AN APPLICATION OF CONTINGENT CHOICE MODELLING TO ASSESS ENVIRONMENTAL MANAGEMENT OPTIONS IN THE SHRIMP-MANGROVE SYSTEM IN THE INDIAN SUNDARBANS

by

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ABSTRACT

The Indian Sundarbans, in West Bengal, is inhabited by small-scale farmers and traditional paddy-cum-prawn cultivators; however, this unique region is also ideal for large-scale commercial shrimp aquaculture. Recent policy initiatives may facilitate expansion of commercial shrimp aquaculture in India, potentially setting the stage for conflict between different stakeholders in the Indian Sundarbans. This research project presents policymakers with an *ex ante* analysis of four alternative development scenarios, based on a more participatory approach to the decision making process. Using a contingent choice modelling methodology to quantify the preferences of local stakeholders for economic, social, and environmental attributes, policymakers and local stakeholders can measure and compare the preferences of local stakeholders for alternative management options. Local stakeholders, including shrimp fry collectors, shrimp farmers, and agricultural farmers, prefer a sustainable approach to development in the region, especially with respect to the management of mangrove forests, and access to alternative income generating opportunities.

Keywords

discrete choice experiment, India, mangrove forest, natural resource management, shrimp aquaculture, stakeholder analysis, sustainable development, Sundarbans

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Much has been written about the Sundarbans, the location for this research project. However, titles such as “Spell of the tiger: the man-eaters of Sundarbans” (Montgomery, 2002), and “The hungry tide” (Ghosh, 2004) do not necessarily evoke pleasant images of fieldwork in such a wild and remote area. Nevertheless, with the amazing support I received from my supervisors, research collaborators, and family and friends in Canada and India, I managed to make it home, with many wonderful experiences to boot.

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GLOSSARY

CIDA	Canadian International Development Agency
CMFRI	Central Marine Fisheries Research Institute
CRZ	Coastal Regional Zone
CZMA	Coastal Zone Management Authority
CZMP	Coastal Zone Management Plan
DCE	Discrete Choice Experiment
DSS	Decision Support System
FAO	Food and Agricultural Organization
FI	Field Investigator
GOI	Government of India
Ha	Hectare
HS	Household Survey
ICEF	India-Canada Environment Facility
IIA	Independence of Irrelevant Alternatives
ICM	Integrated Coastal Management
MNL	Multinomial Logit
MT	Metric Ton
JMM	Joint Mangrove Management
MoEF	Ministry of Environment and Forests
MPEDA	Marine Products Export Development Authority
MSSRF	M. S. Swaminathan Research Foundation
NCZMA	National Coastal Zone Management Authority
NCZMP	National Coastal Zone Management Plan
NEERI	National Environmental Engineering Research Institute
NGO	Non-governmental Organization
PRA	Participatory Rural Appraisal
RRA	Rapid Rural Appraisal
Rs.	Rupees

SCZMA	State Coastal Zone Management Authority
SEAI	Seafood Exporters Association of India
SHARP	Shastri Applied Policy Research Project
UNESCO	United Nations Educational Scientific and Cultural Organization
WI	Wealth Index

CHAPTER 1: INTRODUCTION

1.1 Overview

Since the 1970s, shrimp aquaculture has grown significantly in the coastal zones of Asia, with significant impacts on the environment, and on the lives of local people. On the one hand, biologically rich mangrove ecosystems have been, and continue to be, affected by the growth of shrimp aquaculture, to the detriment of certain stakeholders and local communities that rely on them for their livelihoods (Alauddin & Hamid, 1999). On the other hand, governments in developing countries in South and Southeast Asia view shrimp aquaculture as a means to generate economic growth, export earnings, and employment for marginalized communities on the coast. These governments have supported the growth of the shrimp farming industry, along with funding institutions like the World Bank, since the 1970's. In India, large-scale shrimp aquaculture started with a US $425 million loan from the World Bank in the mid-1980s (Martinez-Alier, 2001).

Farmers have traditionally practiced low-density shrimp rotation culture with rice in *bheries*[1] in the Indian Sundarbans, in West Bengal (Food and Agricultural Organization of the United Nations (FAO), 1992, 1999b; Primavera, 1998a). The advent of intensive shrimp aquaculture significantly altered the nature of shrimp cultivation, starting in the 1980s. Increased intensification, feed supplements and other external inputs, and export-oriented production are now the norm. However, in 1994, an outbreak

[1] For the purposes of shrimp aquaculture in West Bengal, *bheris* are "large impounded shallow water areas with facilities for drawing tidal water" (Food and Agricultural Organization of the United Nations (FAO), 1999a).

of white spot disease in Andhra Pradesh quickly spread to Tamil Nadu, Orissa, and West Bengal on the west coast, and Goa, Karnataka, and Gujarat on the east coast (World Bank (WB) *et al.*, 2001). Small-scale shrimp farmers in the Indian Sundarbans suffered significant financial hardship due to shrimp crop losses; consequently, the revival of shrimp aquaculture in West Bengal has been relatively slow. The introduction of more sophisticated management techniques for shrimp cultivation, by large input suppliers, is an important catalyst for renewed interest in shrimp farming in the Indian Sundarbans.

