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Degradation of Water Bodies and Wetlands in West Bengal: Interaction with Economic Development

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DEGRADATION OF WATER BODIES AND WETLANDS IN WEST BENGAL: INTERACTION WITH ECONOMIC DEVELOPMENT

FINAL REPORT

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Preface

Environmental degradation associated with economic development is visible in many places. Wetlands are not exceptions. Loss in area, change in the quality of water as well as the loss of flora and fauna raise concern about such costs of development in and around coastal and non-coastal wetlands. The present work contains the case studies of selected coastal and non-coastal wetlands in West Bengal that focus attention on the impact of developmental activities on these aspects. Chapter 1 of this report describes the background and objectives of this study. Chapter 2 explains the methodology adopted for selection of wetlands in the State. Chapters 3-5 study the non-coastal wetlands in the sample. Chapter 3 describes the essential features of the selected wetlands. Chapter 4 identifies and describes the uses derived from the wetlands by people living in their neighbourhoods. For the most part, these are driven by the immediate economic interests of people trying to make a living so that the wetlands have been modified deliberately to promote economic activity. Often, there are negative impacts on the environmental quality of the wetlands. This chapter also measures the benefits of these uses, identifies the nature and measures the level of the consequent degradation of the wetlands. One of the findings that emerge from chapters 4 and 5 is that the degradation of each of the wetlands has been caused by a myriad of activities that have also affected them in different ways. Chapter 5 builds on chapter 4 by looking at each type of environmental loss and tries to identify the extent of the impact of each type of activity on the scale of the degradation.

Similar studies have been performed for the coastal wetlands in the sample. These are reported in chapters 6-8. Chapter 9 concludes the present work and offers some policy prescriptions for the above wetlands studied. It is hoped that the analytical methods adopted and the policy prescriptions offered in this report will find larger use in the context of the wetlands not studied in this report.

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CHAPTER 1: Introduction

Till the early 1970s, wetlands were largely unappreciated, rejected and disregarded as ecosystems and viewed as landscapes only. In human terms, they were considered of little or no value, providing breeding grounds for insects such as mosquitoes, obstructing overland and water transportation, curtailing the amount of land available for agriculture and inhibiting the growth of settlements. So they were reclaimed for human use. Since then a deliberate and determined lobby has been arguing for their conservation. This movement began with concern for the increasingly threatened wildlife, particularly birds. In the year 1971, at a conference held at Ramsar, in Iran, a decision was taken to safeguard all the important wetlands in the world for protecting especially the bird species. It had 55 signatories by the early 1990s and now has 90 contracting parties, including India, which signed the convention in 1982 (see appendix A).

1.1. Types of wetlands

Wetlands are found on every continent, except Antarctica and in every climate from the tropics to the tundra (see Appendix B). They cover approximately 4-6% of the earth's land surface (an area of 5.3 x 10^6 km ^{2}). Wetlands are usually categorised according to their characteristic vegetation, their location (coastal or inland), the salinity of the water they carry or other biological, chemical, hydrological and geographical features (see Appendix C for definition of wetlands). The inland wetlands include lakes, ox-bow lakes, peat lands, swamps, marshes and floodplains. Lakes are larger bodies of standing water, which occupy a distinct basin. A meandering stream may wash away the edges and the loops may cut-off afterwards generating basins. The shallow crescent-shaped lakes thus formed are ox-bow lakes. Peat lands incorporate bogs and fens. They may be forested and accumulate peat. Bogs are acidic, poor in nutrients, and receive water from precipitation only, whereas fens are richer in nutrients and receive water primarily from overland flow and or groundwater. Swamps or forested wetlands are areas with little or no peat accumulation. Marshes or herbaceous wetlands and flood plains are flooded areas along rivers or lakes. Estuaries, lagoons, coral reefs, creeks, mangroves, salt marshes are among the coastal wetlands. They sustain highly productive ecosystems, with the potential for supplying nutrients to adjacent areas (Davidson 1991). Estuaries are confined coastal water bodies with an open connection to the sea and considerable amount of salt in it. Lagoons are salt water bodies that are partly separated from the sea by barrier beaches. Coral reefs are tropical shallow salt water ecosystems with consolidated living colonies of microscopic organisms. The mangrove swamp is an association of halophytic trees and shrubs growing in brackish to saline low-lying tropical and sub-tropical coasts. Salt marshes are a collection of natural halophytic grasslands and tiny brushwood on alluvial sediments along saline water bodies. Tidal flat or mud flats are unvegetated areas alternately bared and drowned by falling and rising of tide.

1.2 Functions and values of wetlands

Humans depend on biological resources for food, energy, construction, medicine and other intangible benefits as well. Indeed, biodiversity and humans have had a close and mutually supportive relationship for thousands of years. The biological resources upon which people depend have the typical character of being renewable, when they are managed well, but biological resources that are abused can also become extinct. Thus we need to know how much of a resource we have spent up and how much of a burden we leave behind on our future generation. So we should keep track of our resource base and the state of our environment.

Wetlands have many functions that are considered to have socioeconomic value. They provide refuge and breeding ground for many species, including commercially valuable furbearers, waterfowl and timber. They often contain a high diversity of species, control floods and droughts and improve water quality. In the recent past, nonconsumptive benefits of wetlands such as recreation, archaeology, education and science were usually given lower priority in measurement plans than directly consumptive values because their values which are largely aesthetic are difficult to quantify. But in recent years these values are being given greater attention worldwide.

The total biodiversity (flora and fauna) of wetlands is high in comparison with terrestrial ecosystem. Wetlands provide protective cover and maturation areas for a wide range of invertebrates and vertebrates. In North America for example muskrats and beavers are entirely dependent of wetlands ecosystem whereas raccoons and various species of deer are partially dependent on wetlands. In many areas, the remoteness and inaccessibility of wetlands has attracted species that may not be totally wetland dependent but take advantage of the protection and shelter they provide. For example the Pantanal in Brazil, Paraguay, and Bolivia provides an important habitat for the jaguar (Dugan 1993).

Some wetlands (usually peat land) contain potential energy for human consumption. In developing countries with shortages of energy and fuel, peat harvesting can be an attractive financial proposition if extensive peat deposits are available. This can have the effect of replacing imported energy sources and reducing foreign-exchange requirements. However, large scale harvesting of peat has led to the destruction of peat-land ecosystems. Wetlands specially peat lands play a significant role in the carbon cycle and presently are net sinks of carbon. A recent estimate reveals that the amount of carbon held in soil as organic matter is at a mean level of 1601 Gt., of which about 20% (412 Gt. of C) is stored in peat lands.

The best known function of wetlands is as a provider of year-round habitats, breeding areas, and wintering sites for migratory birds, depending on their location. One example is the prairie pothole region in United States, where the value of the region as habitat for breeding birds, especially waterfowl has been thoroughly documented. More than half of the waterfowl production in North America occurs in this region. Wash is the most important estuarine habitat in the UK, supporting over 250,000 waterfowl each winter.

Wetlands are efficient in trapping pollution and processing waste in human-dominated landscapes. Wetlands have been found to be important “sinks” for pollutants moving from upland areas, preventing their movement into surface water and groundwater. Artificial wetlands are being used to treat wastewater. Declines in these functions due to climate change could have important economic and aesthetic implications, particularly in heavily developed areas.

Mangroves stabilize shorelines and decrease coastal erosion by reducing the energy of waves and currents and by holding the bottom sediment in place with plant roots. They also act as windbreaks and protection from coastal storms, forming a cost free, self-repairing barrier. Mangrove habitats can be used for tourism, education and scientific study. For example the Bengal Tiger (Panthera tigris) population in The Sundarbans mangrove is a focus for tourism in Bangladesh, and thousands of visitors go to Trinidad's Caroni swamp mangrove area every year to view the great numbers of Scarlet. Over 2/3rd of fish caught for human consumption as well as many birds and animals depend on coastal marshes and swamps for part of their life cycles, so they are vital to the world ecology.

1.3. Impact of environmental change

Climate change will have great effects on wetlands by altering their hydrologic regimes. Any alteration of these regimes will influence biological, biogeochemical and hydrological functions in wetland ecosystems, thereby affecting the socioeconomic benefits of wetlands that are valued by humans. These hydrologic changes will also alter the vegetation types in wetland areas and will affect other functions performed by them. Some carbon-sequestering wetlands will change from CO_2 sinks to sources of CO_2 due to a lowering of the water table or increased temperature. Drying of northern wetlands could lead to declines in CH_4 emissions. Climate change will affect the aerial extent and distribution of wetlands. Regional studies from east China, the United States, and southern Europe indicate that the area of wetlands will decrease if the climate becomes warmer. IPCC (Intergovernmental Panel on Climate Change) has attempted a detailed assessment of the potential impacts of climate change on the structure and functions of wetlands.

Wetlands are probably more endangered than tropical forests. They are places of intense biological activity including the breeding of many species of fish. It is estimated that half of all the world's wetlands have disappeared since 1900, due to dredging, filling, draining and ditching along with a rich range of life forms. Vast areas of mangroves are being destroyed either directly or as a secondary result of other activities. Often this destruction for short-term economic gain takes precedence over long term benefits. The data regarding their loss are well documented in U.S.A. In the lower 48 state of the United States, approximately 53% of the original wetland area has been lost – 87% of this loss is attributed to agricultural development, 8% to urban development and 5% to other conversions. Many wetlands, especially in tropical regions, have so far escaped the impacts of human activities owing to their remoteness and unsuitability for agriculture. In recent times population pressures and technological advances have extended human influences into previously undisturbed areas (Armentano 1990). For example in 1989 it was calculated that only 82% of Indonesia's peat swamp forests remained in their original condition (Silvius, 1989). For some provinces (e.g. South Sumatra), it is predicted that no swamp forest will be left by the year 2000.

Rising seas would cause saltwater to encroach upon freshwater estuarine and tidal areas – often used for municipal and industrial freshwater supplies. Increased salinity of water damages farmlands. Wetlands that nourish the world's fisheries would be damaged. Around Subang, in Indonesia, for example the predicted encroachments of the sea would reduce greatly the annual harvest of fish and shrimp, destroying the livelihood of tens of thousands. The world's wetlands are vital to the ecology and economy of many coastal areas. Not only is their biological productivity per unit of energy input very high, but they have been the natural, source of various food crops, including rice and palm plants, and are a continuing source of genetic stock for future crop development. Coastal wetlands can adjust to slow levels of sea – level rise, but they cannot keep pace with a rate of rise of greater than about 2 mm per yr., i.e., 20 cm per century.

Temperature can affect evapotranspiration rates, which has implications for the hydrological regime of wetlands, by transporting water from the ecosystem to the atmosphere. Precipitation regulates the direct inflow and amount of water to wetland ecosystems, which in turn regulates the hydrologic regimes. The effect of a change in precipitation on a given wetland will depend on the type of wetland, topographic and geographic characteristics of the region (drainage area, relief etc.). For example, very large wetlands like the Okawango delta in Africa, are supplied with water from a considerable distance.

Wetlands are sensitive to extreme climate events such as heavy spring flooding and summer drought. Extreme droughts make wetlands more sensitive to fire which could impact ecological functions such as vegetation cover, habitat value, and carbon cycling. At the same time, such biomass burning is likely to result in massive emissions of smoke particles (aerosols) to the atmosphere. Seawater intrusion into some inland wetland due to sea-level rise can result in an encroachment of salt-tolerant wetland communities. Decreased water availability will cause wetland loss due to drying. The movement of water in itself can benefit wetlands because it contributes to nutrient exports.

Poiani and Johnson (1993) conducted a study in the prairie pothole region of the US. They project a 3% increase in the overall size of this wetland under current climate, but a decrease of nearly 12% under the greenhouse scenario. If open water areas decrease, emergent plant species may spread over entire wetland. These change have serious implications for the wildlife in the region because these areas are extremely important breeding areas for waterfowl. When temperature increases by $3^{o}C$ the Canadian and US grassland may decline by 15% and 28% respectively. The Aspen parkland model projects the decline of 56% in the number of wet basins with a rise in temperature. In another study by Zhang and Song (1993) in China where 75% of the country's wetlands are located, it was found that the areal extent of herbaceous wetlands is declining continuously.

1.4. Effects of anthropogenic interference

Along with all these self-governing factors, most of the causal factors currently threatening the endurance of wetlands are anthropogenic in nature i.e., induced or influenced by man. These factors include:

- Habitat loss or modification often associated with habitat fragmentation, which include pastoral development, cultivation and settlement, forestry operations and plantations, fire and pollution.

- Accidental or deliberate introduction of exotic species, which may compete with, prey on or hybridise with native species.

- Disturbance, persecution and uprooting including deliberate eradication of species considered being pests.

- Incidental takes particularly the drowning of aquatic reptiles and mammals in fishing nets.

- Diseases, both exotic and endemic, provoked by the presence of large numbers of domestic livestock or introduced plant species.

- Limited distribution, which may compound / effects of other factors.

The world's wetlands and mangrove swamps currently occupy an area of about a million sq. km., equal approximately to twice the area of France. In spite of their significant importance marshes and tidal mudflats have suffered significant losses in recent decades. For example, Burd (1992) reported between 10-40% loss of salt marsh areas in Southeast England since 1973 due mainly to erosion. The rapid movement of pollutants around the coast, from accidental spillage's or unlicensed discharges, is also a recurrent threat to many habitats.

In many areas the demand for fuel wood from mangroves is well above a sustainable level and it is increasing as the human population increases. In addition, the commercial use of wood for pulp results in some areas being more or less clear-felled. Natural regeneration takes time and often the area is converted to other forms of land use such as agricultural or aquaculture. The conversion of mangrove to aquaculture results in destruction of mangrove flora and fauna due to changes in the drainage conditions, nutrient availability, as well as being adversely affected by run-off from ponds and channels. It may kill the prawns or fish directly by poisoning them. In the Indo-pacific area it was estimated in 1977, that 1.2 million ha. of mangroves forest had already been converted to aquaculture pond. The building of ponds for salt extraction causes extensive damage to mangroves. The land has to be cleared of all trees and shrubs, leveled and dyked, a canal system has to be built and the soil surface compacted so that even if the ponds are later abandoned the chemical and physical properties of the soil have been so changed that recolonisation of mangroves is impossible. Rubbish and solid wastes are deliberately dumped into these habitats. Mining within the mangrove system completely destroys the system. Chemical wastes for mines are also another cause of such destruction. Drilling for oil occurs in some mangroves and both spillage and the associated pipelines and roads which alter the drainage of the area can be very destructive to the ecosystem. Another threat to mangroves is a diversion or alteration of freshwater flow into them. In arid, semiarid or seasonally dry regions the mangroves are dependent on inputs of freshwater, but in these regions there is high demand for freshwater. So its flow into the mangroves is regarded as wasteful. Consequently, rivers are often dammed or diverted so that their waters can be used on land. The reduction in freshwater results in the gradual replacement of mangrove species with some more salt tolerant species. Mammals within the mangrove system are affected by lack of freshwater, while fishery resources may be depleted by the higher salinity and reduced nutrients.

Turner (1988) has classified the main threats to wetlands into five groups:

1. In-filling: This may be unintended as in siltation from upstream erosion, but is more often intentional where there is a conflict regarding the land-use pattern for various kinds of commercial development and recreation. Some wetlands are in or close to cities, and are swallowed up in urban expansion. In Hong-Kong, Singapore there has been a planned housing development by in-filling the wetlands. In Marril, Bombay and Calcutta occupation of wetlands was the only realistic option for many immigrants. Coastal wetlands are often obvious targets for building industrial plants because the pollutants they generate need to be sited away from population centers.

2. Excavation: Large scale peat extraction disfigures wetlands landscapes (e.g., Ireland) and limits their values for other uses. Other examples of extractive industry are oil and gas (e.g. Nigeria, Cameroon, and Ivory Coast). The extraction of salt, involving boiling brine, can devastate wetland wood (e.g. Benin). Alternatively, excavation may be incidental to construction projects or navigational improvements (e.g. dredging ports and marinas, widening shipping channels, laying pipes).

3. Changes in hydrology: Wetlands are very sensitive to anything that alters the characteristics of the water flowing in, or changes its level. Hence such things as upstream river basin development disturb them.

4. Chemical Changes: The delicate eco-system in a wetland suffer from changes in the chemical content of its water intake. This can arise from municipal pollution (discharges, untreated sewage, hazardous waste etc.) or from farm chemicals and irrigation water. A reduction in freshwater intake will cause increased salinity.

5. Biological effects: Any of the above changes will have consequences on the wetland biomass. For example, eutrophication may result from the nutrients obtained from farm chemical run-off. The removal of trees, or aforestation schemes will set off a biological chain-reaction. Over hunting or over fishing of certain species or the introduction of exotic fauna, will also upset the previous balance.

1.5. Theoretical issues

Pigou, was one of the first economists who addressed the economics of conservation. Until recently, the central concerns have been associated with the question of the optimal inter-temporal utilization of fixed natural resource stocks. In the next few years, the issues of sustainability can be expected to alter the parameter of social activity significantly. Sustainable development has become the buzzword of the present century. It refers to creating a style of economic development, which is sustainable within the context of the planet's ecosystem and human society. This is mainly because the environment and ecosystem degradation has almost reached the end of the line and is almost threatening the very existence of man and the civilization which he has built so laboriously and painstakingly. Man, the creator of the civilization has taken the role of its destroyer with his full knowledge. Man has multiplied its race very fast that overtax the agricultural potential of the land. To generate resources for their needs man is frantically searching pastures a new and the first causality of this onslaught is the marginal and sub-marginal lands. Tropical forests that are home for millions of biological species are cleared for agriculture, grazing and lodging. As a result the area under forests and wetlands are shrinking very fast all over the world, with India being no exception.

