the VU and TS are more active and creating a possibility for piracy of PQ by either VU or TS. The possibility by TS is more because of more increments and narrow gap (divide) from PQ.

PQ shows another possibility to pirate the upper part of LT but as the upslope contributing area is increasingly shared by IB, LT etc. the rate of increase becomes slower and itself becomes prone to be pirated.

Sl No.	Name of the channels	Head wads erosion length in (cm) March,07	Head wads erosion length in (cm) Sept. ,07
1	IJ	2.5	6.5
2	GH	2.5	8.0
3	EF	1.0	5.5
4	E_1F_1	3.0	70.0
5	CD	6.0	12.0
6	C_1D_1	2.5	18.0
7	QP	1.5	3.0
8	AB	2.5	5.0
9	VU	8.0	33.0
10	TS	6.0	40.0
11	MN	4.0	10.0
12	O_2O_1	3.0	15.0
13	KL	2.0	4.0

Table-2 : Showing the amount of valley lengthening (07.09.06 to 03.09.07)

The concentrated energy along the channels are responsible for valley deepening. The records of the measurements during Premonsoon (2007) and those during monsoon are presented both is tabular form (Table -3) and diagram (Fig- 3) with accurate spatial location. The points F, D, L and U experience down-cutting to an amount of 6.0, 7.8, 6.0 and 7.0 cm respectively during monsoon period. The down-cutting is assisted by the knick development at the source region where surface runoff falls from certain height being collected from sheet flow. This down cutting and associated back wasting help in the removal of both lateral and basal support of the materials at the source and an over hanging slope develops. This slope thus retreats back by the dislodgement of the overhanging materials and resultant valley lengthening. Thus valley deepening and valley lengthening are intricately correlated and become inseparable.

Table-1; Showing the order and the attributes of the channels (5th Order Drainage Basin)

Sl No.	Order	AverageLength (m)	Average width (cm)	Average Drainage basin area (sq m)
1	1st	1.377	21.441	0.669
2	2nd	6.995	24.447	8.3075
3	3rd	16.1625	21.599	19.037
4	4th	56.475	25.875	86.929
5	5th	119.45	23.30	224.503

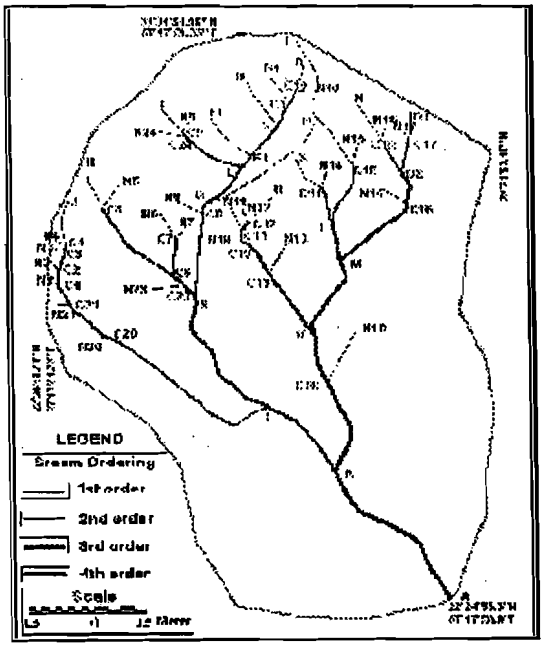

Fig-2, Map showing the channel groups into different orders (Strahler 1952, 57)

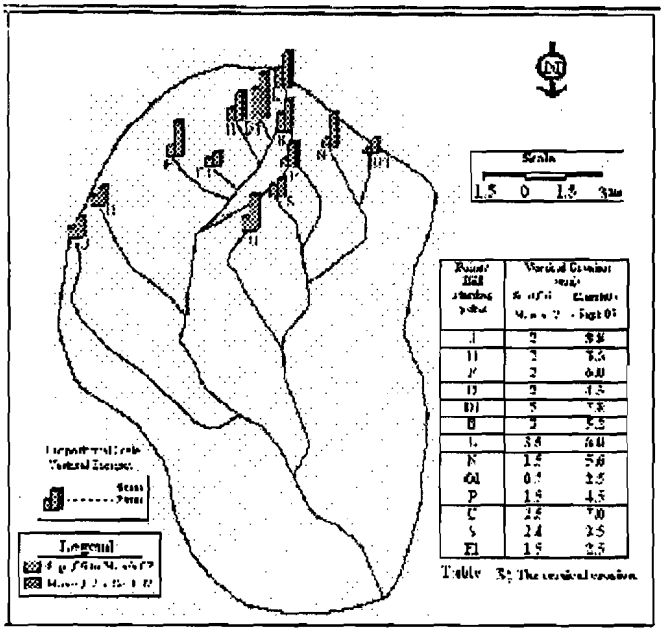

Fig-3, Map showing the amount of vertical erosion at (Valley deepening) at certain points along channel bed

The relation between gradient & channel depth, gradient & channel width and gradient deposits along the channel of a discontinuous gully is plotted in scatter diagram to identify the correlation co-efficient following Strahler, 1954 and Moriswa,1962 (Fig-4a,4b,4c). The respective regression equations for these relations are Y= 0.2135x + 11.36; Y = 0.2294x + 41.61; and Y= 0.9127 x + 3.7264 the value of R^2 becomes 0.0273, 0.0315 and 0.0025 respectively. Megascopically it can be inferred that with increasing channel gradient, depth increases, but width and depth of deposit in channel bed decreases.

