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Contents

ENVIRONMENTAL MANAGEMENT AND PROSPECTS OF COASTAL TOURISM UNDER THE CHANGING SHORELINECHARACTERS OF HUGLI-SUBARNAREKHA COMPLEX

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Abstract

Coastal belt of East Midnapore District and Balasore District in between River Hugli Mouth and Subarnarekha River Mouth with their coastal landform diversity, seasonal diversity, rural diversity and heritage diversity offers tremendous potential for tourism in their typical coastlines and rural areas. Tourism sector is one of the largest sources of employment in the coastal belt and can contribute crores of revenue annually under well-managed environment friend fully development plans. The perception of local people about area development is also in favors of tourism expansion and associated employment generation schemes. Government of India has earmarked tourism as a potential employment generation area for focused development in tenth five years plan. The majority of middle class Bengali tourists are budget tourists who prefer rural coastal belts with tourist attraction with homely environs and diverse scenic beauty. Certain specific pockets in rural areas like those near beaches, wetlands, sand dunes, riverbanks, islands, places of pilgrimage, places of historical significance, places of scenic beauty offer scope for coastal tourism and rural tourism of diverse kinds such as eco-tourism, beach tourism, craft based tourism, agri tourism, adventure tourism, marine food and local food based tourism, nature camping tourism, festival tourism, water route based floating camp tourism etc.

Keeping the views in mind the present study is connected to identify the places of potentials, existing infrastructures, and to analyse the changing coastline characters, seasonal diversity and significant environmental status of the coastal belt, socio-economic conditions and various occupational structures of the local people, and to formulate a scheme of tourism development under the guidelines of coastal zone management notifications.

Key Words : *HAT Phase, LEO Scheme, Eco tourism, Coastal Village tourism, Budget tourists, Agri tourism, Adventure tourism, CRZ Notifications, Multi-tire impact levels, Heritage coasts, Estuarine complex, Leisured class people, Tourism attractions, Tourism circuits.*

Coastal tourism in Hugli-Subarnarekha estuarine complex :

In the middle of previous century, coastal areas of Hugli- Subarnarekha estuarine complex emerged as the new form of tourism destination for the leisured classes of Bengal. In fact the coast was considered an environment to avoid due to the forces of nature and evil i.e. the Bay of Bengal cyclones and tidal waves with vagaries of south-west monsoon season. However, during the previous century the impact of Bengali movies, writers, environmentalists and romanticists led to the beach and coast line being discovered as a site for pleasure, a place for spiritual fulfillment and a site for tourism as bathing slowly developed as a social and leisure activity between 1950 and 1970.

A number of key landmarks in the early stage of coastal tourism can be recognized for the coastal belt between Hugli River mouth and Subarnarekha River mouth, including :

- Beercool, a place near Digha (now under sea) was selected as a summer resort of warren Hastings for health reasons as well as bathing (1778).
- Mrs. Hastings after bathing on the sea of Digha near Beercool described the natural beauty of the place (golden color sands, gentle sea breezes, bluish water etc.) and compared the place with Brighton of the west (a coastal resort of Southern England).
- The Natural beauty of shoreline waterscape, forestscape and landscape of the present area described in 'KapalKundala' (1876), a famous novel of Bankim Chandra Chattopadhyay.
- Historical Significance of Hijli and Khejuri islands (1687) under the Rules of Nwabab Sayesta Khan of Bengal and Job Charnak of East India Company.
- Construction of Hijli Tidal canal at 1866 by East India Irrigation and Canal Company and Orissa Coast Canal at 1887 by the same company to promote navigation and irrigation in the coastal belt of Medinipur fringed with extensive saltflats.
- The sandy coast of Digha on Bay of Bengal was selected as destination for coastal recreation and tourism at the time of Dr. B.C. Roy (1950), the then chief Minister of West Bengal.
- The rise of resorts and holiday homes with a wide range of social and ancillary services to meet the needs of visitors at the decades of seventies, eighties and nineties of previous century at Digha, Shankarpur, Junput and Talsari coast.
- Finally, the extension of Railway route from Tamluk to Digha encouraged growing access to coastal recreation and tourism for the leisured class of Kolkata.

Tourism Prospects :

Tourism has emerged as a new sector of economy since 1980s at the coastal belt of East Medinipur and Balasore district in between Hugli estuary and Subarnarekha estuary. Many local people are involved in transport, accommodation and business components of tourism. Following attractions of coastal belt form one of the central components of tourism.

Table 1. Tourism attractions and visit to attraction at the coastal belt of Hugli-Subarnarekha estuarine complex

Category of attractions	Percentage of attractions	Visits to attractions
1. Wide and compact sandy sea beach for walking, playing, horse riding and car driving.	8	10
2. Sea- bathing at Digha, Shankarpur and Duttapur	8	15
3. A number of other seaside resorts at Manderbani, Junput and Shankarpur	5	4
4. Fishing harbours and Marine foods at Talsari, Shankarpur (Food Plaza) and Petuaghat.	5	3
5. Historical remains and other historic properties at the museum of Depal (Dharas).	3	0
6. Picnicking, Nature camping and coastal tracking (Digha-Talsari-Subarnarekha R.)	3	2
7. Leisure place on Digha – Shankarpur shoreline for health reasons or for fresh Oxygen.	4	5
8. Coastal wetlands and mangroves of Talsari, Digha estuary, Manderbani, Pichabani, Junput, Masnad i Ala, Balari, Nayachara.	3	2
9. Wildlife attractions. (e.g. Birds, reptiles etc.)	2	0
10. Dune forests dominated by casuarinas Trees and cashew nut Trees.	2	0
11. Street markets of various items on shells, mats and bones etc.	3	5
12. Rail travel for pleasure on specially designed train.	3	15
13. Water based travel for pleasure on inland waterways (e.g. by canal boats or flotels.)	4	0
14. Local products processed (e.g. cashew nuts and fish and chips).	3	2
15. Scenic beauty of different seasons in the in the coastal villages (Attractive seasons)	5	0
16. Beach festivals and other local festivals (Makar Sankranti for holy deep).	2	1
17. Highest Astronomical Tides and Tidal floods of Sept- Oct. period.	2	15
18. Excursion sites for day tripping at coastal sectors.	3	5
19. Science show and exhibition, Marine-Aquarium, nature park and Boating, Library and Coastal Resource Centre For education and training.	2	4
20. Leisure place on the riverbanks for amusements and enjoyments (Hugli, Rupnarayan, Rasalpur & Subarnarekha.)	5	2
21. Coastal High Road, a new circuit for tourism expansion on the river bank of Hugli mouth	3	0
22. Junput-Gopalpur to Rasulpur river mouth, a wonderful tracking route along the shoreline	2	0
23. Island trips to Nayachar, Balari and Radhapur.	3	3

Table 1. Tourism attractions and visit to attraction at the coastal belt of Hugli-Subarnarekha estuarine complex *(contd...)*

Category of attractions	Percentage of attractions	Visits to attractions
24. Historic Anjelli, Kedagree, Kaukhali and Kunjapur.	4	0
25. Historical Tamralipta, Nutshal, Geonkhali.	4	2
26. Historical Dariapur and Kapalkuldala Temple.	3	2
27. Historic Masnad-I-Ala mosque on the bank of Hoogly river mouth.	4	0
28. Jelingham project on the bank of Hugli river at Nandigram.	2	0
Total	**100**	**100**

Source : Based on Field Survey

Tourism potential zones of the coastal belt between Hugli-Subarnarekha estuarine complex are categorized on the basis of attraction, infrastructure and diversity of landscape ecology (Figure 1.)

Physical environment of the Coastal belt :

The entire coastal belt from Hugli river mouth to Subarnarekha river mouth is categorized into different coastal sectors on the basis of Physical environmental diversity and tourism potentiality. The alluvium coast between Subarnarekha river mouth to Rasalpur River is distinctly characterized by the location of wide space parallel beach ridges and beach ridge-caped sand dunes, inter-dune lowland surface with sediment filled, palaeo-tidal basins, shore parallel wide sandy beaches and beach fringed sand dunes and barrier spits with back barrier narrow lagoons of salt marsh deposits. Other part of the alluvium coast on the western bank of Hugli River mouth between Rasalpur river and Rupnarayan River is charactersid by wide estuarine tidal flood basins of sediment filled Low land flats, estuarine islands and bars of salt marsh deposits and bank margin wide tidal flats fringed with natural levees. Palaeo channels and abandoned courses of streams are visible on the lowland coast of estuarine complex.

Both the diverse coastal belts are fed by many larger rivers and tidal inlets. Extensive salt marshes, mangrove swamps and salt flats were existed on the inter tidal regions of wide river mouths and inlet channels. Some of the tidal spill basins of the past are now protected by earthen embankments at Digha coast for farm fishing and salt extraction. Most of the coastal wildernesses are now domesticated for different uses. The northern and western limits of the coastal belt are restricted by the extension of historical Hijli Tidal canal and Orissa coast canal of British Rules in Bengal.

Major attractions for the visitors in the above mentioned coastal belt may include as wide and compact sandy sea beaches, emerged tidal flats, river flats and river banks of diverse vegetation cover, salt marshes and mangroves, open sea wave environments of barrier beach areas, forested dune belts, boating at canals and rivers for pleasure, visit to the historical places and sea side resort coastal villages of scenic beauty, coastal tracking routes, sites of camping and

Table 2. Potential village tourism sites selected on the basis of river front locations, sea front locations and landscape ecological diversities from the coastal belt between Hugli-Subarnarekha estuarine complex

Sl. No.	Name of P.S.	Selected mouzas of potential village tourism with J.L.nos. at the coastal belt.
1.	Nandigram (Purba Medinipore Dist.)	110,157,189,221,241,252,253.
2.	Khejuri (Purba Medinipore Dist.)	2,3,4,54,89,99,100,103,104,120.
3.	Contai (Kanthi) (Purba Medinipore Dist.)	332,416,474,506,507,574,583,619,624,631.
4.	Ramnagar (Purba Medinipore Dist.)	214,217,237,242,244,245,246,282,296.
5.	Digha (Purba Medinipore Dist.)	73,77,78,91,98,211,212,213,215,216,
6.	Bhograi (Balasore Dt.)	149, 162, 172, 279, 300, 347, 348, 351, 352, 354
7.	Baliapal (Balasore Dt.)	85,87,88,154,155,194,197,212,214, 215.

Source : Census of India, 2001

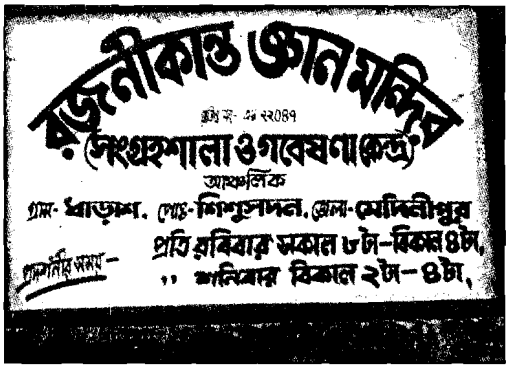
nature parks, picnicking sites, sea bathing and adventure tourism, available local products and marine foods etc.

Rupnarayan Plain is situated towards northeast of Kanthi Coastal Plain and separated by Haldi River and Rupnarayan River into a single physical domain of coastal sector. The east-ward and south-east ward sloping ground (3m to 5.5m in height from the mean sea level) of Rupnarayan Plain is restricted by the location of Hugli River estuary section to the east of East Medinipur coastal belt. This part of the physical unit is characterized by tide dominated and river dominated coastal systems. Major morphotypes of the region include as flood plain surface, abandoned channels or palaeo channels, lowlands and seasonal wetlands of marsh deposition (river dominated coastal morphotypes); and estuarine banks, tidal flats, tidal creeks, bars and islands of swamp deposits (tide dominated coastal morphotypes). Potential tourism attractions are yet to be explored in the region. Major attractions for the visitors in the coastal belt may include as river banks of Hugli, Rupnarayan and Haldi; Nayachar-Balari-Radhapur islands, boating at Hugli estuary and Hijli Tidal canal for pleasure, visit to the historical sites at Tamralipta Port, Natsal, Geonkhali and Hijli, Haldia Industrial complex, Port and market sites and local festivals.

River Hugli and Subarnarekha on both side of the coastal Plain surface act as two major sediment feeders into the sea ward limit of coastal zone of the present geomorphological domain. Unconsolidated alluviums of entire shoreline are affected by erosion except the sediment input zones of two major river mouths (Photo plates).

Sediment records of the coastal belt

Sediment samples are collected from different sub environments of different coastal sectors in pre-monsoon, Monsoon and post monsoon seasons for mechanical and chemical analysis. Coastal processes of different physical settings are involved in deposition of sediments at present. Some of the lithological logs are collected and analysed for the records of sequential changes



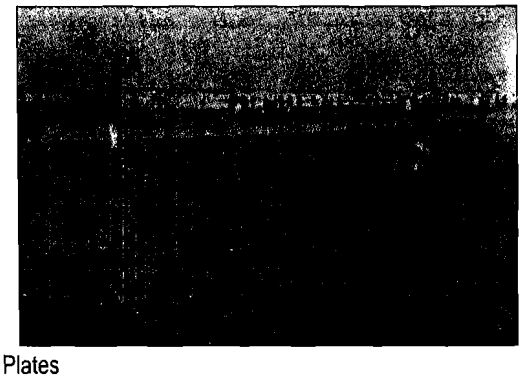


Photo Plates

in coastal plain depositional environments from the recent geological past to modern day coastal environment. Finally, the soil Salinization areas and land use potentialities are estimated in the coastal sectors for resource utilization by the local people.

Lowland alluviums of the coastal plain areas with tidal channels are affected by salinity and alkalinity due to high temperature, evaporation, ground water fluctuation and salt water percolation in the dry season and rain water ponding or water logging in the monsoon season. Thus, rice paddy cultivation is practiced in the Aman season and vegetable production grows in the winter and summer seasons on loamy soils of coastal low lands immediately behind the wind deformed sand dunes parallel to the coastline. Use of encroached seawater in protective fish farms for commercial and industrial fishing and in protective salt-pans for salt production are also responsible for the spread of soil salinity in the coastal lowlands.

Unconsolidated sandy alluviums of beach plain areas and coastal sand dunes are colonized by certain plant species and they may remain in the primary landscape without destabilizing forces like cyclonic storms and tidal floods. They act as first line of defense in the lowland coast. Coastal habitats and marine resources are badly affected in few places by land use alterations. A few land use survey has conducted on the shoreline villages with the help of cadastral maps to estimate the land use alteration on the fragile environment.

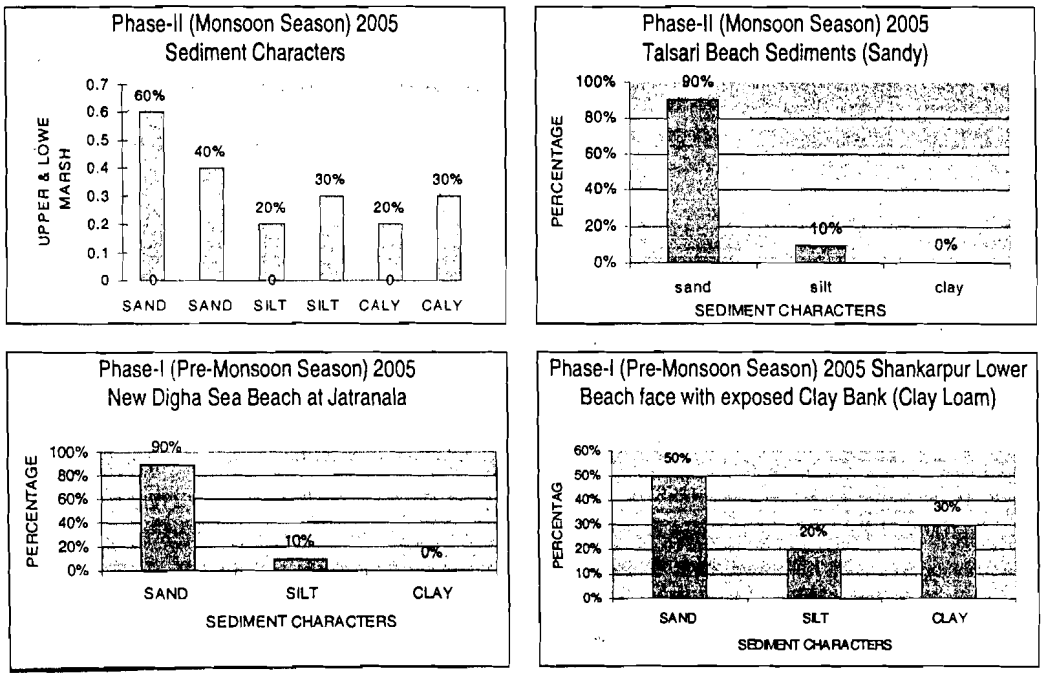


Figure 2. Grain size distribution of beach sediments within the coastal belt of Hugli-Subarnarekha estuarine complex.

Shoreline displacements and coastal change hazards :

Temporal shoreline changes are monitored in pre-monsoon, monsoon and post-monsoon seasons with the dumpy level survey. A number of beach profile forms are selected to estimate the shoreline displacements with super imposition of time series profiles for the erosive sectors and depositional sectors. Shoreline beaches and beach fringed dune landscapes, river bank sites with wetlands and vegetations, shore front waterscapes and inland water bodies of rivers and canals are estimated as potential attractions for tourism expansions at the coast. Thus, they are studied with the help of Remote Sensing Images, Survey of India's toposheets and digital photographic records.

Coastal change hazards are documented on the basis of multi tire impact levels with the use of time series satellite image data and seasonal field works. The magnitude of storm characteristics with strong wind force, storm rainfall, storm surge and waves and the elevation of coastline dune barriers jointly produced the impact at the landfall of cyclones in the past. By considering the magnitude of wave run up, the highest reach of the waves on the beach, relative to coastal elevation, a new scale has been developed that categorizes net erosion and accretion during storms and also at the time of monsoon and H A T phases (Highest Astronomical Tidal phase).

It is observed that there is a progressive change of the shoreline at the erosional sectors under the annual variation of energy regimes. The beach fringed dune ridge does not recover nearly as rapidly as the beach. Dune sands are constantly eroded in one place on the shorefront and deposited in another place of coastal sector by waves, long shore currents and storms. Long shore transport of sediments is partially arrested in few pockets in the form of barriers spits

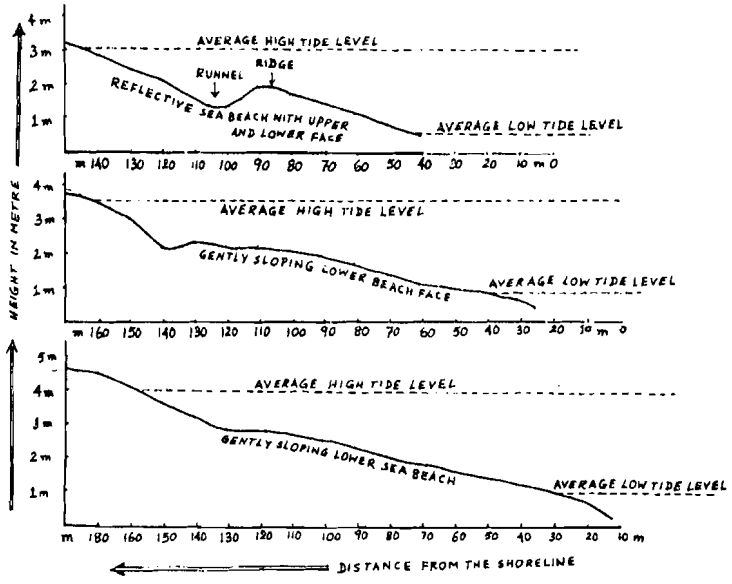


Figure 3a. Beach profile forms of Digha, Shankarpur, Mandarboni, Talsari, Junput

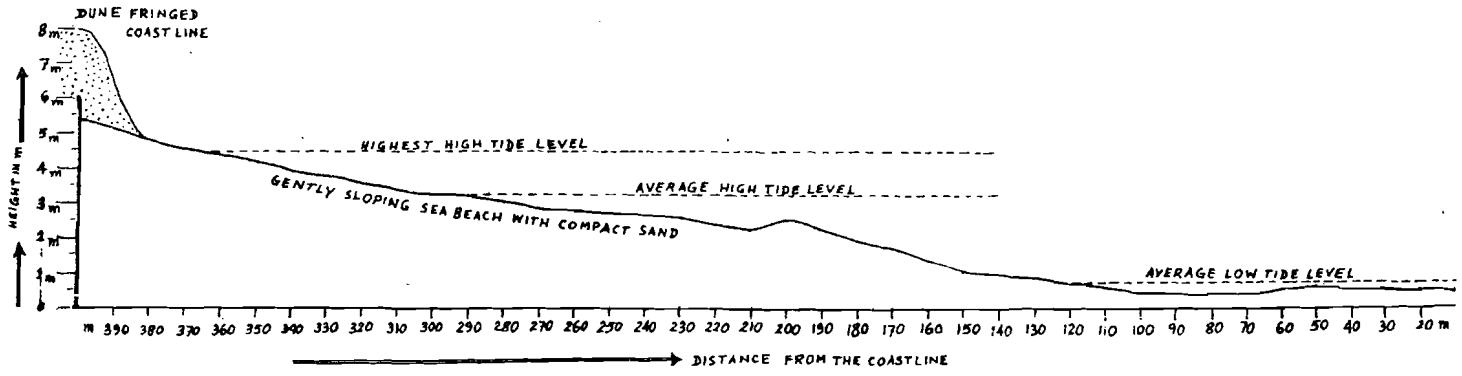


Figure 3b. Beach profile forms of Digha, Shankarpur, Mandarboni, Talsari, Junput

particularly at the mouth of Subarnarekha River, Pichabani tidal channel and Rasulpur River along the modern shoreline. Barrier coasts of the developing spits are composed of barrier beaches, barrier dunes or beach ridges, protected lagoons or back waters immediately behind the dune barriers and tidal inlets. They are unique in characters. Barrier coasts are important for a number of reasons; they protect the main land of low- lying coastal plain from the open sea wave environment and flooding during storms, for recreational use and the unique ecosystems which exist on barrier beaches, dunes and wetlands. (Paul, 2002)

Coastal processes of different sectors :

(An assessment with the application of LEO scheme)

Following method of assessment is considered for the monitoring coastal processes of potential tourism sites (Goudie, 1976) of Hugli-Subarnorekha complex. All the three sites with wide sandy benches and beach fringed sand dunes are very attractive to the tourists for bathing and rasting in summer and winter. The littoral environment of the following monitored sites is gradually changing with increases water levels in monsoon phase, astronomical tides and cyclonic phase. Local variation of tidal amptitude, tidal range, long shore current drift and rip current under variable beach plan shape, beach gradient, inlet locations and human modifications of shores should be studied for the supply of informations to the tourists about the shoreline attraction sites.

The Littoral Environment Observations at Digha

A.	Station identification :	Old Digha (East of Hotel Sea Hawk)
B.	Date :	4th September 2005
C.	Time using the 24hrs system :	8 am., 12 noon, 5pm.
D.	Surf observations:	
	1. Wave period	6 per minute to 8 per minute
	2. Breaker height	2 m to 2.5m
	3. Breaker angle	15 degree to 25 degree
	4. Breaker type	collapsing breaker
E.	Wind Observations :	
	1. Wind speed	10 to 14m/sec.
	2. Wind direction	SW to SSW
F.	Foreshore slope	3 degree to 5 degree
G.	Width of serf zone	30 m to 45 m
H.	Long shore currents :	
	1. Dye distance	25m
	2. Current speed	3.4m/sec
	3. Current direction	SSW to NNE
I.	Rip currents (Rip channel spacing in meters) : 2.9 m (If absent record 0)	
J.	Beach cusps (Distance between the horns of adjacent cusps in meters) : 70 cm to 100 cm (If absent record 0)	

The Littoral Environment Observations at Shankarpur

A.	Station identification :	Shankarpur bathing spot (in front of Hotel Belabhumi)
B.	Date :	3rd September 2005
C.	Time using the 24hrs system :	8 am.,12 noon, 5pm
D.	Surf observations :	
	a. Wave period	7 per minute to 8 per minute
	b. Breaker height	2 m to 3m
	c. Breaker angle	15 degree to 25 degree
	d. Breaker type	collapsing breaker
E.	Wind Observations :	
	a. Wind speed	10 to 14m/sec.
	b. Wind direction	SW to SSW
F.	Foreshore slope	2 degree to 4 degree
G.	Width of serf zone	30 m to 45 m
H.	Long shore currents :	
	1. Dye distance	30m
	2. Current speed	3.5m/sec
	3. Current direction	SSW to NNE

I. Rip currents (Rip channel spacing in meters) : 4.9 m
(If absent record 0)

J. Beach cusps (Distance between the horns of adjacent cusps in meters) : 1.5 m to 2.5 m
(If absent record 0)

The Littoral Environment Observations at Talshari

A.	Station identification :	Infront of Subarnapur village (Barrier beach)
B.	Date :	2nd September 2005
C.	Time using the 24hrs system :	8 am., 12 noon, 5pm
D.	Surf observations :	
	a. Wave period	7 per minute to 8 per minute
	b. Breaker height	2.5 m to 3m
	c. Breaker angle	10 degree to 20 degree
	d. Breaker type	collapsing breaker
E.	Wind Observations :	
	a. Wind speed	10 to 14m/sec.
	b. Wind direction	SW to SSW
F.	Foreshore slope	3 degree to 5 degree
G.	Width of serf zone	35 m to 55 m
H.	Long shore currents :	
	1. Dye distance	35m
	2. Current speed	3.5m/sec to 4.0m/sec
	3. Current direction	SSW to NNE

I. Rip currents (Rip channel spacing in meters) : 2.5 m
(If absent record 0)

J. Beach cusps (Distance between the horns of adjacent cusps in meters) : 1 m to 1.5 m
(If absent record 0)

Seasonal wind and temperature records :

Wind velocity and directions are recorded in pre- monsoon, monsoon and post-monsoon seasons in various coastal sectors with digital anemometer and wind vane instruments. The wind, quite apart from its major function of generating waves, plays an important part in the movement of beach material. Coastal sand dunes are an important aspect of wind action on the coast. The lower wind velocity in the winter season (post-monsoon) is not sufficient to move moist sand, which could be moved by much stronger winds. High wind speeds in the pre monsoon summer throws sand particles on the wide sandy beaches and on the backshore areas of the coast.

Table 3. Wind Velocity Records at Shankarpur with Digital Anemometer

Height – 1.5 mt from local surface

Recorded on September 2005 (02.09.2005)

Frequency of records	Time slots of wind velocity records				
	4.16 pm	4.18 pm	4.20 pm	4.22 pm	4.24 pm
1.	2.7 m/s	2.0 m/s	1.9 m/s	2.2 m/s	1.8 m/s
2.	2.8 m/s	1.9 m/s	1.9 m/s	2.3 m/s	1.8 m/s
3.	2.8 m/s	1.9 m/s	2.0 m/s	2.2 m/s	1.7 m/s
4.	2.7 m/s	2.9 m/s	2.0 m/s	2.1 m/s	1.7 m/s
5.	2.6 m/s	1.2 m/s	2.1 m/s	2.0 m/s	1.8 m/s
6.	2.7 m/s	2.1 m/s	2.0 m/s	2.0 m/s	1.7 m/s
7.	2.6 m/s	1.9 m/s	2.0 m/s	2.1 m/s	1.8 m/s
8.	2.7 m/s	2.0 m/s	2.0 m/s	2.2 m/s	1.9 m/s
9.	2.7 m/s	2.0m/s	2.0 m/s	2.2 m/s	2.0 m/s
10.	2.6 m/s	2.0m/s	2.0 m/s	2.2 m/s	1.9 m/s
11.	2.5 m/s	2.1m/s	1.9 m/s	2.3 m/s	1.9 m/s
12.	2.6 m/s	2.3m/s	1.9 m/s	2.4 m/s	1.8 m/s
13.	2.6 m/s	2.5m/s	1.8 m/s	2.8 m/s	1.8 m/s
14.	2.6 m/s	2.6m/s	1.7 m/s	2.6 m/s	1.8 m/s
15.	2.6 m/s	2.9m/s	1.7 m/s	2.6 m/s	1.8 m/s
16.	2.5 m/s	2.9m/s	1.6 m/s	2.7 m/s	1.8 m/s
17.	2.4 m/s	2.8m/s	1.6 m/s	2.6 m/s	1.9 m/s
18.	2.4 m/s	2.9m/s	1.6 m/s	2.7 m/s	2.0 m/s
19.	2.6 m/s	2.7m/s	1.8 m/s	2.8 m/s	2.3 m/s
20.	2.7 m/s	2.6m/s	2.0 m/s	2.9 m/s	2.4 m/s

Table 4. Wind Velocity Records at Junput with Digital Anemometer

Height – 1.5 mt from local surface

Recorded on September 2005 (03.09.2005)

Frequency of records	Time slots of wind velocity records				
	10:15 a.m	10:17 a.m	10:20 a.m	10:22 a.m	10:25 a.m
1.	0.6m/s	1.5m/s	1.3 m/s	1.3m/s	0.8m/s
2.	0.6m/s	1.6m/s	1.3 m/s	1.2m/s	1.0m/s
3.	0.6m/s	1.6m/s	1.4 m/s	1.1m/s	1.0m/s
4.	0.7m/s	1.6m/s	1.3 m/s	1.1m/s	1.1m/s
5.	0.8m/s	1.5m/s	1.3m/s	1.0m/s	1.2m/s
6.	0.8m/s	1.5m/s	1.2m/s	1.0m/s	1.5m/s
7.	0.8m/s	1.5m/s	1.2m/s	1.0m/s	1.6m/s
8.	1.1m/s	1.5m/s	1.3m/s	1.1m/s	1.8m/s
9.	1.2m/s	1.6m/s	1.4m/s	1.1m/s	1.7m/s
10.	1.1m/s	1.4m/s	1.5m/s	1.0m/s	1.6m/s
11.	1.1m/s	1.3m/s	1.5m/s	1.1m/s	1.5m/s
12.	1.2m/s	1.3m/s	1.5m/s	1.0m/s	1.3m/s
13.	1.5m/s	1.2m/s	1.4m/s	1.0m/s	1.2m/s
14.	1.4m/s	1.1m/s	1.5m/s	1.0m/s	1.2m/s
15.	1.4m/s	1.3m/s	1.6m/s	1.0m/s	1.2m/s
16.	1.3m/s	1.4m/s	1.5m/s	1.0m/s	1.2m/s
17.	1.2m/s	1.4m/s	1.5m/s	0.9m/s	1.1m/s
18.	1.3m/s	1.5m/s	1.5m/s	0.8m/s	1.1m/s
19.	1.5m/s	1.5m/s	1.6m/s	0.8m/s	1.0m/s
20.	1.4m/s	1.4m/s	1.7m/s	0.7m/s	1.0m/s

Table 5. Wind Velocity Records at Talshari with Digital Anemometer

Height – 1.5 mt & 2.0 mt from local surface

Recorded on September 2005 (04.09.2005)

Frequency of records	Time slots of wind velocity records							
	10.05 am.		10.15 am.		11.25 am.		11.35 am.	
	Height at 1.5 m	Height at 2.0 m	Height at 1.5 m	Height at 2.0 m	Height at 1.5 m	Height at 2.0 m	Height at 1.5 m	Height at 2.0 m
1.	3.2	2.2	2.5	2.3	3.2	3.2	2.4	3.8
2.	3.1	2.3	2.4	2.4	3.3	3.0	2.2	3.9
3.	3.2	2.3	2.3	2.3	3.9	3.0	2.0	4.0
4.	3.2	2.4	2.3	2.2	3.2	2.5	2.0	4.1
5.	3.2	2.4	2.4	1.9	3.8	3.0	2.7	4.3
6.	3.0	2.4	2.5	2.1	3.9	3.3	2.8	4.3
7.	3.0	2.3	2.4	1.9	3.7	3.2	2.8	4.0

Table 5. Wind Velocity Records at Talshari with Digital Anemometer *(contd...)*

Height – 1.5 mt & 2.0 mt from local surface

Recorded on
September 2005 (04.09.2005)

Frequency of records	Time slots of wind velocity records							
	10.05 am.		10.15 am.		11.25 am.		11.35 am.	
	Height at 1.5 m	Height at 2.0 m	Height at 1.5 m	Height at 2.0 m	Height at 1.5 m	Height at 2.0 m	Height at 1.5 m	Height at 2.0 m
8.	3.0	2.4	2.4	2.0	4.0	3.1	2.7	4.9
9.	2.8	2.4	2.5	1.9	3.9	3.5	2.6	4.6
10.	2.9	2.5	2.4	2.0	3.7	3.6	2.5	4.4
11.	2.9	2.4	2.3	2.1	3.6	3.9	2.5	4.0
12.	3.1	2.3	2.4	2.0	3.5	3.6	2.5	3.9
13.	3.0	2.4	2.5	2.2	3.4	4.0	2.5	5.1
14.	3.5	2.4	2.3	2.1	3.4	4.0	2.5	4.9
15.	3.4	2.3	2.0	3.1	3.3	3.7	3.0	5.2
16.	3.4	2.2	2.3	2.7	3.6	3.8	3.0	5.4
17.	3.2	2.0	2.2	2.5	3.7	4.0	2.9	5.4
18.	3.1	2.1	2.2	2.4	3.5	4.3	2.7	5.1
19.	3.1	2.3	1.9	2.4	3.6	4.3	2.7	5.2
20.	3.0	2.2	1.9	2.5	3.6	4.5	2.7	5.9

TEMPARETURE PROFILE ACROSS THE SHORELINE AT SHANKARPUR

(To record the micro climatic parameters of the coastal zone)

Time : 4.40 pm. – 4.50 pm.

Recorded on
September 2005 (02.09.2005)

Shore zones	Temperature profiles	Temperature records
Shoreline	Sea Water temperature	31.7°C
	Air temperature at 1.6 m altitude	29.9°C
Lower beach face	Landward limit of swash marks	30.0°C
Upper beach face	Air temperature at 1.6 m altitude	29.7°C
	Surface temperature	29.7°C
	Sub-surface (5 cm.depth) temperature	31.7°C
	Sub-surface (10 cm depth) temperature	32.5°C
Fore-Dune ridge	Air temperature at 1.6 m altitude	31.6°C
	Surface temperature	40.5°C
	Sub-surface (5 cm.depth) temperature	34.4°C
	Sub-surface (10 cm depth) temperature	35.2°C

TEMPARETURE PROFILE ACROSS THE SHORELINE AT JUNPUT

(To record the micro climatic parameters of the coastal zone)

Time : 10 am. – 11 am.

Recorded on
September 2005 (03.09.2005)

Shore zones	Temperature profiles	Temperature records
Shoreline	Sea Water temperature	29. 3°C
	Air temperature at 1.8m altitude	26.3°C
Lower beach face	Surface temperature	27.1°C
	Sub-surface (10 cm.depth) temperature	29.8°C
Upper beach face	Air temperature at 1.6m altitude	26.1°C
	Surface temperature	27.1°C
	Sub-surface (5 cm.depth) temperature	28.4°C
Beach ridge terrace (Under tree shades)	Air temperature at 1.6m altitude	26.6°C
	Surface temperature	26.6°C
	Sub-surface (10 cm depth) temperature	27.7°C

TEMPARETURE PROFILE ACROSS THE SHORELINE AT TALSARI

(To record the micro climatic parameters of the coastal zone)

Time : 9.40 am. – 10.00 am.

Recorded on
September 2005 (04.09.2005)

Shore zones	Temperature profiles	Temperature records
Shoreline	Sea Water temperature	36.3°C
	Air temperature at 1.8 m altitude	33.7°C
Lower beach face	Surface temperature	31.4°C
	Sub-surface (10 cm.depth) temperature	32.9°C
Upper beach face	Air temperature at 1.0 m altitude	30.6°C
	Surface temperature	32.8°C
	Sub-surface (5 cm.depth) temperature	34.1°C
	Sub-surface (10 cm.depth) temperature	35.7°C
Barrier Dune under tree shades	Air temperature at 1.0 m altitude	31.5°C
	Surface temperature	31.2°C
	Sub-surface (5 cm depth) temperature	29.5°C
	Sub-surface (10 cm depth) temperature	29.1°C
Back barrier salt marshes	Air temperature at 1.0 m altitude	31.8°C
	Surface temperature	33.4°C
	Sub-surface (5 cm.depth) temperature	34.1°C
	Sub-surface (10 cm.depth) temperature	34.3°C
Swampy surface	Water temperature	32.7°C
	Sub-surface (5 cm.depth) temperature	34.8°C
	Sub-surface (10 cm.depth) temperature	40.8°C

Wave Characters, monthly sea levels and beach profile forms :

Net erosion and accretion during seasonal high sea levels and during storms can be categorised with a scale of impact level by consideration of the magnitude of wave run up, the highest reach of the waves on the beach, relative to coastal elevation at different places. Beach-dune interaction is very complex both in mainland coast and barrier spit coast. The dune does not recover nearly as rapidly as the beach over weeks to months. The cross sections of coastal front positions are showing active dune retreat all along the sandy shores.

WAVE RECORDS AT TALSARI

Date : 04.09.2005 Time : 12.30 to 1.00 pm.

Wave Height	Wave Frequency	Wave Length	Swash Limit
1.50 m	7/ minute	15 m	42.5 m
1.50 m	8/ minute	20 m	32.5 m
1.60 m	5/ minute	15 m	35.0 m
1.30 m	6/ minute	05 m	30.0 m
1.20 m	6/ minute	08 m	41.7 m
0.80 m	6/ minute	10 m	42.5 m
1.19 m	8/ minute	10 m	30.0 m
1.32 m	6/ minute	10 m	32.5 m
1.17 m	7/ minute	25 m	30.0 m
1.52 m	6/ minute	20 m	25.0 m
1.18 m	6/ minute	30 m	30.0 m
1.60 m	5/ minute	05 m	35.0 m
1.70 m	6/ minute	10 m	32.5 m

Statement of monthly highest sea levels at Digha seacoast (River Research Institute)
Tide gauge station at Digha
(Height in meter)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1976	1.40	1.42	1.68	2.07	2.22	2.04	3.68	4.10	3.45	2.17	3.39	1.53
1980	1.51	1.91	2.19	2.14	1.01	2.03	3.65	3.51	3.38	3.39	1.55	1.69
1984	1.91	2.13	2.24	2.95	3.86	2.86	3.16	3.67	2.78	2.78	2.37	1.32
1989	2.74	2.42	2.32	2.22	2.32	2.52	2.56	2.37	2.56	2.97	2.68	3.10
1993	1.87	1.35	1.82	1.97	1.80	1.79	1.91	3.22	2.69	2.64	2.39	2.24
1996	2.64	2.45	2.59	2.69	2.62	1.94	4.21	5.36	2.54	4.86	2.79	2.44
1999	1.94	2.94	3.37	4.05	4.69	5.36	5.36	5.36	4.69	5.96	2.94	3.37
2002	2.96	2.96	3.95	4.52	4.99	4.75	5.54	5.51	4.75	3.95	3.47	3.25

Source : RRI, Digha

Statement of monthly lowest sea levels at Digha sea coast (River Research Institute)
Tide gauge station at Digha
(Height in meter)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1976	-1.98	-2.10	-2.60	-2.72	-2.24	-1.56	-1.86	-1.76	-1.76	-1.37	-2.88	-2.75
1980	-2.56	-2.63	-2.64	-2.47	-2.03	-2.06	-1.79	-1.90	-2.76	-1.90	-1.85	-1.90
1984	-1.86	-1.90	-1.97	-2.06	-1.86	-2.01	-1.33	-2.01	-2.10	-1.72	-1.95	-1.72
1989	-2.26	-2.30	-2.34	-2.34	-2.28	-2.31	-2.34	-0.01	-0.02	-1.48	-1.26	-1.66
1993	-2.06	-1.86	-1.88	-2.03	-1.78	-1.52	-1.91	-1.96	-0.33	-0.20	-3.59	-3.57
1996	-1.97	-2.01	-2.03	-1.98	-1.98	-1.96	-1.93	-2.05	-2.06	-2.06	-2.06	-1.64
1999	-1.92	-2.00	-0.02	-1.91	-1.46	-1.85	-2.01	-1.98	-2.08	-1.46	-1.39	-1.84
2002	-1.54	-2.10	-2.13	-2.14	-2.08	-1.74	-1.64	-2.22	-2.09	-1.72	-0.97	-1.44

Source : RRI, Digha

Talshari Barrier Beach (Monsoon Phase) 04.09.2005
(Beach profile form) Summer Beach

Station	Distance (in meter)	Back sight	Inter sight	Fore sight	CL	RL
A	0	2.21m			3.21m	1.00m
	10		1.80m			1.41m
	20		1.35m			1.86m
	30		1.43m			1.78m
	40		1.39m			1.82m
	50		0.54m			2.67m
	60		1.11m			2.10m
	70		1.58m			1.63m
	80		1.52m			1.69m
	90		1.49m			1.72 m
	100		1.51m			1.70m
	110		1.71m			1.50m
	120		1.84m			1.37m
	125		1.66m			1.55m
	130		1.84m			1.37m
	135		1.87m			1.34m
	140		1.87m			1.34m
	143		1.93m			1.28m
B	145			2.22m		0.99m

Dune cliff height from the local surface : 7.5m

Landward extension of the dune belt and extension of back barrier marsh and swamp

After 145m (Continued)

Dune/Marsh/Swamp	Width	Remark
Dune Row	30m	
Dune Flat	30m	
Dune Row	30m	
Dune Flat	30m	
Dune Flat	30m	
Dune Row	22+8m	
Dune Flat (Landward Limit)	21m	(Tree Line of Casuarinas)
Upper Marsh	9m	
Upper Marsh	30m	
Middle Marsh *(Salicornia)*	30m	(Zone of Tidal creeks)
Lower Marsh *(Salicornia / Portertia)*	30m	(Clayey flats with tide pools)
Swampy ground *(Acanthus)*	30m (Talshari Channel),	Depth of water column=1.30 meter

Findings : 1. Total Width of the beach: 145m
2. Height of the Beach fringed Fore dune Ridge: 8.40m
3. Beach gradient: 1 : 3.34 (Beach Face); 1 : 1.2 (on shore Face)
4. Tide amplitude: 3.67m
5. Tidal range: 2.67m
6. Marsh Height: 4.00m (Upper marsh)
7. Total width of dune field (Barrier Dune): 201m
8. Channel Bank Marsh: 99m

Beach Profile Form (Mandarbani) 11.02.2006

Time : 1 pm. (at Low Tide) Post Monsoon

Winter Profile

Station	Distance	Back sight	Inter sight	Fore sight	CL	RL
(A)	0 (Water Line)	3.95m			4.45m	0.50m
	10m		3.93m			0.52m
Rippled flat	20m		3.92m			0.53m
with bar	30m		3.92m			0.53m
	40m		3.91m			0.54m
	50m		3.80m			0.65m
	60m		3.90m			0.55m
Linear	70m		3.99m			0.46m
Tide Pool	80m		4.00m			0.45m
	90m		3.99m			0.46m

Beach Profile From (Mandarbani) 11.02.2006 *(contd...)*

Station	Distance	Back sight	Inter sight	Fore sight	CL	RL
Linear	100m		3.98m		4.45m	0.47m
Tide Pool	110m		3.85m			0.60m
	120m		3.75m			0.70m
	130m		3.62m			0.83m
	140m		3.50m			0.95m
	150m		3.40m			1.05m
	160m		3.09m			1.36m
Beach face	170m		2.71m			1.74m
	180m		2.51m			1.94m
	190m		2.11m			2.34m
	200m		1.84m			2.61m
	210m		2.15m			2.30m
	220m		1.97m			2.48m
	230m		1.82m			2.63m
	240m		1.74m			2.71m
	250m		1.67m			2.78m
	260m		1.58m			2.87m
	270m		1.46m			2.99m
	280m		1.35m			3.10m
	290m		1.22m		4.45m	3.23m
	300m		1.09m			3.36m
	310m		1.03m			3.42m
	320m		0.84m			3.61m
	330m		0.63m			3.82m
	340m		0.46m			3.99m
	350m					4.21m
	360m		1.32m			4.46m
	370m		1.14m			4.64m
(B)	380m	1.57m	0.94m	0.24m	5.78m	4.84m
	384m		0.63m			5.15m
	394m					5.45m
(C)				0.33m		

Dune Cliff 2.50m from the local Surface

Findings :

1. **Total Width of the Beach :** **394m**
2. **Height of the Beach fringed Foredune Ridge :** **7.95m**
3. **Beach gradient :** **1 : 7.70**
4. **Tidal amplitude :** **5.15m** (Summer Tide)
5. **Tidal range :** **4.65m** (Summer Range)
6. **Marsh Height (elevated by siltation) :** **4.5 to 5.2m**
7. **(Siltation Rate 8.33cm per year) :** **2.5m at 1969**

Representation of topographic form with RL values of the different Railway stations across the coastal plain of East Medinipore

Name of the Station	Distance from the nearest shoreline	RL values (Height from the m.s.l.)
1. Digha Railway Station	1.5 Km	7.40m
2. Tikra	5.0 Km	5.17m
3. Ramnagar	7.0 Km	**Ramnagar khal** (W=47.5m) 5.865m **Gubda khal** (W= 30.5m)
4. Badalpur	16.0 Km	3.920m **Pichabani khal** (W=20m)
5. Sujalpur	23.0 Km	4.65m
6. Sitalpur	25.0 Km	4.34m
7. Kanthi	32.0 Km	4.96m
8. Nachinda	42.0 Km	3.80m **Orissa coast canal** (W= 11.4m) **Kolbagda khal** (W= 14.7m) **Boroge khal** (W= 40.39m)
9. Heria	49.0 Km	4.42m
10. Deshpran	61.0 Km	4.32m **Suripur khal** (W= 18.4m)
11. Laban satyagrraha	73.0 Km	3.555m **Narghat khal** (W= 5.60m) **Haldi River** (W= 457 m)
12. Nandakumar	83.0 Km	3.875m
13. Tamluk	93.0 Km	5.86m

Post Monsoon Beach Profile Form (09.02.2006)
(New Digha Near Jatra Nullah)
Winter Beach

Station	Distance	Back sight	Inter sight	Fore sight	CL	RL
(A)	0	2.99m			3.49m	0.50m
	10m		2.69m			0.80m
	20m		2.49m			1.00m
	30m		2.40m			1.09m
	40m		2.26m			1.23m
	50m		2.50m			0.99m
	60m		1.88m			1.61m
	70m		1.64m			1.85m
	80m		1.52m			1.97m
	90m		1.43m			2.06m
	100m		1.49m			2.00m

Post Monsoon Beach Profile Form (09.02.2006) (New Digha Near Jatra Nullah) Winter Beach (contd.)

Station	Distance	Back sight	Inter sight	Fore sight	CL	RL
(A)	105m	2.99m	1.64m		3.49m	1.85m
	110m		1.50m			1.99m
	120m		1.22m			2.27m
	130m		0.90m			2.59m
	140m		0.60m			2.89m
	150m	(Laterite		0.21m	5.18m	3.28m
(B)		appron) 1.90m				
	160m		1.23m			3.95m
	170m			0.01m		5.17m
(C)						

Findings :

1. **Total Width of the Beach :** **149m**
2. **Height of the Beach fringed seawall :** **5.17m**
3. **Beach gradient :** **1:2.1** (2.1cm vertical fall per 1m horizontal distance)
4. **Tidal amplitude :** **2.89m**
5. **Tidal range :** **2.39m** (Winter tide)
6. **Marsh elevation behind the seawall :** **3.28m** (2.5m at 1969)
7. **Siltation Rate :** **2.11cm per year at the marsh**

Post Monsoon Beach Profile Form (09.02.2006)

(Digha East Near Gangadharpur) Winter Beach (At Rising Tide) (Time : 4.30 pm.)

Station	Distance	Back sight	Inter sight	Fore sight	CL	RL
(A)	0	3.00m			3.50m	0.50m
	10m		2.73m			0.77m
	20m		2.43m			1.07m
	30m		2.18m			1.32m
	40m		1.94m			1.56m
	50m		1.81m			1.69m
	60m		1.66m			1.84m
	70m		1.49m			2.01m
	80m		1.41m			2.09m
	90m		0.99m			2.51m
(B)	100m	1.18m		0.37m	4.31m	3.13m
	110m			0.66m		3.65m
(C)						

Dune Scarp=15.5m

Findings :

1. **Total Width of the Beach :** **110m-130m**
2. **Height of the Beach fringed for dune Ridge :** **3.65m + 15.5m = 19.5m**
3. **Beach gradient :** **1:3.3** (3.3cm vertical fall per 1m horizontal distance)
4. **Tidal amplitude :** **3.65m**
5. **Tidal range :** **3.15m** (Winter tide)
6. **Marsh elevation :** **3.65m** (2.5m at 1969)
7. **Siltation Rate :** **3.11cm per year at the marsh**

Post Monsoon Beach Profile Form (09.02.2006)
(Jamra-Shyampur) At Rising Tide
Winter Beach (Time : 11-15 am.)

Station	Distance	Back sight	Inter sight	Fore sight	CL	RL
(A)	0	2.69m			3.69m	1.00m
	10m		2.45m			1.24m
	20m		2.19m			1.50m
	30m		2.10m			1.59m
	40m		1.94m			1.75m
	50m		1.70m			1.99m
	60m		1.33m			2.36m
	70m		0.96m			2.73m
	80m		0.85m			2.84m
	90m (Remain of the Embankment =			0.26m		3.43m
(B)	1.5m					

Dune Scarp=8.5m

Findings :

1. **Total Width of the Beach :** **90m-100m**
2. **Height of the Beach fringed for dune Ridge :** **3.43m + 8.5m = 11.93m**
3. **Beach gradient :** **1:38** (38cm vertical fall per 1m horizontal distance)
4. **Tidal Amplitude :** **3.43m**
5. **Tidal range :** **2.43m**
6. **Marsh Height behind the dune belt :** **3.43m** (2.5m at 1969)
7. **Siltation Rate at the Marsh :** **2.51cm per year at the marsh**

Post Monsoon Beach Profile Form (10.02.2006)
(Shankarpur)
Winter Beach

Station	Distance	Back sight	Inter sight	Fore sight	CL	RL
(A)	0	4.00m			4.50m	0.50m
	10m		3.72m			0.78m
	20m		3.49m			1.01m
	30m		3.25m			1.25m
	40m		3.04m			1.46m
	50m		2.85m			1.65m
	60m		2.67m			1.83m
	70m		2.43m			2.07m
	80m		2.15m			2.35m
	90m		1.92m			2.58m

Post Monsoon Beach Profile Form (10.02.2006)

(Shankarpur) Winter Beach (contd.)