The intensified nature of production and the attractive short-term financial benefits that accrue from a switch to shrimp production from rice cultivation, presents policymakers with numerous challenges regarding the sustainability of shrimp aquaculture in the Indian Sundarbans (Neiland *et al.*, 2001). Unlike Andhra Pradesh, Tamil Nadu, and Orissa, non-traditional shrimp cultivation is in its infancy in the Indian Sundarbans, which presents policymakers and local stakeholders with an *ex ante* opportunity to implement polices that mitigate the risks associated with shrimp cultivation and fry collection. This opportunity is especially relevant in light of fragile economic, social, and environmental conditions in the region. Increasing salinization of groundwater and agricultural land due to anthropogenic and natural processes are already taking their toll on the biodiversity of the region, on the economic capacity of farmers to generate sufficient livelihoods, and on the social fabric of this relatively recently settled area (United Nations Environment Programme (UNEP), 2004). While more intensive shrimp cultivation represents a possible means to generate additional income and employment in the short-term, the medium and long-term consequences of expansion and intensification of shrimp cultivation are potentially devastating for the economic, social

and environmental sustainability of the Indian Sundarbans. Other regions also stand to suffer negative consequences if the biophysical productivity of the Indian Sundarbans is compromised.

1.2 Problem Statement

There are two major problems associated with the sustainability of shrimp aquaculture in India, and more specifically, in the Indian Sundarbans: the environmental and ecological impacts, and the social and economic impacts on local and regional stakeholders. These problems are interlinked, resulting in a complex web of interactions, trade-offs and conflicts (Martinez-Alier, 2001).

1.2.1 Environmental and ecological trade-offs

The current practice of extensive, semi-intensive, and intensive shrimp aquaculture (Appendix A: Definition of Shrimp Farming Systems) is detrimental to the environment, and the ecological functioning of coastal ecosystems. Negative effects include the conversion of mangroves, coastal wetlands, and farmland into shrimp ponds; salinization of drinking water and agricultural lands; and the decline of biodiversity, and the destruction of larvae and many fish and crustacean species (Bhatta, 2004; Bhatta & Bhat, 1998; Bhattacharya & Sarkar, 2003; Hein, 2000, 2002; Martinez-Alier, 2001; Primavera, 1997a, 1998a, 1998b; Samarakoon, 2004; Sarkar & Bhattacharya, 2003).

The conversion of mangroves, wetlands, and agricultural land into shrimp ponds is particularly destructive because of the short-term outlook of commercial shrimp aquaculture operators. Converted land is often degraded within five to ten years after the conversion, with no requirement to rehabilitate or restore it to its previous condition

(Adger & Luttrell, 2000; Barbier & Sathirathai, 2004; Hein, 2000; Martinez-Alier, 2001; Primavera, 1998a, 1998b). The conversion of mangroves not only limits the ability of local communities to access important natural sources of food, fuel, building materials, and medicine, it also destroys a natural protective barrier against storms and erosion, and removes important habitat for many fish and crustacean species. Although the current rate of conversion of mangrove areas in West Bengal is relatively low (Table 1), this is not the case in Andhra Pradesh, Orissa, and Tamil Nadu (Hein, 2000, 2002). Much of the conversion in West Bengal initially took place for agricultural purposes decades ago (Richards & Flint, 1990); now the conversion is from agricultural land to shrimp ponds.

Table 1: Conversion of mangrove coverage to shrimp ponds in Andhra Pradesh, Orissa, Tamil Nadu, and West Bengal

State	Mangrove area converted (Ha)	% of total mangrove area
Andhra Pradesh	8000	40%
Orissa	4000	26%
Tamil Nadu	4000	26%
West Bengal	5000	1.25%

Note: figures are approximate.
Source: FAO (1999a)

Despite enormous pressure for conversion of all mangrove and other forests in the Sundarbans for agricultural purposes, the establishment of Protected Forests, in the late 1800s, limited this process in 24 Parganas District (Appendix B: Land Conversion in West Bengal). A similar situation exists today regarding the trade-off between agricultural land and dedicated shrimp ponds. Higher profit margins associated with shrimp cultivation presents farmers with a tempting option to convert, lease, or sell their land for this purpose. So far, the expansion of shrimp cultivation has been limited in the

Indian Sundarbans due to the outbreak of disease and the associated financial risks, a lack of investment capital amongst local farmers to invest in new shrimp ponds, and the Supreme Court ban on non-traditional shrimp aquaculture within 500 metres of the high tide line[2]. However, none of these factors represent a definitive limit on the conversion of agricultural land to shrimp ponds, unlike the establishment of Protected Forests limiting the conversion of forests to agricultural land in the late 1800s. The risk of disease is now mitigated (although not eliminated) through the establishment of hatcheries that guarantee disease free shrimp seed, and the application of pesticides that limit outbreaks in shrimp ponds. Representatives of large commercial feed suppliers and seafood export companies now provide interested farmers with technical expertise, credit, and a purchase agreement for their products. Finally, the Coastal Aquaculture Authority Act (2005) may lead to an expansion of commercial shrimp cultivation in the Indian Sundarbans[3]. An example of the environmental effects of converting agricultural land into shrimp ponds in Thailand, is documented by Flaherty *et al*. (1999) (Appendix C: Shrimp Aquaculture in Thailand).