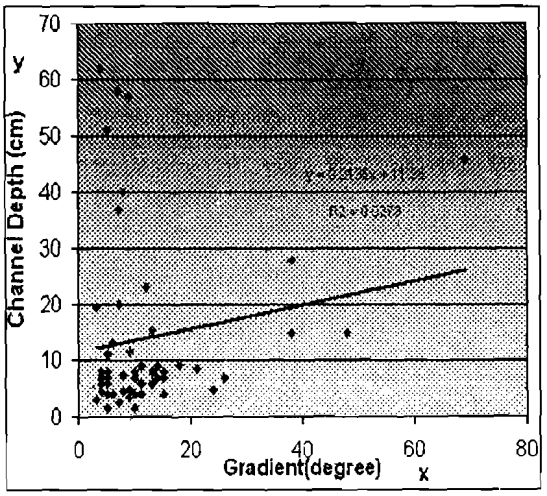

Fig-4a, Correlation between Channel Depth & Gradient

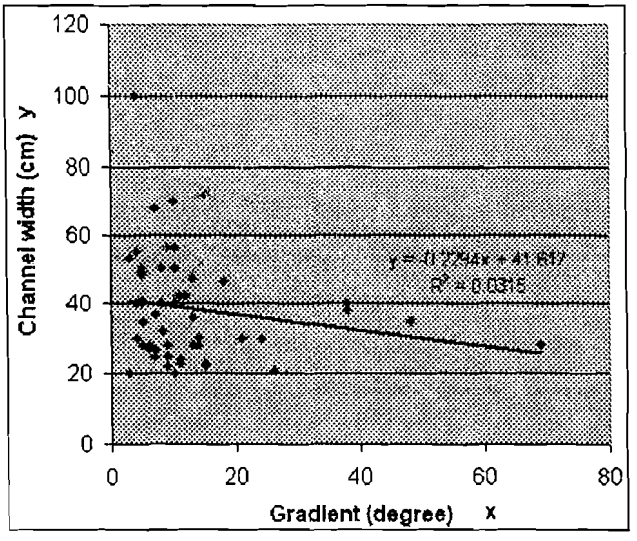

Fig-4a, Correlation between Channel Width & Gradient

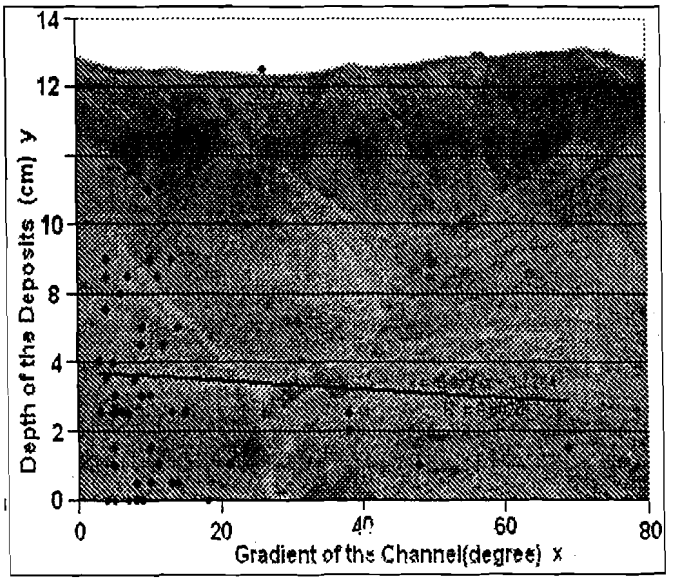

Fig-4a, Correlation between Channel Deposit & Gradient

The classification of links into Source (S) and Ts (Tributary Source) following James and Krumbein (1969) shows that 20 links are assigned as source(S) and 25 as Ts (Tributary Source) which are again classified into Cis (14) and Trans (11). The source links are originated from the high gradient fringe area of the basin and the Tributary Sources mainly Trans links are developed from both the sides of the main channel where both sides are more or less similar in gradient and texture. If one side is steeper enough, the sets of Cis links develop due to more runoff from steeper gradient.

Source(S)	Tributary Source (TS)	
	Cis	Trans
C4J	C20N20	C23N23
C5H	C21N21	C6N6
C5N5	C1N1	C24N24
C9CN9	C2N2	QP
C9F	C3N3	C22N22
C10N10	C41	C13N13
C10B	C5G	C14T
B	C8N8	C18M
C15L	C9E	C16N16
C14N14	E1F1	C17O2
C14S	CD	C12V
C12U	C1D1	
C12N12	C19N19	
C18N	C11N11	
C18N18		
C17N17		
C17O1		
C4N4		
C7N6		
C7N7		

Table-4; Link classification after James & Krumbein, 1969.

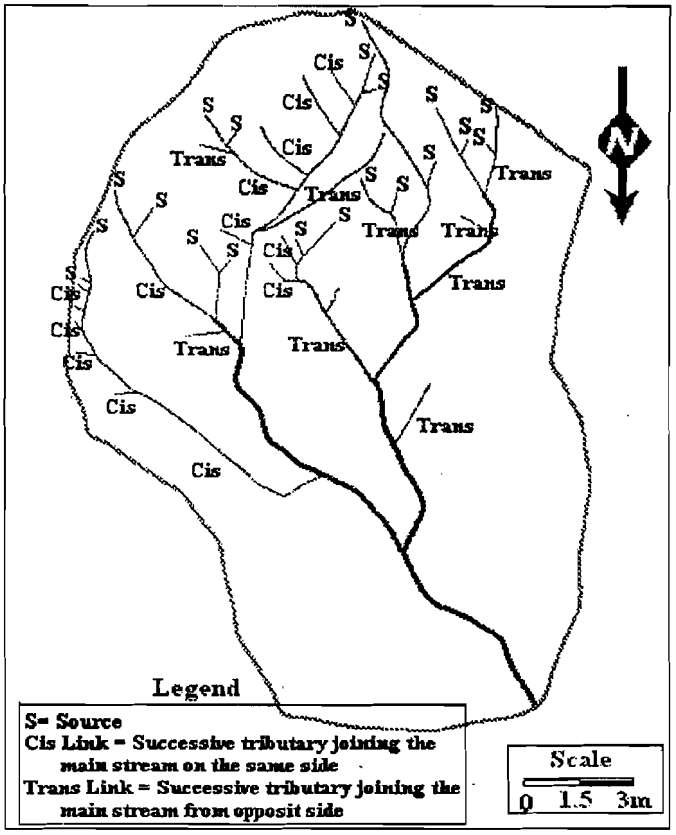

Fig-5, Link Classification (James & Krumbein, 1969)

The Table-5 shows the result of Tri-Axial Compression test. The sample-1is collected from the source region with steeper slope having coarser texture and thus registering less cohesion (C) and greater angle of internal friction (ø) than that of sample-2 which is taken from gentler part having more percentage of clay.

Tri-axial Shear Test (Unconsolidated un drained)		
Sample No	Cohesion (C) Kgf/cm^2	Angle of internal friction (ø) in degree
1	0.3015	23.32
2	1.198	21.97

Table -5 : The result of Geotechnical Analysis.

Measurement of Infiltration (on 06-02-08)

No. - 1	Installment time	Terminal time	Duration (minute)	Amount of water infiltration	Rate of infiltration ml/cm²/s
1st Phase	9.22	9.26	4	500 ml	8.073
2nd Phase	9.26	9.31	5	500 ml	6.458
3rd Phase	9.31	9.46	15	500 ml	2.153
4th Phase	9.46	10.8	22	500 ml	1.467
5th Phase	10.8	10.46	38	400 ml	0.679
6th Phase	10.46	11.21	35	200 ml	0.369
Phase of no infiltr-ation					

Table - 6a

No. - 2	Installment time	Terminal time	Duration (minute)	Amount of water infiltration	Rate of infiltration ml/cm²/s
1st Phase	10.12	10.17	5	500 ml	5.167
2nd Phase	10.17	10.26	9	400 ml	3.588
3rd Phase	10.26	10.50	24	500 ml	1.345
4th Phase	10.50	11.24	34	500 ml	0.949
5th Phase	11.24	12.00	36	400 ml	0.897
6th Phase	12.00	12.26	26	350 ml	0.869
Phase of no infiltr-ation					

Table - 6b

Discussions :

The first order channels are developed at the source region and the valley sides on steeper slopes by concentration of overland flow. Krikby (1969), mentioned that gullies and rills, developed by the concentration of Hortonian overland flow show saturation condition at the heads depending on local factors like gradient and texture. The concerned basin experiences steeper slope (>45°) at the upper margin and channel sides comprising of nearly 35% of the basin and thus are prone to the concentration of Hortonian overland flow and formation of 1st order branches. This generation of rills may be due to the combination of

swales concentrating the flow over a local patch of weak materials or by the initiation on bare soil where particles are loosened by raindrop impact and removed by a surge or wave rain, as water moves down the slope (Morisawa, 1985). The increasing numbers of 1st order streams represent increased runoff intensity (Singh and Dubey, 2000). The branching on valley sides may also be responsible for valley widening, which causes removal of materials from valley sides causing secondary gullies or branching resulting in a bed load effect. The KL, AB, & IJ etc. channels experience most of their 1st order branches from the steeper right bank due to more potentiality of runoff concentration and particle displacement by rain drop splash.

As soon as a channel develops, vertical head cuts are formed. Subsequent periods of incision can cause the head (or Knick) of the initial erosion feature to progress up-gully. Concentration of flow during storms and intense monsoon spells increase peak flow and so the severity of gullying processes is increased. Thus, once the gully is formed it rapidly develops and extends up-slope. The growth and development of the gullies is auto catalytic and regenerative (Kale;1980) in nature, the large they grow, the more flow they attract runoff and faster they develop and extend(Kale.et.al,1995).