Station	Distance	Back sight	Inter sight	Fore sight	CL	RL
(A)	100m	4.00m	1.795m		4.50m	2.705m
	110m		1.67m			2.83m
	120m		1.62m			2.88m
	130m		1.26m			3.24m
	140m		0.82m			3.68m
	150m		0.37m			4.13m
(B)	160m			0.00m		4.50m

Findings :

1. **Total Width of the Beach section :** **160m**
2. **Total Amplitude of the tide level :** **3.68m**
3. **Tidal range across the beach :** **3.18m**
4. **Height of the Beach fringed for dune :** **4.50m + 13m = 17.50m**
5. **Beach gradient :** **1:25**
6. **Marsh Height behind the dune belt :** **4.13m to 4.50m**
7. **Siltation Rate (5.26cm per year) :** **2.5m at 1969**

Post Monsoon Beach Profile Form (10.02.2006)

(Chandpur-Jaldah) Winter Beach

Station	Distance	Back sight	Inter sight	Fore sight	CL	RL
(A)	0	3.22m			3.72m	0.50m
	10m		2.97m			0.75m
	20m		2.80m			0.92m
	30m		2.68m			1.04m
	40m		2.54m			1.18m
	50m		2.28m			1.44m
	60m		1.97m			1.75m
	70m		1.73m			1.99m
	80m		1.59m			2.13m
	90m		1.54m			2.18m
	100m		1.48m			2.24m
	110m		1.35m			2.37m
	120m		1.50m			2.22m
	130m		0.65m			3.07m
	140m		0.20m			3.52m
	145m			0.00m		3.72m
(B)						

Dune Scarp=8.52m

Findings :

1. **Total Width of the Beach :** **145m**
2. **Height of the Beach fringed for dune Ridge :** **3.72m + 8.52m = 12.24m**
3. **Beach gradient :** **1:22** (22cm vertical fall per 1m horizontal distance)
4. **Tidal Amplitude :** **3.72m**
5. **Tidal range :** **3.22m**
6. **Marsh Height (legated by siltation) :** **3.43m** (2.5m at 1969)
7. **Siltation Rate :** **2.21cm per year**

Beach Profile Form at Talshari Spit
Post Monsoon Phase Winter Beach (12.02.2006)

Station	Distance	Back sight	Inter sight	Fore sight	CL	RL
(A)	0	2.90m			3.40m	0.50m
	10m		2.56m			0.84m
	20m		2.26m			1.14m
	30m		1.95m			1.45m
	40m		1.67m			1.73m
	50m		1.44m			1.96m
	55m		1.83m			1.57m
	60m		2.09m			1.31m
	65m		2.01m			1.39m
	70m		1.71m			1.61m
	80m		1.25m			2.15m
	90m		0.94m			2.46m
	100m		0.52m			2.88m
	105m			0.14m		3.26m
(B)						

Dune Scarp=8.52m

Findings :

1. **Total Width of the Beach :** **135m to 140m**
2. **Height of the Beach fringed for dune Ridge :** **10.26m**
3. **Beach gradient :** **1:3.11** (3.11cm vertical fall per 1m horizontal distance)
4. **Tide Amplitude :** **3.26m**
5. **Tidal range :** **2.76m** (Winter tide)
6. **Marsh Height (legated by siltation) :** **3.26m** (2.5m at 1969), Middle marsh
7. **Siltation Rate :** **2.05cm per year**

Seasonal diversity of coastal villages :

The scenic beauty of coastal villages change with seasonal witness and dryness. Potential village sites are ready to welcome the visitors with seasonal diversity of landscape ecology, habitat types, tidal channels and rivers, local products, remaining wilderness and many other attractions. Only, the local infrastructuroal development and good travelling packages by different and good travelling packages by different tourism travel groups can provide the situation to attract the visitors in village sites for recreation and leisure. Following diversity of seasonal attractions can be categorised in coastal village of Hugli subarnarekha stuarine complex :

- **Summer season -** Local fruits (cashew nuts), Charping birds, flowering plants, charping of crickets
- **Rainy season -** Rice paddy fields, wetlands, available fishes, drizzles and frequent rains.
- **Autumn season -** Greenish paddy fields, kash flower, Lotus on the pools of water bodies, festive season.

- **Harvesting season -** Harvest period, diews on the grasses and leaves of plants, charming temperature, Moon-lit nights, Lily flowers on the ponds
- **Winter season -** Local festivals, cool temperature, clear skyes, Boating on the rivers and channels, sea bathing, perfect time for recreation, Bird watching
- **Spring season -** Flowers bloom on the trees, charping birds, Humming bees.

Environmental Management options :

Coastal zone is the product of interaction of the physical nature of the land and sea. Various physical processes of the land and sea participate in the dynamic nature of the coastal zone. Many parts of the coast are subjected to natural hazards ranging from erosion, flooding storm signature, saline water incursion, dune migration and seasonal inundation. However, the development has taken place in the vulnerable areas and developers seek coastal protection. As development increases, intensifies or extends into vulnerable areas the potential impact of hazards increases. People of Kanthi coastal plain and Subarnarekha delta plain suffer as they live and engaged in several activities in the vulnerable areas. Ecological value of the coastal zone is seriously affected by coastal development and protection works. Various protective measures against the natural physical processes of the rivers and sea, and possible effects of sea level rise may increase the risk potential for such conflicts. (Paul, 2002).

Successful land use planning of the coastal zones is dependent on the views and exchange of ideas between different researchers having backgrounds in earth sciences and knowledge in planning. Unfortunately, the communication gap between the two groups is reflected in the several planning activities in the coastal zones. The riviews of physical hazards and extraction of data on geological, geomorphological, hydrological, soil and bio-logical characters might be materials for planning considerations around the coastal region.

For the purpose of effective management the coastal zones should be treated as coastal Regulatory zones (CRZ) with regulating activities by formulating and administering legislation. The CRZ notifications should be followed with some minor corrections to restrict the unscientific activities at the coast. The wetlands behind the dune belt must need preservation for the shake of coastal erosion management and longivity of beach resorts all along the shoreline of Hugli-Subarnarekha complex at present.

The shore fringed dune belt is affected by 3 impact levels of potential hazard over the years with significant rise of waterlevels at south west monsoon, highest astronomical tides and cyclonic storms. As Net dune erosion takes place and net onshore transport of dune sediments modify the physical barrier after each impact level of collision Regime (by undermining the dune base), overwash Regime (by landward drift of dune crest sediment), and Indudation Regime (by flattening dune belt and reducing the relief of dune belt), the wetlands behind them come under direct threat from storm surge and tidal waves. Thus,

restoration of wetlands with restriction of wetland margin fish farms or bheri fishing development, excavetion of tidal inlets and channels, and with scientific afforestation programmes (3 tier forest of indigenous species) on the low elevation dune belt and restriction of shorefront development can stablize the changing shoreline with natural adjustment to the coastal processes in the long time.

Village tourism may develops at least 3 km. inland sites from the modern shoreline and tourists can visit the shoreline without staying on the water-front locations. The area under open shore environment with 3 km distance inland from the shoreline should come under restrictions and extensive afforestation programmes with long rooted grasses, crepers, scrubs and local trees to save the lowland alluvium coast.

Thus, tourism is perhaps one industry which could, if managed properly, be compatible with environmental sustainability. However, coastal sand dunes of Digha recreation site are heavily used and not managed properly and leading to the undermining of dune vegetations and blow-out formation with active soil degradation. Coastal zoning approach is now most ideal solution to coastal management of Purba Medinipur district between Hugli-Subarnarekha estuarine complex. Coastal zoning of the present area may be classified as : general use zone for economic, development and tourism application; habitat protection zone for conservation use; buffer zone for reduction of hazardous impact; nature park zone for beautification, conservation and shoreline stabilization of fragile environment; and no structure zone or subzone for natural change response at the coast.

Managing the coast also involves monitoring changes and the handling of much information (Haslett, 2000). Remote sensing techniques and Geographic Information Systems can provide the comprehensive overviews of the long coasts for mapping and monitoring changes. NASA's coastal zone colour scanner (CZCS) may be interoduced to monitor the coasts of regional diversity. Thus, various powerful tools and field survey techniques are needed in managing coastal problems and in proper use of potential tourism sites of the coast.

Conclusion

Village tourism may be a good potential economic sector to reduce the unemployment problems at the coastal belt of Purba Medinipur and Balasore Districts along the shoreline of Bay of Bengal. Villages having sea front locations, river front locations, other water front or wetland margin locations and having diversity of landscape ecology are highly potential for tourism and recreational uses. Three main wetland landscapes can be identified at the low land coast: tidal flats, floodplains and coastal swamps. Common recreational activities are associated with both coastal and inland wetland environment. Clearly the most serious disturbances to the natural environment are the result of disruptive fixed accommodation, construction activities such as resort towns, camping ground and hotels and infrastructure provision in the form of major roads, railways, embankments or marinas.

Today, the sandy beaches and shoreline sand dunes are getting eroded due to increased magnitude of wave dash activities and tidal currents on the seafront

position. Human intervention in the coastal processes in the form of construction activities are also responsible for the erosion and shoreline displacements in the coastal belts. Certain management schemes are obviously needed for coasts that are under pressure of population growth, development, tourism and industrial pressure. The present authors are also in favour of setting up of Heritage Coasts in Purba Medinipur and Balasore districts for the management of unspoilt and scenic coastlines in between Subarnarekha-Hugli estuarine complex. The aim of heritage coasts may by successful if the quality of coastal scenery and village sites is controlled under conservation to foster leisure activities.

There are various management groups at the coastal districts to observe and manage the coastal problems. The coastal management groups consisting of Forest Department, Irrigation Department, Port Management Group (CPT and HDC), Fishery Department, Tourism Development Corporation, Zilla Parisad, District councils and Development Boards need proper delineation of group boundaries coincident with natural sub-environment systems boundaries at the coast for more holistic and fully integrated management possibilities. The coastal sectors under various management groups can provide oppertunities in promotion of eco-toursism in selective areas under coastal zoming approach. The present coastal belt of scenic beauty, heritage sites, natural channels and canals, marshes and swamps, sandy shorelines and seasonal diversity of coastal villages can provide dynamic attractions under proper management to support the leisured class people of Kolkata and other parts of South Bengal in coming future.

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NATURAL URBAN LAKE ECOLOGY OF AGARTALA, NORTH EAST INDIA

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Abstract

This paper assesses the present micro-environmental status urban natural lake of Agartala City. For this study the present authors selected College Lake which is now located in the middle part of the city and was known for its natural wild environment during early 1950s. The lakeshore ecology and aquatic ecology both were studied systematically for the analysis of present biodiversity status of the lake region. Slope of the lakeshore and plant coverage was analysed by the average of the measurement of number of plants / 25 sq m (*Plant Coverage*) on the selected profiles. It has been attributed though the study that over the 50-55 years the ecology of the lake area degraded due to human interventions. Still this area is very rich in natural and ecological resources, which is very rarely found in an urban area. In the conclusive part the present authors suggest some planning for the sustainable development of the natural lake environment.

Key words : *Urban Lake, Slope, Plant Coverage, Ecology, Biodiversity, Agartala City*

Introduction

Agartala (23°51'longitude & 21°02' latitude), the capital city of Tripura (Fig-1) is considered as one the most ecologically rich city in India. Geomorphologically this city in located in a part of Haora river basin (Nandi, 1974, 1977) and consists of two main geomorphic units namely, (a) tillas or dissected highlands and (b) adjacent plain land of Haora river basin. Tilla lands are relatively high lands and covered by dense vegetation. This unit is formed by estuarine brown clay sand, silty clay, white to gray sandrock with silt band and white clay depositions which are known as "Dupi Tilla Group" (Dutta, 1974). On the other hand the plain land is very flat with some natural lakes. This is created by early erosion and further alluvium deposition by Haora river during late Quaternary period. The natural lakes are formed in the depressions or low lands of the river basin (Dey, 2004).

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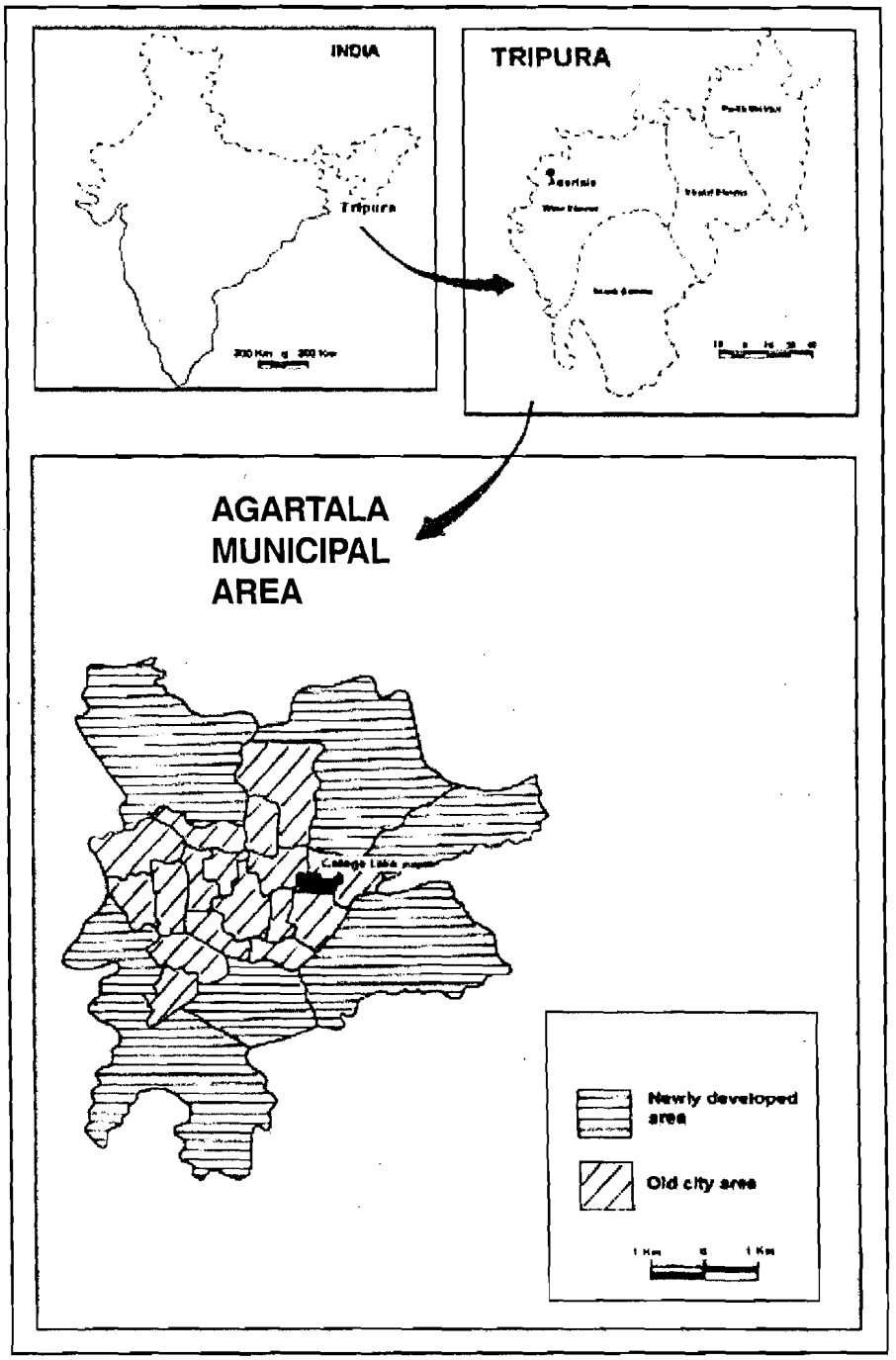

Figure 1 : Location of the study area

It has been observed that over the last 50-55 years the urban morphology of Agartala has been changed and that causes remarkable environmental degradation. Considering the physical and ecological importance, we decided to perform a study on the microenvironmental status of College Lake of Agartala, which was known for its wild environment during early 50s of the last century. This natural lake is located along the R.Haora surrounded by tilla land (College tilla). The main objectives of the study are, (a) to identify the actual environmental condition of this lake, (b) to identify the changing nature of ecology of the lake area and (c) to assess the human intervention and its impact upon the natural environment of the lake areas.

Methodology

Prior to visiting the field area, the present authors surveyed the existing literature such as reports of Geological survey of India, Urban planning division, Settlement Office, Publicity office, Department of Environment of Government of Tripura etc and recent research papers published in different journals and presented in different seminars, congresses etc to prepare a complete fieldwork programme.

Historical literatures often preserve some valuable evidences of physical environmental change as historical events are influenced by environmental conditions. To assess the early environmental change through historical period the present authors used some existing relevant historical records of this area available from different literatures.

During the planning for fieldwork the present authors faced problem of lack availability of authentic data. For the environmental study of any area, the physical and ecological history are very important but the relevant literature have often been very simplified considering the past changes this area and impact of social events. Thus we planned to depend on primary data/ field observation for the assessment of the present microenvironmental status of the natural lake.

The fieldwork was conducted from the January 2004 to May 2006. Different techniques have been applied and instrumental survey works (simple dumpy level and clinometer etc) have been done during fieldwork to find out the geomorphologic evolution of this area. The aims of the field work were- i) to observe natural environmental conditions of the lake area and ii) to detect the impact of human interventions upon the lake area environment. Angle of slopes of different parts of lakeshore areas were measured by clinometer and dumpy level. Pattern and characters of natural vegetation were studied systematically for the assessment of slope and vegetation relationship. Plant coverage and plant base on the different parts of the lakeshore were measured on the basis of the height of the vegetation. These are measured by the following methods:

a) Plant coverage = Number of plants / 25 sq metre

b) Plant base area = Horizontal extension of roots of the plant

Besides that different animal species of both lakeshore area and water were identified during the fieldwork.

Geomorphic and ecological data collected through field investigation during various seasons have interpreted and used for preparing various maps and statistical testing by computer software in the laboratory of the Environmental Geomorphology and Geohazard Research Unit, Department of Geography and Disaster Management, Tripura University. Some antic maps and literature were consulted along with field data for
detection of environmental changes over the last 100 years. Geological and geomorphological map (Scale-1:50000), Current landaus map (Scale - 32˝ =1 mile) published by the Settlement office.(1996), SOI toposheet (Scales: 1:63360 of 1968-'69) etc were also consulted for the preparation of final maps.

Results

Lakeshore morphology: The lakeshore morphology is very undulating. Lakeshore slopes are found from high to low angle. The width of the lakeshore varies from 8m to 45 m, which is actually narrow to medium. This part is covered by different types of vegetation, which play vital role for the stability of the slopes. Near the water mainly grasses are observed. Most of the tall trees are found on the middle parts of the lakeshore. Presently the human interventions are changing the morphology of the lakeshore that also effects the change of plant coverage of this area. The main characters of the lakeshore are as follows:

Micro-level slopes and plant coverage on the lakeshore: During the fieldwork it has been observed that the micro-level angles of lakeshore influence the distribution of plant and "*plant coverage*" on the land. Examination of field data by sophisticated software also strongly supports that medium to high angle slopes are covered by dense tall trees while low angle slopes are covered by small to medium plants. It has also been observed that on the low to medium size slopes vegetation cover is lower. Table-2 and Fig-2-a shows the relationship between plant coverage and micro-level slopes.

From the table-2 it has been observed that most compact *plant coverage* zone is found on 10° to 25° angles on the middle parts of the slopes. Maximum plant coverage found on 20° to 25° angles. With the increase of the angle by more than 30°, the plant coverage has a general tendency to decrease. On the low angle the plant coverage is very low. These parts are mainly covered by high percentage (85 % to 95 %) of small grasses.

Plant coverage analysis according to the height of the plants: Small plants (<1m height, mainly wild bushes, herbs and shrubs) are found on every parts of the lakeshore. The field data interpretation shows that medium types of slopes are suitable for this type of plant growth (Fig-2-b). Maximum plant coverage of this type has been found on 10° slope angle during the field survey. The "*base area*" of this type of coverage decreases with the increase of the angle of the micro-level slopes.

Medium plants (1m to 5 m high trees) normally develop on medium to high angle slopes. High level of plant density has been observed between 20° to 32° angle of micro-level slopes in the study area (Fig-2-c). A general tendency of

Plate 1 : View of College Lake Agartala

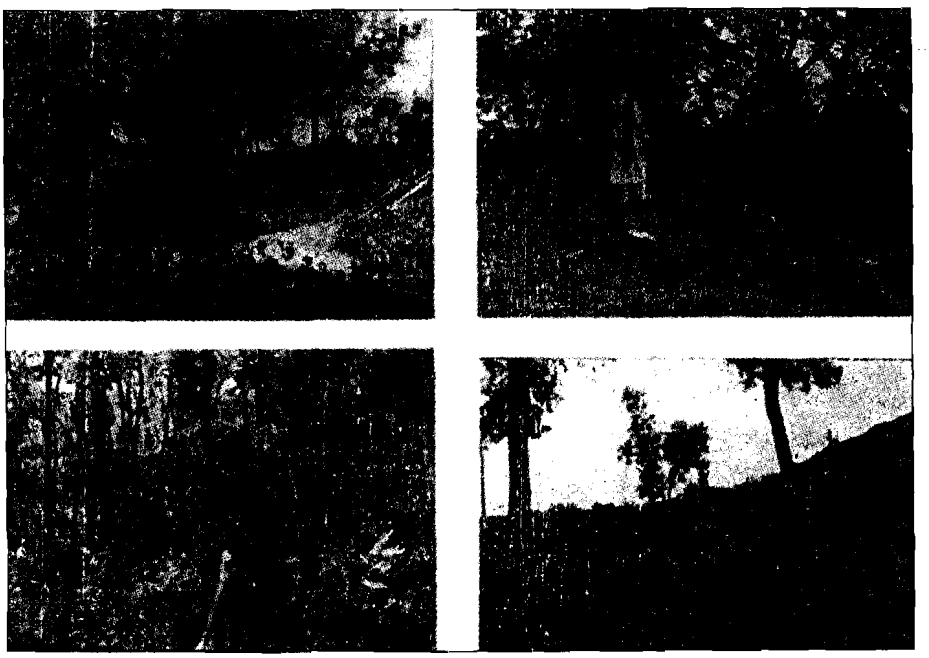

Plate 2 : Slopes and plant coverage on lakeshore

Table 1 : General Morphology of Lake Shore

Properties	Type	Characters
Shape of lake shore	Uneven	This shoreline of the lake always bends at high angles.
Slope of lake shore	High angled slopes	Very steep slopes with 15°-25° angle. These are actually the slope of College tilla.
Vegetation domination	Medium angled slopes	Normally 14° to 8° angle. These are also the slope of College tilla.
	Low angled slopes	< 8° slope. Some of the slopes are very flat and < 3° angle.
	< 1m height	Mainly grasses and bushes are found on the lower and upper parts of the steep slopes. The flat slopes are dominated by grasses.
	1m to 5m height	This type of vegetation is found in the middle and lower-middle parts of the steep slopes. Some big bushes are also found on the medium and flat slopes.
	>5 m height	Most of the tall trees are found on the medium and steep slopes. Some isolated tall trees are also found on the flat slopes.
Human utilisation	Domestic	Cleaning and washing, bathing
	Recreational	Swimming, fishing and hunting
	Social	Religious purpose, water supply
	Commercial	Fishing

Source : Field investigation

Table 2 : Micro-level slopes of the lakeshore and plant coverage relationship

Location	Distance between the stations (IN METER)	Angle of the Slope		Plant domination according to height / 25 m²			Plant coverage / 25 sq m
		Bottom	Top	1m (in number)	1-5m (in number)	>5m (in number)	
Tilla Bottom	0-5	32	24	8	13	0	21
Tilla Slope	5-10	24	16	6	0	2	8
	10-15	16	12	13	1	3	17
	15-20	12	9	15	5	2	22
	20-25	9	14	25	6	2	33
	25-30	14	20	15	0	6	21
Tilla top	30-35	20	6	17	9	4	30

Source : Field data generation

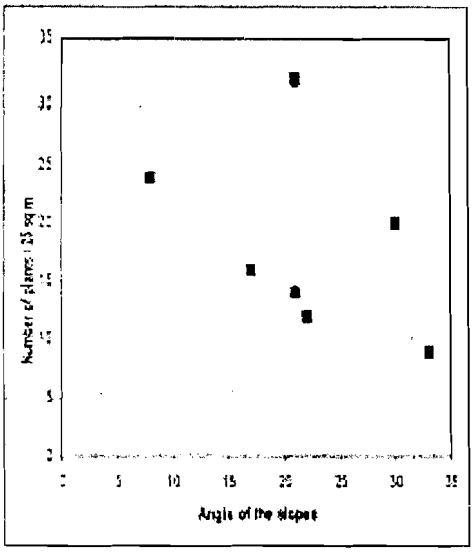

Figure 2-a :
Slope-plant coverage relationship

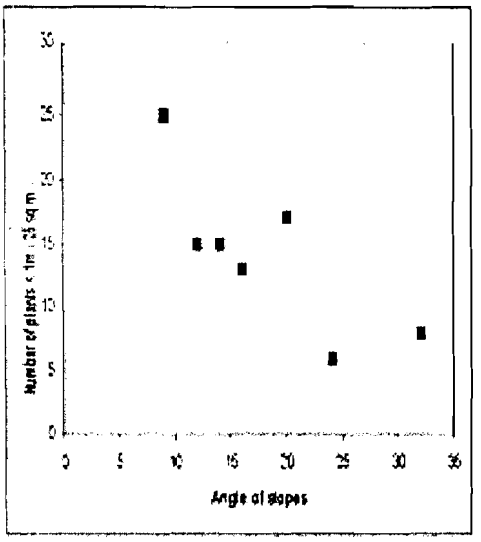

Figure 2-b :
Slope-plant coverage (<1m) relationship

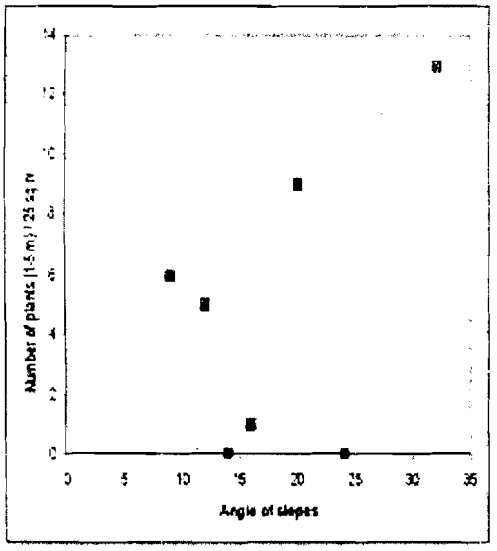

Figure 2-c :
Slope-plant coverage (1m-5m) relationship

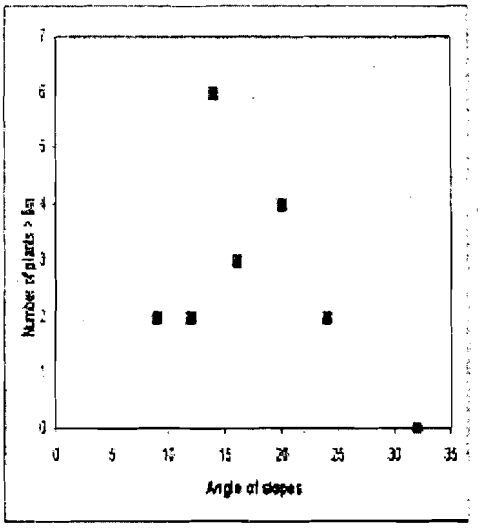

Figure 2-d :
Slope-plant coverage (>5m) relationship

decrease of plant coverage is found with the decrease of slopes. The base area varies from 0.5 m to 1m, which increases with the decrease of slope angle.

Tall trees, more than 5 metre heights are found on the medium slopes. On the medium slopes, between 10° to 25° angle, very dense growth of trees are observed (Fig-2-d). Here the base areas are 0.5 to 1.5 meter. With the increase of the slopes the plant coverage decreases. The base areas also decrease on the higher slopes. On the tilla top where slope angles are less, the tall trees are

found isolated. On the upper shore, where slope angle is low to medium, plant coverage is less than lower-middle parts of the shore and sometimes they are found isolated.

Bathymetry of the lake: The bathymetry of the lake shows that the lake is 1.88 m deep in the middle part. Maximum depth is 2.04m and minimum depth is 0.2 metres. The average depth of the profile WSW-ENE is 1.46 m. Maximum average depth 1.73 m found on the profile SE-NW. The average depth of the profile N-S is 1.50.

Animals and Birds of the lakeshore: The lakeshore is very riche in different types of animals, birds, reptiles and amphibians. The most dominant mammal species are Indian fox (*Canis bengalensis*- Khank Seeal), Jackal (*Aureusi*- Seeal), Otter (*Lutra lutra)*, Musk shrew *(Crocidura Caerulea)* and Flying fox (*Pteropus Medius)*. Total seven reptilian species are found on the lakeshore, which are Well Lizard (*Hemidactylus flaviviridies)*, Gecko (*Gekko gecko)*, Garden Lizard (*Calotes yersicolor)*, Scincidae *(Mabuya carinata)*, Monitor Lizard (*Varanus monitor)*, Cobra *(Naja sp)* and Krait *(Bungarus*- Shakhamuti). During the field study only two amphibian species are found on the lakeshore area which are Frog (*Rana Cyanophlyctis) and* Tree frog *(Bufo malanostic-tus).*

This area is still marked by several bird species. During the fieldwork the present authors identified 18 dominant or main species around the lake. They are Red vented Bulbul (*Pycnonotus cafer)*, Red – Whiskered Bulbul (*Jocosus)*, King Crow (*Dicrurus adsimilis)*, Common house Mynah (*Acredotheris tristis*- Shalik*)*, House Sparrow *(Passer domesticus)*, Indian Tree Pie *(Dendrocitta vagabunda)*, Common Babbler *(Turdoides caudatus)*, Green Bulbul (*Aurifrons)*, Magpie Robin (*Saularis*-Doyel), Tailor Bird *(Orthotomus Sutorius)*, Jungle Mynah (*Acredotheres fuscus)*, Hill Mynah or Gracle *(Gracula religiosa)*, b=Blackheaded oriole (*Oriolus xanthornus)*, Baya Weaver *(Ploceus philippinus)*, Brown Fish Owl *(Ketupa bubo Zeylenesis)*, Scops Owl (*Scops Giri*) and Spotted Owlet (*Athena brama*).

Aquatic Ecology: The study shows that College Lake water is very rich in macrophytic vegetation. Total four types of vegetations according to their character and origin have benn identified, namely: Amphibious, Floating, Submerged and Emergent. Main amphibious macrophytics are Bindi Mutha (*Fimbristylis dichotoma*), Halkalmi (*Ipomoea hederifolia)*, Jhil marich (*Polygonum barbatum)*, Jalmutha (*Cyperus iria)*, Kanchira (*Commelina peludosa)*, Sola Kachu (*Colocasia sp)*, Halencha *(Enhydra fluctuans)*, Ban Kachu (*Colocasia sp)*, Kesur *(Eleocharis dulcis)*, Mutha (*Cyperus rotundus)* etc. Floting macrophytics are Kachuri pana (*Eichhomia crassipes)*, Kalmi (*Ipomea aquatica)*, Khudi pana (*Lemna perpusila)* and Pani Phal (*Trapa natans*). Submerged species are Saluk (*Nymphaea micrantha)*, Panchuti (*Nymphoides hydrophylia)*. The only emergent species observed in this lake is Jhajhi (*Hydrilla verticiliata).*

This lake is also very rich in phytoplankton and zoo plankton species. The main phytoplankton species are *Zygnema sp., Oedogoniun sp.,ulothrix sp.,Spirulina sp., Oscillatoria sp., Microcystis sp., Merisinopedia sp., Staurostium*

sp., Chlorella sp., Scenedesmus sp., Ankistiodesmus sp., Navicula sp., Spirogyra sp., Eudorina sp., Synedra sp., Closteriun sp., and zooplankton species are *Brachionus sp., Mycis sp., Cyclops sp., Keratella sp., Copepoda , Daphnia sp.*

College Lake is marked by different types of fish species which make this lake economically attractive. Both culturable and wild types of fishes are found in this lake. The culturable fishes are: Catla *(Catla catla)*, Rohu (*Labeo rohita)*, Mrigel (*Cirrhinus mrigala)*, Bata *(Labeo bata)*, Kalbos *(Labeo calbasu)*, Silver Carp *(Hypothalmicthyes molithrix)*, Grass Carp *(Ctenopharyngodon idelea)*, American Rui *(Aristichthysnobills nobills)*, Galda and Chingri (*Macrobrachium rosenbergii).*

This lake is dominated by wild fish species like Punti *(Barbus ticto)*, Tangra *(Mystus sp.)*, Sol *(Channa striatius)*, Gajar *(Channa marulius)*, Lata *(Channa punctatua)*, Magur *(Clarias batrachus)*, Singhi *(Heteroneustes fossilis)*, Chapilas (*Gudusia chapra)*, Kucho *(Amphipnous cucutia) and* Chanda *(Chanda name).*

This lake is especially known for huge number of aquatic bird species. Throughout the year some residential birds are found in this lake, they are Pond Heron (*Ardeoloa grayii*), Common Kingfisher (*Alcedo atthis*-Sporadic), Whitebreasted Kingfisher (*Amauromis phoonicurus* and *Halcyn smyrensis*-Sporadic), Little Pied Kingfisher *(Ceryle rudis)*, and Cormorant *(Phalacrocorax niger)*. Besides that some migratory birds also visit this lake during the winter. They are Dubchick (*Podiceps ruficollis)*, Grey Heron *(Ardia cinerea)* and Cotton teal (*Nettapus coromandelianus).*

We also found that the college lake is also very rich in other types of life forms. Some reptiles, amphibians, and benthic fauna also identified during the fieldwork. Among the reptillan species very Checkered Keel (*Xenochrophis piscator*-back water snake) and *Enhydris enhydris* are very rarely found. Among the amphibian fauna two species has been recorded in the list. In the lake common Toad (*Bufo melanostictus)* and Indian Buli Frog (*Rana tigrena)* was once very common but now they are very rare. This lake is also very rich in benthic fauna. The main species are Gastopoda, Crustacea, Polychaete, Chiromid and Bivalvia.

Result & Discussion

Plant coverage zones of the lakeshore: The plant coverage analysis shows that there is a clear relationship between micro-level slopes and plant coverage. On the basis of the study the lake shore area can be distinguished in to two "*plant coverage zones*": High coverage zone and low coverage zone. The high coverage zone is marked by 10° to 25° micro-level slopes that are found on the lower-middle part of lakeshore. Maximum high trees are concentrated in this zones and this part is mostly rich in green cover. The low coverage zones occur on two types of micro-angle, less than 10° slopes and more that 25°. Small to medium plants with some isolated tall trees (>5m height) is found in this zone. This zone covers the upper and bottom parts of the lakeshore.

Present status of biodiversity: Records say that only 100 years ago these tilla lands were dominated by different wild animals like tiger, leopard, wolf, elephant etc. It has been recorded that upto 1952 the wild elephants were very common

at the surrounds of College Lake. Now only very few foxes, squirrel, flying foxes etc are found. Only 50 years back Monitor Lizards (Gosap), Otter (Ud or Pani Kutta) etc were also very common near the lake and the adjacent tillas, but now they are very rare. Among the snakes only few Cobras and Kraits (Shakhamuti) are found in this area. So it is clear that ecological change occurs in this place during recent years. Still the lakeshore ecology is very rich with 18 types of bird species, 7 types of reptile species, 5 types of mammal species and 2 types of amphibian species (Fig-3-a).

The aquatic ecology of the present study area is also very remarkable (Fig-3-c). In this lake 11 types of macrophytic amphibious vegetation observed. These are the dominant vegetation of College Lake. Besides those 4 types of floating, 2 types of submerged and 1 emergent type macrophytic species are found (Fig-3-b).

Total 22 plankton species are identified in this lake among which 16 are phytoplankton species and 6 are zooplanktons. In this lake a remarkable amount of fish fauna species have been observed. Out of the 19 fish fauna species 9 are culturable and 10 are wild species. It is also remarkable that recently 10 wild fish species like Sol, Lata, Chanda, Tangra, Punti, Gajar, Magur, Singhi, Chapilas and Kucho have become rare which were very common only 25 years ago.

Total 9 aquatic bird species are observed through the field investigations among which three are migratory species, which are observed during post monsoon season. Some species are now very rare in this area which area Whitebreasted Kingfisher, Little Pied Kingfisher and Cormorant. Though decreasing, still some reptilian species (2), amphibian species (2) and benthos (5) are found in this lake.

Human intervention and present ecological problems: Human interventions on College Lake area started from the 40s of the last century when the MBB College contraction started. From that time human settlements started to develop on the adjacent tilla area and the lake became very important source of water supply. Fishing in the lake water also became very popular since it played as a main economic source of the surrounding refugee colonies during the 50s and the 60s. Now this lake is used several ways for the satisfaction of the local habitants. The main uses of the lakes are:

Domestic use of lake water: Some domestic use of lake water has been observed which play a vital role for the degradation of the ecology of the lake. They are as follows:

- Local people use this lake for bathing.
- Cleaning of utensils are also very common in this lake
- Washing of clothes and other materials are found
- Cleaning of cars, motor cycles, scoters etc.

Social use of lake water: It has been observed that the lake also plays a vital

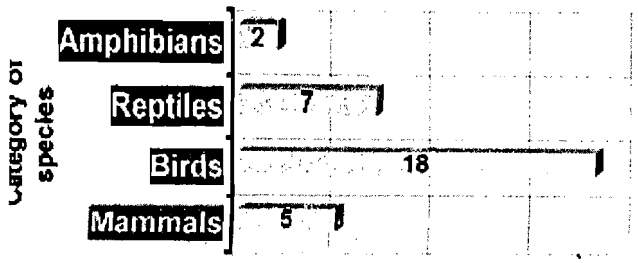

Figure 3-a : Biodiversity status of the shore region of College Lake

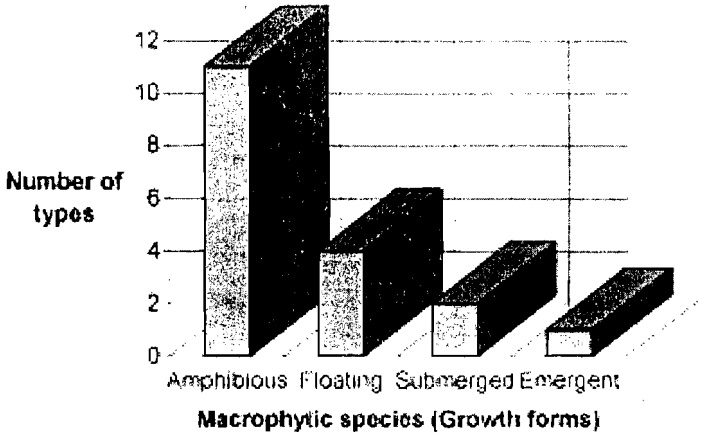

Figure 3-b : Macrophitic vegetations of College Lake

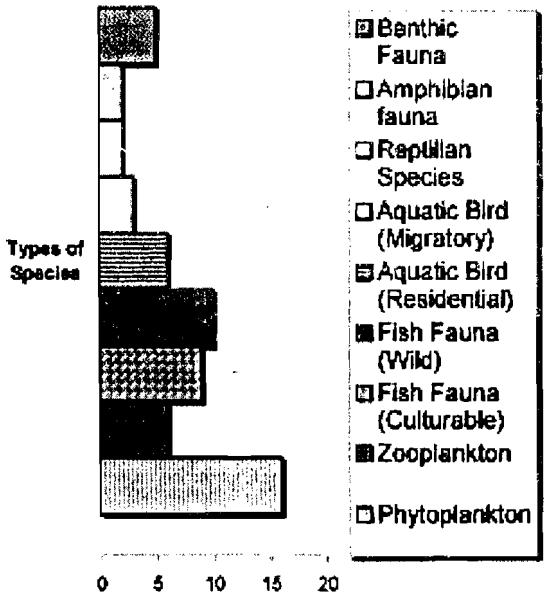

Figure 3-c : Aquatic biodiversity status of College Lake

role for the culture of the local people of this area. The social uses of the lake are as follows:

- Lake water is pumped regularly for fire brigade.
- During the summer season the deficiency of water in the College tilla area is managed by lake water.
- Lake water is used for the religious purpose at and around College Tilla.
- Walls are constructed along the lake shore.

Recreational use: The recreational uses of the lake are also very important for the ecology of the lake area. These are as follows:

- Fishing and fishing competitions
- Boating in the lake. (presently it is stopped)
- Swimming competitions and swimming training.
- Picnic on the lake shore. (Presently this is rarely found.)
- Hunting and catching of birds, though presently it is not seen very often.

Commercial uses: Though little has been used for commercial purpose, but the increasing rate of commercial use of the lake cannot be ignored from ecological and environmental point of view. The main uses are as follows:

- Cleaning of cars, tracks, buses etc.
- Culture of fishes and catching of fishes.

Over the last 20-25 years it has been seen that with the growth of settlements the pressure on the lake is increasing. The human activities on the lake are now creating problems for the natural environmental condition and the ecology as well. The main environmental problems detected through the study by the present authors are:

I. The construction of building and walls on the adjacent tilla and lake shore are causes the loss on many plant species and degrading the plant succession of the lake area.
II. Water of the lake collected desperately, which creates problem for the aquatic environment.
III. Washing of clothes, cleaning of utensils and other domestic materials cause the mixing of detergents with the lake water. This is one of the main causes for the increase of the pollutants in the lake water.
IV. Cleaning of cars and other vehicles is another factor for increasing of pollutants in the lake area.
V. Swimming, bathing and recreational fishing etc not only create pollution problems, but also these activities are creating problems for the normal aquatic ecological growth by disturbances.

Conclusion

The entire ecology of College Lake falls within a very fragile environment. It is very evident that the natural environmental conditions of College Lake Basin have been degraded during the last 50 to 55 years. From the early 1950s human interventions played a vital role in changing the environmental conditions of this area since the college tilla was selected for constriction of MBB College

and family quarters of the college teachers and employs. As a result of that the forest area started to decrease and the natural environment of the lake area deteriorated. Under these circumstances this is the high time to save the natural environment of the lake to develop of the environment of Agartala town. From this stand point human interventions should be minimized at and around the lake area and no further construction should be allowed within 200m of the lakeshore. Hunting of birds and illegal fishing should be stopped and at the same time cleaning and washing should be minimized to control the pollution in the lake. Finally the target should be development of natural Aquatic Park in the lake, which will also attract the people.

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IRRATIONAL RESOURCE EXTRACTION INTRODUCING INSTABILITY IN SLOPE AND HYDRODYNAMICS –A case Study at Lish-Chunkhola Basin, Darjeeling.

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Abstract

Mining and environmental degradation is intricately related through a complex of interacting physical and anthropogenic processes. An attempt for proper cognition into the inter working of physical processes of environment and that into the subsequent effect of mining to break such systematic interactions, is made taking a case study at Lish-Chunkhola area of Darjeeling Himalaya. The geomorphic imbalance mainly through increased slope failure and soil erosion induced by mining in such a tectonically sensitive zone affects the hydro-dynamics of the Lish river through increased siltation at foot hill region, raising of bed levels, development of shoals, bars, constriction of channel, increased magnitude of meandering and thus offers increased potentiality to flood.

Key words : *Mining, Degradation, Slope instability, Soil erosion, Siltation, Flood.*

Introduction

Availability of good quality resources in abundance and their rational uses through scientific extraction can ensure the development and sustenance of a society through harnessing optimum utility from resources and can thus offer stability to environment by helping to maintain systematic interaction among the different components of it. Since the initiation of commercial coal mining from hill slope exposures at the Lish-Chunkhola area, the environment has increasingly been loosing its resilience through increased slope failure, soil erosion and resultant siltation as no care has been taken to restore slope and soil stability. The crude dissection of hill slope, down slope displacement of over burden, removal of surface cover etc. help in slope failure and increased soil erosion. The dislodged materials, in turn, are washed down slope and are carried along the channel ultimately affecting the hydrodynamics by supplying increased sediment load whose volume being too large to be managed by the streams with the available energy on gentle foot-hill slope and thus initiating deposition within channel bed which further attracts deposits to be accumulated in the form of bars and shoals causing secondary hydrologic meandering of channels and in extreme cases channel bifurcation and braiding. The irrational anthropogenic action causing sediment generation at the upper catchments and subsequent siltation at the lower sink zone causes significant effects on

geomorphic processes and thus hazard initiates (Korup et. al. 2004 and Remaodo et. al. 2005). Stocking (1983) considered environmental degradation as a result of breaking the systematic interaction among existing physical, economic and social processes through irrational interaction of man with land. In the mountain catchments most of the channel avulsions are made by landslides at their sources and along valley side slope helping in lengthening by head ward erosion and broadening by valley slope retreat. (Korup 2004; Basu and Ghatowar, 1986; Basu and Ghosh, 1993). The proper understanding into the source to sink sediment transfer processes helps in environmental engineering and hazard mitigation (Anthony & Julian, 1999).

The Study Area

The study area is located at the Kalimpong C.D. Block-1 at the southern boundary of district Darjeeling within the latitudinal coverage of 26°55'30" N to 26°56' N and longitudinal coverage of 88°32'10" E to 88°32'44" E covering mostly the Southern fringe of mountain Himalaya and Terai region (Fig. 1). The mining and associated destruction to hill slope is mainly restricted to the left bank of the Lish, 10 km. north of Bagrakot and at the Chunkhola basin, the left hand tributary of the Lish immediately just above its journey to foot hill.

The mining affected Lish valley side stretches between the altitude range of 700 – 300 m. The base of this valley side, being dissected and punctured for the extraction of coal, is steeper than the upslope section due to constant down channel removal of dissected overburden materials during high discharge period. The channel gradient along Chunkhola is much (1:2.5) and so the loose & friable materials originating from weathering and mining are readily drained down to the Lish bed. The valley side slope of the Chunkhola is also steeper indicating its natural potentiality to slope and soil instability.

The study area is geologically composed of Damuda Series of rocks consisting of shale, carbonaceous shale and sand stone being intercalated with coal seams. (Fig. 1B) Being sandwiched between Main Boundary Fault to the south and Dalling thrust to the north, all those rock beds are naturally crashed and unconsolidated due to extreme tectonics being assisted by deep seated mechanical & chemical weathering. Entire slope is seen to be covered with loose and unconsolidated debris. Due to the presence of carbonaceous shale and crashed coal, the cohesion of the rocks, debris or soil is considerably less. Almost entire of the chunkhola basin and the mining affected valley side of the Lish are thus naturally prone to slope failure & soil erosion.

The Resource :

Coal – Its Quality : Due to tectonic disturbances the coal seams are not continuously exposed on the surface with same width for a long distance. The dip and strike of the coal seams and their physical and chemical properties vary due to variation in the intensity and duration of tectonics and according to distance from igneous intrusion. The degree of thermal alteration of the coal depends on the distance from the source of heat as well as intensity of heating.

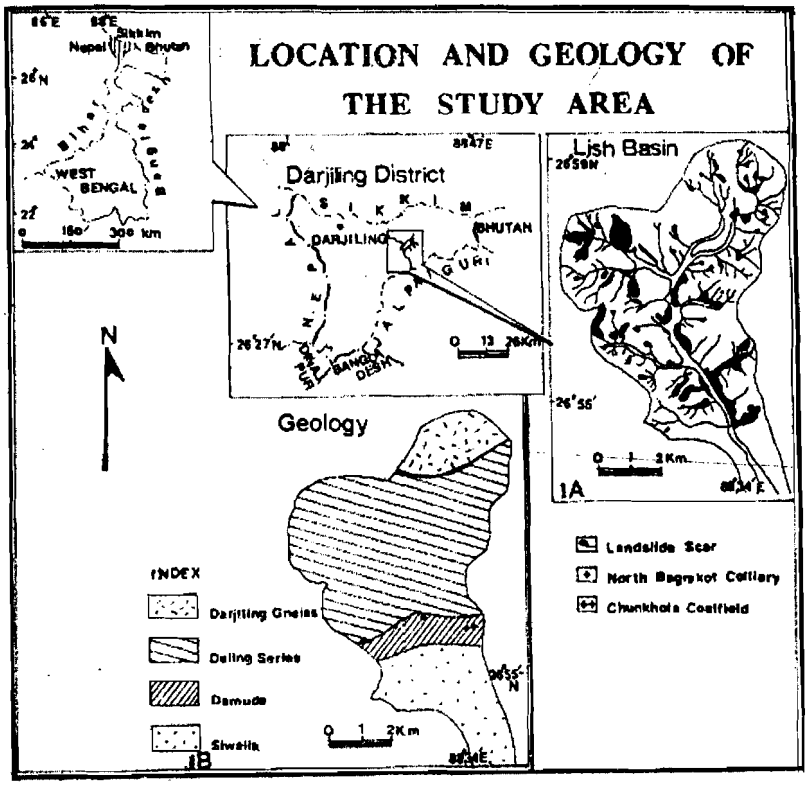

Figure 1. Location and Geology of the Study Area

The chemical analysis (Kar, 1978) of coal samples collected at an interval of 5 cm away from igneous contact is given in table 1.

In extreme cases, due to thermal alteration, the coal is turned into natural coke (Jhama) with distinct columnar joint and vesicular structure.

The other type of coal, most commonly found in Darjeeling, is highly fractured, flaky, slickensided and powdery in nature with bright luster. This disturbed coal has low volatile and hydrogen content and the rank attained is generally high (Semi-anthracitic). This disturbance is due mainly to the tectonic events

Table 1. Showing the composition of thermally altered coal

Sl. No.	Distance from the contact	Moisture (%)	Volatile Matter (%)	Ash (%)	Fixed Carbon %
1.	At the contact	1.10	1.00	20.10	77.80
2.	5 cm away from the contact	2.08	3.07	19.85	75.00
3.	10 cm away from the contact	2.80	4.97	18.70	73.54
4.	15 cm away from the contact	3.21	6.72	18.85	71.22
5.	20 cm away from the contact	3.82	7.60	18.47	70.11

Source : Records of the G.S.I. (Bose, P. N. 1989–90)

related to the post Permian upliftment of Himalaya and the result is seen in the crashing of rocks mainly shale & coal.

The third and most uncommon type of coal found mainly at the central portion of Damuda width, away from thrust contact, characterized by the presence of distinct band of vitrain (bright) and durain (dull). This coal registers lower rank, i.e. ortho lignitous to orthobituminous. Fig.-2 shows the relation between carbon and hydrozen content of the above three types of coal collected from Pankhabari, Bagrakote and Kalijhora.

Table 2. Composition of Darjeeling Coal (Non-thermally metamorphosed)

Sample No.	Moisture (%)	Volatile Matter (%)	Ash (%)	Fixed Carbon %
I	2.52	3.42	25.74	68.32
II	3.20	12.28	22.18	62.36
III	14.40	8.86	12.64	63.96
IV	3.00	12.16	12.12	72.60
V	4.21	14.09	19.14	62.56
VI	2.30	7.76	31.12	58.82
VII	2.05	4.54	32.00	61.41
VIII	0.70	10.40	21.10	68.80

Source : Records of the G.S.I. (Bose, P. N. 1989–90)

Note :	Sample No.	Location	Source
	I	Right bank of Tista, north of 17.5 mile stone on Siliguri – Kalimpong Rd.	Bose, P.N. (1889 – 90)
	II	Right bank of the Churonthi	Bose, P. N. (1981)
	III	Lish Valley	Bose, P. N. (1889 – 90)
	IV	Junction of Kalijhora & The Tista	Bose, P. N. (1891)
	V	Churonthi Valley	Bose, P. N. (1889 – 90)
	VI	Tindharia	Bose, P. N. (1889 – 90)
	VII	Manzing Khola	Ghosh, T. K. (1986)
	VIII	Right Bank of Ramthi River	Ghosh, T. K. (1985)

Coal; Its Quantity : From the point of overall nature of the distribution of coal with its irregularity in exposure and variation in the width, it is difficult to have an estimation of the total reserve of the coal in this area. Besides, quantity of the coal, mined already by the earlier private collieries is not known.

Mr. P. N. Bose, the then Deputy Superintendent of Geological Survey of India did much to establish the economic importance of coal. Through a detailed survey in the Lish and Ramthi valleys he has explored that 5.5 million tones of almost immediately available good quality coal belonging to class A (<16% ash) and class B (16% - 22% ash) from an area of not more than 97 acres i.e. about three twenteeth of a square mile can be mined (Bose 1889 – 1890) (Table 3). If the 'C' type coal (% of ash>22%) is considered the amount will be nearly 10 million tones. For whole of the explored area between Lish and Ramthi of nearly

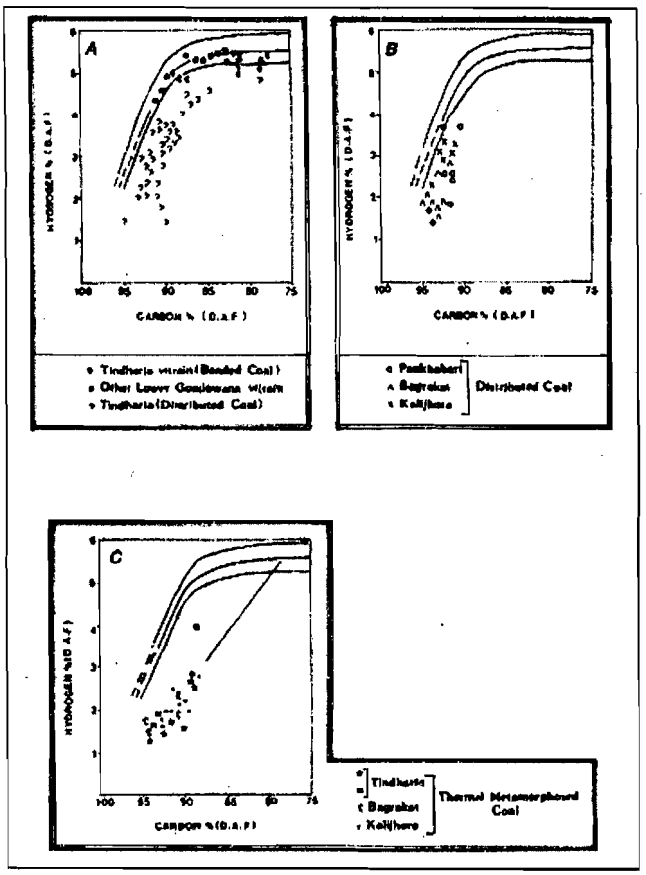

Figure 2. Relationship between Carbon & Hydrogen contents of Darjiling Coal

1.56 km, the estimated amount would be 20 million tons. All these estimation are based on the workable depth limit at 300 m. where as, in Europe there are coal mines of more than this depth in rocks quite as highly disturbed as those are dealt with. For the facility of calculation a uniform average dip of 45^0 for all the coals seams has been assumed.

From the overall nature of the distribution of the coal exposure it can be estimated that at least one million ton of coal will be available up to a depth of 50 meters from Ramthi area only. In course of mining and further investigation information may be unfolded regarding the continuity of the seams and the figure of coal reserve in that case may increase (Ghosh, 1985). So it can be inferred that the total coal deposits of this area can go for a huge amount.

Coal mining at Darjeeling – Its history & processes

In spite of the limited reserve, limited extension and tectonic disturbance, the extraction of Darjeeling coal seemed to have significant value specially for the

economy of North Bengal due to the remoteness of other collieries of Raniganj and Jharia. The history of coal mining at Darjeeling started in the year 1896, when a Calcutta Based farm has established their mining site at 10 km north of Bagrakot Railway station and extracted 7231 tons of coal during 1896 – 1900 (Banerjee et. al. 1980). The coal beds, exposed along the valley side, were crudely dug out and in this process a significant amount of deforestation was made.

Table 3. The availability of the coal from different seams, Ramthi-Lish Area, Darjiling

Coal seam at Ramthi-Lish Area	Available quantity of coal in tons
1	746,592
5	186,648
5a	349,965
5b	279,972
6-7	519,214
8-10	509,040
11-12	328,755
13-15	1903,809
16	106,050
17	395,354
18	267,246
TOTAL	5592,645

Source : Records of the G.S.I. (Bose, P. N. 1989–90)

In 1943 Mr. M. K. Roy established M/s. Himalayan coal and Mineral Industries Pvt. Ltd at Chunkhola basin after obtaining a lease for 30 years for coal extraction. Without preparing large scale detailed geological map, the miners were in a hurry to collect coal in a crude method with traditional accessories like Kodalis, pickaxe and shovel etc. The nearly vertical coal seams, exposed on valley wall, were too weak to permit easy timbering or could not be used for pillar due to its crashed nature and so, a major part of the overhanging rock wall had to back cut to attain a stable slope (Jain, 1975). To obtain a few tonnes of coal the entire slope has been dissected eventually leading to the formation of innumerable gullies being facilitated by the land slips. Mining operations had been stopped in 1964–65 following litigation and competition from good quality coal of Jharia and Raniganj. One, when visiting the Lish – Chunkhola would be surprised to observe the vicious cycle of soil erosion and land slips which have been in progress since the abandonment of quarry operations.

Discussion

The North Bagrakot coal mining site (Fig. 3) shows a deserted and dissected look as it is left without any erosion and slide resisting treatment (Plate 1). A slump of nearly 875m. length and the width of 175m. occurred along the left

bank of the river Lish. The surface and subsurface excavation due to removal of coal from the base of the slope after extensive deforestation have triggered the slumping. The disintegrated materials at the base of left bank were also washed down by the flowing flood water and thus the slumping has been continued. The two tier topography has developed at the crest of the scar and the flat portions of the slumped landform are extensively used for pasturing by the local villagers of Chunabhati. This exposure to pasturing is detrimental to the growth of vegetation for stabilizing the already dislodged materials. The extended surveillance reveals the continuous growth of the slumping area. Another crescent shaped scar has developed beyond the slump zone (Fig- 3). It covers almost 0.185 sq. km. area. The basal scour below the crescent scar is remarkably less because of the accumulation of the slided materials from this scar. To avoid the deposits the river takes a sinuous bend causing the opposite concave bank more prone to erosion (Fig – 3). The basal stability further down slope has continuously been disturbed by the erosion of Lish and excavation as well as removal of coal. Although the commercial mining in these areas had been ceased during 1964 – 65, the slope failure is still continuing as the quarries were left without any protective measures. Some times local people, in a search of coal disturb the slided materials and keep the destruction alive (Plate2, 3, 4) affecting the stability and so, more and more materials thrown downward to the river bed causing the constriction of the channel (Ref A-B section, Fig – 3C) as well as rising of channel.

The mining and associated dissection of slope at the upper catchment supplies huge waste to run down the steep gradient during rain and is ultimately contributed to the bed load of the Lish (Plate – 1). The numerous gullies and disastrous slips in the Chunkhola basin involving loose, friable and cohesion less Gondwana sandstone and shale also discharge additional material into the parent river Lish and these make it incapacitated particularly in its lower reach. The excess load forces the stream to leave the material with in the channel favouring the formation and gradual growth of shoals and bars and thus the easy flow of water is hindered.

The technical committee to the State Flood Control Board, West Bengal after their field inspection of Lish-Ramthi area during 4-5th April, 1957, reported that the Lish River bed in the plain is rising at the rate of 1.5 feet (45.7 cm) per year. The old road bridge on the Lish river is nearly covered by riverine debris and present bridges have already been raised several times and even then the hazards are not yet over. A new site for the construction of bridges, some 3 km downstream is to be investigated (Jain, 1975).

The cross sectional area thus decreases and being incapable of arresting the usual monsoonal discharge, encourages the water to spill over the flood plain. The pillars of the road and railway bridge near Bagrakot provided temporary shelter to the big boulders and uprooted trees transported from upper reach during monsoon and thus arresting the flood water, invites the flash flood at its lower reach and the damage of the bridges themselves. During the devastating flood of 1954, two parts of Lish road bridge had been damaged while the arches

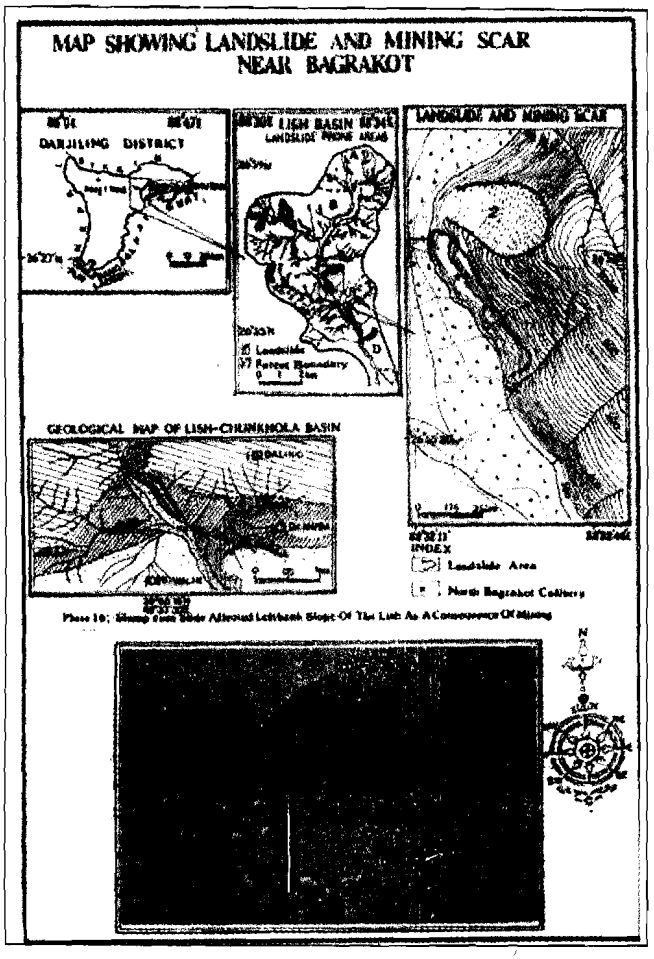

Figure 3 & Plate 1. Map showing Landslide and Mining Scar near Bagrakot

of the bridge had almost been filled up with debris (Dutta, 1955). The numerous landslides and accompanied unprecedented of flood in the Tista and the Lish basin as a consequence of incessant downpour of 809 mm in 3 days (3rd – 5th October, 1968) partially destroyed the Lish road and rail bridges as well as the settlement and tea gardens of Bagrakot and Washabari (Fig.-4). The flood of September, 1983 caused considerable damage to the crops cultivated on the flood plain around the confluence of the Lish river to the Tista (Basu and Ghosh, 1993). In the first week of July, 2002 during the onset of monsoonal rain, a larger portion of N.H.31 has been washed away by a flash flood in the Lish near Odlabari. The hydro-dynamics of the Lish is thus brought under the vicious cycle of siltation, reduction in gradient, incapacitating the stream and further aggradations.

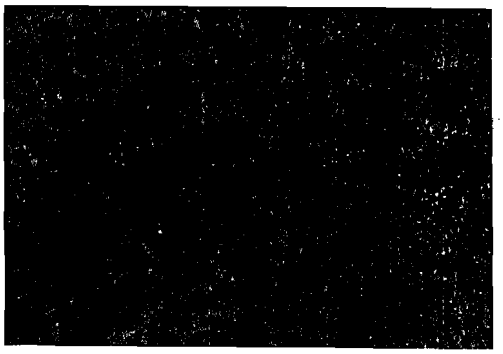

Plate 2. Coal bed being exposed along bank of the Lish(15th Feb. 2000)

Plate 3. Excavation of the exposed coal beds (25th Oct. 2000)

Plate 4. Mining Scar at the Chunkhola Basin

Conclusion

Any anthropogenic impact that is introduced in this terrain upsets the critical conditions of stability of the hill-slopes which, in turn, produces and supplies additional load and thus the river initiates aggradations along the channel being incapacitated. A condition of instability is introduced into the whole system of interaction between morphologic and hydrologic factors. The location specific resource such as coal is considered as a gift from nature but here, in the concerned area it is turned to be the curse as the local persons were seldom benefited from the mining because the workforce for this purpose was brought from Bihar and Orissa and the extracted coal was distributed to different destinations by company vehicles and then by railway. Thus the locals never got any opportunity of getting employed to make income out of this extraction. Moreover, they have to suffer from the adverse effects of deforestation, soil erosion, landslide and resultant siltation and flood. A systematic study of all the sediment source zones with particular reference to the mechanism of slide and soil erosion in relation to the tectonic parameters of slope stability can help in the formulation of site specific erosion or slip treatment plan. The stabilisation of slide scar, economic and lighter engineering structure for in

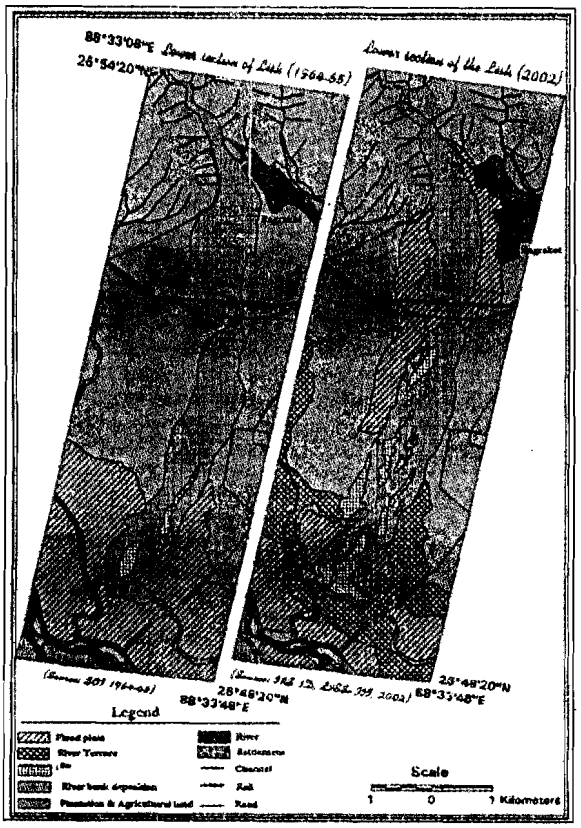

Figure 4. Showing the gradual change in the hydrodynamics at Lower Section of the Lish

situ arrest of dislodged materials through out the basin can relieve the river Lish from the excess load and rising of bed. The river which continuously tries to get adjusted to the dynamic condition may be expected to cut its valley further down into the present deposits as some energy may be available due to reduction of its load and thus a partial removal of the deposits may be possible further down into receiving stream, the Tista. Any sudden stop of sediment supply into such a meandering stream may invite another hazard of bank erosion in its concave portion in the process of adjustment through incision with available excess energy. The Tista, may also suffer from additional load by receiving removed sediment from the Lish. A proper planning of gradual reduction of sediment load may allow the stream sufficient time to get adjusted to the new situation leading ultimately to the balanced hydrodynamic conditions.

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SPATIAL AND STRUCTURAL PATTERN OF URBAN POPULATION AND ITS SOCIAL AND ECONOMIC ATTRIBUTES IN HARYANA, 2001

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Abstract

The paper makes an attempt to analyses the spatial and structural pattern of urban population and its social and economic attributes. Wide regional disparities in urbanization and social and economic development have been observed in Haryana. Urbanisation level has been ascertained on the basis of composite index of some selected indicators. Disparities in the human development have been obtained with the help of human development index (HDI) prepared by UNDP. The index is calculated on the basis of eighteen different indicators of quality of life. The analysis is presented with the help of choropleth maps and tables, which clearly depict east-west divide in the state. Eastern Haryana is more developed than the western parts because of the combination of factors like infrastructure development, proximity to national and state capital and government policies. Fortunately, about 20 percent of the geographical area of the state is under NCR (National Capital Region). Many of the districts including Faridabad, Gurgaon, Rewari, Jhajjar, Rohtak, Sonipat and Panipat are benefited being part of NCR. Presently, three major patterns can be identified in urban Hayana. One, that NCR part of the state is relatively more urbanized than non - NCR areas. Likewise, esastern Haryana is more urbanized than the western part. Thirdly, Haryana has two major urban concentrations encircling the national and state capital. Among them Punchkula, Ambala and Yamunanagar are in the northeast and Panipat, Sonipat, Rohtak, Jhajjar Rewari, Gurgaon and Faridabad in the southeast. The composite HDI of eighteen indicators also endorse the same trends in quality of urban life.

Key words : *UNDP, HDI, NCR, Urbanization*

Introduction

Urbanisation is a global phenomenon with its firm roots in the developed countries of the world. As a continuing spatial process, it is now taking an affluent and steady pace in the developing countries (United Nation, 1982). In the fifties, urbanization was regarded as the concomitant of industrialization and development (Kuznets, 1955) Urban development in India is accepted as a trend of socio-economic development at large. The rapid growth of large urban centers and stagnation or even declining tendency of small towns has been observed as the most obvious trend (Jha. 2006). The process of urbanization in the city population has intensified the aggravation of urban problems throughout the country (Majumdar, 2006; Sinha, 1980). Sharma (2002) analyses the

characteristics of urban population in western Himalaya and found wide regional variations in terms of distribution of urban population and its socio-economic attributes.

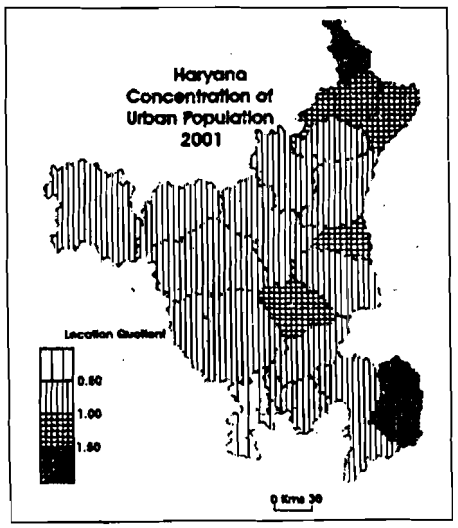
Methodology

The paper is largely based on the Census of India 2001 reports pertaining to Haryana namely Household Tables, Primary Census Abstract, General Population Tables and Statistical Abstract of Haryana, 2005. Location quotient of the distribution of urban population, rural population served by each center and spacing of towns is obtained to assess the spatial pattern of urban development. Composite index of urban development is worked out by using the methodology suggested by United Nation Development Programme (1997). The processed data is presented with choropleth maps and tables.

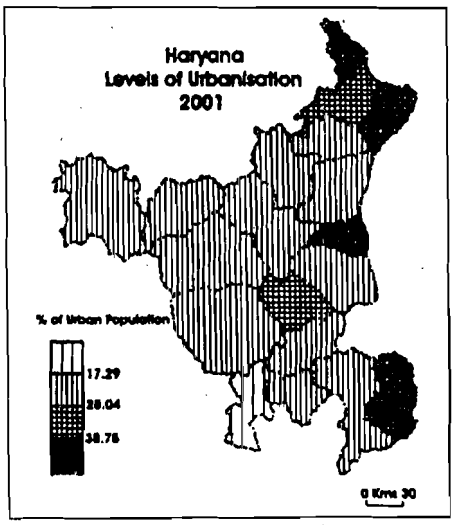
Spatial Patterns of Urban Population:

Concentration of urban population exhibits two trends. It is more in eastern Haryana and the surrounding districts of national (New Delhi) and state (Chandigarh) capitals. Proximity to these capital cities and high accessibility along NH1, NH.2, NH8 and NH10, which offer best facilities for industrial and commercial activities, encouraged migrants. Map1 depict high concentration of population in industrial centers of Faridabad, Panipat, Yamunanagar, Ambala and Gurgaon. Western part is the least industrialized mainly because of low accessibility and poor agriculture and hence concentration of urban population is also low.

As per 2001 census, 28.92 % of the population in Haryana is living in urban areas. Faridabad is the only district where more than half of the population



Map 1



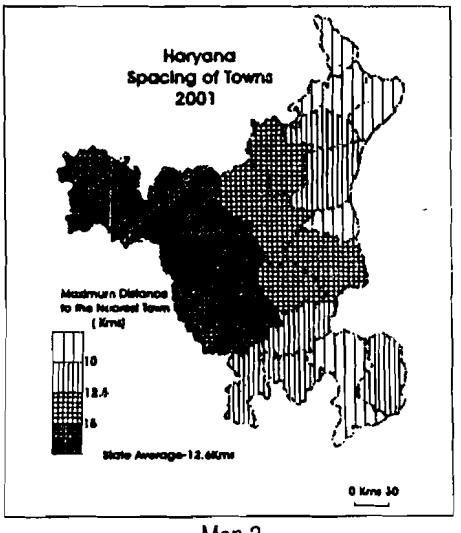
Map 2

inhabits urban areas. Industrial city, Faridabd alone housed more than half of the total district population. Punchkula, Ambala Yamunanagar, Panipat and Rohtak the other high-urbanized districts. These are either industrial centers or administrative center (Punchkula) and are located near to national and state capitals. Mahindergarh, Rewari, Bhiwani and Fatehabad are the least urbanized with less than 20 % of urban population. Map2 clearly shows the impact of industrial development and proximity to the national and state capitals. Thirdly, high soil fertility and availability of fresh ground water for irrigation have increased the agriculture productivity in eastern parts. Many agro-based towns *(mandi towns)*, which are service centers for surrounding villages, have developed in this belt.

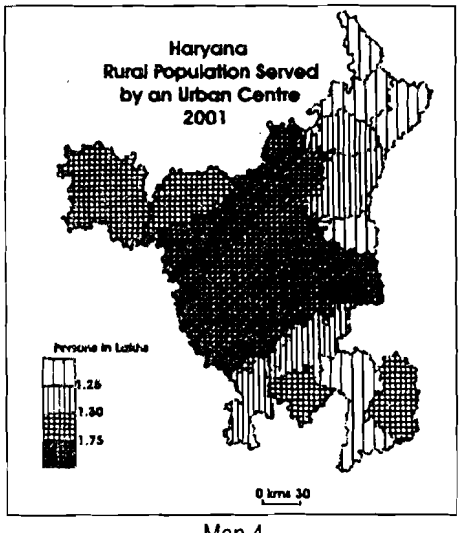
One prime function of the urban centers is to provide services to its surrounding lower order settlements. Rural settlements served by an urban center are inversely related to the level of urbanization. Larger the rural population served by each center low is the level of urbanization. Central and western districts including Hisar, Bhiwani, Jind, Rohtak, Fatehabad, Kaithal and Sonipat served largest number of rural population (Map3). Sirsa, Faridabad and Rewari are other such districts. Faridabad and Rohatak seems to be an exception here because these districts have small number of towns.

Spacing of towns refer to the maximum distance from the nearest urban center. Literally, it means how apart different urban centers are located to each other's. Larger distance between urban centers indicates low level of urbanization and vice versa. Large districts of western Haryana including Hisar, Bhiwani, Sirsa and Fatehabad exhibit maximum spacing between urban settlements. Central district reflect moderate spacing. Least spacing is observed in eastern areas (Map4).

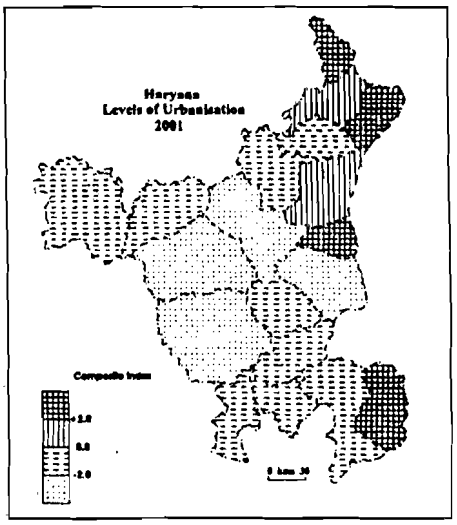
There are different ways to measure level of urbanization. Comparative ranks



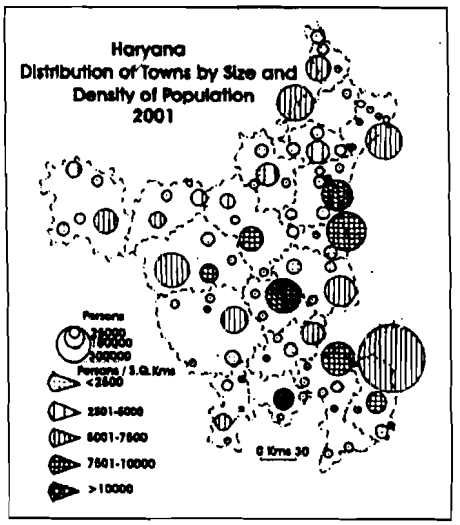
Map 3



Map 4



Map 5



Map 6

of districts change with respect to different indicators therefore it becomes difficult to assess the level of urbanization. Composite score (Z-Score) of the most commonly used indicators like percent of urban population, area served by an urban center and spacing of towns are worked out. The map5 exhibits the high level of urbanization in eastern parts along the NH1 and NH2. Secondly, they are either the industrial centers or the administrative centers. Moreover, proximity to the state and national capitals is another advantage. The western parts lacked all these advantages and hence experienced low urbanization.

Structural Patterns

Haryana has more than hundred towns of various sizes. Faridabad is the largest urban center with a population of over one million. Apart from this the state has 18 class-1 cities. Most of these are district headquarters. Out of the 19 districts as much as 17 have class-1 towns as their headquarter. Only three district headquarters are class-II towns namely, Jhajjar, Narnaul and Fatehabad. Map 6 shows that larger towns / cities are more prevalent in eastern part of the state as compare to the western. Density of population is also high in large urban centers The towns which have larger share of population of old part of the city such as Rohtak Karnal and Rewari are very densely populated. Small urban centers of less than 20,000 populations are thinly populated with average density of about 1600 persons per sq. kms. Population density exhibits positive relationship with the land values, which are generally high in large urban centers.

Proportion of urban population in different class towns is very skewed in favour of class-I cities. Twenty percent of urban centers (class I cities) provide shelter to 72.56 % of the total urban population of the state. Proportion of urban population in class II towns is equal to its share in number of towns.

But in medium and small towns their proportion in urban population is four to eight times less than their proportion in total number of towns (Table1). This is largely because class I towns are focal point of growth and development. Most of the infrastructure facilities are concentrated in large cities, which offer

Table 1. Haryana: Urban Structure, 2001

Sl. No.	Class	No.	% Of Total Towns	Population	% of Total Urban Population
1	Million City	1	1.03	1055938	17.27
2	I	18	18.56	3381357	55.29
3	II	6	6.19	353506	5.78
4	III	24	24.74	727404	11.89
5	IV	32	32.99	468628	7.66
6	V	15	15.46	124017	2.02
7	VI	1	1.03	4454	.0007
8	Haryana	97	100.00	6115304	100.00

avenues of jobs to many people and better quality of life. In contrast the small urban centers lacked all these basic infrastructure and look like overgrown villages.

Table 2 shows the progress in number of towns over the last one century. There is sharp increase in number of towns/cities in post independence period. Resettlement of refugees from West Pakistan was the major contributing factor for their growth during 1941-1961 phase. Impact of green revolution, emergence of Haryana as separate state and subsequent formation of new districts and creation of new district headquarters led to the growth of class I towns. Ambala became the first class I city of the state in 1961. Number of class I cities increased to 11 in 1981 and further to 20 in 2001. Most of these are district headquarters. Increase of large towns is sharper than the number of medium towns. Surprisingly numbers of small towns have declined. This situation is the outcome of poor infrastructure in small towns as compare to large cities. Migration from small to large urban centers is the main cause of this trend.

There were 106 towns/cities in Haryana in 2001. Many of these towns are developed as agglomeration such as Ambala cantt. and Ambala city,

Table 2. Haryana: Number of Towns, 1901-2001

Class/Years	1901	1921	1941	1961	1981	1991	2001
Class-I	-	-	-	1	11	12	20
Class-II	1	1	1	8	4	9	7
Class-III	6	8	11	9	13	17	26
Class-IV	9	8	7	14	23	30	36
Class-V	18	13	21	14	21	20	16
Class-VI	5	8	3	12	2	2	1
Total	39	38	43	58	74	90	106

Yamunanagar and Jagadhari, Faridabad and Balabgarh, Panipat, Panipat Taraf Ansar, Panipat Taraf Makhdum Zadgan and Panipat Taraf Rajputana and Gurgaon and Sukrali and Sankhol and Bahadurgarh. If we consider these urban agglomerations as one urban unit than total urban centers reduced to 97. Faridabad is the largest and only million city in the state. There are 18 class I cities (If Ambala cantt. And Ambala city are treated as one urban agglomeration, otherwise 19) and 6 class II towns. The class III and IV are the largest in number with 24 and 32 respectively. There are 15 class V and only one class VI town. Largest numbers of towns are concentrated in Gurgaon (12), and Yamunanagar (11). (Table 3). Both these districts have large concentration of small towns. These are followed by Karnal (7), Ambala, Faridabad and Bhiwani (6 each). Rohtak district has the least number of towns (2). This is largely because of carving out of Jhajjar district from it during the last decade. All other districts have 4 to 5 towns each. Concentration of small towns (> 20,000 persons) is more in Gurgaon and Yamunanagar districts whereas medium towns (20-50,000 persons) are more in Karnal and Kurukshetra. Large towns (>50,000 persons) are mainly found in Sirsa, Fatehabad, Jhajjar and Hisar and Mahindergarh districts.

Growth of towns / U.A. is worked out for the period 1901to 1951, 1951-61, 1971-81, 1981-91, and 1991-2001. All the towns are grouped into three categories namely consistent growth, fluctuating growth and stagnating growth.

Table 3. Haryana: Number of Towns, Classwise 2001

District/Class of Towns	Million City	I	II	III	IV	V	VI	Total
Ambala	-	2	1	1	1	1	-	6
Panchkula	-	1	-	2	-	1	-	4
Yamunanagar	-	2			4	5		11
Kurukshetra	-	1		3				4
Kaithal	-	1		1	2			4
Karnal	-	1		3	3			7
Panipat	-	1		3	1	1		6
Sonipat	-	1		2	1			4
Rohtak	-	1			2			3
Jajjar	-	1		1	1	2		5
Faridabad	1	1		1	1	2		6
Gurgaon	-	1		1	9	1		12
Riwari	-	1			2		1	4
Mahindergarh	-		1	1	1	2		5
Bhiwani	-	1		1	4			6
Jind	-	1	1	1	2			5
Hissar	-	1	1	1	2			5
Fatehabad	-		2	1		1		4
Sirsa	-	1	1	3				5
Total	1	19	7	26	36	16	1	106

The towns/U.A., which experiences higher growth rate than the state average for four or more periods are considered as consistent growth, which shows higher growth for two to three periods are considered as fluctuating growth and those which shows higher growth rate than the state average for one or less number of periods are considered as stagnating growth. Growth trends reflect a tendency of consistent growth among the class 1 cities (Table 4). Four of these cities are located on the periphery of National Capital. Old cities of historical importance like Rohtak, Ambala and Karnal reveals stagnating growth because of their consistent negligence by the ruling class, otherwise, they are well placed to be developed as industrial centers. Most of the towns both large and small reveal stagnating growth largely owing to poor infrastructure facilities. This is truer about the small towns.

Table 4. Haryana: Growth Trends of Urban Centres, 1901-2001

	CLASS OF TOWNS						
Growth Trends / Class of Towns	**I**	**II**	**III**	**IV**	**V**	**VI**	**Total**
Consistent	5	1	-	-	-	-	6
Fluctuating	8	1	3		-	-	12
Stagnating	6	4	21	32	15	1	79
Total	19	6	24	32	15	1	97

There is significant difference in the growth of urban centers of eastern and western parts of the state. More than half the district headquarters of the eastern Haryana recorded higher decadal growth during 1991-2001 than the state average (50.87%). Comparatively, only one district headquarters namely, Sirsa experienced such distinction from the western parts. This is because it was the center of political power during this decade. Jhajjar, the newly created district recorded the highest growth (96%) followed by Punchkula and Panipat (87% each), and Faridabad (70%). Gurgaon, Sonipat, Kaithal, Yamunanagar and Kurukshetra are other districts, which experienced fairly high growth. Table 5 shows that high growth is experienced by industrial centers (Faridabad, Panipat, Sonipat and Yamunanagar) and administrative centers (Punchkula). Jhajjar and kaithal shows high growth because theses are newly created district headquarters therefore development activities like new administrative complexes encouraged growth. Rohtak, Ambala and Karnal remained in political shadow zone during the reference period, which is also reflected, in their poor growth.

Growth of National Capital Region (NCR) is high because of the special efforts of the center and its constituents state governments. Better infrastructure, favorable government policies, and proximity to Delhi, all favour speedy growth of NCR towns. Rohtak is the only exception. This is mainly because of political animosity, being center of opposition for long time that efforts were not made to develop it. Among the non-NCR districts Punckuala is the leading urban center with a growth of over 87 % during the last decade. Sirsa and Kaithal are

Table 5. Haryana: Decennial Growth Rate of District H.Qs., 1991-2001

Sl. No.	Eastern Haryana	Growth (%)	Western Haryana	Growth (%)
1	Jhajjar	96.20	Sirsa	53.48
2	Punchkula	87.43	Jind	45.93
3	Panipat	87.06	Rewari	43.04
4	Faridabad	70.22	Hisar	38.91
5	Gurgaon	58.57	Fatehabad	38.07
6	Sonipat	52.66	Bhiwani	37.56
7	Kaithal	52.09	Mahendergarh	29.53
8	Yamunanagar	41.92	Haryana	50.82
9	Kurukshetra	39.82		
10	Rohtak	30.00		
11	Karnal	29.92		
12	Ambala	24.92		

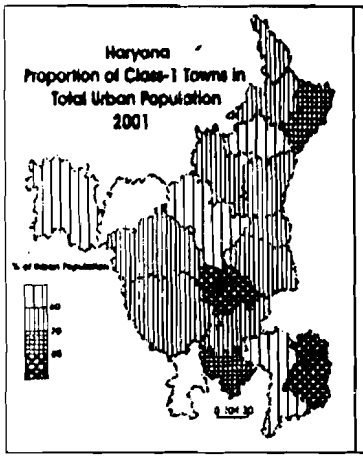
the other two cities, which experienced higher growth mainly for the reasons mentioned in preceding paragraphs. Sirsa was the political centre as discussed above.

Class-I cities of Faridabad and Rohtak depict exceptionally high proportion in total urban population of these districts (>80%). These are followed by Rewari and Yamunanagar (70-80%) Eastern districts reveals higher proportion in class

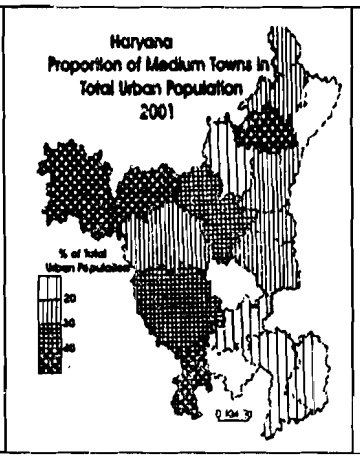
Table 6. Haryana: Decennial Growth Rate of Distt. H.Q.s, (NCR Vs Non-NCR), 1991-2001

NCR Cities	Growth (%)	Sl. No.	Non-NCR Cities	Growth (%)
Jhajjar	96.20	1	Punchkula	87.43
Panipat	87.06	2	Sirsa	53.48
Faridabad	70.22	3	Kaithal	52.09
Gurgaon	58.57	4	Jind	45.93
Sonipat	52.66	5	Yamunanagar	41.92
Rewari	43.04	6	Kurukshetra	39.82
Rohtak	30.00	7	Hisar	38.91
-	-	8	Fatehabad	38.07
-	-	9	Bhiwani	37.56
-	-	10	Karnal	29.92
-	-	11	Mahendergarh	29.53
-	-	12	Ambala	24.92
Haryana	50.82	13		

I cities as compare to western districts. Medium towns reflect reversing trends. (Map 7, 8 and 9). Small towns proportion in total urban population is high in southern distrcts namely, Gurgaon, Rewari, Mahindergarh Jhajjar and Bhiwani districts. Yamunanagar and Kaithal districts in the north also exhibit high proportion in small towns (>15%).



Map 7



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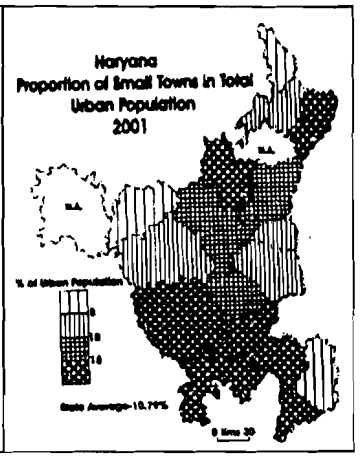
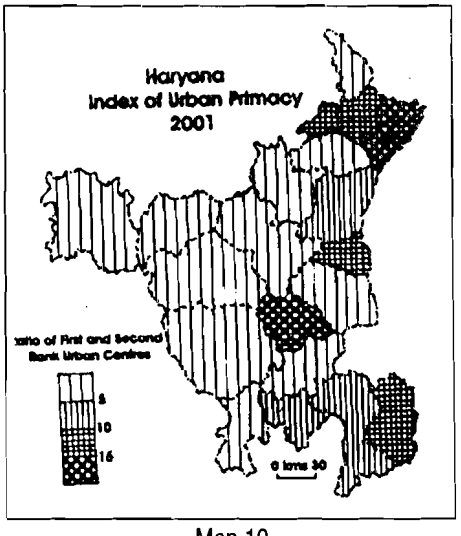
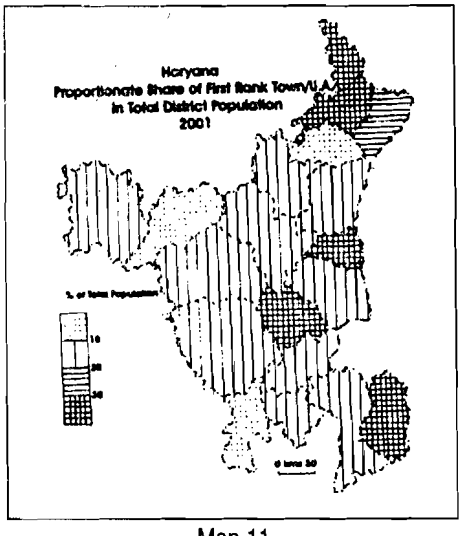


Map 9

Index of primacy can be studied in two ways. One, by calculating ratio of first and second rank towns and secondly by calculating the proportionate share of first rank towns in the total urban population of the district. A city is considered as primate city if first rank city constitute 25 to 30 percent or more of the population of the region. Ratio of the first and second rank towns is very high. The eastern districts shows highly skewed urbanization in favour of large urban centres. This is truer in case of industrial districts of Faridabad Gurgaon Panipat Yamunanagar, Ambala and Rohtak (Map10 and 11).



Map 10



Map 11

Demographic and Socio-Economic Attributes

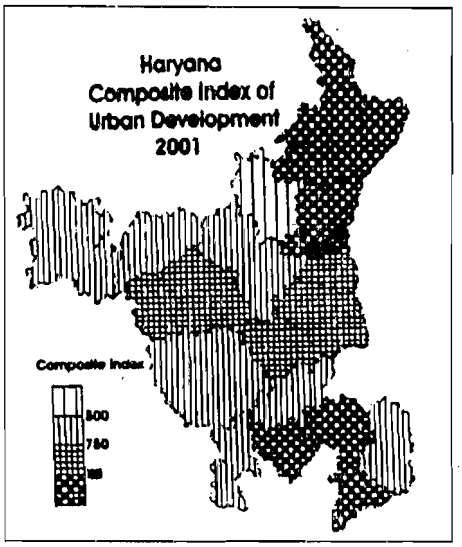
Three components are taken to assess the demographic and socio-economic characteristics of different size towns/U.A. These include sex ratio, literacy rate and work participation rate. Sex ratio is very low in different size towns but class I cities have much lower than the other towns. This is mainly because of higher incidences of male selective migration to these centers. The same factor also explains the difference between urban and rural sex ratio. Urban literacy is high in class I cities as compare to towns of different sizes among both male and females. There are wide rural-urban and male–female variations. Male literacy is higher than females in all class towns but this gap narrow down with increase in size of urban centers (Table 7). Participation rate reveals inverse relationship with size of urban settlements. In both male and females. There are large rural-urban and male–female variations. Participation rate is high in rural areas as compare to urban (particularly the large centers). This is mainly because there is no functional value of literacy in rural areas and they start work at early ages. But in urban areas skilled labour enter the labour force quite late, which adversely affect their participation rate.

Composite Index of Urban Development

Index of urban development is worked out with the help of Human Development Index (HDI) prepared by United Nation Development Programme (UNDP, 1997). The index is based on eighteen indicators. Prominent among them are; Condition and availability of house, proportion of household having access to drainage, tap water, bath room, no exclusive room, sex ratio, child sex ratio, electricity, television, latrine, female literacy, and the like. Map 12 shows a clear east–west divide in urban development. Eastern ditricts located along NH.I are the most developed. These includes Punchkula, Ambala, Yamunanagar, Kurukshetra and, Karnal. Rewari and Gurgaon locating along NH1, also exhibits the same trends. These are followed by Sonipat, Panipat, Rohtak and Hisar district with fairly high level of development. Hisar is the only exception that shows fairly

Table 7. Haryana: Demographic and Socio-Economic Attributes of Urban Population, 2001

Class of Towns	Sex Ratio	Urban Literacy (%)			Work Participation Rate (%)		
		Total	Male	Female	Total	Male	Female
C - I	839	69.59	74.67	63.53	30.34	47.86	9.47
C-II	877	64.39	70.41	57.53	31.50	49.18	11.36
C-III	867	64.52	70.53	57.59	30.14	49.07	12.04
C-IV	861	62.83	70.52	53.92	33.03	47.00	16.82
C-V	863	65.41	74.90	54.36	31.87	48.50	7.92
C-VI	859	60.30	76.41	56.14	27.52	71.27	3.27
All Urban	847	68.11	73.60	61.63	30.64	48.24	9.94
All Rural	866	52.75	65.82	47.17	42.93	50.73	33.91
Haryana (R+U)	861	57.19	65.82	47.17	39.61	50.30	27.22



Map 12

high level of development. This is largely because of the development as a counter magnate town to decongest Delhi (NCRPB, 1999). The whole of western Haryana exhibit very low level of urban development. This includes the distrcts of Sirsa, Fatehabad, Bhiwani, Mahindergarh, Jind and Kaithal. Faridabad and Jhajjar are the only two districts in the east, which shows low level of urban development (Map12). Both of these districts have the leading industrial centres (Faridabad and Bahadurgarh). Large population of these industrial centers particularly Faridabad (>40%) are living in slums which lack access to most amenities.

Conclusion

The principal objective of the study was to understand the spatial and structural pattern of the occurrence of urban centers in Haryana and their demographic and socio-economic attributes. There is significant increase in number of towns in Haryana in the last one century. This increase is phenomenal after the partition of the country. Large-scale migration of refugees from the West Pakistan, formation of Haryana as a separate state in 1966 and successfully implementation of the green revolution were the contributing factors. After 1980s growth is more due to industrial development particularly after the start of labialisation process in 1991. Slowly but steadily industrial development is gaining foothold in this, otherwise agriculture state. Emergence of Faridabad, Panipat and more recently Gurgaon on the industrial map of the country has fueled the urban growth in these areas. Urban growth is more focused on the eastern parts of the state as compare to the western. Secondly, NCR cities/ towns are growing at much faster speed than the non-NCR one. This is largely because of liberal financing of projects, particularly for the development of infrastructure, which helps in attracting private entrepreneurs to invest in industrial sector. Accelerated growth of industrial sector has encouraged

migration from rural and small urban settlements both from within and outside the state. Punchkula and Yamunagar in the north reflect the similar trends. Punchkula being near to the state capital and an important administrative center has developed as a planned city in a very short period of time. Newly created district headquarters namely, Jhajjar and Kaithal also exhibits high growth largely because change in administrative status has attracted development activities and thereby in migration from nearby areas. The sad aspects of these developments are that many areas remained neglected for quite some time. Slow growth of Ambala, Karnal and Rohtak reflects such trends. Western half of the state is clearly way behind in urban development. This is partly because of disadvantageous location and poor resource base. Quality of life measured with the help of Human Development Index also endorses the same. Jind Kaithal Fatehabad Bhiwani and Mahindergarh districts are the least developed. The urban centers of these districts lacked most of the basic amenities.

Enough indications are coming from different sectors of economy that in immediate future Haryana will experience a very high growth of urban population particularly in surrounding areas of national and state capital and along national highways passing through the state. Therefore, it is high time to regulate it through a holistic approach involving people and experts from different walks of life. There must be check on encroachments, unplanned growth, and violations. It is also time for the planners to rethink about the existing byelaws related to the development of road network. The existing restrictions on the construction activities within certain limit of the Right of Way (ROW) from the center of the different level of roads have failed to improve accessibility. Decentralisation of development activities in the non-NCR areas can solve many of the urban problems of the large industrial centers like Faridabad, Panipat and Yamunanagar. Moreover, it is also necessary to develop the areas, which have lagged behind.

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LANDUSE PLANNING AND MANAGEMENT BY GEOMORPHOLOGICAL STUDY IN THE RAKTI BASIN OF DARJEELING DISTRICT, WEST BENGAL, INDIA

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Abstract

The Rakti river basin, covering the hills and plains of Darjeeling District, West Bengal in the Eastern Himalayas shows a striking geomorphic diversity with its normal growth of drainage development. Detailed study of lithology and morphometry depicts that the foot hill region (upto 800m. altitude) stretching east-westward in the middle of the basin, being deeply entrenched by rivers and streams on the weak Permian and Siwalik rock strata have given rise a very fragile dissected landform. This landform having very steep valley side slopes is highly vulnerable to agriculture as well as human settlements unless sufficient measures are taken into account. Therefore, this landform has been categorized as Grade III land of the basin area. Middle hill zone (upto 2000m. altitude) above the dissected foot hill stretching east-westward on the north of the basin, infested by numerous rills and gullies over the hard Archaean rocks has given rise a rugged topography. This topography, although, having steeper ground slope in higher altitude can be considered as less vulnerable since the entire area is characterised by less entrenchment by rivers and streams on hard rock strata. Therefore, this landform has been categorized as Grade II land of the basin area. The alluvial plain on the southern half of the basin (135-400m. altitude approximately) having three distinct fan segments with varied materials is ideal for intensive land utilization. However, the pattern of agriculture and settlements should follow the nature and distribution of deposited materials mostly avoiding the flood prone riverbanks. These entire alluvial fans have been categorized as Grade I land.

Key words : *Siwalik rock strata, Less vulnerable, Less entroanchment*

Introduction

Geomorphological study of the Rakti basin in the Eastern Himalaya has been carried out with an objective to determine the major landform types and their suitability vulnerability to optimum land utilisation for agriculture and settlement. Finally some management strategies have been framed out for each geomorphic landform.

Study area

The Rakti River basin is a sub-catchment of the river Balasan in Darjeeling District, West Bengal of the Eastern Himalaya. This basin is situated between latitudes $26^0 44'11"$ N and $26^0 53'17"$ N and longitudes $88^0 15'18"$ E and $88^0 21'18"$ E. The total area of the basin is 65 Km^2.

Methods and materials

The methodology adopted for such purpose is the various morphometric and quantitative techniques (based on toposheet, geological map, aerial photograph and intensive field investigation) to explain the landform characteristics in the first step and on the basis of such characteristics the whole Basin area has been finally divided into distinct landform units to find out various geomorphological zones with suitable landuse.

Findings

From the morphometric studies of drainage network and composition (Bhattacharya, 1993) it is found that the Rakti River system has a natural development of the drainage network irrespective of strong geological control since the laws of drainage composition have followed the general rules. Detailed study of lithology and the landform configuration through various morphometric techniques like the analysis of slope, relative relief, drainage density and frequency, hydrological network, dissection and roughness indices and their normal distributions and correlations (Bhattacharya, 1993) reveal that the basin is in its young geomorphic cycle being consisted of three distinct geomorphic units of varied shape and form. The units (Fig. 2) are recognised as follows :

a) The Southern Alluvial Plain
b) The Dissected Foot Hill
c) The Rugged Middle Hill

a) The Southern Alluvial Plain

A vast portion on the south of the basin is consisted of wide-open gently slopping plain where the rivers of the Rakti drainage system have deposited huge amount of eroded materials carried down from the upstream due to sudden decrease of velocity resulted from abrupt fall of slope. The deposited detritus have developed a series of alluvial fans which are bounded mainly between 135m. and 400m. (in some places even more than 400m) contours covering an area of 34.88 sq.km. (Fig. 2). The geometry of the fans are strongly controlled by relief, climate, lithology and hydrologic characteristic (Basu and Sarkar, 1990). From the distribution of fan materials and mode of depositions the whole southern alluvial plain can be divided into three distinct fan segments according to the size of the deposited materials separated approximately by certain range of slopes as in the Table - I.

The morphology of the fan segments have been shown in the transverse profiles in Fig. 3c and 3d.

Table 1 : Various aspects of alluvial fan segments

Segments	Area in sq.km.	Slope	Materials	Process	Pedogenesis
Upper	8.00	6° - 16°	Coarse-gravels, cobbles and boulders	Flash floods, debris-flow, and stream action	Moderate
Middle	12.50	1.5° - 6°	Medium-grained sand-silt with occasional boulders	Steam actions and stream floods	Maximum with distinct B (leached) horizon between 30 - 60 cm below surface
Lower	14.38	1° - 1.5°	Fine-grained sand, silt and clay	Stream actions and stream floods	Minimum with weakly developed B horizon

b) The Dissected Foot Hill

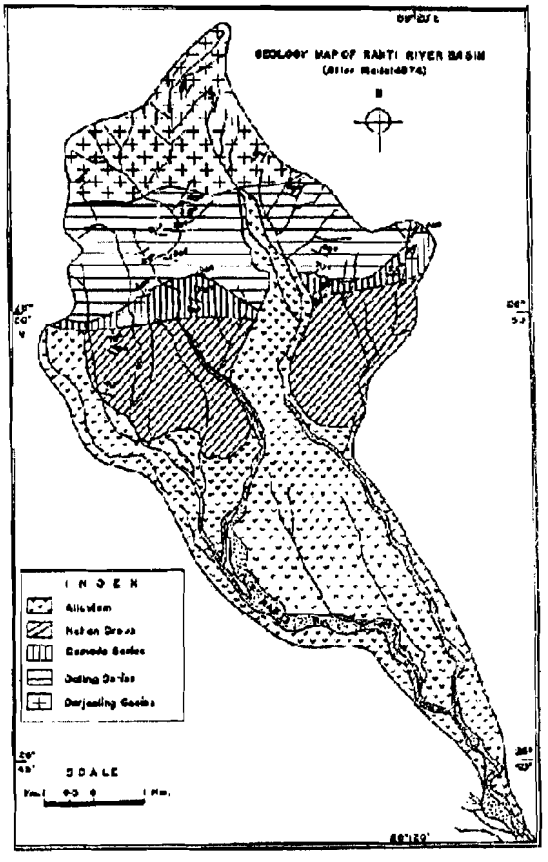

Fig. 1

Geologically this region is constituted of Siwalik-Damuda sandstone and shale with occasional coal bearing seams of lower Gondowana period (Fig. 1) and has depicted distinct thrusts between Siwalik-Damuda and Damuda-Daling series contacts (Chatterjee 1975) and thereby contributed sheared, crusted and folded litho-tectono structure over this region. Moreover the soft sand stone and shale of this region have facilitated the deep incision of the streams and rivers with prominent valley side slopes and ridges. The effect of regional episodic uplifts, which are frequent in the Tista River System (Mukhopadhaya, 1983) are also well manifested in the prevalent process resulting landform characteristics over this geomorphic unit with steep mass-wasted slopes, eroded fault scarps etc. Thus the whole geomorphic unit has exhibited high dissected land surface, preventing the pedogenesis from deeply developed matured soil horizons. This region is mainly confined within 400 m. to 800 m. contours with general

slope varying between 10^0 to 28^0 covering an area of 21.37 sq.km. The morphology of this region has been presented in the transverse profile in Fig. 3b.

c) The Rugged Middle Hill

A distinct break of slope at an altitude of approximately 800 m. has separated this unit from foot hill below with some distinctive characteristics of geologic and geomorphic origin (Fig. 2). The entire region is consisted of Daling series and Darjeeling gneiss type of rocks (Fig. – 1) which exert better resistance in the drainage incision as compared to the foot hill below and thereby the streams have attained comparatively less valley side slopes with widely spaced ridges. The episodic and jerky uplifts have exerted little influence on these harder rocks of Archean period and as a result these zone has been suffered from lesser amount of geological deformities which facilitated relatively low amplitude of relief and dissection. The initiation of higher amount of source heads and confluence points with occasional maswasting, triggered up by chemical weathering on ferruginous rocks etc., have altogether made the terrain rugged. Pedogenesis over this part of hilly area of the basin is mainly consisted of fairly developed horizons. In some places there exists thin to rocky skeletal soils also, due to the presence of very hard rocks and very steep local slope. This area is confined within 800 m. and 2000 m. contours with an area of 8.75 sq.km. having a general slope ranging from 18^0 to 26^0. The morphology of this region has been presented in the transverse profile in Fig. 3a.

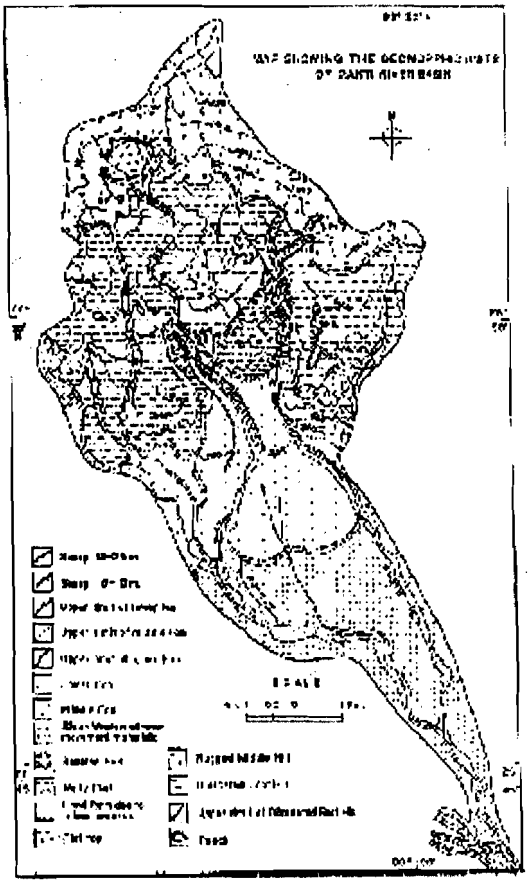

Fig. 2

Land gradation and management

From the foregoing discussion and analysis it becomes quite evident that the geomorphic units of the Basin under study considerably differ from each other in their present shape and form which ultimately provide various degrees of restriction for the efficient utilization of lands. Thus from the view point of the restrictions the

geomorphic units can be graded into three distinct categories as in the Table - II.

From the table it is apparent that the Southern Alluvial Plain having three distinct fan segments belongs to grade I land and thus becomes ideal for land utilization. Although unrestricted agriculture and settlement construction is proposed for this region still this should be done in a planful way since this region is made up of stream transported alluvial detritus having varied sizes and textures. Therefore, the upper alluvial fan primarily constituted of boulders and coarse grained materials can be better utilized if resistant variety of crops, intensive root spreading plants like Chilaune (*Schima Wallichii*), Gokul (*Ailenthus grandis*) Utis (*Alnus nepalensis*) etc. and economically profitable grasses like Amlisho (*Thysanolaena Maxima*), Kash (*Saccharam spontaneum*) etc. are sown. Settlements should be constructed over this fan segment without restriction but considerably away from the river banks which are severely affected by flash flood in the rainy season in most of the years. Middle fan segment, being pedogenically rich, can be utilized for all types of agricultural products. Settlement construction and other economic activities can be carried out according to the need and demand but mostly avoiding the vicinity of the braided rivers which frequently change the courses and create monsoonal flood. Lower fan segment can be utilized with the suitable agricultural products since the development of soil over this area is not sufficient every where. Settlements and other activities can be done as the middle fan area.

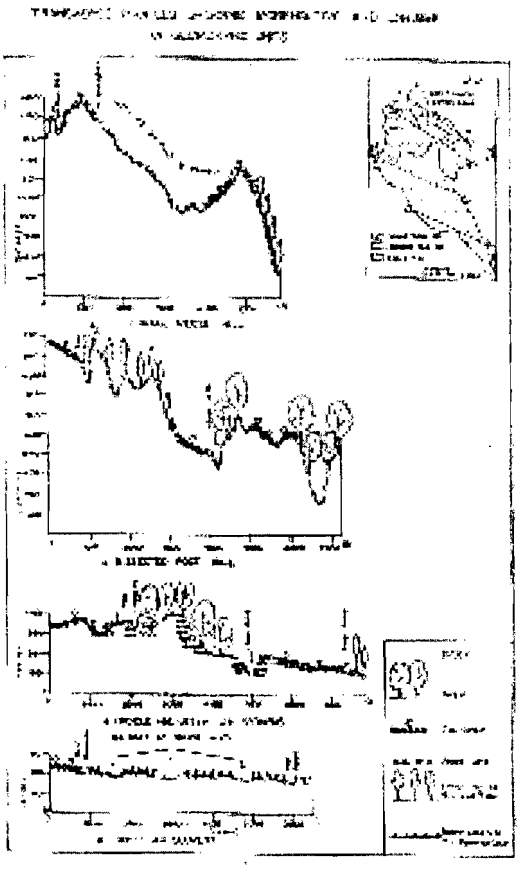

Fig. 3

The Rugged Middle Hill being recognised as Grade II of the extent of land utilisation proves that restricted utilization of soil and land should be done over this area. Scientific terrace cultivation, strip cropping can be allowed only where the soil is well developed and slope is less steep. Since altitude and slope become the two main constraints for tilling of land, the land should be used for woodland purpose and other economic activities like tourism, health resort and aesthetic purpose. Tea cultivation, which is the major primary activity over this geomorpho-

logical landform, should be carried out with much scientific care and techniques. Construction of settlements can be done only over the resistant land surfaces avoiding vulnerable slopes. Congestion of settlements should never be allowed.

The Dissected Foot Hill topography being congenitally and pedo-geomorphologically vulnerable to a great extent falls in the category of Grade III land and therefore, very restricted utilization of soil and land is necessary. High scientific terracing and tillage practice can only be the way of the sustainable utilization of soil and land for agriculture. Tea gardens over this area should be renovated and scientifically maintained. Failure of the maintenance of the tea gardens over this zone has proved to be one of the important causes of landslide occurrences since this zone falls within very high degree of landslide susceptibility (Bhattacharya, 1999). Mass forestation instead of agriculture over the vulnerable slopes is essential as this area has undergone severe deforestation like other areas of the basin, presently having

Table 2 : The geomorphic units with their degree of potentiality for land utilization

Geomorphic Units	Altitudes	Main Features	Grades	Extent of land utilization	Precautionary measures necessary for the lands
Alluvial Fans	135 – 400m.	Depositional land form	I	Unrestricted utilization of soil and land	No precautionary measure necessary. Normal agriculture, settlement construction and economic activities can be allowed in a planful way.
Rugged Middle Hill	800 – 2000m.	Erosional landform	II	Restricted utilization of soil and land	Less intensive, technique oriented agriculture by following the development of soil and steepness of ground slope. Non-congested planned settlement construction avoiding vulnerable slopes is necessary
Dissected Foot Hill	400 – 800m.	Litho-tectono-erotional land form	III	Very restricted utilization of soil and land	High scientific terracing and tillage necessary for agriculture. Sufficient engineering techniques necessary for settlement and other constructions fully avoiding slide occurring zones and steep slopes.

only 22% of forest (Bhattacharya, 1998). Sufficient scientific and engineering know-how should be applied for settlement and road construction over this area. Non-congested wooden houses should be preferred. Settlement constructions should never be allowed over slide prone zones and sufficiently steep slopes over this fragile topography.

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RECENT SEA LEVEL CHANGES AND ITS IMPACT UPON DUNE MORPHOLOGY ALONG SHANKARPUR-DADANPATRABAR COASTAL TRACT, WEST BENGAL

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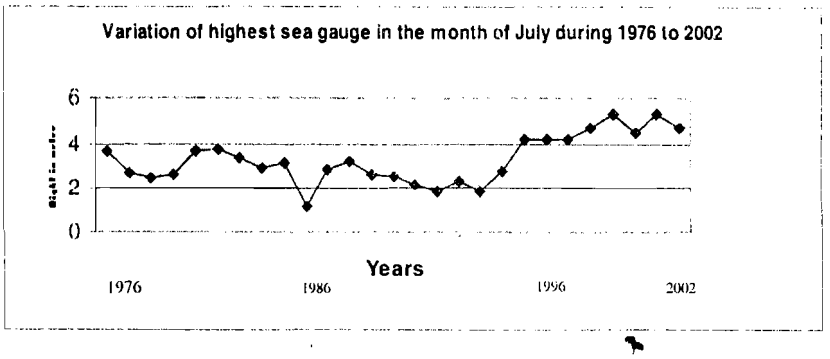
Abstract

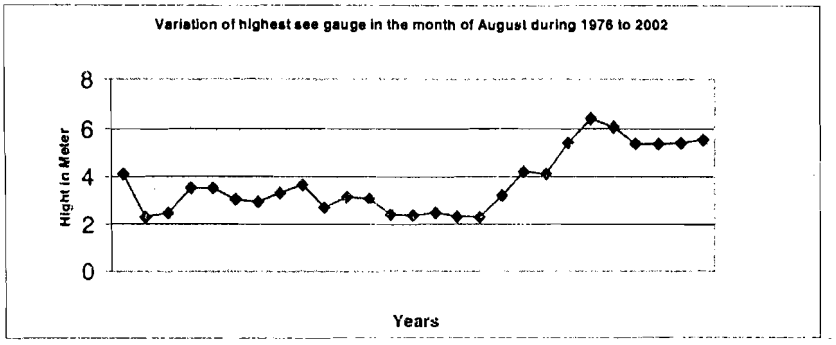
This paper assesses the impact of recent sea level change upon coastal geomorphology especially the coastal dunes along Shankarpur-Dadanpatrabar coastal tract, which is a part of West Bengal coast. Through the tidal gauge data it has been detected that the sea level has rise remarkably along this area over the last 30 years. As a result of that the shoreline has been shifted landward and the entire environment has changed. It has been observed that the front dunes of this area also shifted landward at a rate of 5-10m / year. At many places the dunes are totally destroyed by increasing wave erosion. The inhabitants of this area are now suffering due to dune encroachment and sand drifting. The agricultural lands are also affected by the sand blowing.

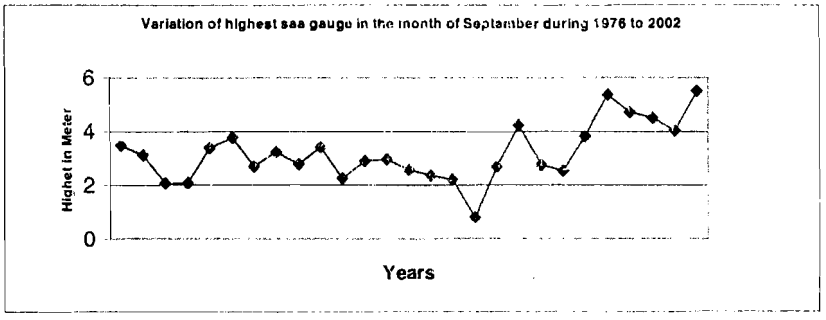
Keywords *: Sea level, coastal erosion, dunes, shoreline shifting, geomorphology*

Introduction

Shankarpur – Dadanpatrabar coastal tract is under Contai subdivision in Purba Medinipur district of W.B (India) lies between latitude 21°37'N to 21°42'N and longitude 87°32' E to 87°45'E and total length of coastal area about 21 km, (Fig. A.1). Geomorphologically this is a part of West Bengal coastal tract which is a characteristically a mesotidal morphology. The study area is a part of Subarnarekha delta, which is nourished by Subarnarekha river over last 6000 years (Bandyopadhyay, 2000). The geological and geomorphological history of the Digha-Shankarpur coastal area has been assessed previously by Niyogi (1970). Later on Chatterjee (1972) Banerjee, Goswami and Chatterjee (1997), Paul (2002) and a number of other geo-scientists also assessed the geology and changing nature of this coastal tract. All the early works, including those mentioned above, have mentioned that this coastal area has been developed almost 15 km during last 6000 years and all the present marine coastal geomorphic units have developed during this time. Geologically it is known as Ancient Digha-Junput coastal deposits (Mukherjee and Chatterjee, 1997). Another two geological units, i.e., a) the older Digha-Junput coastal deposits and b) the recent Digha-Junput coastal deposits have been reported to have developed around 3000 years before present.







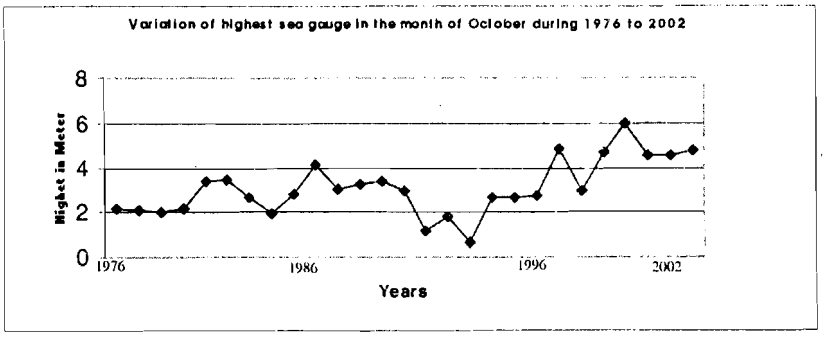


Figure 1. Variation of highest sea gauge during 1976 - 2002

Methodology

Prior to visiting the field area, the present author surveyed the existing literature such as reports of Geological survey of India, Digha Development Authority, Department of Environment of Government of West Bengal etc and recent research papers published in different journals and presented in different seminars, congresses etc to prepare a complete fieldwork programme.

Historical literatures often preserve some valuable evidences of physical environmental change as historical events are influenced by environmental conditions. To assess the early condition of the lake and impact of environmental change upon the lake basin through historical period this author used some existing relevant historical records of this area available from different literatures. There are also some available antic cartographic works and charts, which were used as strong evidence of early environmental change.

Fieldwork : The fieldwork was conducted from the December 2003 to September 2005. The aims of the field work were- i) to field out the geological and geomorphic evidences of long-term coastal evolution and ii) to assess the recent physical environmental change. Seasonal variations of landform were measured for the assessment of seasonal control upon tropical monsoon geomorphology. Various field maps were prepared during fieldwork.

Laboratory testing, mapping : Geomorphic data collected through field investigation during various seasons have used for preparing various maps. Geological and geomorphologic map of this study area, present landuse map (Scale-1: 50000) published by the Geological Survey of India (1995), Survey of India topo-sheets etc were consulted for the preparation of final maps.

Results and discussions :

The Holocene period was marked by several climatic changes. Before 6000 years the average temperature was nearly 2°C higher then present and there was higher precipitation. It was known as Holocene Climatic Optimum. After that, the Earth began to cool and the subtropical areas became drier. During 900 AD and 1200 AD the temperature was higher by a degree or two than today which was called as Little Climatic Optimum. Polar ice retreated a few kilometres. After 1200 AD the climate had a tendency to cool down. During 1450 to 1850 AD the average temperature of Europe was 1°C to 2°C lower that today. This is known as the Little Ice Age and also had an impact on Tropical and Subtropical climate and sea condition. Than the temperature started rise again. Table-1 shows the relationship of global climatic change and its impact on shoreline of the West Bengal Coast.

4.A.iii.a. The important conditions necessary for dunes growth at the coastal area include as :

(a) Strong onshore winds.
(b) Abundant sand supply
(c) Vegetation cover
(d) Low near-shore slopes combined with a large tidal range providing wide expanses of sand, which dry at low tide area (Pathick, 1984).

Table 1. Holocene Landform Development around the West Bengal Coast

Years before present	Climatic significance	Evidence shifting of shoreline		Sea Level Rise / Fall
		Medinipur coast	South 24 Parganas coast	
50	Rapid rise of temperature	Landward (-1000m to -1500m)	Landward (-1000m to -1500m)	Rise
300	Temperature rises after little ice age.	Landward (-6000m)	Data not available	Rise
6000	Cooling after Climatic optimum	Seaward (+1500m to +2000m)	Seaward (+3500m to +4000m)	Fall
8000	Climatic optimum	Landward (Distance estimation not available)	Landward (Distance estimation not available)	Rise

Source : De. S. et. al (2002).

4.A.iii.b. Dune formation : Possibly the process of sand movement by wind contributed to the formation of sand dunes in the following ways :

(i) Sand is moved mainly by saltation.
(ii) Once saltation begins the wind no longer moves grains directly from the surface.
(iii) Sand transport rates are very responsive to wind velocities and to surface texture.

4.A.iii.c. Two main models of coastal sand dune formation have been proposed i.e.

- Dune formation associated with rising sea level (6 to 10m above) condition (transgression) - as sediments are pushed onshore from continental shelves. This seems to have occurred for most of the medinipur coastal dunes at the late Holocene. The earliest and modern dunes in Medinipur coast today date to about 60 - 6000YBP. (Paul, 2002). The ancient dune ridge complex at (Kanthi-Paniparul region was formed by coastal aeolion process during the marine regression between 5000 - 6000 YBP (Gowsami -1999).
- Dune formation in association with falling sea level as exposed off shore sands accumulations become prone to wind depilation. This seem to have occurred for most of the present coastal dunes (New dunes) at the recent or present today date to about - 3000 - 35000 YBP (Gowsami 1993)

4.A.iii.e. Sand transport :

Amount of transported sand is very important for dune formation. Sediment transport depends on the wind velocity, although other factors such as and size and grain shape are important. The amount of sand transport per unit beach width per unit time has been shown by many authors (Bagnold 1941,

Hsu 1973) to be related to the cube of the shear velocity:

$$q = (C"D).(u2_{\grave{a}})^3 \text{ ---------- equation-1}$$

If , it is felt that a 'real' velocity must be included for one's peace of mind:

$$q = C\ (V_{100}\text{-}V_1)^3 \text{ ---------- equation-2}$$

Where, q = weight of sand moved per unit time, C = a constant, D- grain diameter, $U2_{\grave{a}}$ = shear velocity, V_{100}= velocity measure at 1 metre above surface., $V\text{-}_1$ = critical threshold velocity for given grain size.

4.A.iii.d. Sea level change and dune development :

Coastal dunes morphology consists of distinct parallel dune chains and depressions (Pethick, 1984) which have a significance of geomorphic evolution throughout geological time (Dey and Haque, 2003). In the light of the recent hypothesis the following two models of coastal dune formation have been suggested (Viles and Spencer1995, p-68-69):

- Dune formation associated with rising sea level condition (transgression) - as sediments are pushed onshore from continental shelves.
- Dune formation in association with falling sea level as exposed offshore sandy accumulation become prone to wind deflection.

Recent evidence of sea level change :

At mid 20th century the scientists pointed out a serious trend of global warming. During the 70s of the last century a sharp rise of temperature was found due to huge increase human intervention on the Earth. The general rises in the mean temperature of the world's oceans of 0.7°C (3). Consumption of greenhouse gases like CO_2, CH_4, N_2O, CFC-12, HCFC-22 and CF_4 causes global warming and it is estimated that in this century the globe will be warmer 1.5°C to 4°C (17). Global sea level changes are an integral part of climatic change (4). Rise of temperature causes melting of ice and thereby sea level raises; for the contrary, fall in temperature results in fall in sea. Present landforms along the coasts may have the bearing these changes in sea levels.

Dune and vegetation interaction :

Dune movement is one of the most important geomorphic features along the area under reference. Dune movement not only depends on sand supply by wind but also vegetation play important role in the movement of sand dunes. Laing (1954), Ranwell (1912), Disraeti (1984) and many other scholars worked upon the dune-vegetation interaction. Short and Hasp (1982) also classified

Table 2. Statement of Monthly Highest Sea Levels at Digha Sea Coast, Purba Medinipur

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1976	1.40	1.42	1.68	2.07	2.22	2.040	3.68	4.1	3.455	2.17	3.39	1.53
1977	1.45	1.45	1.67	2.09	1.89	2.97	2.71	2.29	3.09	2.08	1.36	1.46
1978	1.40	1.58	1.80	1.90	3.23	2.06	2.44	2.46	2.08	2.00	2.28	1.64
1979	0.60	1.70	1.98	2.04	2.26	2.315	2.595	3.505	2.065	2.165	1.945	2.005
1980	1.505	1.905	2.185	2.135	1.01	2.030	3.645	3.505	3.375	3.385	1.55	1.69
1981	1.70	1.785	2.635	2.59	2.60	2.48	3.74	3.044	3.75	3.49	2.60	1.58
1982	1.86	1.97	2.55	2.47	2.435	3.245	3.375	2.925	2.675	2.665	3.260	1.625
1983	1.805	1.925	2.445	2.375	2.865	2.985	2.915	3.310	3.215	1.96	1.76	1.52
1984	1.906	2.125	2.235	2.945	3.855	2.855	3.155	3.665	2.782	2.782	2.370	1.32
1985	1.135	1.225	1.155	2.34	2.29	2.565	1.21	2.715	3.395	4.085	2.11	1.87
1986	1.23	1.13	2.20	2.31	3.37	2.28	2.88	3.13	2.24	3.05	1.95	2.30
1987	1.23	2.24	2.24	2.24	3.25	3.25	3.21	3.08	2.89	3.26	2.70	1.971
1988	2.19	2.081	2.091	1.501	2.461	2.501	2.611	2.361	2.941	3.361	2.651	3.001
1989	2.741	2.421	2.321	2.221	2.321	2.521	2.561	2.371	2.561	2.97	2.68	3.100
1990	2.54	1.706	2.565	2.476	2.834	2.486	2.206	2.476	2.366	1.176	1.176	0.586
1991	1.97	1.806	2.261	2.301	2.301	2.001	1.861	2.311	2.221	1.821	2.171	2.191
1992	1.871	2.371	2.291	2.311	2.301	2.201	2.301	2.301	0.790	0.680	0.181	0.181
1993	-	1.350	1.82	1.97	1.801	1.791	1.911	3.22	2.69	2.64	2.39	2.24
1994	1.46	2.09	2.54	2.67	2.64	4.21	2.74	4.215	4.215	2.69	2.72	2.34
1995	1.18	1.34	1.51	2.79	5.06	4.01	4.21	4.11	2.74	2.74	2.74	2.74
1996	2.64	2.45	2.59	2.69	2.62	1.94	4.21	5.385	2.54	4.86	2.79	2.44
1997	2.34	2.24	2.69	2.59	4.38	2.74	4.215	6.385	3.81	2..94	2.14	1.57
1998	1.66	2.14	2.14	2.64	4.01	4.69	4.69	6.055	5.355	4.69	4.69	2.94
1999	1.94	2.94	3.37	4.055	4.690	5.355	5.355	5.355	4.690	5.964	2.94	3.370
2000	1.53	3.445	3.915	3.915	4.505	4.505	4.505	5.355	4.505	4.505	4.505	2.94
2001	2.94	3.445	3.445	3.915	4.505	4.505	5.355	5.385	4.010	4.505	3.915	2.94
2002	2.96	2.960	3.470	3.950	4.520	4.990	4.750	5.536	5.510	4.750	3.950	3.470

Source : River Research Institute (R.R.I.), Digha.

the dunes according to vegetation cover. So, the analysis of sand dunes on the basis of vegetation cover is very common in the field of coastal and arid geomorphology.

Dune System :

For practical understanding of the above-mentioned hypothesis, we conducted a study along the selected field area. On the basis of the field study, two main geomorphic classes of the dunes of this area are observed, they are Paleo-dunes and Neo-dunes. Between these two dune colonies, inter-dunal depression is existed. The main features of dunes are given in Table 5.

Table 3. Statement of Monthly Lowest Sea Levels at Digha Sea Coast, Purba Medinipur

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1976	-1.98	-2.10	-2.60	-2.72	-2.24	-1.56	-1.86	-1.76	-1.76	-1.37	-2.88	-2.75
1977	-2.65	-2.15	-2.73	-2.63	-2.27	-2.74	-1.92	-1.92	-2.27	-1.92	-0.77	-0.89
1978	-1.92	-2.27	-1.92	-2.15	-2.27	-1.97	-1.92	-1.79	-1.89	-1.87	-1.78	-1.67
1979	-1.79	-1.87	-1.87	-1.85	-1.79	-1.79	-1.81	-1.83	-1.83	-2.19	-2.19	-2.19
1980	-2.566	-2.63	-2.64	-2.47	-2.03	-2.060	-1.79	-1.900	-2.76	-1.90	-1.845	-1.90
1981	-2.234	-2.315	-2.220	-1.35	-2.28	-1.82	-1.69	-1.495	-2.69	-1.82	-1.88	-2.08
1982	-2.76	-2.49	-2.330	-2.26	-0.58	-0.62	-0.62	-1.995	-1.455	-1.455	-1.465	-0.105
1983	+0.125	+0.155	+0.065	-2.155	-2.205	-1.935	+0.455	-1.135	-1.710	-0.81	-1.706	-1.80
1984	-1.86	-1.90	-1.970	-2.06	-1.86	-2.01	-1.33	-2.01	-2.101	-1.72	-1.95	-1.72
1985	-2.10	-2.04	-2.101	-1.340	-1.45	-1.29	-1.43	-1.965	-2.018	-1.19	-0.785	-0.61
1986	-0.61	-0.51	-2.02	-1.48	-1.47	-1.50	-1.34	-1.47	-1.53	-1.54	-1.58	-1.59
1987	-1.59	-1.59	-1.61	-1.60	-1.57	-1.16	-1.07	-1.08	-1.48	-1.58	-1.68	-1.31
1988	-1.94	-1.944	-1.889	-1.964	-1.954	-1.86	-1.74	-1.294	-1.42	-1.381	-1.164	-1.504
1989	-2.256	-2.299	-2.339	-2.339	-2.279	-2.309	-2.339	-0.009	-0.019	-1.48	-1.26	-1.660
1990	-2.16	-1.824	-1.934	-1.824	-1.804	-1.714	-1.764	-1.454	-1.814	-1.544	-1.764	-1.794
1991	-1.01	-1.56	-1.979	-2.049	-2.059	-2.159	-2.069	-1.639	-0.389	-0.389	-0.389	-0.979
1992	-2.389	-2.389	-2.389	-0.289	-0.339	-0.319	-0.299	-0.289	-0.349	-0.389	-0.409	-0.419
1993	-2.06	-1.864	-1.884	-2.030	-1.784	-1.524	-1.914	-1.964	-0.329	-0.201	-3.590	-3.57
1994	-3.48	-3.52	-3.56	-3.47	-3.47	-2.48	-1.8	-3.38	-3.6	-3.13	-2.60	-2.00
1995	-2.04	-1.91	-2.04	-1.93	-1.95	-1.9	-1.94	-1.87	-1.49	-1.76	-1.99	-1.91
1996	-1.97	-2.01	-2.03	-1.98	-1.98	-1.96	-1.93	-2.05	-2.06	-2.06	-2.06	-1.64
1997	-2.11	-2.11	-2.20	-2.20	-1.58	-1.59	-0.91	-0.93	-0.94	-0.35	-0.35	-0.85
1998	-2.37	-2.35	-2.30	-2.07	-1.885	-1.605	-2.990	-1.805	-1.925	-1.36	-1.35	-0.55
1999	-1.92	-2.00	-2.02	-1.91	-1.46	-1.85	-2.01	-1.98	-2.08	-1.46	-1.39	-1.84
2000	-2.010	-2.060	-2.08	-2.07	-1.84	-1.99	-1.94	-1.86	-2.07	-1.57	-2.06	-1.94
2001	-1.96	-1.91	-1.93	-1.88	-1.88	-1.78	-2.02	-2.02	-2.47	-1.85	-1.96	-1.79
2002	-1.535	-2.095	-2.125	-2.135	-2.075	-1.735	-1.635	-2.22	-2.085	-1.717	-0.965	-1.435

Source : River Research Institute (R.R.I.), Digha.

Conclusion :

Formations distinct dune belts of in this area clearly indicate the dynamic nature of natural environment during the Holocene epoch. Seasonal character of this tropical coastal area plays very vital role in developing the sand dunes along with the natural vegetation. Vegetation cover control movement of dunes and morphological modification along the coasts. The vegetation dispersed in sand mass increases the stability of a dune to resist wind and wave action by many folds. The contribution of vegetation results from both structural and biological interaction of itself with sand mass.

Besides this, it is observed that there is a tendency of sea level rise at a remarkable rate during the last 300-500 years along Medinipur coastal tract (Niyogi, 1970, Pp-1-36). There is ample evidence (Hazra et al. 200, Pp-25-37) of

Table 4. Types of dunes estimated percentage of vegetation cover and characteristic along Shankarpur – Dadanpatrabar coastal

Types of dunes	Estimated percentage of vegetation cover	Characteristic	Vegetation
Mobile sand dunes	0 to <30 % vegetation cover, mainly covered by the grasses and casuarinas plants.	Geologically known as beachfront dune complex, mostly affected by wind in dry season and by wave in rainy season.	*Cyndon doctylon, Borreria artcularis, Eleusineindica, Uphorbia, Ipomonia- pescaprac, Sidacorcorditolia* etc.
Semi- stable sand dunes	30 % to 75 % vegetation cover.	Geologically known as older dune-complex. Found beyond 2 km. From the sea to 15 km. in ward.	*Calotropis gigamatea, Cassia sophera, Cyperus species, Glycosmis Peataphylla,*
Stable sand dune	More than 75 % vegetation covers.	Beyond 10-15 km. from sea, lower height (2 m or less).	*lantanacamara-O panita species pandomus species etc.*

*Source : Field investigation *Dey (2005)*

Table 5. Characteristics features of dune system along this area

Characteristics feature	Places of observations	
	Shankarpur sector (west)	Dadanpatrabar sector (east)
Height	Up to 15m	Less than 2m
Wind ward slope	Slope very steep up to 45-60° angles.	Gentle slope less than 15° angles.
Lee ward slope	Gentle slope10° angle	Gentle slope 5°angle
Surface topography	Ridge form with sharp peak	Undulating with two or more dome.
Dune face	Eros ional on sea side and pogradational on land slide	Stable on both sea side and land side
Beach	Narrow	Wide
Structure	Verbal presents and zigzag beds	Aeolian cross bedding
Sediment type	Medium to coarse sand, poor organic materials, some broken shale	Very fine to medium sand ,good organic materials.
Vegetation	Comparatively poor vegetated :- Common vegetation are Pandanus, Ipomoea, casuarinas etc.	Well vegetated :- common vegetation Ipomoea, lantana camara, Pandanus etc.
Major uses	As natural defense against storm surge and wave	Settlements , fish drying field , seasonal some agriculture field.

*Source : Field investigation report and * Dey(2004-2005)*

Table 6. Shifting of Dunes

Year	Seasons	Shankarpur		Chandpur		Dadanpatrabar	
		Towards beach	**Towards land**	**Towards beach**	**Towards land**	**Towards beach**	**Towards land**
2004	Pre monsoon	3.2m	8m	5.7m	7m	2.5m	12m
	monsoon	nil	5.5m	nil	6.6m	nil	3.5m
	Post monsoon	1.2m	4.5m	2.5m	3.8m	3.3m	6.5m
2005	Pre monsoon	2.8m	10m	4.4m	9m	4.5m	15m
	monsoon	nil	6.0m	nil	5.5m	nil	4.4m
	Post monsoon	2.2m	4.5m	3.5m	5.0m	4.0m	7.5m

sea level rise at a considerable rate (>2 mm per year) in this part during recent years. Prominent landward encroachment of dunes alongwith the shoreline changes strongly support that sea level rise is now at an alarming stage in this area. Human intervention, particularly over the last three decades has also been very significant for the change in coastal environment. Construction of fishing harbour, covering a large area at Shankarpur sector, development of tourism and associated industries (mainly ice and fishing ship/boat-building industries) along the coast has aggravated environmental hazards. Recently social forestry has been introduced by the Department of Forestry, Government of West Bengal to protect the beach and dunes from wave erosion (Plate-2/d). Under these circumstances study of both long-term and short-term environmental influences on the geomorphology of the coast would be very important for sustainable development scheme for the future.

The obvious adverse impact was soon felt when the severe erosion started engulfing the shoreline not only the human establishments so built defying the aforesaid regulation but also the pre existing natural habitat situated on the country side of the seadyke. In spite of various sporadic protective measures so

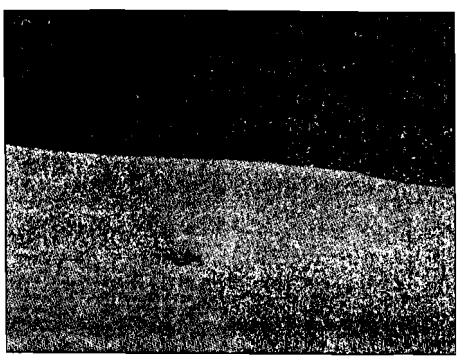


Photo Plate : Landward advancement of sand dune on the coast line (Dadanpatrabar sector)

Photo Plate : Wind pass and shifting of dunes at Jaldah sector

far taken at the extreme vulnerable locations, the ongoing erosion still continues unabated, and at a number of stretches the erosion has already hit the dyke itself, grossly damaging the same by even washing out the brick pitching on sea side slope. In this connection it may be stated that at several vulnerable locations, the crest width is already narrowed to 1 to 2 metre only. Besides, it is also revealed from the records that during high tide, the sea water level started rising abruptly (on an average up to 5.00m.) since 1998 in comparison to that of earlier years when the level usually remain below 3.00 metre. This variation in levels of sea water obviously cause a severe effect for rapid engulfment of bank line.

As a matter of fact, the Sea-dyke not only protects a vast area lying on its countryside against flood, but also prevents ingress of saline water to the countryside, which is dangerous for socio economic life. The area is purely agricultural belt, growing valuable crops viz. Paddy, Betel-leaf, Cashew nut, Chilly plants, etc. Some Hatchery projects. Pisciculture and Salt factories have also grown up near the Sea-dyke. Moreover, entry of Sea water by breaching embankment is likely to damage several public utilities like School, Health Centre, Panchayet Buildings, Pucca roads, Kutcha roads, Residential Buildings, Huts, Tourist resorts, Markets etc. lying within the above mentioned region. It may be mentioned here, that the average ground level in this vast area varies in between 2.5m. to 3.5 m. Obviously if any untoward incident happens in the existing damaged sea dyke, particularly during the high Kotal period when the sea level dangerously surges upto a level of 5 m. to 6 m. the extent of devastation following failure of the dyke could be easily imaginable.

Of late, the situation took an worst turn as was experienced in the last year on 28.8.03 and 29.8.03 respectively when widespread severe damages have occurred in several places of coastal belt at Digha ans Shankarpur, following the high Kotal having been associated with powerful eastern wind. Nearly 120 metres stretch of the dyke with an adverage width of 30 metre has been eroded and washed away from the end of Sea-hawk bent to cross drainage point. The cross drainage structure got completely collapsed by tilting towards Sea. Another stretch of Sea wall between Blue view ramp and Aquarium point for about a length of 60 metre was found hanging where foot path and light posts were badly damaged.

The Sea Dyke between Shankarpur to Jaldah for about a length of 4.0 km. however, has been found to be the worstly affected reach. Entire brick-pitched sea side slope including the crest at most of the places, has been completely eroded away taking vertical slips.

Consequently, considering the very urgency and importance of coastal erosion at Digha Shankarpur area, Govt. of west Bengal promptly constituted an expert Committee under the Chairmanship of the Chief Secretary, Govt. of West Bengal, which will analyses the coastal erosion problem on top priority basis and will suggest the solution to check the onslought thereof. Thereafter, the committee has been holding series of meetings and has already worked out a guide line for implementation of various phase wise measures of both short term and long term perspects at different typical segments of the dyke. Copies of the relevant

portion of minutes of two such particular meetings held on17th, October, 2003 and 4th March, 2004 respectively, are prefaced with this report.

Accordingly the present estimate is prepared following the said guideline, corresponding to the immediate permanent solution for a length of about 4 Km. from Shankarpur to Jaldah by shifting the sea dyke beyond CRZ 500.

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SOME OBSERVATIONS ON THE DIVERSE LATERITIC LANDSCAPE OF SUBARNAREKHA-KANGSABATI-SILABATI INTERFLUVES OF PASCHIM MEDINIPUR, W.B

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Abstract

Tartiary graveliferrous materials and other older alluviums of western margin of Paschim Medinipur district are massively impregnated with sesquioxides (iron and aluminium oxides) in the form of laterites and lateritic soils under favourable geomorphological, hydrological and pedological conditions along with the modifying role of neo-tectonics. Uplift of the depositional surface, change of drainage characteristics, oscillation of ground water table, intense weathering and leaching processes under high rainfall, and denudational chronology all contributed to the development of laterites in the areas of low relief. Some of the deep profiles are exposed on the bank margins of river valleys and platform margins of interfluves in the district. The present paper deals with the variation of laterites under diverse landscapes with varying soil forming processes of the humid tropics. The study is based on field visits to every compartment of physiographic domain of the area, profile records, soil sample analysis and other evidences like fossil records, erosional history, weathering intensity, drainage characters etc.

Key words : *Sesquioxides; Laterites; Oscillating ground water table; Intense leaching; physiographic domain; Interfluves; Lateritoids; Valley cuts and valley fills.*

Introduction

The laterite tract of Paschim Medinipur has evolved in response to the combination of various activities, like post glacial graveliferrous sediment deposits, prolonged weathering processes under hot and humid climate, tectonics in the form of slow but steady uplift of the depositional surface, change of drainage characteristics and rate of denudational processes. The process of laterization is also influenced by high rainfall (1500-2000mm.) and continuous high temperature (22°-25°C) throughout the year (Table-1) and seasonal fluctuation of ground water table (Fig. 1). The basic parent materials of graveliferrous sediments, having sufficient iron bearing ferro-magnesium minerals were congenial for the development of laterites in the area under investigation.

There are three to four types of lateritic materials encountered in the field areas of Paschim Medinipur. Quartz grains or silica particles coated with iron oxides in the form of nodules or concretionary products are found in a type of geomorphic surface resulted from weathered debris and differential rate of erosion. In many areas, the planation surface is capped by laterite hard crust. They are developed

Table 1. Average temperature & rainfall distribution at Medinipur and Jhargram station of Paschim Medinipur district.

Months	Medinipur (1931-60)		Jhargram (1983-88)	
	Temperature in °C	Rainfall in mm.	Temperature in °C	Rainfall in mm.
January	22.0	14.2	19.80	6.90
February	22.8	29.9	22.15	22.38
March	28.0	34.3	27.90	18.35
April	31.5	43.9	31.75	58.82
May	32.2	109.4	32.15	93.03
June	30.9	232.2	31.95	293.15
July	28.9	322.1	30.35	302.78
August	28.9	336.3	28.95	340.10
September	28.9	261.8	28.30	241.95
October	27.2	131.5	26.25	137.37
November	23.0	36.1	22.85	17.53
December	20.0	03.2	20.00	3.82

by eluviation and illuviation processes and also by seasonal ground water fluctuation in a certain depth of soil profile with concentration of sesquioxides which hardened to exposures under the removal of plinthites. A few areas under floral cover have cemented with silica grains and clay particles by hydrated oxides of aluminium and iron concentration. Such cemented surface with hydrated oxides are eroded by surface run-off and remained in the form of messas and earth pillars.

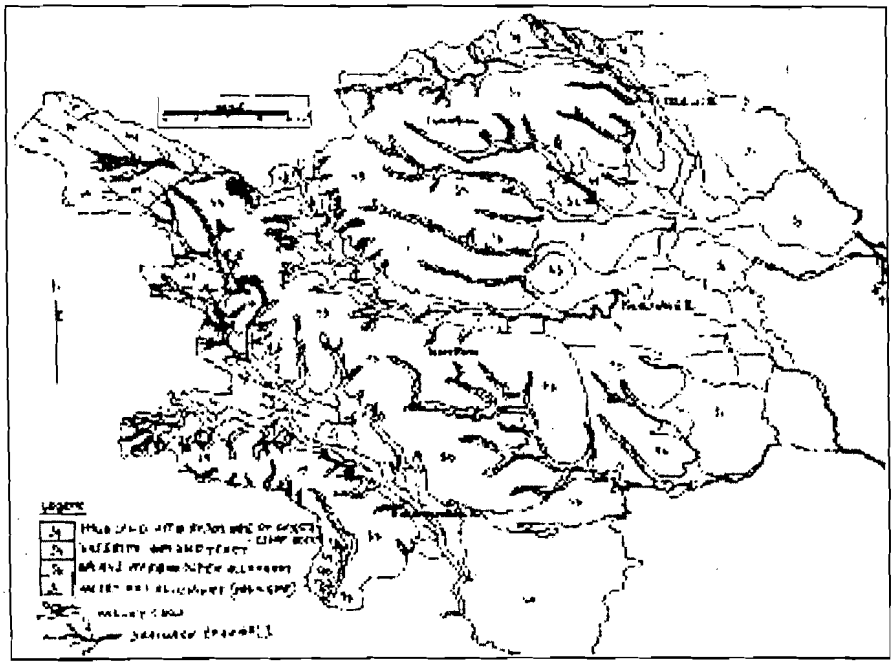

Figure 1. Geomorphic Surfaces and Drainage Character of Paschim Medinipur district.

Laterite conglomerates are formed in the surface of upper terrace by concentration of sesquioxides as cementing agent to agglomerate the gravel beds. It is possible to establish a sequence of soil maturity correlated with the morphology of the landscape. Different geomorphic surfaces give rise to a sequence of younger, mature and relic soils in the parts of Paschim Medinipur district.

There are four major types of laterites on the geomorphic surfaces of the landscape. They include as packed pisolithic laterite of detrital composition, spaced pisolithic laterite of insitu formation, vermiform laterite of indurated sesquioxides and secondary laterite of clay minerals and hydrated iron and aluminium oxides.

The Study Area

The entire area of Paschim Medinipur rises in height gradually from east to west in four significant geomorphic surfaces having different elevations (S_1-20-30 m.; S_2-30-50 m.; S_3- 50-70 m.; S_4- above 70 m.) (Fig. 2). Again the areas are segmented into interfluves by east and south-east flowing rivers (Subarnarekha, Kangsabati, Silabati etc.) following the regional gradient and narrow valley cut areas. Many tributary channels of major rivers have dissected interfluves of highland tracts further with significant valley cut development. Intense rills and gullies on the both banks of major rivers affect the margins of highland tracts. The laterite surface is fringed with the upland tract towards east and gradually stepping down towards the younger alluvium surface of modern flood plain facies.

The basement crystalline complex is exposed on the extreme west with metamorphosed rocks of iron ore series, quartzite, mica schist and basalts which contain ferro-magnesium minerals in the region.

Processes Involved in Formation of Laterites

Laterites at mottled horizon are developed due to the accumulation of sesquioxidic materials leached down to water table. Both pedogenetic processes and ground water movement are responsible for the concentration of iron and aluminium in nodules or slag like concretions in the mottled horizon. Seasonal migration of water table causing upward movement of iron and aluminium into zone alternately affected by wetting and drying. Erosion removes the topsoil (plinthite) of softer variety up to the depth of concretionary zone which irreversibly hardens with sub-aerial exposure to form crust of indurated laterites.

A thick horizon of laterite profile (about 21m.) is exposed on the erosive bank of Silabati river at Garhbeta. The laterite profile is developed over a Tertiary graveliferrous deposit with deep weathering activities under wet and dry conditions and active ground water movement. A zone of concretions is overlain by hard crust at Garhbeta and which extends up to mottled zone of concretionary laterites. The pallid zone lies below this horizon and it is characterized by the accumulation of silica and clay in cemented form. This zone is by definition pale coloured due to leaching of iron, and thus the coexistence of iron depleted and an iron-enriched horizon is developed in the thick profile of Garhbeta.

Nodular horizons are the product of weathering of hard crust laterite

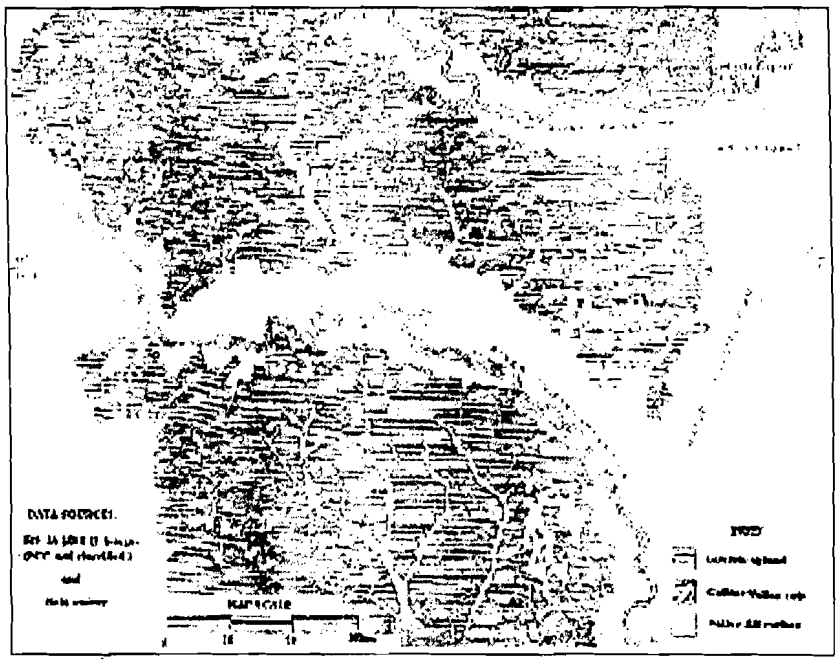

Figure 2. Laterites and landscape of Paschim Medinipur District.

(Banerjee, 1972). Disintegration of quartz grains and re-granulation into nodules in the upper horizons seem to take place by concentric growth of nodules with iron oxides coating.

Geomorphic Characteristics of the Sites to which each type of Laterites are Associated

Massive vesicular or concretionary formations are nearly always associated with uplifted peneplains which were originally associated with areas of low relief and high ground water (Bridges, 1978). Laterite conglomerates are visible on the valley margins and terraced banks of Subarnarekha River and Dulung River basin. The erosive plains of highland tract under Kangsabati-Subarnarekha-Silabati interfluves are associated with concretionary ironstone formation. Uplift of such land surface has resulted in increased fluvial erosion by streams, which have cut deeper valleys and lowered the water table. Valleys are widened by shifting drainage course and incised by undermining the bank walls after the uplift of land surface in the region. Erosion has also stripped of the overlying leached horizons so that the laterite usually occurs as a platform remnant in the interfluves position. The ironstone horizon has become exposed and hardened to contact with the air after removal of softer soil covers from the uplifted surface.

Weathering of an exposed crust has led to the variable growth of modified surface with strong run-off deposits and nodular composition of materials. Variation of laterites is also visible associated with or without the cover of vegetations in the uplifted surface. Planation surface laterites are also visible in the unindurated

condition under forest-covered interfluves. The laterite remains permeable as long as the original soil cover and forest vegetation remain in the areas of interfluves. The laterite is incised and eroded on the bank margins by shifting drainage courses and the planation surface laterite is indurated after deforestation in many places. Deforestation leads to a exposure and indurations of the laterite which loses its permeability. Finally, the deforested areas of indurated laterites are affected by weathering, fragmentation and re-granulation of weathered materials with iron oxide coating. Such development of land surface leads to the formation of wasteland on the margins of degraded forest belts in Paschim Medinipur. Moderate to gently slopping margins of highlands with weathered laterites are also affected by rilling, gullying actions by strong surface runoff at the wet season. Valley floors of gully channels are filled up with concretionary nodules by runoff deposits from the bank margins of eroded highlands. These nodules of concretionary products are also cemented with the concentration of iron and aluminium oxides in few places where the water table is very close to the surface. In Paschim Medinipur, those laterites which were formerly forested and permeable are markedly deformed by weathering and erosion.

The location of inter-bedded silicified wood fossils from the detrital laterite deposits of Garhbeta and Lalgarh surface perhaps provide more significant information about the nature of vegetation at the time of laterite formation than does the vegetation currently seen on the laterite surface of Paschim Medinipur. In many areas of Sal dominated forest floor, iron is readily removed by humus rich solutions and hydrated aluminium oxides, however, concentrated in the surface to produce cemented crust with marginal erosion (Paul, 2002).

The rolling interfluves of Subarnarekha- Kangsabati-Silabati basins are characterized by pisolithic laterites with non-static water table and massive laterites with seasonal static water table. The large vertical spread of pisoliths within such interfluves can also again be associated with a lowering water table. The pisolithic laterites are immature form of laterite which appears to be developed in the immature planation surfaces. The mature planation surfaces can be associated with the exposure of underlying massive laterites after removal of pisoliths bearing surface from the top. The older alluviums and underlying gravel beds of the upper terrace of Subarnarekha river banks are laterized in successive stages. The higher parts of interfluves with hillocks are locally known as 'dungri'. They are mostly forested and characterized by discrete concretion variety of surface form. The areas of degraded forests with exposed planation surface laterites of massive structure are locally known as 'dahi'. The surface is roughened in this part because of weathering and fragmentation of laterite hard crust. The surface is also extended up to the margins of present day river valley alluvium deposits. The younger alluviums of river valleys are cultivated and soils of bank margins are more or less affected by hydrated oxides of iron and aluminium in few places. Finally the course of the riverbed restricts the growth and extension of valley flats between interfluves.

Interactive Role of Pedological, Geomorphological and Hydrological Processes

The above discussion clearly reveals that quite a large variety of lateritic materials can be encountered in different parts of the area under study (Fig. 3). This has

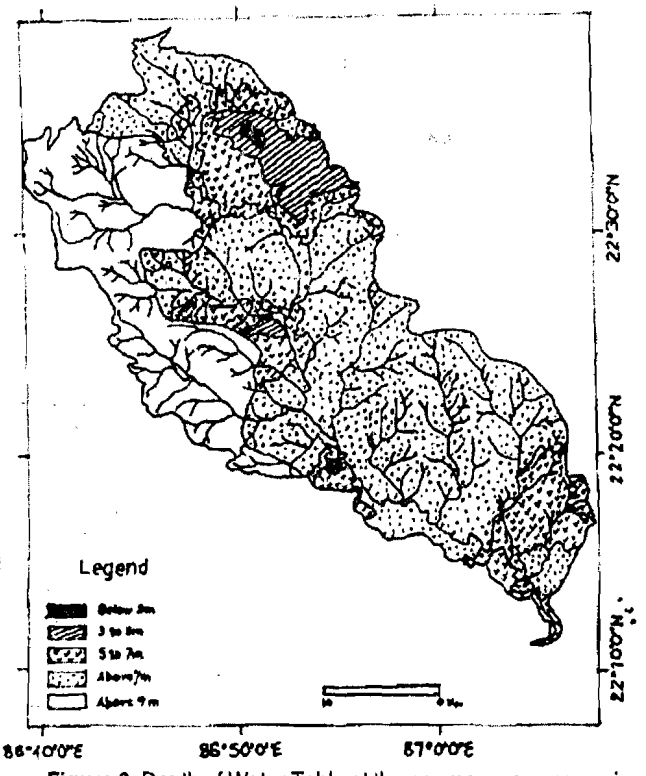

Figure 3. Depth of Water Table at the pre-monsoon season in Dulung river Basin of Subarnarekha- Kangsabati interfluves.

also been pointed out in many of the available literatures (Biswas, 1987; O'Malley, 1911 etc.). Consequently a plethora of confusions and ambiguities have been found to center around the mechanism of formation of lateritoids of Paschim Medinipur. Divergence in opinions of different writers has added much fuel to such debates. But the complexities in nature, appearance and mode of occurrences of lateritic materials of the area can be resolved by considering the relationships and interdependencies among the pedological, geomorphological and hydrological processes operative over the area under investigation.Any geographical site specifically represents a particular pedogenic, geomorphic and hydrologic environment in which a particular set of processes become operative under the dictate of local conditions. Accordingly the soils and forms received their genetic characteristics and are associated with each other.