The problem of environmental conservation can be looked upon from two perspectives, namely those arising from conditions of poverty and underdevelopment and those arising out of negative effects of the very process of development. The first category affects the natural resources like land, soil, water, forests, wetlands, wild-life and so on, as a result of poverty and inadequate availability, for a large section of the population to fulfill basic human need. The second category relates to the side effects of rapid economic growth.

1.6. Objectives of the Study

Wetlands in West Bengal, both inland and coastal, are under increasing pressure for conversion to other, supposedly higher-valued uses. In many cases conversion may be fully justified, but in others it results in short-term private gains at the expense of larger, long-term social losses. Consequently, much more detailed analysis of the economics of wetlands in West Bengal is urgently needed. Therein lies the justification of the present work.

One of the objectives of this study is to find out the usage pattern of wetlands in selected regions of West Bengal, both coastal and inland. A second objective is to identify and select techniques to estimate the direct and indirect economic benefits and costs from all sorts of uses of wetlands in these areas. The next objective is to identify the nature of the degradation of wetlands due to economic activity around them. At this stage it is necessary to study the causal relationship between degradation and economic activities in and around the wetlands. These relationships will help us to identify those activities which are significant for the degradation.

As such no significant economic benefits can be derived from coastal wetlands in their natural state. Consequently this type of wetland has been converted over time from one state to another. It is important to analyse their transition path from historical perspective and to examine both the environmental and economic sustainability of each state. The final objective of the work is to recommend suitable policies for inland and coastal wetlands.

Chapter 2: Field Survey

A detailed survey was carried out to collect relevant information to analyze the present use of wetland for economic purposes and consequent damage in terms of area loss, water quality and loss in biodiversity. The study also covers conversion aspect and value of the benefit derived from converted wetlands.

2.1 Methodology

The first step was designed to select the wetlands to be studied. Districts of the state were divided into two classes: coastal region districts and non-coastal region districts. Satellite and survey map data were used for final selection of the wetlands in each district.

To understand the current situation of the wetlands and the benefits derived by the surrounding households, a field survey was conducted based on the information acquired during the pilot survey. For this purpose 10% of the total households who live around the wetland under survey were selected randomly to mimic the population characteristics. This survey includes the households’ responses to any change in their present environment, i.e., their attitude towards the conversion or preservation of the wetlands. In order to record their responses a structured questionnaire was used. Households were selected among those who derive direct benefit from the wetlands and from those who do not. Care was taken in selecting the samples to include all segments of the population as far as possible including people with different occupation, caste, education level etc. Household-level information was collected through personal interviews using pre set-up questionnaires covering different aspects of the study objective (See Appendix D).

2.2. Selection of Districts

The state of West Bengal is located in the eastern part of India between $21^{0}27^{'}$-$27^{0}15^{'}$ N latitudes and 85055’-$89^{0}45^{'}$ E longitudes (the map of the state is shown in Figure 2.1). As the major part of this state lies in the Indo-gangetic plain, the terrain in general is flat and contains many wetland types. It is rich in wetland resources, being second only to Assam and has the highest number of ox-bow lakes (1489) among all the states in the country. Satellite data (IRS 1 A/B LISS II) of 1992/93 has been analyzed for identifying wetlands in West Bengal. Mapping was done on 1:50000 scale. The Space Application Centre, Ahmedabad has identified 167 wetlands lager than 50 ha. There are 7065 wetlands of size greater than 2.25 ha and 56313 wetlands of size less than 2.25 ha. Apart from that the state has numerous small and large water-bodies making it one of the richest tropical wetland systems in the world. The total wetland area is 504306.56 ha. Apart from being a repository of aquatic flora and fauna of this bio-geographic region, these wetlands provide suitable habitats for the residents and migratory water-birds and contribute much to the socio-economic well-being of the local communities.

In spite of that a survey of the wetlands of West Bengal has revealed that at least 85 per cent of them are under some form of threat, mainly due to human encroachment, drainage and reclamation for agriculture, faulty land use pattern and filling up for urban construction, domestic, industrial, municipal sewage and pesticide pollution, dam and barrage construction leading to siltation, over-exploitation of fishery resources etc. The entire wetland area in this state are situated in three geographic regions, namely,

(1) Sub-Himalayan region
(2) Gangetic region and
(3) Coastal region.

The *sub-himalayan region* extends from hills of Darjeeling to Diara plains of Malda. This region slopes downward from north to south. This area is drained by the rivers originating from the Himalayan range. The wetlands of this region are less extensive than that of the other two regions. The wetlands of this region are distributed in the districts of Darjeeling, Jalpaiguri, Coochbehar, Dinajpur and Malda.

The *gangetic region* physiographically incorporates the moribund delta, mature delta and the Rarh plain. It covers the entire South Bengal plain excepting the active delta and coastal areas. The wetlands of this region are distributed in the districts of Murshidabad, Nadia, Bardhaman, Birbhum, Bankura, Purulia, Hoogly and Calcutta. The moribund and delta regions are dotted with a number of wetlands originating from the shifting of multitudes of channels associated with delta formation. In many places these wetlands have transformed into shallow marshes and some of them are being converted into fields for wet rice cultivation. These two regions cover the inland or non-coastal wetlands of the state. Of the 6049 wetlands covering a total area of 145360.02 ha, natural wetlands cover an area of 107924.65 ha. Remaining part comprises of the man-made wetlands where the seasonal variation of waterspread is remarkably high owing to their usage for irrigation, drinking water and aquaculture.

Coastal wetlands are to be found in three districts: 24 Parganas , Howrah and Medinipore. There are 1007 such wetland covering an area of 360446.54 ha. Among these wetlands 724 are natural and 283 are man-made. Seasonal variation of waterspread is not drastic in these areas. Here the rivers are tidal and lands have sea-front. There are only 20 of wetlands that are larger than 10 ha. But in arial extension these wetlands cover vast areas.

In our study we have selected two districts, one each from the inland (or non-coastal) region and the coastal region. It is a difficult task to identify only a few wetlands out of hundreds of wetlands in these two zones and the criteria for selection may not always be very objective. But the number of wetlands present in the districts and the relevant agricultural yardsticks may serve our purpose. First we concentrate on the Gangetic region because here the wetlands are more extensive than those in the Sub-Himalayan region.

The number of wetlands in the Gangetic region is largest in Bardhaman (631) (the map of the district is shown in Figure 2.2) followed by Murshidabad (608) and Bankura (530). This district is one of the most important ones in terms of agricultural performance in West Bengal. The yield of foodgrains has been highest for the last few years in Bardhaman. There has been a substantial development in the application of high input technology in agriculture like high yielding variety (HYV), chemical fertilizers, pesticides etc. in the district of Bardhaman. It was selected as one of the Intensive Area Development Programme (IADP) districts in the early 1960s. The success of high input modern technology depends on the availability of controlled irrigation facilities. Most of the wetlands in Bardhaman are rain-fed. The use of chemical fertilisers in purely rain fed agricultural plots tends to be risky, as control over water supply is not available. However, extensive use of chemical fertilisers and pesticides has an adverse effect on the quality of the wetlands. The run-off water carrying the residues of hazardous chemical pesticides etc. ultimately finds its way into these wetlands. This drained-off water containing the residues undermines the water quality of the wetlands. Although about 63 per cent of the total sown area in this district is covered by canal irrigation, it is considered to be inadequate. So farmers extensively use the ground water for dry season cultivation. In this connection the wetlands seem to play the very important role for maintaining ground water because in the close proximity of wetlands ground water can be extracted at a depth of 20-30 ft. All these aspects favour selection of *Bardhaman* as the most appropriate one for the study of wetlands in the non-coastal region.

Although South 24 Parganas district contains more coastal wetlands, a major portion (47 per cent) of these wetland areas are under mangrove forests that are fully protected by the Government. We are interested in the study of those wetlands that have intensive interaction with economic development and are privately owned. Most of the coastal wetlands in Medinipur assume an important place for various types of income generating sources as - prawn culture, salt production, fish production and tourism (the map of the district is shown in Figure 2.3). This is another important parameter for selection of Medinipur as a coastal district for this study.

2.3. Selection of non-coastal wetland

For selection of specific wetlands in Burdwan district the type, size and development programmes and consequent degradation of the wetlands have been considered. Total area under wetland in Burdwan district is 6441.77 ha out of which lakes/oxbow lakes, waterlogged (seasonal) and swamp/marsh occupy 3415.94 ha. The rest are reservoirs, tanks and abandoned quarries. Since the former group of water-bodies occupy the significant position in the total water-bodies present in that district they have been taken for study. Altogether ten wetlands which incorporate twenty percent of total area under lakes, ox-bow lakes, waterlogged (seasonal) and swamp/marsh have been selected covering an area of 680 ha (Table 2.1). All these ten wetlands selected are natural with three of them being seasonally waterlogged. In order to avoid variation in biodiversity and benefits these wetlands have been selected from similar agro-climatic and concentrated region. The surrounding households use these wetlands for agriculture, fishing, irrigation, peat, jute retting and grazing their livestock. Among these wetlands Srikhanda, Bater Beel and Padma Beel are drained off in summer and they have substantial variation in water spread in pre-monsoon and post-monsoon seasons.

Table 2.1 Locational profile of surveyed wetlands in Bardhaman

Sl. no.	Name of wetland	Location	Wetland category	Distance from nearest (in km)	
				Rly. Stn.	Road
1	Haruabhanga	Mougram Ketugram II	Oxbow lake	8	2.5
2	Kalobaur Beel	Dainhat, Katwa I	Oxbow lake	3	2
3	Lakshmipur	Majhida Purbasthali II	Lake	4	10
4	Chakkobla	Jahannagar Purbasthali I	Lake	4	3
5	Barokobla	Srirampur Purbasthali I	Oxbow lake	4	1.5
6	Bara Beel	Karajgram Katwa I	Lake	10	2
7	Jalanga	Patuli Katwa II	Waterlogged	1.5	1.5
8	Srikhanda Beel	Srikhanda, Katwa I	Seasonal waterlogged	3	4
9	Bater Beel	Biswarambha Purbasthali II	Seasonal waterlogged	0.5	0.5
10	Padma Beel	Faleya Purbasthali II	Seasonal waterlogged	2	2

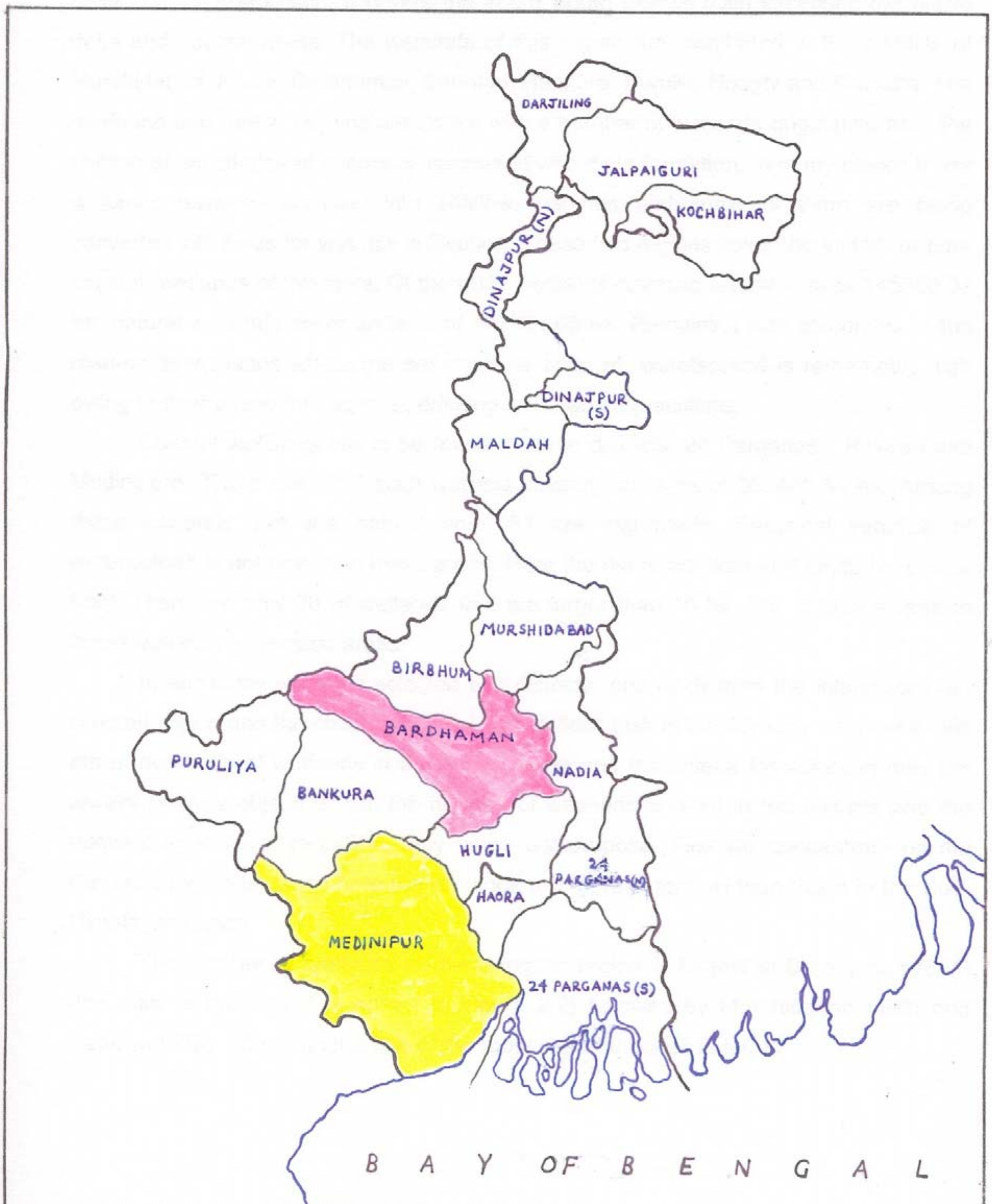
2.4. Selection of coastal wetland

In case of coastal wetlands, original characteristices of the wetlands have changed over time to form other types of wetlands. These changes are perhaps strongly associated with economic activities and anticipated returns from the wetlands. Economics is the driving force for conversion of one state to another state of wetlands. However in our present study wetlands having different economic use and impact on the socio-economic characteristics and biodiversity have been prioritized for selection. The major economic activities of these coastal wetlands are aquaculture in different forms (e.g. traditional aquaculture, mixed aquaculture, shrimp culture, crab culture), salt manufacture and infrastructure development including fish launching centre, market complex etc. Approximately 30% of the wetland area from the above mentioned categories have been selected randomly and surveyed (Table 2.2)

Table 2.2 Locational profile of surveyed wetlands in Medinipur

Category of wetland	Name of the GP	Name of the block	Name of the nearest road	Distance from the nearest road in km
Salt Pan	Kalindi	Ramnagar-II	Digha-mechada high road	3
Aquaculture pond	Kalindi	Ramnagar-II	Digha-mechada high road	8
Salt Pan	Kalindi	Ramnagar-II	Digha-mechada high road	9
Fish launching centre	Kalindi	Ramnagar-II	Digha-mechada high road	12
Salt Pan	Kalindi	Ramnagar-II	Digha-mechada high road	10
Fish launching centre	Talgachhari-II	Ramnagar-I	Digha-mechada high road	3
Salt plant	Talgachhari-II	Ramnagar-I	Digha-mechada high road	6
Salt plant	Talgachhari-II	Ramnagar-I	Digha-mechada high road	2
Aquaculture pond	Talgachhari-II	Ramnagar-I	Digha-mechada high road	0