The rate of valley lengthening differs from one channel to another depending on the gradient, upslope contributing area, soil texture etc. The channel KL registered greater rate of valley lengthening than IB. The rate of increment during 2006 & 2007 is considerable for VU & TS both in pre-monsoon & post monsoon season. The possibility of long continued increment may give rise to the abstraction of upper part of PQ. Most of the channels extend headward towards the western steeper margin due to partial basal sapping at the head where the base of steep slope below knick point is scoured to develop an overhanging slope. The failure of this overhanging slope help in the head ward increment thus favuring the valley lengthening.

Valley deepening depends on their intensity of concentration of energy within the channel. The high intensity rainfall when accumulates in the form of surface runoff (as in cases of EF or C_1D_1), downward erosion or valley incession favours. The greater contributing area, steeper slope and favourable soil texture to help in more surface runoff are responsible for more deepening in channel bed.

The correlation between channel depth and channel gradient shows very low relation as at some places greater depths are recorded inspite of low gradient mainly due to the down cutting of stream to attain gentler slope or that of equilibrium and this is facilitated by the presence of soft rocks. The gradient becomes gentler by down cutting and thus the coexistence of low gradient and greater depth becomes possible. At few occasions greater depths are recorded on steeper gradient and may be due to the strong correspondence between channel gradient and topographic gradient. The process of attaining equilibrium is not achieved still.

The lower association between channel width and gradient is recorded in Fig-4a. The greater concentration of the plotted points along the "Y" coordinate indicates this less dependence. Along with the general negative correlation, in some cases, shorter widths are recorded at the sections of lower gradient. These are mainly along the smaller 1st order channels on the gentler slope where the relation between channel gradient and channel width is not fully established.

The deposits in the channel bed help in the discontinuation of the gully and remain stable at the gentler section at the middle and lower catchments of a rill or gully. The correlation here between gradient and depth of the channel deposit is not also so strong. Inspite of gentle slope, no deposits occurred, where as, on the other hand it is present on more than 60° channel gradient. It may be due to greater concentration of runoff from large contributing area being responsible to down slope displacement even on the gentle gradient allowing less possibility for the sediment to get temporary stability. The latter may be possible for temporary obstruction by either boulders or external matters.

The measurement of infiltration by the field methods proposed by Goudie (1990), at two sites (Table- 6a, 6b) shows remarkable variation in the rate of infiltration due to variation of texture. The effect of gradient is minimized as during the experiment artificial ponding in an area of 12" × 12" is made without allowing water to be free on slope. On the second site water infiltrates more steadily than that of number-1 as it is composed of coarser texture.

The shear strength of soil in the from of cohesion (C) and angle of internal friction (ø) is measured from Geotechnical Laboratory, GSI and both of these vary greatly from site-I to site-II inspite of closure location. The coarser texture will have less cohesion and greater angle of internal friction (sample-I) than that of sample-II. In general, the cohesive clay rich soils resist erosion by water and air better than sandy soils.

The development of branches either exterior and interior depend on certain conditions (James & Krumbein,1969; Abraham,1975). The homogeneous resistance and homogeneity in other topographical and hydrological conditions help in the equal development of Cis and Trans link in the basin. Abraham (1975), Flint (1980), however, observed different topographical, pedological and hydrologic configuration at upper and lower catchment. More Cis links develop at the source region and attributed this to local geographical control on the geometry, where tributary sequences are influenced by the angle of junction, size of the drainage area and asymmetry of the basin divide (Morisawa, 1985). In the study area, most of the 1st order links are source links and are developed on the steeper (>45°) section of the upper catchment and most of the tributary source (Ts) links are of Cis in type and originating from western slope of the channel sides which are responsible for uniclinal shifting of both divide and ridges to wards west.

Conclusions :

Even within a basin of 244.503 sq.m, huge variation in branching, valley lengthening and widening is noticed due to smaller variation of topographic factors mainly steepness and hydrologic factors specially infiltration and upslope contributing area. The lower association among channel gradient and channel depth and that among channel width and gradient shows immaturity in the network development indicating the potential dynamism. The uniclinal shifting of divide towards west by concentrated erosion is facilitated by the development of 1st order links of Cis type on the western valley side due to favourable concentration of surface runoff.

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MORPHODYNAMICS AND VULNERABILITY ISSUES OF NAYACHAR ISLAND IN THE HUGLI ESTUARY SECTION OF GANGA DELTA

Ashis Kr. Paul, Soumendu Chatterjee and Suparna Paira (Majumdar)

Abstract

Nayachar island with halophytic grassland and mangrove swamp has emerged as a new land of Purba Medinipur District on the estuary section of Hugli 1970s. The island has been extended towards south and west with the growth of successive marsh platforms through deposition of finer sediments of tidal flat sequences.
The habitat of marsh vegetations has been changed with outward growth of tidal mudflats, vertical accretion of tidal flats by tidal inundation through the creeks into island under macro-tidal environment of estuarine condition. The low-lying island platforms of these critical ecosystems are vulnerable to flooding; erosion and cyclone induced storm surges that frequently occur in this funnel shaped estuary mouth. However, the high level platform (lying within 7 m height) is relatively stable in compare to the other low lying areas and may be used for development purposes with protective measures. Mangrove afforestation is needed for the bank stability of higher island platforms. The paper deals with the growth sequences and adjustment of vegetations with changing morphology of the island under dynamic geomorphic and hydrologic processes.

INTRODUCTION

Nayachar is a newly emerged island located (21°54'41" - 22°01'30" N & 88°03'00" - 88°08'52" E) at the middle part of the macro-tidal estuary of Hugli River within the complex environmental setting of Bengal delta system. This section of the Hugli estuary represents a dynamic interface between marine and riverine processes of both regular and episodic in nature. From another point of view, Nayachar Island can be recognized as a buffer zone of transition from a human dominated industrial landscape of Haldia bank to a natural space of funnel shaped Hugli estuary that allows the physical processes to operate systematically. Morphology of the Hugli estuary represents an adjustment between the capacity of its channel and the tidal prism. Moreover, such an adjustment had never been static in nature. Due to the changes of biochemistrial conditions in a milieu where the river Hugli converges into the Bay of Bengal with huge plentiful sediment supply, Nayachar Island made its appearance during 1940s as an accumulated sediment body. This is an important estuarine geomorphological unit that presents upheaval morphology in longitudinal profile. After being raised considerably through continuous accretion of sediments, the surface of Nayachar

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Island became colonized by salt marshes, the species association of which underwent through various seres of succession with the changing bio-tidal environment associated with geomorphological dynamism. Presently, there are four consecutive depositional elevation surfaces in this island; each one varies from the other in respect of landscape diversity, vegetation association, wetland types and tidal channel. Thus, each of those surfaces represents a particular estuarine environmental setting where a particular set of processes are operative.

The island exhibits very rich biodiversity in terms of the salt marsh grass and swampy mangrove plant species along with various species of birds, mud snails, small warms, crustaceans and multitudes of other animals. Calcutta Port Trust first set up an environmental park at the northern part of the island and an office in 1990. Afterwards the island surface began to be utilized by the people who have migrated from adjoining areas of Midnapore and North and South 24 Parganas districts. Brick building, animal grazing, fish catching, crab collection, agriculture etc. were the main stay of those people. The island was previously known as 'Agnimari Char' because light of fire (agni) from the numerous brick fields could be visible from the mainland. The buffalo grazing community of 24 Pargans used this no man's land indiscriminately for grazing for 6 months every year (Paul, 1993). A verdict of the Honourable Supreme Court went against them when an objection against their activities was lodged at the court of law. Forests have also been destroyed considerably for the opening up of fish ponds where shrimps, prawns and other types of fishes are being cultured. In addition to all these human interventions into the natural setting of Nayachar, this island is also exposed to possible impacts of storms, erosion, high amplitude tide phase inundation etc. (Paul, 2007).

Thus the physically dominated ecosystems of the island are gradually being brought under the anthropogenic control off setting its natural set up. Currently the issues of its maturity, stability and vulnerabilities have taken a new dimension as the Honourable State Government of West Bengal has proposed to develop industrial hub on this piece of land availing the facilities of Haldia shipping port. Debate centering the question whether it is ecologically as well as environmentally permissible to take a venture to set up industrial projects on an island like Nayachar is still continuing amongst the geo-scientists. This treatise is a humble attempt to analyze the growth stages of the Nayachar island along with its geomorphological changes in terms of its plan shape, elevation, landform features, total area etc.; ecological changes in respect to areal extent of mangrove swamp and salt marsh associations, at the face of dynamic estuarine processes and man-induced processes. It has also been tried to appraise the physical and ecological vulnerabilities of this island to the geo-hazards like erosion, flooding, cyclonic storms, sea level rise etc. Considering the above objectives of the present study, the maturity and stability issues of this island have been addressed keeping the proposal for industrial development in view (Chatterjee and Paul, 2008).

METHODS OF STUDY

The present study is primarily based on the analyses of Survey of India topographical sheets, aerial photographs, satellite imageries prepared in different years and intensive field based surveys and observations. Earliest document that was available for analysis was the aerial photograph of 1969. The Nayachar Island was first mapped by Survey of India and the map was published on the topographical sheet in 1971. Satellite images of 1973 (Landsat MSS), 1975 (Landsat MSS), 1989 (Landsat TM), 1999 (Landsat TM), 2002 (IRS LISS-III), and 2006 (IRS LISS-III) along with the true colour image of 2006 (Wikimapia.org) were classified, further processed and maps thus produced were overlaid in various DIP and GIS software platforms (ERDAS, ArcInfo etc.) to pursue the temporal changes in planform of the island along with the changes in areal expanse of other landscape elements e.g. tidal channel space, dense mangrove, open mangrove, salt marsh, sand bar etc. (Bandyopadhyay et. al 1998). Analysis of digital data in the form of knowledge based classification, also enabled to identify various geomorphic features developed over the island surface.

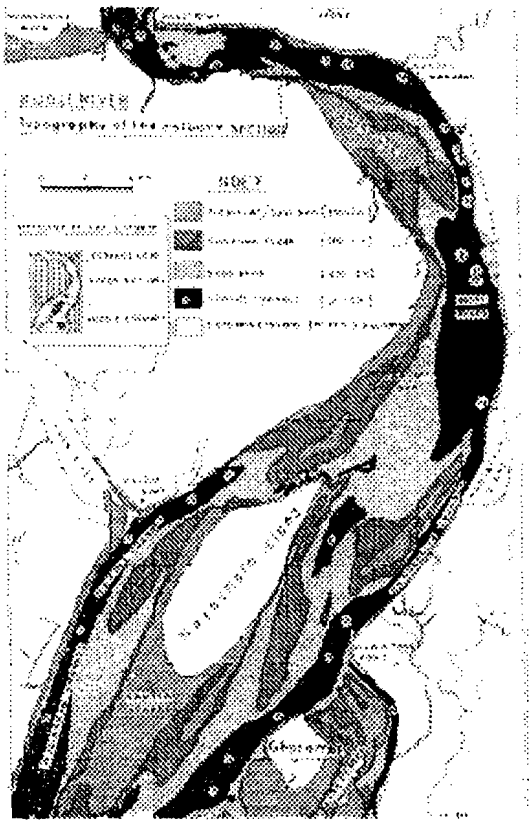

Fig-1 : Location of Nayachar Island
(Source : Paul, A.K. 2002

All the results of such computer based analysis were corroborated with ground truth verification using high precision GPS unit. Topographic sections across the island were taken along selected traverses using standard datum at gauging stations. The plant species were identified on the field some were sampled and identified taking helps from expert. The above mentioned knowledge based classification of satellite image also helped to identify the spatial pattern of vegetation associations on different depositional surfaces. Soil samples from selected geomorphic units were sampled and analyzed in the laboratory. Tide gauge data and bathymetric data were analyzed to assess the frequency of inundation of the different surface platforms. The data of cyclonic storm frequency in the Bengal coast and IPCC estimates of global sea level rise have also been considered to investigate the degree of vulnerability of this estuarine island in question.

RESULTS AND DISCUSSION

Hugli river estuary is the seaward part of a drowned valley system. Analysis of ONGC (Oil and Natural Gas Commission, Govt. of India) drilled borehole sediments led Mallick (1992) to conclude that the entire coast of Bengal had experienced multiple phases of alternate marine transgression and regression between Oligocene and Holocene periods. The last such regression occurred during Late-Pleistocene time when the Hugli River drained its valley that extended in North-East – South-East fashion over the post-regression flvio-marine plain and descended to a lower sea level. This estuary channel deeply scoured its valley which was drowned by raised sea level to be brought under tidal controls and thus the estuary came into being only 6000 years ago.

Hydrodynamic Setting and Depositional Environment:

The width of the estuary exponentially diminishes upstream giving a funnel shape which is adjusted to accommodate the tidal prism through increase in tidal velocities as well as tidal ranges up to a certain distance from estuary mouth. The estuary being funnel shaped, the incoming flood tide is progressively compressed into a decreased cross sectional area as it moves up the bay. Therefore, the velocity of flood inflow increases until the effects of velocity amplification caused by convergence is balanced by frictional dissipation. This has made the Hugli estuary hypersynchronous (Nicholas and Biggs, 1985) one.

Characteristically, the Hugli River mouth represents a flood dominated estuary in which inflowing flood currents are stronger and briefer (2-3 hours) than the outgoing ebb currents (8-9 hours). Tidal flood begins before residual ebb outflow has ended, and thus produces tidal asymmetry and a net upstream movement of sediments. The narrowing and shallowing of the Hugli River and outflow of large volume of fresh water from the river with huge sediment load cause the tide wave to steepen , increasing the tidal range even up to 5.5 m at the mouth of Haldi river. All these conditions like macro-tidal setting, funnel shaped plan, low gradient along the Hugli channel, upstream movement of the sediments large volume of riverine sediments supply etc. have cumulatively created an environment that favours deposition along the estuary section of the Hugli River. This has been manifested in the form of depositional landform development. Estuarine islands like Nayachar are the most conspicuous among all such depositional features.

Table 1: Variation of Monthly Tidal Ranges along the Hugli Estuary Relative to the Position of Nayachar Island

Tide Gauge Station → / Relative Position	Diamond Harbour	Haldia	Gangra	Sagar Island
	Upstream position of Nayachar Island	Nayachar Island	Downstream position of Nayachar Island	Opening of Hugli estuary on the seaward side
Monthly Tidal Range (January)	4.10 m	4.62 m	4.50 m	4.10 m
Monthly Tidal Range (February)	5.24 m	5.20 m	5.02 m	4.60 m
Monthly Tidal Range (March)	5.77 m	5.66 m	5.50 m	5.03 m
Monthly Tidal Range (April)	6.06 m	5.97 m	5.75 m	5.27 m
Monthly Tidal Range (May)	6.01 m	5.92 m	5.70 m	5.22 m
Monthly Tidal Range (June)	4.64 m	4.49 m	4.32 m	3.91 m
Monthly Tidal Range (July)	5.05 m	4.94 m	4.74 m	4.19 m
Monthly Tidal Range (August)	5.43 m	5.46 m	5.24 m	4.64 m
Monthly Tidal Range (September)	6.02 m	5.91 m	5.71 m	5.08 m
Monthly Tidal Range (October)	6.26 m	6.12 m	6.00 m	5.34 m
Monthly Tidal Range (November)	5.92 m	5.84 m	5.67 m	5.10 m
Monthly Tidal Range (December)	5.24 m	5.20 m	5.04 m	4.56 m

In the tide dominated Hugli estuary, tide current energy is greater than wave energy. Being opposed by the tidal energy, the riverine energy diminishes down the estuary. In spite of estuarine hyper-synchronicity, the tidal energy decreases beyond certain distance within the estuary due to friction, which is further augmented in presence of estuarine islands, sand banks etc. Thus, the central segment of Hugli estuary is a low energy zone where tidal currents are balanced by riverine currents over a long term allowing convergence of sediments. Sedimentation is virtually controlled by tides, river flow, waves and meteorology. Lower energy condition in the Hugli estuary relative to that on open coast, causes for the deposition of fine grain silts, mud, clays and biogenic materials in areas of lower turbulence of the moving water, when allowed to be accumulated, these materials flocculate to consolidate and undergo varying chemical and organic changes forming cohesive sediments (Table-1).

Estuaries are typically the areas of active sedimentation continuously being filled up and are contracting in volume, depth, and surface area until the river winds to the sea through a depositional plain and finally the filled in completely. Deposition on the estuary valley floor of Hugli River has caused the sandbanks to be elevated to form islands by vertical accretion of sediments. As vertical accretion continued, part of the island surface became exposed just above the normal high tide level. Once this occurred the mudflats of the exposed island surface got occupied by saltmarsh grasses. Accumulations of finer sediments have been favoured by colonization of saltmarsh grasses and swampy mangroves. Thus the flow

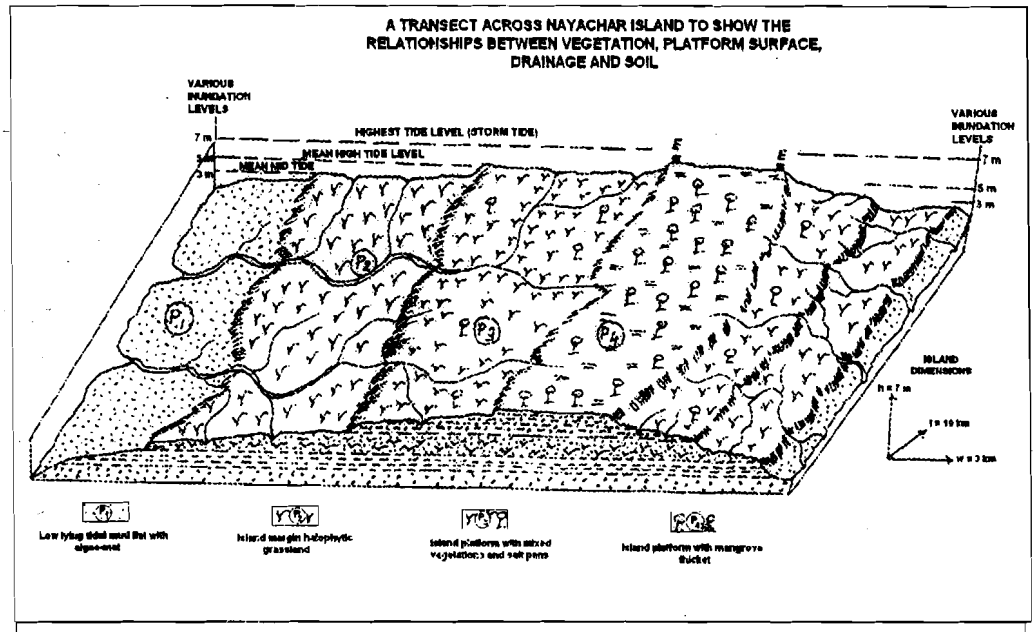

Fig-2

aligned islands of Hugli estuary have come into being in different parts of its middle and lower reaches. Nayachar Island is one of many such islands, namely the Ghoramara, Lohachara, Bedford, Sagar (largest), Sikarpur, Kankramari, Mahisani, Jambu and Chuksar islands. As the tidal currents ebb and flow, shoals move and channels have migrated in response to such shifting of shoals leading to the development of independent, mutually evasive ebb dominated channel (the Rangafala channel to the east of Nayachar island) and the flood dominated channel (the Haldia channel to the west of Nayachar). The ebb channel has a residual outflow of Hugli river water and sediment and becomes wider and shallower seaward. On the contrary, the flood channel is characterized by inflow of seawater into the estuary and becomes shallower upstream. The tidal currents have changed positions through out the history. Therefore, the dimensions of the said estuarine channels and shoals have also undergone changes in response to cutting away of sediments in one place and re-depositing them up in another, which is why many historical estuarine ports along the

banks of Hugli have lost their existence and the Haldia port often requires regular dredging for maintaining the navigable draft.

Geomorphology and Bio-geomorphology :

The hydrodynamic setting and depositional environment of the Hugli estuary have dominantly guided the geomorphology of Nayachar Island. Furthermore, variations in nature and functions of geomorphological processes operative on different morphogenetic zones have strongly influenced plant succession and variability in the spatial pattern of species associations over the island surface. The important geomophological and biogeomoprphological components of the area are as follows (Fig-2).

Saltmarshes and Saltmarsh terraces: Extensive saltmarsh with rich diversity in halophytic grasses, herbs and shrubs species occupy most of the island surface which renders considerable stability to the island. They extend from upper part of the intertidal zone down to about midtide level wherever tidal action is sufficient to flush in sediments. Their substrate is usually muddy but sometimes mixed with sandy sediments. Saltmarshes are less frequently inundated by tides than sandflats and mudflats occupying the lower levels. Saltmarsh species vary with depth and duration of tidal submergence and thus have formed well defined zonation of species parallel to the island boundary. Virtually these zones represent the occupation by each species of a suitable habitat that have moved outward as accretion continued. The succession pattern is therefore often paralleled by the marsh zonation (Table-2).

Table 2: Geomorphic Surface Characterization Diversity at Nayachar Island of Hugli Estuary Section

Marsh Platform (Geomorphic surface)	Altitude (in m)	Area	Geomorphology	Sediment Composition	Vegetation	Hydrology	Age
Low Tide Platform with tidal mudflats and creek mouth sediment lobes	1-2 m	2.86 km^2	Gently to moderately slopping mudflat usually emerged at Low Tide	Unconsolidated silty clay surface with the basement of compact sand	A thin film of algae-mat	Regular tidal inundation and short term exposure to sub-aerial conditions	youngest
Island Rim Platform with active tidal channels. channel margin valley flats and inter channel surface divides	2.5-3.5 m	19.48 km^2	Significant marsh cliffs on the island margins, and inter tidal flats separated with channels and valley flats	Wash over silts at the ebbing tides and fresh silts at the flooding tides	Dense halophytic grasslands	Flooding through the creeks and over spill of tide waters at spring and neap tides	younger
Middle Marsh Platform with vertical creek bank walls, slat flats and primary salt pans	4 – 5 m	14.35 km^2	Relatively higher flats separated with swampy terrain and fresh water wetlands	Peaty soils, Sodium clays and loamy soils	Heathland vegetation with short grasses	Over bank discharge of tidal creeks and flooding at tidal waves	Older
High Marsh Platform with open swamp surface and rain water storage tanks	6 – 7 m	> 13 km^2	Supra tidal flat with swampy terrain and fresh water wetlands	Muddy and saturated with water. Top f the soil is slightly oxidized and brownish in colour, rest of the soil below is bluish grey	Dense mangrove vegetations with scrub and woodland varieties	Salt water encroachment through the tidal creeks at spring tides; rain water storage	Oldest

There are four stage salt marsh systems in Nayachar Island (Fig-3).