The fundamental processes in the formation of lateritoids are deep seated intensive weathering of iron bearing materials composing the country rocks; liberation of iron compounds viz. ferric hydroxide gel (under oxidizing situation), dissolved ferrous hydroxides (under reducing environment) and deposition of these materials under alternative dry and wet condition during the phase of saturated and anaerobic condition oxygen deficiency leads to conversion of ferric ions into ferrous ions which replace the basic cations and aluminium ions from the exchange sites. These replaced ions are lost from the soil system being carried away by water in dissolved condition. The dry phase, on contrary, is characterized by an oxidizing environment that helps in the oxidation of the adsorbed ferrous ions into ferric ions. These ferric ions either precipitate as iron oxides or react with water to form goethite and/or ferric hydroxide (secondary clay). As the adsorbed ferrous ions are expelled from the exchange sites they are readily occupied by hydrogen ions which attack the octahedral clay sheets liberating silicic acid that get re-precipitated as silica. Thus break down of primary clay minerals and their conversion into secondary clay minerals

and liberation of silica take place simultaneously. The secondary clays create mottles when they precipitate and are hardened irreversibly under aerobic condition (Schaetzl & Anderson, 2005).

The hydrological perspectives have dual significance in pedogenic processes of the area. Firstly, the secondary clay minerals are transported by the surface as well as sub-surface water flow away from their source areas in both vertical and lateral directions. Marks of these pathways of water flow through the lateritoids have been found in many instances which clearly establish the role of water flow in the development of laterites. Furthermore, the zones having higher water potentiality along with higher seasonal fluctuations of hydrological conditions (dry & wet) have been found to be more susceptible to the formation of lateritoids. Secondly, the implication of hydrological processes in pedogenic development of the area lies in the fact that seasonal fluctuations of under ground water table have been found to be instrumental in upward transportation of secondary clays and their deposition concentrated at particular depth of the laterite profile.

Geomorphology has played a significant role in regulating the hydrological processes. Morphological characteristics of a particular site have greatly influenced its hydrological behaviour which has, in turn, controlled the pedogenic processes. Amount and direction of slope, concavity or convexity of slope, position of a site in reference to other morphological units etc. are the major geomorphological attributes which have been found to be important in explaining the pathways of water flow along with dissolved weathering products (secondary clay in particular). Moreover, the geomorphological aspects have also precisely defined the depositional environment of those secondary clay minerals (i.e. sesquioxides). The depth and nature of seasonal fluctuations of underground water table are also functions of topographic situations. Hence, hydrologic processes of laterite formation cannot escape the morphological controls. In view of the above understanding of the relationship among pedological, hydrological and geomorphological processes, the complex nature of the lateritic formations of the study area can be explored as follows.

Tectonics and Laterites

During Middle to Early Pleistocene period the Chhotonagpur plateau and its surrounding areas experienced melting of ice sheets and consequently the rivers received maximum energy to transport the eroded materials from the fringe of Chhotonagpur plateau. Thus the graveliferrous materials were transported and deposited on the western part of Bengal Basin under shallow marine environment. In the marine and estuarine environment then prevailing over the area certain salt tolerant species had probably occurred along the estuary margins in the form of woody growth. Wood fossils of such trees has been found in the pallid zone of Garhbeta (Silabati bank) and Lalgarh (Kangsabati bank) laterite profiles that can be taken as a further evidence of the uplift of the said area. Probably the forested bed has been raised due to the local tectonics and gradually fossilized.

The drainage characteristics of the region had been changed due to the above-mentioned tectonic activities at local scale. After the tectonic uplift the rivers

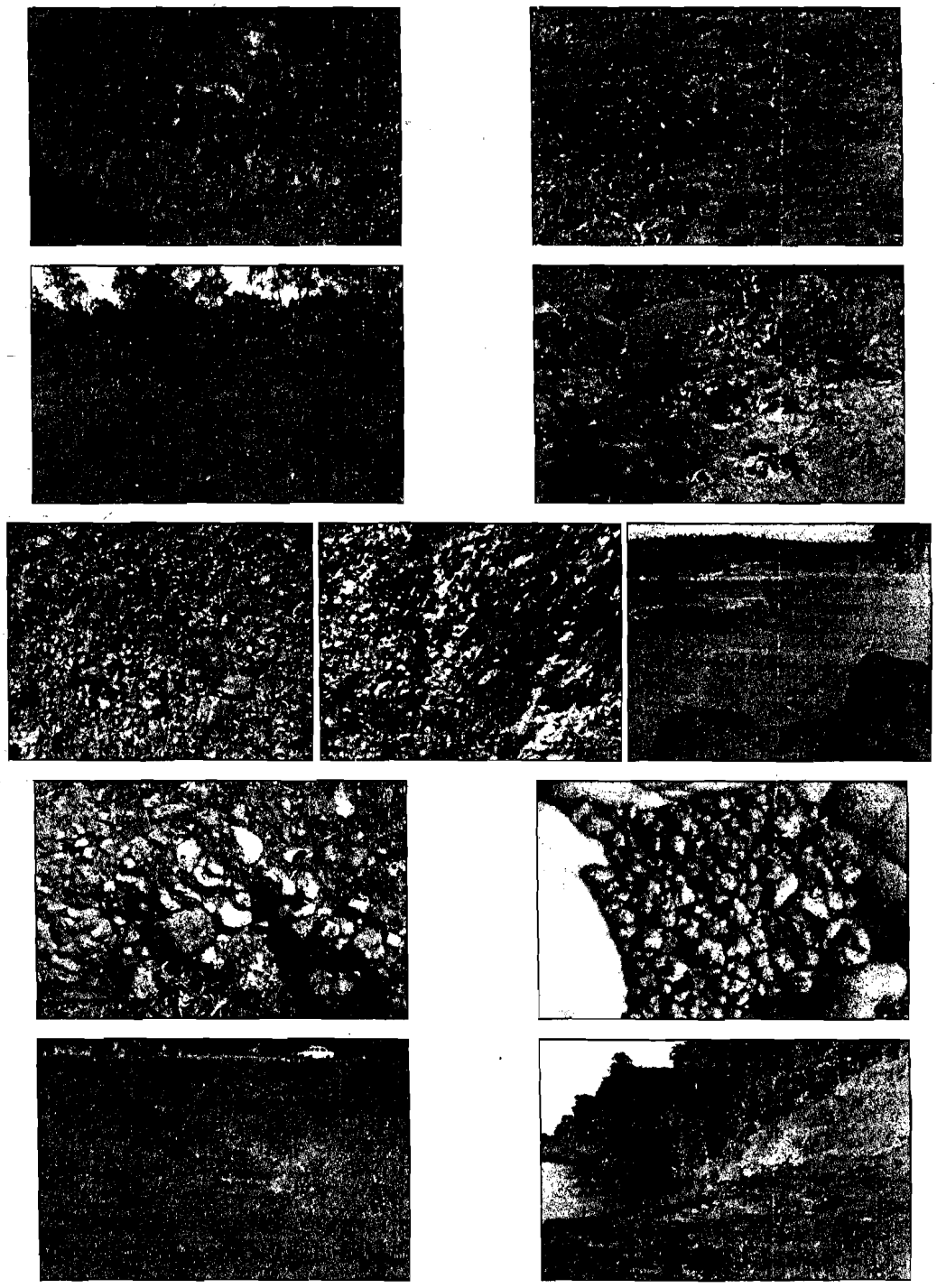

Photo Plates

of the area became energized to transport more sediments with gravels. Such energization had caused the rivers to severely incise their courses as a result of which the Silabati River has exposed its southern bank to surface the wood fossils. Due to the differential rate of uplift certain portions of the plateau margins relatively more uplifted than the surroundings and undergone severe denudation. At present remnants of older denuded surfaces in the form of pediments and older planation surfaces can be observed in the western margin of the study area. Such older planation surfaces are separated by extensive valley cuts. After the fluvial incision, the sea level experienced a rise resulting in a positive change in the base level. As a result of which the energy level of the rivers declined and that change in energy was adjusted by deposition in the form of valley filling and meandering of the river courses (Niyogi, 1972).

Laterite Profile

Originally the lateritic materials are believed to have formed over Archaean, Gondwana and Basaltic surface of plateau by intensive weathering where insitu high-level primary laterites have evolved. Colluvial materials highly rich in iron dominated primary and secondary clay minerals have been deposited over the older deltaic plain (Bengal Shelf) since Upper Pleistocene (More than 275000 years B.P.), a part of which constitutes the study area. In many cases these secondary laterite exhibit most of the profile characteristics of primary laterites. Such a truly developed laterite has been encountered on the right bank of river Silabati at Gangani (22°51' N, 87°20'E) in Garhbeta. The lateritic formation, having areal expansion of several sq. Kms., is topographically a flat topped dissected upland with an elevation of about 70m. River Silabati has carved out this lateritic block to develop a scarp like landform that rises about 21m. from the river bed. Silabati has four significant horizons on the east bank.

1. Loose pisolithic layer (3-4 cm. thick) with gently rolling surface on the gully head margin fringed by plantation area.
2. Duricrust layer (1.8-2.0 m. thick) highly indurated irregular cavities and pipes often cut by gullies, frequently overlain by red clayey soils (sometimes mixed with small concretions) towards the land covered by forest.
3. Mottled zone (variable thickness of 2-4 m.) mixed with sand, hardpan in places.
4. A pallid zone is very thick (17-18 m.) highly dominated by yellowish- white clay with very little sand.

Gullies are very deep and flat floored and they have deposited huge sediments in the form of fans which are now cultivated. Gully heads are connected with surface run off concentration channels coming from the forest floors (Fig. 4).

Laterization and Climate Change

During the formative stage of older deltaic plain this area would have represented a relatively lower topographic position within the flood plain of Silabati that favoured accumulation of colluvial materials (highly rich in primary and secondary clay minerals), being transported from the primary lateritic tracts of

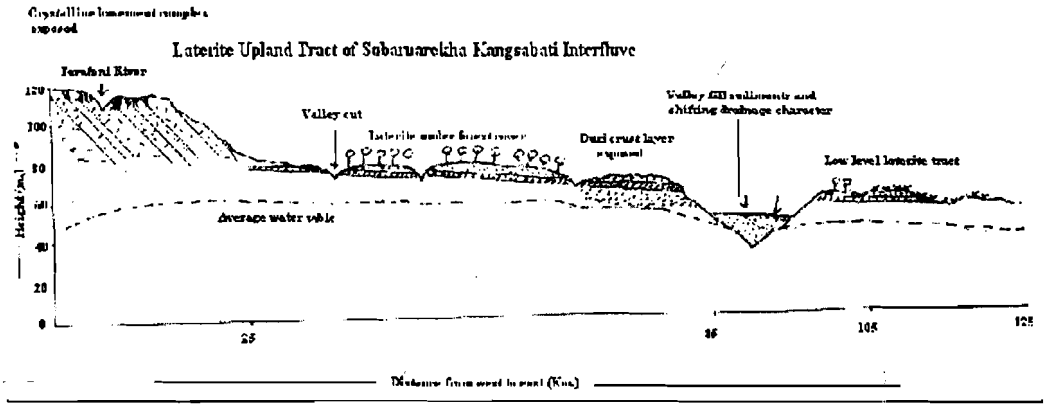

Fig. 4. A schematic diagram of Geomorphic Surfaces and their associated laterites of Paschim Medinipur.

Chhotonagpur plateau. The clay minerals had undergone ferruginization process which was associated with formation of ferruginous-kaolinite nodules. These nodules experienced further pedological modifications through intensive ferralitizaton and leads to the formation of compound pisoliths (Fe-rich and/or Mn- rich) (Achyuthan, 2004). In this process the crystal structure of kaolinites and other primary clay minerals collapses and large volume of amorphous secondary clays of Fe-oxides and -hydroxides) and silica are produced. The silica particles as well as the ferricrete clasts formed the nucleus of reorganized pisoliths around which centripetal enrichment of Fe-clay continued. These pisolithic nodules cemented in detritus iron matrix to form upper duricrust layer. All these processes were operative under more humid climate that prevailed earlier. But presently they are not so prevalent and rate of laterization has become more senile as the climate has become drier.

The intermediate mottled zone is the result of the combined effects of iron clay illuviation and the fluctuation of underground water table. The role of underground water in lateritic processes were significant in the past, as such areas occupied lower topographic positions and they were instrumental in carrying dissolved iron upward from the basement complex beneath the sedimentary deposits. Moreover, leaching of Fe-oxides and hydroxides was also important. There have been found tubular pipe like features within the duricrust layer and mottled layer. They clearly are representing the paths of water movement. Some times those pipes have been filled up with Fe-clay, which have cemented to produce tubular ferricretes. The mottles have developed due to crystallization of Fe-oxides and hydroxides on the fine/coarse alluvial deposits.

The lower most pallid layer is characterized by yellowish-white clay. The most interesting is its unusual thickness (17-18m.). Through flushing during early state of its development has created the pallid zone, which continued to thicken as basal shapping (Mc Farlane,1976) continued along with tectonic uplift of the tract and consequent incision by river Silabati. Thus the great thickness of pallid

zone can be taken as an evidence of tectonic uplift of the area. Such examples are not rare in Australia. Thickening of the pallid zone bas been favoured till the duricrust layer became indurated and impermeable to allow basal sapping. The duricrust surface has undergone severe weathering which released basic materials that have raised the pH value of this layer while the underlying layers are still more acidic reflecting severity of leaching during humid past.

Case Studies under different Sub-environments

Indurated hard crust formation is restricted at the hydro geomorphic situations where settling of sesquioxides-matrix is disfavored due to higher degree of slope associated with more dry condition. Such a surface covered with considerably thick layer of pisolithic and oolithic concretionary nodules have been found on the way towards Belpahari.The detrital laterite of this area occur like loose gravels, each nodule being isolated without having been recemented into solid mass. In many such nodules goethite have been found to crystallize into hematite due to lack of organic matter coupled with drier environment.

Laterites under Forests

The forested areas are generally covered with soils where the laterization process is not so intense as in exposed tracts. Large quantities of organic litters are added to such soils which decompose quickly to produce acidic leachates. Therefore, surface soils in forestlands are characterized by relatively lower pH value. The yellowish- red soils under sal-dominated dense forest of Godapiasal (Salbani block) exhibit a pH value of 5.72 (Table-2). This acidic aqueous leachate readily dissolves hydrated oxides of ferric and aluminium to form ferrous and aluminium compounds. Therefore, in the forests the laterite layers are mostly found to occur at sub-surface positions. However, in some parts having higher slope, the laterite layers have been exposed by severe erosion and it has undergone weathering to form polypisolithic nodular masses. The process of laterite formation is inhibited in forested areas due to more moist condition. The trees are capable of retaining water in soil and thus the range of fluctuation of pedohydrologic conditions is narrowed. Such a situation does not favour the formation of lateritic hard crust near of at the surface (Mc Farlane, 1976).

Some interesting observations associated with laterite formation have been made at a site within the Malabati forest (Binpur-II block) where forest is more open due to degradation. Those observations put some light on the role of hydro geomorphology on laterite formation. The area exhibits three district surfaces lying at three different elevation levels. The uppermost is a nearly plain surface (40m. elevation) with a very thin cover of light reddish brown (10R 4/3) sandy loam soil. These soils have become slightly indurated due to cementation of sesquioxides that has enabled it to escape severe erosion and keep some of its parts slightly elevated above the surrounding surface. The intermediate surface i.e. the upland tract margin is characterized by higher degree of slope, the upper part of which is predominantly erosional in nature while its lower counterpart, separated from the former by a significant break of slope, favours deposition.

Accordingly, denudation has exposed many nodular ferricretes bearing signatures of weathering of underlying lateritic hard crust. Lower margins of this exposed bank is segmented into smaller interfluves separated by micro channels coming down from the upland tracts. These channels are fed with surface run-off as well as lateral seepage water. This section of the intermediate surface is highly potential for lateritic development due its exposure to sub-aerial condition favouring oxidation, wide range of fluctuation of hydrological condition (wetting and drying) being favoured by its characteristic geomorphological setting and large scale deposition of sesquioxides by surface and sub-surface water flow. Under these favourable conditions, the laterite formation is going on and some concretionary nodules have been produced which are in their early stage of formation and can be broken with little knock. The lower most surface represents a basin-like marshy land where all the channels coming down from the upland tract converge. Due to its higher water potentiality, laterization is not favoured in this basin but has been colonized by grasses and thus represents a typical 'lateritic marsh'. The observations related with the newly formed lateritoids over the intermediate surface give insight into the formation of 'platform margin' laterites which have probably been produced by the same mechanism under comparable hydro geomorphic setting.

Bank Margin Laterites

Another well-distributed variety of laterite of Paschim Medinipur is conglomeratic laterites. In such lateritoids various types of pebbles, cobbles, shingles and sands of fluvial or fluvio-marine origin are bound together in a matrix of ferralitic-lateritic materials. In many places (viz. Tarafeni river bank of Binpur-II) saprolites have taken the place of pebbles, cobbles, gravels etc. that may or may not be mottled and/or coated. Such type of graveliferrous lateritoids has been encountered on the terraced bank surfaces of Dulung river near Chilkigarh (beside Kanakdurga Temple). Each of such surfaces is associated with a particular type of graveliferrous laterites having undergone a certain degree of laterization. Virtually four such surfaces have been observed on the left bank of the river. The lower most surface lies 1.15 m. above the then water level of the river. This is a hard lateritic crust composed of sands, shingles, pebbles, gravels and cobbles (fluvial deposits) impregnated into a matrix of lateritic materials. This is reddish yellow in colour (7.5YR 6/8), highly indurated and gets flooded during rainy season. As such, sesquioxides and other lateritic constituents are favoured to be deposited at this surface and those materials have undergone more intensive laterization as they experienced a wide range of wet and dry condition. The second surface, lying about 0.75 – 1.00 m. above the lower most surface also enjoys more or less same hydrogeomorphological situations which are favourable for laterization and hence, graveliferrous hard lateritic layer has developed on this surface. Fluvial geomorphic activities have modified this surface through pit hole formation, sheeting etc. by hydraulic action during flood. The third terrace surface, lying about 2 m. above the second surface, is similarly composed of fluvial sedimentary deposits which have been

Table 2. Chemical Properties of Soil samples collected from the study area showing the variability of pH at diverse depth and topography and the loss of nutrients due to severe erosion.

Sample No.	Sample Site	pH	Organic Carbon (%)	Nitrogen Kg/hectare	Phosphorus Kg/hectare	Potassium Kg/hectare
1	Amkola Mouza(Binpur-II)	6.10	0.03	45.00	237	118
2	Sahari, Balpahari (upper layer)	6.15	0.03	46	50	131
3	Sahari, Balpahari (lower layer)	5.40	0.04	55	42	143
4	Dulung River Bank-upper terrace, fourth surface (Chilkigarh)	5.60	0.06	59	50	109
5	Dulung River Bank-upper terrace, third surface (Chilkigarh)	6.15	0.01	42	101	169
6	Patina, Nayagram-surface layer	5.65	0.08	62	50	115
7	Patina, Nayagram, sub-surface layer	6.02	0.05	65	101	139
8	Salbani (Bhadutala) top soil	4.87	0.12	76	52	153
9	Salbani (Bhadutala) pisolithic granules	6.80	0.01	46	143	164
10	Salbani (Godapiasal) Forest floor	5.70	0.02	52	59	138
11	Salbani, Godapiasal (valley fill alluviums)	5.94	0.19	68	72	42
12	Godapiasal rail station (Excavation site)	6.45	0.09	59	144	124
13	Godapiasal rail station (Clay layer at a depth of 1 m.	6.20	.02	41	98	87
14	Salbani, Chaktarini (Erosional surface)	5.70	.01	39	101	149
15	Garhbeta, Gangani (Duricrust layer)	6.22	0.03	43	101	95
16	Garhbeta, Gangani (mottled zone)	5.20	0.01	35	110	55
17	Garhbeta, Gangani (Pallid zone)	5.30	0.02	37	48	40

modified by pedogenic processes. The soils of this terrace is in an early stage of laterization but more advanced than that of the top most surface because here laterization is more favoured on this surface due to higher pH value (6.15) and colour is, therefore, more dark (dark reddish brown- 5YR 3/2). At the highest surface laterite formation is less favoured as pH is lower (5.65) due to decomposition of organic litter added from the overlying forest. All these surfaces discussed above are exposed on the riverfront.

Conclusion

On the basis of above observations and their probable explanations following

conclusions can be drawn.

1. The different types of lateritic formations in Paschim Medinipur can be attributed to variations in geomorphological, hydrological and pedological conditions.
2. Shifting of river courses as a consequence of tectonic activities has largely influenced the degree of laterization process.
3. Clearing of forests have led to the formation or exposure of hard crust in many occasions which have further been modified by surface runoff channels in the form of rills, gullies and ravines.
4. In many places duricrust layer has been intensively weathered and fragmented into pisolithic and oolithic isolated nodules.
5. Upland lateritic tracts are fringed by older alluviums to the east which has undergone laterization to a certain extent with the concentration of sesquioxides transported from the upland tracts.

The above conclusions have been drawn on the basis of observations and primary measurements but further in depth study is needed to strengthen them.

Acknowledgement

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GEOGRAPHICAL RECONNAISSANCE OF WATER SCARCITY AT KURSEONG MUNICIPALITY – An Attempt Towards Better Management

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Abstract

Water supply in a hill station like Kurseong is a troublesome task, where maximum of the surface water immediately drains after the rainfall down the steep slope leaving almost no possibility of surface and subsurface storage. The condition is further deteriorated by the seasonal concentration of rainfall experiencing a long (Middle of October to that of April) moisture deficit season when rate of evaporation far outweighs that of precipitation. As a consequence, the residents have to suffer from acute water scarcity during those days of no rainfall because the municipal authority hardly manage to supply the minimum required water. The storage reservoir at Dowhill receives 1.737 and 0.358 M. lit. water per day from Daraykhola, Chitroikhoha, Pahakhola and Babukhola through the existing network of pipe lines during wet and dry season respectively where the daily demand of water at Kurseong Municipality area is 3.0718 M. lit / day at a rate of 70 lit / day / person for residential population and 40 lit / day / person for floating (Tourist & School) population. At the present growth rate, the demand of water per day may reach 9.15 M. lit / day in 2051. Public Health Engineering Dept. at Kurseong, considering the urgency of improvement of the supply system, planned for establishment of few reservoirs, tapping of new streams of upper and distant slope, increase of diameter of the receiving pipes etc. The present study reveals the necessity of long continued thorough geologic, geomorphic and hydrologic study of the concerned slope, upper & lower catchments of jhoras in a holistic and cognitive approach.

Key Words : *Precipitation, Evaporation, Discharge, Perception, Jhora, Water scarcity.*

Introduction

Kurseong being established in the year 1879 on steep southern slope of mountain Himalaya gradually becomes famous as a hill station of "White orchid" with hospitable climate, exciting natural beauty and established tradition of sophisticated school education. The attractive job opportunity from tea industries, educational institution and world heritage Himalayan Railway, increasing tourism, health care facilities from T.B. Sanatorium, and sub-divisional hospital etc. setup a strong pull for concentration and rapid growth of population at Kurseong town. In spite of suffering from geomorphological, geotechnical and hydrological constrains, the municipality has to bear the burden of ever increasing population and settlement. In addition to this, the fast growing educational institutions and

tourist constitute huge to make the burden unbearable and as a result, congestion and scarcity of basic amenities become inevitable.

Water being a life supporting resource, rightly deserves immediate attention to its availability with adequate quantity as well as standard quality and the proper preservation for future use from present day users and planners. Geographers, engineers, hydrologists and other physical and social scientists responded of this urgent issue from various point of view. The demand of water and the governance of its supply through planning in Kolkata municipality is studied by Basu and Main in 2001. Problems and prospects of water supply in Darjiling town was carefully studied by Rumba in 1986. Urbanisation and its effects on surface and sub-surface hydrology is an important facet of study of water scarcity in an urban area (Lama 1994, Lama and Sarkar, 1995). Thorough study in varied aspects of existing water use is to be made for proper cognition into the factor responsible for water crisis, (Dabi Daniel and Inderson 1999). The prospect of hill springs as potential source of fresh water has analysed by Rai, Singh and Solanki in 1988. The rational management of available water resource through proper planning for assuring the optimum relation between supply and demand is felt very urgent (Beaumont, 1983, White and Howe, 2004).

The present work makes an attempt to address the problem of water scarcity in Kurseong municipal area in the light of increasing demand, seasonal concentration of rain, decreasing discharge from drying jhoras and springs for increasing human occupation on slopes by deforestation and removal of surface cover. An attempt is also made to review the existing water supply system and the proposal for future augmentation from geographical point of view.

The Study Area

Location : Kurseong town is situated at a height of 1500 m above mean sea level consisting of 20 wards spreading over 5.05 sq. km. within 26°51'25" N - 26°52'55" N latitude and 88°16'35"E - 88°17'10" E longitude (Fig.–1). Being situated at the junction of Hill Cart Road and Pankhabari road, two trunk route connecting Darjiling to the north and Siliguri to the south, its location attains a nodal character.

Physical Background

Kurseong is located on the Senchal–Mohaldiram ridge which extends from Ghum at the north to Kurseong at its south ranging from an elevation of 2438 m to 2621 m in its northern half and about 2134 m towards the south having highest points at East Senchal (2621 m), Tiger Hill (2717m) and West Senchal (2488 m). The Senchal–Mahaldiram ridge is divided in two spurs, one extending towards SSW and other at SE direction. The area, between these two spurs, is highly dissected by numerous tiny streams and produce a rugged topography having a few human habitation. The western slope of Senchal-Mahaldiram ridge on which the total Kurseong and its suburb is situated, is comparatively gentle (12°-20°) dip-slope whereas the eastern escarpment slope is steeper (25° – 35°). Though the ridge top or crest is the ideal place for the expansion of hill settlement

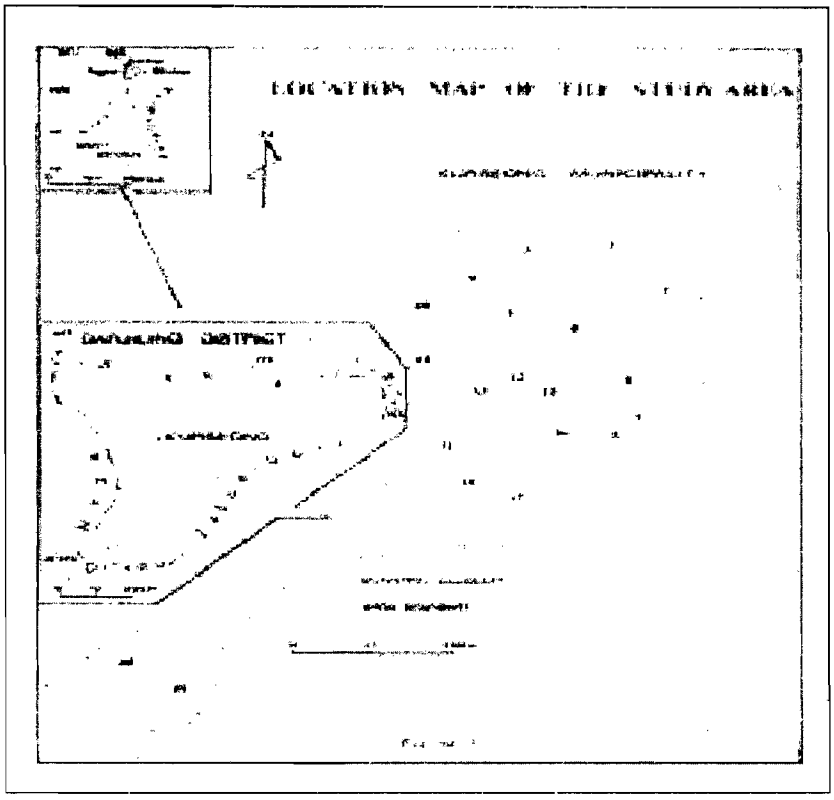

Figure 1. Location Map of the Study Area

but, in this case, as the water divide is narrow (250 m on an average), the town flourished on the comparatively gentle western slope. Here the ridge is highly dissected by the first order streams of both Balason and Mahanadi basins and at some places it becomes narrow and sharp on which the development of township is not possible. The study area being located almost at the upper section of the water divide between the Balason and the Mahanadi, mainly drained by the first order, non-perennial and torrential streams with high erosional capacity. The southern steep escarpment is drained by Rakti Khola, a tributary of the Balason, whereas the eastern slope is dissected by Shivkhola, the tributary of the Mahanadi. For the sake of development and growth of Kurseong town the natural vegetation is continuously being reduced. Beyond the municipality, the western slope is mainly covered by the tea gardens and some scattered trees, on the other hand, the eastern escarpment slope on which the settlement is less is still covered by forests eg. Paglajhora R.F., Mahaldiram R.F. etc. and with some patches of tea gardens and scattered trees.

The Problem

Kurseong municipality being situated on steep slope at the upper catchment of Hussain Khola watershed suffers from the availability of surface water. In spite

of receiving almost maximum amount of rainfall in West Bengal, Kurseong suffers from the water scarcity because of immediate drainage of rain water on steep slope and absence of depression as well as sub-surface storage. The sufficient accumulation of available surface water is not also possible because of its closer vicinity to the water divide. A perception survey was carried out for prioritization of the urban problems. Seventeen of such problems are identified of which, water crisis, transport, sewage, sanitary and garbage problems are disclose as alarming. All (150) the responses are grouped into rank I to rank IV according to the relative importance of the problems as the respondents perceive and as it is revealed by the opinions from an individual respondent (Table-1). 35% of all the responses considers water crisis as the most alarming problem. 69 responses for 1st priority problems are recorded, of which 54% (37) are equivocal about water crisis, which demands immediate attention from authority as well as inhabitants.

The Methods

The present study aims to investigate into the physical viz. edaphic, climatic, geomorphic and human attributes of the study area leading to the scarcity of water. The edaphic factors are evaluated based on the available published and unpublished information form DTRI, Kurseong and laboratory analysis of collected soil samples from upper catchment of Hussain Khola. The analysis of the seasonal distribution of rainfall in relation to the evaporation potential is made on the

Table 1. Showing the relative importance of Urban Problems

Urban Problems	Rank of the problems				Total
	I	II	III	IV	
Water Crisis	37	14	4	0	55
Transport Problem	8	15	2	1	26
Sewage Problem	5	7	4	0	16
Sanitary Problem	3	6	4	1	14
Garbage Problem	5	0	7	0	12
Unemployment	2	2	0	0	4
Lack of Recreational Facility	0	2	2	0	4
Landslide	1	1	1	0	3
Footpath Problem	1	2	0	0	3
Street Light Problem	1	1	0	1	3
Weather Problem	1	1	0	0	2
Pop Problem	1	0	1	0	2
Smoke Problem	2	0	0	0	2
Health (Hospital)	1	0	0	0	1
Deforestation	0	0	0	1	1
Schooling (Govt.) Problem	0	1	0	0	1
Ration Card Problem	1	0	0	0	1

***Source** : Perception Survey*

basis of information available from meteorological office, Kurseong for the identification of surplus and deficit situation of surface water in normal condition. The geomorphic factors mainly slope, distance from water divide, physiographic configuration for laying off the pipe lines etc. are studied from both SOI Topographical Map (1:50,000) and field investigations. The hydrologic factors mainly potential discharge from a hill springs are measured in the field during dry season mainly with draining, storing and measuring the stored water during unit time. Hazen Williams formula (PHE Report) is used for the calculation for contribution of the Jhoras (or hill springs) to the storage reservoir at Dowhill in connection to diameter of pipe, coefficient of friction and rate of frictional head loss. The maximum possible discharge from the streams during dry and wet seasons are also consulted from the unpublished report of PHE, Kurseong Division. The rate of population growth and the tendency of increasing demand are evaluated from census reports of concerned years and the potential demand of water in future is estimated through the calculation of population projection up to 2051 (Table–3) by geometric progression method. The total demand of water from residential as well as tourist and School and / or College sector are calculated taking the average demand of 70 lit / person / day from residential sector and of 40 lit / person / day from tourist / school sector (Following municipality report).

Results and Discussion :

The variable thickness of regolith and soils is the longitudinal slope profiles depends on the rate of weathering and intensity of mass movement, connected with slope gradients. Most frequently the regolith of several meters thick, is preserved over flattened watershed or spurs in the upper valley reaches. At their base the weathered gneisses form the rounded less-decomposed structures of core stones. (Froehlich and Sarkar, 2000). On an average, the soil of Kurseong is composed mainly of the coarse sand (48.6 – 59.9%) (Table–2), indicating greater porosity and water holding capacity mainly at the upper (A_p) horizon. The percentage of clay particle ranges from 6.9 – 14.7, the maximum being registered at B_2 horizon within 97 – 114 cm from surface. This indicates the illuviation of the elluviated particles of this level. The argic layer at B_2 horizon introduce impermeable character which, in turn, helps the upper horizons to hold more moisture than usual. Generally, the depth of soil on steep slope of Kurseong area is less. Soil character of upper catchment of the hill streams are the essential indicators of their perenniality. The continued supply of water into the channel, long after the rainy season, can be expected from the soil of greater depth, with greater water holding capacity and bulk density. Five distinct soil horizons viz. A_p, A_c, B_1, B_2, and C are identified at 0 – 13 cm, 14 – 31 cm, 32 – 37 cm, 38 – 114 cm. and 114 – 130 cm depth respectively, indicating the lower depth of soil.

Kurseong experiences a sharp increase in population since 1950, the maximum increase of 49.56% recorded during 1991 – 2001 followed by that of 48.59% during 1981 – 91 (Fig.–2). Households, the basic units for water demand, also registered sharp growth at a rate of 30.35% and 34.13% during 1981 – 91 and 1991 – 2001 respectively (Fig.–2).

Considering the growth of population during 1951 – 2001, an average growth rate (0.244) is calculated and projected population for 2011, 2021, 2031, 2041 and 2051 are calculated accordingly. An additional tourist population of 10% and school / college / office population of 5% are included according to municipality report (Table-3). Due to sharp increase of residential as well as floating population, the total required amount for supply increases at a faster

Table 2. Showing the change of soil character with depth from surface

Depth (cm.)	Practical size Distribution (<2.0 mm fractions only) (In %)					Textural class	Water holding capacity (%)	Porosity (%)	Bulk Density (gcm^{-3})
	Coarse sand (0.25-2mm)	Fine sand (0.25-0.05m)	Coarse silt (0.05 – 0.02)	Fine silt (0.02 – 0.002m)	Clay (<0.002mm)				
0-13 (A_P)	52.2	21.0	8.5	5.6	12.7	Sandy Loam	39.23	40.02	1.39
13-31 (A_C)	50.9	22.6	8.9	7.2	10.4	Sandy Loam	37.56	38.26	1.36
31-97 (B_1)	48.6	22.7	7.8	6.3	14.6	Sandy Loam	38.21	39.59	1.36
97-114 (B_2)	50.8	23.0	7.2	5.3	14.7	Sandy Loam	36.32	37.29	1.33
114-130 (C)	59.9	18.2	8.7	6.3	6.9	Loamy Sand	35.01	36.3	1.37

Source : Saha, Mondal, Bisen, 1995

rate. The required amount at present is 3.07 M. Lit / day, which may rise to 3.82, 4.75, 5.91 and 9.15 M. Lit / day on 2011, 2021, 2031, 2041 and 2051 respectively (Table-3).

One attempt is made to calculate the amount of contribution from the tapped jhoras to the storage reservoir at Dowhill. The diameter of the pipe, length of the pipe, the static head differences for each jhora, rate of frictional head loss and available active head etc. are given due consideration in this regard. The contribution of jhoras during July and January conditions is calculated to get the idea of supply in wet and dry seasons. The diameter of pipe line from Daray Khola, Chitroi Khola and Pahakhola is 3" i.e. 76.2 mm. Only that from Babu Khola is 6 i.e. 52.2 mm. At present through these pipes total contributions from the jhoras during wet and dry seasons is 1.737 M Lit/day and 0.36 M. Lit / day (Table-4) respectively which it too less to satisfy the present demand. The authority cannot supply water throughout its municipal area daily but has to divide the entire area into numbers of sectors and planned for sector wise distribution of water. Thus a particular sector receives water at an interval of 2

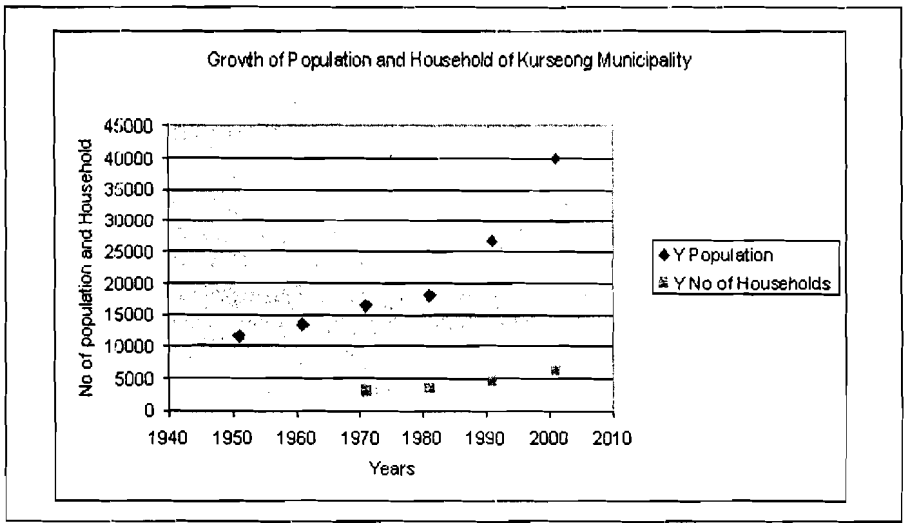

Figure 2. Showing the trend of population and household growth

Table 3. Showing the projected demand of water at Kurseong Municipality

Year	Residential population	Demand from Residential population (M.Lit) [@ 70 Lit / capita / day]	Floating population (Tourist + School) (10% + 5% = 15%)	Demand from floating population (M. Lit) [@ 40 lit / capita / day]	Total Demand (M. Lit / day)	Wastage (10%) while arriving supply point	Total Required amount (M. Lit / day)
2001	40,019	2.8013	6,002	0.2401	3.0414	0.0304	3.0718
2011	49,784	3.4849	7,468	0.2987	3.7836	0.0378	3.8214
2021	61,931	4.3352	9,289,	0.3716	4.7068	0.0471	4.7539
2031	77,042	5.3929	11,556	0.4622	5.8551	0.0586	5.9137
2041	95,840	6.6836	14,376	0.5750	7.2586	0.0726	7.3312
2051	1,19,225	8.3458	17,883	0.7153	9.0611	0.0906	9.1517

***Source** : Field Survey (Household wise) and Municipality Office of Kurseong*

– 3 days in normal condition and this duration may even goes up to even a week in dry season.

So far the perception of local inhabitants is considered, water crisis is the most important urban problem, inviting immediate attention from local authority and government. Almost all the respondents feel water crisis as an ever increasing problem due to faster growth of demand on one hand and decreasing supply from jhoras on the other. The less and even decreasing depth of soil due to increasing soil erosion and landslips favoured by deforestation and removal of soil cover at the upper catchments of the jhoras can hold less moisture and this makes the jhoras incapable of releasing sufficient water for long duration after the rainy season. The jhoras are thus turned to ephemeral. The analysis of relative relation between precipitation and evaporation shows the surplus condition only during the monsoon months.(Fig-3) In the year 2001, for example, 100% of annual rainfall was concentrated during five months period (16th May

– 15th Oct.). The other of seven months period does not receive any rainfall and suffers from deficit of moisture for a continuous duration (Fig.- 3).

The cumulative deficit become unbearable making almost all the supplying jhoras dry and unproductive. The discussion with the senior and educated members of the society during perception survey revealed the gradual concentration of almost all the rainfall during rainy seasons. The chief executive engineer of PHE was of the opinion that this concentration of rainfall may be due to the absence of condensation nuclei in the form of spores as a result of extensive deforestation. This concentrated rainfall during rainy period immediately drains faster down slope, sometimes causing soil erosion and landslide and thus cannot be utilized to harness optimum utility. The increasing growth of population and consequent demand on one hand, the gradual concentration of rainfall, extensive deforestation etc. on the other are thus making the situation more aggravating. The Kurseong Municipal authority thus planning to store this surplus water in a number of newly constructed reservoirs and to tap the jhoras of far high attitude (Fig. – 4) to ensure supply in dry seasons.

Conclusion and Recommendations

From the above analysis it is clear that immediate improvement of existing water supply system of Kurseong is essential to cope with increasing scarcity. The seasonal distribution of rainfall and flow character of the streams suggests

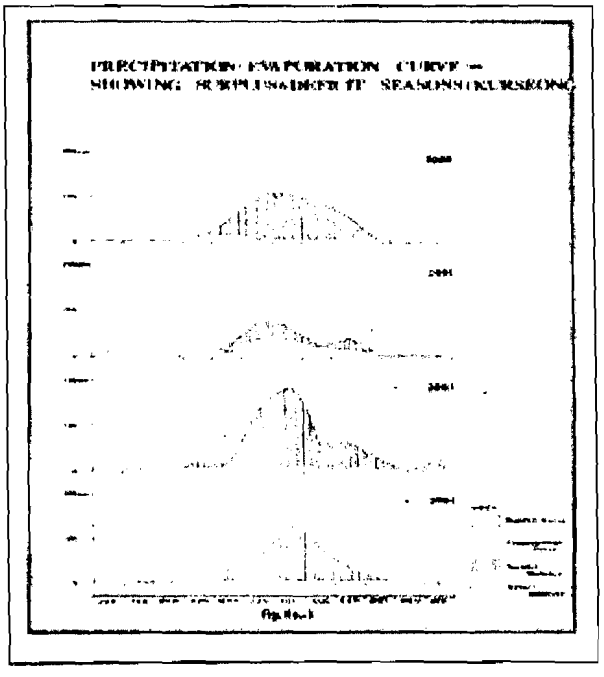

Figure 3. Precipitation-Evaporation Curve– Showing surplus & deficit Seasons (Kurseong)

for the targeting of new jhoras at far higher and less disturbed slopes. For this purpose, the improvement proposal includes the tapping of 8th mile Khola, Tendulkar Khola, Aringalay Khola, Thotey Khola and Sepoydhura Khola (Fig.-4) together yielding 3.319 M. Lit/day (in Rainy season) and 1.705 M. Lit/day in dry season (Table-4).

The water from these five sources is to be carried down to the proposed storage reservoir of 18 M. Lit capacity near Sepoydhura (1751m) through the gravity main of 250 mm diameter with available hydrostatic head of 147.90 m. The geologic, hydrologic, geomorphic and environmental effects of this construction has to be analysed prior to its execution. The possible downward pressure from construction material and stored water has to be studied by the analysis of compressional and tensile strength through Tri axial compression test of slope forming materials. The possible hydrologic impact of arresting such a huge amount of water from the source region on down stream sectors, the effects on sediment character etc are to be given due consideration. The intensity of pressure on land through land use, rate of present and potential

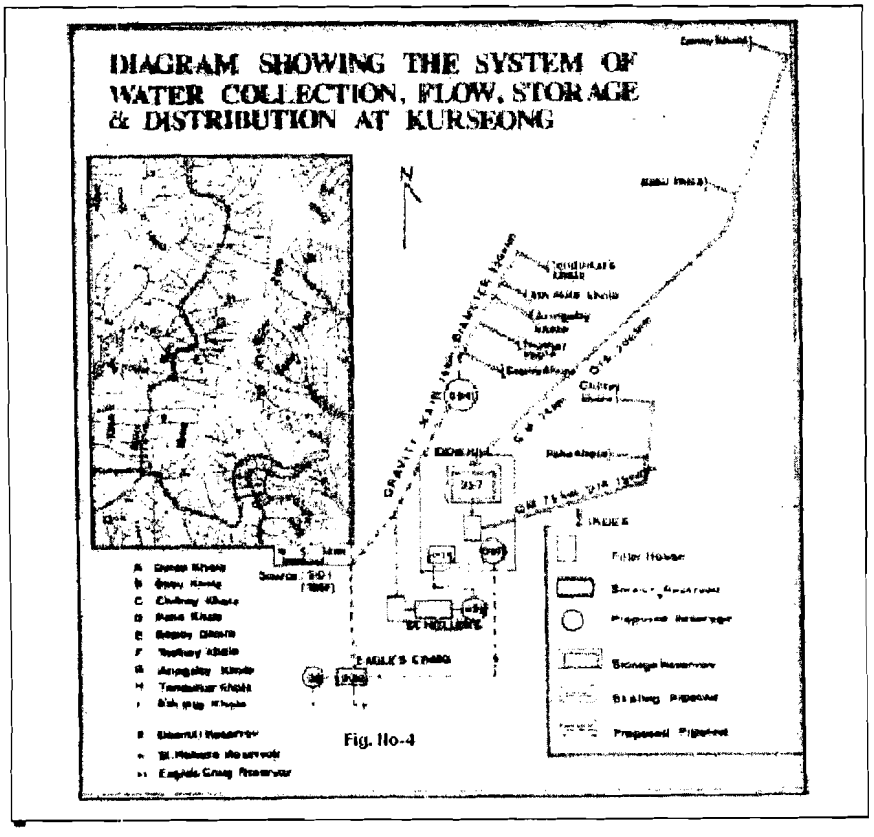

Figure 4. Diagram showing the system of Water Collection, Flow, Storage & Distribution at Kurseong

Table 4. Showing the physiographic and hydrologic attributes of the kholas contributing water to Dowhill Storage Reservoir

KHOLA / STREAMS		DARAY KHOLA	CHITROI KHOLA	PAHA KHOLA	BABU KHOLA
ATTRIBUTES					
1.	Diameter of pipe line (D) *	76.2mm	76.2mm	76.2mm	152.2 mm
2.	Length of gravity Main	11 KM	2.5 km	5 km	7 km
3.	Height of Receiving (tapping) point	1860 M	1770m	1705m	1840 m
4.	Height of Dowhill reservoir	1670 M	1670 m	1670 m	1670m
5.	Static head difference	190 M	100m	35 m	170m
6.	Rate of permissible frictional head loss (H)	5m/km	4.5m/km	5.5 m/km	5m/km
7.	Total frictional head loss	11 km x 5m/km=55m	2.5 km x 4.5 m/km = 11.25	5km x 5.5 m/km = 27.5m	7km x 5m/km = 35m
8.	Available head	190 m-55 m = 145m	100m-11.25m = 88.75m	35 m – 27.5m = 7.5m	170m-35m = 135m
9.	Active gradient	145m : 11000m = 1:75.86	88.75m : 2500m = 1:28.17	10m : 5000m = 1 : 500	135 m : 700 m = 1 : 51.9
10.	Co-efficient of friction along the pipe line (C)*	120 (maximum)	120 (maximum)	120 (Maximum)	120 (Maximum)
11.	Daily contribution to storage Reservoir (M. Lit / day) Hazen Williams Formula $Q = 7.436x10^{-9}xCxD^{2.63} x H^{0.54}$				
	a) Rainy Season (July Condition)	$Q = 7.43x10^{-9}x120x76.2^{2.63}x5^{0.54}$ Q=0.18945497 M.Lit/Day D = 76.2 mm H = 5m/km	$Q=7.436x10^{-9}x120x76.2^{2.63}x4.5^{0.54}$ Q = 0.178997689 M.Lit/Day D = 76.2mm H 4.5m/km	$Q=7.436x10^{-9}x120x76.2x2.63x5.5^{0.54}$ Q=0.199461028 M.Lit/Day D = 76.2mm H = 5.5m/km	$Q=7.436x10^{-9}x120x152.2x50.54x2.63$ Q=1.168732081 Mlit/day D = 152.2m, H=5m/km
	b) Dry Season (January Condition)	$Q=7.436x10^{-9}x120x508^{2.63}x5^{0.64}$ Q = 0.6522078M.Lit/Day D = 50.8mm H = 5m/km	$Q = 7.436x10^{-9}x120x48.68^{2.63}x10^{0.54}$ Q = 0.055079169 M lit / Day D = 48.68mm H = 10m/km	$Q=7.436x10^{-9}x120x44.45^{2.63}x5.5^{0.54}$ Q=0.04833027 M. lit/Day D = 44.45 mm H=5.5m/km	$Q=7.436x10^{-9}x120x152.2x50.54x2.63$ Q=0.18945494M. lit/day D = 76.2 H=5m/km
12.	Maximum Possible Discharge. * Wet Season Dry Season	1.31 M Lit/Day 0.68 M.Lit/Day	0.89 M. Lit/ Day 0.45 M.Lit/Day		

* Dept. of Public Health Engineering, Kurseong.

soil erosion at the upper catchments of the targeted streams have to be analysed in details. The analysis of perenniality in the term of duration (in days) after significant rain with respect to forest cover, soil depth and land use etc have to be studied thoroughly before going into the execution of such a huge project.

The perfect water supply system in a hill station like Kurseong depends on proper cognition into the interworking of relevant geologic, geomorphic, edaphic, climatic, hydrologic and demographic factors. Long continued study of these factors can reveal the systematic interaction among these, and only this can help in planning for a future supply scheme in accordance with the increasing demand, changing climate and increasing slope instability. The alignment of pipelines, construction of storage reservoir on such a steep and instable slope essentially need to make a detailed geotectonic study of soil and slope forming materials. The nature of seasonal distribution of rainfall has to be studied for proper work- plan of future supply project for better functioning of it yielding optimum utility.

Acknowledgement

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WOMEN-ENVIRONMENT RELATIONSHIP WITH SPECIAL REFERENCE TO COLLECTION OF DOMESTIC WATER, FUEL AND FODDER — Case Study of Four Selected Mouzas of Nayagram Block, Paschim Medinipur, W. B.

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Abstract

There is a strong case for launching a project to examine in detail the position of women in rural Bengal more so in the South Western Bengal where the natural environment in the past was closely related to forest which have vanished over the years. Along the shrinkage of forests the natural water availability and availability of pasture for domestic animals must have also suffered adversely. It is not very difficult to formulate a general hypothesis that water, fuel and fodder basically belong to the domain of the women folk in rural West Bengal in so far as household management is concerned. Since, natural vegetation is closely linked with the fodder prospects and the deterioration overtime must be logically connected with the sufferings of women. To what extent this statement is valid depends upon the local environmental situation which is why a large number of cases will be probed, differing widely in their locations and environmental settings. In the present paper attempts have been made to assess the relationship between women and their immediate environment and to delineate the struggle for existence in four mouzas of Nayagram Block, Paschim Medinipur, West Bengal.

Key words : *Pasture, Household management, Struggle for existance*

Introduction

A healthy environment is crucial in order to meet the primary needs of the world pupulation. Women particularly those living in the rural areas of third world countries play a major role in managing environmental resources— soil, water, forests and energy. Their tasks in agriculture and animal husbandry as well as the household maintenance make them the daily managers of the living environment. They have a profound knowledge of the plants, animals and ecological processes around them.

The principal victim of environmental degradation are the most underpriviledged people and the majority of them are women. Their problems and their immediate environment are very much interrelated. Because of the complex cycles of poverty, inappropriate development and environmental degradation, the poors have been forced into such ways of living as induce

further destruction. The links between poverty and the state of environment, have only recently begun to be recognised by environmentalists, development specialists and those engaged in raising the status of women.

There are innumerable facets of life in which women are compelled to react with their natural surroundings. The collection of domestic water, domestic fuel and fodder are only three major facts in the sphere of interaction between women and natural environment, relatively untrodden by technology, al though, there are a large many cases where women come into contact to perform their major tasks of life i.e. raising their families.

A survey had been conducted in four mouzas at Paschim Medinipur District of West Bengal at some depth through observations at visual facts relating to the phenomenal environment and human practices, group discussions and canvassing open-ended and closed questionaire schedule among a sample of 32 households differentiated along age, income ethnicity and gender.

Objective of the Study

The main objective of study is to assess the relationship between women and their changing environment in some specific habitats of Nayagram Block Paschim Medinipur District of West Bengal and of examine how much extent people particularly women suffer and combat against this changing environment to perform their essential tasks to run the family such as collection of domestic water fuel and upkeep of domestic animals.