Fig.2.1. The map of West Bengal showing selected districts



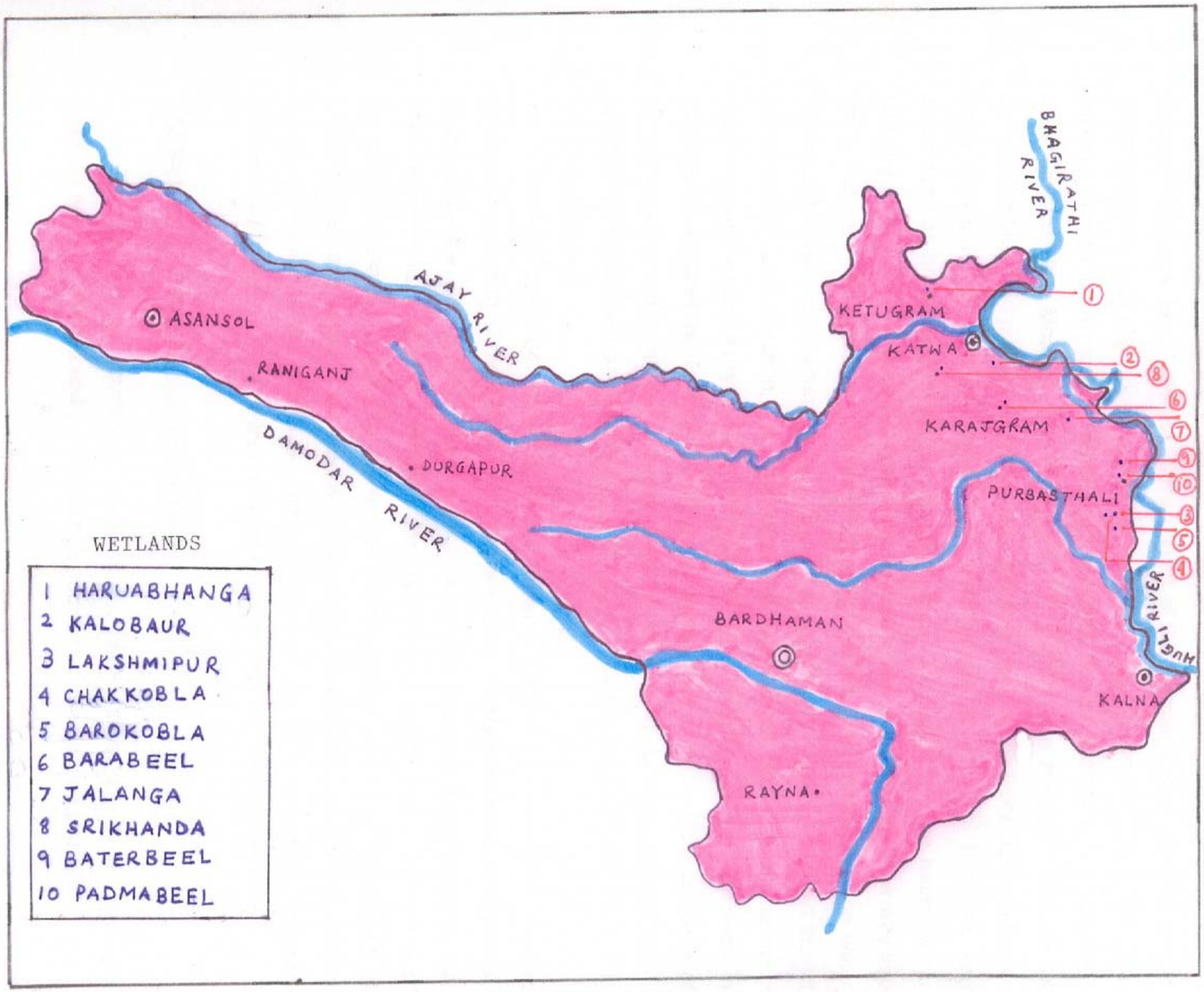


Fig.2.2. The map of Bardhaman district

Fig.2.3. The map of Medinipur district

Chapter 3 :Description of selected non-coastal wetlands

Ten non-coastal wetlands selected in Bardhaman district are natural water bodies with three of them being seasonally drained. There is wide variation in water spread in both the pre-monsoon and the post-monsoon seasons among these selected wetlands. Physical profiles of ten selected wetlands in this district are described below.

3.1. Physical Profile of Selected Wetlands

The salient features of the selected wetlands from non-coastal wetland are presented in Table 3.1. It is based on field investigation and information collected from Block Development Offices, Gram Panchayats and peoples who live around the wetlands. Different economic activities and the number of households who derive benefits were identified and used as proxy variables to highlight the importance of inland wetlands. Economic activities in and around the selected wetlands and the number of households deriving benefit from the wetlands have been presented in Table 3.2

Table 3.1 Salient features of the different wetlands in Bardhaman district

Name of wetland	Average depth of water (mt.)		Water spread (sq. mt.)		Area of wetland (ha.)
	Pre-monsoon	Post-monsoon	Pre-monsoon	Post-monsoon	
Haruabhanga	4.12	6.86	80000	95000	10
Kalobaur	3.36	8.39	320000	380000	40
Lakshmipur	1.07	5.34	100000	140000	15
Chakkobla	1.07	4.12	260000	500000	60
Barokobla	6.86	9.91	200000	250000	25
Bara Beel	1.07	2.74	350000	500000	56
Jalanga	1.67	3.81	550000	750000	75
Srikhanda	0.38	6.86	20000	750000	80
Bater Beel	0.46	2.14	200000	2700000	275
Padma Beel	0.23	2.14	5000	180000	20
Mean	2.03	5.23	208500.00	624500.00	65.60
S.D.	2.13	2.70	169017.59	766153.63	77.68
C.V.	104.92	51.67	81.06	122.68	118.41

Table 3.2 Economic activities in and around the selected wetlands in Bardhaman district

Name of	Name of the benefited Villages	No. of Deriving benefit	Economic in and around the wetland
Haruabhanga	Notungram, Ratanpur, Narayanpur, Kamolbari, Raghupur, Narasinghapur	250	Fishing,irrigation,
Kalobaur	Daspara, Notunpara, Gopalganj, Devnathpara	360	Fishing,irrigation, jute-retting, fodder
Lakshmipur	Majhida (Khalpara, Patelmath,Tanaghata Kuthipara), Lakshmipur, Alunirmath, Ghoshpara	110	Fishing,irrigation, fodder
Chakkobla	Bhatshala, Sahapur, Gopalpur, Bidyanagar, Rajapur	210	Fishing,irrigation
Barokobla	Kobla, Chakrathpur, Chanpahati, Hemothpur,	130	Fishing,irrigation, fodder
Bara Beel	Chandpur, Subhpur, Karajgram, Durgagram	1000	Fishing,irrigation, aquaculture,fodder
Jalanga	Srirampur,Hamidpur, Santoshpur,Khadatpara	400	Fishing,irrigation
Srikhanda	Chandrakota, Mastapur, Aurangabad, Palankpur, Ghushombi, Goalpara	400	Fishing,irrigation, jute-retting, fodder
Bater Beel	Biswarambha, Sajiara, Kalekhantola, Hrishi, Ramkrishnapur, Benagarh	250	Fishing,irrigation, jute-retting
Padma Beel	Hrishi, Sajiara,Purbasthali Bishwarambha, Faleya,	100	Fishing,irrigation, jute-retting, fodder
Total		3210	

3.2. Description of selected Wetlands

3.2.1. Haruabhanga beel (HB)

Location: Haruabhanga beel is located at Mougram Gram Panchayat under Ketugram 2 block in Bardhaman district (see Figure 3.1). It is said that this beel was formed due to change in direction of the river, the Ganga. HB can be approached through waterways either from Maugram, headquarter of Gram Panchayat or from Katwa, sub-divisional headquarter of the district Bardhaman.

Economic Activities: HB is surrounded by vast agricultural land. The main economic activities of this wetland are fishing, irrigation for boro paddy and other dry-season crops. It has been estimated that approximately 250 households from neighboring villages derive these benefits (see Table 3.2).

3.2.2. Kalobaur beel (KB)

Location: Kalobaur beel is located at Dainhat under Katwa-1 block in Bardhaman district (Figure 3.2). It is said that this beel was formed due to change in direction of the river, the Ganga. KB can be approached through rail from Katwa, sub-divisional headquarter of the district Bardhaman.

Economic Activities: KB is surrounded by villages and agricultural land. The main economic activities around this wetland are fishing, jute retting and irrigation for boro paddy and other dry-season crops. It has been estimated that approximately 360 households from neighboring villages derive these benefits.

3.2.3. Lakshmipur Padma beel (LPB)

Location: Lakshmipur Padma beel is located at Majhida Gram Panchayat under Purbasthali-2 block in Bardhaman district. It is basically a low land area and act as a catchment basin for rain water from upland agriculture land. LPB can be approached through rail from Katwa, sub-divisional headquarter of the district Bardhaman.

Economic Activities: The vast agricultural land extend all around the LPB. The main economic activities of this wetland are fishing, and irrigation for boro paddy and other dry-season crops. It has been estimated that approximately 110 households from neighboring villages derive these benefits.

3.2.4. Chakkobla beel (CB)

Location: Chakkobla beel is located at Jahannagar under Purbasthali-1 block in Bardhaman district (see Figure 3.3). It is a low land area. The beel was formed due to water logging. CB can be approached through rail either from Kalna, sub-divisional headquarter of the district Bardhaman or from Katwa, sub-divisional headquarter of the district Bardhaman.

Economic Activities: CB is surrounded by vast agricultural land and villages. The main economic activities of this wetland are fishing and irrigation for boro paddy and other dry-season crops. It has been estimated that approximately 210 households from neighboring villages derive these benefits.

3.2.5. Barokobla Bansdaha beel (BBB)

Location: Barokobla Bansdah beel is located at Srirampur Gram Panchayat under Purbasthali-1 block in Bardhaman district (Figure 3.4). It is man-made and well maintained. BBB can be approached through rail from Kalna, headquarter of the district Bardhaman.

Economic Activities: There are dwelling on three sides of this wetland and on one side are agricultural lands. The main economic activities of this wetland are fishing and irrigation for boro paddy and other dry-season crops. It has been estimated that approximately 130 households from neighboring villages derive these benefits.

3.2.6. Bara beel (BB)

Location: Bara beel is located at Karajgram Gram Panchayat under Katwa-I block in Bardhaman district (see Figure 3.5). It is a man-made water body. BB is well connected by road (5 km) from Katwa town, sub-divisional headquarter of the district Bardhaman.

Economic Activities: BB is surrounded by vast agricultural lands. The main economic activities around this wetland are fishing and irrigation for boro paddy and other dry-season crops. It has been estimated that approximately 1000 households from neighboring villages derive these benefits.

3.2.7. Jalanga beel (JB)

Location: Jalanga beel is located at Patuli Gram Panchayat under Katwa-II block in Bardhaman district. It is low land water-logged area. JB can be approached through rail from Katwa, sub-divisional headquarter of the district Bardhaman.

Economic Activities: JB is surrounded by vast agricultural land. The main economic activities of this wetland are fishing, jute retting and irrigation for boro paddy and other dry-season crops. It has been estimated that approximately 400 households from neighboring villages derive these benefits.

3.2.8. Srikhanda beel (SB)

Location: Srikhanda beel is located at Srikhanda Gram Panchayat under Katwa-1 block in Bardhaman district. It is a seasonal water logged water body. SB can be approached through road from Katwa, sub-divisional headquarter of the district Bardhaman.

Economic Activities: SB is surrounded by vast agricultural land. The main economic activities in and around this wetland are fishing, jute retting. The wetland is also used as agricultural land for boro paddy and other dry-season crops by draining water to the river. It has been estimated that approximately 400 households from neighboring villages derive these benefits.

3.2.9. Bater beel (BTB)

Location: Bater beel is located at Biswarambha Gram Panchayat under Purbasthali-2 block in Bardhaman district (see Figure 3.6). It is also a seasonal water-logged wetland and connected with River through drainage canal. BB can be approached through road from Katwa, sub-divisional headquarter of the district Bardhaman.

Economic Activities: The vast agricultural land and villages extend all around the BTB. The main economic activities of this wetland are fishing, jute retting and this wetland is also used as an agricultural land for boro paddy and other dry-season crops by draining the water through canal. It has been estimated that approximately 250 households from neighboring villages derive these benefits.

3.2.10. Padma beel (PB)

Location: Srikhanda beel is located at Faleya under Purbasthali-2 block in Bardhaman district. It is seasonal water-logged wetland, but well connected with river Ganga through drainage canal. PB can be approached through rail from Kalna, sub-divisional headquarter of the district Bardhaman.

Economic Activities: PB is surrounded by vast agricultural land. The main economic activities in and around this wetland are fishing, jute retting and irrigation for boro paddy and other dry-season crops. It has been estimated that approximately 100 households from neighboring villages derive these benefits.

3.3. Biodiversity

The surveyed wetlands in Bardhaman district support the survival of a large number of fish, snakes, frogs and a wide variety of other aquatic animals (see Appendix E). These wetlands also provide habitats of a large number of birds including migratory ones. Particularly in winter season these migratory birds gather in a large numbers in the surveyed wetlands. Flora diversity is also large in the surveyed wetlands. As flora, faunas and birds are highly interdependent for their feeding, breeding and growth, loss of any aquatic plant or aquatic animal disturbs the food chain for whole kingdom of plant and animal. The population of aquatic animals and birds are dwindling very rapidly in recent year due to increase in anthropogenic activities like fish catch, jute retting, irrigation and fodder collection. The surrounding population of the surveyed wetlands believe that both varieties and number of non-commercial aquatic animals have been reduced heavily as compared to 15 years back because of excessive and inappropriate application of pesticides in upland areas and net fishing. Loss in biodiversity is highest for seasonal wetlands where water is drained out. The environment and biodiversity are also disturbed by the interaction of the villagers' activities in and around the wetlands, for example noise from diesel pump-set and fish catch. Poaching of birds is also an important factor for decrease in the birds' population in and around the wetlands.

Fig.3.1. View of Haruabhanga Beel

Fig.3.2. View of Kalobaur Beel

Fig.3.3. View of Chakkobla Beel

Fig.3.4. View of Barokobla Bansdaha Beel

Fig.3.5. View of Bara Beel

Fig.3.6. View of Bater Beel

Chapter 4: Benefits and Degradation: Non-coastal Wetlands

Major economic benefits in and around the wetland derived by the surrounding population are Fish catch, Irrigation, Jute-retting and Fodder. Each benefit has been valued through market price method and surrogate price technique (Table 4.1).

4.1. Fishing benefit

Fishing benefit is derived from all the surveyed wetlands. The value of average annual fish catch of different variety per household has been collected which has been estimated by market price method. This value when multiplied by the number of households deriving this benefit gives the value of yearly benefit obtained from fish catch from that wetland. In some wetlands this value is directly obtained from fisherman's co-operative society. Fish benefit has been estimated by the following formula : -

TV_{Fish} = Total number of households deriving this benefit × Average annual fish catch per household (in Rs.).

4.2. Irrigation benefit

The water from the wetland is being used for irrigation in the surrounding agricultural fields. The value of water used for irrigation can not estimated by the market price method. Instead the surrogate price (substitute price) technique for estimating the value of water used for irrigation is employed. The price of the water from an alternative source can be used for it's valuation. The difference between price of water used in irrigation from other sources like privately owned shallow tubewells or submersibles and wetland, per acre of land is being considered to be the value of wetland by this valuation method. The difference occurs due to the fact that volume of water extracted per hour from the surface of a wetland is much more than that of a non-wetland using groundwater source (using a machine of the same horse-power). This has been calculated by using the following formula:

$$TV_{Irrigation} = \text{Reduction of average irrigation cost (Rs.) per ha. due to wetland} \times \text{Total area (ha.) irrigated from the wetland}$$

Table 4.1. Benefits derived from different wetlands per annum (Rs.)

Sl. no.	Name of wetland	Fishing	Irrigation	Jute retting	Total
1	Haruabhanga	160000	160000	0	320000
2	Kalobaur	144000	70000	20000	234000
3	Lakshmipur	112000	60000	0	172000
4	Chakkobla	180000	70000	0	250000
5	Barokobla	300000	40000	0	340000
6	Bara Beel	600000	350000	0	950000
7	Jalanga	200000	350000	0	550000
8	Srikhanda*	125500	0	50000	175500
9	Bater Beel*	500000	0	75000	575000
10	Padma Beel*	10000	0	12000	22000
Total		2331500	1100000	157000	3588500.00
Mean benefit		233150	110000	15700	358850.00
Standard deviations		183648.52	135236.42	26255.37	267502.03
Coefficient of variation		78.77	122.94	167.23	74.54

*Seasonally drained

4.3. Jute retting

The surrounding households are deriving the benefit of jute retting from the wetlands. The value of this benefit cannot be measured by market price method. Instead, indirect market price method (surrogate price) is used for it's valuation. Ponds can be hired on rental basis for jute retting. But if wetlands are used for this purpose no such rent is charged. The money saved for jute retting in the wetland may be considered as the value of jute-retting benefit. The general expression is as follows :-

$$TV_{\text{Jute - retting}} = \text{Total number of households deriving this benefit} \times \text{Average money (Rs.) saved by each household}$$

4.4. Other benefits

It has been found from field survey that people in the surrounding areas of wetland use this wetland for grazing their cattle. By doing so they can save 15-35% of total annual cost of cattle feed. These wetlands are also being used for various domestic purposes like bathing, washing clothes and utensils, raring up ducks etc. Nearly fifty households from each wetland of Barokobla, Bara Beel, Jalanga and Bater Beel get these benefits. But it is very difficult to compute those benefits due to lack of relevant information and presence of non-quantifiable variables. So the exact value of these minor benefits are not included in the analysis of benefits derived from wetlands. Instead we end up with just mentioning these advantage procured by the surrounding households due to the presence of these wetlands.

The value of all these benefits as obtained from field survey is shown in Table 4.1. The average benefits from fishing income per annum is Rs. 233150 which is more than double the average irrigation benefits per year, Rs. 110000. The benefits of jute-retting though small compared to other benefits, being Rs. 15700 per annum on average is worth mentioning.

4.5. Estimation of benefits

Wetlands play an important role in the history of human civilization. Water being the main source of life, all great civilizations grew up along riverbanks like Indus, Ganges, Nile, Euphrates and Tigris. Affinity of human towards wetlands is ancient too as their presence in the close vicinity had been playing a significant role in commanding the distribution of human settlements. Wetlands in close proximity had been providing the surrounding population with all their basic necessities of life -- be it as a source of drinking or irrigation water or fertile soil for harvesting or supplying materials for building homesteads etc. Since the dawn of civilization the interlinkage between this natural environment and economy is all embracing. Despite their functions as regulators of water regimes and habitats of distinctive ecosystems wetlands have significant commercial and economic importance too.

Table 4.2 Number of households deriving benefits across different wetlands

Sl. no.	Name of wetland	Fish	Irrigation	Jute retting	Total
1	Haruabhanga	125	125	0	250
2	Kalobaur	200	100	60	360
3	Lakshmipur	90	20	0	100
4	Chakkobla	20	200	0	210
5	Barokobla	60	50	0	110
6	Bara Beel	400	800	0	1000
7	Jalanga	100	300	0	400
8	Srikhanda*	200	0	200	400
9	Bater Beel*	150	0	100	250
10	Padma Beel*	75	0	20	95
Total		1420	1595	380	3175.00
Mean		142	159.5	38	317.50
Standard deviations		107.61	245.88	66.30	267.03
Coefficient of variation		75.78	154.16	174.47	84.11

*Seasonally drained

The surveyed wetlands are used as storage of water, which collect either from runoff or from drenched water of nearby rivers. This water is used initially for irrigation in periods of water scarcity. A number of commercially valuable flora and fauna are also grown in these wetlands by the neighbouring community, among which fish is the most important one. The huge economic benefits obtained from net fishing have tended these wetlands to be converted to aquaculture ponds. The drained off wetlands provides cultivable land for culturing food crops especially rice. The population encompassing the wetlands also uses these wetlands for jute retting and forage. From Table 4.2 it is revealed that 142 households on average derive fishing income which is lesser than average number of households receiving irrigation benefit (about 160). The average number of households receiving the benefit of jute retting is even lesser (38) because only four out of ten surveyed wetlands render this benefit.

Since there is variation in the number of households benefited and the total commanding area under each of the surveyed households due to wide variation in the area of these wetlands it will be more justified to convert the benefits derived into per household and per unit area. Table 4.3 shows such conversion of benefits into per household unit.

Table 4.3 Benefits derived (Rs.) per household from different wetlands

Sl.no.	Name of wetlands	Benefits derived per household from			Total benefits derived per household
		Fishing	Irrigation	Jute retting	
1	Haruabhanga	1280.00	1280.00	0	1280.00
2	Kalobaur	720.00	700.00	333.33	650.00
3	Lakshmipur	1244.44	3000.00	0	1720.00
4	Chakkobla	9000.00	350.00	0	1190.48
5	Barokobla	5000.00	800.00	0	3090.91
6	Bara beel	1500.00	437.50	0	950.00
7	Jalanga	2000.00	1166.67	0	1375.00
8	Srikhanda*	627.50	0	250.00	438.75
9	Bater beel*	3333.33	0	750.00	2300.00
10	Padma beel*	133.33	0	600.00	231.58
Mean		2483.86	773.42	193.33	1322.67
Standard deviation		2703.55	910.54	283.30	870.82
Coefficient of variation Coefficient of variation		108.84	117.73	146.53	65.84

*Seasonally drained

Here we find that the mean income per household from fish catch is highest being Rs. 2483.86 as all the ten surveyed wetlands render this service to the neighbouring population. However the intensity of this benefit differs from one wetland to the other as the standard deviation assumes a high value of Rs. 2703.55. The average value of irrigation benefit is Rs. 773.42 with a standard deviation of Rs. 910.54. Four wetlands of them delivers the service of jute retting, the average value of this benefit being Rs. 193.33. The standard deviation is Rs. 283.30. The total benefit per household presumes an average value of Rs. 1322.67 per annum with a standard deviation of Rs. 870.82. The coefficient of variation of all these benefits are also shown in the last row of Table 4.3. These data reveal that fishing has a lower coefficient of variation than irrigation or jute retting.

The benefits derived per unit area (Table 4.4) of these wetlands will help us to compute the variations of different benefits derived from them. This in turn will indicate the inclination towards conversion of these wetlands. Obviously the more the benefits obtained in money value for a specific direction of conversion the more inclined the surrounding people will be towards that conversion among various options available to them. This will also allow us to compare the concentration of diversified benefits derived from various wetlands.

4.6. Degradation of Wetlands

Wetlands though have tremendous potential for developments are the most threatened of all ecosystems today. Once lost the biological wealth contained in it cannot be easily regenerated. A study by the Wildlife Institute of India reveals that around 70-80% of fresh water marshes and lakes in the Gangetic floodplain region has been lost in the last 50 years. The rich mangrove areas have almost been halved from 700000 ha in 1987 to 450000 ha in 1995 (Ref. Sustainable Wetlands, IGIDR 1999).

Sometimes the damages to wetlands are unavoidable result of pressure on land but in many other cases it happens because the true value of wetlands are misunderstood. Though they play a pivotal role in maintaining the economy and ecology of the surrounding region they are becoming the first onslaught whenever land is required for expansion of various developmental activities. In inland areas agricultural and unplanned urban developments are taking toll on wetlands. Encroachments are also being made for roadways and railways construction. Wetlands are also being invaded for aquaculture and pisciculture. The wide area of Gangetic floodplains are shrinking due to construction of dams upstream, changing course of fresh water for irrigation, domestic and industrial uses. In densely populated areas wetlands are being transformed or filled into ports, bus stands, airports, estates, and recreation areas. The glens and watersheds are gradually degrading and increased siltation from them results in the demotion of present status of nearby wetlands.

Table 4.4 Benefits derived (Rs.) per unit area of the wetlands

Sl. No.	Name of wetland	Area (ha.)	Total benefit(Rs.)	Total benefits per ha.
1	Haruabhanga	10	320000	32000.00
2	Kalobaur	40	234000	5850.00
3	Lakshmipur	15	172000	11466.67
4	Chakkobla	60	250000	4166.67
5	Barokobla	25	340000	13600.00
6	Bara Beel	56	950000	16964.29
7	Jalanga	75	550000	7333.33
8	Srikhanda*	80	175500	2193.75
9	Bater Beel*	275	575000	2090.91
10	Padma Beel*	20	22000	1100.00
Total		65	3588500.00	96765.61
Mean		65.60	358850.00	9676.56
Standard deviation		77.68	267502.03	9472.94
Coefficient of variation		118.41	74.54	97.90

*Seasonally drained

All these are about direct conversion of wetlands into apparently more productive forms. These ecosystems are being put into environmentally degraded situations in spite of their omnipotent prominence. They nurture a wide range of flora and fauna. Any change in their hydrologic regime affects the species diversity in them, which has also been regarded as their degradation as supports the ecologists and environmentalists. A number of wetlands are being degraded indirectly as being common property resource through eutrophication and salinisation. Application of high input technology also has an adverse effect on the water quality of the wetlands. The success of high input modern technology depends on usage of chemical fertilisers, insecticides, pesticides etc. However, the run-off water transporting the residues of hazardous chemical inputs of agriculture finally finds their way into these wetlands which undermine the water quality of these wetlands. This is regarded as another aspect of wetland degradation. The antropogenic activities though imperative for human civilization ultimately impair his surrounding ecology unknowingly. Again, the unconsumed fertilisers accumulating in the neighbouring wetlands promote irrepressible organic growth thus choking the system of oxygen. This disrupts the lifecycle of wetland ecosystem. An exotic weed, water hyacinth for instance is frequently seen clogging wetlands thus destroying the natural balance of these ecosystems. Introduction of outlandish fish species may supplant native ones with no natural predators. This may capsize the chain of wetland ecosystems. The water quality can be distorted by pollution from boats, domestic sewage and industrial effluents, which in turn may alter the composition of aquatic flora and fauna in them.

The change in wetland area and its water quality are considered as wetland degradation. Another aspect of wetland degradation has been indicated by the number of species dependent on wetland that are becoming threatened or extinct. Their conversion and other human activities around the wetlands as overfishing, grazing by domestic livestock, disturbance from recreational activity and tourism etc. puts the ecological chain in jeopardy. A large number of migratory water-birds visit West Bengal from Central Asia, Siberia, Ladakh and other parts of Himalayas. During their annual migration these water-birds halt at the wetland sites to rest and feed that are essential for migration and crucial to their survival. Their existence is thus directly linked with the conservation of wetlands

Loss of water-birds' habitat along with other aquatic species through direct and indirect modification and non-sustainable utilization of water-birds as poaching, illegal trapping and hunting have led to decline of several water-birds' population and no of species. Their extinction is considered as another measure of wetland degradation. Specifically, the absolute number of species lost or threatened is the correct indicator of degradation.

4.7. Indicators of degradation

4.7.1. Area loss

Those parts of the wetland areas that have temporarily or permanently been converted to other apparently more productive uses are considered to be the loss of wetland area (Table 4.5). These conversions have occurred during past 15-20 years as has been obtained from the field survey. The adjacent inhabitants have devoted the converted areas mainly to agricultural operation. Other than this a considerable part of wetland area has been transmuted to aquaculture ponds where various fish variety are grown for commercial purpose. Around 4% area of Barokobla Beel has been filled up for building homestead. The seasonally converted areas of Srikhanda, Bater Beel and Padma Beel are reclaimed in post-monsoon season for boro-paddy cultivation.

Table 4.5 Loss in area of the surveyed wetlands

Sl. no	Name of wetland	Percent of area lost in 15-20 years	Reason for loss in area
1	Haruabhanga	10	converted for agriculture
2	Kalobaur	5	converted for agriculture
3	Lakshmipur	10	converted for agriculture
4	Chakkobla	44	converted for aquaculture and horticulture
5	Barokobla	4	Encroachment
6	Bara Beel	14	converted for agriculture and aquaculture
7	Jalanga	13	converted for agriculture
8	Srikhanda*	97	fertile wetland soil (agriculture)
9	Bater Beel*	93	fertile wetland soil (agriculture)
10	Padma Beel*	97	fertile wetland soil (agriculture)

*Seasonal conversion

These transformations have occurred due mainly to population and developmental pressure and partly to unawareness about the environmental consequences as well as socio-economic impact of their utilization. However, the primary objective for permanent and seasonal conversion is the fertile and productive soil of wetland, which is replete with rich nutrients (Appendix F).

4.7.2. Biodiversity loss

The loss in biological diversity is another indicator of ecosystem degradation as it disturbs the ecological chain and disrupts the biosphere. Wetlands sustain highly productive ecosystem with potential for supplying nutrients to the adjacent areas (Davidson 1991).

Table 4.6 Loss in Biodiversity in the surveyed wetlands

Sl. no.	Name of wetland	Loss in biodiversity			Total loss in biodiversity across wetlands
		Fish	Aquatic animal	Bird	
1	Haruabhanga	1	0	1	2
2	Kalobaur	0	1	0	1
3	Lakshmipur	1	0	0	1
4	Chakkobla	1	0	0	1
5	Barokobla	1	1	0	2
6	Bara Beel	4	2	2	8
7	Jalanga	1	1	0	2
8	Srikhanda*	3	1	1	5
9	Bater Beel*	2	2	2	6
10	Padma Beel*	2	1	2	5
Total		16.00	9.00	8.00	33.00
Mean		1.60	0.90	0.80	3.30
Standard deviation		1.17	0.74	0.92	2.50
Coefficient of variation		73.36	81.98	114.87	75.66

*Seasonally drained

The total biodiversity (flora and fauna) of wetlands is high in comparison with terrestrial ecosystems. Wetlands provide protective cover and essential feeding, breeding and maturation areas for a wide range of invertebrates as well as cold and warm-blooded vertebrates. They provide refuge for migratory birds. In order to measure the biodiversity loss data have been collected from bird watchers, fisherman community and surrounding farmers.

According to them, number of birds, natural fish and aquatic animals (snails, frog and other insects) have been steadily dwindling each year. This is a common phenomenon for all the surveyed wetlands. For quantitative analysis we have taken the number of species presently found/arrived/visiting the wetland. This figure is then compared with the figures of five years back obtained from the respondents. Similar figures have been collected for fish and other aquatic animals.

4.7.3. Water Quality

One key measure of water quality is dissolved oxygen (DO). Dissolved oxygen is important in wetlands because the chemical activity of the oxygen enables them to 'cleanse' themselves by oxidising both naturally occurring (e.g. vegetative) and introduced (e.g. run-off) wastes. Also, fish and other aquatic faunas need DO to 'breathe'. They extract it from the water contained in the wetlands and without adequate level of DO they will die. Fish, for example, are specially sensitive to dissolved oxygen levels and need 4 to 7 mg of DO per litre of water for their optimum growth. The DO should not be below 2 mg per litre. The DO level of water of different wetlands under study was estimated on spot using a portable DO meter (Oxi320, WTW, Germany). To estimate the water quality of the wetlands other parameters measured were pH, temperature and conductivity. The water quality profiles of the inland wetlands have been presented in Table 4.7.

It is observed from Table 4.7 that DO of the wetlands varied considerably, ranging from 0.91to 6.94 mg/l. However, except Bater Beel, Chakkobla Beel and Jalanga, The DO were above 2 mg/l. The pH value of water of all the surveyed wetlands were well within the acceptable levels (5.5 to 9.0). However, for optimum growth of aquatic fauna, especially fish the pH of water should lie between 7 to 8 i.e., slightly alkaline. It is observed from Table 4.7 that pH of wetlands' water, under study, were either below 7 or above 8.

Table 4.7. Water quality

Name of wetland	Date	DO (mg/l)	pH	Temperature (°C)
Haruabhanga	11.04.2000	2.00	6.49	30.6
Kalobaur	12.04.2000	3.99	8.69	30.6
Lakshmipur	13.04.2000	2.90	6.51	30.0
Chakkobla	14.04.2000	0.39	5.87	30.0
Barokobla	15.04.2000	6.94	8.17	30.4
Bara Beel	16.04.2000	3.32	6.76	30.6
Jalanga	14.04.2000	1.29	5.11	30.6
Srikhanda	10.04.2000	2.04	6.57	30.7
Bater Beel	13.04.2000	0.91	6.56	30.4
Padma Beel	13.04.2000	2.41	6.32	30.0
Mean		2.62	6.71	30.39
Standard deviation		1.87	1.03	0.28
Coefficient of variation		71.48	15.41	0.94

CHAPTER 5: Benefit-Cost degradation relation: Inland wetlands

Cost-benefit analysis estimates the net effect on the economy from the activity being assessed. This is the most common method of project appraisal where benefit can be valued. Economic analysis of wetlands has generally focussed upon the choice between wetland conservation on one hand and conversion and development on the other hand and depends on techniques and costs of each.

5.1. Cost-Benefit analysis

An essential presumption in the cost benefit analysis is that a society will be economically efficient in it's use of resources when all costs and benefits, both direct and indirect, tangible and intangible are included in the analysis. The objective of such analysis is the maximisation of net social benefit. Environmental attributes and services are considered as commodities, which can be traded. Since a market price for an ecosystem does not exist, it is assumed that the demand for the ecosystem is the derived demand for the goods and services that the system contributes or supports. The benefits provided by the environment include non-marketed items and certain intangible benefits. These benefits collectively constitute the economic welfare of a society. If goods and services that our society has been endowed with, are lost, as is the case with wetland conversion, a loss is imposed on the economy as a whole. Whether or not this change is justified depends on the net benefits generated by alternative use of the wetland and distribution of those benefits. A primary objective of cost-benefit analysis is to determine whether a given policy proposal would generate a Potential Pareto Improvement.

As has been mentioned earlier most of the converted wetland area has been devoted to agriculture (Table 5.1). In the first wetland 1% of total area (10 ha.) i.e., 1 ha. has been converted. Cultivators have apportioned this entire land. In Kalobaur 5% of 40 ha. area has capsized and entire of this 2 ha. wetland has been transformed to agricultural field.

Table 5.1. Conversion of wetlands area to other forms

Sl.n	Name of Wetland	Area (ha.) converted to				Total area in ha
		Agricultur	Aquaculture	Horticultur	Encroachme	
1	Haruabhanga	1	0	0	0	1.00
2	Kalobaur	2	0	0	0	2.00
3	Lakshmipur	1.5	0	0	0	1.50
4	Chakkobla	0	21.12	5.28	0	26.40
5	Barokobla	0	0	0	1	1.00
.6	Bara Beel	2.84	5.00	0	0	7.84
7	Jalanga	9.75	0	0	0	9.75
8	Srikhanda*	77.6	0	0	0	77.60
9	Bater Beel*	255.75	0	0	0	255.75
10	Padma Beel*	19.4	0	0	0	19.40
Total		369.84	26.12	5.28	1	402.24
Mean		46.23	13.06			40.22
Standard deviation		88.49	11.40			79.22
Coefficient of		191.42	87.28			196.96

*Seasonal conversion

In Lakshmipur again 10% of 15 ha. i.e., 1.5 ha. wetland has been transmuted for farming purpose. Coming to Chakkobla we find that the trend of transition has been reversed in favour of aquaculture. Around 80% of converted land has been remade as aquaculture ponds and remaining 20% high land surrounding the ponds has been reclaimed for horticulture. Through this conversion 21.12 ha. and 5.28 ha. of wetland have been dispensed among aquaculture and horticulture respectively. In Barokobla 4% of 25 ha. has been encroached for human settlements. This 1 ha. land has been proclaimed for building homestead. In Barabeel by and large 14% wetland area has been altered for agricultural purposes. Around 5 ha. area has been devoted to aquaculture and remaining area has been transformed to arable land. In Jalanga about 13% wetland area is found to be transgressed for agricultural usage which accounts for 9.75 ha. wetland area. All these wetlands have been converted once and for all so that they can never regain their original status. However, some of the surveyed wetlands are converted to agricultural field during post-monsoon season for cultivation of boro crops. They fill up with water again in rainy season. These features are obtained in three of the surveyed wetlands namely, Srikhanda, Bater Beel and Padma Beel. In each of these wetlands more than 90% area are switched to agricultural field. Around 78 ha. in Srikhanda, 256 ha. in Bater Beel and 20 ha. in Padma Beel are acquired by the process of seasonal conversion.

Table 5.2 Benefits obtained (Rs.) from converted wetlands in Bardhaman

Sl.	Name of	Value of the benefits derived from converted				
		Agricultur	Aquacultu	Horticultur	Encroachme	Total
1	Haruabhanga	15502	0	0	0	15502
2	Kalobaur	31004	0	0	0	31004
3	Lakshmipur	23253	0	0	0	23253
4	Chakkobla	0	950400	396000	0	1346400
5	Barokobla	0	0	0	375000	375000
6	Bara Beel	44026	225000	0	0	269026
7	Jalanga	151145	0	0	0	151144
8	Srikhanda	1202955	0	0	0	1202955
9	Bater Beel	3964637	0	0	0	3964637
10	Padma Beel	300739	0	0	0	300739
Total		5733260	1175400	396000	37500	7342160
Mean		573326	117540	39600	3750	734216
Standard deviation		1247013.	301058.9	125226.2	11858.54	1237215.
Coefficient of		217.51	256.13	316.23	316.23	168.51

*Seasonal conversion

The sole purposes of these conversions are aimed at augmented income. The total gains from converted wetlands have been classified under different heads in Table 5.2. The agricultural benefits have been measured on the basis of household survey. The average benefits obtained from agricultural activities have been measured to be Rs.15502 per ha. On this basis the agricultural benefits have been computed from all the converted wetlands. The aquaculture render a benefit of Rs. 45000 per ha. of wetland. The converted aquaculture ponds of Chakkobla and Bara Beel provide benefits of Rs. 950400 and Rs. 225000. Around the ponds in Chakkobla horticulture is being performed which provide a benefit worth Rs. 396000. This benefit has been computed on the average value of horticulture activity giving a return of Rs. 75000 per ha. of land. In Barokobla 1 ha. land has been utilised for building homestead. The land values in that area is Rs. 375000 per ha. The rental value of this land is assumed to be the gain from this conversion, which stands at 10% of the land value. On this ground the net benefit from the converted wetland of Borokobla figures at Rs. 37500.

As has been mentioned earlier, apart from these permanent conversions, three wetlands are seasonally converted in the post-monsoon season to generate fertile farmland through soil enrichment (Appendix G). They again regenerate to their rudimentary form when cultivation cycle is over. In Bater Beel the benefit from such conversion amounts to be 40 lakhs (approx.) whereas from Srikhanda and Padma Beel gains from such conversions aggregate at Rs. 12 lakhs and 3 lakhs respectively.

Now we concentrate on the concluding portion of cost-benefit analysis. Here we have compared the benefit from converted wetland and benefit foregone due to their conversion. The ratio of these two figures account for the justifiability of conversion. To begin with, in Haruabhanga, the benefit foregone is more when compared to conversion, their ratio being less than unity (Table 5.3-scenario 1). Perhaps, for this obvious reason it is apparent that conversion has been the least in this wetland. In all other wetlands the benefit-cost ratio is greater than unity and short term conversion is justified from beneficiaries' point of view. In Chakkobla overall 44% of the wetland has been modified permanently and it is justified on the premise that benefit-cost ratio is highest among all the wetlands. Considering the seasonally drained wetlands the benefit-cost ratio is higher in Bater beel and almost entire part of this wetland is converted to agricultural field in post-monsoon season.

It is time to have an in-depth view of the consequences of all these anthropogenic activities being performed in and around the wetlands. The households encompassing these wetlands are not aware of the loss in biological diversity due to the utilization of the wetlands. Neither the government nor any NGO has taken any effort to make these people cognizant about the ecological loss and consequent degradation of these wetlands. So during the survey, it was observed that they were ready to pay only for the upkeep of the wetlands as a source of irrigation water or fishing and other benefits. Since the loss in biodiversity affects the ecological chain on the whole, it acts upon both the beneficiaries and the non-beneficiaries. Such damage of the environment reflects on all the households in the Block, where the wetland is situated. They on average are willing to pay Rs. 20 per household per year. Incorporating such imperceptible loss in terms of WTP the benefit-cost ratio is seen to get reduced to a considerable extent (Table 5.3 scenario 2).

Table 5.3. Benefit-cost ratio for wetlands in Bardhaman district

Sl.no.	Name of wetland	Benefit-cost ratio (scenario 1)	Benefit-cost ratio (scenario 2)
1	Haruabhanga	0.48	0.28
2	Kalobaur	2.65	0.98
3	Lakshmipur	1.35	0.48
4	Chakkobla	12.24	9.65
5	Barokobla	2.76	0.57
6	Bara Beel	2.02	1.43
7	Jalanga	2.11	1.59
8	Srikhanda*	7.07	5.61
9	Bater Beel*	7.41	6.58
10	Padma Beel*	14.09	3.60

*Seasonal conversion

Inspite of high value of benefit-cost ratio the whole wetland area is not being converted because there exists some causal relationship between multifarious economic benefits derived from these wetlands and their degradation.

5.2. Causal Relationship

The inter-linkage between economy and natural environment is all embracing. Every economic action can have some effect on the environment and every environmental change can have some impact on the economy. As long as human activity is at a level below the regeneration capacity of the natural environment, there is no secular downfall in the quality of these resources. If their demotion go beyond a certain edge then such natural regeneration may not even be possible and additional costs may have to be incurred to make them more amenable. Such decay of natural resources, or loss in the quality of the environment imposes a burden on present and future generations.

It has been observed that there exists a relationship between the degradation of the wetlands and the benefits derived from them through various economic activities by the surrounding population. The structural factors which exert explanatory power to the relationship between benefits and degradation include benefits derived per household and benefits derived per unit area of wetland. Different functional forms are needed for estimating the effects of various economic activities on the degradation level. This is so because various aspects of environmental quality have measured degradation. These are :

i. Proportion of total area converted seasonally or permanently to other uses,
ii. Biodiversity loss per unit area of wetland, which has been measured by species extinction of variety of bird, fish and other aquatic animals in particular wetlands,
iii. Water quality in terms of dissolved oxygen.

In the first approach of our analysis, degradation has initially been measured by percentage loss in area of wetlands (AL), whether seasonally or permanently, to other economic uses. It is found to be a function of irrigation benefit derived per household (Irr_{hh}), and fishing benefit derived per household (fs_{hh}) from these wetlands, i.e.,

$$AL = f(Fs_{hh}, Irr_{hh})$$

with $f^{/} Fs_{hh} < 0$ and $f^{/} Irr_{hh} < 0$.

Evidences suggest that wetlands provide a steady source of water for irrigation to the surrounding cultivated land, even if the deep tubewells and submersible pumps fail to lift water in the adjacent areas during a drought. So the irrigation benefits derived from a wetland is associated with its conservation, as its conversion will result in suffering to the adjacent farmer community. Hence, $f^{/} Irr_{hh} < 0$.

Again, fishing benefit obtained by the surrounding population will oppose conversion of the wetlands. Even if conversion take place in favour of aquaculture ponds for augmented fishing income that will definitely accrue to a meager number of beneficiaries. From the conversion table it is also evident that wetlands in most of the cases have been turned into agricultural lands rather than aquaculture ponds. The probable reason for this is the uniform better distributive impact of transformed land. Hence the sign $f^{/} Fs_{hh} < 0$.

In the second approach of identifying the benefit-degradation relation, the degradation has been viewed from the ecological perspective. The loss in biological diversity is another indicator of ecosystem degradation as it disturbs the ecological chain and disrupts the biosphere. Wetlands sustain highly productive ecosystem with potential for supplying nutrients to the adjacent areas (Davidson 1991). The total biodiversity (flora and fauna) of wetlands is high in comparison with terrestrial ecosystems. Wetlands provide protective cover and essential feeding, breeding and maturation areas for a wide range of invertebrates as well as cold and warm-blooded vertebrates. They provide refuge for migratory birds too.

As benefits derived from wetland increase they become susceptible towards conversion. With increasing rate of conversion livelihood of many species -- fish, snail, snake, frog, insects etc.-- are being destroyed and specific variety of aquatic animals are becoming extinct from a particular wetland. So higher value of benefit derived per unit area of wetland is accompanied by higher species extinction. So, there is a positive correlation between biodiversity loss per unit area ($BD_{loss/ha}$) of wetland and total benefit derived from the same (Tb_{ha}),

$$Tb_{loss/ha} = \mu (Tb_{ha})$$

$$\text{with } \mu^{/} Tb_{ha} > 0$$

The multi-faceted benefits that are held responsible for biodiversity loss are agricultural benefit, fishing benefit, irrigation benefit etc. We can explicate the reason for the disastrous impact on biodiversity loss in the following manner. As more agricultural benefit is being derived in the form of reduction in the cost of fertiliser for the soil at the bottom of wetlands more land is reclaimed for cultivation. This land is however obtained by draining off water from the wetland area seasonally. This results in the loss of aquatic fauna as their habitat is being fragmented. The disturbance caused at their shelter makes their existence vulnerable. Again the water carrying the residues of chemical fertilisers and pesticides from the surrounding agricultural fields finally finds their way into these wetlands, which pollutes the water. These toxic chemicals disrupts the life cycle and destroys the aquatic faunas present in the wetlands as hydrologic parameters are strong controllers of wetlands' ecosystems (Gosselink and Turner 1978, Novitzki 1989). Indiscriminate and excessive fishing for commercial purpose is beyond the natural regeneration capacity of these species which is another cause of their destruction. Over exploitation of aquatic faunas for trade is also threatening species. Incidental take, particularly drowning of aquatic reptiles and mammals in fishing nets is one of the causal factors. These species are undesirable to the fisherman while of immense importance and desirable to maintain the ecological balance. Lastly, with increasing volume of irrigation the net water content of the habitat place of the aquatic faunas are diminishing. This results in lesser availability of water per unit of life-form, which inhibits their growth.

Coming to the aspect of imperiled bird species the available data suggests that agricultural and irrigation benefit per unit area of wetland aggravates the loss of bird community. Indiscriminate application of chemical fertiliser, pesticides, excessive net fishing, jute retting, artificial draining of water in summer etc. result in scarcity of food and loss of habitat for birds, fish and other aquatic animals. The physical interference of human being in the course of various anthropogenic activities as agriculture, deliberate poaching of birds threaten their year round habitats as wetlands are providers of feeding, breeding and maturation areas of the bird population. Also the irrigation facility accentuates the loss of aquatic animals. The birds prey on some of these aquatic faunas. The loss of these animals result in shortage of food and consequently birds arrive in lesser numbers. Also the irritating noise of a number of pump-sets that draw water from wetlands to the surrounding agricultural fields disturbs their peace. All these anthropogenic activities on one hand enhance benefits from the wetlands but aggravates the problem of biodiversity loss on the other. Hence, $\mu^{/} Tb_{ha} > 0$.

In the third approach, the water quality has been used as an indicator of degradation of wetlands. In order to judge the water quality, dissolved oxygen (DO) of the water samples collected from all the ten wetlands have been measured in the laboratory. It has been found from the water analysis data that there is a wide fluctuation of DO ranging from 0.39 mg/l to 6.94 mg/l. Higher value of water signifies better quality of water. Usually the level of DO stands at 7 mg/l in fresh water at 25°C. The deviation of the actual value of DO from the standard level of 7 mg/l, denoted by DO_{dev}, is considered to be the degradation of wetlands in our analysis. In this regard the degradation is found to be dependent on fishing benefit (Fs_{ha}) and irrigation benefit (Irr_{ha}) derived per unit volume of water whose water quality is being analysed, i.e.,

$$DO_{dev} = h(Fs_{ha}, Irr_{ha})$$

$$\text{with } h^{/} Fs_{ha} < 0 \text{ and } h^{/} Irr_{ha} > 0$$

Fishing and irrigation activities have direct influence over the water quality of wetlands in terms of DO. As fishing increases other things remaining the same, dissolved oxygen in water also increases due to stirring of water and hence degradation decreases. This explains $h^{/} Fs_{ha} < 0$. Again as more and more water is drawn from the wetlands for irrigation purposes the volume of water contained in it reduces. This results in concentration of salts and other suspended materials, which reduces the level of dissolved oxygen and consequently degradation increases. Hence, $h^{/} Irr_{ha} > 0$.

5.3. Empirical Results

In order to explain the degradation, multiple regression analyses have been done (Table 5.4). Degradation in terms of area loss has been considered as the dependent variable while total benefit per household from irrigation and fishing as the explanatory variables. The regression results have been evaluated on the basis of goodness of fit of the model and significance level of the parameters.

From the regression results it is evident that though both the parameters of fishing benefit and irrigation benefit per household are opposing area loss being negatively related to the dependent variable the contribution of fishing benefit per household in explaining the loss in area is not significant. This may be due to the fact that more benefit could be obtained from the corresponding wetland had it been converted to aquaculture ponds. Moreover, the benefit from such converted wetland would then accrue to a fewer population than the fishing benefit from the existing wetlands which is now dispersed among a large number of population. Perhaps this distributive impact is acting as a preventive agent in favour of the conservation of the wetlands in its natural form. Again, the predominance of irrigation benefit per household is found to be significant at 5% level. This is so because some direct as well as indirect benefits are inherent to these wetlands as sources of irrigation. Irrigation supports a vast area under boro paddy cultivation, which directly and indirectly sustains a large section of population by providing them with food and employment as agricultural labourer.

In the second model of multiple regression analysis the result shows that 66% of the total biodiversity loss is being explained by the total benefit derived per unit area from the wetlands. The positive relationship between the dependent variable and explanatory variable is statistically significant at 1% level. Figure 5.1 supports this conclusion.

In the third model association between water quality measured in terms of dissolved oxygen (DO) and total benefit derived per unit area, have been judged. Data obtained concerning these variables have been used for the analysis of multiple regression. It can be inferred from the analysis that irrigation benefit per ha. of wetland is positively correlated while fishing benefit per ha. is negatively correlated to the dependent variable DO_{dev} and both the explanatory variables, irrigation benefit per ha. and fishing benefit per ha. are significant.

We have made an attempt to judge the dependence between DO_{dev} and total benefit by plotting the data concerning these variables. The scatter diagram of DO_{dev} against total benefit exhibits a U-shaped stretch (Figure 5.2). This enables us to infer that as benefit per unit area increases, water quality tends to improve. But as benefit level exceeds a specific level the water quality starts deteriorating. This is quite obvious from the change in the direction of the $DO_{deviation}$ – Benefit curve. This peculiar nature of the curve may be due to the larger share of irrigation benefit compared to the fishing benefit. It is worth mentioning that fishing activity increases the level of DO while irrigation, by lowering the water level, reduces the level of DO. Thus the nature of the curve depends upon the two divergently reacting forces.

Figure 5.1 Graphical representation of positive relation between biodiversity loss and benefit generated from non-converted wetlands

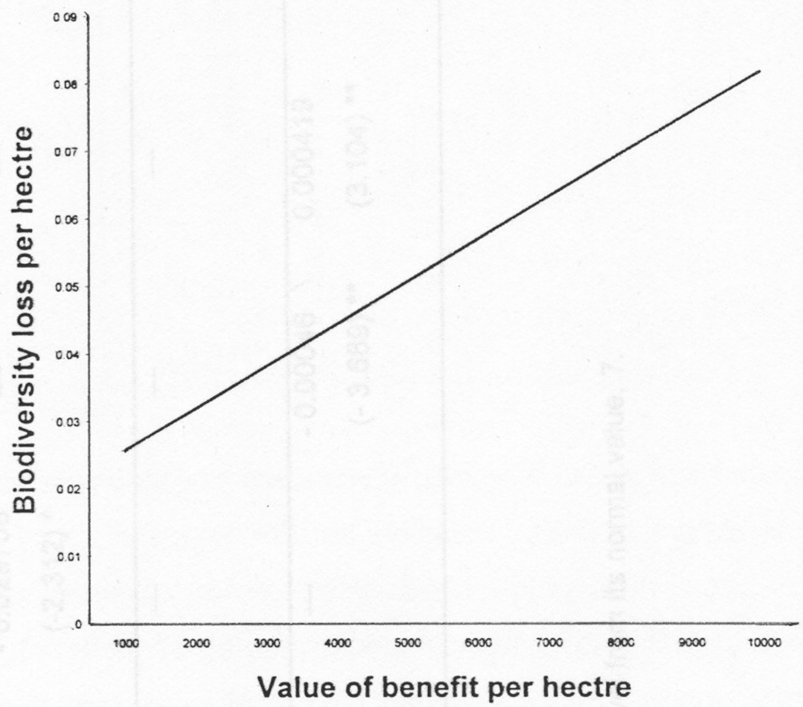


Table 5.4 Multiple regression results

Model	Dependent variable	Intercept	Explanatory variable					R^2
			Fishing Benefit per Household	Irrigation benefit per household	Fishing benefit per hactre	Irrigation benefit per hactre	Total benefit per hactre	
1. Linear Multiple regression	Area loss	68.520092	- 0.002746 (-0.634)	- 0.029738 (-2.312) *	—	—	—	0.43725
2. Linear Multiple Regression	Biodiversity loss per Hactre	0.019323	—	—	—	—	0.0000062 (2.304) *	0.39893
3. Linear Multiple regression	DO_{dev} ***	5.702672	—	—	- 0.00046 (- 3.689) **	0.000419 (3.104) **	—	0.66109

N.B. (1) Figures in parentheses indicate t-value

(2) * Significant at 5% level.

(3) ** Significant at 1% level.

(4) *** DO_{dev} is deviation of dissolved-oxygen level from its normal value, 7.

Table 5.5 Share of fishing and irrigation

Sl. no.	Name of wetland	Share of fishing	Share of irrigation	DO $_{dev}$ mg/l
1	Haruabhanga	0.50	0.50	5.00
2	Kalobaur	0.62	0.30	3.01
3	Lakshmipur	0.65	0.35	4.10
4	Chakkobla	0.72	0.28	6.61
5	Barokobla	0.88	0.12	0.06
6	Bara Beel	0.63	0.37	3.68
7	Jalanga	0.36	0.64	5.71
8	Srikhanda*	0.72	0	4.96
9	Bater Beel*	0.87	0	6.09
10	Padma Beel*	0.45	0	4.59

*Seasonal conversion

It has already been mentioned that standard level of DO in fresh water stands at 7 mg/l. Any deviation from this approved level indicated by DO $_{dev}$ mg/l is considered to be the degradation of water under consideration. So higher value of DO $_{dev}$ mg/l signifies higher damage or degradation. To be specific the highest level of DO $_{dev}$ (6.61mg/l) has been obtained from water sample collected at Chakkobla where damage is also highest. The fishing activity performed in the wetlands acts as a stirrer and increases the oxygen absorbed to the water contained in them. On the contrary, irrigation activity reduces that level. In the surveyed wetlands as share of fishing in total benefit increases, water quality improves and damages decrease. Starting from Haruabhanga where share of fishing is 0.5, we find that damage is at a level of 5. Moving down it is observed that augmented share of fishing reduces the damage. Also, largest share of fishing in Barokobla has curtailed the damage to the lowest level (0.06 mg/l) and lowest share of fishing in Jalanga corresponds to the most damaged quality of water. The water quality of Chakkobla, however, shows an ambiguous result where considerable extent of fishing cannot bring down the damage and the quality of water is the poorest. This conflicting outcome may be due to the decomposition of substantial amount of foliage in the water of Chakkobla from the surrounding horticulture. It is noteworthy that in the last three wetlands water is drained in the post-monsoon season. We have omitted these three wetlands in the analysis of water quality.

Chapter 6: Description of Selected Coastal Wetlands

Surveyed wetlands are located in Ramnagar-1 and II blocks of Medinipur district. Survey includes aquaculture (traditional, mixed and prawn) ponds, salt pan and fish launching centre spread over 9 *mouzas.* Where more than 2550 households are deriving their livelihood. The major development activities on the surveyed wetlands are fish growing/ fish catching, salt production and marine fish landing and marketing. Types of wetlands under study are described below.

6.1 Aquaculture ponds

At the initial stage of transformation natural coastal wetland mainly tidal flats/ mud flats (Fig 6.1) were converted to ponds for fish growing. At this stage all most all-common sea fishes like *parse, bhagan, gule, tengra* and different varieties of prawn that had been available on natural coastal wetlands are grown in these ponds (Figure 6.2). The process involved trapping of seawater from creek through inlet-channel. The water thus entrapped within the wetlands contained seedling of common sea fish, which were grown there. The process was known as *traditional fishing*. This process of aquaculture is still in practice in this coastal area. In this act some area of natural coastal wetland has been converted to non-coastal wetland in the form of embankment and road. Biodiversity loss and environmental degradation were not significant as compared to natural coastal wetland at this stage. But with the development of scientific shrimp culture in general and tiger prawn in particular the scenario changed drastically (Fig 6.3). A lion share of the traditional ponds was converted to commercial prawn culture in the early 1990s. The prawn culture was considered to be more capital intensive and subject to high risk factors. Eventually more than 90% (exclusion of upcoming World Bank Fishery project) of the area under prawn culture became abandoned. There is no economic benefit from the abandoned wetland. Instead there is enormous environmental loss due to residual impact of prawn feeding on water and surrounding land. There are some indirect indicators of environmental hazards like skin disease to those who expose themselves to water discharged from ponds having prawn cultivation, and reduction of seedling of common sea fish that was available before adoption of prawn culture as reported by the local population. It can be mentioned here that the development of prawn culture also develop the net fishing of seedling of tiger prawn from seashore. This practice has a detrimental effect on seedling of other aquatic animals because fishermen destroy the seedling of other aquatic animals during separation of seedling of prawn.

6.2. Salt pan

Salt pan is also man-made typical coastal wetland (fig 6.4). Salt extraction from seawater is nothing new for the people living around coastal region of *contai* subdivision of medinipur district. It is almost a century old practice. However, the present practice of large-scale salt manufacturing is the product of development of solar evaporation technique. This technique has been utilized since early 1970s. As a consequence of this development a large area of natural coastal wetland suitable for salt production was switched over to salt pan. The process of salt production involves the storage of seawater in a specifically designed salt pond to raise the desired degree of salinity of water for salt extraction. There is no such report or local complain regarding environmental hazards with this practice, rather there is an additional benefit of fishing which grow naturally within the salt ponds. But a sizeable portion of the wetland has been converted permanently to non-wetland because of infrastructure required for salt production. Human interaction associated with salt production has reduced the number of migratory birds arriving around the wetland and some aquatic animals as compared to 30 years back. It can be mentioned here that bengal salt plant, one of the oldest salt manufacturing plant is abandoned at present (fig 6.5) and approximately 50% of the abandoned area has been converted to commercial prawn culture sponsored by world bank.

6.3 Infrastructure Development on coastal wetland

Government of West Bengal has developed infrastructure that includes fish launching center, ice factory, market complex, office building, hotels and access road to sea beach etc (Fig 6.6). Government is earning good amount of revenue from these infrastructure developments and large number of population earns their livelihood utilizing this infrastructure. By this outgrowth all most all features of coastal wetlands have lost. This developmental activity also indicates that the conversion process of coastal wetlands to non-coastal wetlands may gear up in the direction of development of tourist spot, encroachment for settlement etc.

6.4 Biodiversity

Natural coastal wetlands in Medinipur district (viz, open flat banks and edges, shallow creeks and swamps) have a very rich and varied fauna. There are about 50 species of animals, of which 22 species are fishes, 18 birds and several other species of vertebrates and invertebrates (Appendix H). Wetland conversion poses the most serious threat to habitat destruction and survival of these species.

This coastal region is also rich in flora. It contains more than 10 identified species. Open flat blanks and edges are ideal place vegetation like *Giria* and *Lona durba.* A special feature of these types of vegetables is that they can survive even if they are submerged under sea water for hours. But due to conversion only few grasslands (Lona durba) are left inside the coastal region under study.

Fig.6.1. View of natural coastal wetlands

Fig.6.2. View of aquaculture ponds (Traditional)

Fig.6.3. View of aquaculture ponds (Mixed)

Fig.6.4. View of salt pan

Fig.6.5. View of abandoned salt pan

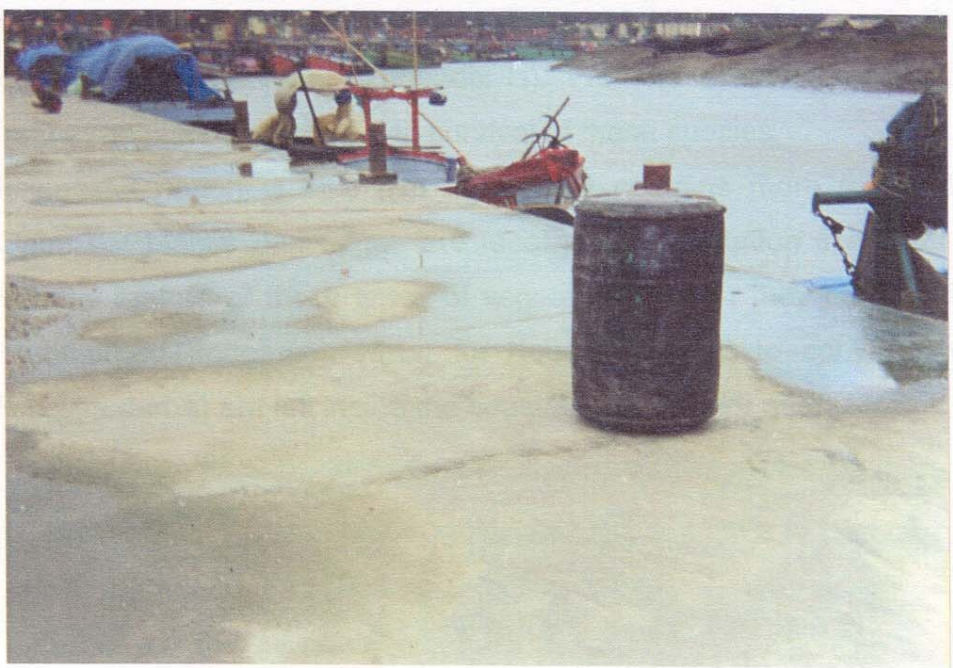


Fig.6.6. View of fish launching centre

Chapter 7:Coastal wetlands: Economic benefits and degradation

According to the report on Wetlands of India, 1998, ISRO, coastal wetlands in Medinipur district consist of natural and man-made type. Lagoon, creek, tidal/mud flat, sand/beach/spit/bar, salt marsh/marsh vegetables, and other vegetables are natural coastal wetlands. Salt pan and aquaculture ponds are man-made type. Increased population pressure on coastal wetlands and development of solar evaporation technology for salt manufacture are considered to be the most important parameters for converting natural coastal wetlands to aquaculture ponds and salt pan.

7.1. Man-made conversion of coastal wetlands

The process of conversion from natural coastal wetlands to man-made types wetlands started approximately 35 years ago. Major conversion took place in early 1970s when maximum number of salt pan was constructed for commercial salt production. To understand the complex system of coastal wetlands, a detailed field investigation was carried out. The study covers the entire spectrum of population who are closely associated with different economic activities on coastal wetlands at present. To capture the conversion aspect from natural coastal wetlands to the present state, in-depth discussion with knowledgeable persons belonging to co-operatives, associations, institutional heads and individuals was held.

Natural processes influence the change of ecology and biodiversity of the entire stretch of Digha-Contai coastal region in Medinipur district. Emergence of new land what is locally named as *new char* opened up the opportunities for establishing new settlement. For example, the village *Showla* and *Dadanpatrabar* under the jurisdiction of Kalindi Gram Panchayat are such new settlements. Poor people migrated from neighbouring areas and built up shanties on the newly emerging land immediately after independence. Fish catch from natural coastal wetlands was the main source of livelihood. But with increasing population on coastal land, fish catch on open land became unprofitable. To raise income from fishery they converted the natural coastal wetlands to aquaculture ponds. The practice is very simple. They enclose an area of the coastal land by embankment made of earth and allow sea water along with sea fish and seedling to enter there during high tide. Then they store sea water for few months so that common sea fish can grow. This kind of aquaculture practice, locally called *traditional fishing* was started after 1965.

In the early 1950s, Government of West Bengal also made one investigation to see whether this coastal wetlands would be suitable for salt manufacture for commercial purpose or not. The investigating team concluded that approximately 10,000 acres of coastal wetlands could be utilized for commercial salt production at Digha-Contai coastal region in Medinipur district. With this epoch making findings some private entrepreneurs invested money to install salt manufacturing industry on coastal wetlands. Large investment was made during the early 1970s. Aquaculture and salt production were more or less stabilized with some modification of techniques. Meanwhile Government also installed some fishery projects during 1960s and 1970s on the coastal belt. To facilitate the marine fishing, Government of West Bengal also initiated some fish-launching centers, ice factory and approach roads, to access some important coastal beach like Shankarpur.

7.2. Benefit from converted coastal wetlands

Major development activities on coastal wetland are Aquaculture, Salt manufacturing and Infrastructure development. Direct benefits have been calculated by estimating annual value of wetland products/ services from unit area of wetland. Each benefit has been valued through market price method. Economic benefit per acre of converted coastal wetlands is shown in Table 7.1

7.2.1. Aquaculture

As aquaculture ponds are man-made and belong to some individual or co-operative of fishermen community, the annual value of fish production from particular ponds has been estimated with the figure given by respective owner/head of the co-operatives. Four to five aquaculture ponds were selected randomly from each village/mouza to estimate the average value of benefit per acre of aquaculture pond. It has been found that benefit per acre of ponds across the mouzas is more or less uniform for a particular type of aquaculture. However the value of benefit varies widely among different types of aquaculture. For example for traditional fishing the value of benefit has been estimated in the range between Rs. 2000 and Rs. 2500 per annum while for prawn culture it lies in the range Rs. 40,000 - Rs. 100,000 per annum. In some ponds this value is directly obtained from fishermen's co-operative society.

7.2.2. Salt pan

Salt is the unique product of the coastal wetlands in Medinipur. In order to value the salt pan, the yield of the salt and selling price of salt have been collected from different salt manufacturers and total annual sale value of the salt has been calculated. It has been found that the benefit per acre of land per annum varies from Rs. 2500 to Rs. 3000. However, salt pans also add some additional value from fishing during off- season. The usual practice is that the manufacturer leased-out the salt ponds during the off-season to the workers of the salt plant for fishing and received a lump-sum amount. It has been estimated that the benefit from such fishing income varies between Rs. 1000 and Rs. 1200 per annum.

7.2.3. Infrastructure development

It is very difficult to calculate benefit in this sector. However, on the basis of government revenue the estimated revenue per acre of land is approximately Rs. 75000 per annum. Apart from the government revenues, 10, 000 to 15, 000 households directly or indirectly benefited from the infrastructure development through marine fishing, transport and trade. It has been estimated that the average benefit from infrastructure development is maximum among all the anthropogenic activities in and around the coastal wetlands[1]

[1] Indirect benefit from marine fishing has been estimated using the results of a previous survey in Shankarpur coastal region (Das et al, 1999)

Table7.1 Benefit obtained from different types of man-made coastal wetland in Medinipur district

Name of the converted wetlands	Total surveyed area in acre	Average benefit per acre of converted coastal wetlands (Rupees)	Standard deviation	Coefficient of variation
Traditional aquaculture	698	2250	354	15.71
Mixed aquaculture	538	5500	707	12.86
Prawn cultivation	11	70000	42427	60.61
Salt pan	1500	3850	495	12.86
Infrastructure development	89	277840	72238	25.99

7.3. Degradation of coastal wetlands

Area loss is one of the most important indicators for degradation of natural coastal wetlands. Majority of the area under natural coastal wetlands has been converted to different types for economic purposes. As a matter of fact ecology of the entire stretch of Digha-contai coastal zone has been disturbed. It is evident from the field survey that large biodiversity was present before man-made conversion of wetlands. According to local people there are different varieties of fish, crab and other aquatic animal which use the natural coastal wetlands as breeding ground. On the other hand presence of large quantities of aquatic plant like *giria* and *lona durba* would supply sufficient nutrient for all aquatic faunas. Due to loss of breeding ground and aquatic flora, availability of fish and other aquatic animal is reduced substantially in the surveyed areas. Consequently the number and types of birds used to visit these wetlands is reduced remarkably. Survey results reveal that before any conversion of the natural coastal wetlands approximately 20-25 different types of fish were available. But fishing was very difficult as it was open mud flat type and availability of fish was controlled by tidal phenomenon. In addition different types of aquatic animals other than fish were present. According to bird watchers/ bird poachers, about 12 types of birds including migratory birds used to visit these coastal wetlands in large numbers before conversion took place. With the introduction of aquaculture, salt production and other anthropogenic activities in and around coastal region the biodiversity scenario changed substantially. From survey it is evident that biodiversity loss is maximum for prawn culture where the benefit accrued is maximum. However due to lack of relevant information it is difficult to conclude that these species are endangered or not. But it can be concluded that in this coastal region number of birds and quantities of fish decreased enormously. Loss in biodiversity in and around the converted wetlands due to different activities are shown in the following Table 7.2

Table 7.2 Loss in Biodiversity for different activities

Bio-diversity loss	Aquaculture			Salt Pan	Infrastructure Development
	Traditional	Mixed	Prawn		
	Loss	Loss	Loss	Loss	Loss
Fish (no. of species)	3-5	8-10	18-20	5-8	20-25
Other aquatic animal (no. of species)	1-2	4-6	5-8	3-5	5-8
Bird (no. of species)	5-6	5-7	8-10	2-4	10-12

7.4. Water Quality

Dissolved oxygen content, pH and temperature of water of nine converted coastal wetlands under study were estimated on spot with the help of portable DO meter, pH meter and digital thermometer. The water qualities of the coastal wetlands are given in Table 7.3.

It is observed from the table that DO variation was not so wide, ranging from 1.46 to 5.42 mg per liter of water. In general dissolved oxygen contents of coastal wetlands water, under study were not in the desired level. But except one, namely Deulibangla, the DO level of all the wetlands were above 2 mg per liter. However, pH value of water of all the coastal wetlands were within the permissible limit. Water quality in terms of DO level is best in aquaculture ponds, but worst in salt pans. In some prawn-culture ponds, the water quality is not also up to the mark for the maintenance of aquatic lives.

Table7.3. Water quality of coastal wetlands in Medinipur

Wetlands location	Type	Date of survey	DO (mg/ltr)	pH	Temperature (°C)
Bainchibania	Salt pan	13.07.2000	2.43	6.85	27.6
Dadanpatrabar	Prawn culture	14.07.2000	3.80	7.3	27.4
Torsiakhal	Creek near Aquaculture	15.07.2000	3.61	6.9	28.1
Baisakhal	Creek in natural wetland	15.07.2000	3.96	6.6	26.5
Keuria	Prawn culture	17.07.2000	2.37	7.1	27.4
Shankarpur	Near fish launching centre	17.07.2000	2.43	6.7	26.2
Deulibangla	Salt pan	17.07.2000	1.46	7.2	26.7
Tajpur	Aquaculture	18.07.2000	4.32	6.9	26.7
Alampur fisheries	Aquaculture	20.07.2000	5.42	6.8	26.3

Chapter 8: Changing pattern of coastal wetlands with development activities

In the following sections evolution of man-made coastal wetlands have been studied to judge the sustainability of various stages of conversion. Long term benefits from each type of converted wetlands have been estimated and the intangible impact of these conversions on the ecology have also analysed. It will help in formulating appropriate policies for developmental activities in and around the coastal region.

8.1 Evolution of man-made coastal wetlands

At initial stage total area under coastal belt was distributed among different categories of typical coastal wetlands. One common feature of all coastal wetlands is that they receive seawater during high tide and drain it out during low tide situation. The neighbouring people realized that these coastal wetlands can generate economic benefits. Several options for extracting benefit from the wetlands were open to them if some conversion is allowed on the natural coastal wetlands. The first conversion took place in the form of fish growing ponds by private entrepreneurs. Seawater trapped during high tide through channels carried common sea fishes in these ponds which could grow there. Neither foreign seedling nor artificial feeding were required for this practices. Locally this practice is called *traditional fishing.* Second important conversion took place in the form of salt pan. Anticipating the feasibility of large-scale salt manufacturing in the coastal region of Medinipur and 24-paraganas, the Expert Team recommended that approximately 10,000 acres of coastal land in Medinipur could be utilized for salt production. With the development of some infrastructure facilities, some private entrepreneurs started salt production in the early 1970s. At the same time, a part of traditional fishing ponds established in the first stage of conversion and a few natural coastal wetlands were converted to mixed aquaculture ponds. The main feature of this practice was to introduce the culture some foreign fish seedling, which have good market price, and also to allow artificial feeding to enhance their growth. Government of West Bengal also started few Fishery Projects (Alampur Fishery and Digha Fishery) on the coastal region of Medinipur near Digha. The practices of both traditional and mixed aquaculture were continued till early 1990s. But with the opening up of export market for prawn trade, prawn cultivation became more lucrative than other activities in this region. In spite of high risk and investment, a large number of these traditional and mixed aquaculture ponds were converted to prawn cultivation in the early 1990s. Prawn cultivation still exists in spite of the fact that majority of the existing aquaculture ponds used for prawn cultivation have failed to operate within three to four years of practice since their inception. The reason for this failure was perhaps the attack of a virus locally known as *Thailand Virus.* It can be mentioned here that World Bank has also initiated a fishery project based on prawn cultivation in an abandoned salt pan at Dadanpatrabar.

Changing pattern of surveyed coastal wetlands during the last 50 years is shown in Tables 8.1- 8.8. In the table, CW means natural coastal wetlands, SP means salt pan, AQ means aquaculture, FLC means fish launching centre, PC means prawn culture and AB means abandoned state of man-made coastal wetlands. In each Table, conversion among various types of wetlands during 5 years are shown in percentage term.

Table 8.1. Initial situation [before 1965]

	CW	SP	AQ
CW	57.46	31.89	10.65

Table 8.2. Transition 1[1965-1970]

	CW	SP	AQ
CW	84.37	0.00	15.63
SP	0.00	100	0.00
AQ	0.00	0.00	100

Table 8.3. Transition 2 [1970-1975]

	CW	SP	AQ
CW	6.58	61.74	31.68
SP	0.00	100	0.00
AQ	0.00	0.00	100

Table 8.4. Transition 3 [1975-1980]

	CW	SP	AQ
CW	100	0.00	0.00
SP	0.00	100	0.00
AQ	0.00	0.00	100

Table 8.5. Transition 4 [1980-1985]

	CW	SP	AQ	FLC
CW	0.00	0.00	0.00	100
SP	0.00	100	0.00	0.00
AQ	0.00	0.00	95.16	4.84

Table 8.6. Transition 5 [1985-1990]

	SP	AQ	FLC
SP	100	0.00	0.00
AQ	0.00	100	0.00
FLC	0.00	0.00	100

Table 8.7. Transition 6 [1990-1995]

	SP	AQ	FLC	PC	AB
SP	48.42	0.00	0.00	29.36	22.22
AQ	0.00	60.19	0.00	39.81	0.00
FLC	0.00	0.00	100	0.00	0.00

Table 8.8. Transition 7 [1995-2000]

	SP	AQ	FLC	PC	AB
SP	100	0.00	0.00	0.00	0.00
AQ	0.00	100	0.00	0.00	0.00
FLC	0.00	0.00	100	0.00	0.00
PC	0.00	3.58	0.00	67.38	29.04
AB	0.00	0.00	0.00	0.00	100

In the initial situation table it is observed that before 1965 the total surveyed wetland area was distributed under three heads. Approximately 57% of coastal wetland was in its natural form, about 31% was salt pan and rest 10% was aquaculture ponds. In the next stage of transition (1965-70) approximately 16% of the natural coastal wetlands were converted to aquaculture ponds while the rest 84% remained in its previous form. In the second stage of conversion only 7% of the coastal wetlands remained undisturbed while 62% and 32% of them were converted to salt pan and aquaculture ponds respectively. In the next five years (1975-80) no such conversion took place. It is interesting to notice that in the fourth stage (1980-85) of conversion no coastal wetland under our study, remained in its original state and entire surveyed natural wetland area was converted either to salt pan or to aquaculture ponds. However, another new venture in the conversion activity grew up in this period as some part (4%) of the aquaculture ponds was converted to fish launching centre. In the subsequent period of next five years (1985-90) no transition occurred among the surveyed wetlands. During the first five years of last decade (1990-95) prawn culture was started in some of the salt pans (29%) and aquaculture ponds (40%), while some area of salt pan (22%) were abandoned due to non-economic and non-environmental reasons. These evolutions are shown in transition table 8.7. In the last conversion table 8.8 the recent conversion pattern is exhibited (1995-2000). The salt pans, aquaculture ponds, and fish launching centres remained in their own state, but some part of the prawn cultivation ponds were converted to aquaculture ponds (3%) and some of them were deserted (29%). The practice of prawn culture was accompanied with maximum profit but the risk factor was there all along. So prawn culture could not be sustained and a part of the converted area has remained unused.

8.2. Long-term benefit

On the basis of the transition pattern of man-made coastal wetlands observed during the last 35 years, long-term benefit per acre (Rs.) from each type of conversion has been computed. The future benefits from these converted wetlands have been calculated over the 35 years time-span in total. Benefits in future years have been discounted to get the present value (at the rate of 10%). Present values of benefits over 35 years for different types of converted wetlands are shown in Table 8.9. It is observed from the Table that highest benefit would be accrued from infrastructure development (Figure 8.1). Second highest is the benefit from prawn cultivation, in spite of the fact that a part of it would become unused to render further economic benefit.

Then the value of benefit descend to the case of aquaculture ponds. Accrual from aquaculture ponds is nearly one-third of that from prawn cultivation. Moreover, this type of converted wetlands sustain for a prolonged period of time. So, during the last five years, a transition (though not very significant) is observed from prawn culture to aquaculture (mixed type).

Table 8.9. Long-term benefits from different types of converted wetlands

	TF	AQ	SP	PC	FLC
Benefits/acre (in Rs.)	41424	101260	70882	361730	5115333

8.3. Benefit-degradation curve

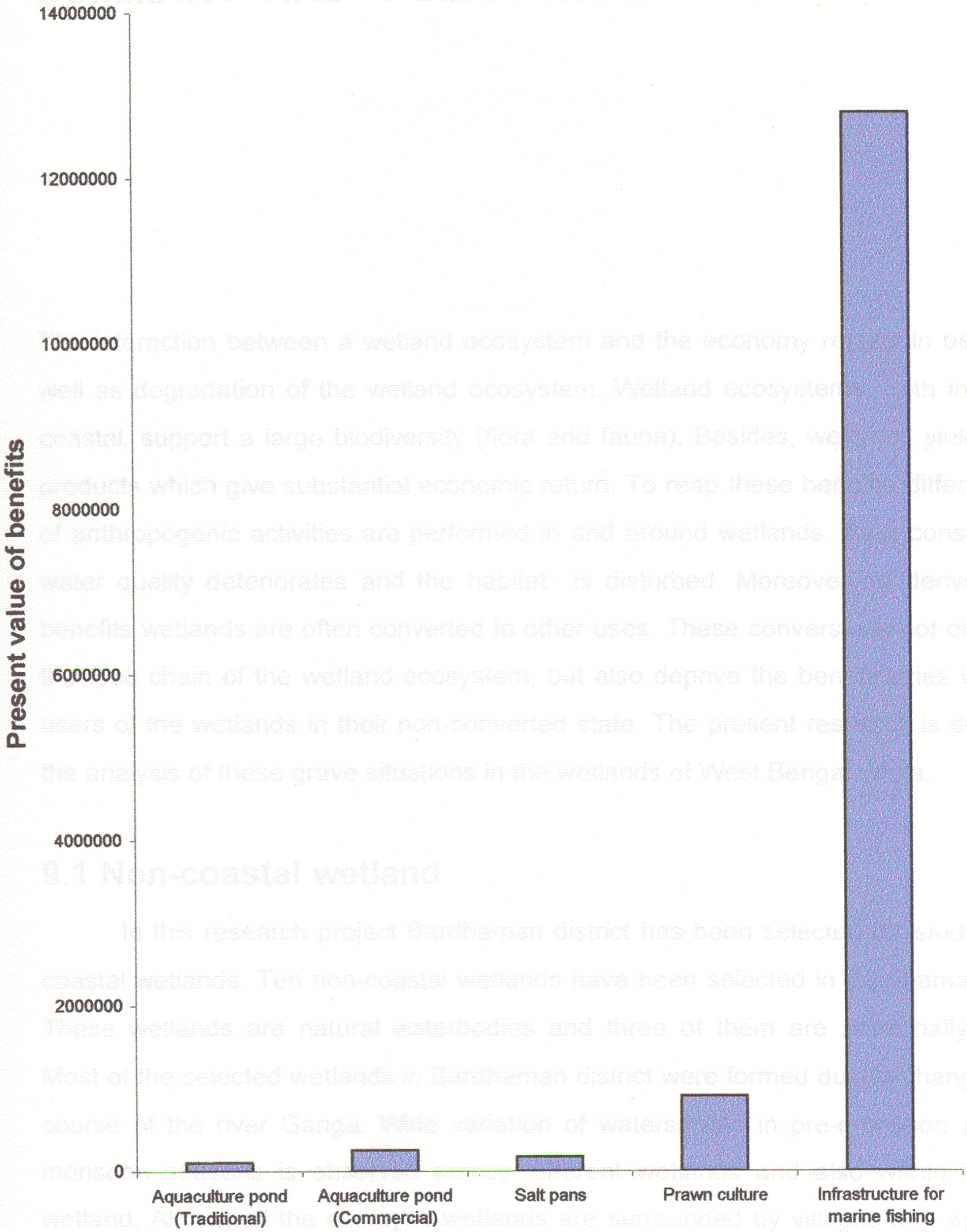
Because of the anthropogenic activities in and around the coastal wetlands, some degradation of the local environment occurs. A number of species has become extinct in the vicinity of the converted wetlands. Water quality of the wetlands also have deteriorated. Some plants stop growing in the converted coastal zone. However, the extent of degradation varies from type to type.

Table 8.10. Functional relationship between biodiversity loss and benefit

Type	Functional form	R^2
Linear	16.57 + 0.0001* (biodiversity-loss)	0.771
Quadratic	13.36 + 0.003 * (biodiversity-loss) – 0.000000001* $(\text{biodiversity-loss})^2$	0.943

Figure 8.2 shows the relation between loss in biodiversity and average annual benefit per acre of wetland. The positive relationship between loss and benefit accrued is quadratic in nature (Table 8.10). Almost total extinction is observed for infrastructure development. Extinction of species is least in aquaculture (traditional) ponds, but it is not insignificant. For prawn culture, the loss of biodiversity is almost the same as in infrastructure development sites. Thus from the perspective of biodiversity, situation worsens as more and more economic benefits are derived from coastal wetlands.

Fig.8.1. Expected long-term benefits from converted coastal wetlands



Chapter 9: Conclusion and Recommendations

Realising that all the developmental activities in and around the wetlands pose serious threats to the wetland ecosystems, an in-depth study has been carried out in two districts of West Bengal. The study reveals that in the case of non-coastal wetlands conversion and indiscriminate use of the remaining wetlands are often justified on developmental grounds but once the deterioration of water quality and loss in bio-diversity are brought into consideration the gains are nullified to a large extent, making such conversion inappropriate. Some developmental activities seem to be less damaging than others. For example, the fishing activities carried out in the existing wetlands, are less damaging than irrigation activities that draw out water from the water bodies so long as the ponds are not converted for use in commercial aquaculture,. The causal relationships between benefits derived from the wetlands and different degradation indicators support this fact.

For coastal wetlands the scenario is almost the same. Some conversions in the name of developmental activity cause these coastal wetlands to reach non-regenerable and non-reusable states. For example a sizeable area of coastal wetlands that were converted for prawn culture in Medinipur district were abandoned after few years of operation. These deserted wetlands neither generate any economic benefit nor can they be converted back to their original state. Thus an asset for the society is lost for ever, posing a burden on future generations. Inspite of these, for the sake of economic development some form of conversions must be allowed on these wetlands. When used for aquaculture (other than shrimp culture) and as salt pans coastal wetlands have retained their value than when they have been used for prawn culture. In addition, . functional relationships between degradation and the nature of utilization show less damage for these types of conversions.

We recommend the restriction of conversion of non-coastal wetlands that have not been touched so far. The converted wetlands generate considerable earnings for the people who live in their neighbourhood, but cost-benefit analysis reveals that the consequent disruption in ecological equilibrium makes this unjustifiable in most of the cases. Agricultural activities like irrigation and jute retting disturb the hydrology of the wetland ecosyste. To prevent their ruin, the seasonal conversion of wetlands must be arrested. For best results, indiscriminate use of their water should be prohibited. The intensity of cropping in the surrounding area should be observed so that the requirement of water for irrigation can be supplied from alternative sources. This may raise other problems, but the preservation of wetlands can help ease some of these difficulties. If, say, water is supplied from the underground reservoirs via shallow tubewells, maintenance of the water table will be considerably easier if wetlands in the vicinity are left undrained.

Among all sorts of conversion of coastal wetlands, infrastructre development provides the highest return. Conversion for prawn culture despite providing high initial returns, but these returns are not available for very long periods. Moreover, collection of seedlings of prawn from seawater affects off shore marine fishing within a few kilometres of the shoreline as this process disturbs the biological chain: undesired species are thrown away by the collectors, generally women and children. We recommend that prawn culture or similar activities on wetlands be discouraged. Off shore marine fishing should be encouraged in its place. It is also worth mentioning at this point that in recent years, a very small portion of converted wetlands are being used for crab culture. Hence, infrastructure development for fish landing and marketing, though it occupies some wetland area and has adverse impact on the local environment, becomes essential. This will reduce the pressure for conversion of the coastal wetlands for prawn and aquaculture. It is our belief that adoption of these policies will help preserve the wetlands along the Medinipur coastline.

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Appendix A: International protected area system

In the field of nature conservation there are two international conventions and one international programme that include provision for designation of internationally important sites in any region of the world. These are,

- World Heriatge Convention
- Ramsar (Wetlands) Convetion
- UNESCO Man and the Biosphere (MAB) Programme

The convention on wetlands of international importance especially as Waterfowl Habitat was signed in Ramsar (Iran) in 1971, and came into force in December 1975. The Ramsar Convention is an international treaty that provides a framework for the coordinated designation and conservation of internationally important wetland habitats. This convention provides a framework for international co-operation for the conservation of wetland habitats. As of 1994, 81 states were contracting parties to the convention and 654 Ramsar wetlands had been designated, covering an area of over 43 million hectares (Navid 1994).