Zone-I: Pioneer salt marsh on the upper mudflat with a low salinity cliff;

Zone-II: A fairly level general salt marsh with creeks and salt pans or salt marsh pools;

Zone-III: A second level general salt marsh with creek rim and island margins;

Zone-IV: A high marsh zone bordering the mangroves.

More open saltmarshes are lying with the fringe areas. As the tidal water spreads

over the vegetated areas during high tide muddy sediments are trapped and retained by the filtering network of stems and leaves of the saltmarsh vegetation, while subsurface root network helps in binding those sediments to form a depositional terrace that slopes gently from high spring tide line to the high neap tide line, then more steeply to the mid-tide line. In areas where saltmarsh vegetation is absent the substrate remains as a mobile inter-tidal zone and where the vegetal cover has been removed, the terrace is dissected and degraded by erosional activities of tidal creeks. Though the spread and vertical growth of saltmarsh platforms have been aided by abundant supply of sediments but aggradation has also been augmented considerably by accumulation of organic peat derived from decaying plant remains. Nayachar Island exhibits four saltmarsh terraces each representing a cycle of short duration marsh erosion followed by a phase of longer and rapid accretion (Fig-4). Accretion has been found to be faster on the lower most terrace, submerged by every high tide and slower on the next upper terrace which is inundated only during high spring tide. The third terrace is rarely flooded only by occasional very high amplitude tides during cyclonic events and therefore, accretion is further less than the second platform while accretion on the top most surface is manifested only by

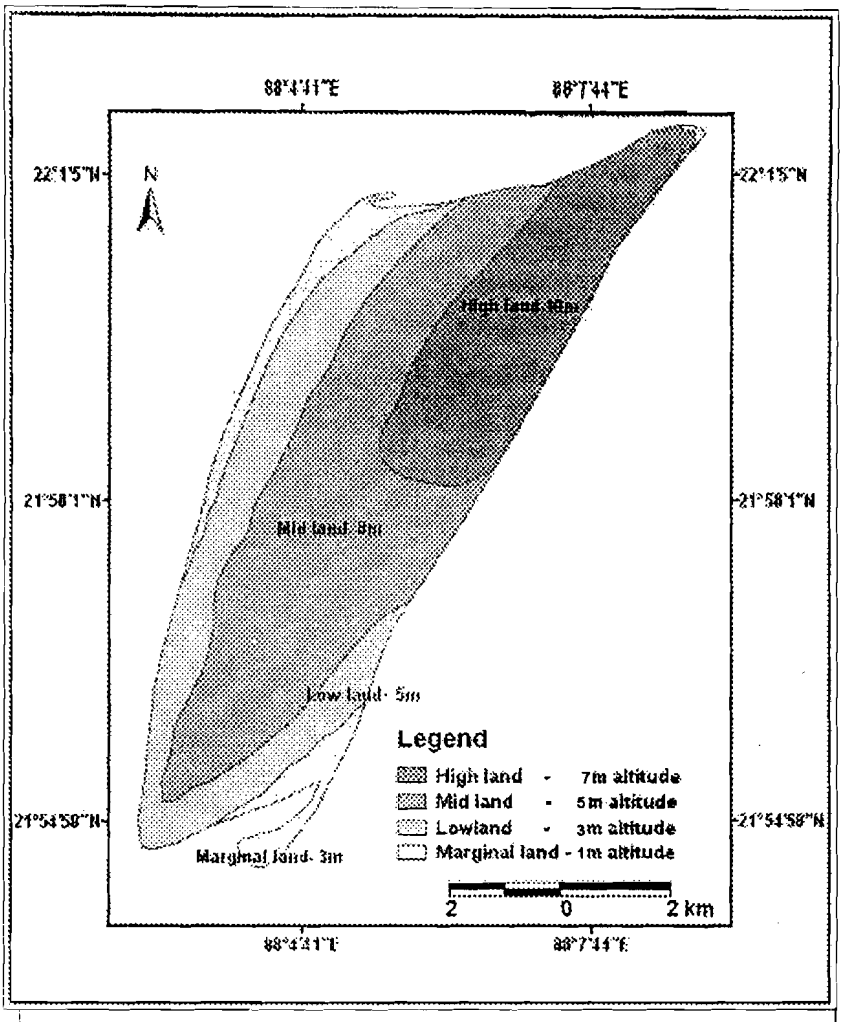

Fig-3: Marsh platform surfaces on Nayachar Island, identified form LISS-III, 2006 image

organic accumulation (Table-3).

Table 3: Surface Maturity Estimation of Nayachar Island on the basis of Surface elevation

Vegetation Types of Different Platforms	Island Platform Surface with Elevation (in m)	Island Bank Character	Number of Creeks Passing through Platform Surface	Major Creeks	Minor Creeks	Number of Cross Channels	Surface Maturity
Mangroves and freshwater marsh plants	Platform-I (Elevation:6–7m)	Eastern bank of Nayachar Island towards Rangafala Channel (Narrow and stepped surface)	7 creeks	3	4	1	Mature surface
Heathland vegetation with short grasses	Platform-II (Elevation: 4-5m)		8 creeks	3	5	3	Near mature surface
Dense halophytic grasslands	Platform-III (Elevation: 2.5-3.5m)		17 creeks	4	13	5	Pre-mature surface
Bare surface with a thin film of algae mats	Platform-IV (Elevation: 1-2m)		17 creeks	4	13	5	Dynamic or unstable
Mangroves and freshwater marsh plants	Platform-I (Elevation:6–7m)	Western bank of Nayachar Island towards Haldia Channel (Wide and slopping surface)	16 creeks	2	14	1	Mature surface
Heathland vegetation with short grasses	Platform-II (Elevation: 4-5m)		15 creeks	7	8	3	Near mature surface
Dense halophytic grasslands	Platform-III (Elevation: 2.5-3.5m)		35 creeks	6	29	5	Pre-mature surface
Bare surface with a thin film of algae mats	Platform-IV (Elevation: 1-2m)		35 creeks	6	29	5	Dynamic or unstable

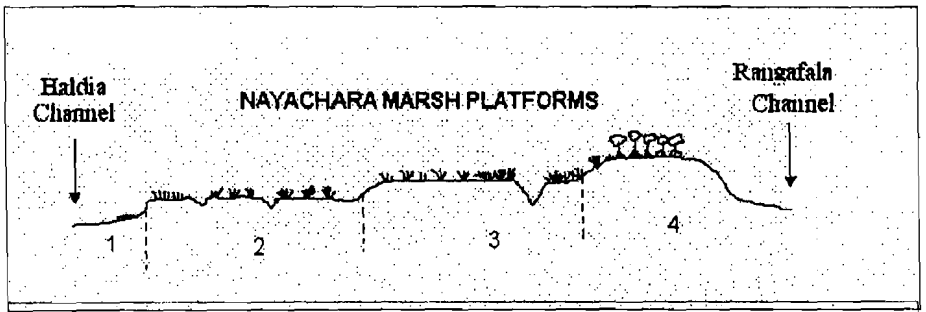

Fig-4: Schematic cross section along marsh platform surfaces

Sections through terraces exhibit stratified deposits of organic matter, fine sand and mud depending upon wave condition. Fine sands can be attributed to occasional storm waves while mud deposits signify continuous accretion during tidal rise and fall related to calm weather.