The collection of shrimp fry in the Indian Sundarbans significantly limits the abundance of adult shrimp available for the capture fishery. Furthermore, high levels of

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[2] In 1996, the Supreme Court of India ruled that non-traditional shrimp aquaculture be banned within 500 meters of the high tide line, and that existing non-traditional shrimp farms be dismantled. The ruling was based partly on a report by the National Environmental Engineering Research Institute, which found that the costs (including environmental costs) associated with non-traditional shrimp aquaculture far outweighed the benefits by a factor of 4:1 (National Environmental Engineering Institute (NEERI), 1995).

[3] The Coastal Aquaculture Authority Bill (2004) passed in the 204th session of Parliament, and the President of India assented the Coastal Aquaculture Authority Act (2005) on June 23, 2005. A new Coastal Aquaculture Authority was constituted under the Act with its headquarters in Chennai, and the existing Aquaculture Authority (originally established following the Supreme Court ruling in 1996) will be subsumed into the new Authority. The Coastal Aquaculture Authority is responsible for the regulation of aquaculture, including shrimp farms (The Hindu Business Line, January 14, 2006). According to the sponsor of the Bill, Union Minister of Agriculture, Sharad Pawar, the Act will provide a positive boost to the development of aquaculture in India (The Hindu, January 17, 2006).

by-catch of other species discarded by fry collectors negatively affects other capture fisheries (Bhattacharya & Sarkar, 2003; Ronnback *et al.*, 2003; Sarkar & Bhattacharya, 2003). Central to both capture fisheries and fry collection are mangrove forests, which are an important nursery habitat for shrimp fry and other juvenile species. This clearly represents a direct trade-off between capture fisheries and fry collection, but also an indirect trade-off between the shrimp capture fishery and shrimp farming. The direct trade-off is based on the complex environmental and ecological relationship between shrimp fry collection and by-catch on the one hand, and recruitment of adult shrimp on the other hand (Nathan, 2006). The indirect trade-off is based on the economic dynamics of demand from shrimp farmers for wild shrimp fry to stock their ponds versus the availability and effort required to capture adult shrimp in the Bay of Bengal. In the former case, the open-access nature of fry collection leads to overexploitation of shrimp fry stocks, which ultimately limits the recruitment of adult shrimp stocks available for the shrimp capture fishery. Apart from the ecological effects of overexploitation of shrimp fry, which includes declining stocks of shrimp fry and adult shrimp, and declining stocks of other species due to by-catch, the economic benefits of both in-shore and off-shore activities are neither maximised nor equitably distributed. Furthermore, the environmental impact of unregulated access to mangrove areas and fragile coastal areas for fry collection represents an important negative externality that may have long-term consequences for the health and maintenance of mangrove ecosystems along the coast (Bhattacharya & Sarkar, 2003; Sarkar & Bhattacharya, 2003). In turn, damage to mangrove ecosystems will not only compromise the safety of communities exposed to natural disasters (Danielsen *et al.*, 2005), but will also lead to greater erosion of

productive agricultural land, and declining stocks of juvenile pelagic and non-pelagic species that rely on the nursery function of mangroves for their survival.

Pollution due to the intensification of shrimp aquaculture under extensive, semi-intensive, and intensive practices is a major negative environmental externality. The impact on the environment of feeds, disinfectants, algicides, pesticides, antibiotics, and other chemicals used in shrimp aquaculture is compounded by the absence of effluent treatment (Hein, 2000; Paez-Osuna, 2001a, 2001b; Primavera, 1998a). The depletion of groundwater, and the salinization of drinking water and agricultural land is also a major problem identified by communities close to commercial shrimp aquaculture operations (Hein, 2000; Paez-Osuna, 2001a, 2001b; Primavera, 1998a).

1.2.2 Social and economic impact on local and regional stakeholders

There are a number of ways local stakeholders are affected by shrimp aquaculture. Landless communities often lose access to natural resources, which limits their ability to generate a livelihood (Hein, 2000, 2002; Primavera, 1997a, 1998a). Others gain direct or indirect employment from the shrimp aquaculture industry, such as shrimp fry collectors who generate a livelihood by supplying shrimp farms with wild shrimp fry harvested from mangrove areas. This stakeholder group is comprised primarily of marginalized women who are paid little for their effort, and who are often exposed to health problems associated with the collection of shrimp fry (Crow & Sultana, 2002; Frankenberger, 2002; Sarkar & