AN ECONOMIC ANALYSIS OF MANGROVES IN SOUTH ASIA

V. Santhakumar[1], A.K. Enamul Haque[2], Rabindranath Bhattacharya[3]

1 Introduction

The tropical wetland ecosystems including mangroves are known to provide a number of ecological services and economic benefits. Though there were attempts to carry out economic analysis of the contributions of coastal wetlands located in the developing countries such as Thailand (Sathirathai, 1997), Indonesia (Ruitenbeek, 1994), and Mexico (Barbier and Strand, 1998)[4], we have not come across any such study in South Asia[5]. An important reason for this lacuna is the absence of adequate information and data linking physical features or ecological characteristics (for example, the area under mangroves) and economic activities (such as fishing) for a sufficiently long period of time. Thus there is a crucial need for applied economic research on the ecology-economic linkages of ecosystems such as mangroves in different contexts having varying physical, economic, and institutional characteristics in South Asia. It is with this motivation that this research project was formulated and implemented in India and Bangladesh. It aimed at identifying and/or valuing some of the important economic contributions of mangroves. The other objective was to see the influence of institutional structures or property rights on the economic use of these mangroves. The study was carried out in three locations – Cochin (in Kerala) and the West Bengal and Bangladesh part of Sundarbans, which is the biggest single stretch of mangroves in the world.

Thus the central issue that was analysed in the project was the following: how do mangroves, located in different biophysical, economic, and institutional environments affect the production of certain goods and services? Broadly, the methodology employed was to identify this influence from the cross-sectional secondary data or primary data collected from different stakeholders. Nevertheless, the actual conduct of the study in each of the three locations mentioned above was tuned to local conditions and the availability of (or possibility of collecting) primary data.

---

[1] Associate Fellow, Centre for Development Studies, Thiruvananthapuram 695011, Kerala, India

[2] Director, Institute of Development, Environment and Strategic Studies, North South University, Dhaka, Bangladesh

[3] Professor, Department of Economics, University of Kalyani, West Bengal, India

[4] For a review of these studies, see Barbier, 2000.

[5] We came to know that some attempts in this direction are going on currently in the Bangladesh part of Sundarbans, as part of the forest conservation projects funded by international organisations.

The paper is organised as follows: The relevant literature is reviewed and the distinct contribution of this study is noted in Section 2. This is followed by the description of the separate studies carried out in Cochin, and Bangladesh and West Bengal part of Sundarbans in sections 3, 4, and 5. The results and insights of the study are synthesised in section 6, which also carries some observations relevant for policy-making.

2 Review of Literature

Mangroves may be described as the tropical and subtropical coastal vegetations. The ideal habitats for mangroves are deltas, shelter bays, and muddy estuarine mouths.

The mangroves in the tropical countries are highly productive ecosystems and they generate a number of direct and indirect goods and services. These include products like timber, fuel wood, honey and wax, fish, fish fingerlings, forages, etc., and services like flood control, erosion control, storm surge protection, shoreline protection, ground water recharge, nutrient recycling, micro climate regulation, ozone layer stabilisation, recreation, etc (Dixon and Lal, 1997; FAO, 1982). An important function of mangrove forests is the provision of food and shelter for large and varied groups of fish and shellfish. Mangroves also provide a buffer between land and shallow sea, preventing erosion of the land and saves life during cyclones or storm surges. Mangrove swamps are also the natural sewage treatment plants. Tiner (1985) listed major wetland values. He divided values into three broad categories: Fish and Wildlife Values – comprising fish and shellfish habitat, waterfowl and other birds habitat, Furbearer and other wildlife habitat, and Endangered Plant and Animal habitat; Environmental Quality Values – comprising values derived from water quality maintenance (pollution filter, sediment removal, oxygen production, nutrient recycling, and chemical and nutrient absorption), aquatic productivity, microclimate regulator functions, and ozone layer maintenance function; and Socio-economic values of wetlands – comprising values from flood control, wave damage protection, erosion control, groundwater recharge and water supply, timber and other natural products, livestock grazing, fish and shell fishing, hunting and trapping, recreation, aesthetics, and education and scientific research.

Valuing these goods and services are critical in terms of the conservation of the mangroves. There were a number of attempts to review the related theoretical and empirical issues and provide guidelines to value these goods and services (Barbier, 1994; Barbier et al, 1997; Barbier, 2000; Malor et al, 1997). They have seen from their review of empirical studies that even when some of non-marketed, ecological goods and services are accounted, the benefits of conservation of mangroves become more than that of their conventional use by destruction. Barbier (1994) divided the environmental functions of mangroves and coastal wetlands into stock and flow functions. The *regulatory functions* of wetlands, such as nutrient cycles, microclimatic functions, energy flows, etc., are flows while the *structural components* of the wetlands, such as biomass, non-biotic matter, species of flora and fauna, are the stocks from which societies derive benefits. He then used the Total Economic Value (TEV) (comprising use and non-use values) to derive the value of the environmental functions. In terms of deriving use value of the services of the wetlands, like fish, fuel wood, recreation, transport, etc., he suggested the use of Individual Choice Models (ICM), Conditional Value of Information (CVI), Contingent Valuation Method (CVM), Travel Cost Method (TCM), Indirect Opportunity Cost approach (IOC), Indirect Substitution approach (IS), as well as use of replacement costs. He also suggested using a *production function approach*, to capture indirect use value of regulatory ecological functions:

$Q = f(X_1, X_2, \ldots X_k, S)$, where $f_s > 0$ and $f_{ss} < 0$, S is the area of mangrove in a coastal region, Q is the output and X's are the standard inputs of a commercial fisheries. Using this approach, Bell (1997) derived the economic value of the contribution of coastal wetlands in supporting recreational fishing in South-eastern United States, with the assumption of a Cobb-Douglas production function and a linear demand curve for recreational fishing. It used an annualised flow of consumer surplus to find the capitalised value of per acre of wetland using a discount rate. He used cross-section data on recreational fisheries from 10 south-eastern states of USA. Bergstrom et al (1990) discussed conceptually the recreational value of wetlands within the framework of Total Economic Value. The empirical part of this study measures expenditure and consumer surplus associated with on-site, current recreational use of a coastal wetland area. They used CVM on an experimental market to elicit consumer's surplus. Costanza et al (1989) studied the values of wetlands of Louisiana using WTP (willingness to pay) and energy-analysis based methodologies. They have argued for using a low value for discount rate for valuing renewable natural resources. They have also argued that no reasonable amount of effort will produce very precise estimates of wetland values, because of the available limited information and uncertainty. Kahn and Kemp (1985) employed theoretical and empirical concepts from ecology and economics to derive a lower bound of the marginal damage function of the degradation of the wetlands and analysed its impact on the fisheries in Chesapeake Bay. Using the estimates of supply and demand curves from time-series data, the study utilised the concepts of consumers' and producers' surplus to assess indirect effects of waste discharge to an aquatic system.

Barbier (2000) provides an overview of the approaches used to value the contribution of mangroves to fishery. The production function approach used by a number of studies has formulated either static or dynamic models and these have been employed for case studies carried out in developing countries. In general, in the production function approach, environment (or in this case wetlands or mangroves) is treated as an input and the value of changes in productivity is estimated. The welfare contribution of this input is measured in static approach, as employed by Sathirathai (1997) in Thailand, through producer and consumer surplus measures of changes in market equilibrium for harvested fish (Barbier, 2000). In the dynamic approach, as used by Barbier and Strand (1998) in Mexico, the wetland support function is determined in terms of the changes in the long-run equilibrium conditions of fishery or in the harvesting path to this equilibrium. It has been recognised that the multiple use-functions of ecosystems such as mangroves makes the task of valuation using production-function approach complex and difficult. Gottfreid (1992) made a theoretical attempt in this direction and viewed ecosystems as long-lived multi-product factories. He suggested estimation of consumer surplus under various management alternatives, but recognised that the required data is quite intensive and elaborate.

The absence of reliable data made Ruitenbeek (1994) use cost-benefit analysis for various hypothetical management options, from clear cutting to a cutting ban, incorporating linkages among mangrove conservation, offshore fishery productivity, traditional uses and benefits of erosion control, and biodiversity maintenance functions of the mangrove in Bintuni Bay area of Irian Jaya, Indonesia. It showed that selective cutting is the optimal management strategy for this mangrove area. The exercise is based on actual data but used assumptions on the extent of linkages between different functions of mangroves.

However, the value or the contribution of wetlands depends on the management policies and institutional structure including property rights. Freeman (1991) shows that economic values of resources depend in part on the management regime. The value of a resource supporting a commercial fishery will depend on whether the fishery is optimally managed or having open access. So Freeman stressed the institutional factors on economic values of resources. Using assumptions of elastic and inelastic demand for products, Freeman simulated value of the wetlands under open access regimes and found that with inelastic demand, wetlands have more value under open access. Using different regulatory regimes and elasticity of demand, the paper concluded [using a simulated exercise on Ellis and Fisher (1987) data] that resource values are influenced by market conditions and the regulatory policies that determine the conditions of access and rate of utilisation of the resource. Barbier (1994) argues that open access exploitation and imperfect market are widely prevalent in relation to the use of wetlands and mangroves in tropical regions. The property rights and institutional structures associated with mangroves also create social conflicts. Martinez-Alier (2000) considered the conflicts between mangrove conservation and shrimp exports in different parts of the world such as

Ecuador, Honduras, Sri Lanka, Thailand, Indonesia, India, Bangladesh, Philippines, and Malaysia to find who are the losers and the gainers of conservation of mangroves. It shows in most of these countries mangroves were in public land but governments give concessions for shrimp farming or the land is enclosed illegally by shrimp growers. This results in uprooting of the mangroves and loss of livelihood for many people. In most of these countries, there was opposition to shrimp culture, led by the poor people who were trying to preserve their way of livelihood. Destruction of mangrove ecology, from these experiences, is seen not only as an ecological threat but a social threat as well. In Bangladesh, coastal shrimp farms are responsible for the destruction of 50000 acres of mangrove in Cox's Bazar area.

Most of the empirical studies reviewed here were based on time-series or panel data set, on the linkage between extent of mangroves and some economic activity (i.e., fishery). Such data is nonetheless not available in the case study areas chosen for this research project. Though data on offshore fish catch is available in the case of Cochin, the data on changing area under mangroves is not available. Of course, there were a number of biological studies, which studied the composition of fauna in water or soil samples collected from different spatial and vertical position of the wetlands[6]. These studies may be identifying the presence or absence of certain fish types (or the presence or absence of phytoplankton and zooplankton to provide food for fish growth[7]) in these samples. These are rather inadequate to make any judgments on the (increased or decreased) availability of an economically valuable good in a locality. Similarly, the quantum of fish production from existing mangrove areas like Sundarbans, as reported in FAO (1982), as a way of highlighting the fishery contribution of these ecosystems, is also inadequate to see what happens when there is a change in the quality or quantity of mangroves.

Based on the review of literature, we thought of using the following strategies for our study.

1. Analyse the existing secondary data and/or compile a primary data set that can be collected within the time frame of this study (i.e., a maximum period of one year), which provide some linkage between mangroves and economic goods and services.
2. Analyse the existing institutional structures or property rights on the use of mangroves, and outline their implications for sustainable management.

Since the availability of secondary data, the possibility of collecting relevant primary data, and the institutional structure vary from one place to another, there were some differences in the

---

[6] For a listing of a sample of these studies, see the reference of Devi and Venugopal (1989). The methodology of such studies can also be seen in this paper.

[7] For example, such an attempt can be seen in Sundararaj (1978).

way the study was carried out in three locations namely, Cochin, and West Bengal and Bangladesh parts of Sundarbans. The details of the study, carried out in each location, are described in sections 3, 4, and 5.

3 Mangroves in Cochin (Kerala), India

The mangroves in Cochin are fragmented small patches situated in urban and semi-urban areas. This has a number of implications. First of all, direct dependence on mangroves for livelihood items such as fuel wood or timber, is much lower here compared to other regions. For example, people use commercially available fuel wood or fuels such as kerosene, LPG gas, etc., instead of depending on mangroves for collecting fuel wood. Secondly, the protection of shoreline from erosion or flooding is not a sufficient justification for keeping mangroves in larger areas. This is because of the fact that land prices are quite high (to the tune of US$ 60 to 100 per square meter), and engineering structures that take much lesser land than the minimum area of mangroves needed to provide shoreline protection at an equivalent level, will be cheaper. Thus we concentrated on the linkage between mangroves and estuarine fishery, as the focus of the study in Cochin.

It was evident from the review of literature that most of the empirical studies on the linkage between mangroves and fishery were based on the analysis of time-series data or panel data from different comparable regions (Lynne et al, 1981; Costanza et al, 1989; Barbier, 1994; Sathirathai, 1997; Barbier and Strand, 1998). Such data is, however, simply not available in Kerala. Thus we have had to employ other strategies in this context to study the relationship between mangroves and estuarine fishery. The alternative method employed in Kerala is described below.

3.1 Mangroves and Fish-capture Farms

There are a number of traditional fish production (or capture) systems lying adjacent to the remaining stretches of mangroves in Cochin. In each of this system, an artificial separation of the water body is made and is controlled. A typical unit of such a fish-capture system is shown in Figure 3.1.

Water is allowed to enter the enclosure at the time of high tide. The water carries small fries or seedlings of different varieties of fish. These seedlings are blocked with the use of a net and bigger ones trying to go out of the enclosed water body are caught. Systems of this type have varying sizes of mangroves in their boundary. For some, the boundaries are covered completely by the mangroves, some have significant patches, and some systems have no mangroves in their boundary. Thus we thought that if there exists any relationship between the extent of mangroves and estuarine fish production, it may be reflecting in the output of these fish-capture systems. Hence we attempted to find whether there exists any significant relationship between quantity of fish production and the extent of mangroves on the boundary of these water bodies used for fish collection.

Figure 3.1 A Typical Fish-capture System Bounded by Mangroves

In order to carry out this exercise, data was collected from 16 of such traditional fish production systems located in different parts of the Cochin backwater system, on their inputs, nature of wetlands, associated mangroves, and most importantly the harvested output. More specifically, the following data were to be collected.

External Inputs

Labour – time, wages; Capital – machinery if any, chemicals, nets, depreciation, lease rent, and construction costs;

Nature of wetlands;

Area, depth, position of the water body within the larger ecosystem, and ownership;

Nature of mangroves; and

The situation of the boundary of wetland: Coverage by the mangroves, the degradation levels, and the ownership of the land having mangroves.

Output

The quantity of different varieties of fish harvested per period, and prices

Based on a preliminary assessment of the production in these farms, it became clear that the technology used by all of them is of similar nature, (i.e., essentially encircling a part of the wetland, and collect the grown up fish). The effort used for harvesting is also of similar level (i.e., putting a net near the opening of the water body to collect fish on prefixed dates, following a local calendar). There are no external inputs given to fish production system in the form of seed, feed, or disease control, and thus it is safe to assume that the growth of fish or fish output by and large depends only on natural conditions of the water body (i.e., extent of mangroves, depth, spatial location, and other factors determining the availability of nutrients and fish seedlings). Thus the focus was centred on these 'natural' parameters that might influence the output of production.

The data was collected for a period of 12 months from January to December 2001, to get an average picture of fish production from each of these farms. The details of these farms are given in Table 3.1. These farms have different extent of mangroves along their boundaries, with some covered fully or partially and others having none.

Table 3.1 Details of Traditional Fish Farms Located in Cochin Backwater System

Farm	Proportion of area of mangroves	% the perimeter of the farm having mangroves to the total	Distance from the river mouth (in km)	Average Depth in cm	Area of water surface (in acres)	Area of farm (in acres)	Total output of 10 catches of fish type namely *Dobsoni*	Total output of 10 catches of fish type namely *Monoceros*	Total output of 10 catches of fish type namely *Indicus*
1	.00	0.00	12	86.87	23.64	23.64	7655	286	724
2	.00	39.96	14	58.18	10.60	10.60	2545	124	405
3	.39	7.66	12	131.44	9.09	9.13	2634	247	143
4	.00	0.00	20	81.57	33.07	33.07	4054	290	1105
5	23.5	34.99	10	45.00	7.80	10.20	315	105	85
6	.78	4.22	11	48.95	8.21	8.27	5473	250	499
7	11.8	10.83	13	42.70	2.95	3.35	532	142	116
8	33.0	49.07	13	54.00	1.25	1.87	573	20	30.5
9	38.0	41.96	13	32.33	2.14	3.45	322	38	31.5
10	11.3	48.89	13	51.00	5.57	6.28	1274	191	115
11	4.51	29.19	13	43.00	0.72	.75	596	193	109
12	6.39	30.57	10	64.80	4.35	4.65	1060	287	183
13	.87	8.74	10	55.34	5.15	5.20	606	173	72
14	12.1	41.50	11	71.19	3.50	3.98	468	153	76
15	7.99	53.11	4	43.00	10.44	11.35	2124	205	463
16	2.88	36.44	4	48.00	9.46	9.74	3041	344	949

3.1.2 Results of Data Analysis

The output of three important fish (shrimp) varieties per unit area of each farm is plotted against the proportion of the area of mangroves to the total area of the farm. The distribution of this relationship is visible from the three scatter-diagrams given in Figures 3.2 to 3.4.

At the outset, these scatter diagrams give an impression that the fish output per unit area of farm declines with the extent of mangroves. This picture is emerging for all the three types of fish namely, *Dobsoni*, *Monoceres*, and *Indicus*, as evident from figures 3.2, 3.3, and 3.4. Multiple regression exercises were also carried out (Tables 3.2, 3.3, and 3.4). Here the output per unit area (of farm) of each type of fish is taken as the dependent variable, and the independent variables are proportion of the area of mangroves (to the total area of wetland), distance of farm from river mouth (in km), and average depth of the farm (in cm). (We are aware of the limitations of this exercise due to the small sample size, and hence the results should be seen as only indicative). Though the regression results too show that the mangroves have a negative influence on the per unit output of all three types of fish, it is statistically significant in the case of only one type namely, *Indicus*.

In order to see whether the presence or absence of mangroves have some impact, the extent of mangroves is incorporated in the regression as a categorical variable (i.e., 0 -absent; 1 -present). The results show that the presence of mangroves as binomial variable (1 - present, 0 -absent) could explain only a lesser part of the variance, compared to the case where proportion of mangroves was used.

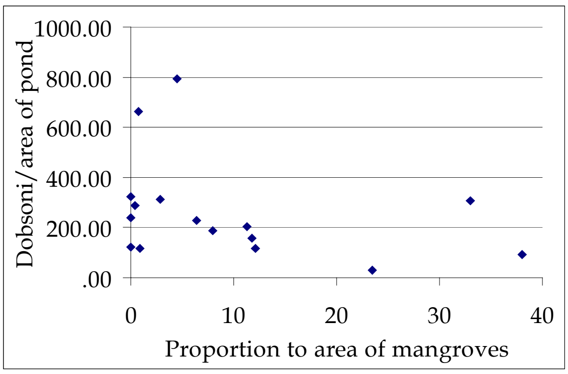


Figure 3.2 Fish Output per Area of Pond Vs Proportion of Area of Mangroves (*Dobsoni*)

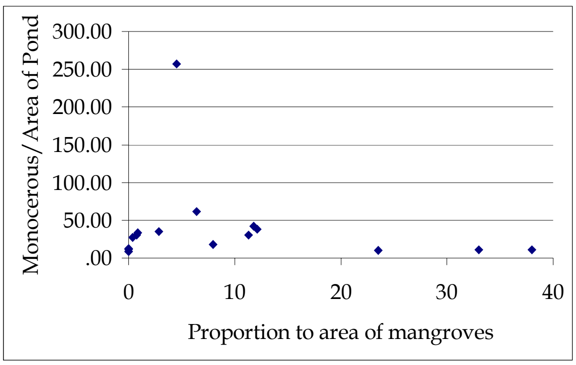


Figure 3.3 Fish Output per Area of Pond Vs Proportion of Area of Mangroves (*Monocerous*)

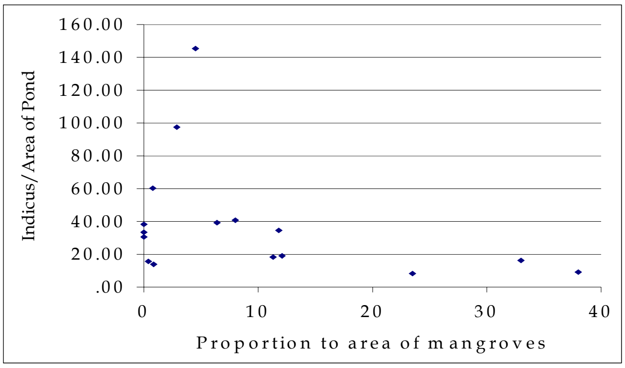


Figure 3.4 Fish Output per Area of Pond Vs Proportion of Area of Mangroves (*Indicus*)

Table 3.2 Multiple Regression of Fish Output/Area of Pond with Characteristics of Farm (Proportion of Area of Mangroves) (*Dobsoni*)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.398 [a]	.158	-.052	208.0656

a. Predictors: (Constant), Proportion of area of mangroves, distance from the river mouth in km, average depth in cm

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	97787.633	3	32595.878	.753	.542 [a]
	Residual	519495.5	12	43291.290		
	Total	617283.1	15			

a. Predictors: (Constant), Proportion of area of mangroves, distance from the river mouth in km, average depth in cm

b. Dependent Variable: *Dobsoni*/Area of Pond

Coefficients[a]

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	423.214	217.085		1.950	.075
	average depth in cm	-2.215	2.623	-.263	-.845	.415
	distance from the river mouth in km	3.837	15.109	.071	.254	.804
	Proportion of area of mangroves	-7.606	5.090	-.450	-1.494	.161

a. Dependent Variable: *Dobsoni*/Area of Pond

Table 3.3 Multiple Regression of Fish Output/Area of Pond with Characteristics of Farm (Proportion of Area of Mangroves) (*Monocerous*)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.367[a]	.134	-.082	62.2708

a. Predictors: (Constant), Proportion of area of mangroves, distance from the river mouth in km, average depth in cm

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7221.400	3	2407.133	.621	.615[a]
	Residual	46531.903	12	3877.659		
	Total	53753.303	15			

a. Predictors: (Constant), Proportion of area of mangroves, distance from the river mouth in km, average depth in cm

b. Dependent Variable: *Monocerous*/area of pond

Coefficients[a]

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	86.870	64.970		1.337	.206
	average depth in cm	-.927	.785	-.373	-1.181	.261
	distance from the river mouth in km	2.221	4.522	.139	.491	.632
	Proportion of area of mangroves	-1.760	1.523	-.353	-1.155	.271

a. Dependent Variable: *Monocerous*/area of pond

Table 3.4 Multiple Regression of Fish Output/Area of Pond with Characteristics of Farm (Proportion of Area of Mangroves) (*Indicus*)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.598[a]	.357	.197	32.4379

a. Predictors: (Constant), Proportion of area of mangroves, distance from the river mouth in km, average depth in cm

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7022.757	3	2340.919	2.225	.138[a]
	Residual	12626.580	12	1052.215		
	Total	19649.337	15			

a. Predictors: (Constant), Proportion of area of mangroves, distance from the river mouth in km, average depth in cm

b. Dependent Variable: Indicus/Area of Pond

Coefficients[a]

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	105.999	33.844		3.132	.009
	average depth in cm	-.757	.409	-.504	-1.852	.089
	distance from the river mouth in km	-.392	2.355	-.040	-.166	.871
	Proportion of area of mangroves	-1.813	.794	-.601	-2.285	.041

a. Dependent Variable: Indicus/Area of Pond

In summary, there is no evidence for a positive relationship between the extent of mangroves and the fish output in these farms. This is somewhat surprising since a number of biological studies or reports have indicated the possibility of positive contribution of mangroves towards estuarine fishery. Moreover, if providing nursery and nutrients were the functions of mangroves, one would expect an increase in fish production in places with mangroves than in areas having no mangroves. Hence the negative relationship or no relationship, visible in this location, needs to be explored further.

There may be several reasons for this somewhat surprising result. First of all, it was found that the farms having larger areas of mangroves in their boundary have smaller water surface exposed to air. This water surface may have an impact on fish production due to the need to have aeration. An attempt was made to measure this area of water surface. The output of each type of fish per unit area of this water surface of each farm is plotted against the proportion of mangroves in Figures 3.5, 3.6, and 3.7. The regression exercises were carried out with fish output per unit area of water surface and the results are reported in Table 3.5, 3.6, and 3.7. However, we could not see much difference in the pattern of relationship. This shows that the reduction of the area of water surface is not the major reason for the observed negative relationship or for the lack of positive relationship.

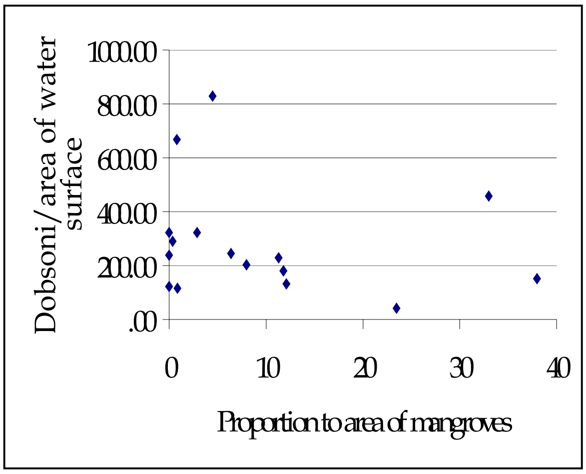


Figure 3.5 Fish Output per Area of Water Surface Vs Proportion of Area of Mangroves (*Dobsoni*)

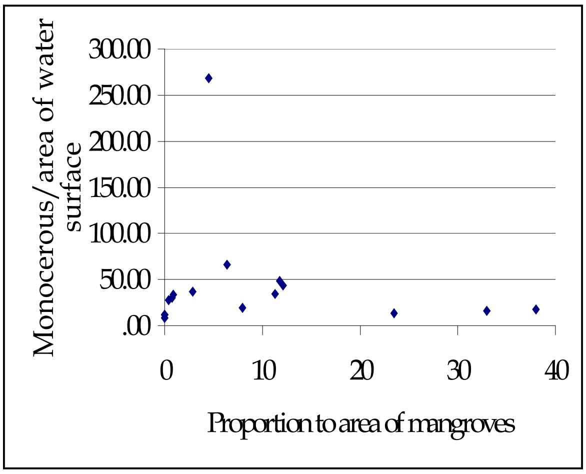


Figure 3.6 Fish Output per Area of Water Surface Vs Proportion of Area of Mangroves (*Monocerous*)

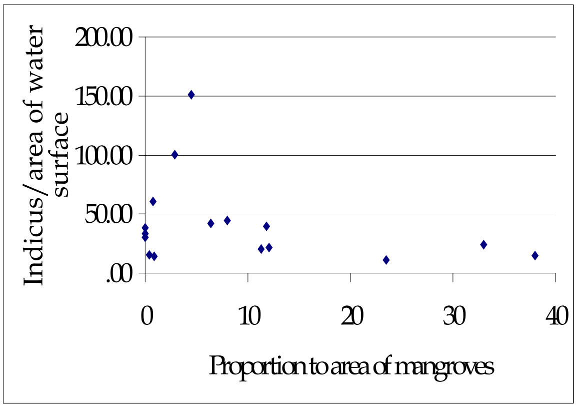


Figure 3.7 Fish Output per Area of Water Surface Vs Proportion of Area of Mangroves (*Indicus*)

Table 3.5 Multiple Regression of Fish Output/Area of Water Surface with Characteristics of Farm (Proportion of Area of Mangroves) (*Dobsoni*)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.281[a]	.079	-.152	223.8769

a. Predictors: (Constant), Proportion of area of mangroves, distance from the river mouth in km, average depth in cm

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	51409.630	3	17136.543	.342	.796[a]
	Residual	601450.6	12	50120.879		
	Total	652860.2	15			

a. Predictors: (Constant), Proportion of area of mangroves, distance from the river mouth in km, average depth in cm

b. Dependent Variable: DOBWATER

Coefficients[a]

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	411.336	233.582		1.761	.104
	average depth in cm	-2.145	2.822	-.248	-.760	.462
	distance from the river mouth in km	4.478	16.257	.080	.275	.788
	Proportion of area of mangroves	-5.202	5.477	-.299	-.950	.361

a. Dependent Variable: DOBWATER

Table 3.6 Multiple Regression of Fish Output/Area of Water Surface with Characteristics of Farm (Proportion of Area of Mangroves) (*Monocerous*)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.355[a]	.126	-.093	64.8453

a. Predictors: (Constant), Proportion of area of mangroves, distance from the river mouth in km, average depth in cm

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7253.262	3	2417.754	.575	.642[a]
	Residual	50458.992	12	4204.916		
	Total	57712.254	15			

a. Predictors: (Constant), Proportion of area of mangroves, distance from the rive mouth in km, average depth in cm

b. Dependent Variable: MONOWATE

Coefficients[a]

Model		Unstandardised Coefficients B	Unstandardised Coefficients Std. Error	Standardised Coefficients Beta	t	Sig.
1	(Constant)	89.876	67.656		1.328	.209
	average depth in cm	-.971	.817	-.377	-1.188	.258
	distance from the river mouth in km	2.368	4.709	.143	.503	.624
	Proportion of area of mangroves	-1.658	1.586	-.321	-1.045	.317

a. Dependent Variable: MONOWATE

Table 3.7 Multiple Regression of Fish Output/Area of Water Surface with Characteristics of Farm (Proportion of Area of Mangroves) (*Indicus*)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.571[a]	.326	.158	33.7653

a. Predictors: (Constant), Proportion of area of mangroves, distance from the river mouth in kms, average depth in cms

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6626.904	3	2208.968	1.938	.177[a]
	Residual	13681.135	12	1140.095		
	Total	20308.038	15			

a. Predictors: (Constant), Proportion of area of mangroves, distance from the river mouth in km, average depth in cm

b. Dependent Variable: INDIWATE

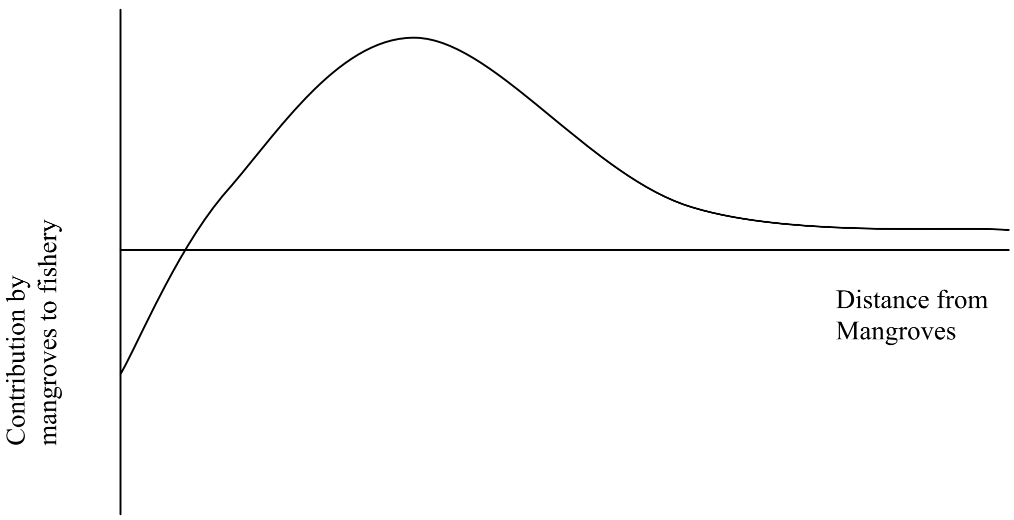
Coefficients[a]

Model		Unstandardised Coefficients B	Unstandardised Coefficients Std. Error	Standardised Coefficients Beta	t	Sig.
1	(Constant)	109.353	35.229		3.104	.009
	average depth in cm	-.783	.426	-.513	-1.839	.091
	distance from the river mouth in km	-.437	2.452	-.044	-.178	.862
	Proportion of area of mangroves	-1.680	.826	-.548	-2.034	.065

a. Dependent Variable: INDIWATE

Potential Causes for the Observed Negative Relationship between Mangroves and Fish Output

The available information or data enable us to make only some speculative remarks on the factors that cause this negative impact. It may be the case that small fish-capture systems of the kind considered here are inappropriate units to study the contribution of mangroves. This may be due to the fact that the positive contribution of mangroves is reflected in locations beyond the boundary of these farms. Moreover, areas very close to mangroves might be more prone to higher levels of eutrophication. Thus the expected positive contribution of mangroves to fish production depends on the distance from the mangrove, and this relationship may be following a non-linear form of the following type.



The ecological reason for the above type of behaviour may be the following: Though mangroves provide nursery ground and nutrients to fish, in order to have proper growth of fish it should move away from near mangroves at some stage of its life. This may be due to the fact that in areas very close to mangroves, there can be excessive nutrients, creating an environment with less oxygen and not conducive for the growth of fish. This negative effect will come down as distance increases from the location of mangroves, and if small fish fingerlings, which took shelter near mangroves have moved that far at the growing stage.

On the other hand, if we take the pattern observed in this study as valid for the whole estuarine fishery or even off-shore fishery of Cochin, then one can speculate the following:

1. In a situation where biomass and nutrients are already higher in the water body (due to climatic features, urban sewage, etc), the additional nutrients provided by the mangroves do not cause any beneficial impact. Instead it is only causing more eutrophication and slower growth of fish in the locality.

2. Though mangroves provide shelter, the eutrophication caused by the presence of mangroves causes low growth of fishery in localities close to mangroves.

3. In a situation such as Cochin where mangroves are highly fragmented, and area is densely populated, the expected positive contribution of mangroves need not take place.

These potential explanations remain tentative since we are not in a position at present to verify the validity of any of them.

4 Mangroves in West Bengal (India)

The Indian Sundarbans, i.e., mangrove forests in the delta of Ganga and Brhamaputra rivers - comes under the jurisdiction of the South 24 Pargana and the North 24 Pargana districts of West Bengal state of India and covers an area of 9630 sq. km. The Sundarbans was declared a biosphere reserve in 1989. Each and every biosphere reserve includes representative examples of natural ecosystems (Core Area) within a bio-geographical province. They serve as:

i) Centres of education and of genetic richness or unique natural features of exceptional scientific interest (Core Area).

ii) Areas suitable for experimental manipulation to develop access and demonstrate the methods of sustainable development (Manipulation Zone).

iii) Examples of harmonious landscapes resulting from traditional pattern of land use (Non-forest area Manipulation Zone).

iv) Examples of modified or degraded ecosystems that are suitable for restoration to natural or near natural conditions (Restoration Zone).

People are not barred from the biosphere reserve, as they are also an integral part of the environment and an essential part of the landscape. Human activities determine its long-term conservation and compatible use. Basically they are encouraged to participate in its management, which ensures a stronger social acceptance of the conservation activities (Ministry of Environment and Forests, 1989).

From the management perspective, Sundarbans biosphere reserves are subdivided into different parts (Table 4.1).

Table 4.1 Zones and Area (Sundarbans Biosphere Reserve)

Zone	Area in sq. km
Core Area	1700
Buffer Area 1. Restoration Zone 2. Manipulation Zone a) Forestry b) Agriculture	 245 2225 5460
Total Area	9630

Source: Vyas, 2001

The core zone is protected securely for conservation of biological diversity with the other uses like eco-tourism and nature education. On the other hand, the demarcation of the restoration zone is for the purpose of enhanced value addition of the resources, recreations, tourism, and fishing.

The existing area of the Sundarbans may be subdivided into six main localities from west to east based on the characteristics of different delta lobes and sweet water flow.

Zone 1 This zone is the area covered by Sagar-Mahisani-Ghoramara-Sandhead group of islands, which is situated at the estuarine mouth of Hooghly River and covers an area of 90 sq. km. Within this, approximately 15 sq. km would be considered as Restoration Zone and the remaining 75 sq. km may be considered as Manipulation Zone (Agriculture). Leaching helps to reduce the salinity of the soil; another factor behind changing salinity is the recent water release by the Farakka barrage.

Zone 2 Zone 2 is the area covered by Mahisani Island in the west to Thakuran River in the east. It covers an area of 900 sq. km out of which 200 sq. km is Restoration Zone and the rest of 700 sq. km is Manipulation Zone (Agriculture). This is the second delta lobe among the five lobed Sundarbans deltas. The characteristic of this zone is the transitional effect of lack of sweet water. Two important spots of the zone are:

a) Crocodile Breeding Farm at Bhagabatpur Island and

b) Wildlife Sanctuary at Lothian Island.

Zone 3 Zone 3 is the 1600 sq. km area lying between the rivers Thakuran and Matlah. Out of this, 1400 sq. km is covered by forest. The upstream sweet water is absent in this area; however, it faces the effect of rushing backwaters.

Zone 4 Zone 4 is has an area of 1700 sq. km and is the Core Zone of the Biosphere Reserve. The east of the area is demarcated by Harinbhaga River, west limit is the river Matlah, and in the north there are rivers Netidhopani and Gosaba. This area already comes under the Sundarbans Tiger Reserve and also a National Park that covers an area of 1330 sq. km.

Zone 5 Zone 5 is the area that lies to the north of the Core area. This 885 sq. km area lies in the Buffer Zone of Sundarbans Tiger Reserve. The area falls with the Manipulation Zone (Forestry). It also contains a wildlife sanctuary. In this region forest exploitation based on the principle of conservation, management, and sustained yield in order to meet local demand of the forest people is allowed. A trickle of sweet water comes from the river Ichhamati for the eastern part of the forest.

Zone 6 Zone 6 is probably the largest zone covering 4455 sq. km, which comes inside the boundary of Manipulation Zone (Agriculture). This zone too receives some trickle of sweet water from the Ichhamati River. Aquaculture, agro-fisheries, etc., are the common practices of the local population. This saline area is of importance not only for its extensive use for cultivation of Tiger Prawns, but also for the popularity of agro-fishery (Table 4.2).

Table 4.2 Zones and Area (Operational)

Zone No.	**Description**	**Total Area**	**Manipulation Zone**		**Restora -tion Zone**	**Core Zone**
			Forest	**Agriculture**		
1	Sagar-Mahisami-Ghoramara-SandHead group of islands	90		75	15	
2	East-Thakuran River West-Mahisand island Area-900 sq. km.	900		700	200	
3	Between the River Thakuran & Matlah	1600	1370	200	30	
4	Core area of Sundarbans Tiger Reserve	1700				1700
5	Buffer Zone of Sundarbans Tiger Reserve	885	885			
6	Area North of forest & lying to the east of Matlah	4455		4455		
	Total	9630	2255	5430	245	1700

Source: Vyas, 2001

4.2 Benefits of the Sundarbans *Mangal*

The Sundarbans mangroves are not only rich in its floral and faunal diversities but provide benefits, both direct and indirect, as well.

4.2.1 Direct Benefits

a) brackish water fishes, shrimps, crabs, honey, wax, and tannin, which cater to the local demand, as also the demand of the metropolitan city. Exporting dried fish, shrimps, crabs, and honey brings in substantial foreign exchange.

b) The floral species serve as the major provider of fuel woods; Valuable timbers used for domestic purposes and/or for making furniture, etc.

c) Fruits of some of the tree species like *Keora* and *Ora*; medicinal plants

d) Sundarbans Biosphere Reserve offers scenic beauty, scope for adventure, and eco-tourism.

4.2.2 Indirect Benefits

a) The mangrove leaves falling in the water provide rich nutrients for the young fishes besides acting as an ideal nursing ground for them. Water here is more enriched due to the presence of different micro-organisms as well.

b) Mangrove vegetations check soil erosion resulting from inundation and strong wind that blows across the islands. It also helps to reduce the intensity of cyclonic storms originating in the Bay of Bengal. The mangroves are also responsible for causing heavy rains by exuding water vapour in the atmosphere.

c) The life of Calcutta port depends much on the lower Sundarbans delta as this low-lying area provides adequate spill area in the estuaries.

d) The Sundarbans area also acts as a buffer zone and coastal land. Moreover, a part of the effluent released from Kolkata city comes directly to the Matla estuary.

e) The mangroves with their under roots protect the young fishes from the predators and provide safety from the strong tidal waves. It also acts as shelter for different species of crustaceans [Sanyal, (2000); Naskar, (2002)].

4.2.3 Forest Resources

Timber and Fuelwood

Compared to Bangladesh part of Sundarbans, Indian portion receives less of fresh water inflow. Hence, major tree species like *Heritiera* and *Nypa* are found mostly on the eastern part of river Matla. The yield is also higher for trees found in the eastern part. The eastern part of the Matla, however, has been declared as Tiger Reserve. Moreover, restrictions have been continuously imposed in the buffer area on felling of certain timber species, i.e., *Sundari*, *Passur*, *Dhundul*, and *Kankra*. Restrictions on *Hental* had been increased gradually before finally being discontinued since 1991. Restriction has also been imposed on fodder species *Keora*. Collection of *Golpata* has been stopped since 1978. The coupes area has also been systematically reduced and, at present, only 1000 hectors (10 sq. km) are worked annually.

Computing from Management Plan (2000-'01 to 2009-'10) figures in past five years' average felling works out to be 28978.6 (approximately) quintals annually. Outturn of small timbers and fuelwood is calculated at 60000 quintals (approximately).

4.2.4 Honey and Wax

Collection of honey in the Sundarbans is one of the major seasonal activities. In the Sundarbans mangroves, one among the four bee species - *A. Dorsata* (Rock Bee) migrates between March and June, every year, from the Himalayas. Incidentally this particular species contributes approximately 80 per cent of the total honey production in India. In the Sundarbans the major host plants of honeycombs are, *Excoecaria agalocha* (Genwa) contributing 39 per cent of the total honey production; *Avicenia* species (Bain) contributing 16 per cent; Ceriops (Goran) contributing 11 per cent; and *Rhizophora mucronota* (*Garjan*) contributing 10 per cent. Genwa branches are ideal for comb formation and these branches have maximum number of combs per unit area. It is interesting to note that Goran that occupies 90 per cent of the forest area, nests only 11 per cent of the combs. The reason could be the bushy structure of these *C.decandra* and unbranched and thick crown of *C.tagal* – suitable for formation of hives. Preferences for honeybees are trees along narrow creeks in forest blocks distant from human settlements.

Sunny days and optimum intermittent rains are the most conducive factors for honey production. Storms, cyclones, high tides or floods are detrimental to pollination. The honey collection season extends roughly between fourth week of March and first week of June, i.e., before the onset of monsoon. Bulk of the honey is produced and collected in the first phase, i.e., between March and May. Quality-wise too, honey collected during the first phase is the best (Sen, 1995).

A sketch is presented below showing collection period, nesting plants, and quality of honey available in the Sundarbans.

Sl. No.	Name of the Plants	Period	Quality of Honey
1	Khalsi & others	20th March to 15th April	Thick white & creamy
2	Hetal	31st March to 15th April	Do
3	Goran, Math Goran	1st May to 20th May	Reddish
4	Bain	1st May to 5th June	Do
5	Genwa	20th May to 5th June	Reddish & slightly Acidic
6	Keora	15th April to 5th May	Redish, tinge, slightly light

Source: Sen (1995)

In the Sundarbans the honey collectors are referred to as *Moules*. Early tribal settlers, mainly *Lodhas* and *Mundas* are the traditional honey collectors in the region together with the non-tribal Muslims. The Scheduled Caste people, the later immigrants to the region, gradually acquired the traditional skill; honey collection soon became an integral part of their other seasonal activities. The *moules* are settled mainly at the fringe villages of the forests of Gosaba, Kultali, and Patharpratima in the South 24 Parganas. In the North 24 Parganas concentration of *moules* are found in the villages of Hingalganj P.S. adjacent to Jhingakhali forest block. The traditional honey collectors, the tribesfolk are highly indebted and in the process lost much of their lands. The debt cycle starts typically with borrowing money from the moneylender for paying permit money to the Forest Department and the boatman against the promise of a large share of honey and wax collected. It is reported that in many areas the moneylender charges 25 per cent interest per annum against loan advanced. The other two communities - the Scheduled Caste and Muslims are engaged predominantly in fishing activities and many a Scheduled Castes person owns boat, which they hire out to the band of *moules* and doubles up as *mahajans* (Sen, 1995).

The Forest Department issues about 1000 permits every year to groups of three to five members. Permit holders are allowed to access only the Buffer Zone of Sundarbans Tiger Reserve and the entire area of forests of 24 Parganas division. The honey collectors are required to sell the entire quantity of honey and wax collected to the forest department at a price prescribed by the latter. The rates are revised annually. Though, as yet, no official information on buying price is available, Sen in her report (Sen, 1995) mentions the buying price of honey by the Forest Development Corporation of West Bengal as Rs 28 and Rs 32 per kg for honey and wax respectively. As far as honey is concerned no distinct trend is visible. However, in case of wax there has been quite a sharp decline in quantity extracted after a certain jump in the year 1998-'99. To calculate value of total honey collected as reported in management plan, we have used average current price as obtained from our field survey. In case of wax we have used average of last five years price as found in the Management Plan.

4.2.6 Fish Resources

A large area of the western Sundarbans Forest Division consists of water with bountiful estuarine fisheries comprising of 772.86 sq. km of large canals, rivers, and estuarine and 75.78 sq. km of small canals in Basanti sub-division; 848.38 sq. km of large canals, etc. and 23.30 sq. km of small canals in Alipur and Diamond Harbour sub-division leaving out about 20 km into Bay of Bengal from southern boundary of reserve forest-part of foreshore fishing activities.

Fishing grounds in the Sundarbans comprise of large dead or semi-dead rivers running mainly from the north to the south. From the point of view of fisheries, the estuarine complex of the Sundarbans may be divided into five systems: Saptamukhi; Calchara-Curzon creek; Thakuran; Matlah; and the interconnecting link system. Each system exhibits an intricate network of creeks, canals, rivers and their tributaries. The fisheries of the Sundarbans may also be classified into three categories: Capture fisheries; Brackish water fisheries; and Foreshore fisheries. (There is also an offshore fishery in the Bay of Bengal.)

It is estimated that out of 3.5 lakh ha of coastal brackish water, 1.80 lakh are potential, of which only 40000 ha are utilised as traditional nona-*gheries* (salt water aquaculture water bodies). The total banks and ponds of fresh water area is 19802.34 ha. There exist other fresh water bodies of 891 sq. km in reclaimed areas in which 2500 ha are fresh water small reservoirs; upper rivers and creeks (upstream of the reservoir) constitute 320 ha and the rest of 1460 ha are tanks and riverbeds (Roychoudhury, 1998).

It is interesting to note that the entire East Indian coastal fishery down to Andhra Pradesh receives inputs from the Sundarbans *Mangal* in the form of it being acting as nursery, breeding and feeding grounds etc. for 90 per cent of coastal aquatic fauna.

In the Sundarbans, the availability of fish in the natural water may be classified into three types – 1) Marine species: The species, which migrate in the upstream to breed in the sweet water, and after breeding go back to the sea. *Hilsa*, *Topse*, etc., are the examples of these types. 2) Sweet water fish: Those, which are natural products of middle stream of the Ganges. However, they migrate downstream to the salt water for breeding purposes. Examples are Pangas, *P.Monodon*, etc. 3) Marine fishes: They migrate to the less salty water of the estuary for breeding and food. Examples are *Gurjari*, *Chanpra* Prawn, etc. In salt water of the Sundarbans, 130 species of fish, prawn, and crabs are available.

On an average in the Sundarbans, actual fish catch amounts to 60000 tonnes per year. Though fishing activities continue throughout the area, production starts increasing from the onset of monsoon and reaches its peak during winter (November-January), i.e., 81.9 per cent of total fish catch. Only 3.6 per cent of the total catch occurs in the summer.

On an average, around 4000 individuals engage themselves in fishing activities daily with an average catch of 1.5 kg/fisherman/day. The latest data on fish yield on Sundarbans is for the year 1996-'97. The figures of total fish yield between 1992-'93 and 1996-'97 are presented below (Table 4.3).

Table 4.3 Fish Yield in Sundarbans

Year (Feb.-Jan.)	Total Fish Yield (Metric tonne)
1992-'93	36900
1993-'94	34578.5
1994-'95	24476.6
1995-'96	34280.4
1996-'97	51126.1

Source: Sanyal P.

Apparently yield for the last five years generally hovered around 35000 tonnes but for the last reported year when it registered a sharp increase. Indications are there that presently the total catch has not gone back to the pre-1996-'97 years.

4.2.6.1 Brackish Water Fishing (*Nona Ghari/ Bheri*)

The owners of these *gheris* are mostly rich peasants, *jotdars* or tradesman. In the Sundarbans about 150 such *gheris* exist. Every year between October and mid-November, water from these *gheris*, adjacent to the rivers, is drained out completely. At the end of November, they are refilled with water from the rivers that bring in a wide variety of fishlings like *Bhetki*, *Bhangar*, *Parse*, and *Bagda* who mature here feeding on rich nutrients brought in with the same water. These fishes are netted in the months between January and July.

4.2.6.2 Fishing in the Rivers

The activities of the traditional fisherman revolve around catching fishes from the major rivers like Matlah, Bidyadhari, Thakuran, and their innumerable tributaries throughout the year. Nets are cast during ebb. Tidal water gradually increases and brings together with it varieties of *Khaira*, *Bhola*, *Topse,* and other marine fish species. As soon as the tidal water recedes, five or six men together furl the nets to reap the fish harvest (Das, 1983).

4.2.6.3 Fishing in the Forest

Driven by acute poverty, which has pushed many people to venture into the forest, number of fishermen operating in the Sundarbans rivers has increased considerably over the years. These people generally hunt fish, which enter the innumerable creeks together with tidal water, using nets from near the banks of rivers in the southern part of the Sundarbans. There is a compelling reason for such dangerous adventure. Since the fishermen hardly possess any boat or net of their own, they depend on the moneylenders for support. However, during the off-season, the catch per unit of effort (CPUE) in the rivers is much less compared to the jungle creeks. Hence, the moneylenders prefer sojourn into the forests. These activities continue between October and January - the only period when they are gainfully employed. Generally the local forest offices issue permits to a team of 7/8 people against payments of Rs 8/9. The permits are renewable every seven days. No permits are issued after the winter months (Das, 1983).

4.2.6.4 Tank and **Bilse** *(water pods within paddy fields) Fisheries*

Ruhi, *Katla*, and some varieties of carps - the sweet water fishes are cultivated in the tanks. Tanks and beels are rarely owned by the poor.

Poor and marginal farmers particularly from Canning, Basanti, and Gosaba depend on this source for livelihood during the lean season. In the monsoon, during the sowing season, a variety of fish species like *Shoal*, *Kai*, and *Tangra* enter the paddy fields with waters flowing in from the adjacent tanks/*beels* to lay eggs. The spawns mature rapidly surviving on rich nutrients available in the paddy fields. Come autumn, the end of cropping season that also marks the beginning of a prolonged period of unemployment for the vast majority. Perhaps with a net or with angles the people catch these fishes and sell them at throwaway prices in desperate efforts to make both ends meet (Das, 1983).

4.2.6.5 Winter Migratory Bag-net Fishery

A typical feature of the lower zone of the Hooghly-Matlah estuary during the winter is hunting fish by migratory fishermen with stationary bag-net units (*Been Jals*). A large number of fishermen migrate in groups to suitable zones on the sea face and establish temporary settlements for roughly 3.5 months from the end of October to early February. The two main concentrations of such groups are on Sagar Island at the estuary mouth and the others around Frasergunje, Bakkhali, Kalistan, and Jamboodwip islands (upper and lower).

The importance of these camps, known as k*hutis*, has increased dramatically in terms of proportional contribution in total yearly fish catch from different sources. While in the 1970s brackish water *bheries* dominated the fish catch scenario, by the mid-eighties winter bag-net fisheries became the dominant contributor to the total fish catch of the Sundarbans. Between 1984-‘85 and1993-‘94, winter migratory bag-net fishery constituted 67.2 per cent of the total annual fish catch in the entire estuary (Dey, 1997).

4.2.6.6 Fish Seed Collection and Resource Degradation

All the river systems that are free from pollution are sources of huge quantity of fish seeds. A large number of women, men, and children are engaged in collection of tiny prawns and fin fishes using rectangular marshed nets. The demand for Tiger prawn and another species of prawn, which had been finding the ideal habitat in the mangroves for the past two centuries and is one the rise, are indiscriminately exploited today threatening their very existence, since they fetch high price in the market. In the process of catching and isolating prawn seeds from other varieties of fishes, many other economically valuable and edible marine species are destroyed. Year-round seed collection activities on the already endangered riverbanks are also threatening collapse of the embankments of the islands.

Collection of tiger prawn post larvae is causing harm to the fish and shellfish diversity as such reducing per capita minimum catch of 70 in 1991 to 27 in 1995. Supreme Court of India has recently directed to practise only ‘traditional’ and ‘modified traditional’ aquaculture.

At the time of a single prawn seed collection, the average number of other destroyed species is as follows: 318 (other prawns), 8 (fish), 60 (crabs), 1 (mollusc), 13 (unidentified), i.e., total 400 of others.

The details of seeds destroyed per shrimp seed collection is as follows. On an average, in order to catch 8106 of shrimp seeds, each collection destroys 1304937 other prawn, 60581 fish, 246097 crabs, 8391 molluscs, and 66792 unidentified macro plankton, i.e., a total of 168601 Meroplanktons (Sanyal, 2001).

Of late attracted by encouraging growth and production of tiger prawns, businessmen from other areas excavated or renovated semi-intensive prawn farms on the river flats, inter-tidal mangroves, habitat zones, and paddy fields. In the process, mangrove forests area protection has been neglected and cleared in several parts of the Sundarbans mangroves converting them into brackish water prawn farms to the utter neglect of the natural laws and rules of *mangal* succession and / or sustainable productivity of the natural eco system.

Recently a study (Das, Mitra et al, 2001) was conducted on the shrimp fry collectors in selected villages of Gosaba and Sagar blocks. Two of the interesting findings of the study are the following: (a) family size of the prawn fry collectors is a little larger than the average (i.e., 5 to 6 persons); and (b) those from the age group of 15-25 are engaged in collection of prawn seed the maximum.

4.2.6.9 Crab Fishing in the Sundarbans

Crab market witnessed a rapid growth over the past three decades, both domestic and international. Crab catching is an important supplementary activity for the fishermen in the Sundarbans. Crab meat is not only a source of protein but its shells are high on export list as well.

Initially only the poorest of the poor people belonging to Scheduled Caste were engaged in fishing. The activity needs only *sik* or *don* to carry out operations. The gears used are affordable to them. This is not a caste-based occupation though 75 per cent of crab fishermen belong to Scheduled Castes. Non-Scheduled Castes are increasingly resorting to crab fishing, mainly because it is an economically rewarding pursuit and all members of the family can participate. Though the Department of Fisheries claims to use successfully improved technology for crab fishing and culture, majority of the crab fishermen still rely on their old technique that is affordable to them.

Crab fisheries are spread over II blocks each in South 24 Parganas and North 24 Parganas in the Sundarbans according to a Rapid Assessment Survey of crab fisheries, carried out by Directorate of Fisheries, Government of West Bengal in 1988-‘89.

4.3 The People

Large-scale reclamation and settlement started immediately after the 24 Parganas were handed over to the East India Company. The pace of reclamation and the growth of settlements picked up pace from the early nineteenth century with leases being granted to the settlers. By the early twentieth century, over 5000 sq. km of area was brought under cultivation. In the 24 Parganas, Bakharagunj, and Khulna (now in Bangladesh) depletion of forests were the maximum. The pace of reclamation recorded dramatic increase between 1940 and 1980, particularly in the 24 Parganas. Almost 5230 sq. km of wetland area vanished during this period. Many embankments were constructed to protect the reclaimed land from the ingression of tidal water after clearing forest lands. Premature reclamation and construction of bunds and dykes gave rise to serious ground water drainage problems affecting agricultural productivity of the region as sweet water is available only at 600-700m of depth. In most of the areas of the region the salinity level of water is too high for rice cultivation. Though about 90 per cent of the population depend on agriculture, productivity of this dominantly mono cropped region remains pegged at a very low level. The productivity per unit area in the Sundarbans region has been estimated at less than 2.5 tonne per hector. The yield of winter rice (main crop) has remained at between 1.0-1.5 tonne per hector for many years. The incidence of double or multiple cropping is rare. The proportion of landless labourers and marginal farmers is much higher in the Sundarbans compared to the West Bengal State average. Of the agricultural families, 54.21 per cent have been recorded as landless labourers. Of the total land owning families, small and marginal farmers account for 85.22 per cent of the total with an average holding of 0.82 hector per family (Chaudhuri and Chaudhuri, 1994).

In order to survive or supplement income accruing from agriculture that hardly suffices for four to six months, the people of the region indulge in a variety of other economic pursuits i.e., livestock, forestry, fishing, honey collecting, hunting, etc. In other words, mangrove forests of Sundarbans play a very important role economically in the lives of the local inhabitants.

Associated with the ecosystem of this delta, there are basically six major population groups: Agriculturists; Captive/capture breeders of fish (*bheri* owners); Fishermen and collectors of fish; Collectors of honey; Collectors of timber and fuel wood; and Collector of non-timber minor forest products.

4.4 Plan for Primary Field Survey: Design and Results

To identify and assess the nature and extent of dependence of the groups of people identified above and thereby the value they extract from the forest and the value they assign to the natural system of the Sundarbans, we planned to carry out our investigation among them. The task was somewhat daunting, as the areas remain almost inaccessible for about half of the year. Owing to vagaries of nature they are so near but so distant from the mainland. Even beyond rainy seasons communication exists only through waterways, which are primarily tidal channels. This implies that commutation time of a boat is heavily dependent on the daily ebb-tide cycle.

However, we could locate an NGO (Tagore Society for Rural Development) with extensive network in the area. We had decided to entrust the society with the responsibility of collecting primary data on our behalf while maintaining a close liaison with our team of investigators. We identified a suitable sampling design based on the work of Chattopadhyay and Mukherjee of ISI, Calcutta. We decided to collect information preferably from permit holders who were allowed to enter the forests of the Sundarbans for collecting fish, honey and wax, and timber and fuel wood (including minor forest products).

The area known as the Sundarbans with the districts of North and South 24-Parganas has 19 development blocks with 1375 villages. If we assume an association between the proximity of villages from the forest and use of forest-based resources, we may expect 36 per cent of these villages to derive such benefits directly.

With a somewhat different objective in view, Chattopadhyay (1995) conducted a pilot enquiry during 1982-‘83. It revealed that a total of 6483 groups of permit holders from 157 villages under 19 police stations (some lying outside the jurisdiction of the Sundarbans) visited forests for different purposes. It was observed that, from the distribution of permit holders and the villages they came from, 19 villages out of 157, i.e. 12 per cent were sending 75 per cent of groups. Using statistical tests of contiguity three zones were identified based on the proximity to core forest area – nearest (Zone I, ≤ 5 km), nearer (Zone II, 5 to 10 km), and distant (Zone III, > 10 km). Using Relative Intensity (R.I.) - low (< 5 per cent), medium (5 to 15 per cent), and high (>15 per cent) as indicators 53 out of 157 villages were found to be relevant. R.I. is defined as:

[Total count of the permits issued to the males of a village (for all purposes) / Total number of male worker in the village] 100.

Ultimately, out of these 53 villages 15 (little more than 28 per cent) from six development blocks, were selected randomly. They were drawn from nine cells constituted by three zones and three R.I. levels. Thus, the ultimate sample size used for our survey was 15 villages. Due to logistical problems, we had to concentrate on 6 development blocks (viz, Gosaba, Basanti, Sandeshkhali I & II, Hingalgunj, and Hasnabad).

Currently legal felling has stopped completely in the core area and limited permits are allowed to use the buffer area only. Thus, we have decided to collect data for our study from 15 villages.

4.4.1 Agricultural Land Holding and Forest Dependence

Tables 4.4 and 4.5 explore whether extent and nature of dependence on various forest resources have any relationship with the amount of agricultural land holdings. From Table 4.4 we find that 52.45 per cent of our respondents own some agricultural land, while 47.55 per cent are landless; it become clear that the landless people's dependence is much higher for all the items collected from the forest compared to people with some amount of land holding. Most of the respondents in this group of landholding engaged in shrimp netting (12.5 per cent) and crab catching (12.5 per cent). Fishing is the other important activity that the respondents belonging to this land holding category are engaged in (7.81 per cent).

Table 4.4 Relationship between Land Ownership and Extent of Forest Use

Ownership of culti-vable land	No. of respon-dents	Per cent	Type of use											
			Fuel wood		Fishing		Honey Collection		Shrimp Fry Netting		Woods other than fuel wood		Crab	
			No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Own	214	52.45	37	17.29	74	34.58	23	10.75	136	63.55	6	2.8	32	14.95
Doesn't own	194	47.55	69	35.57	109	56.19	35	18.04	164	84.54	12	6.19	35	18.04

Table 4.5 Amount of Land Holding and Extent of Use

Area of Holding	No. of respo-ndents	Per cent	Type of use											
			Fuel Wood		Fishing		Honey Collection		Shrimp Fry Netting		Wood other than fuel wood		Crab	
			No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
=>1to<=5	128	31.37	5	3.91	10	7.81	4	3.13	16	12.5	1.0	0.78	16	12.50
=>5to<=10	13	3.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	3	23.08
=>10to<=20	5	1.23	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	20.0	0.0	1	20.00

We find that almost 46 per cent of the respondents are dependent on the forest in different ways and hence the rest do not depend directly on the Sundarbans.

In the category of land holding between 5 and 10 *bighas*, there are too few (i.e., 3.19 per cent) respondents. Among them only 23 per cent of respondents are engaged in crab catching and no one from this landholding category depends on the forest directly in any other way. They are mainly farmers. We came across only five respondents owning land between 10 and 20 *bighas*. Among them only one is engaged in shrimp fry collection and others in crab catching.

The general state of economy of the Sundarbans as is borne out of secondary data as described in the earlier section matches with our observations. Though we worked with a very small sample size that does not cover many blocks of the Sundarbans, we find that about 48 per cent of the population in our sample is landless as compared to the overall figure of about 54 per cent. Small and marginal farmers also dominate the scenario with approximately 70 per cent of the sample population falling in this category. We came across a very depressed state of agricultural productivity across the blocks. There are only traces of double cropping with negligible presence of irrigation.

4.4.2 Extent of Forest Dependence (Block-wise)

Table 4.6 gives some indications about the block-wise extent of forest dependence of our sample respondents. In our sample, we have considered 13.9 per cent of the total population from Gosaba, 6.58 per cent of the total population from Basanti, 4.4 per cent of the total population from Hingalgunj, and about 2.05 per cent of the total population from Hasnabad who are engaged in livestock, forestry, fishery, hunting and plantations, and orchards and allied activities (Census, 1991). Though we have considered Sandeshkhakli-I & II blocks in our sample, we have not found any direct dependence (though they definitely derive off site benefits) of these people on forest. Thus, we have not included these two blocks in this Table.

Table 4.6 Extent of Forest Dependence

Block	Single use %	Double Use %	Triple Use %	More than three use %	Total %
Gosaba	30.72	34.97	18.5	15.74	100
Basanti	33.35	57.71	9.99	-	100
Hingalgunj	21.64	51.66	19.98	6.71	100
Hasnabad	16.67	83.33	-	-	100

To explain the intensity of forest dependence we classified the use of forest into four categories – single use, double use, triple use, and more than three uses. Block-wise percentage for forest use reveals that in Gosaba, Basanti, Hingalgunj, and Hasnabad a significant number of people depends on forest and use the Sundarbans either for a single purpose or for double purposes. In Gosaba, though the dependence on forest for single and double purposes is very high, the use of forest for three or more than three purposes is not negligible (15-18.5 per cent). In Hingalgunj (7-20 per cent) too, the nature of dependence is the same. In Basanti and Hasnabad, however, the nature of dependence is mostly for single and double purpose uses. Very few respondents from Basanti use the forest for three or more purposes and none of the respondents from Hingalgunj is in this category.

The Table reflects the intensity of dependence of our sample respondents on the Sundarbans biosphere reserve. Absence of alternative productive and gainful options may push the inhabitants into abject poverty the forest becomes gradually denuded and/or entry into it is restricted. The situation necessitates that the policy-makers and rulers appreciate the desperation of the poor people of Sundarbans and design a comprehensive forest management policy.

4.4.3 Item-wise Collection and Valuation

If we take a look at the nature of average collection and valuation of different resources across the blocks (Table 4.7) we find that average fuel wood collection is highest in Gosaba block with an average collection of 680 kg per year which is roughly 11 times more than Basanti and is equal to Hingalganj where the average collection is 650 kg. Average income from fuel wood in Gosaba (Rs 686.54) is more than 10 times that of Basanti and slightly higher than Hingalgunj. In our sample, Hasnabad does not report any fuel wood collection. Average earning from wood other than fuel wood is the highest in Gosaba (Rs 638) followed by Basanti (Rs 318.6) and Hingalgunj (Rs 261.7) in descending order. Once again Hasnabad does not report collection of wood other than fuel wood.

Average fish collection in Hasnabad is the highest (325.5 kg) followed by Gosaba with an average catch of 161.3 kg. Average catch in Basanti and Hingalgunj is much less compared to the other two blocks with an average catch of 87.9 and 49.2 kg respectively. Hasnabad, however, occupies the highest rank in terms of average earning from fish (Rs 9768.97), which is significantly higher than Hingalgunj (Rs 1750) and Basanti (Rs 2650.85). Gosaba though ranks second among the blocks with average earning of Rs 4392.24 from fishes still lags far behind Hasnabad.

Honey collection in Basanti and Hingalgunj is almost the same at an average of 12 kg each. Gosaba reports a slightly higher collection (15 kg) compared to the two blocks above. Hasnabad, on the other hand does not figure in honey collector's list. Average earning from honey is, however, highest in Basanti (Rs 698.9), which is, almost Rs 218 more than Gosaba's average (Rs 482.90). Hingalunj's average is much less at Rs 398. Possible reason for this discrepancy could be the greater presence of non-permit holding honey collectors in Basanti. These honey collectors sell their produce to private traders who offer a higher price compared to prices offered by the Forest Department – the prices at which the permit holders are bound to part with their collection.

It is difficult to conclude from our field study whether any steady decline or increase is associated with this activity because the very nature of the activity presupposes certain chance factors in locating the place and trees in search for honey hives.

Table 4.7 Block-wise Item Collection and Valuation (at current prices)

Block	Item	Tc	Ac	Tv	Av	Nr
Gosaba	F.W	163275	680.31	144174	686.543	70
	Fish	33877	161.32	922370	4392.24	109
	Honey	3133	14.92	101400	482.857	35
	Shrimp	7777000	37033.3	1319200	6281.9	159
	Crab	6797	32.36	149678	712.752	41
	O.W			133970	637.952	14
Basanti	F.W	3700	62.7119	4100	69.4915	2
	Fish	5188	87.9322	156400	2650.85	28
	Honey	720	12.2034	41240	698.983	10
	Shrimp	1337000	22661	232300	3937.29	46(96)
	Crab	3360	56.9492	85800	1454.24	17
	O.W			18800	318.644	3
Hingalgunj	F.W	39000	650	35180	586.333	36
	Fish	2950	49.16667	105000	1750	17
	Honey	720	12	23880	398	12
	Shrimp	1690000	28166.67	557200	9286.67	54(133)
	Crab	1120	18.66667	12000	200	8
	O.W	0	0	15700	261.667	2
Hsanabad	F.W	0	0	0	0	0
	Fish	9440	325.5172	283300	9768.966	28
	Honey	0	0	0	0	0
	Shrimp	336000	11586.21	134900	4651.724	25(28)
	Crab	0	0	0	0	0
	O.W	0	0	0	0	0

Tc = Total collection, Ac = Average collection, Tv = Total valuation, Av = Average valuation, Nr = Number of respondents, OW = other wood

Average shrimp collection in Gosaba is highest at 37033 pieces followed closely by Hingalgunj where the average stands at 28167 pieces. Basanti and Hasnabad stand distant third and fourth with average catch of 22661 and 11586 pieces respectively. Average earning from shrimp collection is the highest in Hingalgunj (Rs 9288.70) followed by Gosaba (Rs 6281.90), and Hasnabad (Rs 4651.70). Basanti, on the other hand, reports rather low average earning at Rs.3937.27. Many respondents from the villages in Basanti had reported a drastic fall in shrimp fry sale proceeds because of excess supply. To them, paradoxically, though collection has improved over the years, standard of living has not improved.

In our findings from the field survey, prawn larvae collection stands out as the single most important activity with largest number of people engaged in it. It corroborates the secondary information sources, which also claim the same. As far as the destruction of other species, in the process of collection of prawn seeds is concerned, the respondents, as expected, could not provide any quantitative estimate. However, most of the respondents but a few conceded that a fairly large number of other species are destroyed.

Hasnabad does not feature in the crab map. Average crab collection is highest in Basanti (56.9 kg) followed by Gosaba (32.36 kg) and Hingalgunj (18.7 kg). Average earning is also highest in Basanti (Rs 1454.24) followed by Gosaba (Rs 712.80) and Hingalgunj lying low with Rs 200.

Among the blocks we surveyed, Hingalgunj, Basanti, and Gosaba figure prominently as far as the large presence of crab fisheries is concerned. This is quite in agreement with the official findings. Beyond this any comparison about the macro level findings and micro survey results about average catch and average earning in terms of time spent in the activity by a single individual is not possible because of two reasons:

1) The Rapid Survey report does not come out with any information on actual time spent by an individual, but mentions only catch per day/per individual.

2) Since the Rapid Survey was carried out in 1988-'89, the sale price data has become dated.

Our findings are the following: 82 kg, 81 kg, and 52 kg are collected per month by a single individual in Hingalgunj, Basanti, and Gosaba respectively.

If the catch can be distributed evenly as per the Rapid Survey information, the respective figures for Hingalgunj, Basanti, and Gosaba are 150 kg, 210 kg, and 185 kg. This is much higher than what we have found. Though no definitive comment is possible, it may be put forward as a hypothesis that crab availability has declined over the years in the three blocks concerned. It is also worth mentioning that distance travelled has increased for our respondents over the past five years.

4.4.4 Item-wise Average Distance Travelled, Average Time Spent, and Average Cost for Journey to Forest

We get an idea about item-wise average distance travelled, average time spent, and average cost incurred (Table 4.8) in these operations by the sample respondents belonging to five different blocks. The respondents belonging to selected sample villages in Sandeshkhali I and II reported no dependence on forest for any items as described in Table 4.4. Hence, Blocks Sandeshkhali I and II are excluded from the tabular presentations.

Table 4.8 Item-wise Average Distance Travelled, Cost Incurred, and Time Spent per Respondent

Block	Item	Average distance travelled (at present) km	Average distance travelled (five years back) km	Average time spent (in month)	Average cost per respon-dents (in Rs)
Gosaba	Fuel Wood	2.61	1.59	0.44	150.00
	Fish	13.94	7.43	4.14	1317.78
	Honey	8.80	7.56	1.03	451.52
	Prawn Larvae	2.09	1.23	5.30	247.80
	Crab	14.68	8.97	3.23	1940.00
	O.W.	6.75	2.00	1.00	220.00
Basanti	Fuel Wood	11.00	-	1.00	-
	Fish	21.15	9.30	4.06	3784.6
	Honey	23.83	11.00	1.54	916.67
	Prawn Larvae	6.40	4.81	3.83	852
	Crab	17.87	10.47	2.43	2410
	O.W.	-	-	-	-
Hingalgunj	Fuel Wood	6.48	0.37	0.62	210.00
	Fish	22.55	4.33	3.64	2372.73
	Honey	23.50	2.40	0.88	600.00
	Prawn Larvae	14.01	4.97	5.48	1224.1
	Crab	14.72	4.20	1.70	1200
	O.W.	-	-	-	-
Hasnabad	Fuel Wood	-	-	-	-
	Fish	22.00	5.50	5.00	3550.50
	Honey	-	-	-	-
	Prawn Larvae	32.00	35.50	6.00	3240.40
	Crab	-	-	-	-
	O.W.	-	-	-	-

It clearly emerges from the Table 4.8 that in all the blocks average distance travelled (in km) by the sample respondents at present is greater than the distance they generally covered five years ago for all the items in question. However, the increase in distance travelled at present varies across the blocks and within items. Increase in distance travelled for fishing is significant for all the blocks showing manifold increase. In Gosaba, however, there is not much of a change in this respect. In case of Prawn larvae, rise in distance travelled in Hinglgunj is noticeable, though in three other blocks increase is barely significant. One special feature to be noticed for Hasnabad is that the people from this block travel much greater distance for prawn larvae collection compared to other blocks, which implies that their operations are carried out in the creeks and rivers inside the forest.

Distance travelled for fuel wood collection has registered a significant increase in Hingalgunj, whereas in Gosaba it shows no major change. Though no response is available on this count from Basanti, people from this block happen to travel the longest distance, among the blocks, for fuel wood collections. However, read with other field information it may be surmised that people in Basanti use fuel wood collection for domestic purposes – makes two or three sojourns a year with no direct monetary cost involved. In case of wood other than fuel wood, information is scanty with no definitive response available from Hingalgunj and Basanti with Gosaba reporting only a marginal increase in distance travelled. It may, however, be conjectured that in Hingalgunj and Basanti no separate visit is undertaken for the collection of wood other than fuel wood. Both fuel wood and other wood are collected simultaneously. Distance travelled for crab catching has also increased in all the three blocks where such activities take place with Hingalgunj reporting the largest hike.

4.4.4.1 Cost and Time Spent

The most costly activity turns out to be fishing, which also involves maximum travelling and time spent except for Hasnabad, where prawn larvae collection involves maximum travelling and time spent. In general, the observed trend is that average cost rises with increase in distance travelled and time spent for all items.

Possible Explanations

Is this for the destruction and/or degradation of mangrove forest that distance travelled and hence operational costs have increased? Looking from this angle, Hingalgunj seems to be the most affected in the past five years. The pattern is also visible in Basanti and Gosaba, but to a lesser extent. Hasnabad's basic dependence for fish and prawn larvae collection was in adjacent

Ichamati and Raimangal rivers within 5 km. However, they are reportedly now travelling far ahead. It may then be surmised that those two rivers are no more that productive and hence there has been manifold increase in distance travelled and cost incurred. It should be mentioned that many people travel from Hasnabad to far off places like Namkhana, Kakdwip, Digha, etc., during the winter season to participate in winter bag-net fishing in the temporary settlements or *khutis* for a monthly salary.

There is, however, a caveat. The increase in distance travelled and the consequent hike in cost has been necessitated by declaration of core area that prohibited access to some forest areas. A number of respondents from Gosaba, in particular, reported that they have to travel in a roundabout way, bypassing forest blocks within the core area, for harvesting. They also complained of shortage of government permits.

4.4.5 Collection and Standard of Living

The Table 9 shows the perceptions of the respondents regarding change in collection and standard of living in their areas during the past five years. Firstly, regarding the question of collection over the last five years, 12.99 per cent of the total respondents did not make any comment; whereas regarding the question of standard of living 99.26 per cent of the total respondent made some remarks (i.e., only 0.74 per cent of the total respondents had no comments about it).

Table 4.9 Perception about Collection and Standard of Living of the Respondents

Perception	Collection during the last five years (%)	Status of standard of living over the last five years (%)	Total Respondents
Improved	11.27	58.33	408
The Same	27.70	7.11	
Declined	48.04	33.82	
Sub Total	87.01	99.26	
No Response	12.99	0.74	
Total	100.00	100.00	

Secondly, on the question of collection, only 38.97 per cent people had suggested that collection had either improved or remained the same over the past five years, whereas 48.04 per cent people opined that collection had been declining during the period. The percentage of the total respondents who felt that their standard of living had been improving or remained the same over the past five years is 65.44. Only 33.82 per cent people commented that their standard of living had been declining during the same period. These findings provide us with some clues about the socio-economic characteristics of the rural Sundarbans. Such rather contradictory perceptions of the respondents may be explained in following terms.

a) Reduction of soil salinity, introduction of improved method of farming, use of fertiliser, etc., have resulted in increase of output per hector in some villages and hence the feeling of improvement in standard of living for some people in some areas.
b) Widespread activity of shrimp fry collection and ready cash flow from that may have also contributed to the feeling of well-being.
c) Though collection of different items from the forest has been declining and people now travel more than that of five years ago to collect the same items (whether the quantity has remained same as five years ago or not is unclear), but they obviously receive better price compared to previous years, which in turn makes them better off. It may be conjectured that the rural poor now has become organised and enjoys some bargaining power to make smart gain for their produce, which, in turn, results in improvement in the standard of living of the rural poor.

4.4.6 Purpose for Seasonal Immigration

As far as the immigration to the sample villages are concerned, catching shrimp fry attract many immigrants for its abundant availability and scope for earning quick bucks. As a purpose of immigration box honey collection stand second with 18 per cent being involved in it. Though box honey collectors are attracted it is to be noted that the present technology used in the box honey collection is beyond the means of the rural poor. Hence, the beneficiaries from these activities are well-off people from outside. Catching fish is the third choice for the immigrants (13 percent). Of the immigrants, 7 per cent carry out miscellaneous activities like crab catching, boat repairing, etc (Table 4.10).

Table 4.10 Purpose of Seasonal Immigration

Immigration	Purpose								
	Shrimp fry netting		Box-honey collection		Fish catch		Crab		No of respondents
	No.	%	No.	%	No.	%	No.	%	408
	129	32	75	18	54	13	28	7	

4.4.7 Availability Status of Tree and Fish Species

Table 4.11 describes the availability of trees and fishes in the Sundarbans according to the perceptions of our respondents. According to them, *Sundari* is the most endangered tree species among all. Of the sample respondents, 42.6 per cent report that the tree is not available at present. In aggregate, 49.9 per cent respondents report that the tree is either less available (7.3 per cent) or not available (42.6 per cent) in the corresponding sample area. The second most scarce tree species, according to the sample respondents is *Dhundul*. Approximately 37 per cent of the total respondents report that the tree is either less available (30.8 per cent) or not available (6.3 per cent) at present. *Pasur*, the other important tree species has also become scarce now, and 34.7 per cent of the total respondents suggest that the tree is very much less available (34 per cent) at present. Beside these, *Tara*, *Garjan*, *Keora,* and *Garan* are the other important tree species, which have also been reported as scarce species. All together, 16.42 per cent, 11.51 per cent, 6.37 per cent, and 6.37 per cent of the total respondents corroborate this view in each case.

Table 4.11 Availability Status of Trees and Fish Species

Trees	**L.A**	**%**	**N.A**	**%**	**Fishes**	**L.A**	**%**	**N.A.**	**%**
Sundari	30	7.35	174	42.64	Boal	11	2.69	169	41.42
Genwa	2	0.49	0	0.00	Hilsa	33	8.08	7	1.71
Garan	18	4.41	8	1.96	Paira	16	3.92	1	0.24
Tara	57	13.97	10	2.45	Med	23	5.63	26	6.37
Pasur	139	34.06	3	0.73	Pangas	48	11.76	60	14.70
Garjan	31	7.59	16	3.92	Kan	29	7.10	0	0.00
Keora	10	2.45	16	3.92	Naina	12	2.94	48	11.76
Dhundul	126	30.88	26	6.37	Dantne	15	3.67	0	0.00
					Jaba	22	5.39	3	0.73
					Sele	17	4.16	18	4.41
					Nadosh	4	0.98	89	21.81
					Chingri	23	5.63	0	0.00
					Bhetki	32	7.84	3	0.73
					Bhangar	90	22.05	0	0.00
					Leta	37	9.06	3	0.73
					Bhola	16	3.92	2	0.49
					Shoal	24	5.88	3	0.73
					Parse	24	5.88	0	0.00

N.A. – Not available, L.A. – Less available

Among fish species, the scarcest species according to the respondents is *Boal*. About 41.4 per cent of the total respondents suggest that the species is not available at present in the corresponding sample area. The proportion of those who supported the view that the fish is less available at present comes to 2.7 per cent. The second most threatened fish species (as revealed in Table 4.11) is *Pangas*. All together, 26.5 per cent of the total respondents report that the species is either less available (11.8 per cent) or not available (14.7 per cent) at present. It indicates that the availability of these species is gradually declining in the corresponding sample area. The respondents (21.8 per cent) also report *Nadosh* as the other important endangered fish species in the Sundarbans. According to the sample respondents, the availability of *Bhangar* is also declining. Those who feel that this fish species is less available in the survey area are 22 per cent. Besides these, *Naina*, *Med*, *Hilsa*, *Leta,* and *Sele* are the other important fish species, which are also reported scarce by the respondents. In total 14.7 per cent, 12 per cent, 9.7 per cent, 9.7 per cent, and 8.5 per cent of the total respondents support it. In this context, it should be noted that though we received very few responses about some other important fish species (*Bhetki, Shoal, Bhola, Chingri, Kan*, etc), in general, many respondents informed us that these species too have become 'rare', possibly either due to over-catch of such fishes or pollution of water resource in which they are born and reared.

We make the following observations from the brief description above about the availability of some important trees and fishes in Sundarbans in the opinion of the sample respondents.

Among trees, *Sundari*, *Pasur*, and *Dhundul* are the most endangered species since a significant number of the total respondents support the view that these species are either less available or not available in the sample area.

Besides the above three, *Tara*, *Garjan*, *Keora*, and *Garan* are the other tree species, which are gradually becoming scarce in the area.

Among fishes, *Boal* is the most endangered species followed by *Pangash*, *Bhangar,* and *Nadosh*. Some of the respondents reported that fish species like *Hilsha*, *Naina*, are also scarce.

Though very few responses were received about the availability of *Bhetki*, *Bhola*, and *Chingri,* etc., some people in this region told us that these species too have become rare.

4.4.8 Annual Expected Benefit Had There Been Free Access to Forest

Table 4.12 Annual Expected Benefit Had There Been Free Access to Forest

Item could be Collected	Total quantity Expected (kg)	Total Value (at current price)	No. of respondents	Average Value (Rs)
Timber	45190	1322135	129	10249.10
Fuel wood	453300	416210	182	2286.87
Fish	47878.5	1474185	152	9698.59
Prawn Larvae	3400000*	452000	39	11589.74
Honey	11513	313840	114	2752.98
Golpata	13185	42600	13	3276.92
Crab	39137	672380	127	5294.33

* In units of pieces

From Table 4.12, we get some indicative information about the perceived annual benefits from the forest of 238 respondents (out of total sample size of 408) had there been free access to the forest. It seems that the respondents have a high discount rate reflecting a preference for the present benefits sacrificing future potential benefits and they want to gather different items from the forest as much as possible at present. Here most people want to collect fuel wood, timber, fishes, crab, and honey from the forest as much as possible. Their stated expected benefit from the forest in terms of expected market value of different items (which they expect to derive) is Rs 4693350 (annually). Therefore per head benefit in this case would be Rs 19719.96 (annual).

The per-head expected benefit obtained from the above Table is therefore Rs 19719.96. On the other, the actual benefit, which the respondents derive at present, is Rs 12504.45. The Table showing actual valuation of present benefit, block-wise, is given below (Table 4.13).

Table 4.13 Item Collection for All the Blocks (Valuation in Total)

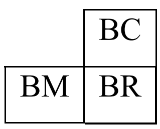
Total Respondents: 358

Block Item	**Block-wise Total Value (Rs)**				
Item	Gosaba	Basanti	Hingalgunj	Hasnabad	Total
F.W.+ O.W.	278144	22900	50880	0	351924
Fish+Shrimp+Crab	2391248	474500	674200	418200	3958148
Honey	101400	41240	23880	0	166520
Total	2770792	538640	748960	418200	4476592

If we distribute evenly these two types of benefits over the population of the sample blocks, as per Census 1991 (6602 persons) engaged in livestock, forestry, fishing, hunting and plantation, and orchards and allied activities then the corresponding figures would be Rs 130191175.9 and Rs 82554378.3 respectively. These figures may be shown in tabular form in the following way.

Zones Considered	**Total Expected Benefit (annually) at current prices (Rs)**	**Total Actual Benefit (at current prices) at present (Rs)**
Considering (Core + Manipulatioin + Restoratioin) Zone	130191175.9	-
Only (Manipulation + Restoration) Zone	-	82554378.3
Core Zone	47636797	-

The above sketch can be represented by the following diagram as well:



BM => Benefits from Manipulation Zone
BR => Benefits from Restoration Zone
BC => Benefits from Core Zone

Based on the expected benefits of the respondents excluding the agricultural zone we capture all the remaining areas of the Sundarbans Biosphere Reserves. From the Table we get

B (M+R+C) = Rs 130191175.9

On the other hand, at the time of computing actual benefit we consider only B (M+R):

B (M+R) = Rs 82554378.3

Therefore, the contribution of the core area to the benefits of the respondents is expected to be BC = Rs 47636797. It should be noted that there is no reason to assume that the respondents derive such benefits from the core area only. Respondents may derive part of these benefits from M and R areas as well. But there is no doubt that a substantial portion of these benefits are expected to come from the core area, since at present respondents can operate in M+R areas only and thus they have very few expectations about additional benefits from these zones. Thus, if we consider BC = Rs 47636797 then the expected benefits from the core area would be around Rs 28022 (Rs 47636797/1700 = Rs 28021.6) per annum/ sq. km.

If, instead of the sample blocks, we distribute evenly two types of per head benefits as above over the population of the Sundarbans in aggregate (25915 persons as per Census 1991) engaged in similar activities then the corresponding figures associated with expected and present benefits would be Rs 511042763.4 and Rs 324052821.8 respectively. Hence, in this case

B (M+R+C) = Rs 511042763.4,

B (M+R) = Rs 324052821.8,

and so BC = Rs 186989941.6 per annum.

Therefore, if we consider the total population of the Sundarbans engaged in livestock, forestry, fishing, hunting and plantation, and orchards and allied activities then the expected benefits from the core area would be Rs 186989941.6/1700 = Rs 109994.1 or, around Rs 109994 per annum/ sq. km.

Per head benefits, which could be derived from the forest, is important to us because if people were being denied free access to the forest then the beneficiaries would be compelled to sacrifice these benefits. This provides a hint that we have to design some institutional mechanism to implement successful forest management policy that will provide benefits that should be greater or equal to the benefits, which they expect to receive from the forest. Table 4.12 indirectly corroborates the fact of high dependence of the people of Sundarbans on the mangrove forest resource for survival. This issue will be taken up in the next section.

4.5 Institutions, Policies, and Conclusions

Between 1860s and '70s the then British Government felt the need for establishing a forest department in order to systematise felling operations as also to enhance revenue from the forest. The first Forest Act was enacted in 1865, which was given the final shape by 1927. The Act established monopoly control of the Forest Department over most of the forest lands save the forests owned by the *zamindars*. The act remained in vogue almost in the same shape till early 1970s; prior to 1972 there was no wildlife protection or management act in operation. However, from the early 1970s a series of acts were passed for wildlife protection and management of forest. Prior to 1980 management in Protected Areas meant protection works and creation of fire lines glades, water ponds, watchtowers, and tourist lodges. Commercial forestry operations were common in most of the protected areas. The issue of forest people's welfare was never in the agenda of the forest department. The importance of involving people, who enjoyed free access to forest prior to the enactment of the Forest Act, was not considered and they were the first of the casualties of the act, for a long time.

However, glaring failures in the field of conservation belatedly ushered in the perception of the official circles in the 1970s. Thanks to the success of experiments made in now famous Arabari in the district of Medinipur (West Bengal), the Government started tinkering with the idea of ensuring people's participation in the conservation and the management of forest. Again it took another 20 years for the government to come up with a semblance of institutional design that would make the participation of people possible and practicable. Lack of such thinking, in the meanwhile, spelt the doom for another pious idea, i.e., 'social forestry' that was taken up in the 1980s.

National Forest Policy-1988 woke up to the idea of making people a part of the forest policy and stressed the need for reorientation of forest use policy according priority to the needs of primary stakeholders, i.e., people within and around the forest. Finally, in 1990 following a Government of India order, provision was created for Joint Forest Management (JFM) through the creation of Forest Protection Committees (FPCs). Again by a Government order in June 1996, resolutions for formation of Eco-Development Committees (EDCs) in and around national park and wildlife sanctuaries was undertaken. FPCs are for the people living in the fringe areas of the forest and EDCs are for the people living within the wildlife areas.

Officially (Vyas, 2001) there are 32 FPCs involving 12084 families who are responsible for protecting 57162 hectares of forest. Similarly 14 EDCs have been constituted involving 4283 families who are in charge of protection of 200070 hectors of forest. As a matter of privilege and compensation for the villagers' effort and sacrifice the FPC members are given access to free collection of NTFPs. The EDC members, however, do not enjoy usufruct rights. The thrust in EDCs is on generating implanting income and implementing micro-plans.

Certain claims of success are made officially about the efficacy of these institutions in providing incentives to their members in order to restrain them from accessing forests. The programmes include some income-generating activities, material benefits, construction works, tree plantation, etc. Reportedly in some FPC areas concepts of 'self-help group' and 'revolving fund' have made a promising beginning.

In our sample areas where the survey was carried out, two FPCs and five EDCs exist in paper. Our aim was to rudimentarily verify the existing state of functioning of these sets of institutions, awareness of the people about the rules and norms of these institutions as also the activities undertaken by these institutions over a span of past five years.

Table 4.14 shows that awareness about EDCs' existence is completely absent in two FPCs – Hemnagar and Kalitala/Perghumti in Hingalgunj Block. The two FPCs were constituted in 1998 and 1999 respectively and membership still remains stagnant at the official minimum of seven. In other words, after the constitution of executive committees three and two years back, nothing has come about in the shape of involving people for taking up any activity. Among the five EDCs, villages of Lahiripur/Chargheri report nearly 100 per cent awareness about the existence of EDC in their area. Awareness about the existence of EDCs is pretty high in Sonagan (77 per cent) and Pakhirala (80 per cent). However, in Amlamethi the awareness is only 40 per cent and in Lahiripur / Santigachi it is a poor 13 per cent. Awareness about norms of EDC presents a mixed bag, while Pakhirala and Sonagan's awareness about the norms shows around 65 per cent of the respondents in positive light. In Lahiripur / Chargheri awareness of norms is 73 per cent. However, in Lahiripur-Santigachi awareness about EDCs' existence is at an abysmal low of 7 per cent. Awareness on other counts is insignificant. Amlamethi reports a very low 10 per cent awareness in this respect. Ironically, in Amlamethi as high as 37 per cent of the respondents are aware of EDCs' general activities and 20 per cent received some personal benefits. A possible reason for lack of awareness about norms of EDCs in Amlamethi may be found in the failure of EDCs executive committee to actively try and involve people. Many a respondent reported that some executive members operated in close liaison with the forest department personnel and they kept the general members and the people at large in the dark about meetings or proceedings. The particular EDCs were formed in 1992, but even by the end of 2001, only less than half of the total families have become members. The EDC functionaries admit that meetings are held irregularly. The same is true for Lahiripur.

As for the other three EDCs, Lahiripur / Chargheri reports a very high percentage of awareness about general activities of EDCs (97 per cent) and about 87 per cent of the respondents received some personal benefits. Pakhirala EDC also reports a very high 80 per cent and 63 per cent respectively on these two counts. Sonagan shows a reasonable performance on these counts at 77 per cent and 67 per cent respectively.

It may be summed up from the observations made above that only three out of seven FPC/EDC are functioning, at least, in the nominal sense. However, one distressing factor to note is that even in the functioning EDCs general membership has stagnated at a very low level. Even in EDCs like Pakhirala and Sonagan general membership is about 60 per cent and 45 per cent of the total number of households respectively and that too after almost a decade of their existence.

Compensation in terms of community and individual benefits provided do not appear to be anywhere near substantial to generate enthusiasm among people to participate actively in the activities of FPCs/EDCs. We have already noted that the three PCs under our preview are either defunct or non-functional. The EDCs, which are functioning, have reported certain activities at the community level but restricted only to digging canals or ponds, providing for street solar lights in some stretches, metal links in some portions of roads as well. Private benefits are restricted to distribution of saplings and smokeless *chulah,* which are grossly inadequate to compensate for perceived loss arising out of restrictions imposed on free access to forest produce.

Agents (like most mangrove forest dependent population of the Sundarbans) who live close to their subsistence level and have no alternative income earning opportunities, are concerned that the income they derive from the exploitation of the resource meets their subsistence requirement in each period. If conservation of the mangrove involves an unacceptable level of access constraint, subsistence constraint may drive alienated people to draw down the resource to a shut-down point. It will be more so if the resource (like the wetlands of Sundarbans) is almost a free access resource. To put it in another way, conservation is costly in terms of foregone benefits (if not in terms of conservation expenditure). If the conservation strategy implies less access and use of a resource and in the process, violation of subsistence constraints, people can hardly be expected to adopt conservation strategy though it may be very rewarding in the long run.

Table 4.14 Awareness about FPC / EDC

Name of the Village	Question	No. of Respon-dents aware of it	%	No. of Respondents unaware of it	%
[Gosaba] Pakhirala E.D.C.	Awareness about E.D.C	24	80	6	20
	Norms of E.D.C.	19	79.16 (63.33)	5	20.84 (16.67)
	Awareness about E.D.C's general activities	24	80	6	20
	Personal benefits received *Note: 2 respondents unaware about EDC/FPC but receive benefit*	25	104.2 (83.33)	1	4.17 (3.33)
[Gosaba] [Amlamethi] E.D.C	Awareness about E.D.C.	12	40	18	60
	Norms of E.D.C.	3	25 (10)	9	75 (30)
	Awareness about E.D.C's general activities	11	91.67 (36.67)	1	8.33 (3.33)
	Personal benefits received	6	50 (20)	6	50 (20)
[Gosaba] [Sonaga] E.D.C	Awareness about E.D.C	223	76.67	7	23.33
	Norms of E.D.C.	20	86.96 (66.67)	3	13.04 (10)
	Awareness about E.D.C's general activities	23	100 (76.67)	0	0
	Personal benefits received Note: 1 *respondent unaware about EDC/FPC but receive benefit*	20	86.96 (66.67)	4	17.39 (13.33)
[Gosaba] [Lahiripur/Santigachhi] E.D.C	Awareness about E.D.C	4	13.33	26	86.67
	Norms of E.D.C	2	50 (6.67)	2	50 (6.67)
	Awareness about E.D.C's general activities	4	100 (13.33)	0	0
	Personal benefits received	3	75 (10)	1	25 (3.33)
[Gosaba] [Lahiripur/ Chargheri] EDC	Awareness about E.D.C	29	96.67	1	3.33
	Norms of E.D.C	22	75.86 (73.33)	7	24.14 (23.33)
	Awareness about E.D.C's general activities	29	100 (96.67)	0	0
	Personal benefits received	26	89.66 (86.67)	3	10.44 (10)
[Hingalgunj] [Hemnagar] F.P.C	Awareness about F.P.C.	0	0	0	0
	Norms of F.P.C.	0	0	0	0
	Awareness about F.P.C's general activities	0	0	0	0
	Personal benefits received	0	0	0	0
[Kalitala/ Perghumti] F.P.C	Awareness about F.P.C.	0	0	0	0
	Norms of F.P.C.	0	0	0	0
	Awareness about F.P.C's general activities	0	0	0	0
	Personal benefits received	0	0	0	0

Figures in the parentheses indicate the percentage with respect to the awareness about E.D.C and F.P.C

The effect of a rise in output prices (e.g., shrimp, prawn, timber, etc., in this case) may generally increase the value of foregone benefits resulting from conservation. Depending on site-specific biophysical conditions, foregone benefits and discount rate, upward movement of price may generate incentives to degrade the resource. The extensive participation of poor people in the trade of prawn larvae all along the Sundarbans bears a testimony to this phenomenon.

In these circumstances public intervention is required to support poor users of wetland mangrove resources so that they may avoid the afore-described low-level equilibrium trap (Baland and Platteau, 1996). In general, subsistence-constraint users have much greater incentives than more well off users to seek to conserve their resource base, since they have limited alternative income sources. In such circumstances, a good ground exists for state interventions that enable these poor users to overcome the initial barrier presented by conservation. The other rational for such interventions is the presence of externalities and market failures.

Our experience based on field survey indicates that in many situations, though not always, co-ordination and leadership problem play an important role in collective resource management through EDCs or FPCs. Subsistence-constrained poor people generally need externally provided economic incentives to be induced to conserve the resource they depend on. External catalytic role by state via local-level institutions (where the stake-holders play the dominant role in decision-making process) can play a significant role here. Even NGOs or political parties can act as catalytic agents. Trust and co-ordination may be created under the impulse of catalytic agents who may even come from outside the resource user community. All these imply that in many situations state intervention could be reshaped to institutionalise collaboration between state and resource users.

There remains yet another dimension of the problem, the absence of 'global markets' in the benefit of mangrove biosphere reserve. Developing countries face major problems of appropriating the global benefits of sustainable use of the Sundarbans. As long as those global values cannot be captured by the host country (and for that matter local users), preservation of biosphere may become a risky venture. The means of appropriation could be resource transfers under conventional aid, transfers under the Global Environmental Facility (GEF), debt-for-nature swaps, etc. It is imperative that such mechanisms be strengthened and added to (Pearce and Moran, 1994).

5 Sundarbans in Bangladesh

Sundarbans, the largest mangrove forests of the world, is a protected area since 1927 under the Forest Act. Before 1927, many parts of Sundarbans Forest were converted for non-forest uses (like agriculture and settlement). Under the Forest Act, the unsettled area of Sundarbans came under the control of the Department of Forests and no further encroachment was allowed. Until 1989, the forest management was based on both harvest and preservation. Forest products like wood and timber were extracted regularly by the Forest Department from selected areas (excluding three tiger reserves). In 1989, the Government of Bangladesh, to preserve Sundarbans, put a moratorium and now no timber can be legally harvested from Sundarbans.

Sundarbans plays an important role in environmental and ecological processes. Low oxygen mangrove soils play an important role in de-nitrification working as a natural filter by removing toxicants from water and sediment. It also plays an essential role as a buffer in protecting the densely populated agricultural settlements from the aggression of frequent cyclones, tidal waves, and storm surges common in that area.

An elaborate network of rivers, channels, and creeks intersects the Sundarbans forest. These waterways are of various length and width and occupy an area of approximately 175,000 sq. km. The larger rivers passing through the Sundarbans forest before converging with the sea join together and form estuaries at the confluence. There is a significant alliance between the estuarine system of the Sundarbans and its ecology. The characteristics and patterns of the hydrological regimes are the primary determinants of the ecology of the SRF. The coastal mangroves occupy a special ecological niche where saline marine water meets fresh water and where the productivity is dependent on the nutrient rich tidal waters and sediment-laden stream flow from upstream.

5.1 Administration and Management

Administratively, the Forest Department of Bangladesh is the legal occupier of the Sundarbans. It has divided the Forest into two Forest Divisions: Sundarbans East and West Divisions. The West Division comprises of two ranges: Satkhira and Khulna while the East Division also comprises of two ranges: Chandpai and Shoronkhola.

Besides being valuable as a unique ecosystem with many critical functions and consequences on the local environment, the Sundarbans is an important resource base. It is the single largest source of forest produce in the country. Forests, fisheries, wildlife, and water are the mangrove resources of the Sundarbans. Because of the extensive and diverse resource available, the forest generates large-scale employment opportunities. It provides livelihood and employment to an estimated 112,000 people working seasonally as woodcutters, fishermen, honey and wax collectors, golpatta, fuelwood, and grass collectors, shell collectors and in the SRF-dependent industries. Apart from the large number of people employed by contractors in commercial exploitation of trees, the local people themselves are dependent on the forest for necessities such as timber for boats, poles for house-posts and rafters, golpatta and grasses for thatching and matting, fuel wood tannin for fishing nets and food. It is therefore likely that the total employment figure is many times greater, approximately estimated to be 1,200,000.

A reasonably large industrial sector depends on the Sundarbans for the provision of raw materials. Some of the more prominent industries based on the mangrove resource base are the Khulna Newsprint Mill (KNM), the Khulna Hardboard Mill (KHBM), the Dada match factory and a number of sawmills, fisheries industry and fish refrigeration plants, shrimp farms, wood processing, and furniture-making industries. Formal industrial sector employment is likely to be about 10,000 or more.

5.2 The Study and the Methodology

The objectives of the study are (1) to analyse the dependence of the different groups on the ecology of Sundarbans, and (2) to analyse the impact of degradation of Sundarbans on these stakeholders. To achieve these objectives, a questionnaire survey was administered in the impact zones of Sundarbans Forests (north and north-eastern localities) among the various stakeholders. The questionnaire was designed to answer the following questions:

a. What impact (if any) the quality of forest has on their efforts to obtain economic goods from the Sundarbans Forest?

b. What alternative do they have to reduce pressure on the forests?

5.2.1 The Sample – Basic characteristics

To analyse the economics of production from Sundarbans, the survey was conducted among the fishermen, honey collectors, wood, and grass cutters during the months of May-June 2001. A total of 480 samples were collected (Figure 5.1). The questionnaire had several sections: socio-economic profile, community profile, and production and cost profile.

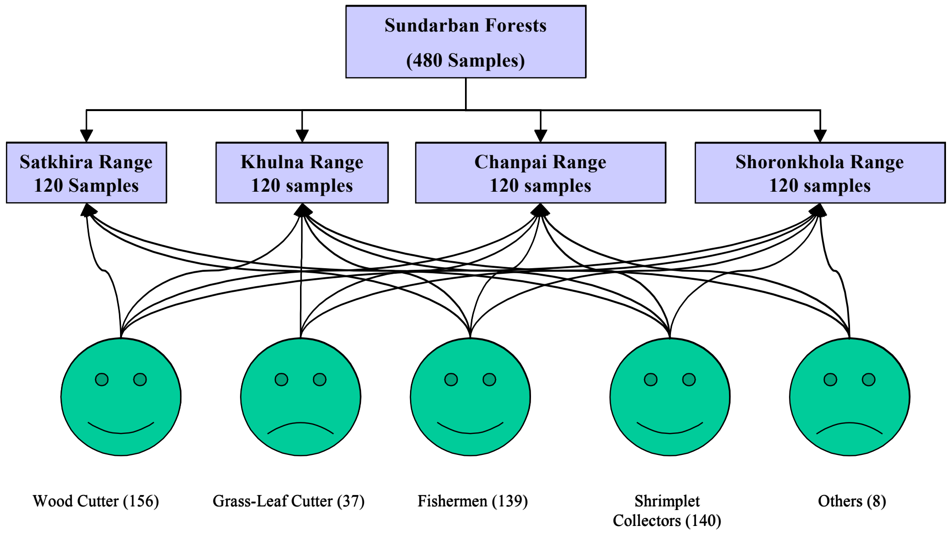


Figure 5.1 The Structure of the Survey

5.3 Economic Goods of Sundarbans

Major economic goods from Sundarbans include fire wood and softwood timber, honey and wax, fish, shrimp and shrimplets, and grass and leaves. Of these, collection of fire wood and softwood were banned since 1989 but the Department of Forests was allowed to collect timber of dead trees (Figure 5.2).

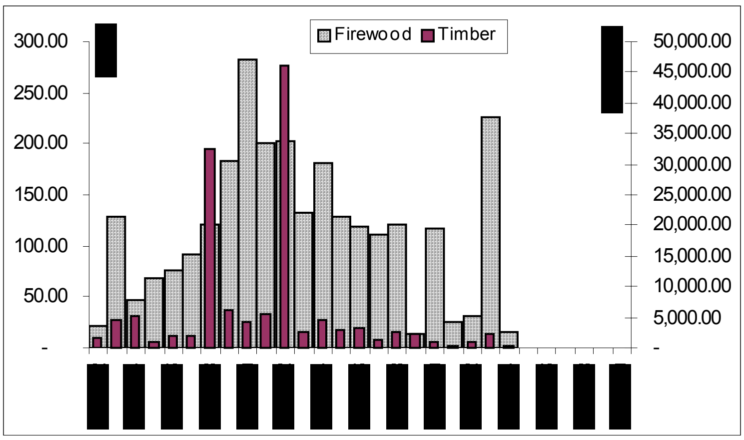


Figure 5.2 Collection of Timber and Fire wood from Sundarbans

However, collection of fish, honey, wax, and leaves are not prohibited in Sundarbans. Government did put a temporary ban on collection of shrimplets from Sundarbans in late 1990s but it was never fully effective (Figure 5.3) because it involved huge cost of policing. Most of the shrimp fry collectors are small-scale fishermen and they live around the Sundarbans areas.

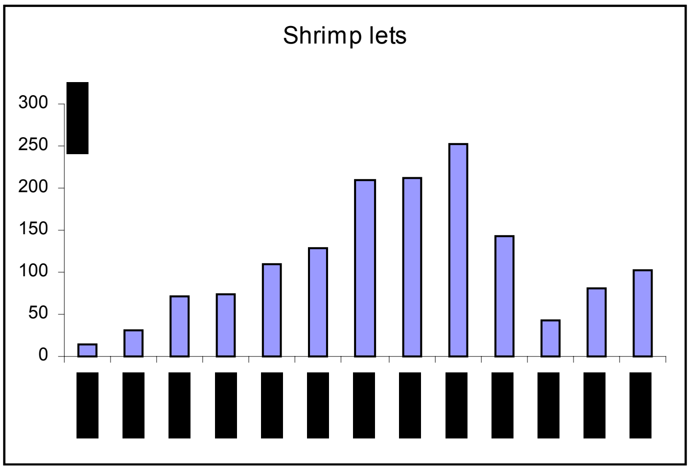


Figure 5.3 Collection of Shrimplets from Sundarbans

Sundarbans forests provide livelihood to nearly millions of people living around the forests (it is illegal to settle inside the forests); the forest itself is rich in biodiversity. Moreover, it protects life and property of millions of people from the crashing cyclones that often hit southern coasts of Bangladesh. Yet, this forest is under tremendous pressure from the people.

Various groups of people regularly visit the forest area to collect the 'goodies'. In return, they pay a token entry fee and royalty at a fixed government rate. There is a widespread belief that the forest is under stress. Evidences from field data shows that the rate of 'unofficial' collection of all kinds of forest products is still continuing and the forest is under threat. Field observations also show that the forest has been deteriorating at a much faster rate in the western zone than the eastern zone.

5.4 Analysis of Socio-economic Characteristics

Survey data were analysed to understand the following socio-economic characteristics of the stakeholders.

5.4.1 Skills and Jobs of the People around Sundarbans

Given the fact that entry into the forest is now severely restricted and since no woodcutting is legally allowed from 1989, we expected that the primary distribution of occupation would be mostly either agriculture or fishing. Table 5.1 presents the occupational distribution of the people living around the forest ranges. It shows that of the respondents, a large majority of the people is still dependent on collection of resources from the forests ie, collection of wood/timber, grass and leaf, fish and also shrimp fry.

Table 5.1 Distribution of primary occupation

% within Forest Range

		Forest				
		Satkhir	Khuln	Chadp	Shoronkhol	Tota
Primar Occupatio	Wood	41.7%	23.3%	27.5%	37.5%	32.5%
	Honey		3.3%		1.7%	1.3%
	Grass-leaf		15.0%	14.2%	1.7%	7.7%
	Boatma				.8%	.2%
	Fisherma	30.0%	28.3%	29.2%	28.3%	29.0%
	Shrimp Fry	28.3%	29.2%	29.2%	30.0%	29.2%
	Agricultural		.8%			.2%
Tota		100.0	100.0	100.0	100.0	100.0

To investigate further into this, Table 5.2 presents the nature of job search in the community. It shows that most of the people living around the Sundarbans look for jobs in fishing and forestry-related activities even after 10 years of moratorium on timber collection from Sundarbans. A total of 174 communities were surveyed for Table 5.2.

Table 5.2 Nature of job search in the community

% within forest Range

	Forest Range				Total
Sales	Satkhir	Khuln	Chadpa	Shoronkhol	
Forestr	4.8%	15.6%	36.5%	41.7%	29.0%
Fishin	76.2%	81.3%	60.6%	50.0%	65.7%
Factory	4.8%				.6%
Transport/Vehic operatio	4.8%				.6%
Other	9.5%	3.1%	1.9%	8.3%	3.6%
Total	100.0	100.0	100.0	100.0	100.0

In terms of the educational background, Table 5.3 shows that most of the people do not have educational level to negotiate jobs in government or non-government offices.[8] This implies that most of them should find jobs in informal sector of the economy as unskilled workers. The duration of occupation in a year shows (Appendix 5.1) that most of people spend more than six months in their primary occupation. Appendix 5.2 presents the length in the occupation by generations. It shows that except shrimp fry collectors, most of the people have been engaged

[8] A minimum of Grade VIII level of education is needed for any office job in Bangladesh.

in their occupation for more than two generations. Consequently, it presents a case with a high degree of rigidity among the people to change professions.

Table 5.3 Educational background

% within Forest Range

Grade	Forest Range Satkhir	Khuln	Chadp	Shoronkho	Total
Grade	17.9	20.2	30.4	7.6	18.8
Grade	10.7	18.0	14.5	24.1	17.4
Grade	26.8	14.6	2.9	8.9	12.6
Grade	21.4	15.7	15.9	20.3	18.1
Grade	5.4	7.9		7.6	5.5
Grade	8.9	3.4	5.8	3.8	5.1
Grade	1.8	3.4	1.4	6.3	3.4
Grade		4.5		2.5	2.0
S.S.	5.4	5.6	2.9	3.8	4.4
Grade	1.8	1.1			.7
H.S.			1.4	1.3	.7
Bachel				1.3	.3
Total	100.0	100.0	100.0	100.0	100.0

It is clear from the distribution of primary and secondary occupations, the Table on job duration that not all of them spend all the 12 months in Sundarbans. Most of them have a second occupation to which they switch during some months of the year. On an average, more than 50 per cent of the people reported a second occupation. The next best choice for job is working as agricultural labourer. Pattern of land use also confirms this. Table 5.4 presents this scenario. It shows that land is predominantly used either for fishing (shrimp farms) or for agricultural uses. In some areas land is not used for housing or settlement implying that settlement in these areas are on public land or outside the vicinity of Sundarbans.

Table 5.4 Pattern of land use (in the areas surrounding Sundarbans)

% within forest range

Natural	Forest Range Satkhir	Khuln	Chadpa	Shoronkhol	Total
Settleme			17.8%	45.8%	15.9%
Farming/Fisheri	100.0	99.2%	78.0%	52.5%	82.4%
Shops/Trad			4.2%	1.7%	1.5%
Total	100.0	100.0	100.0	100.0	100.0

5.4.2 Pattern of Land Use and Migration

Table 5.5 shows that more than 50 per cent of the people of the region migrate out of their current home to search for job elsewhere. People living near Satkhira Forest Range migrate mostly to other rural locations. People from Khulna, Chadpai, and Shoronkhola migrate mostly to urban locations.

Table 5.5 Pattern of out-migration

% within forest range

Do not	Forest Range				Total
	Satkhir	Khuln	Chadpa	Shoronkhol	
Urban	25.0%	25.8%	49.2%	63.3%	40.8%
Rural	43.3%	32.5%	9.2%	12.5%	24.4%
Oversea	5.0%	.8%	3.3%	.8%	2.5%
Total	100.0	100.0	100.0	100.0	100.0

What are the jobs people are searching for? Table 5.6 shows that most of them search for jobs in farms and in the transport sector. In Shoronkhola, some of them are employed in the service sector (in shrimp farms or in other places) and few find jobs in the construction sector.

Table 5.6 Searching for New Jobs in...

% within forest range

Sales	Forest Range				Total
	Satkhir	Khuln	Chadp	Shoronkhol	
Service				25.0%	7.1%
Far	60.9%	51.4%	16.2%	5.4%	32.8%
Forestr	1.1%			1.1%	.6%
Factory			6.8%	14.1%	5.6%
Transport/Vehic operatio	25.3%		52.7%	19.6%	24.5%
Constructio	11.5%	48.6%	20.3%	20.7%	24.1%
Other			4.1%	13.0%	4.6%
Total	100.0	100.0	100.0	100.0	100.0

The present study shows that a large number of people migrate to areas near Sundarbans, during the harvest season.

5.4.3 Extent of Dependency on Sundarbans Resource

It is clear from the discussion above that people living around Sundarbans depend on the resources of Sundarbans. The question is, how strong is their dependence and to what extent it affects the ecology of Sundarbans?

Appendix 5.4 presents the amount of average weekly collection of resources and average depth of travel by people inside the forest to collect these resources by Range. The result shows that to collect shrimp fry, people from Khulna range travel the longest distance of 27.6 km, while people from Satkhira have the highest collection rate per week of 1187 fries a week. Incidentally, the quality of mangrove in Satkhira Range is the worst.

For fish collection, people from Chadpai travels on average the longest distance of 63 km. In terms of collection rate, Khulna and Chadpai people have the maximum weekly collection. In terms of timber collection, people from Chadpai collect the most, nearly 6.9 tonnes a week and people from Satkhira collect the least, nearly 0.6 tonne per week. On the other hand, people from Khulna travel the longest distance to collect timber, nearly 53 km inside Sundarbans. For fire wood collection the result is similar. To collect grass and leaf, a kind of roofing materials for local use, Khulna people again travel the longest distance but the people from Chadpai region collect the maximum volume.

5.4.4 Impact of Degradation of Sundarbans

Sundarbans forest supplies valuable input to the economy of the region. This contribution of Sundarbans may be measured using various methods. Changes in productivity method, relocation cost method, property and land value approaches, are few of them (Dixon, *et. al.* 1994 for more lucid and elaborate discussion on this). In this study, we were interested to find the contribution of Sundarbans in terms of productivity changes. Based on this we want to analyse the institutional arrangements needed to preserve the value of Sundarbans.

5.4.4.1 The Model

Standard production function literature would use a production function where natural resources like Sundarbans Forest Reserve (in land area) would be considered as a vital input. However, since land area of Sundarbans did not change since 1927 (after the enactment of the Forest Act), it appears that no estimate of the contribution of Sundarbans may be found. Mathematically, it is as follows:

$$Q = f(X_1, X_2, ..., X_n, R) \qquad (1)$$

where Q is production, X_1, …, X_n are inputs and R is natural input (free inputs) and since R is constant (area of Sundarbans is constant) in our analysis, R would, therefore, drop out from the equation.

To deal with this, we used the quality of Sundarbans Reserve Forest in this equation. Therefore, our production function would look like the following:

$$Q = f(X_1, X_2, ..., X_n, \alpha) \quad \text{.......} \quad (2)$$

where α is the quality of forests (other notations are same as in equation 1).

Literature on forestry would use density of forests or biomass per acre as the quality of forests. Unfortunately, this is not available for all areas of Sundarbans. However, field information provided a good and a reliable proxy on this.

5.4.4.2 Problems in Estimation

Quality of Forests

Sundarbans forests are divided into four Forest Ranges. These are: Satkhira, Khulna Range, Chadpai, and Shoronkhola (from west to east). Field data suggest that the quality of forest largely depend on access to the forests; and the quality of forests has deteriorated more in the eastern region than in the western region. In the east, the Baleswar River works as a natural barrier. At the same time, link to urban centres from Chadpai and Shoronkhola range areas are not well developed and so the human pressure is far less compared to Satkhira and Khulna forest ranges. After collating all observations, we used dummy variables for each of the ranges as a proxy to capture quality changes.

Production Function or Cost Function?

While collecting field data, it was further revealed that most of the people involved in collection of forest and fisheries resources from Sundarbans could not provide reliable information on the quantity and quality of various inputs they used during production whereas cost and quantity of production data are more readily available. Given this, we estimated a cost function (the dual of the production function) for each product.

5.4.4.3 The Cost Function Approach

Considering the above problems, we estimated the cost functions for four economic goods collected from Sundarbans forests. Cost function for honey could not be estimated owing to lack of data.

In theory, the impact of degradation on the productivity may be captured using a production function approach, where quality of the forest is a variable and time-series data are collected on production, input use, and quality of the forest. The following function:

To estimate this production function, we need time-series data on these inputs. An alternative is to estimate the dual function - the cost function using the cross-section data in the following form:

$$C = f(Q, \alpha) \quad \text{.......} \quad (3)$$

where C is the cost of production, Q is output, and α is the quality of forests.

As mentioned earlier, we have used *Range Dummy Variable* to deal with the quality change in the forests of Sundarbans. The estimated cost functions are:

Cost function for fish harvest

Cost function for fish production is estimated from 149 observations available from the data collected from all ranges of Sundarbans. The estimated function is:

$$C = 3200.06 + 70.21Q - 0.049\,Q^2 + 0.000003\,Q^3 + 9271.46 * D2 + 4617.5\,D34 \quad \text{.......} \quad (4.1)$$

(1.66) (8.21) (-6.24) (6.05) (3.45) (2.11)

$R^2 = 0.496$ N = 149

Where C is cost per season in *Taka*, Q is output per season in maund,[9] D2 =1 for Khulna Range, and D2=0 for other ranges, D34=1 for Chadpai and Shoronkhola Ranges and D34=0 for other ranges. Figures in the parentheses are t-statistic.

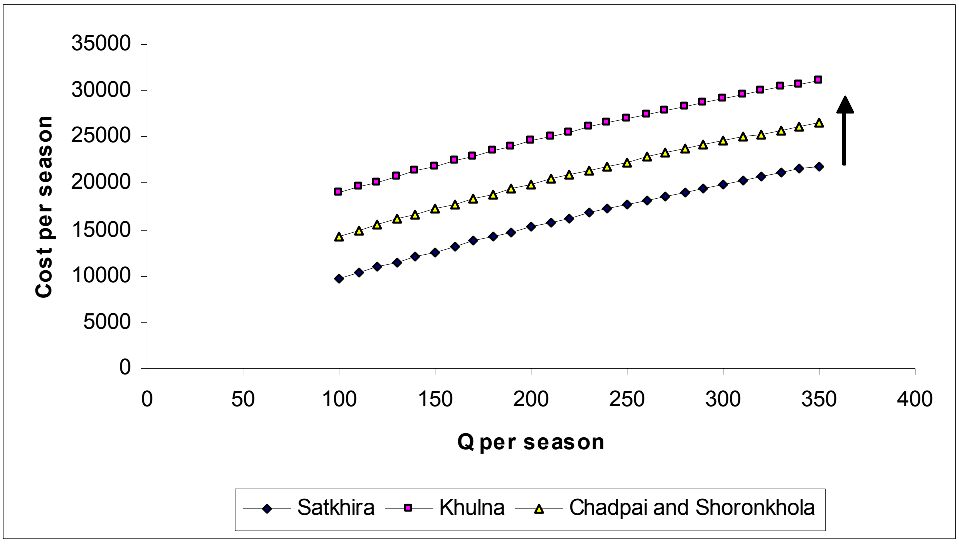


Figure 5.4 Cost Functions for Fish

[9] 1 maund = 37.324 Kg.

We have attempted to estimate the above cost function using range dummy for each range. The range dummy was used as a proxy to account for quality changes between the ranges. It is expected that cost function will shift downward if better quality of forest generates externality to the producers. However, the extent of externality will be different between different production activities. For example, a degraded forest may increase the cost of shrimplet collection, cost of timber collection, and so on. Attempts are being made to estimate these cost functions.

In Figure 5.4, it is clear that Satkhira Range has the least cost of production, Khulna has the highest cost of production, and Chadpai and Shoronkhola ranges have the medium costs of production. However, one should also note that Khulna is predominantly an urban centre and the cost of production is likely to be higher than others. However, when we compare the cost of production between Satkhira range and Chadpai and Shoronkhola ranges, it is evident that a better quality of forests is associated with higher costs of production. According to field data, average cost of fish production per season is around 6458 *Taka*, while average quantity of fish caught during the season is around 1.35 tonnes per team of fishermen, and the market value of these fish is nearly 45,404 *Taka*.

Summarising from above, it may be concluded that a better quality of forests is associated with a higher cost for harvest of fishes. It is unlikely that fishermen would have any economic reason to invest in preservation or protection of the Sundarbans forests. This finding is contrary to the common perception that traditional fishermen would take positive interest in the protection of the forests.

Cost function for shrimp fry collection

Cost function for shrimp fry collectors is estimated from 148 observations available from the data collected from all ranges of Sundarbans. The estimated function is:

$$C = 7543.31 + 0.055\,Q - 7.7\times10^{-8}\,Q^2 + 2.32\times10^{-14}\,Q^3 + 5725.062 * D2 - 3517.85\,D3 - 5809.226\,D4 \quad (4.2)$$

(4.6) (4.46) (-3.89) (3.59) (3.32) (-2.15) (-3.38)

$R^2 = 0.593$ $N = 148$

Where C is cost of shrimp fry collection per season in *Taka*, Q is output per season in number D2 =1 for Khulna Range, and D2=0 for other ranges, D3=1 for

Chadpai and D3=0 for other ranges, D4=1 for Shoronkhola and D4=0 for other ranges. Figures in the parentheses are t-statistic.

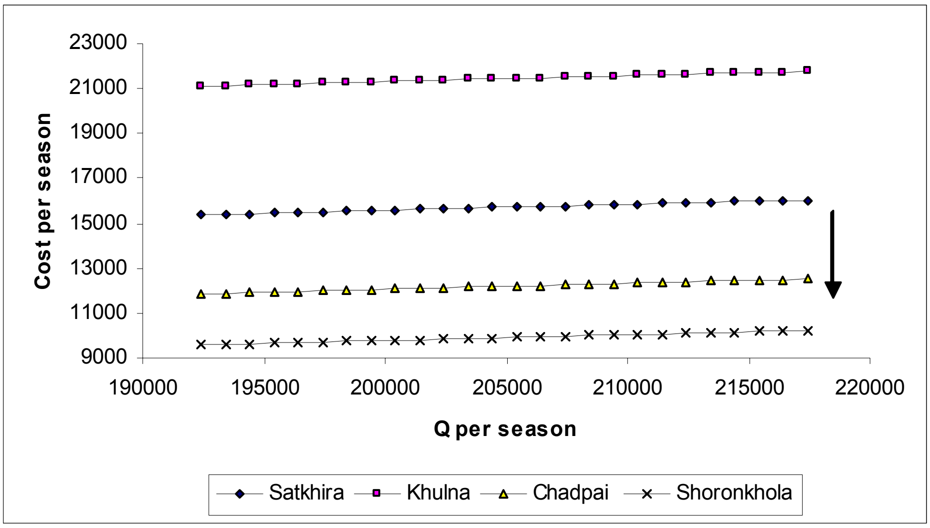


Figure 5.5 Cost function for shrimp fry collection

Cost function estimates for collection of shrimp shows a different picture. In Figure 5.5, it is clear that Shoronkhola Range has the least cost of production, Khulna again has the highest cost of production, but cost of collection of shrimp fry in Chadpai and Satkhira Ranges are higher than the Shoronkhola Range. We should again note that Khulna is a predominantly urban centre and so the cost of production is likely to be higher than others. However, when we compare the cost of production between Satkhira, Chadpai, and Shoronkhola ranges, it is evident that a better quality of forests is associated with least costs of production implying that the positive externalities of dense forests have passed on to the shrimp fry collectors.

According to field data, average collection cost of shrimp fry per season is around *Taka* 3915, while average quantity of fish caught during the season is around 22000 per team of shrimp fry collectors, and the market value of the fry is nearly 17,933 *Taka*.

It may be concluded that a better quality of forests is associated with a lesser cost for collection of fry. So, it is more likely that fry collectors would have some economic reason to invest in preservation or protection of the Sundarbans forests.

Cost function for grass and leaf collection

Cost function for collection of grass and leaf products from Sundarbans forests is estimated from 98 observations available from the data collected from all ranges of Sundarbans. The estimated function is:

$$C = 5236.81 + 2.675\ Q - 0.000731\ Q^2 + 4.38x108\ Q^3 + 7015.07 * D2$$
$$(2.27) \quad (1.28) \quad (-1.84) \quad (2.18) \quad (3.16)$$
$$+ 34211.73\ D34 \ldots\ldots (4.3)$$
$$(8.12)$$
$$R^2 = 0.685, \; N = 98$$

Where C is cost of shrimp fry collection per season in *Taka*, Q is output per season in number D2 =1 for Khulna Range, and D2=0 for other ranges, D34=1 for Chadpai and for Shoronkhola and D34=0 for other ranges. Figures in the parentheses are t-statistic.

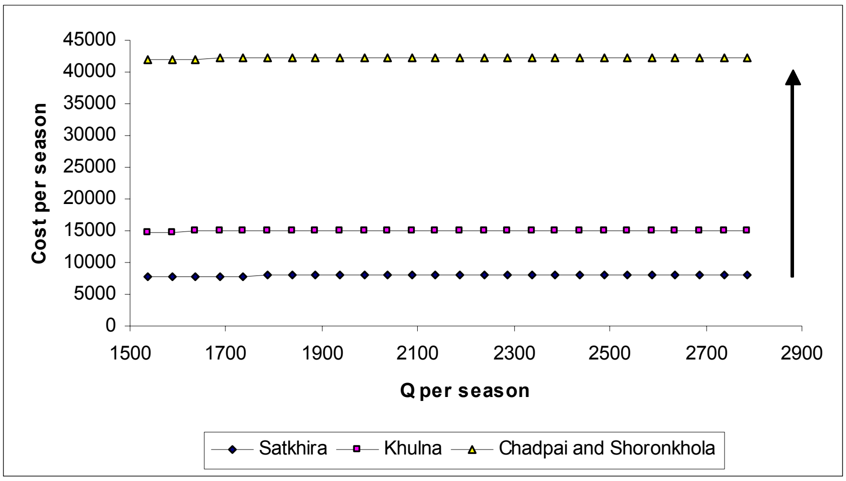


Figure 5.6 Cost function for grass and leaf collection

In Figure 5.6, it is clear that Satkhira Range has the least cost of production, and Chadpai and Shoronkhola has the highest cost of production. This implies that a better quality of forests is associated with higher costs of production. According to field data, average cost of collection of grass and leaf is around 16326 *Taka* per season, while average quantity of grass and leaf collected during the season is around 122.16 tonnes per team of grass cutters and the market value of these is nearly 50,779 *Taka*.

It may be concluded that a better quality of forests is associated with a higher cost for harvest of grass and leaf. Perhaps this is true if we consider the risks involved in collection of grass and leaf from dense forests. So it is unlikely that grass cutters would have any economic reason to invest in preservation or protection of the Sundarbans forests.

Cost function for timber and firewood collection

Cost function for collection of timber and fire wood products from Sundarbans forests is estimated from 71observations available from the data collected from all ranges of Sundarbans. The estimated function is:

$$C = 6081.23 + 1.452\, Q - 0.000122\, Q^2 + 7.26\text{x}10^{-9}\, Q^3 + 3914 * D2$$

(5.53) (1.35) (-0.70) (1.05) (3.16)

$$+ 23419.1\, D34 - 0.6823\, Q_{\text{Grass and leaf}} \ldots\ldots\ldots (4.4)$$

(7.98) (-0.59)

$R^2 = 0.685$, N = 98

Where C is cost of shrimp fry collection per season in *Taka*, Q is output per season in number D2 =1 for Khulna Range, and D2=0 for other ranges, D34=1 for Chadpai and for Shoronkhola and D34=0 for other ranges, and $Q_{\text{Grass and Leaf}}$ is the quantity of Grass and Leaf (which is often a joint production with timber and firewood). Figures in the parentheses are t-statistic.

From Figure 5.7, it is clear that Satkhira Range has the least cost of production, and Chadpai and Shoronkhola have the highest cost of production. This implies that a better quality of forest is associated with higher costs of production of timber and firewood. According to field data, average cost of collection of grass and leaf is around 14142 *Taka* per season, while average quantity of timber and firewood collected during the season is around 233.4 tonnes per team of fire wood and timber collectors and the market value of these is nearly 28169 *Taka*.

It may be summarised that a better quality of forests is associated with a higher cost for harvest of timber and firewood. Perhaps this is true if we consider the risks involved in collection of timber and firewood from dense forests. It has also been observed that firewood and timber collection is often associated with grass and leaf collection by the same team in the same season, which reduces the costs.

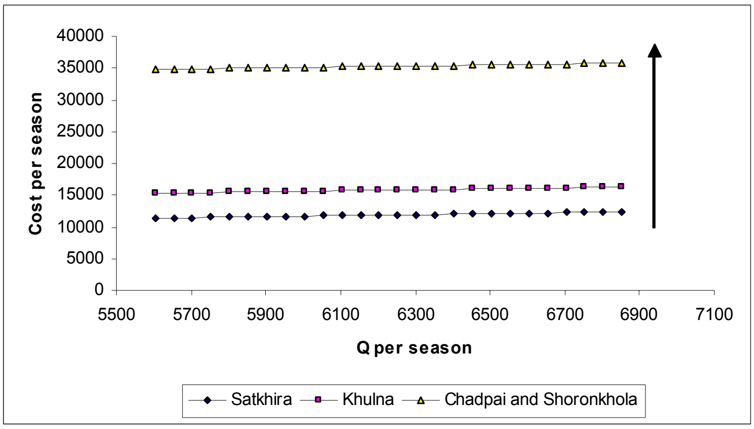


Figure 5.7 Cost of collection of timber and firewood

The findings on timber and firewood collectors suggest that they also have no economic reason to protect the forests. Dense forests increase their cost of production and so it has negative externalities on their seasonal harvests.

5.5 Concluding Observations

In terms of alternative skills for people dependent on Sundarbans, the study shows that after 10 years of suspension of timber harvests, nearly 32 per cent of the people are still primarily woodcutters. This implies that collection of timber and firewood did not stop at all. Nearly 29 per cent are fishermen and another 29 per cent are shrimp fry collectors. Nearly 29 per cent of the people still search for jobs in harvesting forest products and nearly 65 per cent seek jobs in fisheries. In areas with dense forests (Shoronkhola and Chadpai) 23 to 50 per cent people remain involved in jobs related to timbers from 9 to 12 months, the rest switching to other professions. Wood cutters, fishermen, grass and leaf collectors, and honey collectors are engaged in their profession for nearly two generations, whereas shrimp fry collectors are engaged for less than two generations.

In terms of switching jobs between on and off seasons, Appendix 5.3 shows people dependent on forests resources and non-forest resources switch to farming or agricultural activities during the off-season. This shows that unless farming becomes more rewarding, it would be difficult to reduce pressure on forest and non-forest resources of Sundarbans.

In terms of land use pattern, farming and fishing (shrimp) are the two major uses of land in the region. Thirty-two per cent of the people do migrate to elsewhere after the season. Forty per cent migrate to other urban locations for finding alternative jobs and others migrate to rural areas in the off-season. During this time, they work as agricultural workers, construction workers, and rickshaw pullers.

This study has also used secondary data on the production of commodities from different administrative regions of Sundarbans. Since these different administrative regions are known to represent different qualities of mangroves (in terms of the density and degradation of mangrove forests), an attempt was made to find the impact of the quality of mangroves on the production of commodities such as fish, fish fry, honey, timber, and grass and leaves (which is being collected by the local people for covering their roofs).

Primary data show that on an average, each team of shrimp fry collectors (a team consists of three to five persons) collects nearly 706 fry per week and travels up to 15 km inside the forests. Value of production per season is between 4000 *Taka* to 30,000 *Taka* and the average value of collection is around 17,333 *Taka* per season. Fishermen collect 40 kg of fish a week (average) and travels up to 44 km inside the forests for catching fish. Value of collection is nearly 45,000 *Taka* for a team of fishermen per season. Timber collectors gather nearly 38000 *Taka* worth of timber per season per team. They travel about 50 km inside the forest and collect nearly 4 tonnes of timber and fire wood per week per team during the season. Grass and leaf collectors travel nearly 44 km inside the forests and collect nearly 4 tonnes of grass and leaf per week per team.

In order to see the impact of quality of mangroves on the production of commodities, a cost function approach was used. It was hypothesised that if mangroves contribute positively towards the production of a commodity such as fish, then the cost of production of fish in areas where mangroves are of higher quality would be low. However, the analysis showed that this hypothesis was confirmed only for fish fry, and not for other commodities. Instead, a positive relationship between the quality of mangroves and cost of production (i.e., higher the quality of mangroves, higher the cost of production) is observed for fish, timber, honey and, and grass and leaves. This may be due to the fact that the people have to put in more effort to access and harvest products in a dense forest than in a degraded or thin forest.

6 Synthesis and Concluding Observations on the Studies in India and Bangladesh

The mangroves in Cochin and Sundarbans (West Bengal and Bagladesh) are different in many respects. First of all, the mangroves in Cochin are highly degraded, fragmented, and situated in the urban and semi-urban localities around Cochin City. Whereas Sundarbans is a large area having significant portions of intact forests and with limited access to, and use by, human beings. There are also differences in terms of the institutions and property rights. A greater part of the remaining patches of mangroves in Cochin are owned by individuals or by local governments. This ownership is for the land and does not have any special regard to the existence of mangrove forest in these pieces of land. On the other hand, a major part of Sundarbans in both West Bengal and Bangladesh is declared as protected areas and managed by the forest departments of the respective governments, and receive global attention and resources for the conservation. Thus the study carried out in these two contrasting locations provides insights on the contribution of mangroves in diverse contexts.

The study in Cochin showed that the extent of mangrove does not have much impact on the level of fish production in these farms located in Cochin. Though insignificant in certain cases, we could see significant negative relationship in some other cases, between the extent of mangroves and fish production. The discussions with farmers have also strengthened this indication, as they were of the opinion that the presence of mangroves was not conducive for enhanced fish production in their farms. The probable reason may be the excessive degradation of the water body due to the accumulation of biomass from mangroves in areas closer to them, which makes an environment not so conducive for the optimal growth of fish.

In order to see the impact of quality of mangroves on the production of commodities, a cost function approach was used in the study conducted in Bangladesh. It was hypothesised that if mangroves contribute positively towards the production of a commodity such as fish, then the cost of production of fish in areas where mangroves are of higher quality would be low. However, the analysis showed that this hypothesis was confirmed only for fish fry, and not for other commodities. Instead, a positive relationship between the quality of mangroves and cost of production (i.e., higher the quality of mangroves, higher the cost of production) is observed for fish, timber, honey and, and grass and leaves. This may be due to the fact that the people have to put in more effort to access and harvest products in a dense forest than in a degraded or thin forest.

Instead of focusing on the possible relationship between mangroves and commodity production, the study in West Bengal part of Sundarbans puts the emphasis on assessing the dependence of (or the benefits derived by) local people from the mangroves. It indicates the kind of economic returns that must be served by protected mangroves (biosphere reserve) if such land use is to be economically preferred to the alternative existing land-use. The analysis showed that the respondents expect to get a per capita annual benefit of around 20000 Indian rupees (US$ 400) if free access is given to them to enter Sundarbans forests. However, currently when their access is controlled, they receive only Rs 12500 (per capita per annum on average). Based on this, the study estimates that expected benefit of the local people from one sq. km of the core area, which is being conserved as a biosphere reserve, comes to around Rs 110000 per annum (approx. US$ 2300).

The studies carried out in three locations (i.e., Cochin, West Bengal, and Bangladesh) provide some general insights on the economic contribution of mangroves in the context of developing countries such as those in South Asia. The following discussion elaborates these aspects.

1. The studies, especially those carried out in Cochin and Bangladesh, show that popular claims on the positive contribution of mangroves to fishery in each and every context need to be viewed with caution. The economics of positive externalities are rather complex. While the literature on mangrove ecology clearly shows positive externalities from existence of mangrove forests, such benefits need not translate into positive economic benefits to the users in every context. The context needs to be understood carefully. There may be contexts where such positive contribution through the provision of nutrients and shelter is nullified by the excessive degeneration of the water body caused by the degradation of biomass generated from mangroves. Or if the level of nutrients is already high in a context, then the biomass from mangrove will lead only to degradation of the water body and thus making it harmful for the growth of fish. Moreover in areas where there are dense forests, the limited accessibility and the consequently increased risk and cost of collecting fish, may create a situation in which better quality mangroves are not conducive for enhanced fish production within the mangrove area. Of course, our studies have not attempted to value the contribution of mangroves towards offshore fishery, and thus our comments are valid only for estuarine fishery.

2. An important implication of the not-so-positive impact of mangroves on fishery (and other goods such as honey, timber, grass and leaves except fish fry as evident from Bangladesh) is that the people who collect these commodities do not have adequate incentives to protect mangroves or to keep its quality intact. It was well known that the people who own land do not have adequate incentives to protect mangroves in their territory due to the possible benefits accrued by others. However, what is evident from this study is that even people who use mangroves for commodity production, which is not apparently destructive of the forests such as fish collection in nearby waters, cannot

be expected to have incentives to protect the forests. For example, given a choice the people who own fish-capture farms in Cochin backwater would try to reduce the extent of mangroves in the boundary of their farms. This may be the reason for not seeing many farms with extensive mangroves in their boundaries. Similarly those who catch grown-up fish in Sundarbans have an incentive to see the quality of mangroves degraded. This has implications in terms of reshaping institutions for protecting mangroves around the world. Users, in these cases, are not found to have been enjoying positive benefits from the forests and so it would be difficult to argue that by introducing shared-management responsibilities the mangrove could be protected.

3. The results show that benefits accrued to mangrove users cannot be taken for justifying conservation of the quality and quantity of mangroves. This is true when mangrove is left under private or public ownership. Probably, any level of effort to create awareness among local people on the possible benefits of mangroves to them may not translate into actions for preserving them. This is due to (as evident from the discussion in the previous paragraphs) that the derivation of benefits by local people may lead to a gradual decline in the quality and quantity of mangroves. Or high quality of mangroves is a cost enhancing factor for the derivation of benefits by the local people or those directly dependent on mangroves. The justification may have to be grounded on other values, probably global environmental values arising out of the need for carbon sequestration and/or biodiversity conservation, or simply non-use values attached to mangroves by the global community.

4. The study, both in India and in Bangladesh, shows that local direct users would lose from a stronger mode of conservation. If global community decides to conserve certain stretches of mangroves, then the results of this study show that this job cannot be entrusted upon the local direct user communities without adequate compensation. Thus the individual ownership or community-based management regimes without compensation from the outside world or from other beneficiaries may not be appropriate to conserve mangroves. For this, a new institutional framework needs to be established. This is again due to that, without external compensation, the incentive of the local community is to degrade the quality of mangroves.

5. It would be better to devote international resources to conserve certain important stretches of mangroves, rather than thinly distributing resources to create awareness and other means to protect each and every piece of mangroves. That may be true even within

the country and regions. For example, efforts in Cochin should also be concentrated on preserving a few of the remaining fragmented patches of mangroves, which have some unique characteristics. This too may require some allocation of resource by the larger society. Efforts and mechanisms to conserve each and every patch of the fragmented mangroves may be costly and unwarranted.

6. The crucial factor in the conservation of mangroves is the compensation to the people who directly use it, and whose access will have to be limited if that piece of mangroves is to be protected

Since the land sustaining mangroves do not have private rights predominantly, and many commodities collected from the mangroves do not have proper markets, efforts should be made to assess the extent of compensation. Thus exercises such as the one carried out in West Bengal part of Sundarbans are of great importance

REFERENCES

Baland, J. and J. Platteau. 1996. *Halting Degradation of Natural Resources: Is there a Role for Rural Communities?* FAO of U.N. and Clarandon Press, Oxford.

Barbier, E. B. 1994. 'Valuing Environmental Functions: Tropical Wetlands', Land Economics, 70 (2): 155-73.

Barbier, E. B. 2000. 'Valuing the Environment as Input : Review of Applications to Mangrove-fishery Linkages", Ecological Economics, 35: 47-61.

Barbier, E. B., M. Acreman and D. Knowler. 1997. *Economic Valuation of Wetlands: A Guide for Policymakers*. Ramsar Convention Bureau, Geneva

Barbier, E. B. and I. Strand. 1998. 'Valuing Mangrove – Fishery Linkages', Environmental and Resource Economics 12: 151-166.

Bell, F. W.1 1997, 'The economic valuation of saltwater marsh supporting maring recreational fishing in the southeastern United States', *Ecological Economics* 21:243-254.

Bergstorm, J. C., J. R Stoll., J. P. Titre and V. L. Wright. 1990. 'Economic Value of Wetland Based Recreation', Ecological Economics, 2: 129-147.

Chattopadhyay, K. 1995. *The Desperate Delta: Social Ecology of Sundarbans*, Gyan, New Delhi.

Chaudhuri B., A. Chaudhuri. 1994. *Mangroves of Sundarban*, *Volume 1, India*; IUCH – The World Conservation Union.

Constanza, R., S. C Farber and J Maxwell. 1989. 'Valuation and Management of Wetland Ecosystems', Ecological Economics 1: 335-361.

Das S, K. Mitra, et al. 2001. 'A study on Socio-Economic and Socio-Cultural Problems of the Costal People of Sundarbans' Workshop on Sundarbans Day, 3, June, Observed by Sundarban Biosphere Reserve & Zilla Parisad – 24 Parganas (South), Calcutta.

Das. S. 1983. Sundarbaner Matsajibider Arthanaitik Chitra' (Madhyanna) Vol. 13, No.1-4, Kolkata

Devi. K.S. and P. Venugopal. 1989. 'Benthos of Cochin backwaters receiving industrial effluents', Indian Journal of Marine Sciences, 18; 165-169.

Dey D. K. 1997. 'Winter Migratory Bagnet Fishery of the Hooghly Estuary – An Economic Evaluation', CIFRI Bulletin No. 76, November.

Dixon, J.A and P.N. Lal. 1997. 'The Management of Costal Wetlands Economic Analysis of Combined Ecologic Economic System', in P. Dasgupta and K. Maler (ed.), *The Environment and Emerging Development Issues, Vol - 2*, Clarendon Press, Oxford.

Dixon, John, Louise Fallon Scura, Richard A Carpenter, Paul B Sherman. 1994. *Economic Analysis of Environmental Impacts*, Earthscan publications, 2nd edition

Ellis, G., and A. Fisher. 1987. 'Valuing the enviornment as input', Journal of Enviornmental Management, 25:149-156.

FAO Report. 1982. Management and utilization of mangroves in Asia and the pacific, Food and Agricultural organization of United Nations, Rome.

Freeman, A. M. 1991, 'Valuing enviornmental resources under alternative managemetn regimes" Ecological Economics, 3:247-256

Gottfried, R. 1992, 'The value of watershed as a series of linked multiproduct assets', Ecological Economics, 5, 145-161.

Kahn, J R., and W. M. Kemp. 1985, 'Economic losses associated with the degradation of an ecosystem: The case of submerged aquatic vegetation in Chesapeake Bay', Journal of Environmental Economics and Management, 12:246-263

Lynne, G. D., P. D. Conroy and F. L. Prochaska. 1981. 'Economic Valuation of Marsh Areas for Marine Production Process (Florida)', Journal of Environment Economics and Management, 8: 175-186.

Malor, K. G., A. Sara, C. Clark and W. Enrique. 1997. 'The Economics of Coastal Wetlands', a Beijer Discussion Paper, Beijer Institute of Ecological Economics, Stockholm, Sweden

Martinez A, J. (2000) 'Ecological Conflicts and Valuation – mangroves vs. shrimp in the late 1990s', *Manuscript* .

Naskar K (2002), 'Status of Mangrove Ecosystem in Indian Sundarbans', Woorkshop on Sundarbans Day, 3rd June. Sundarban Biosphere Reserve & Zilla Parisad – 24 Parganas (South), Calcutta.

Pearce, D. and D. Moran. 1994. *The Economic Value of Biodiversity,* Earth Scan Publication Ltd, London.

Roychowdhury M. 1998. 'Fisheries & Fishers – The wealth of Sundarban Wetland'; Meenbarta, special edition on Wetland, June, Calcutta.

Ruitenbeek, H.J. 1994. 'Modelling economy-ecology linkages in mangroves: Economic evidence from promoting conservation in Bintuni Bay, Indonesia', Ecological Economics, 10:233-247.

Sanyal P. 2001. *Sustainable Fishing in Hugly – Matla Estuary,* Workshop on Sundarban Day.

Sathirathai, S. 1997. Economic Valuation of Mangroves and the role of Local Communities in the conservation of the resources: Case study of Surat Thani, South of Thailand', Final Report Submitted to the Economy and Environment Program for Southeast Asia (EEPSEA), EEPSEA, Singapore.

Sen S. 1995. 'Impact of Mangrove Eco-system on the Rural Scenario with Reference to Moules: A case study of 24 Parganas (South), West Bengal', (Unpublished), Anthropological Survey of India, Calcutta.

Sundararaj, V. 1978. 'Suitability of a mangrove biotope for brackish water aquaculture', Seafood Exports Journal, 10 (12): 23 –27.

Tiner, R. W. Jr. 1985. 'An Overview of Freshwater Wetlands', in *Wetlands and Water Management on Mined Lands*, (eds) Brookes, R.P., D.E. Samuel and J.B. Hill, Pennsylvania State University.

Vyas P. 2001. 'Sundarbans Biosphere Reserve' Workshop on Sundarbans Day, 3rd June, Calcutta, Observed by Sundarbans Biosphere Reserve & Zilla Parishad – 24 Parganas.

Appendix 5.1

Duration in Primary Job in a Year by Range

% within Primary Occupation

Forest Range		Class of Q1_8 Up to 4 months	Between 4 and 6 months	Between 6 and 9 months	Between 9 and 12 months	Total
Satkhira	Wood Cutter		17.6%	17.6%	64.7%	100.0%
	Fisherman		28.6%	14.3%	57.1%	100.0%
	Shrimp Fry collector		22.6%	29.0%	48.4%	100.0%
	Total		21.8%	23.6%	54.5%	100.0%
Khulna	Wood Cutter		30.0%	30.0%	40.0%	100.0%
	Honey Collector		100.0%			100.0%
	Grass-leaf collecter			20.0%	80.0%	100.0%
	Fisherman			55.6%	44.4%	100.0%
	Shrimp Fry collector	20.0%	5.0%	30.0%	45.0%	100.0%
	Agricultural worker				100.0%	100.0%
	Total	8.7%	10.9%	32.6%	47.8%	100.0%
Chadpai	Wood Cutter	16.7%		33.3%	50.0%	100.0%
	Grass-leaf collecter	20.0%		20.0%	60.0%	100.0%
	Fisherman	50.0%	25.0%		25.0%	100.0%
	Shrimp Fry collector	15.2%	30.3%	30.3%	24.2%	100.0%
	Total	21.2%	23.1%	25.0%	30.8%	100.0%
Shoronkhola	Wood Cutter	5.9%	23.5%	47.1%	23.5%	100.0%
	Honey Collector				100.0%	100.0%
	Grass-leaf collecter			50.0%	50.0%	100.0%
	Fisherman		41.7%	25.0%	33.3%	100.0%
	Shrimp Fry collector	15.6%	15.6%	28.1%	40.6%	100.0%
	Total	9.4%	21.9%	32.8%	35.9%	100.0%

Appendix 5.2

Generations Involved in Primary Occupation by Range

% within Primary Occupation

Forest Range		Primary Occupation Wood Cutter	Honey Collector	Grass-leaf collecter	Boatman	Fisherman	Shrimp Fry collector	Agricultural worker	Total
Satkhira	Less than 2	10.0%				13.9%	100.0%		36.7%
	Between 2 and 3	38.0%				38.9%			27.5%
	More than 3	52.0%				47.2%			35.8%
	Total	100.0%				100.0%	100.0%		100.0%
Khulna	Less than 2	39.3%	25.0%	16.7%		58.8%	37.1%	100.0%	40.8%
	Between 2 and 3	46.4%	50.0%	50.0%		23.5%	60.0%		44.2%
	More than 3	14.3%	25.0%	33.3%		17.6%	2.9%		15.0%
	Total	100.0%	100.0%	100.0%		100.0%	100.0%	100.0%	100.0%
Chadpai	Less than 2	66.7%		76.5%		37.1%	91.4%		66.7%
	Between 2 and 3	33.3%		23.5%		34.3%	8.6%		25.0%
	More than 3					28.6%			8.3%
	Total	100.0%		100.0%		100.0%	100.0%		100.0%
Shoronkhola	Less than 2	50.0%		50.0%	100.0%	64.7%	88.9%		65.5%
	Between 2 and 3	40.9%	50.0%	50.0%		26.5%	11.1%		27.7%
	More than 3	9.1%	50.0%			8.8%			6.7%
	Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%

Appendix 5.3

Distribution of Primary and Secondary Jobs by Range

% within Primary Occupation

Forest Range		Secondary Occupation: Wood Cutter	Honey Collector	Grass-leaf collecter	Boatman	Fisherman	Shrimp Fry collector	Agricultural worker	Farmer	Other	Total
Satkhira	Wood Cutter					12.0%	16.0%	32.0%	14.0%	26.0%	100.0%
	Fisherman						50.0%	25.0%	25.0%		100.0%
	Shrimp Fry collector	10.0%						60.0%		30.0%	100.0%
	Total	1.6%				9.4%	15.6%	35.9%	12.5%	25.0%	100.0%
Khulna	Wood Cutter			96.2%					3.8%		100.0%
	Honey Collector					50.0%	50.0%				100.0%
	Grass-leaf collecter	28.6%	7.1%	7.1%		7.1%	42.9%		7.1%		100.0%
	Fisherman						50.0%	37.5%		12.5%	100.0%
	Shrimp Fry collector	12.5%		12.5%		75.0%					100.0%
	Total	8.3%	1.7%	45.0%		15.0%	20.0%	5.0%	3.3%	1.7%	100.0%
Chadpai	Wood Cutter			100.0%							100.0%
	Grass-leaf collecter	21.4%			7.1%			50.0%	21.4%		100.0%
	Fisherman						42.9%	42.9%	14.3%		100.0%
	Shrimp Fry collector					10.7%	3.6%	57.1%	7.1%	21.4%	100.0%
	Total	5.9%		3.9%	2.0%	5.9%	7.8%	51.0%	11.8%	11.8%	100.0%
Shoronkhola	Wood Cutter					23.5%	17.6%	32.4%	8.8%	17.6%	100.0%
	Honey Collector	50.0%				50.0%					100.0%
	Grass-leaf collecter					50.0%		50.0%			100.0%
	Fisherman						87.0%	4.3%		8.7%	100.0%
	Shrimp Fry collector				2.9%	17.1%	2.9%	45.7%	5.7%	25.7%	100.0%
	Total	1.0%			1.0%	16.7%	28.1%	30.2%	5.2%	17.7%	100.0%

Appendix 5.4

Range	Stat	Shrimp Fry		Fish		Timber		Firewood		Honey		Grass and Leaf	
		D	Q	D	Q	D	Q	D	Q	D	Q	D	Q
1	N	41	40	37	38	49	49	2	2			33	34
	M	11.4	1187.6	22.1	37.1	17.5	685.0	17.5	478.1	-	-	15.9	935.1
	S	9.6	849.2	8.0	25.6	7.0	266.7	3.5	643.4			6.5	592.5
2	N	47	48	46	46	32	32	12	12	7	7	44	45
	M	27.6	1006.6	32.6	50.9	53.2	730.1	30.1	846.0	63.5	288.8	66.3	735.6
	S	24.5	415.7	27.2	144.5	20.7	354.7	23.8	299.1	29.8	460.7	25.1	348.7
3	N	38	48	38	38	24	24	11	11			19	19
	M	2.0	451.1	63.3	60.8	36.6	6936.0	7.8	2174.0	-	-	40.5	7219.2
	S	1.5	340.9	29.1	189.0	10.8	1996.1	5.9	526.2			8.9	2077.2
4	N	61	58	51	46	46	48			2	2	1	1
	M	17.9	451.1	57.1	17.0	100.6	958.8	-	-	300	9.3	70.0	9.3
	S	23.1	340.9	59.2	12.6	60.8	1067.7			0.0	0.0	.	.
T	N	187	184	172	168	151	153	25	25	9	9	97	99
	M	15.7	706.8	44.4	40.7	53.4	1760.9	19.3	1401.3	116.1	226.7	44.1	2041.1
	S	20.5	614.3	41.1	118.4	48.8	2456.0	19.9	820.4	107.4	417.6	28.6	2722.6

Range: 1 – Sathkira, 2 - Khulna, 3- Chadpai, 4- Shoronkola, T – Total
D - Travels up to km inside; Q - Weekly collection of Fry in number; Q* - Weekly collection in Kg
Statistics: N- Number; M- Mean; S- Standard Deviation