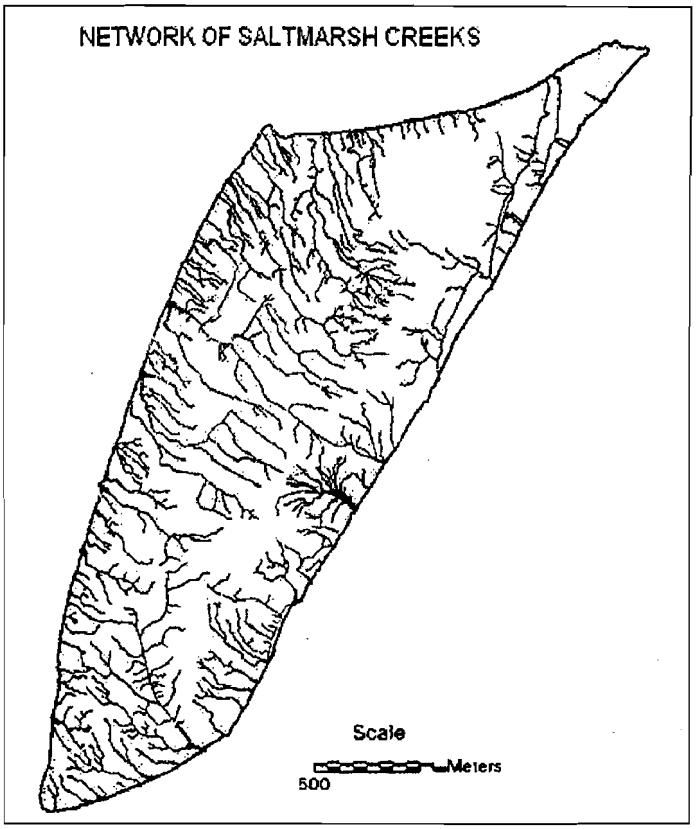

Fig-5

Saltmarsh Creeks: Another important component of the saltmarsh surfaces are the typically dendritic and intricately meandering network of tidal creeks. They are the channels within which the tide raises until the water floods the marsh surface and then act as the channels that drain the ebbing water from the saltmarshes. Patterns of saltmarsh creek networks have maintained noticeable correspondence with terrace morphology. The set of tidal creeks that developed over the highest surface just after its emergence as an island, have extended their courses through all the successive lower terraces that were sequentially developed afterwards. Some of such older creeks have captured each other from opposite sides by headward erosion and now run from the eastern margin to the western margin across the island. Many of these earlier creeks have lost their flow due to sedimentation on their valley floor favoured by lower degree of slope and now exist as abandoned creeks. The set of creeks developed over a lower terrace have extended their courses upward through the higher surfaces by headward erosion. Before encroachment into the higher surfaces, such creeks, in many cases, have followed a course parallel to the cliffed boundary separating two adjoining saltmarsh platforms at different elevations. Number of creeks has increased towards the lower terraces indicative of poorer level of maturity gradually towards the island fringe. With maturity, creek frequency has decreased over the upper saltmarsh terraces due coalescence of creeks by capturing. Interestingly, the creeks have been found to be oriented in a north-west - south-east or in just reverse fashion in resemblance to that of the island expansion. Areas of steeper slope are associated with parallel pattern of creek

development while dendritic pattern is more common on gently slopping sections. On the lowest terrace, the creeks are in early stages of development, therefore, wide and shallow in cross section but they become narrower and deeper on older surfaces, and their banks are higher and steeper with frequent local slumping (Table-4).

Table 4: Physiographic characters of the marsh platforms

Depositional platforms	Drainage density Km/km2	Geomorphological features	Sediment characters
Higher Platform	0.5-1.5 km	Marsh platform, swampy tract, salt pans, creeks	Clayey
Middle Platform	3.0-3.5 km	Marsh platform, tide pools, creeks	Silty
Lower Platform	3.5-4.0 km	Marsh platform, creeks, sloping surface	Loamy
Marginal surface	4.0-4.2 km	Island rim, salting cliff, low marsh Tidal mud flat, creek mouths	Muddy (Fresh silt and Fine sands)

Mangrove swamps: The uppermost depositional surface of Nayachar Island is primarily occupied by the mangrove swamps surrounded by high level saltmarshes. Inward parts are dominated by freshwater swamps representing an advanced stage in vegetation succession to land vegetation. Mangroves are found in the upper part of inter tidal area and dominated by species of several genera including *Avicennia, Bruguiera, Xylocarpus, Nypea, Ceriops, Rhizophora* etc. (Bhakat and Maiti, 2003). Mangroves have also played similar roles in facilitating sediment accretion like the saltmarshes. Sediments carried into the mangroves by high tide floods are retained to build up depositional terrace with an outward slope. The network of stems and pneumatophores that diminishes flood currents has been instrumental to promote accelerated vertical accretion. The substrates are dominated by mud along with peat accumulation. The terrace thus formed has risen to a height in the northern part of the island where regular tidal flood water can not reach and therefore sedimentation is very slow. Accumulation of organic debris compensating subsidence due to compaction has now become the only process of accretion in this part of the island. But to the south of this highest part of the top most surface, active sedimentation is still operative where the mangrove colony is interspersed with mudflats and saltmarshes. In this southern section of mangrove forest, lying relatively at lower elevation in comparison to its northern counterpart, active changes in response to changes in creek morphology have been recorded, while such changes are almost absent in the north representing a advanced level of maturity.

The Evolution of Halophytic Marshes in Nayachar Island:

The extensive marshes of island platforms and certain mangroves of a matured platform of Nayachar Island are unique in the down stream section Hugli estuary. They are not typical marine marsh like tide dominated Sundarban and Subarnarekha deltaic marsh. The development in Nayachar Island is the finest in West Bengal coast (Fig.-6).

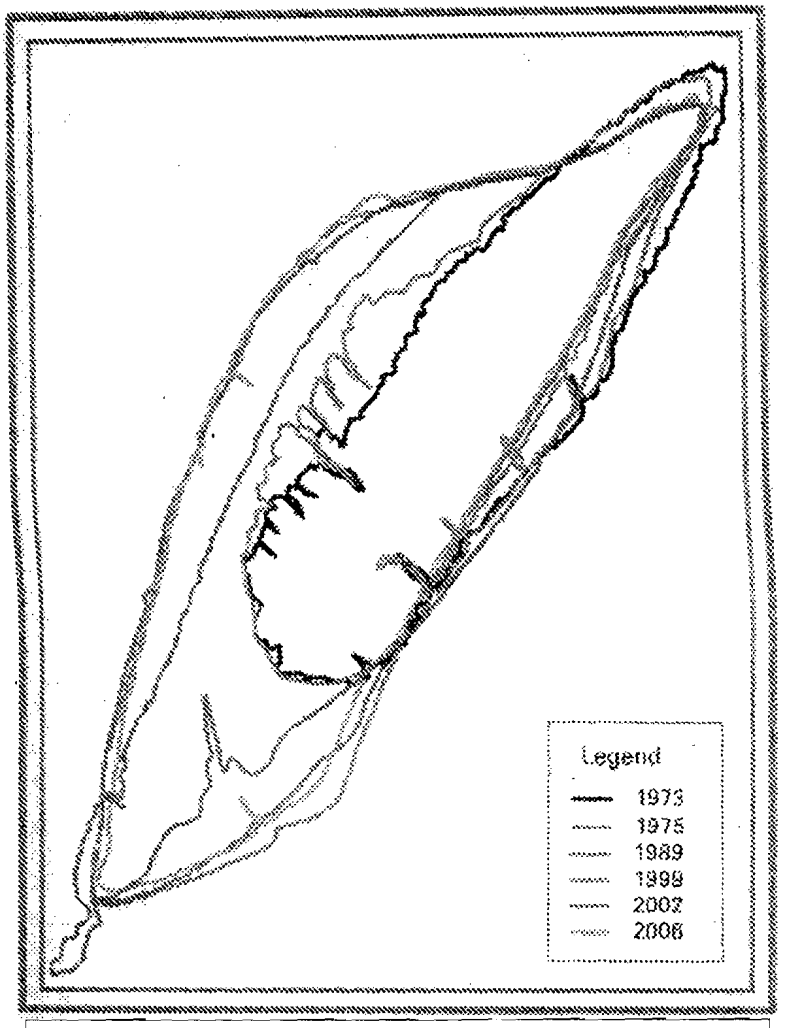

Fig-6: Change in island configuration over time (1973 – 2006)

Marshes of Nayachar consist of mud and silt and often considerable admixtures of finer sand and coarser sands deposited upon the original river bed of Hugli estuary section and later overspread to a greater or less extent with plants. In Nayachar the river bed beneath the marshes consists of sand flats and actual inspection of drilling site at central part of the island and the exposures of sediments on the erosive banks of tidal creeks and island rims shows that the marshes grow outward from the island platform and inwards from the protective sand bars and tidal sand ridges (Table-5).