The study is organised at mouza level and within each mouza the results of the household level enquiries will be disused through the mouza level and household level perception survey schedule.

Study Area

In West Bengal the surest proofs of steady environmental change are to be had from the undulating western plateau margine of the South Western parts of the state, namely, the districts of Paschim Medinipur, Bankura, Birbhum and Puruliya. For the present study we have taken Nayagram Block of Paschim Medinipur for general environmental study and four mouzas, namely, Dalkisol (138), Bhalukbasa (174), Kshemasol (287) and Rokhni (282) for detailed door to door perception survey.

Nayagram block is situated at the South Western part of Paschim Medinipur district and have a crucial location between Bengal-Orissa border. The astronomical location of Nayagram is 21°50´N – 22°15´N latitude and 80°55´E – 87°15´ E longitude. The most significant physical component of this block is the river Subarnarekha, the lifeline at this area.

Data Base

The present study depends on the information of various sources. These are categorised into secondary information from census and other statistical reports, various maps, i.e. toposheets, satellite imageries, cadastal maps and primary information from field.

Table 1. Broad facts about Nayagram Block

Physiography& Elevation (mt)	Buried rock out-surfaces resembling pediments of yellow regims, flood plains, valley fills, extensive and banks and lateritic uplands. Highest elevata = 80, Lowest elevatum = 40
Soil	Lateritic, grey loam, red loam, having a high clay content.
Drainage	North-west to south-east flowing the principal river Subarnarekha having numerous point-bars, natural levees, paleo-channels and flood plains.
Climate	Prevalence of humid tropical climate with hot summer & cool winter and relatively well distributed rainfall.
Natural vegetation	Dense, open and degraded sal, scrublands eucalyptus plantation & forest blanks, protected forest with sal, tendu, arjun, asan, kusum, mahua, bamboo, bhela, babui grass.
Distance (km) from Head-quarters to Kolkata	Nayagram to Kharagpur = 50 (Rd.), Kharagpur to Medinipur = 13 (Rly.)Medinipur to Kolkata = 133 (Rly.)
Mode of Communication	Kolkata to Kharagpur –Train & Bus; Kharagpur to Nayagram–Bus.

Broad Facts about the Selected Block

A brief list about the natural set-up, socio cultural conditions of our selected block, Nayagram are given in Table 1.

Results from Mouza Level Survey

At present we come to the point of questionair schedule which deals not only the fuel, fodder, drinking water condition of four selected mouzas but also the above said condition of individual household. First we will assess how women cope with such an environment, what is the condition of drinking water, fuel, fodder and whether womenfolk feel any problem or not to collect these three daily requirements and we vanalyze all these facts with the help of mouza-wise questionnaire schedule of four selected mouzas, But before that it is much more relevant to present here. Population statistics and few major categories of economic data of these four selected mouzas.

Population

The four sample mouzas have seven localities among which two are in Dalkisol (*Mukhi para, Santal para),* two in Kshemasol *(Sadgope para, Santal para),*One in Rokhni (*Rokhni para)* whereas two are in Bhalukbasa (*Uttar Bhalukbasa and Dakshin Bhalukbasa).* These seven localities consist of 107 families among which 8 in Dalkisol, 67 in Kshemasol, 19 in Rokhni and 12 in Bhalukbasa. The total general caste families are 16 where as total Scheduled Caste and Scheduled Tribe families are 11 and 80 respectively. Among these 107 families we have taken 32 families as sam-ple to whom we asked our questions. Among 32 samples 5 are in SC families 23 are ST families and 4 are in general caste families. The average family size of SCs, STs and other general castes are 5.0,

5.83 and 7.25 respectively. The total estimated population of SCs, STs & others are 55 (11 x 5.0), 466 (80 x 5.83) and 116 (16 x 7.25) respectively. Thus, the total estimated population of four mouzas is 637 and the aver-age family size of four mouzas is 5.95. If we take this family size as ideal for whole Nayagram Block then the estimated population in 2004 is 122252, whereas the actual population according to 2001 census is 123937. The difference of only 1685 persons is quite perceptable keeping in mind the fact of demographic growth. If we take into consideration the family size of different ethnic groups then we see that there is a great difference between the family size of other general castes (7.25) with Sched-uled Castes (5.00) and Scheduled Tribes (5.83). This case is contradictory to our prenotion that socio-economically backward classes have larger family size. In the case of Nayagram, Scheduled Castes have this power to capture maximum socio-economic facilities to their favour and have consciously reduced their family size because they know that it is the only means by which they can fight against the present degraded physical environment. The relatively higher family size of Scheduled Tribes indicate the socio-economic backwardness and unconsciousness. The higher rate of family size of non-Scheduled population is an indicator of complacency and higher economic status. The demographic and occupational characteristics of selected four mouzas are given in the following table (Table 2.).

Water

There are total 13 dug wells and 1 spring and no tubewell as drinking water sources in the above four mouzas. Among 13 dug wells 6 are located in Bhalukbasa, 2 in Dalkisol, 4 in Kshemasol and 1 in Rokhni. The spring is located at the forest fringe of Dalkisol. Among 13 dug wells 5 are *pucca* and 8 are *kutcha* and five years before these mouzas have 12 dug wells. 6 wells of Bhalukbasa serve 12 families whereas 2 wells serve 9 families of Dalkisol, 67 families of Kshemasol are served by only 4 wells and only 1 well serves 19 families of Rohkni. The drinking Water situation is worst at Kshemasol and Rokhni whereas Dalkisol and Bhalukbasa are two rather fortunate villages. All dug wells of Kshemasol dri-up in summer and the people suffer from acute scarcity of water. Then they have to walk 3 kms per day to bring the water from a wells situated in paddy field of nighbouring mouza. The same position is found at Rokhni. The drinking water supply is quite normal at Dalkisol end Bhalukbasa. The average water level of four mouzas during pre-monsoon and monsoon period are 14' and 3' which are quite low. It is difficult to dug well at greater depth in these areas because the loose structure of undernith soil. The average quantity of water needed of 4-5 members is 220 lts. per day which may rise upto 370 lts. for 9-10 members of a family. The pre--monsoon requirement of water is high (280 lts.) than the monsoon (240 lts.) and post-monsoon period (260 lts.). It is seen particularly at Kshemasol because during summer season they use the sources of drinking water for bathing and other domestic purposes also. All the ponds, tanks dry up during this season. The requirement of water is high also because of soft water which produce plenty of lather when soaps

Table 2. Gender Differentials in Socio-Demographic Structure

Categories	Dalkisol (138)		Bhalukbasa (174)		Kshemasol (231)		Rokhni (282)	
	1991	2001	1991	2001	1991	2001	1991	2001
Total Population	38	30	102	86	319	474	167	174
Total Male Population	19	12	48	44	149	240	73	84
Total Female Population	19	18	54	42	170	234	94	90
Total S. C. Population	1	5	28	19	29	58	0	0
Total Male S. C. Population	1	3	12	9	12	21	0	0
Total Female S. C. Population	0	2	16	10	17	37	0	0
Total S. T. Population	20	21	74	67	229	283	140	174
Total Male S. T. Population	10	11	36	31	104	135	63	84
Total Female S. T. Population	10	10	38	36	125	148	77	90
Total Literates	29	17	24	35	61	206	43	97
Total Male Literates	17	10	18	27	49	139	30	64
Total Female Literates	12	7	6	8	12	67	13	33
Total Main Workers	11	10	38	48	164	189	85	37
Total Male Main Workers	10	8	35	26	89	108	43	31
Total Female Main Workers	1	2	3	22	75	81	42	6
Total Agricultural Lab	3	2	18	4	103	8	4	16
Total Male Agricultural Lab	3	2	1	0	47	7	2	11
Total Female Agricultural Lab	0	0	17	4	56	1	2	5
Total Cultivators	2	7	15	53	44	43	78	23
Total Male Cultivators	1	4	15	31	32	43	40	23
Total Female Cultivators	1	3	0	22	12	0	38	0
Total Man, Proc etc in Household Industry	01	0	5	8	15	194	3	63
Total Male Man, Proc etc in Household Industry	01	0	3	5	8	66	1	15
Total Female Man, Proc etc in Household Industry	0	0	2	3	7	128	2	48
Total Marginal Workers	0	5	31	18	31	84	31	77
Total Male Marginal Workers	0	0	0	10	6	33	1	23
Total Female Marginal Workers	0	5	31	8	25	51	30	54
Total Non workers	27	20	33	15	124	201	51	60
Total Male Non workers	9	8	13	4	54	99	22	30
Total Female Non workers	18	12	20	11	70	102	29	30

***Source :** District Census Handbook (Medinipur District).*

are used for cleaning clothes. To bring domestic water to home is a laborious job particularly during summer season and generally women have to do this.

Fuel

The inhabitants of these four mouzas use different types of fuel which are mostly collected from neighbouring areas. Kshemasol and Rokhni have no forest and Dalkisol and Bhalukbasa have their own forest cover. All of four mouzas use small branches and twigs, crop wastes, husk and bran of rice, straw as fuel. They also use leaves except Bhalukbasa and Kshemasol alone use cowdung cakes. The people of these mouzas do not use any other imported fuel like coal, kerosene, gas etc. Dalkisol and Rokhni mostly use split wood from neighbouring *jungle* Kshemasol and Bhalukbasa tlso collect fuel from neighbouring *jungles*. People are compelled to use fuel from other sources like husk and bran of rice and straw though their use is restricted. The requirement of fuel of 4-5 members of a family is 11 kg split wood per day which is 14 kg and 17 kg for a family of 6-8 persons and 9-10 members. Though Rokhni and Kshemasol have no forest cover yet, forest is the main supplier of fuel to them. Among four mouzas, Bhalukbasa and Dalkisol have their own Forest Protection Committee, namely, *Bhalukbasa Banaraksha Committee* and *Kamlatota Banaraksha Committee*. An F.P.C. was in Rokhni and neighbouring villages, namely, Chandua and Palasia 5 years back from now. This F.P.C. was abolished because of internal dispute between villagers and Forest Department. Even in Bhalukbasa and Dalkisol, now the villagers are not the member of F.P.C. though they were all the members of the same 2 years back. They became extremely unhappy to the activities of Forest Department and gradually left the F.P.C. No villagers of these three mouzas get any profit from FPC Bhalukbasa and Dalkisol have 61.51 percent and 62.58 percent of forest cover to their total geographical area in 1998. According to 1991 census these four mouzas have their own forest cover which are 79.84 percent in Dolkisol, 1.56 percent in Bhalukbasa, 38.845 in Kshemasol and 14.96 percent in Rokhni. There is no natural forest cover at Kshemasol amd Rokhni in 2004. The afforestation programme has been launched at Dalkisol and Kshemasol between 1998 and 2004. *Eucalyptus* is the only planted tree.

Fodder

At Rokhni and Dolkisol cattle are allowed to graze all the year round with cattle herder whereas at Kshemasol and Bhalukbasa cattle are freely grazed all the year round except monsoon period. There are no grazing ground as such at these four mouzas. Cattle mainly graze in *jungle* at Bhalukbasa and Dalkisol whereas on fallow and uncultivable land at Rokhni and Kshemasol. Now all mouzas suffer from shortage of fodder and there have not been any appreciable change during the last five years. Grasses and leaves in *jungles* and fallow lands are the main sources of fodder which were also the major sources in the past. The mouza level information relented the above facts are shown in Table 3.

Results from Household Survey

Now we will discuss the relationship between women and changing environment with special reference to collection of water, fuel and fodder in our selected mouzas of Nayagram Block serially.

Table 3. Information From Mouza Level Survey
Dalkisol, Bhalukbasa, Rokhni & Kshemasol, Nayagram Block, Paschim Medinipur–2004

Population

Mouza (J.L.No.)	Locality	No. of Families (2004)			
		General	S.C	S.T.	Total
Dalkisol(138)	Mukhi Para	I	6	—	7
	Santal Para	—	—	2	2
Bhalukbasa(174)	Uttar Bhalukbasa	—	3	5	8
	Dakshin Bhalukbasa	—	—	4	4
Rokhni (282)mi (282)	Rokhni Para	—	—	19	19
Kshemasol	Sodgope Para	15	2	—	17
	Santal Para	—	—	50	50
Total		16	11	80	107

Water

Particulars		Mouzas			
		Dalksol	Bhalukbasa	Rokhni	Kshemasol
Sources of Drinking Water	Well	P=2	P-1, K-5 = 6	P-1, K-1=2	P-2, K-2 = 4
	Tubewell	—	—	1	1
	Other (R/S/T)	—	—	—	—
Depth to Water Level in Feet	Pre-Monsoon	10-12	11	10	10-12
	Monsoon	2-3	1	1.5	2-3
	Post-Monsoon	5-6	7	6.5	5-6
Water Scarcity	Pre-Monsoon	Moderate	Moderate	Acute	Acute
	Monsoon	No	No	No	No
	Post-Monsoon	No	No	Moderate	Acute

Water

Particulars		Mouzas			
		Dalksol	Bhalukbasa	Rokhni	Kshemasol
Requirement as per Family	4 - 5	250	200	200	300
	6 - 8	300	250	250	350
	9 - 10	350	300	300	380
Seasonal Need for a Family of 6-8 in Litre	Pre-Monsoon	300	300	300	200
	Monsoon	200	150	200	400
	Post-Monsoon	250	250	250	300

Note : P = Pucca K = Kutcha R = River, S = Spring

Fuel and Forest

Particulars		Mouzas			
		Dalksol	Bhalukbasa	Rokhni	Kshemasol
Types of Fuel Used	Woods, twigs	✔	✔	✔	✔
	Crop wastes	✔	✔	✔	✔
	Leaves	✔	✔	✔	✔
	Cowdung cakes	Nil	Nil	Nil	✔
Requirement as per Family Size in Quintal coal Equivalent PerYear	4 – 5	7.3	7	7.5	7.5
	6 – 8	8.2	8.8	8	8
	9 – 10	9	9.5	9.5	9.5
Forest Area in Hectare	1956 – 66	95.63	189.8	Nil	Nil
	1981	105.22	4.05	20.23	80.94
	1991	105.22	4.05	20.23	80.94
	2004	82.3	159.54	Nil	2.54
Forest Protection Committee	Present	✔	✔	—	—
	Absent	—	—	✔	✔
No. of Members of FPC		Nil	Nil	Nil	Nil
Income from FPC in Rs. Per Family		Nil	Nil	Nil	Nil
Area Deforested in Hectare	1966 – 81	Nil	184.75	Nil	Nil
	1981 – 91	Nil	Nil	Nil	Nil
	1998 – 2004	22.92	Nil	20.23	78.40
Area Afforested in Hectare (2004) Species Under New Plantation		12.95 *Eucalyptus*	Nil	Nil	2.54 *Eucalyptus*

Fodder

Particulars		Mouzas			
		Dalksol	Bhalukbasa	Rokhni	Kshemasol
Grazing Time of Cattle	With Cattle Herder	All the year round	June to Nov.	June to Nov.	All the year round
	Without Cattle Herder				
Areas of Availability of Cattle Feed	Cultivable &Uncultivable Land	—	Dec. to May	Dec. to May	—
	Jungle			—	—
Adequacy of Cattle Feed (2004)	Yes	—	—	—	—
	No				
Adequacy of Cattle Feed (1998)	Yes	—	—	—	—
	No				

Table 4. Chemical analysis of soil samples of different sites

Soil Sample Sites	Soil P^H	Ammonical Nitrogen lbs/ acre	Nitrate Nitrogen lbs/ acre	Phosphate lbs/acre	Potassium lbs/acre	Organic carbon (wt by %)
Soil at the Edge of Forests	Very slightly Acidic (6.5)	Low (13)	Medium (18)	Low (<20)	Very High (>350)	Low (<.5)
Soil of Paddy Field	Medium acidic (6.5)	Low (13)	Medium (18)	Medium (0-50)	Medium (100-250)	Low (<.5%)

Mouza - Dalkisol (138)

Dalkisol is a small newly settled mouza (Map No-1) along the main road of Nayagram block. The rolling topography of pure red and lateritic soils covered with *sal* forests is the main physiographic character of this area. Cultivation is sparse, reclaimed out of past forest. Recently, on the deforested areas, plantation of *eucalyptus* and *akashmoni* are found. A natural spring situated at the edge of the forest supplies domestic as well as irrigation water.

The climate is modified tropical monsoon type. The chemical analysis of soil samples of different sites is given in Table 4.

The soil analysis indicates that the cultivated soils have been gradually deprived of the original natural contents of the soil leading to further destabilisation and destructurisation.

This mouza has only 9 households among which one is general Hindu caste, two are Scheduled Tribe and six are Scheduled Caste category families. This general caste family is rich, educated and engaged mainly in trade and commerce as well as cultivation. The monthly family income of this particular family is more than Rs. 8000. Other people live to medium range of income of Rs. 2500 to 4000 per month. The main occupation is cultivation. Only illiteracy retards their economic prosperity. Only 15 percent of the total population are literates while females are all illiterates.

The mouza has two private tubewells and one spring for domestic use. Fortunately, there is no water scarcity in this village, all the year round. Ordinarily they do not use the spring water for bathing but in times of crisis they also use this spring water for bathing purpose. All water sources are located quite close to the households. The job of collection of domestic water is not so hard for females of this area. All respondents acknowledge that the overall domestic water situation is the same as before.

The people collect fuel, fodder and other forest products from the forests. The Hindu general caste family purchase their fuel materials from the other inhabitants within the mouza and from the market at Nayagram. For this purpose this family spends Rs.600.00 per month on an average. The forest is located within 2 kms. and the time taken for collection of the necessary goods is 3-4 hours per day. The villagers claim that 5 years back the forest was located within 1 km. and they had to spend only about 2-3 hours per day.

Table 5. Chemical analysis of soil samples of different sites

Soil Sample Sites	Soil P^H	Ammonical Nitrogen lbs/ acre	Nitrate Nitrogen lbs/ acre	Phosphate lbs/acre	Potassium lbs/acre	Organic carbon (wt by %)
Soil of Fallow Land	Strongly Acidic (5)	Low (13)	Medium (18)	Medium (20 - 50)	Low (<100)	Low (<.5)
Soil of Cultivated field	Medium Acidic (5.5)	Low (13)	Medium (18)	Low (<20)	Low (<100)	Medium (.5-.75)

Male members of the general caste family and both male and female of the other Scheduled category families upkeep their own domestic animals. The existing forests supply the fodder requirements to local communities, some extent of crop wastes are also used as cattle feed. The SC and ST families spend Rs. 7 per day while this rises upto more than Rs.25 per day in the general caste family. Only this particular family of Hindu general caste heirs the professional cattle herders at the cost of Rs. 3000 per year and others tend their cattle themselves.

Mouza - Kshemasol (287)

The topography of Kshemasol (Map No.-2) is slightly more undulating a compared to that of Rokhni (282). The soils are red and lateritic. The lateritic exposures are shorn of any vegetative cover. The mouza lies on a drainage divide without any principal river or stream. It suffers from oppressive hot summer, cool winter with a relatively short rainy season. There is no sign of any type of natural forests except that a very small plot has been planted with *eucalyptus*. This mouza has a large portion under monoculture because there is no irrigation facilities. The chemical analysis of two soil samples of different sites is given in Table 5.

The soil characters indicate that there is a general poverty in soil nutrients which are slightly better in the uncultivated soils due to human impact.

This multi-ethnic mouza has three (3) settlement clusters of fifteen (15) general caste, two (2) Scheduled Caste and fifty (50) Scheduled Tribe families. About 50 percent of the total population are literates among which females constitute only 9 percent. The villagers are all engaged in agricultural activities and their average income never rises to more then Rs. 5000 per family per month.

This area has three (3) private wells and one (1) government well which become completely dried up in pre-monsoon months. In this period the domestic water situation becomes extremely acute when the ponds existing within the mouza also become completely dry-up. During this time the villagers fetch domestic water from the only one large masonry well situated within the cultivated fields of the neighbouring mouza, Gambhoria (291), 3 kms. away from the settlement of Khemasol. This water is used for all domestic purposes.

Only male members of the general caste and Scheduled Caste families and both males and females of Scheduled Tribe families collect water in these months from outside the mouza. At this time all the families have to spend about 5 hrs/ man/woman/day to collect domestic water. In other months only females fetch the domestic water. In these problem periods the villagers use water as little as possible for bathing and other domestic purposes and for this they suffer from various skin diseases. The village people get adequate water only in monsoon months. Purification of drinking water is not done due to economic problem even in the period of diseases. There is a general resentment against the politico-administrative organisation for this deplorable water situation in this mouza. In spite of their strong demand for tubewells, they do not get a single tubewell till now. Dug wells could have been constructed. But the sub-surface geological situation is similar to that in Rokhni. It prevents the villagers to go in for construction of dug wells to a greater depth.

The villagers use small twigs, leaves from forests of neighbouring mouzas, all types of crop wastes from their own fields, *jhanti* from shrubs and scrub lands within the mouza as domestic fuel. Everybody except a few poor Santals has to purchase a large amount of fuel from the Forest Department. The cost of fuel varies from Rs. 50-350 per month per fimily. The time taken for fuel collection from forests is 6-9 hrs. per week per family equivalent to a travel time of 4 kms. between home and forests. Only the male members of the general caste families and both males and females of Scheduled Caste and Scheduled Tribe families do this job. 5 years back the task was much easier.

The females of the Scheduled Caste and Scheduled Tribe families and both males and females of the general caste families tend their cattle. It is not necessary to hire the professional cattle herder because domestic animals are freely grazed on common property resources for 7 months. During the rest of the year the cattle are kept at home. Because of the scarcity of fodder available within the mouza the villagers have to meet the fodder need from crop wastes. They have to spend a minimum sum of Rs. 5 per day on an average per family.

Mouza - Rokhni (283)

Rokhni is a small uniethnic tribal village of Nayagram Block situated far away from the river Subarnarekha. The general topography is almost flat. The plot pattern indicates that besides a few places in the western part, all lands have been converted into cultivated lands from forests (Map No-3). It is a matter of guess to the period when deforestation took place but the settlement is quite old and the forests in all probability vanished much before the last century. Now, the mouza has no forest cover even any plantations. The soil is red loamy and not very infertile. The chemical analysis of two soil samples of different sites is given in Table 6.

The soil character that is indicated from the above table is not much different from that in most parts of the study areas . Usually the soil reaction is acidic and the nutrient status is low but over the cultivated lands there is a greater percentage of organic matter leading to a slight increase in the nitrate nitrogen

Table 6. Chemical analysis of soil samples of different sites

Soil Sample Sites	Soil P^H	Ammonical Nitrogen lbs/ acre	Nitrate Nitrogen lbs/ acre	Phosphate lbs/acre	Potassium lbs/acre	Organic carbon (wt by %)
Soil of Road Side Fallow Land	Strongly Acidic (5)	Low (13)	Medium (18)	Medium (20 - 50)	Low (<100)	Medium (.5-.75)
Soils of Cultivated land	Neutral (7)	Low (13)	Medium (18)	Medium (20 - 50)	Low (<100)	High (>.75)

content and p^H value. Cultivation is totally dependent on monsoon rainfall because this mouza has no other sources of water. Because of the nature of the terrain the climate is very hot and oppressive in summer season and cold in winter.

It is a pure Santal mouza with two linear settlement clusters. Most of the villagers are very poor and illiterate. Only 25 percent of the total population are literates and the female literacy rate is 10 percent. The inhabitants are mainly engaged in agricultural ativities and forestry. Because of their poverty and low ethnic status, they are the victims of negligence from different governmental organizations and aids.

The mouza has one old government well which is the only source of drinking water. This well gets completely dry-up during the summer when the villagers have to go to the neighbouring mouzas to collect domestic water. This task is too difficult for women because collection of domestic water is the sole responsibility to them. They take their bath and wash clothes in the ponds of neighbouring mouzas. The situation becomes worst during the pre-monsoon months when women have to walk 2 kms and spend 4 hrs. per day to collect domestic water. It is only the rainy season when they have adequate drinking water from within the mouza itself.

The inhabitants can not even think of boiling or filtering the drinking water at the time of diseases because it is cost prohibitive. The villagers are very vocal about their deprivation by the Gram Panchayet.

They collect their necessary domestic fuel from the forests of neighbouring Mouzas about 3-3.5 kms. away. The inhabitants also collect various forest products for commercial purpose and the survival of many villagers depends on it. They have to spend 7 hours per week to collect all these materials. Five years back, the distance between their settlement and forest was less (2-2.5 kms) and a lesser time was required (4-5 hrs.). The situation will become severe after few years if the forests vanish in such a rapid rate in the neighbouring mouzas.

The villagers do not own much domestic animal resources. The females mostly take care of their cattle. A few families can afford to feed their cattle from their own crop wastes and the cost rises upto Rs. 15 per day per family. Other poor people graze their cattle on common property resources (Biswas, 2001) and forests in other mouzas. Cattle feed situation becomes acute during summer months when vegetation cover is practically non-existant.

The central problem of the mouza is that it is a drought prone area cereal crops are impossible during the dry months. Because of their poverty, illiteracy and low ethnic status, the people can not draw the attention of the governmental organisations though they have one elected Gram Panchayet member.

Apart from drought, absence of natural vegetation and social and economic deprivation of the Santal population, the special problem of Rokhni lies in its sub-surface geology composed of the superficial laterites and unconsolidated, deeper layers composed of materials containing finer sands, shales and alluvia. Irrespective of whether there unconsolidated materials were formed due to riverine processes in the past or due to leaching from above, there is the absence of a cementing material in them. The result is that below the surficial laterites including the carapasse, the mottled layer and the palid layer, there is a zone which can not withstand much vertical pressure. As the pressure increases, the materials forming this zone slip sidewise. This sidewise slip becomes active when a hole is dug into the vertical layers of the surface geology. Whenever there is an attempt to dig a well through these layers, the upper true lateritic layers can hold themselves because of internal cohesion, but the lower layers, because of their structural looseness, slip off to fill in the space created by withdrawal the materials due to digging. This underground slip-off does not allow open wells to be dug below a depth of 30' at the maximum. But as Rokhni is situated in an area where the depth to ground water is more than 30' during dry summer months, permanent wells reaching to the ground water can not be constructed. This particular phenomenon is also observable in Kshemasol which is one of the several mouzas studied by us in Nayagram block.

Mouza - Bhalukbasa (174)

Bhalukbasa is situated at the West Bengal–Orissa border in the extreme south western part of Nayagram. Undulating topography is characterised by red and lateritic soils covered with pure stands of *sal*. Some parts of the forests have been converted into degraded *jhanti jungle* due to excessive human interference. Cultivated lands have been reclaimed out the past forests in relatively recent times (Map No-4). In some areas the lateritic exposures do not contain any vegetative cover at all. This area has no drainage channel and not even a single pond. Climate is almost the same as that in Dolkisol. The character of soil is shown in Table 7.

Table 7. Chemical analysis of soil samples of different sites

Soil Sample Sites	Soil P^H	Ammonical Nitrogen lbs/ acre	Nitrate Nitrogen lbs/ acre	Phosphate lbs/acre	Potassium lbs/acre	Organic carbon (wt by %)
Soil of *Jaher Than*	Medium Acidic (5.5)	Low (13)	Medium (18)	Low (<20)	Low (<100)	Low (<.5)
Soil of Paddy Field	Medium Acidic (5.5)	Low (13)	Medium (18)	Medium (20 - 50)	Medium (100 - 250)	Medium (.5-.75)

The above soil analysis indicate that usually the soil reaction is acidic. The nutrient status is low but over the cultivated fields there is a greater presence of organic matter leading to a slight improvement in the nutrient status and the water holding capacity.

Before 1960s this mouza was uninhabited. Very recently the people from neighbouring areas have gradually settled in this mouza. At present this area has two small hamlets, namely, *Uttar Bhalukbasa* having 8 households and *Dakshin Bhalukbasa* with only 4 households. Only 3 families of *Uttar Bhalukbasa* belong to the Scheduled Caste category and others are all Scheduled Tribe mainly, Mundas. Only 25 percent of the total population are literate while the female literacy rate is practically nil. Because of the remoteness and backwardness, the villagers cannot draw any attention of the government organizations towards their socio-economic deprivations. Other than agricultural activities, forestry is the main occupation. The economic status of the inhabitants is low in this mouza.

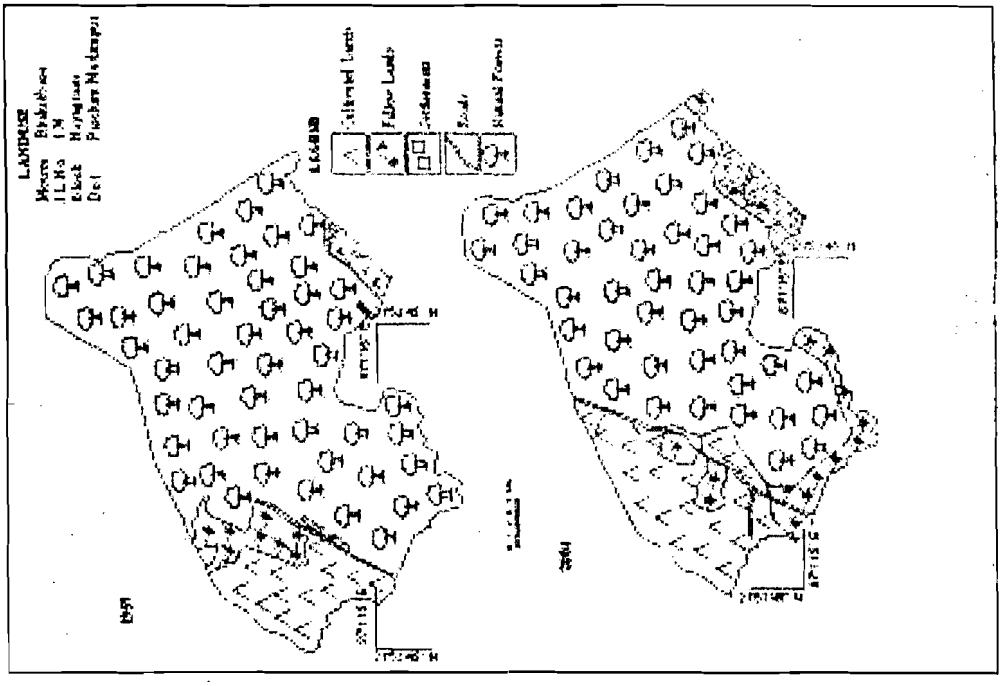
This mouza has one government well and 5 private wells. The villagers do not usually face any water crisis during any part of the year. For bathing and other domestic uses the people use water of the river Maruli which passes through the neighbouring mouza, Ramkrishnapur. The task of collection of domestic water does not involve much time as all the sources are located close to the homesteads. During summer, the inhabitants use the well water for all domestic purposes because the river Maruli dries-up. The people of this mouza are just oblivious about the necessity of the purifying the drinking water at the time of diseases. The opinion of the villagers about the overall situation of domestic water is quite favourable.

The forests not only provide the villagers with fuel but also other products for commercial purposes as well as fodder. Both males and females of all ages collect forest products within a distance of 2 kms. The time taken for collection of these materials is about 4 hrs. per day.

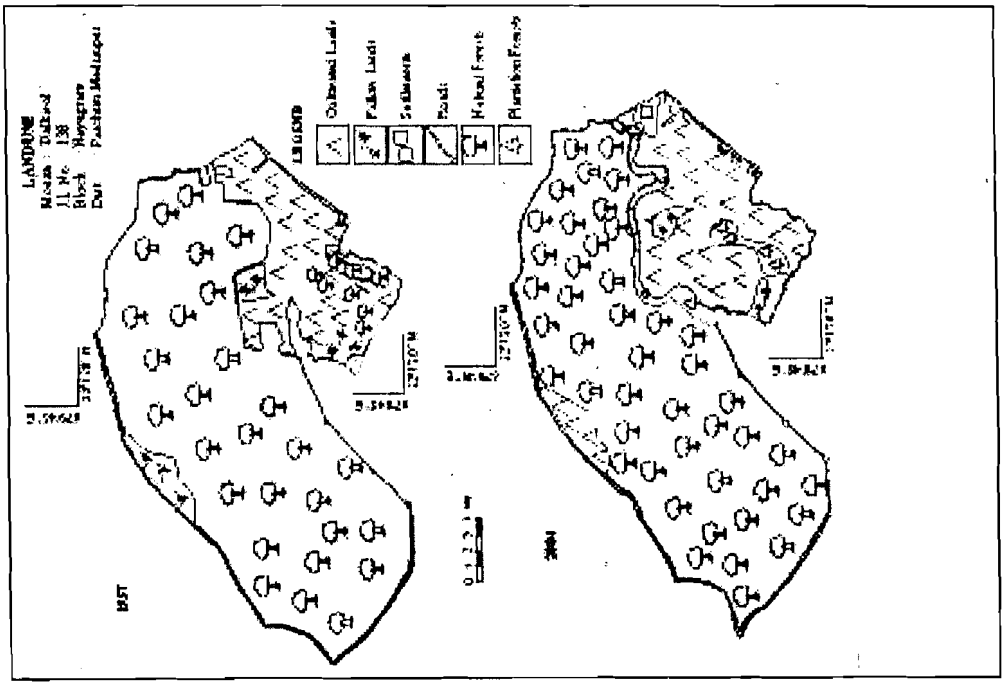
Generally, females of the families look after the cattle. The livestock get more or less sufficient fodder from common property resources. A few families can afford to feed the cattle from their own sources of crop residues. The average cost of fodder purchased from the market varies from Rs. 5/- to Rs. 13/- per day per family depending on the number of animals and the season. Usually the families tend their cattle themselves.

Explanation & Conclusion

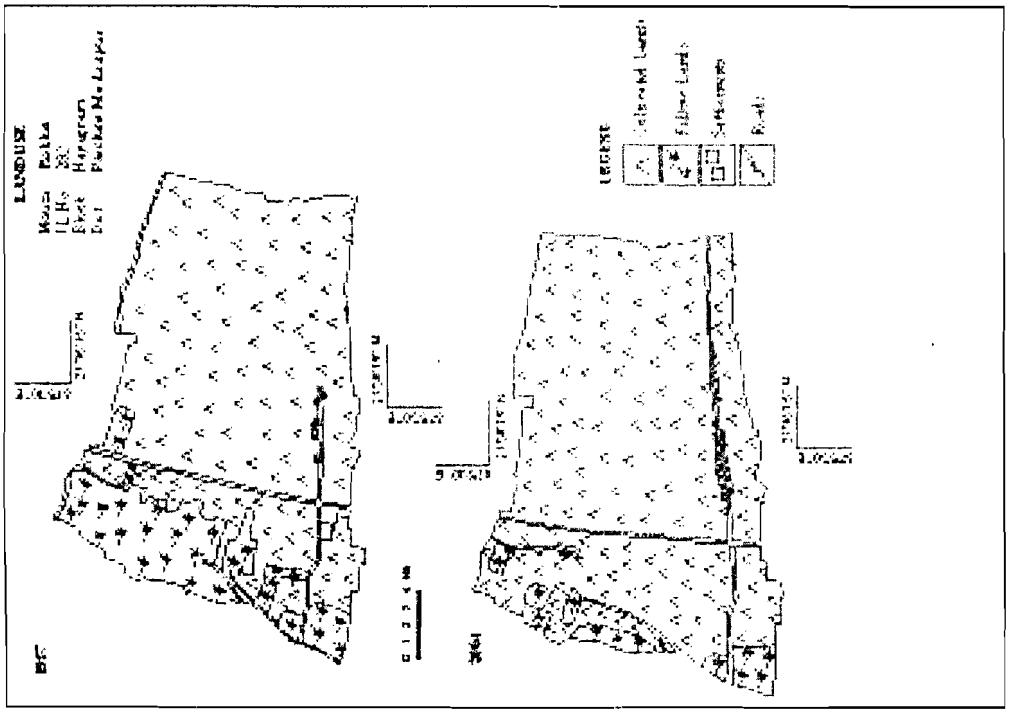
In Paschim Medinipur particularly, the role of women in collection of fuel wood, fodder and domestic water has a difference from that in many other parts of South Western West Bengal. Many of the rural communities are dominated by the Hindu caste society. In such a society a stigma is associated with the concept of women doing outdoor work therefore even in the great stress, the collection of fuel and domestic water from distant sources in generally done by menfolk. If the source of fuel and water is close at hand that is within the notional bounds of the settlement, women are permitted to collect domestic water fuel



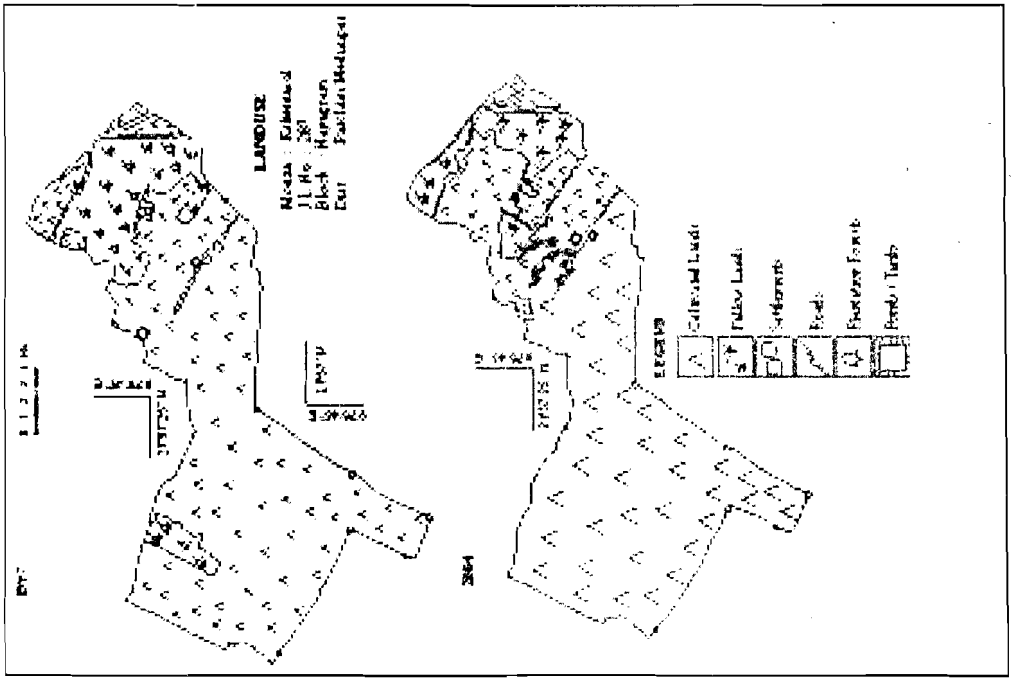
Map 2.



Map 1.



Map 4.



Map 3.

but as the source becomes more distant then it is the responsibility of the male members of the family to collect the resources. It often happens that the fuel source is not negotiable after meeting all other requirements of daily household activities. In such cases there is no alternative than spend cash in order to buy the fuel wood requirements from the fuel wood vendors who visit the villages from time to time or to purchase fuel wood from the nearest market. This phenomenon is generally found in villages which are caste dominated and also enjoy some amount of agricultural prosperities.

In villages where tribals are predominant or are considerable in number and agriculture is not very prospective, women of the families are mostly pushed towards collection of water, fuel and fodder irrespective of within the sources are distant or near at-hand.

Although the above behavioural pattern seems to be governed by the degree of agricultural prosperity and the distance of the sources of fuel, fodder and water from the homestead, it has got a different dimension which is basically related to ethnicity and culture. Among non-tribals the primary fact is that women are generally found to be moving out of their own localities. But among tribals the gender oriented division of labour stays irrespective of economic condition and environmental advantage or disadvantage. In other parts even within a prosperous agricultural environment, it is the women who take care of fuel, fodder and water requirements of the family.

The core problems of water, fuel and fodder have been highlighted in our selected areas. These are the aspects in which male dominance starts from the grass roots. The super fluity from these basic deprivations women by men starts from the rural world and ultimately build up upwardly towards the male chauvinism in the so called higher levels of human civilizations of semi-urban and urban worlds. The most basic of all female deprivations by males start at the village level with respect to the collection of water, fuel, food, fodder etc. are only associated phenomena but even among these associated phenomena, fuel and fodder are definitely more important than others. The overall result of these is not only the reduction in the effective leisure hours in the hands of rural women but also a contraction of their opportunities to train up their youngsters appropriately to cope up with the needs of the next generation. Collection of water, fuel and fodder, therefore, can be seen as a core problem in the overall woman-man-environment relationship determining the fate of human civilization (Biswas and Mondal, 1996).

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A BOON IN BOOSTING BUSINESS - A CASE STUDY WITH IFFCO EXPERIENCE USING GEOGRAPHICAL INFORMATION SYSTEM - PART-I

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Abstract

The real strength of Geographic Information Systems (GIS) shall be evinced when the business houses embrace them as a part of their regular operational functionalities. This can be a genuine source of employment and wealth generation. Indeed it is becoming a part of mainstream business and management operations around the world in organizations as diverse as cities, state governments, utilities, telecommunications, railroads, civil engineering, petroleum exploration, retailing, etc. in private and public sectors. This array of institutional types is integrating GIS into their daily operations, and the applications associated with these systems are equally broad from infrastructure management, to vehicle routing, to site selection, to research and analysis. This paper coins an example on how the business prospects could be ameliorated for a major fertilizer company operating in India, mentioning the most important trends in extending business intelligence with geographic information systems. The framework proposed in this Part-I segment of the paper provides outline of several modules with a view to evolving the scope of hiking fertilizer use in areas having better potentials. Preliminary results indicate the utility of the proposed framework, as well as opportunities for further development, including its suitability for generalisation to other areas. In the last part of this paper are presented the trends in the evolution of GIS, Business Processes and Business Intelligence and some conclusions. In Part-II (to be published following the current one) a treatise with an emphasis on pedological consideration in building up resources module shall be dealt with.

Keywords : *Remote Sensing, Geographical data processing, GIS, Spatial analysis, EBG, SWOT Analysis, PISCO, IFFCO, Modeling, Spatial Decision Support System, FLASC, Business Intelligence.*

Introduction

Medium resolution remote sensing data can be amply used to generate current spatial thematic information necessary for proper business planning. A large amount of Geographical Information (GI) data already exists that hardly warrants frequent updating. They are most often collected by public organizations in the framework of their mandated management activities, focused on the needs of GI users and potential users for economic development and for the improvement

of commercial and public services to the citizen. Many of these organizations are beginning to explore the use of Geographic Information Systems (GIS) in their decision making processes by generating maps that convey information assembled from their respective database. Over the last decade we have confronted with a lot of examples of GIS applications that have produced useful spatial data products for different organisations from public to private sectors. The applications have clearly been beneficial but most of organisations are still facing with the challenges of implementing applications of GIS technology, as suggested by on-going popularity of jargons as "Enterprise GIS", "GIS data sharing", "Multipurpose GIS", "Multi-participant GIS". In order to progress on those problems, the hope is to develop a more systematic theoretical foundation for understanding of GIS application implementation within and among organizations. In this context Bijan, Azad,(2000)[1] narrates "One of the keys to this better foundational understanding is to do with the business processes (and their tacit/explicit knowledge content) which GIS aims to improve. Finally, we need some way of judging which processes are likely to be improved in which situations with the applications of GIS. In other words, improving GIS implementation is highly dependent on being able to adequately and properly capture the embedded tacit and explicit knowledge in business processes and apply them through GIS". Certain relevant jargons are discussed :

EBG

Economic & Business Geography (EBG) performs an important role as an economic and business information intermediary. In addition, EBG explores, conceptually, theoretically and empirically, the geography of business information, i.e. the nature of locational and regionally important economic information, geographically significant differences in quantity, quality and timeliness of available information, differences in access to such information, the behaviors (e.g. corporate disclosure strategies) leading to such differentiation as well as changes in information policies and how these changes may influence business behaviors and rearrange economic structures. An improved understanding of the nature of information will, in turn, help in the investigation of the role of spatial and place-specific information in business and public-sector decision-making processes.

SWOT Analysis

SWOT stands for Strengths, Weaknesses, Opportunities and Threats. This is a modern management tool for analysis of an individual or organization that allows the scrutiny of current situation and helps make decisions about that individual or organization. This tool aims to relate the strengths and weakness of the organization based on an internal audit of the organizations capabilities and opportunities and threats revealed by the analysis of the external environment. For example, when assessing various alternatives, it is often a good idea to bias a certain selection according to the strengths of the organization, so that they can do what they are good at, while perhaps also

building up their expertise in areas of weakness. Similarly, one should try to exploit appropriate opportunities, while being careful of threats, such as aggressive competition or the potential for the economy to affect operations. There are software packages that can be used to assist SWOT analysis, and it is a very useful technique for providing support for decision processes.

Modeling

Modeling in a decision-making system is a very useful activity, as it allows you to consider in more detail the outcomes of certain alternatives. There are a large range of models that can be run, many in conjunction with GIS.

PISCO

PISCO stands for Purpose, Input, Solutions, Choice, Operation. It is a simple decision-support methodology that builds on a range of thinking tools. It provides a general pattern for making decisions, even for just thinking about something. Its main strength is to cover a range of operations and so help structure the thinking about the problem. As such, it is a product of the Rational Comprehensive model.

Associated with PISCO is a detailed tool called TEC, which stands for Target, Expand, Contract. The idea is to direct thinking to specific points, at any stage of PISCO process, specify the target of the thinking, expand upon the target to get as much as possible on the target, then contract those thoughts to a few important point.

Study Domain – The IFFCO Endeavour

The Indian Farmers' Fertilizer Cooperative Organisation (IFFCO) ranks amongst the largest Cooperative Business Organisation set up anywhere in the world. It primarily deals in production, archival and distribution of commercial fertilizers in India, in addition to engaging itself with training programme for farmers' enlightenment how to optimize the farm benefits. In 2000-01 IFFCO came up with a venture using GIS as a tool for enhancing their business prospects. They sought to address some specific areas in a bid to expand their business gamut and also to outsmart their business rivals with adequate allocation of resources and timeliness of action. The identified domains can be segmented as under :

- Resource Module
- Logistics Module
- Weather Module
- Business Module

Responsibility of IFFCO was to provide data on daily transaction of fertilizer sales, based on the stock collected by zonal/state/area officers of IFFCO. IFFCO also provided society-wise sale point figures, a quick estimate of total fertilizer availability, and the quantum of replenishment needed by a sale point at that point of time. All these data were recorded in Relational Database Management System (RDBMS).

Data Used and Methods

- Indian Remote Sensing Satellite IRS-1C/1D LISS-III and WIFS digital images
  Characteristics of LISS III DATA : Spatial resolution 23.5 m, spectral resolution of 4 bands (0.52-0.59, 0.62-0.68, 0.77-0.86 and 1.55-1.70mm), Swath 142 km.
  Characteristics of WIFS data: Spatial resolution 188 m, spectral resolution 2 bands (0.62-0.68, and 0.77-0.86mm)n Swath 774 km.
- Collateral data :
  Topographic maps published by the Survey of India (SOI), Govt. of India.
  Soil map published by National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), Indian Council of Agricultural Research (ICAR), Govt. of India.

In the present study WIFS data was the major source of image data used because of its swath that covers almost a complete state. Besides, its temporal resolution of 5 days (vis-à-vis 24 days for LISS III data) helps tide over the cloud menace. Representative WIFS data pertaining to Kharif, Rabi and Zaid seasons were procured to cover all states. The use of LISS III data was limited to some specific areas where detailed study was made.

RESOURCE MODULE DELIVERABLES

One Time Land Use / Land Cover Data

The base layer of one time Landuse/Landcover was generated with three Seasons' WIFS data complemented by requisite ground truth information. Representative data pertaining to Kharif, Rabi and Zaid (summer) seasons were processed separately to generate thematic land use /land cover (lu/lc) map of the states with the following targets (Table-1).

Permanent land cover features like Forests, Wasteland, Water bodies Settlements and Rivers were identified which are not relevant from IFFCO's viewpoint. The only dynamic land use feature in most part of India that entails fertilizer usage worth mentioning has been agriculture.

The task here had been to generate one output layer of thematic lu/lc map showing round the year agricultural activity. Two specific software programs were used to accomplish this. First one was so-called 'Referential Refinement' – a tailor-made algorithm to eliminate silly mistakes using multi-layer thematic outputs of same spatial domain. It refined gross blunders that might have crept in the individual layers mostly originated from spectral confusion. The final step was 'Aggregation' – another tailor-made algorithm to enable fusion of multiple thematic maps into one layer output that evinced round-the-year land use activity in each state.

It must be stated here that despite the commissioning of above two algorithms the significance of 'stratified segmentation' cannot be over-emphasized. So here in this paper the study area has been stratified as 'Irrigated' and 'Non-irrigated' zones. This was done based on satellite data info as well as the info provided by the irrigation departments of the respective state governments.

Table 1.

Data Used	Target Spatial domain	Target Crop	Target Temporal domain
WIFS	Entire State	Aman Paddy	Kharif Season
WIFS	-do-	Potato & Mustard	Rabi Season
WIFS	-do-	Boro Rice (Summer Paddy)	Zaid Season

Logistics Module

This module was designed to study how best the fertilizers could reach the site of demand from the nearby warehouse of IFFCO. It was especially significant so far as the demand situation varied drastically throughout the progress of seasons.

Weather Module

India continues to be affected by the vagaries of monsoon. Onset of monsoon and timely occupation of retail warehouses by IFFCO brands are paramount. The success of this kind of business is especially contingent on proper planning and timeliness of action. Also this has a much greater social ramification so as to save the farmers from the evil clutches of black-marketiers of fertilizers who add fuel to the crises by artificially tightening up the inventories.

Onset of monsoon varies from place to place and so is peak fertilizer demand. It is paramount to compute crop growing period (CGP) and assess the sequential demand of fertilizer throughout the year. CGPs corresponding to each meteorological station were worked out and maximum fertilizer requirement in a particular CGP was understood in advance. The National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) manual was used to garner rainfall and humidity data.

Number of Stations Computed

West Bengal : 16 Orissa : 14 Assam : 7

A sort of thematic map called Thiessen Polygons were generated in the GIS platform using point information (Met stations) in the form of met data to identify the area of influence of each meteorological station. The goal was to move fertilizer at least 15 days in advance of the start of CGP and fill the retail selves in a bid to have a definite edge over the other business contenders and to pin down the black marketers of fertilizers. There was a provision for up to 3 CGPs for a particular meteorological point. The output of the module had been to indicate when to move the fertilizer in a particular meteorological domain marked by the respective thiessen polygon and also to generate user interface to select meteorological station graphically/textually and the following input were considered significant :

- Rainfall Data
- Humidity Maximum and Minimum
- Rainfall Distribution

Business Module

All the above modules' output went into this module's input and better business intelligence ought to evolve as the output of this module. A lot of different procedures for identification and improving business processes were developed and tried by businesses with varying degrees of success. Some of the most notable earlier procedures included Porter's Value Chain and Total Quality Management (TQM), which had been used during the 1980s. Business Process Reengineering was popular during the 1990s. The 1990s also saw the emergence of the Enterprise Resources Planning (ERP) software package and most of these procedures were actively evolving. Harmon, (2003)[4] is of the opinion that Business Process Reengineering is evolving into Business Process Redesign. Sharp, et al, (2001)[8] have propounded other processes such as Continuous Quality Improvements, Management by Objective, Management by Walking Around, Customer Focus Management have also emerged.

The use of Information and Communications Technology (ICT) and Business Process Management is becoming a core competency that every business must have in order to function in today's global and highly competitive business environment. All of the various business process improvement procedures are merging into the single discipline of Business Process Management. Bustard, et al, (2000)[2] presented a useful list of four major business processes including: business process improvements, business process reengineering, technology transfer, and process standardization. Harmon (2003)[4] completed a similar list, which include the following three processes: 'improvement process', 'process redesign' and 'process reengineering'.

In today's world, business is acquiring the new information management technology through the purchase of commercial off-the-shelf (COTS) solutions. GIS solutions are part of COTS solutions because in business areas, it is not affordable to develop and maintain custom software that closely matches their business processes and requirements. The COTS solution is then configured or tailored to match, as closely as possible, the existing business processes. But a perfect match is not possible and adjustments must be made. Most of the major COTS evolving GIS solutions incorporate industry accepted best practices and implementing these practices as part of the COTS implementation could provide additional efficiencies. In actual practices most businesses use a combination of custom application and business process modification to implement a new COTS solution. Although GIS is often viewed as a technology project and an arena for the technically sophisticated computer professional, the development of a successful enterprise GIS is dependent more on proper management participation and supervision than on technical solutions.

Some exotic examples

Regarding Romania, as in most of other countries, government agencies in charge of geographic information have the combined challenge of improving performance, learning to cooperate through partnerships within the limitation of budget restrictions, and satisfying increasing user demands. Otherwise, they

will be unable to accomplish their goal of providing valuable information to support increased knowledge and national policy.

"The Romanian customers often requests the integration of the data pertaining to various processes into a single database that would feed information to a variety of automated systems and applications. The result will be a relational geographical inventory of all infrastructure components, digital geographical maps generated at all users level, more effective work flow management, better operations organization and, by all means, cost monitoring. This is why geospatial solutions are the implicit part of an integrated system, and the geospatial information has to be considered the foundation of an effective management based on an integrated decision system." [Foca, M., (2004)[3]].

"For those specialized in operations developed at the level of (big) city hall, this level of complexity in IT problem it is not to shock and the decision of this city hall in order to propose an ambitious project and to develop such complex system for information management, it seemly to be a natural consequence of the solution of awareness problem. But for somebody accustomed to the slowness of movements in Romania in general and in public sector, in particular, the existence of such a project could be amazingly, and CHB as institution should be revolutionary" [Ienculescu Popovici, M. (2005)[5]].

Another example is of Botswana, a developing nation in the African continent. Here an Integrated Geographic Information System (IGIS) is being developed by the Government with three primary data sets (Geodetic, cadastral and topographic) as the beginning. Once operational, it will provide geographic information in the country with fully advanced Web based Technology.

The output generated in the present study has been presented in Table 2.

Table 2. Output Generated *(With IFFCO Relevance)*

Dynamic Feature through Remote Sensing data	Static Features through Conventional methods	Block-Wise Statistics
Kharif Only, Rabi Only, Double Crop, Triple Crop Etc. Plantation (Tea Estates)	Texture, Depth, Erosion And Slope; Ecological Subregion Map (Generic Types); Soil Testing Results (District-Wise)	Fertilizer demand quantified (Spatial as well as Temporal)

FLASC• (Farmer Level Advisory Service Centre)

The idea was coined from integrated mission for sustainable development (IMSD) – a watershed concept by DOS/ISRO aimed at uplifting the living standard at grassroot level by interfacing remote sensing and GIS. The output of such project can be used for achieving this end.

IFFCO sought Bankura District, West Bengal output for certain pilot interest. Instead of WiFS data here better spatial resolution IRS-LISS-3 data was used to prepare current landuse showing distribution of wastelands and surface

water bodies also. As per IFFCO requisition the output with following emphasis were delivered :

- ❖ Ground water potential zone showing areas for immediate extraction of drinking water
- ❖ Potential zones for ground water recharge
- ❖ Soil map with emphasis on erosion status

Moreover an Integrated Land And Water Resources Map Showing the following was delivered :

High Priority Areas For :

- ❖ Agricultural Development
- ❖ Fodder Development
- ❖ Soil Conservation
- ❖ Water Conservation

Trends

The key to thriving in a competitive marketplace is staying ahead of the competition. Making sound business decisions based on accurate and current information takes more than intuition. Data analysis, reporting, and query tools can help business users see through a sea of data to synthesize valuable information from it - today these tools collectively fall into a category called "Business Intelligence (BI)." It is important to mention that BI is not a single application. It consists of a series of components that interact behind the scenes to extract electronic data, assemble it, analyze it and display it in a form that is easy to work with and understand.

Ionita, A., (2005)[6] presented a point of view regarding the synergistic power that can be exploited by extending business intelligence with geographic information systems, based on the scope, the fundamentals, and the commonalities. Each of the functions of BI and GIS suggest four areas in which research and applications should focus: human resources, data management, decision making and collaboration, and planning systems.

Conclusions

Certain business enterprises can only think of staying ahead of competition only if they have an adequate understanding of the geospatial entities on which their business thrives. This understanding shall transcend into the requisite BI that happens to be the mark of survival in this open economy where survival of the fittest is the keyword. Thus the need for coordinated and collaborative business processes is changing the face of how these processes are modeled, executed and managed. GIS is important in BI because most business problems include significant spatial components and GIS enables decision makers to leverage their spatial data resources more effectively. Customer Relationship Management, Enterprise Resources Planning, Supply Chain Management, and more others are acronyms for some solutions designed to extract and analyze information from data warehouses and allow decision-makers to perform at a

higher level of efficiency. But data on it's own has no value. Without simple visual ways to integrate, display and analyse, it is possible to end up with massive amounts of data but no information. From a particularly point of view, the geo-spatial data and maps managed within an enterprise GIS represent a kind of common "language" that is understood within and across organizational boundaries. This "language" has the power to weave together and integrate traditionally disparate business functions. Each of these diverse functions is ultimately dependent upon the location and spatial relationships between real property, assets, and people.

Acknowledgement

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APPLICATION OF GIS IN PLANNING AUTOMOBILE ROUTES OF KHARAGPUR

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Abstract

This paper describes the attempt made to collect data and develop a GIS (Geographical Information System) database to apply querying and analysis capabilities of GIS for planning urban mass transport routes in Kharagpur. The main focus of the work is to locate the trip attraction zones and trip generation zones in the town and to find out the minimum travel time routes between these zones. Concentration of different public utility centers in the town are taken as the indicators of trip attraction zones where as zones with high population density & growth rate, high literacy rate, higher proportion of secondary and tertiary sector workers and high land value are considered to be potential for trip generation. To estimate the travel time of a link, the speed of a vehicle is assumed to be a function of four variables (namely the road width, road condition, abutting landuse and the traffic volume) and the result is arrived up on by doing a regression analysis using the available data to get the coefficients of the four variables. The time taken to traverse a link is then calculated by dividing the length of the link by journey speed. This database is used for analysis and querying for the optimum routes, thus serving as a useful tool in the planning process.

Keywords : *Automobile route, Kharagpur, GIS, Polygon, Arc, Attributes, query, analysis, Origin, destination zones, Optimum routes.*

Introduction

GIS for transportation has now emerged as the technology with considerable potential for achieving dramatic gains in planning, design, implementation and maintenance of transportation projects and transportation management in urban areas]. Kharagpur is the fastest growing town of West Midnapore and numbers of vehicles in the city are growing rapidly. There is phenomenal shift to personalized mode of travel in the recent past, as seen by the increased rate of vehicle ownership & growth (Govt. of W.B. Motor Vehicles Dept. West Midnapore Registration Information - 2001). Such a growth of individual vehicles aggravated the problem of traffic congestion, environmental pollution, safety hazards and resulted in high energy consumption. This crisis is common to all the rapidly growing cities of India. To find the way out from this dilemma, recommendations for urban mass transport have been made by several committees (National transport policy commission - 1988 and Report of study group on alternative systems of urban transport - 1987), which revealed the need for an efficient intracity public transportation system, operating on properly planned routes.

Objectives

Analysis and study of the nature of urbanization, land-use pattern, demographic & socio-economic character of the people of different wards is the primary objective of this assignment. These are the basic determining factors of the future transportation scenario of the town. At the second stage, movement of people within the town and present traffic condition of the region will be studied. Finally a comprehensive database of all major roads of the town will be developed to plan for a more efficient public transportation system.

Methodology

Public transportation is identified as the area of interest and Kharagpur as the action area. The methodology consists of two parallel processes. The first process starts with the Literature study and data collection on Kharagpur (e.g. from Kharagpur municipality office Midnapur-Kharagpur planning authority office, census office- Kolkata & primary survey). Parallel to this the literature study on application of GIS in transport planning and familiarization with GIS software (Mapinfo-7.8) are done. Second stage is the Preparation of different thematic maps (based on urban growth, Land use, road network, & Socio economic data) for overlay analysis to identify the zones of greater public mobility & potential zones for trip attraction and trip generation. In the next stage from the collected data a comprehensive database of all the major roads is created to calculate the travel time of all the links. Once the origin and destination zones are identified and travel time of all the links are available, the least resistant and most economic routes are easily suggested in the GIS based road network coverage model.

CITY PROFILE

Location & Growth History

Kharagpur is the largest city in West Midnapur district. It is located on 22°30'N & 87°20'E, 16Km south-west from Kolkata and 9 Km south to Midnapur. It is connected by National High way - 6 and a junction of south Eastern Railway. The name Kharagpur from the name of lord Khargeswar Shiva owes it origin to the Bengal Nagpur Railway Settlement in 1901. The railway workshop was established in 1904. The kharagpur I.I.T. campus at Hijli was established in 1951 and Kharagpur Municipality was constituted in 1954. Present day Kharagpur town consist of disjoined urban units like the Railway settlement at the core, surrounded by Municipal areas consisting 30 wards and few non-municipal areas (Fig.5). Total population of Kharagpur town in 2001 is 329770 and it covers a total area of 123 sq. km. [Ref. 15].

Traffic & Transportation Scenario

Kharagpur is served mainly by two modes of transportation in intracity level. One is cycle rickshaw and another is bicycle and motorbike. Recently few Maruti van and auto rickshaw are also operating for public transportation but their

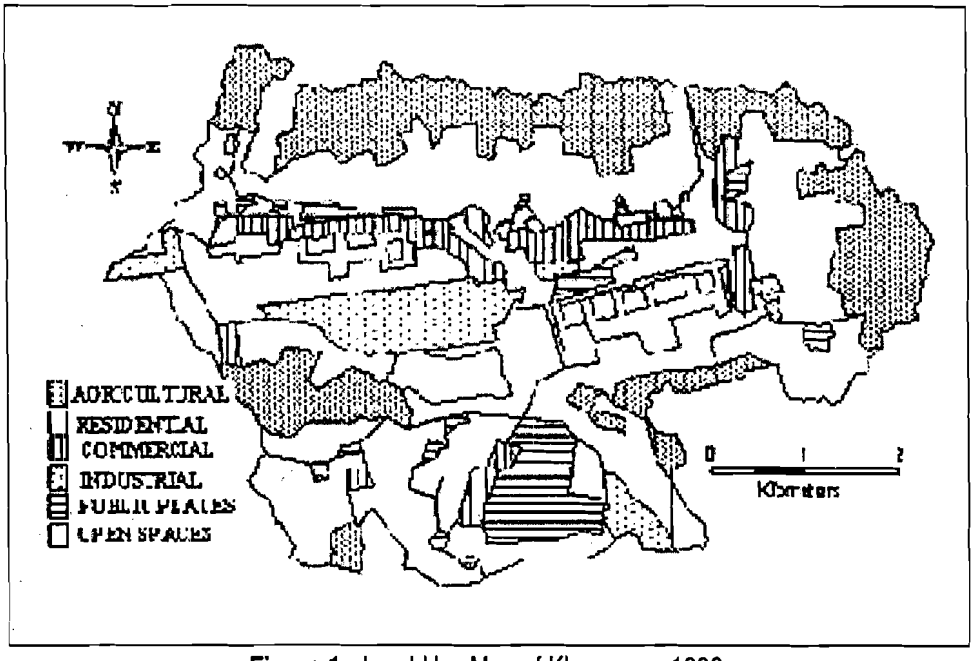

Figure 1 : Land-Use Map of Kharagpur, 1996.

numbers are very low. Narrow roads and lack of planning prohibit the use of large or medium size vehicles for public transportation. Only few main roads e.g. Inda Golebazar road, Kausalya-puratan bazar road , I.I.T. bypass, Nimpura road and Malancya road are served by Bus and Auto rickshaw. Buses are mainly for intercity transportation and not serve any purpose for intracity passengers.

Road Network : Kharagpur has about 228 Km of motorable roads among them about 96 km are in the Rail way area and remaining 134 km. are in the municipal area. The NH6 acts as by pass over the northern boarder of the city.

Road Density : The average road density (Motorable roads) of the city is 1.86 km/sq.km which is far below the optimim level to support over 300000 population. Road density of the railway area is quiet normal 3.36 Km./sq.km. Ward No – 8, 9, 13, 14, 15, 19, 26, and 30 have a moderate road density but the roads are narrow (3 – 4m) road conditions are also not well. The road density of the other words is very low.

Right Of Way : Most of the roads in railway area has a right of way over 5 m. The main roads e.g. Gole Market Roads, Inda Kausalya purtan bazaar road, I.I.T. bypass, Nimpura road & Malanchya road are more than 8m wide. But they constitute only (13%) of the total network. Other roads are very narrow (3 – 4 m) and not accessible by heavy vehicle.

Traffic Volume : The major traffic corridors in the city are the Inda – Goal Market road, Inda- Kausalya – Puratan Bazar road, and malanchya road. In peak hours traffic volume rises over 7000 vehicle per hour. (including by bicycles). Where

as traffic volume is below 500 veh/hour in the narrow lanes of the municipal area.

Stream speeds and delays : The stream speeds is high in the less congested railway areas about 30 – 40 km./hr. where as it is very low (Below 20 km,/hr) in highly congested roads and narrow lanes of municipal areas. [ref. 19].

Modes of transportation and their advantages and disadvantages : The main mode of public transportation operating today is cycle-rickshaw. Which is driven manually. Therefore the speed is very low but the fare is high. Therefore the use of bicycle and motorbike is increasing day by day. Only children and women who do not know cycling travel in rickshaw.

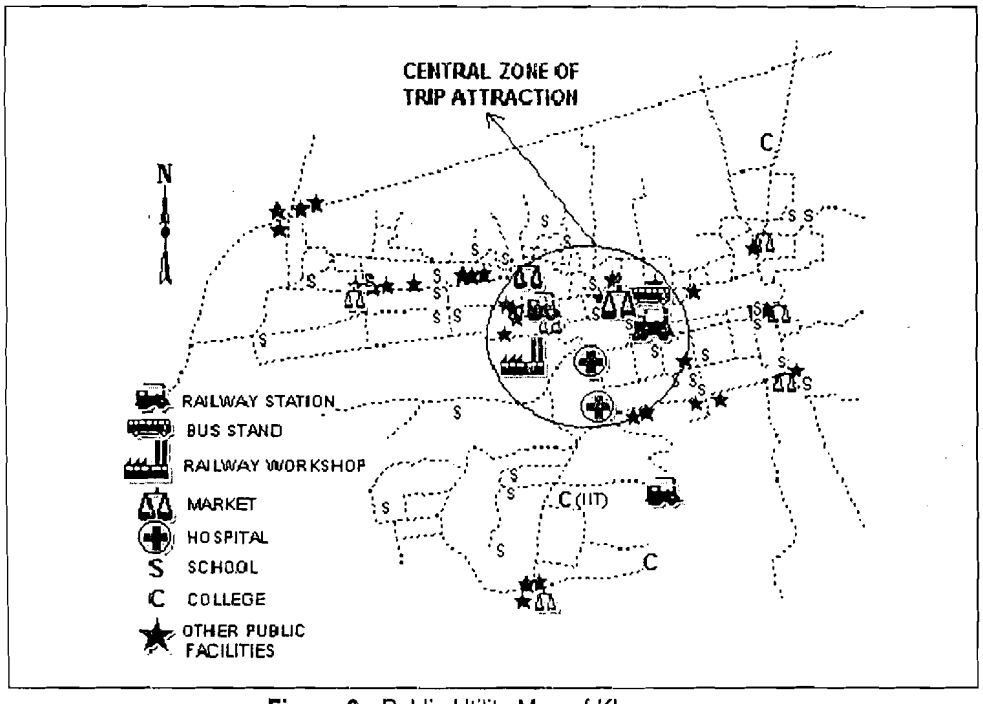

Figure 2 : Public Utility Map of Kharagpur.

Recently few maruti van and auto rickshaw are operating in selected location for general public and school children transportation. A primary oral survey shows that people are preferring this mode of transport than rickshaw, because these auto mobiles are time saving as well as money saving. therefore Auto rickshaw and marutivan service may be the only alternative of cyclerickshaw. If a proper plan is being made for this service then it will discourage the increasing rate of private cars & motorbikes and will be helpful for children and women in their way to school and working places.

Trip Attraction Zones

From the public utility map of kharagpur (fig.1) it is found that most of the

public facility centers are concentrated at the core of the city. "West Bengal urban development project - road construction and major reconstruction schemes, Feasibility study report"- show the traffic volume on major roads of Kharagpur and their right of way which exactly corresponds with the primary survey that also conducted regarding these two factors . These show that the traffic volume flows towards the city centre in the morning and out words in the evening because of the majors zones attraction are at the centre e.g. rail way station Bus-stand, Goal Market and other offices Railway workshop, Rail way schools. The Kharagpur Railway station has a daily sale of ticket average 12485 in the year of 2003 - 2004. From the primary survey of the cycle stand surrounding the Main Bus stand it has been estimated that the number of daily passengers traveling by bus are more than 6050/day. The sub rail way station Girimaidan also has a daily cell of ticket over 4000. The total number of students of schools in the centre are also over 4600 (6 Schools).Therefore there is large number of flow of passenger towards the city centre.

The second attraction zone is the south with 16 school and colleges with total number of students over 1086, Municipal office SERSA stadium railway garden and many Hotel, Restaurant, Swimming Pool etc.

There are two tertiary attraction zones, one in the north east with two High schools and Kharagpur city college another in the Northwest 8 schools, Post Office, Electric Office Cinema Halls etc.

Trip Generation Zones

As there are no sources of secondary data about the trip generation zones some indirect indicators are taken to find out the potential zones for Maruti and auto rickshaw passengers. At first all the ward boundaries of Kharagpur are digitized as different polygons then all demographic and socio-economic attributes are added to each ward. After that a *Structured Query Language* (SQL) is chosen with following conditional statements to select potential wards for trip generation. [ref. 17].

Population density >= 4000 persons/sq km.
Literacy rate >= 60%
Persons Engaged in secondary & tertiary sectors to total population >= 21%
Land value >= 60,000 rupee/katha.
Those wards are separately taken where-
Decadal growth rate of population >=15%

Inspite of meeting all these criteria the railway settlement is not included in the list because of its central location.

[High population density and growth rate is directly related to the number of passengers available, where as high literacy rate and engagement of people in the secondary and tertiary sector indicates higher mobility of people as well as better standard of living, and ability to afford Maruti and auto rickshawa services. Land value is also another indicator of financial condition of the inhabitants].

From the above analysis 21 wards are selected and it is found that there are

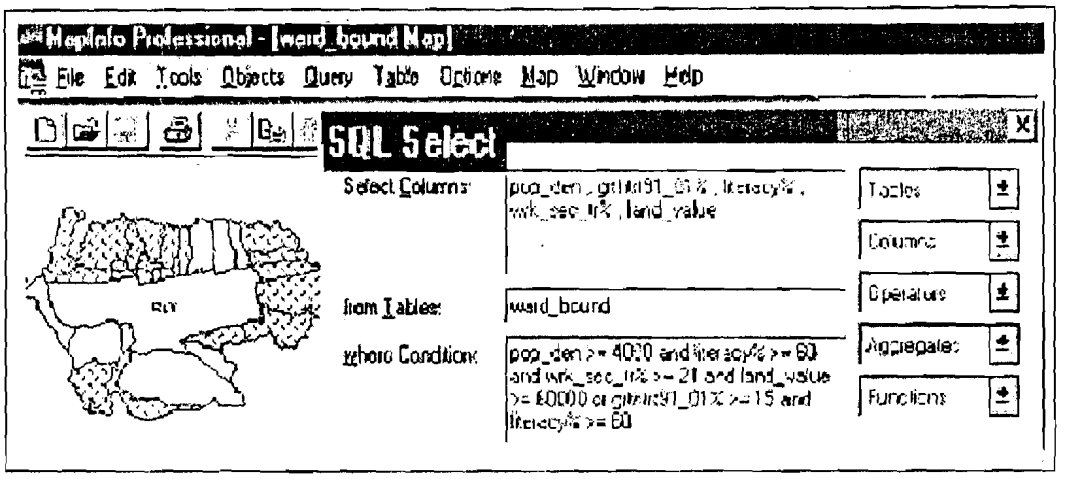

Figure 3 : The Graphical User Interface of Mapinfo for Conditional Query Making.

three major and two minor zones of trip generation. (fig.-4).

(1) North west [word no - 20, 19, 15, 17, 14, 13 and lower part of 18].
(2) North central [Ward no. 12, 10, 8, 9 and 7, lower part of 6].
(3) North east [Ward no. 1, 2, 3, & parts of 4].
(4) South west [ward no. 24,25 up to Salua].
(5) South east [towards Balarampur covering ward no.28 & 29].

Travel time estimation

The speed of a vehicle on a road depends upon many factors like the road conditions, surfacing, traffic volume, abutting land use, width of the road, composition of traffic volume of the day on street, weather condition, parking and encroachment etc. A model to calculate the speed on a road shall ideally consider all the factors involved. But such a model becomes highly complex. Therefore for simplicity it is assured that the speed of a vehicle on a road depends on four major factors:

$$S \text{ (Speed)} = a_0 + a_1W + a_2 LU + a_3V + a_4C \quad [\text{ ref. 7 \& 8 }]$$

Where– V = Hourly traffic volume, LU = Abutting land use,
W = Width (Row) in meters, C = Road condition.

a_1, a_2, a_3, a_4 are their respective co-efficient and a_0 is a suitable constant. The landuse and the road condition are qualitative parameters, which need to be quantified in order to use them in the multiple regressions.

The road conditions are given weightage in a three-point scale.

Good condition - 3, Medium condition - 2, Bad condition - 1.

The land use has been given the wightage using a six-point scale. The pedestrian interference is the main factor, which is taken into consideration in deciding the scale of land use.

Open space– 6, Sparsely populated residential–5, Densely populated residential–4, Public & Semipublic–3, Mixed residential & Commercial–2, Commercial-1.

A multiple regression analysis of the variables is done to get the values of coefficients in MATLAB (mathematical analysis software), where the road conditions, traffic volume, abutting land use and width of the road are taken as independent variables and observed speed of the vehicle (for few randomly selected links only by traveling in auto rikshaw, Table-1.) as dependent variable. The network is labeled by numbering the nodes as 1,2,3 etc. and links are identified as 1–2, 2-3, 3-4 etc. (Fig-4).

Table 1 : Data input for regression analysis

Links	W Width (m)	LU Land use code	V Traffic volume in 1000	C Road Condition	S Speed in 10s Km/hr.
8- 13	7	2	5.513	2	2.10
13 -14	7	3	2.462	3	2.5
36 - 5	8	5	1.714	3	3.5
36.13	5	3	2.836	2	2.2
6 - 31	3	4	0.504	1	1.6
24 - 28	8	6	0.619	3	4.1
29 - 26	7	2	4.218	2	2.3
22 - 25	8	5	0.859	3	3.4
35 – 12	5	5	3.112	3	2.3
10 - 12	7	6	2.174	2	3.2
1 – 2	3.5	4	0.412	1	1.7
9 - 8	6	1	9.671	2	1.1

***Source :** Primary survey*

Following Normal equations are used for the regression analysis.

1. $\Sigma S = n.\ a_0 + a_1 \Sigma W + a_2 \Sigma LU + a_3 \Sigma V + a_4 \Sigma C$
2. $\Sigma W.S = a_0 \Sigma W + a_1 \Sigma W^2 + a_2 \Sigma W.LU + a_3 \Sigma W.V + a_4 \Sigma W.C$
3. $\Sigma LU.S = a_0 \Sigma LU + a_1 \Sigma W.LU + a_2 \Sigma LU^2 + a_3 \Sigma LU.V + a_4 \Sigma LU.C$
4. $\Sigma V.S = a_0 \Sigma V + a_1 \Sigma W.V + a_2 \Sigma LU.V + a_3 \Sigma V^2 + a_4 \Sigma V.C$
5. $\Sigma C.S = a_0 \Sigma C + a_1 \Sigma W.C + a_2 \Sigma LU.C + a_3 \Sigma V.C + a_4 \Sigma C^2$ [ref. 5]

The regression analysis with the above equations gave the values for the co-efficient as follows.

$a_0 = -0.291762$, $a_1 = +0.135754$, $a_2 = +0.3730934$, $a_3 = -0.003876$, $a_4 = +0.209395$

S (Speed) = -0.291762 + 0.135754W + 0.3730934 LU -0 .003876V + 0.209395C

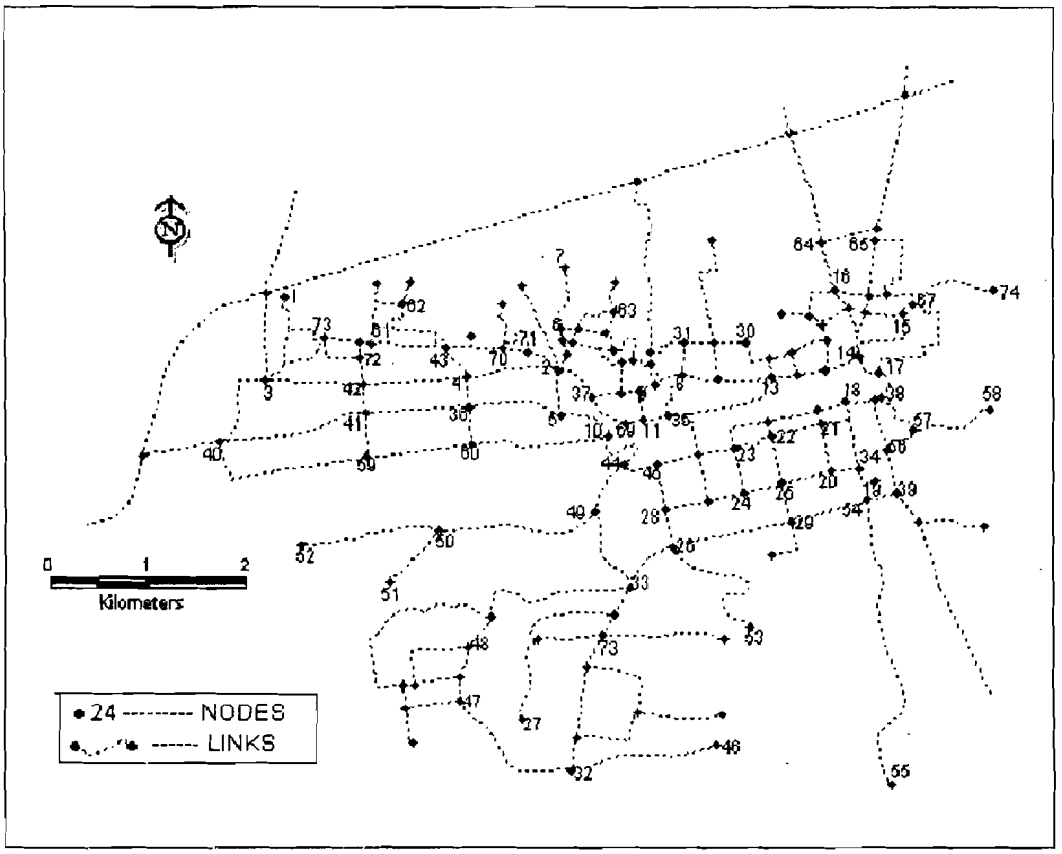

Figure 4 : Road Network Coverage – KGP.

This equation gives the speed in 'os Km/hr. The correlation coefficient obtained 0.78, which implied a satisfactory level of relationship. The negative sign for the coefficient indicate that the speed in inversely proportional to the variable eg. Traffic volume. It can be seen that the Land use and Road condition are the most influential parameters in determining speed.

Using this equation the speed of vehicles on other roads are calculated and when the length of the link is divided by the speed the outcome is the time required to traverse the link. This model helps in calculating the impedance factor required for the network analysis, the travel time of each link is shown in Table-2 (table shortened). The main drawbacks of the model are the subjectivity interest in the ranking of land use and the road condition and the lack of precise data of every link. Still the model serves the purpose with an acceptable degree of accuracy.

SUGGESTION FOR PUBLIC TRANSPORTATION ROUTES

After the calculation of travel time of each link in the network it is very easy to find out the minimum travel time path between two points in the network.

Table 2 : GIS database of road network coverage, KGP.

road_network Browser

link	width_m	rd_con_code	traff_volume	landuse_code	speed_km_h	length_km	trv_time_minute
4-36	4.0	2	450	5	25.00	0.270	0.6
37-9	6.0	2	2,055	2	20.00	0.540	1.6
9-8	6.0	2	9,036	1	10.00	0.450	2.7
8-13	7.0	2	5,540	2	20.00	0.945	2.8
13-14	7.0	3	2,360	3	25.00	0.900	2.2
14-15	8.0	2	6,680	2	19.30	0.850	2.6
36-5	8.0	3	1,650	5	35.00	1.035	1.8
5-2	3.5	3	750	5	22.50	0.500	1.3
5-10	5.0	3	1,250	5	28.80	0.540	1.1
10-11	5.0	3	1,100	5	28.80	0.400	0.5

Therefore the last stage of planning is to find out the least resistant path between the zone of trip generation and zone of trip attraction. At first the travel time of all the links are entered in the attribute table as new column, then instead of taking the shortest path, shortest time distance routes are followed to reach the destination. To cover the whole zone some time the routes are deviated from the optimum path but not exceeding the maximum travel time limit of 40minutes. To estimate the number of people could be served by these routes, a 400m (5 minutes walking distance) buffer zone is created along both side of the routes and overlaid on the ward boundary polygons. The common area between the buffer zone and each wards are separately calculated and multiplied by the population density of respective wards. The results are as follows.

There are five trip generation zones (fig – 5) A,B,C,D and E and four routes have been suggested.

1) A-O-C : Travel time 32 minutes. This route will serve 40000 people
2) B-O-D : Travel time 34 minutes. This route will serve 30,000 people.
3) B-O-C : Travel time 31 minutes. This route will serve 42,000 people.
4) E-O : Travel time 32 minutes. This route will serve 38,000 people.

Total Travel time of each route includes 15-stoppage time and all the people could be served reside within 5 minutes walking distance from the routes.

Conclusion

In present day world transportation problems and planning are prime concern of all city planners, because the economic development of a region is highly dependent on its transportation facilities and infra structure. Proper planning may develop a highly efficient transport system within the same infrastructure. Transportation problems involve such multi criteria analysis that needs some modern technologies like GIS to handle that huge volume of data.

The model developed to calculate the speed of vehicles on a road was crosschecked with the primary survey data and gave values very close to the actual values. The routes suggested by the model will serve more than 1.5

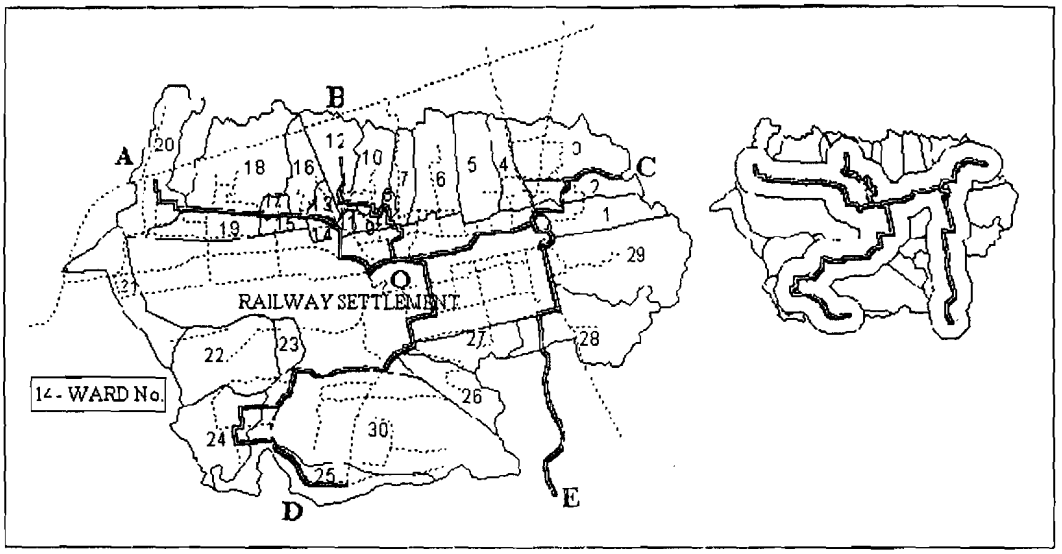

Figure 5 : Proposed Routes for Public Transportation with 400m Buffer Zone as 5 Minutes Walking Distance

Lakh people previously who were depend on bicycle, rickshaw or motorbike. The newly planned transport service will save money and time and will provide job opportunities for auto and Maruti driver. Mass transport will also decrease the tendency of using private cars and motorbikes, thus traffic congestion as well as air pollution will also decrease.

Though the project has explored the possibilities only at a threshold level. There is lot of scope for future work, especially in developing the data base into a full fledged road facility management system which will help in taking decision on every thing related to transport system of Kharagpur and in future government under taking transport system may be developed for the betterment of the city.

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REMOTE SENSING AND GIS TECHNIQUES FOR LAND-USE/LAND-COVER MAPPING AND ISSUES OF FLOOD AND ITS MANAGEMENT –A case study on Tapasia Mouza in the Kaliaghai River Basin

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Abstract

The applicability of remote sensing and GIS has been tested in a small mouza. Tapasia Mouza (JL No. - 590) situated in the Narayangarh block of Paschim Medinipur district of West Bengal has been selected as the study area. The resource problems and opportunities have been extensively examined. Flood and high erosion are the nagging menace that contribute to the lack of socio-economic development.

Introduction

Remote Sensing technology is a useful method of surveying, identifying, classifying and monitoring of different earth resources. This is the technology that provides for the acquisition of data with in short duration of time, in an interval of time, also covering a large area, which can be used for proper management of different resources. Satellite imagery are widely used in the fields of agriculture, forestry, watershed management, urban and rural planning, etc.

Geographical Information System is another useful method of capture, store, manipulate, analysis and display all forms of spatial and non-spatial data for better management of geographical area.

This study was carried out to prepare a land-use/land-cover map of the Kaliaghai river basin by using Satellite imagery through Digital Image Processing and to prepare a land-use/land-cover map & flood map of Tapasia Mouza (JL No.-590, Narayangarh Block) using cadastral map through GIS methodology.

Description of the study area

Location: Tapasia Mouza (JL No. - 590) is situated in the Narayangarh block of Paschim Medinipur district of West Bengal. It is bounded by 87°28'32.15"E to 86°29'45.55" E longitude and 21°06'34.08" N to 22°07'51.30" N latitude.

It is situated in the lower part of Kaliaghai river basin, which is located between 87° 05' 33.06" E to 87°47' 37.70" E longitude and 21°59'35.23" N to 22°21' 27.87" N latitude. Survey of India topographical map nos. 73N/3, 4, 7, 8, 11, 12, 16 and the imageries IRS-ID, LISS-III- Path/ Row 107_56 and 108_56 represent Kaliaghai river basin. The total geographical area of Kaliaghai river

basin is 1569.96 sq km and 0.4431 sq km of Tapasia Mouza, is about 0.03% of total Kaliaghai river basin area.

Soil and Topography: The kaliaghai basin is mainly composed of alluvial soil. Besides it lateritic and red soils are also found in the North-west portion.

The topography of Kaliaghai river basin is generally flat and the undulation is found at places, which gradually disappear in the transition from lateritic and red soils to alluviam.

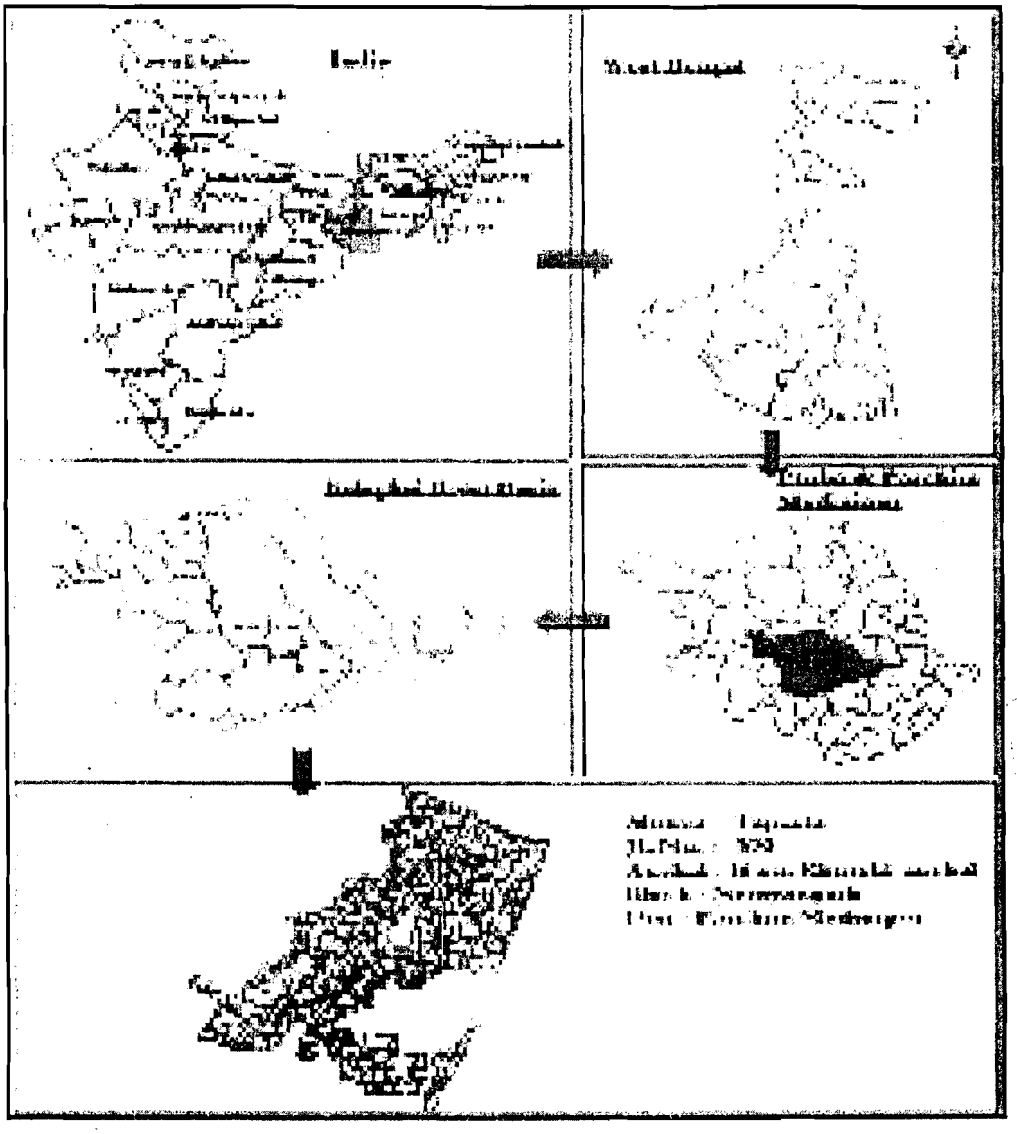

Figure 1. Location Map of the Study Area

Climate: A fierce dry heat in hot weather, a short cold weather and a moderate rainfall characterize the climate of the area. The seasons are generally distributed as the hot summer (April-May), Monsoon Season (June-September) and cold seasons (November-February). The average annual rainfall of the area is 1428 mm. The mean Maximum temperature, which is on an average 80°F in December, rises to 85°F in February 94°F in March and 102°F in April and May.

Data used:

Different type of data used for this work, like–

i. Satellite imagery.
ii. Toposheets of corresponding image.
iii. Cadastral map of Tapasia mouza.

Table 1. Satellite imageries

Satellite and sensor	Year	Path & Row	Extension		Source
			Longitude	Latitude	
IRS-1D-LISS-III	4th Feb. 2002	107 _ 56 108 _ 56	UL- 87°28'32.15"E, LR-86°29'45.55" E,	22°07'51.30" N 21°06'34.08" N	ISRO, RRSSC, Kharagpur,IIT

Table 2. Toposheet and other materials

Toposheet and other materials	Year of publication	Source
73-n/3, 73-n/4, 73-n/7, 73-n/8, 73-n/11, 73-n/12, 73-n/16	1976	Survey of India
Cadastral map of Tapasia mouza	1912-13	District record room, Medinipur

Methodology

In laboratory with help of image processing S/W – ERDAS and ARC INFO different tasks are performed, using satellite imagery and mouza map.

Geo-referencing : Single rectification is performed on manually tracing Toposheet map and cadastral map by using Ground control points and map to image rectification on the satellite imageries. The Lambert conformal conic projection and Everest datum is used for the geo- referencing process.

Mosaic : Using two scenes (IRS-ID, LISS-III- Path/ Row 107_56 and 108_56) with help of ERDAS IMAGINE software mosaic process is run to get total basin area in a single scene.

Create AOI layer : To extraction of the Kaliaghai river basin area AOI layer is created by help of AOI tools in the ERDAS software on the rectified Toposheet.

Sub-setting : Kaliaghai river basin area is extracted by sub-setting from the mosaic image using AOI layer.

Classification : Taking the rectified subset images supervised classification performed. From the tonal values of original FCC imageries, land cover classes are selected and for classification a signature editor is created to supervise the computer S/w. This classification is performed taking 8 classes.

These are : a. Water body, b. Moist fallow, c. Bare soil, d. Good agricultural land, e. Poor agricultural land, f. Settlement patches, g. Dense sal, and h. Poor forest.

Filtering : The classified output was subjected to smoothening using median filter. 3 * 3 kernels are used in the median filtering in stages to get the smoothened out put.

Raster to vector : Taking the smoothened out put raster to vector conversion is performed with help of ERDAS IMAGINE software. Using this output vector layer with their attribute land-use map of Kaliaghai river basin is prepared.

Vector layer generation : To digitized different point and line features vector layers are creates and then by help of Arc Tools (ARC INFO) those features are digitized. Point, line tools are used for this purpose.

Different vector layers are created, like-

1. Boundary layer (line) to show the Kaliaghai river basin boundary.
2. Drainage layer (line) for prepare drainage map of Kaliaghai river basin.
3. Location layer (point) to show actual location of Tapasia mouza in the Kaliaghai river basin and to show some cultural features of the mouza.
4. Polygon layer to prepare land-use land cover map and flood map of Tapasia mouza.

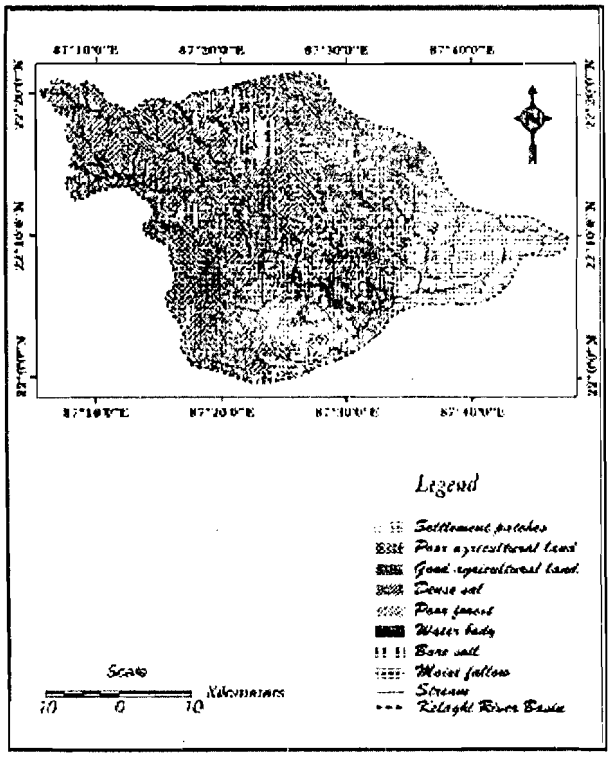

Figure 2. Land-use map of Kaliaghai river basin

Table 3. Land-use/land cover classification statistics for Kaliaghai river basin

Sl. No.	Land-use/ land-cover class	Area in sq Km	% of the total basin area
1	Water body	4.6565	0.77
2	Moist fallow	66.9551	11.05
3	Bare soil	24.5359	4.05
4	Good agricultural land	109.3254	18.03
5	Poor agricultural land	182.6467	30.13
6	Settlement patches	140.1697	23.12
7	Dense sal	36.8856	6.09
8	Poor forest	40.9901	6.76
	Total	**606.165**	**100%**

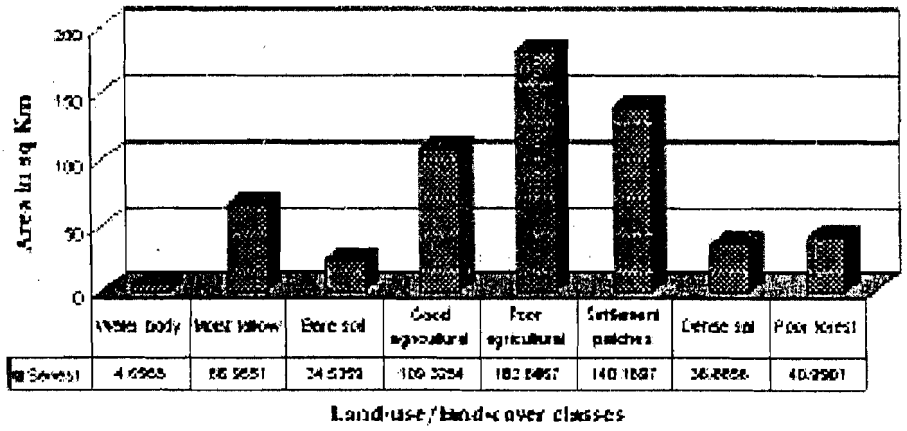

Figure 3. Bar graphs for Land-use/land-cover classes with their areal extent

Attribution to the vector coverage : The attributes are given against all digitized features against their real existence on the Earth surface.

All the data about land-cover/land-use of the mouza are entry to the vector coverage (polygon) with help of ARC INFO software.

Preparation of drainage map of Kaliaghai river basin : Using three vector layers (boundary, drainage & location point) the drainage map of Kaliaghai river basin is prepared.

Preparation of land-use/land-cover map of Tapasia Mouza : With help of ERDAS IMAGINE software using the vector coverage (polygon) land-use/land-cover map is prepared (Figure-6). According to the class statistics a bar diagram is produced with help of micro soft exel (Figure-5).

Preparation of flood map and cultural of Tapasia Mouza : Using the polygon vector coverage and corresponding attribute the flood map is prepared (Figure-7) and using polygon vector coverage & point vector coverages and corresponding attribute cukturel map is prepared (Figure-8).

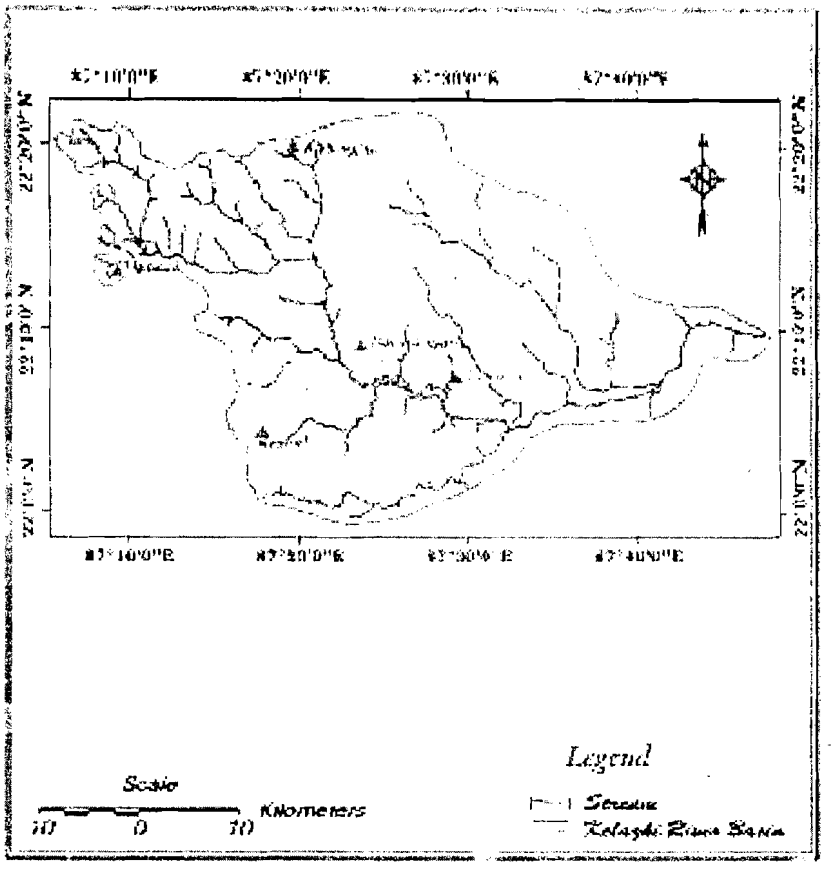

Figure 4. Drainage map Kaliaghai river basin

Tapasia Today–problem & its management aspect :

Tapasia is a backward mouza of 14 no. Khurshi Anchal, Narayangarh, Paschim Midnapur. This mouza remains backward in terms of the availability of amenities for its development.

About 65% geographical area of the mouza is used by agricultural activity. People of this area depend upon agricultural activity, mainly on paddy cultivation. The agricultural fields are mainly consist of alluvial soil, which is suitable for crop.

The main problem of the villagers is the electric facility, yet electric lines of 11000 voltages pass through the northern portion of the village. Electric connections is satisfactory for this village, but suffers from frequent power cuts.

There are two mini deep tubewell (pump) and three shallow pump (Figure-8) in the village. But in summer season shallow pump can't supply sufficient water for agriculture due to high depth of ground water level (bgl). Two mini deep tubewell (pump) can't fulfill the demand of irrigation water in the southern part of the village. The canal in the west part, tributary of Kaliaghai, becomes dry in the summer season, and is not used as a source of irrigation. Only from

Table 4. Land-use/land cover statistics for Tapasia Mouza, Feb-2006

Sl. No.	Land-use/ land-cover class	Area in sq m	% of the total mouza area
1	Paddy	146223	33%
2	Other crop	44310	10%
3	Cultivated fallow	97482	22%
4	Natural/planted vegetation	39879	9%
5	Settlement	8862	2%
6	Khal	13293	3%
7	Pond	26586	6%
8	Homestead land	35448	8%
9	Open land	24370.5	5.50%
10	Village road	6646.5	1.50%
	Total	**443100**	**100%**

Source : IRS–ID–LISS III and Cadastral Map of Tapsia, Land Records Dept., Govt. of W.B.

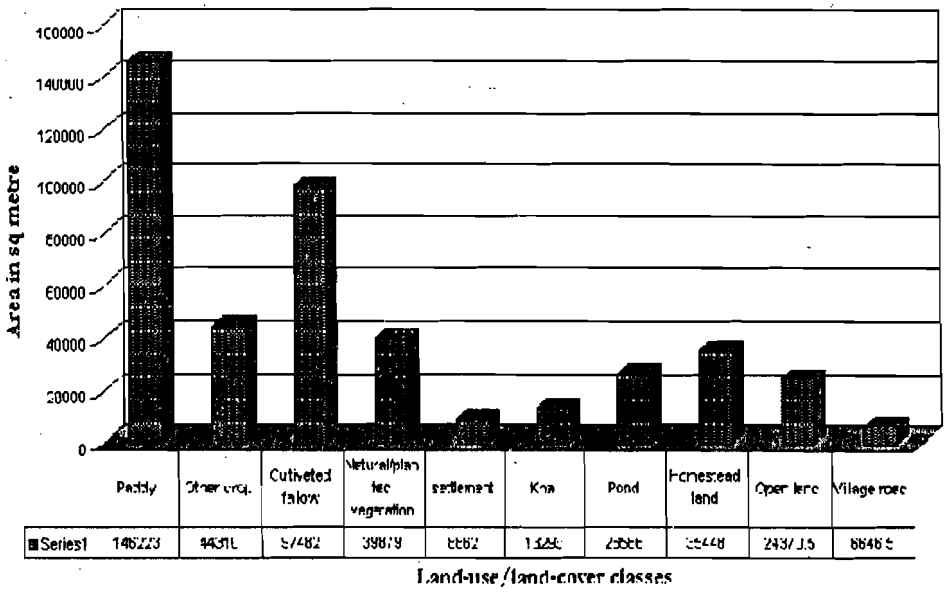

Figure 5. Bar graphs for Land-use/land-cover classes with their areal extent

ponds the irrigational water for cultivation is supplied to few plots.