All nominated Ramsar sites are placed on the list of Wetlands of International Importance. Each contracting party to the Ramsar (wetland) convention is obliged to nominate at least one wetland of international importance. However, a country can be party to the World Heritage Convention with out having a natural site inscribed on the list, and may participate in the MAB programme without designating a biosphere reserve. Each state party is obliged to list at least one site.

Recently, the protected area approach has been extended to protect natural habitats in the international commons, including the high seas, Antarctica and outer space. In these instances, parties have agreed to protect natural habitats not by establishing protected areas but by mutually agreeing to regulate or ban certain activities in the area concerned. This type of protection is illustrated by the Antarctica Treaty System where under the most recent protocol to the Antarctic Treaty the entire area is to be declared a protected area.

Appendix B :Regional Extent And Distribution Of Wetlands

Europe And The Mediterranean Basin

Europe and the mediterranean are densely populated and have long histories of civilization and industrialisation. So there are only a few entirely natural wetlands left in this area. Survey of literature reveals that by the end of 1970s, 10% of france's wetter areas and 60% of those of britain and the netherlands had been drained. There has, however, been extensive creation of artificial wetlands such as reservoirs, fishponds, and gravel pits. In tunisia for example, while 224 km^2 of open water have been created while since 1881, 190 km^2 of natural wetlands have been lost. Since most european countries have now joined the ramsar convention the rate of destruction of wetlands has slowed down. Even so, data for all the european and mediterranean ramsar sites reveal that only 58 of the 318 wetlands are definitely not threatened in some way.

North America

Canada is estimated to hold 24% of all the world's wetlands, occupying over 1.27 million km^2. The original wetland area of USA (excluding Alaska and Hawaii) may have been around 890,000 km^2 of which only 47% remains. There were a further 690,000 km^2 in Alaska and Hawaii. Over all, it is estimated that around 1.11 million km^2 of wetlands remain in the whole of the USA.

Latin America And The Caribbean

Many of the wetlands in South America are in an almost pristine state. In contrast most of the wetlands, in the Caribbean have been intensively exploited. The wetlands of South America can be subdivided into three major systems : those of the Pacific lowlands, those of the Andean Chain and those of the Atlantic- Caribbean lowlands to the north and east of the Andes.

The Chilean Fjordland in the Pacific lowlands includes around 55,000 km^2 of wetlands. The important wetlands in this area are Lake Tota, in Colombia, delta of river Orinoco and Amazon, Pantanal, covering around 200,000 km^2 , Usumacinta Delta on the Gulf

Coast of Mexico, covering around 10,000 km etc. In many of the Caribbean islands there are some freshwater lakes in old volcanic craters.

Africa

Wetlands cover one percent of Africa's total surface area (at least 345,000 km^2). In Equatorial Africa, the three largest wetland systems are : the Zaire swamps (Covering 80,000 km^2), the Sudd in the upper Nile (Cover 50,000 km^2) and the wetlands of the Lake Victoria Basin (about 50,000 km^2). The floodplains of the Niger and Zambezi Rivers, the Chad Basin (around 20,000 km^2) and the Okavango Delta (16,000 km^2) are also major wetland areas. There are also a further 12,000 km^2 of wetland in Southern Africa.

Asia and the Middle East

It has been estimated that there are some 830000 km^2 of peat bogs and swamps in the USSR and about 900000 km^2 of marshy ground subject to seasonal flooding. In the Middle East, the most extensive wetlands occur in Iraq where the Tigris and Euphrates Rivers create a vast complex of shallow lakes and marshes covering about 15000 km^2. It is estimated that there are around 1.2 million km^2 of wetlands, excluding permanent rice paddies, in the region covered by the Directory of Asian wetlands. This Directory gives information on 947 of the most important wetlands, covering 734000 km^2.

Australia and Oceania

The major wetland types in this region are sea-grass meadows, mangrove swamps, coastal salt marshes and flats, monsoonal freshwater floodplains, southern and inland swamps, lakes, river and creek channels and bogs. The sea-grass meadows off the coast of Australia are some of the largest in the world. Mangroves in this region cover 12000 km^2 in Australia, 9250 km^2 in Papua New Guinea and about 28500 km^2 in Irian Jaya, but only 640 km^2 in the Oceanic islands and a small area in New Zealand. Salt marshes occupy about 9200 km^2 in Australia and are also found in New Zealand. At the nexus of the Lachlan and Murrumbidgee Rivers there are nearly 1500 km^2 of wetlands and another 400 km^2 of swamp along the Macquarie River in New South Wales. Lakes, both saline and freshwater, permanent and temporary, are found throughout the region.

Appendix C:Definition of wetlands

Circular 39 definition of wetlands : It was presented by the U. S. Fish and Wildlife Service in 1956. It states , “ The term wetland refer to lowlands covered with shallow and sometimes temporary or intermittent water. They are referred to by such names as marshes , swamps , bogs , wet-meadows , potholes , sloughs and river-overflow lands”. Shallow lakes and ponds usually with emergent vegetation as a conspicuous feature are included in the definition , but permanent water streams , reservoirs and deep lakes are not included.

U. S. Fish and Wildlife Service definition : The wetland scientists in the U. S. Fish and Wildlife Service in 1979 presented this definition of wetland as , “Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water”. Wetlands must have one or more of the following three attributes :

a) at least periodically, the land supports predominantly hydrophytes

b) the substrate is predominantly undrained hydric soil and

c) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.

Legal definition : The term wetland mean those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support and that under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soil condition.

U.S. Environment Protection Agency (EPA) and Army Crops of Engineers : Wetlands are areas that are inundated or saturated or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

International Biosphere Programme (IBP) : Wetlands are part of the surrounding ecological structure and several stages in the succession from open water to dry land or *vice versa,* occurring at sites situated as a rule between the highest and lowest water-levels as long as the flooding or waterlogging of the soil is of substantial ecological significance.

Space application centre (ISRO) : All submerged or water-saturated lands, natural or man-made, inland or coastal, permanent or temporary, static or dynamic, vegetated or non-vegetated, which necessarily have a land-water interface are defined as wetlands.

Appendix D: Questionnaire

Survey on wetland area

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PART A

1. Place :

1.1. State :
1.2. District :
1.3. Block :
1.4. Police Station :
1.5. Village (J. L..No.) :
1.6. Identification no :

2. Household profile :

2.1. Name of the head of the household :
2.2. Father's/ husband's name of the head of the household :
2.3. Caste :
2.4. Annual household income from all sources :
2.5. Do you have any earning (direct or indirect) from neighbouring wetland ? Yes/ No

2.5.1. If yes,

*How do you account ?
*What is the approximate annual value ?

2.6. Details of each member of the household :

Name	Relation With head	M/f	Age	Occupation		Annual income		Education
				Major	Minor	Major	Minor	

Code :

A. Occupation
Agriculture : 1
Agriculture allied activities : 2

Wage labour : 3
Fisherman and related activities : 4
Salt production and related activities : 5
Petty business : 6
Service holder including pensioner : 7

B. Educational qualification
Illiterate : 0
Literate : 1
Below class x : 2
Madhyamik : 3
Higher Secondary : 4
Graduate : 5
Post graduate : 6

3.1. Land holding and land use pattern :

Land holding	Benefited from wetland	Non-benefited from wetland	Seasonal wetland
Operational			
Own			
Leased-in			
Leased-out			

3.2. Land use pattern for Benefited/ Seasonal land :

Crop name	Wetland area	Season	Variety	Benefit derived

3.3. Cost of cultivation for crop growing in areas Benefited and Non-benefited from wetland (separate sheet has been used) :

Components	Crop name 1				
	O	H	W	Quantity	Value
Seeds					
O.manure					
C. Fertilizer					
Pesticide					
Weedicide					
L. Preparation					
Planting/seedling					
Interculture					
Harvesting					
Irrigation					
Miscellaneous					

Components	Crop name 2				
	O	H	Wl	Quantity	Value
Seeds					
Organic manure					
Chemical Fertilizer					
Pesticide					
Weedicide					
Land Preparation					
Planting/seedling					
Interculture					
Harvesting					
Irrigation					
Miscellaneous					

Code :
O = Own
M = Market Supply
W = Wetland

3.4. Value of Agricultural Products and By-Products :

Name of the crop	Crop name 1	Crop name 2	Crop name 3	Crop name 4
Variety				
Quantity of production				
Price of crop				
Total value of crop				
Quantity of by-product				
Value of by-product				
Total value of production				

3.5. Details of benefits derived from the wetland:

3.5.1. Seedling :
3.5.2. Irrigation :
3.5.3. Land used for other season :
3.5.4. Flood control :
3.5.5. Fishing :
3.5.6. Salt production :
3.5.7. Jute retting :
3.5.8. Others :

4. Details of livestock :

Name	Nos.	Grazing place/feed			Any difference of health status
		Home	Wetland	Others	
Draught					
Cow					
Calf					
Goat					
Duck					
Poultry					

5.1. What are the plants found in the wetland ?
Give local name and quantity.

Local name	Quantity
1.	
2.	
3.	
4.	

5.2. Do you observe any increasing or decreasing trend of plants ? Yes/ No
Specify.

6.1. Which birds are observed in the wetland ?

Local name	Season	Approximate number
1.		
2.		
3.		
4.		

6.2. Name the species of aquatic animals (fish, snake, toad etc.) found in this wetland.

6.3. Are they naturally growing or cultivated ? Yes/ No

6.4. Do you observe any increasing or decreasing trend of aquatic animals or birds ?
If so, what is the reason for this variation ?

7. State the aesthetic and cultural values associated with this wetland.

8. Is there any change of area of wetland ?

9. How many families are associated with this wetland ?

10. Are you satisfied with the present state of the wetland ? Yes/ No

11. If ‘no’ what are the alternatives and what benefits do you expect ?

12. If you are against conversion , how much are you willing to pay for preservation of the wetlands ?

Part B

Questionnaire on Flora, Fauna and Birds

1. Aquatic Plants (Give local name and yes/no)

Local name	Present	Past	Loss

2. Aquatic animals (Give local name and yes/no)

Local name	Present	Past	Loss

3. Birds (Give local name and yes/no)

Local name	Present	Past	Loss

Part C

1. Present area of the wetland
2. Loss in area compared to 15 years back and present use of that converted wetland
3. Name of the villages surrounding the wetland
4. How many families directly or indirectly derive benefit from this wetland ?
5. Identify development programmes in and around the wetland
6. Quantify and value the above mentioned benefits per year
7. Water spread and commanding area for irrigation purposes

Appendix E:Biodiversity: Non-coastal wetlands in Bardhaman

FLORA

Local name	Scientific name
Hingcha	Enydra fluctuans Lour.
Kalmi-sak	Ipomoea aquatica Forrsk.
Sushni-sak	Marsilea minuta L.
Kachuripana	Eichhornea crassipes
Shaola (Moss, Lichen, Algae)	
Gachh-khar	
Chuno-khar	
Danicha	
Kanta Shaola	
Saluk	Nymphaea Wild
Durba	Cynodon dactylon (L.) Pers.
Sola (Indian cork)	Aeschynomene aspera L.
Bena	
Shaola (Moss, Lichen, Algae)	

Fauna

Fish

Local name	Scientific name
Rahu	Labio rohita
Catla	Catla catla
Calboas	Labio calbasu
Mrigal	Cirrhinus mrigala
Punti	Puntius stigma
Magur	Clarious batrachus
Kucho Chingri (Shrimp)	
Lata	Ophicephalus punctattus
Grass carb	Ctenopharyngodon idella
Silver carb	Hypophthalmichthys militrix
Sole	Ophicephalus striatus
Boal	Wallago attu
Koi	Anabas testudinius
Singi	Heteropneustes fossilis
Tangra	Mystus seenghala
Folui	Notopterus notopterus
Pancal	Mastacembus pancalus
Ban	Mastacembus armatus
Bele	Glossogobius giuris
Chanda	Chanda nama
Maurala	Ambylopharyngodon mola
Khalsa	Trichogaster fasciatus

Aquatic animals

Local name	Scientific name
Keute (Cobra)	Naja naja
Kachhap (Tortoise, Turtle)	Lissemys sp
Kankra (Crab)	
Genri (Snail)	
Samuk (Snail)	
Jal dhonra (Non-venomous snake)	
Meteli	
Frog	Rana sp
Toad	Bufo sp

Bird

Local name	Scientific name
Common Teal	A. crecca
Intermediate Erget	Ergetta intermediae
Little Erget	E. garzetta
Open bill stork	Anastomus oscitans
Fantail Snipe	G. galinago
Common Kingfisher	Alcedo hercules
Bronze winged Jacana	Metopidius indicus
Majhari Pankauri	P. furcicollis
Lesser Whistling Teal	Dendro cygnajavanica
Cotton Teal	Nettapus coromandelianus
Moorhen	Gallinula chloropus
Kite	
Little Cormorant	P. niger
White breasted waterhen	Amaurornis phoenicurus

Appendix F: Soil Analysis

For analysis of soil, samples were collected from inside the wetlands under study and also from adjacent agricultural high lands for each of the wetland. They were brought in the laboratory and analysed for estimation of nitrogen, phosphorus, potassium. For estimation of N, P and K soil samples were first dried in an air oven at 105°C. After obtaining the dried samples N, P and K estimation were carried out following standard methods (Ref. APHA, AWHA, Standard Methods for the Examination of Water and Waste Water, Washington, DC 1975.). N, P, K and pH data for some of the wetlands and their respective adjacent agricultural lands have been tabulated in Table 4.6.

It is observed from the soil analysis that N, P and K contents of the wetland soils were in general higher than the respective values of the adjacent agricultural lands. However, in few cases like Nitrogen content of the Bater beel soil (0.17%) is slightly lower than the nitrogen content of the adjacent agricultural land (0.28%). Higher concentrations of nutrients in the wetland soils may be due to accumulation of runoff water from the higher agricultural lands containing excess chemical fertilisers, which were not consumed in agricultural plant growth. However, pH of both types of the soil were normal (pH range varies from 6-8 for rice and grass; Ref. Kanawar J.S., Micronutrient Research in India, ICAR Publication). For nitrogen, phosphorus and potassium contents of soil there are no toxic level, although higher N, P, K contents may enhance the vegetative growth and thereby retard the reproductive growth (Ref. Biswas T.D., Textbook of Soil Science, 1994). Fe and Al contents of the collected soils were also analysed but no significant conclusions could be drawn because Fe and Al are not available to the plants at higher pH.

Table 4.6 Analysis of soil nutrients

Sl. no.	Name of wetland	Nutrient	Soil inside the wetland (%) on dry basis	Soil of the adjacent upland (%) on dry basis
1.	Srikhanda Beel	N P K pH	0.33 0.08 1.12 7.00	0.17 0.05 0.80 6.50
2.	Bater Beel	N P K pH	0.17 0.08 1.74 7.00	0.28 0.06 1.54 6.50
3.	Lakshmipur Padmabeel	N P K pH	0.30 0.02 1.72 7.00	0.28 0.06 1.54 6.50
4.	Bara Beel	N P K pH	0.12 0.07 1.39 7.00	0.17 0.05 0.80 6.50

Appendix G:Enrichment of soil through organic manure

Other important agricultural benefits of the wetland are the enrichment of soil through organic manure. The aquatic plants decompose during monsoon season and settles down at the bottom of the wetland. This sedimented sludge improves the fertility of the soil at the bottom layer. When the water is drained off during the summer agricultural activities are carried on in this soil which requires lesser application of fertiliser. This certainly helps the growers through reduction in input cost. Again the process of jute-retting contributes in this regard.

The difference between farm input cost of wetland and non-wetland for similar crop(boro paddy) per acre is being considered to be the value of wetland. This is applicable for seasonal wetlands only. Total value of this benefit is derived as:-

$TV_{\text{Input cost}}$ = Average input cost reduction per ha. $\times$ Total area of seasonally converted wetland under the crop under consideration

Appendix H: Biodiversity : coastal wetlands in Medinipur

Flora

Local name	Scientific name
Gama	
Gharani	
Harkocha	Acanthus ilicifolius
Giria	
Keya	
Satabori	
Hatal	
Bani	
Pitpalia	
Dhani	
Lona Durba	

Fauna
(a) Fish

Local name	Scientific name
Parse	Liza parsia
Gule	
Chingri	
Bhetki	Lates calcarifer
Tangra	Mystus bleekeri
Aich	
Kunkuni	
Dakur	
Bhangar	Liza tade
Chang	Channa gachua
Khalsa	Trichogaster fasciatus
Toni	
Chanda	Chanda nama
Khaira	
Gangtara	
Tulafutki	
Bhola	
Chaua	
Guchia	
Dheucha	
Indicas	
Rekha	

(b) Aquatic animals

Local name	Scientific name
Keute	
Jaldhora	
Jalgethia	
Kencho	
Kankra	
Nona sap	

© Birds

Local name	Scientific name
Common Teal	A. crecca
Majhari Pankauri	P. furcicollis
Choto Pankauri	P. niger
Open bill Stork	Anastomus oscitans
Saras	
Keri	
Surulia	
Tuntuni	
Lalpaya	
Ratjaga	
Falcon	
Common Kingfisher	Alcedo hercules
Rangamatia	
Kank	
Owak	
Dachora	
Kite	
Snike	