Table 5: Change detection of island morphology and vegetations using Remote Sensing data

Year	Change in area (ha)	Change in area of salt marsh (ha)	Change in area of Sand Bar (ha)	Change in area of dense mangroves (ha)	Change in area of open mangroves (ha)	Areas reclaimed (ha)	Change in Area of Tidal Channel space (ha)
1973	2747.679	1388.913	00.65	275.5152	1050.727	9.0972	72.7776
1975	3069.655	1414.290	120.54	246.5991	1346.386	0	61.731
1989	4155.796	1326.485	680.58	465.7442	906.7959	1371.728	52.55258
1999	5132.160	2283.840	206.37	690.4800	1427.400	401.850	38.34
2002	4865.967	1166.201	543.00	568.9135	2242.67	527.9817	81.30743
2006	4814.713	4016.982	222.09	225.4441	0	261.5446	31.59819

The surface platforms and colonization of halophytic marshes have developed sequentially in the island in response to varying tidal inundation levels and higher rate of sediment accumulation under estuarine depositional environment. The following depositional sequences have been identified in Nayachar Island:

a. Estuarine sand flat sequence- Initial deposition of sand size materials in the form of sand bar under estuarine process within the mid-channel position of Hugli flared up section opposite to Hugli River mouth.

b. Initial rough surface with sheltered spots for accumulation- The surface of the bar was roughened by development of sand waves and pools or swells between successive sand waves structures. Some sheltered spots accumulate more tidal silts at and near the turn of tide and a large amount of silt is also carried back again with the ebb tide.

c. Vertical and lateral growth of island platforms- Centuries of accumulation took place over the original floor particularly near the margin of high water. These patches of accumulation centres cause more deposition of fresh silts in the inundation zones at the high water level and so grow in surface height and also laterally on the surface margins. The troughs and lower parts of the platform surface are now able to be filled up with greater amount of finer sediments at the ebbing tides. The little mud banks may grow up around the small obstacles developed due to the growth of weeds and algae-mats over the island platform.

d. Spread of grasslands and mangroves- The upper marshes are affected by submergence at regular frequency around the summer equinox and autumnal equinox. These two circumstances are very significant for the growth and spread of marshes on the platforms for the distribution of seeds by the high level tides. Between these two periods (summer and autumnal equinoxes), as there is a long period of non-tidal exposure in summer and winter phases, therefore, considerable desiccation occurs in the higher marsh platforms of the island. Tidal creeks are

lined by mangrove thickets in the high platforms as mangrove seeds are transported towards the creeks margins at the equinoxes and adjusted in the saline tract in compare to the lower marshes in which river water washing takes place regularly at the summer monsoon phase.

e. Modification of marsh physiography- Gradually, formation of level surface on the margins of creek banks, slight depressions in the marsh surface, tide pools or salt pans with evaporation rate in emerged marsh and widening and deepening of tidal creeks take place successively with maturity of marsh surface. Finally, modification also takes place with rain water storage in the depressions of the higher parts of the island platforms.

Continuation of lateral growth and vertical growth of marsh platforms in the inter-tidal region under favourable sheltered conditions led to further development of the island (Table-6).

Table 6: Change in the shape and area of island

Year	Area (ha)	Length/Width	Plan shape	Remark
1973	2747.679	8.0 / 2.3	Oval shaped	Accretion
1975	3069.655	10.0 / 3.5	Pointed northward	Elongation
1989	4155.796	12.5 / 3.8	Elongated	Extension
1999	5132.160	19.0 / 4.0	Near elliptical	Extension & Marginal erosion
2002	4865.967	22.0 / 4.5	Near elliptical	Accretion & Southward fragmentation
2006	4814.713	29.8 / 4.5	Near elliptical & Pointed northward	Accretion & Southward fragmentation

CONCLUSION:

The purpose of this paper has been to discuss the morphodynamics of marsh platforms, and vulnerability issues in high tidal estuarine delta of the Hugli River section. From the above analysis, Following conclusions emerge.

1. Marsh platform evolution
2. Vegetation sequences on the marsh platforms
3. Comparison with other areas of Sundarban marine marsh
4. Problems of vulnerability issues

1. The present study shows that the Hugli deltaic estuarine area is characterized by a high tidal range, seasonal dry and wet climate, high evaporation rates, seasonal inputs of large amounts of sediment at the freshets of the Hugli river and inputs of tidal sediments at the dry period from marine environment, and under this physical and hydrological set up a complex array of tidal flat landforms with marsh vegetations have been developed over time. Some types of geomorphic change have been identified in the island: vertical accretion of tidal flats, lateral progradation of tidal flats towards south involving tidal and storm wave deposition, current erosion of accreted tidal flats at the ebbing tides, in-channel depositon of sediments within the tidal creeks, erosion of the northern banks and eastern banks of the island by tidal currents, slumping of matured creek banks, formation of saline blanks and salt pans on the inner platforms. Such variety of landforms result from the interaction of geomorphic processes usually influences the character of marsh plant habitats. The island is tapering towards north, and aligned with the tidal flood flows and ebb flows within the estuary section, and also extended towards south with vertical and lateral growth of tidal flat surfaces. The various platform development of island surface is responsible for the variation in the magnitude and frequency of geomorphic processes over time in the estuary section particularly by incidences of cyclones, severe flood induced river runoff and action of tidal waves.

2. The patterns of vegetation change are the result of the nature of habitat evolution in the island under such estuarine tidal environment. The major sequences of vegetation change include: channel valley and channel bank sequences, higher elevation and lower elevation platform sequences, island rim and outer estuary mudflat sequences, and local interruptions to landforms with episodic erosion and deposition and associated plant sequences.

3. The halophytic grassland of Nayachar island platforms is luxuriant in growth in compare to the marine marsh of Sundarban. The higher platform s with mangroves has reached a self-maintaining stage in equilibrium with geomorphic processes, present tidal range with channel creeks, and inundation frequency. *Avicennia* community of mangroves exists on unstable surfaces of the island and do not maintain successional relations with other plants of marsh vegetations. The bare spots of central marsh platforms and bare areas adjacent to tidal creeks are the results of excessive evaporation and resultant degradation of marsh vegetations. The degree of geomorphic change of platform development has influenced the vegetation pattern in the island.

4. The vulnerability issues associated with flooding, erosion and storm waves cab disturb the stability of tidal flat surfaces. The area of sand flat has increased in the island in different cyclone years (6.80 km^2 in 1989 and 5.43 km^2 in 2002). However, the area of halophytic grasslands has also increased to 40.16 km^2 after the year 2002 due to outward growth of marshes on the prograding tidal mudflats. Significant erosion may

take place on the island banks possibly due to the incidences of cyclones and magnitude of tidal currents resulted form tidal waves. Stability os surfaces may be achieved with vertical accretion and rising elevation of the marsh platforms.

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