Flood is the major problem of this village in the monsoon period. About 60% of total geographical area of the village is inundated frequently in this season (Figure-7). This village is situated in the lower part of the Kaliaghai river basin. Though the economic condition is dependent on agricultural activity flood is the main cause of its backwardness. The Amon crop (rainy season crop) is totally destroyed by this flood is some years. Main cause of flood is location of the village in the lower basin (Figure-4). In the upper basin relative relief, average

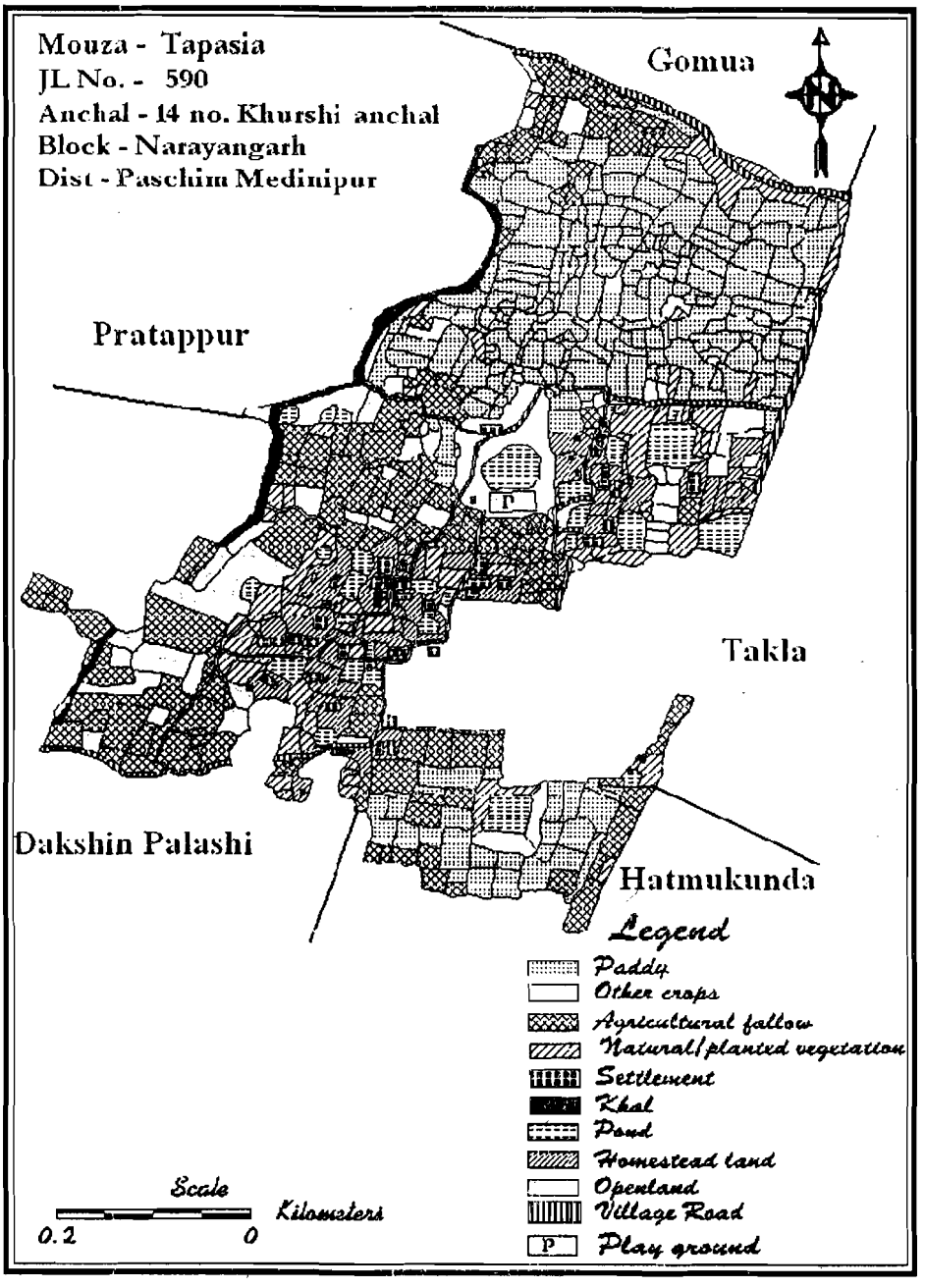

Figure 6. Land-use/land-cover map of Tapasia Mouza, Feb. 2006

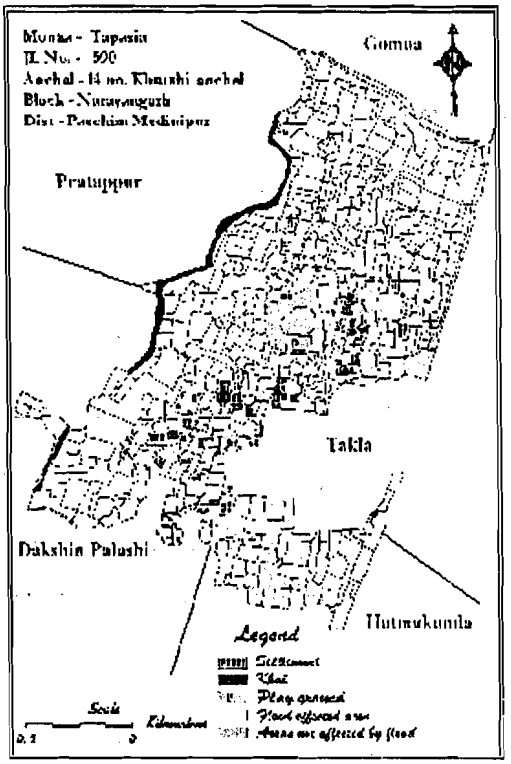

Figure 7. Map showing flood affected plots of Tapasia mouza

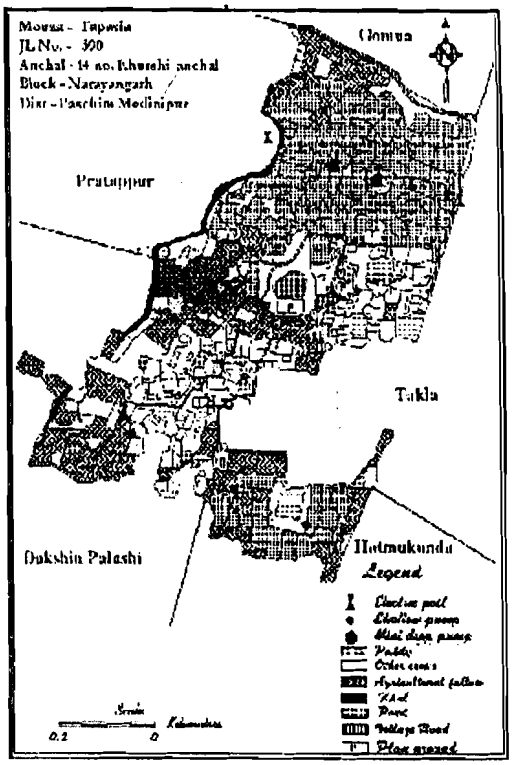

Figure 8. Cultural map showing irrigation system & associated features of Tapasia mouza

slope, drainage density and frequency are more. These are the causes of erosion in the upper basin. The eroded material transferred to the lower basin where the above conditions are very low. Channel depth decreases every year due to excessive sedimentation. So the channel can't contain and pass out excess water and spill during the rainy season. Another cause for the flood and its steadiness is the netting across the crop river/canal in for the purpose of catching fish by fisherman. Some causes are responsible for flash flood. These are as follows–

i. Soil erosion
ii. Peak discharges
iii. Textural condition of the alluvial
iv. Heavy rainfall in short time
v. Heavy rainfall on the upper catchments area.

Another problem of this village is communication network system, though the village is connected with the NH-60 away from 10 km and district high way from 4 km. Most of the village path is kutcha, which is not suitable for free walk in the rainy day.

To control the flood one action plan was taken few years ago for drazing the

silt, but it is not succeeded till today. This problem may be removed by implementation of this plan.

There is another action plan not netting across the river/channel for catching fish by the fisherman excessively. If frequency of netting becomes less it will help mitigate water logging for long time.

To protect the erosion in the upper part of Kaliaghai river basin, which is the cause of excessive sedimentation in lower part, some action should be taken–

1. Rationally agriculture activity to be performed.
2. Check damp construction in the upper catchments area in every tributary, where it falls into next order stream.
3. Increasing vegetation coverage to reduce run-off

For demandable supply of irrigational water in summer season two or more mini deep tube well (pump) are needed- one in the southern part and another in the south west part. For it electric facility should be essential, also foe domestic purpose.

According to Gram Sarak Yojna the morum road, which is connected with NH-60 and district highway, should be metalled.

Conclusion

Economy of Tapasia mouza has been far from satisfactory, stands on agriculture (mainly paddy that too is irregular). The crops are frequently affected by flood in the rainy season and at the same time suffer from lack of irrigational water in the summer season. To develop its economy flood should be mitigated, and the supply of irrigational water has to be ensured according to farmers demand for agriculture practice.

Acknowledgement :

My thanks due to Dr. D.K. Pal, Co-ordinator, Dept. of Remote Sensing & GIS, Head, Dept. of Geography & Environment Management, Vidyasagar University for providing Digital Image Interpretation lab. Facility to carry out my work. Also spatial thanks to Dr. Asish Kumar Paul, Dr. Ramkrishna maity, Dr. Soumedu charjee and Mr. Utpal Roy, teaching staff of Dept. of Geography & Environment Management, Vidyasagar University for their valuable advice during this work.

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NATURAL ENVIRONMENTAL CONTROLS UPON GEOMORPHOLOGY : STUDY ON JHARGRAM BLOCK IN PASCHIM MEDINIPUR DISTRICT OF WEST BENGAL.

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Abstract

This paper assesses the natural environmental controls upon geomorphology of Jhargram Block in Paschim Medinipur district of West Bengal. The Jhargram block, which is a part of the south-eastern fringe of the Chotonagpur plateau, has a long history of geological development, which-accounts for the diversity of landforms as well as natural forest resources. The tropical-monsoon type climatic conditions along with the biotic ambience play important role for the development of landform and soil. The topography is characterized by the exposures of formation belongings to Archean, Tertiary and Recent ages. Two major types of soil are found in this area namely Latosols and Alluvial soil. Most parts of the study area are dominated by Laterites, which are comparatively infertile in nature. Productive alluvial soils are seen in the vicinity of riverbanks.

Key words : *Fringe, Biotic ambience, Archean, Tertiary, Latosols, Infertile etc.*

Introduction

Appropriate geomorphological study of any regional context in India appears to be a real challenge because of its ever-changing environmental conditions compounded by the lack of availability of sufficient data. Due to the dynamic nature of environmental conditions to assess the geomorphic features and its impact on environment is very difficult. From this standpoint of view the future prediction over any possible change is considered to be really very critical. Thus the Jhargram study area where the forests have an important role to play along with the tropical monsoon climate in shaping the geomorphology of the region.

Location of the study area

Jhargram Block in Paschim Medinipur district of West Bengal lies between latitude 20°15 N to 22°29 N and longitude 86° 54 E to 87°16 E covering an area of 539.63 Km^2 (Fig-1). This area consists of 13 Gram panchayats, one municipal (Jhargram Municipal) area, 405 (out of 604) inhabited villages and total population is about 2,06,539 persons according to 2001 census report. This

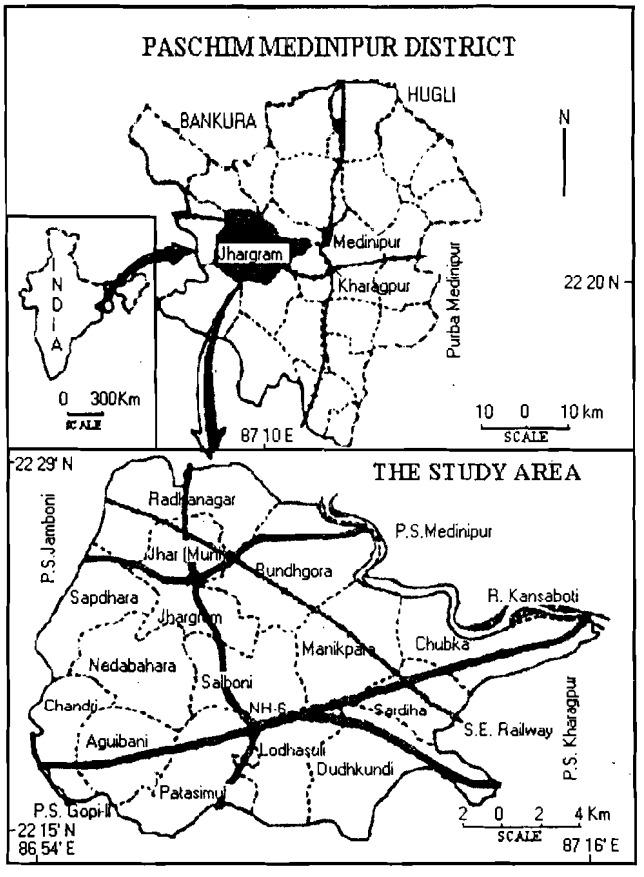

Figure 1. Location Map of the Study Area

area is covered in survey of India (SOI) 1:50,000 scale topographical map nos. 73 J/14, 73 J/15, 73N/2 and 73N/3. Geographically, this block is located in a typical hard undulating laterite soils covered substantially by dry tropical forests comprising sal, segun, and mahua etc. Considering the geographical and historical importance of this area the present authors decided to conduct a study upon the landform development of this area. The main objectives of this study are:

a) To assess the present natural environmental condition of the study area.
b) To identify the natural environmental influences upon the geomorphology and soils in tropical climatic condition and the resultant biotic ambience.

Natural Environmental factors controlling landform development

Geological set-up : The study area Jhargram block, which forms a part of the south-eastern fringe of the Chhotonagpur plateau, has a long history of geological development, which accounts for the diversity of landforms as well as natural forest resources. The study area is characterised by the exposures

Table 1. Stratigraphy succession of the Jhargram Block

Period	Major Foundation	Types of rock & sediments
Recent and sub-recent to Pleistocene	Newer alluvium	Silts, silty clays, some clean sands
	Older alluvium	Intercalated sandy and clayey layers. Also coarse angular Pebbles. Lateritic capping lateritic gravels.
Pleistocene to tertiary	Riverain deposits	Gravels, sands & clays Laterites
Tertiary	Sandstone & shale's	Sandstone and shale's
Precambrian	Archean formations	Gary micaceous schist's, phylite quartzite, epidiorite, amphibolites of iron are series and also granite & granite rocks at places.

Source: First working plan (1975 to 1985), [1] Southern Circle, Medinipur (w), Vol: 1.

of formation belongings to Archean, tertiary and recent ages. The stratigraphy succession of the Jhargram Block and adjacent areas is shown in Table-1.

Climatic condition : The study area is located in the Tropical monsoon climatic zone. The general climatic characters of the area are hot and dry. It has a very hot summer with fierce dry heat, moderate winter of short duration and a general dryness of the atmosphere. The rainy season is mainly observed from June to September. High temperature is the characteristic of summer months. At this time hot westerly winds from central India penetrate in this region and then temperatures become exceptionally high. The mean maximum and mean minimum temperatures in different months of the year at Jhargram block are given below (Table-2).

At Jhargram, the mean Maximum temperature, which is about 28^0 C in

Table 2. Mean monthly temperature of Jhargram Block

Month	Temperature conditions	
	Mean maximum in 0^0 C	Mean minimum in 0^0 C
January	29.97	5.55
February	30.53	10.55
March	37.19	14.43
April	40.52	18.87
May	42.16	19.98
June	38.74	22.20
July	34.97	23.31
August	34.41	23.31
September	34.97	22.76
October	33.30	17.76
November	31.64	9.99
December	27.75	7.22

Source : District Statistical Hand Book, [3] 2002

Table 3. Annual Rainfall of Jhargram Block, since 1980 to 2002

Year	Annual rainfall in mm.	Year	Annual rainfall in mm	Year	Annual rainfallin mm
1980	1509	1988	1324	1996	1328
1981	1538	1989	1202	1997	1497
1982	1408	1990	1460	1998	1322
1983	1522	1991	1507	1999	1278
1984	1478	1992	1362	2000	1304
1985	1606	1993	1352	2001	1252
1986	1306	1994	1404	2002	1272
1987	1232	1995	1502	22 yrs.	1452 (av.)

Source: Directorate of forest, Govt. of W.B., First working plan, West Medinipur forest Division No 1, and revised program of working plan-2002

December, rises to 37^0 C in March and maximises to about 42^0 C in May. On the other hand the mean minimum temperature, which is about 23^0 C in July fall to as low as 5.5^0 C in January. With the advent of the southwest monsoon normally at the latter part of the month of May the sky gets plenty of reflectors in the form of cloud and the insolation is reduced to a bearable level.

Rainfall : Rainfall in the study area is mainly controlled by the southwest monsoon circulation. The average rainfall of Jhargram block is about 1450 mm. The annual rainfall looks bounty but the distribution is utterly skewed and the area is rendered drought prone. The annual rainfalls of Jhargram block are given below (Table-3).

Most of the rainfall in concentrated in a few months of the year, mainly during June to September and months starting July till August record highest rainfall, because the southwest monsoon rains start in the months of June and continues till September. The rainfall decreases from October onwards with the onset of dry winter. Thus the block is a moderate rainfall region in Paschim Medinipur District. The study area dominated by the southwest monsoon has the following season.

1. **Pre-monsoon :** (March to June) : From the beginning of March temperature rapidly rises normally up to the first week of June. This results in a fall of barometric pressure and comes under a meso-scale circulation pattern owing to the proximity of Bay of Bengal. As a result a moderate breeze starts blowing from the South in the afternoon to bring in quick relief to the people of this region.
2. **Monsoon :** (July to October) : This is the season of rains accompanied infrequently by cyclones, which in a synoptic scale event generate in the Bay of Bengal during the late monsoon and proceeds towards the coast. The humidity increases to about 80%. This episode is very important for growing crops like paddy and other rainfed crops vegetables.
3. **Post-monsoon :** (November to February) : In this season the weather is delightful and exhilarating. Some times temperature are falls to 10^0 C. The precipitation in this season is generally scarce.

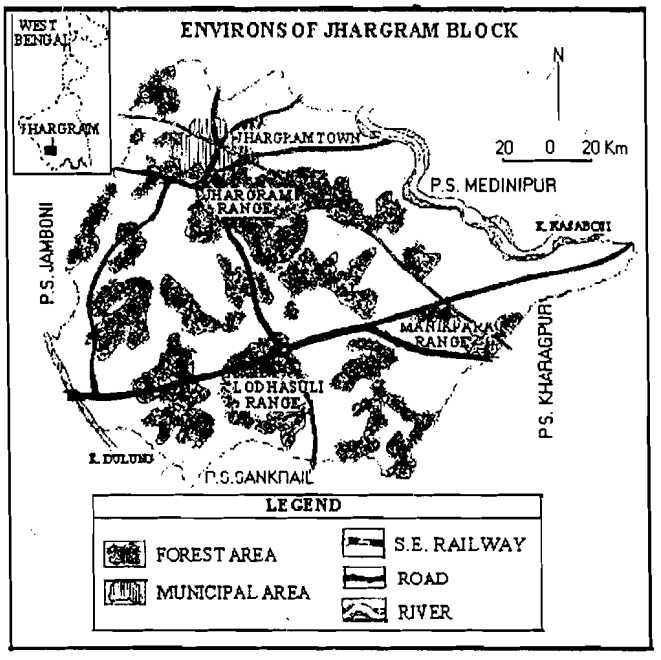

Figure 2. Forest Map of the Study Region

Natural vegetation : Natural forests in Jhargram block play an important role in the natural resources as well as the economic development of the region. In 2001 census report 15400 hectares (17.59%) are under forestland. Per capita forest area in the study area comes to 0.08 hectares, as compared to 0.06 hectares for India. Jhargram block contains 93 forest bearing mouzas and 3 beat offices namely Jhargram beat, Dhabani beat and Pukuria beat (Fig-2). The block is the home to a rich biodiversity that is essential to the physical and environmental wellbeing. The dominant forest tree in the study area is Sal (Shorea robusta). Others species like Mohua, Palash, Piali, Piasal etc trees, shrubs, herbs and weeds associated with Sal as undergrowth. H.G. Chapman[2] (1936) assessed that these types of forest belong to Northern Tropical Dry Deciduous forest. The forest statistics of Jhargram block are given below (Table-4).

Table 4. Forest statistic of the study area, 2001

Name of the Beat	No of Mouzas	Total forest area (Hectares)	Plantation Area (Hectares)
Jhargram beat	45	2813.864	165.20
Dhabani beat	23	587.592	141.50
Pukuria beat	25	1599.036	159.65
Total	93	5000.492	466.35

Source: Based on forest office (Jhargram range) Paschim Medinipur District 2001.

Methodology :

Two different types of methodology have been followed for this study. These are :

Fieldwork : Geomorphic data collected through field investigation during various seasons have been incorporated for preparing various maps. Different techniques have been applied and instrumental survey works have been done during fieldwork with simple dumpy level, clinometer etc to find out the geomorphologic features of this area.

Secondary data collected and mapping : Secondary sources of data have been procured mainly from Census of India (2001) and Statistical Bulletin (2002) of Medinipur district. Some important maps and literature collected from the line departments or agencies were also consulted along with field data for assessment of geomorphic development.

Results and Discussion :

Geomorphic feature : Jhargram Block is situated between plateau and plain region in the western tract of Paschim Medinipur district. The highest elevation of the surface found in the North-western portion is about 104 m and then lowest elevation has been recorded at about observed 61 m towards the east and south-east of the bulk of study area. The topography of the study area is characterized by an undulating terrain patterns. The study region may be classified into the following physiographic units :

1. **Highland region :** The highland region is situated on the part of west and North- west portion of the study region. Maximum elevation is recorded about 104 m and lowest elevation is recorded is about 61 m. The altitude of this area is 43 m. above mean sea level. Sal, Segun, Mahua etc trees grow on the lateritic soil of this area. The only urban centre has been developed in this area is 'Jhargram town'.
2. **Plain region :** Plain region is situated on the south, east and north-eastern part of the study region as isolated fluvial pockets. Maximum elevation is recorded about 61 m and lowest elevation is recorded is about 46 m. The relative relief of this area is 15 m. Fertile alluvial soil deposited by river Subarnarekha and their tributaries covers the plain area. Most of the productive agricultural lands are found in this region.

Run-off morphology : The formation of the west Medinipur highland as well as Jhargram area is lateritic, which occupies nearly the entire area except the river banks (marked by sediment deposition). In the north-western part of the study area schist's crop up from beneath the lateritic flats at some places indicating the characteristic feature of the geological history of the formation of the study area during the Quaternary period (O'Malley[3], 1912). Towards the farther north a grey and bluish-grey micaceous schist's band with gneissose character is found. Other important formations are quartzite grits, slates etc. The lateritic rooks are the dominating stratigraphic formation of this area. The laterite highland of this area is remarkable for the development of run-off channels, which often play a vital role for soil erosion of this area.

Table 5. Types of gullies and their morphology

Type	Morphology	Place of observation
Scour network gully	Run-off water concentrated in rills or depressions and channels network extends on to the gently undulating land. The channel floor is normally rugged and degraded. Depth of the channels decreases near the river.	Open forest area and near along the Dulung bank area
Complex network channels	Run-off water concentrated in rills or depressions and channels network extends on to the gently undulating land. The channels become wider near the river. Undercutting and gravitational slumping of gully head.	Baita, Angarkuria and along Kansai River bank

Source: Field investigation report during different seasons.

Types of gullies : The field investigation has confirmed mainly two types of run-off channels or gullies and associated morphological structures; they are as follows (Table-5).

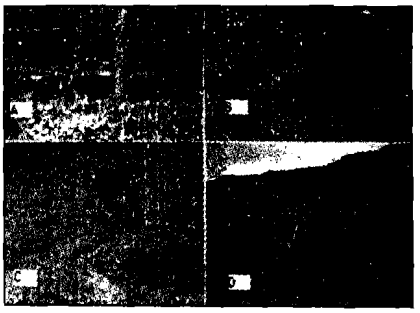

Figure 3. Various types of Soil erosion

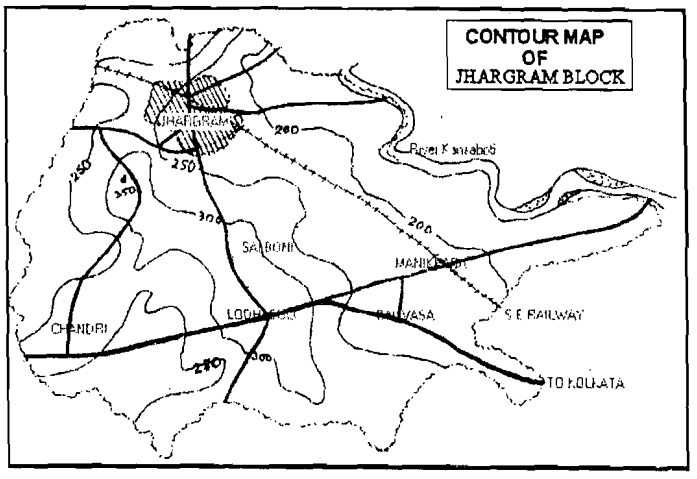

Figure 4. Relief Map of the Jhargram Block

The field investigations have substantiated main three major causes for the development of run-off channels (gully) in the study area :

a) During the monsoon season excess water by heavy torrential rainfall flows on unprotect tilled bare lateritic soil of this area, which facilitates the development of run-off channels.
b) Slopes towards the river aggravates down cutting and headword erosion during the wet season.
c) Poor vegetation cover on the lateritic soil causes unhindered high-speed flow of water, which acerbates the predicament.

Drainage : Although no broad river worth the name runs through in the study area, tributaries of Kangsabati, Kaleghai and Dulung River are well dissected in the region and build up dendritic drainage pattern. They are all tributaries of seasonal flow and thus remain almost dry except rainy season. The study region is bounded and intersected by several rivers, which have the general flow direction run from the west to east. The principal rivers among them are the Kangsabati (Kassai), the Keleghai, and the Dulung. They become full to the brim in monsoon months only. Severe soil erosion is experienced during the rainy season by the over land flow and river action.

Soil development : Three major types of soil is found in this area namely Laterite, Red loams and alluvium soil. The main classes of soils are as follows (Fig-5) :

Name of the soils	Characteristics of the major soils
Laterite soil	From the Pedogenetic point of view Laterite soils are formed by the laterization process in tropical and subtropical climate area. Laterite soils are characterized by silica leaching and sesquioxide (R_2O_3) enrichment. They are especially characteristic of the tropics and are composed of iron and aluminium hydroxides. Most of the parts of this area are covered by Laterites soil, which is rather poor in fertility status. PH value varies from 7.5-9.5.
Red loam	These types of soils are characterized by argillaceous soil with a cloddy structure and presence of few concretionary materials. Texture varies widely from yellowish clay loam to pebbly sandy loam bit underlying structure is compact by morrum layer mixed with clay. Sometime mixed with Archean rock materials, organic matter in such soil are an extremely low pH value varies from 5.5 to 6.5
Alluvium soil	Soils are developed in the river basins area by the fluvial depositions. As such they are the most fertile in nature and most of the agricultural productive areas are marked by this soil. pH value varies from 6.5-7.5

Source: Field investigation report, 2005

General Assessments :

From the above analysis, the following facts have come out:

1. Existing climate and vegetation play significant role in sloping up the geomorphological set-up of the study region. For the long-term development

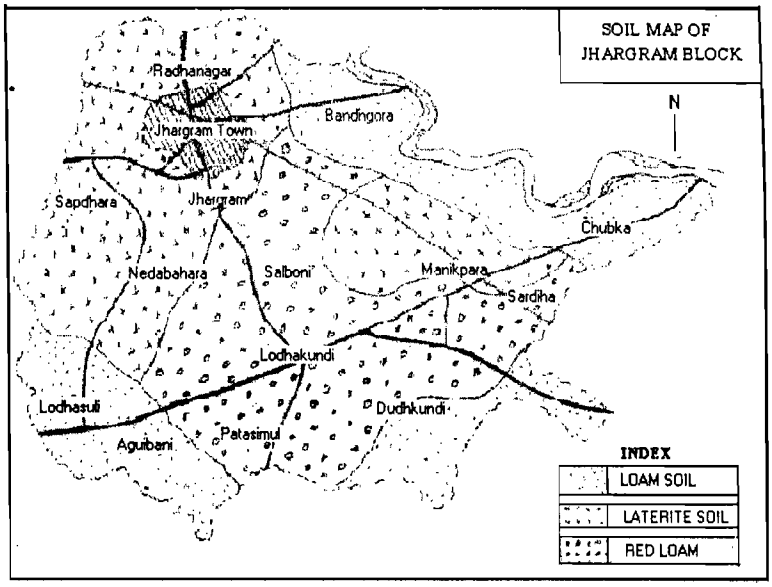

Figure 5. Soil Map of the Jhargram Block

of the landform lithology and structure assume significance along with the Quaternary climatic changes. It has been observed that the monsoon type of climatic condition influences upon the short-term change of the geomorphology of the study area.

2. Dwindling natural forest play a vital role for the changes of climatic conditions and induces deleterious impact on natural environmental phenomena at the study region also.
3. Seasonal variations play important role for the runoff channel development and soil erosion. During the monsoon season excess water by heavy rainfall flows on sloping lateritic soils of this area, which causes the development of run-off, induced gullies (first order channels in drainage network).
4. Natural vegetation plays the vital role for soil development and landform dynamics of the study area. Natural vegetation should be the best management measure for the soil preservation and natural development of the landform of this area.

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GEOGRAPHICAL ASSESSMENT OF DEVELOPMENT IN BATHANBARI VILLAGE AND ITS' SURROUNDINGS

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Abstract

Development is a continuous process in any human society. The objective of any development is determined by physical and economical opportunities of that particular area. Bathanbari of Barddhaman, West Bengal is a remote village with minimum economic activities and opportunities due to some physical constraints. The objective of this paper is to find out the scenario of development and prospects of the village under the unfavourable geographical circumstances.

Key words : *Riverine action, Laterite and grey alluvium, Socio-cultural willingness*

Introduction

Man has always some impact on the landscape. According to Jones (1977) man's geomorphological behaviour is unusual in three ways. Firstly human activities controlled more by economic restraints than by environmental factors. Man has the technology ot build virtually any environment. No other process can claim that. Secondly, his activities extend beyond the land areas to that of the ocean. Thirdly, man can choose this impact in relation to time, location and magnitude.

Bathanbari is a village by the side of the river Barakar. The river has been eroding nearly 30% of its land since last fifty years. The village community depends on the enclosed river. In most of the cases the difficulty lies not identifying the ways in which man has modified fluvial system, but in identifying the rivers and the channels that undoubtedly remain in their natural state. But sometimes his actions produce side-effects which constitutes hazards and therefore need further management by man-using the river for waste disposal which leads to pollution, while dams produce sedimentation of reservoirs, reducing their storage capacity. So, the action man takes in response to this hazards is in extricably bound up with his perception. But every reaction turns in a problem when action to take place without concerning and consulting the 'son of the soils' who share their living and suffering with the neighbour 'the river' for long time.

Against a background of increasing demand for land, much of it in developing and underdeveloped areas. Where the geomorphological knowledge is scanty, a number of aspects of environmental management always be considerable. Any growth of settlement whether rural or urban is truly

dependent on the options of geomorphological characteristics of the place. The entire living; economic, social, cultural, political are very much effects of geomorphological offerings and constraints of that particular region. For example, transport system and communication ways are very important for development of any area. Bathanbari, the present study area is practically remotest village which has very limited communication system. Even an underprepared natural pathway (within forest) is the single short-cut route to reach the nearest township, Maithon. And this undulating pathway takes nearly one hour walk because there are no other transport options except bi-cycle and motor-byke. So, here geomorphology takes an active role giving advice on the beneficial use of topography and surface materials in planning specific routes and layouts.

As man is an important geomorphic agent, the multifacet geomorphological knowledge can obviously influence every sphere of human development and hence the environment-friendly living.

Location of the Study Area

The village, Bathanbari is situated in the Bardhhaman District which is in the western part of West Bengal. The latitude and longitude are 23°47′35″ N and 86°49′05″ E respectively. The Judiciary Limit. No or J.L number is 4 under the Police Station of Salanpur. The village is close to river Barakar and Maithon Barrage reservior. Most of the north and north-western part of this village are now under the river. The Banshkatia village in the east, Hadulla village in the south, Sarkuri village in the west and Barakar river in the east-this may be counted as the locational situation of Bathanbari village (Fig 1).

The village is under administration of Barddhaman zilla Parisad and governing body & 145 km from the district town of Barddhaman and near about 250 km from the State capital Kolkata.

Huge riverine action, construction of barrage causes severe impact on the land resource of Bathanbari village. Nearly 1/3 of this village is now under the river and the present village has only 1/5 settlement coverage of its total area where agriculture is the pre-dominant economic activity.

Geomorphology

Bathanbari and its surrounding is a part of the transitional zone of lower Bengal Plain and western highlands. According to the topographical division, the Bathanbari village is located in the margin of extended part of Chhotanagpur plateau. The placement of contours indicate that it is a part of a low undutating plateau which is nearly 520 m high in respect of mean sea level.

According to the physical setting, the village is sited in the banks of river Barakar. It draws water mainly from Maithon reservior.

Undulating topography, scattered denude irregular monadnocks and small tillas are the common features of this region. The area has a very prominent slope in the northern and western part. Where as in the northern and north-eastern part the slope is gentle and in the southern and south-western part, it

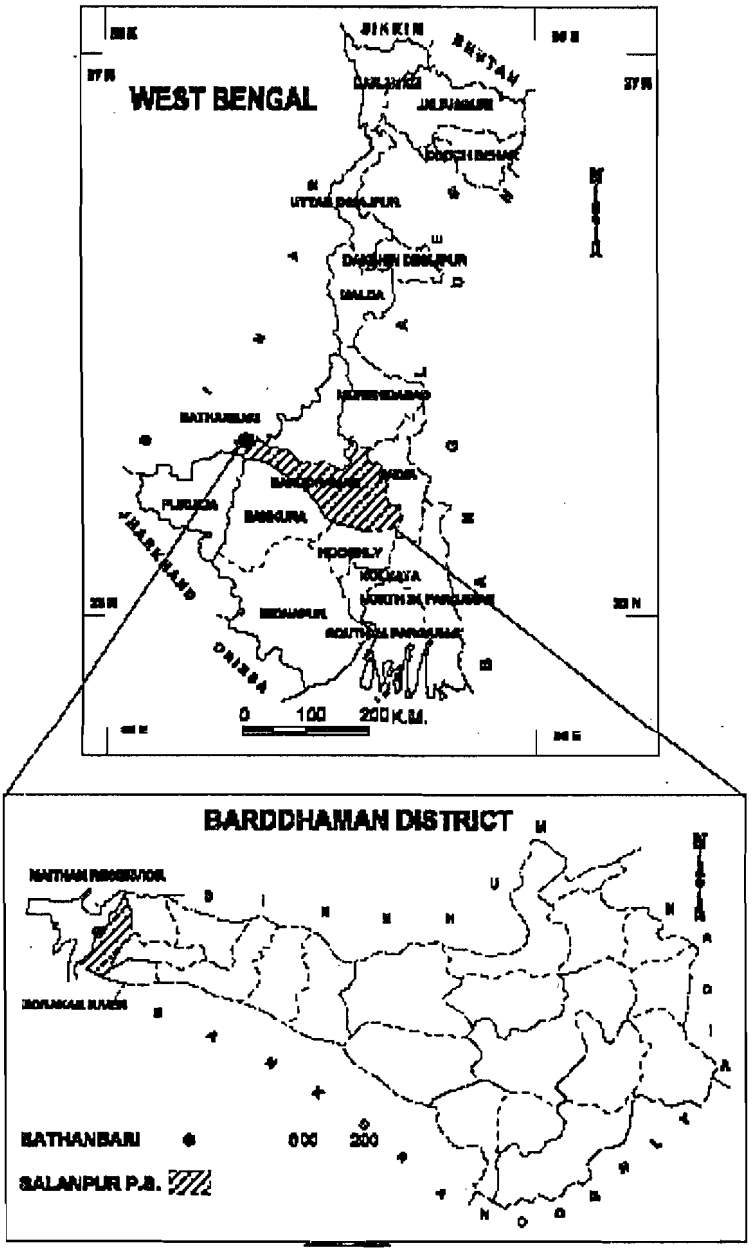
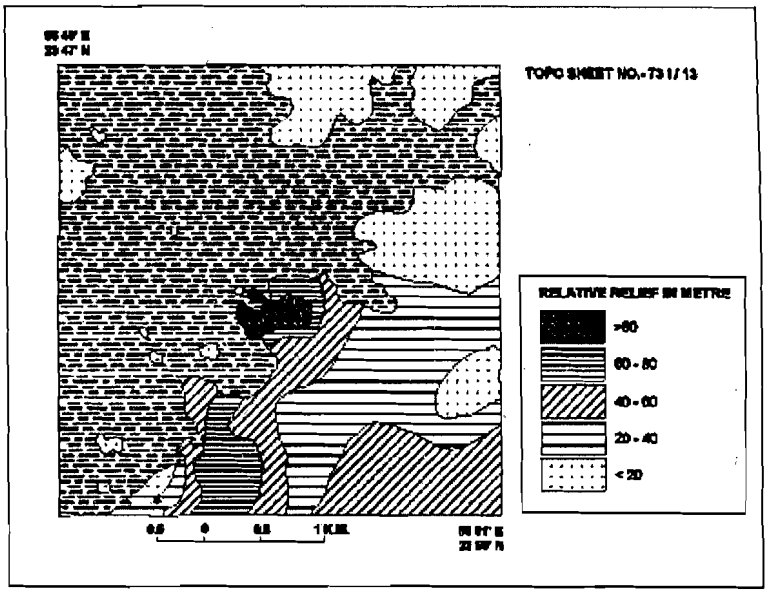


Figure 1. Location Map of the Study Area

has a steep slope. Some weathered hills and tillas are also observed in the surrounding region of the village with the exception of north (Fig. 2).

The major part the village is covered with alluvionl soil. There are some variety of intrusions observed in that area and other soil types also are observed in the central and south-eastern part of this village. The nearest well known hill is Maithon hill (220 m) which is within 10 km of the village.



SLOPE ZONES MAP
OF BATHANBARI VILLAGE AND IT'S SURROUNDING

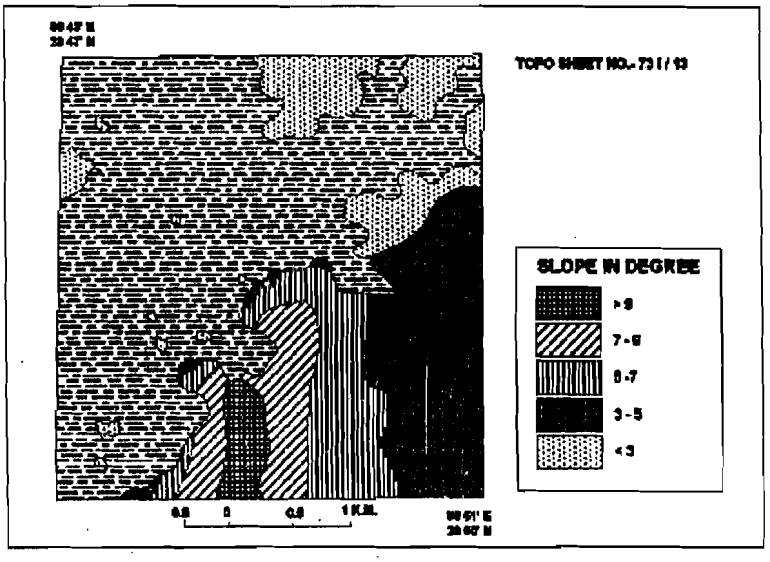


Figure 2 & 3. Relative Relief Map of Bathanbari Village and it's surroundings

Climate

Generally the area has hot and moderately dry climate. The condition which prevail in the eastern and western halves of the district of Barddhaman differ completely. In the western region, Galsi is very dry and the soil character is laterite which is very dry and porous. It is an area where the hot westerly

winds from central India penetrates and influence the climate, and exceptionaly high temperature and dryness are the features of the summer. The mean average temperature on summer season is 35^0 - 37^0C and in winter it is 15^0 - 17^0C. The monsoon character is as same as other inland part of eastern India. Due to norwester and westerly wind, the rain obviously releaves the people of this region. Due to the close association with the river Barakar and Maithon reservoir, a cool wind is very common in evening and nights makes the weather very comfortable. Actually the region is hot and dry but the adjoining water mass creates a comfortably good weather.

Geology and Soil

The Barddhaman district is generally covered and enriched with alluvium except some parts of Asansol subdivision (Bathanbari village, Salanpur p.s. is located here) where Gondowana rock exposure is common. The area has an average slope of 20 - 30 meters per km where the general elevation is 150 - 300 m from msl (mean sea level). The western portion of Barddhaman resembles a promontory cutting out from the hill ranges of central India and consists of basin, rolling and rocky country with a laterite soil rising into rocky hillocks on the right bank of Ajoy and Barakar and shut in on the west, not and south by hills of Chhotonagpur and the Santal Parganas.

The Gondowana System is represented in the Rajmahal hills, the Damodar valley, several Chhotonagpur districts and in Orissa. The Barakar consists of conglomerates, sandstones (which is often coarse), shale and coal seams of somewhat irregular character thirving out at short distance.

The soil charater of Bathanbari village and its associated area are quiet different is respective of the regional character. The presence of river Barakar and its siltings has blended the red laterite and grey alluvium. The adjoining areas of the river are mostly alluvium, particularly the top soil. So there is a prominent variation in areal fertility of the soil.

Physiographic Constraints and Scope of Economic Activities

Bathanbari is an agro-village. More then 50% of total working population is engaged in agriculture, directly and indirectly. Industrial activities are truly absent here.Comprehensively, the economic activity of this village is still in primary stage. Landscapes are at the same time mineral, aesthetic an strategic resources. Due to its closest association with a river and long history of capturing of lands by river,a sustained development is quite impossible here. The northern lands of the village, which are obviously fertile mostly, are not used for the purpose of agriculture because of the vulnerability of the lands closest to river. So, a good portion of lands are now used in other ways like plantation of trees to protect land and soil erosion, religious centres, waste lands etc. Secondly, most of the areas in southern slope are covered with natural forest and social forestry to save the soil erosion, the underground aquifer and the natural water bodies. Laterite is predominating and leaching process is very active in that particular area.

Table 1 : Bathanbari village : Land use Scenario

Year	Land use in %			
	Forest	Unirrigated / irrigated cultivable land	Cultivable waste	Area not available for cultivation
1971	5%	40%	2%	53%
2001	10%	39%	3%	48%

Source : Census of Barddhaman District, 1971 and 2001.

As per as the land use scenario is conserned census defined 'Area not available for cultivation' is mostly represented the area under river capture and the narrow strinp residential area develoed along the two main unmettaled road located central part of the village. The forest area is mostly observable in the south and south-east section of the where plantation is started from a decade back to protect soil and riverine land erosin. And obviouly rest of the area experiencing agricultural activities.

So, agricultural activities and associated settlements are mostly developed in relatively flat topped areas of that village situated in the Barakar highland. Due to the erosional activity of the river in one side and unfertile undulating land with a prominent slope restricted the possible economic activity within a narrow streach of two kilometers along the side of main (unmettaled) pathway of this village which connects the river-ghat and the mettaled road which passes througe the eastern part of the village.

Now, local people generally flies to nearby towns and cities like Asansol, Dhanbad for services because actually there are no other openings of economic activities within village. It is a outcome of poor communication system and inadequate accessibility to market. Even forest resource base small industries (i.e. cottage industry) are not so common because of the severe stagnent, unproductive, unambitious living and associated suffering with social depression which is simply the symptom of physical separation and compulsion.

There are two aspects to environmental approach to development. The first is man's planned and carefully judged responses to the existance of the various geomorphological situation as well as hazards. The second branch concerns man's alteration or conservation of the landscape in such a way that he gains some sort of benefit. As fer as the socio-economic and cultural scenario is concern, the people are actually expect nothing from their village soil. The historical geomorphological experience and as well as no pace development attitude by local governence create an unique atmosphere .Most unfortunately the rich families of this village do not invest their earning even for the upgradation of their establishment and always try to take off to settle in nearby town and cities.

The Economic Activities of the Area :

(a) Agriculture :

Agriculture is the leading occupation for the people of Bathanbari. Nearly 60%

of total working population are engaged in agriculture directly and indiretly.

Water is the key factor for agriculture in Bathanbari village. Maithan barrage is the blessing for agricultural activities in the region where the problems are undulating land forms and unfertile laterite pockets. Truly the geomorphological evolution dictates the fate and future of agriculture in this village.

As per as the primary survey is concern 30% of total area is under cultivation. Unfortunately a great (north and nort-west part of the village) landmass was under Barakar river due to massive riverine action and formation of barrage. So, as the land area of their village is decreasing, the self-sufficient and prosporous agro-base economy is now quiet impossible for the people of Bathenbari.

According to the local people and primary observation rice, green vegetables and some seasonal vegetable are the common products of the area. But the agricultural prospects of this region is still very gloomy because of unsuitable physical scenario and socio-cultural willingness and practices.

Table 2 : Bathanbari village : Economy -- structure of working

Year	Total		Agriculture%	Industry and allied %	Service and others %
	Worker	Non-worker			
1951	-	-	-	-	-
1961	108	214	93	7	0
1971	111	304	78	14	8
1981	223	338	80	20	20
1991	147	597	67	30	3
2001	369	475	50	20	30

Source : *Census of Barddhaman District, 1961 and 2001.*

(b) Other activities :

In Bathanbari, 'the business' is strictly restricted in small shops and weekly markets. Fishing (whose marketing is dependent upon the tourists of Maithan) is another economic option for the Bathanbari villagers.

Service holders and other workers who are basically bound within Rs. 2000/ - to 3000/- monthly income extended their working field to Maithan and other district towns like – Chittaranjan, Durgapur, Barddhaman etc. They represent only 30% population of working population.

Still the economy of the village is very much depressed because of growing active and passive unemployment. As there is a gloomy scenario in the agricultural fields and young people get mostly minimum education, a large number of working class people come out from the village running for any other possible prosporous world. There are 50% of non-workers and 30% of them are aged between 15 – 34. The scnario no doubt allows black market economy in every sphere of society.

Human Development Scenario Under This Physiographic Constraints :

Bathanbari has its own social structure than other villages of the region because

of its geomorphologial history and associated social developments.

* The two religion, Hindus and Muslims live here together.
* Only vaishya community is dominating here in Hindu religion.
* Except the vaishya other several so called castes live without any divisions.
* 7% of total population are S.C. and 32 % of total population are S. T.
* According to primary survey information there are habitatinal (locational) variation according to peoples relegion and caste.

Table 3 :

Year	Area	Total population	Population		No. of Households	Population		Population	
			M	F		SC	ST	Literate	Illiterate
1951	226.57	352	..	..	..	..	..	..	..
1961	↓	322	178	144	61	63	164	21	301
1971	↓	415	207	208	68	↓	↓	28	387
1981	↓	561	285	278	87	↓	↓	106	455
1991	↓	744	396	348	99	↓	↓	210	534
2001	↓	844	449	355	130+	60	269	383	461

Source : Census of Barddhaman District, 1961 and 2001.

(a) Education :

In the village Bathanbari only one primary school is found. This is a Primary School without provision of class X and with inadequate number of teaching staffs and de-proportionate students.

The nearest High school is situated 5 km far from Bathanbari and college is nearly 20 km far from this village. But there are only 10 graduates in the village.

The most depressing scenerio is that Bathanbari is within the declared Literate District Barddhaman, but it has still 58% illiterate people. Among the literate people only 17% passed Madhyamik and 2% passed H. S. examination.

There are so many talking about technical and vernacular education for the backward areas of the state. But the primary observation does not find any sub-divisional and Panchayet Training Centre where the villagers will involve in any earnings.

(b) Settlement :

In the early stage of this decade Bathanbari village has not more than 200 residential houses which are mostly concentrated in both sides of three unmettaled roads lying east-west of this village. There are nearly 8 - 10 Paccabari in this village – these are mostly placed in the eastern side of the village around the Bathanbari Rajbari which is now a deserted house.

The settlements are mostly dominated by straw-roofed clay walled houses, even some of them are two storied also. Generally more or less all the houses have a 'gola' of rice and places for cows and cattles.

According to the primary observation, the owners of the cemented houses are mostly businessman. They have radio, T.V., permanent tubewell in their houses. But mostly straw roofed and tilled roofed houses are common features of the village.

(c) Communication and Transport :

Communication and transports are in primitive age in and around this village. In true sense, walking is the communication for the village people to come into the contact with nearest town Maithan. There are no bus service, train service, motor service, even ferry services from or within the village.

Radio plays outstanding role here, till today. Newspaper is quiet uncommon in the Bathanbari village. There are no Post-Office and Telegraph Office in this village. Even the popular gram mancha, yatra ground, cinema hall, video parlour are not available in this village.

Generally bi-cycle is common for the people, 3 to 5 scooters are also visible in this village. But the main communication pathway joining Maithan is not still motorable.

The people are very much in demand for a good communication and transport system as several tourist spots are located around the area.

So, these socio-economic background as well as pre-dominent physical compulsion are the prime causes for underdeveloped educational and cultural pratices in Bathanbari village.

Conclusion :

Man has always had in impact on the landscape sometimes intentional, sometimes unintentional, sometimes desirable, sometimes adverse. Nature is not always so generous, so kind to man to operate his wishful living and make a good imprint within its canvas. Man first perceive the scope of nature and then move with ambition. Man as a geomorphic agent often captivated with some restrictions or any one may call it 'nature's law'. As per as the history of Bathanbari village and its surroundings are concern human impact has de-accelerated time to time by geomorphic hazards like river capturing and geomorphic limitation like unfertile soil and landform with moderate slope.

According to the local habitat and the primary observations, a good communication system and healthy and reciprocal commercial and as well as cultural interaction with nearby towns and economic centres can only break the wall of isolation and symptom of under development which is simply developed due to historical perspective of the nature's behaviour.

Considering the geomorphological compulsions of the area ,development is essential for the continuation of human living in and around the area. Ecological stability as well as the positive offerings of that geomorphological scenario will be the key factor for selected and fruitful economic activities which create a positive and enthusiastic cultural atmosphere. Here the geomorphological compulsions create a mass psychological ,hesitational and pessimistic attitude towards prospectous life.

As a geomorphic agent man alters landforms direstly by excavating and piling up earth, reclaiming land and causing subsidence. So, in this junction the urgent task in Bathanbari village and its surrounding are to make confidence among common people about the prospect of development (and clear the confusions about prosporous future) within given frame of geomorphic scenario. The geomorphological knowledge can afforad new road, building, stop destructive of natural materials by weathering, strongly responses to river floods, control and prevent the soil erosion and promote collective and co-operative effort of mankind promisingly within the environment. As man's understanding of the landscape and his understanding of his own effects on it have improved, so he has been able to intervene deliberately with an informed concerned for the environment friendly better living. It should be a key of sustainable development.

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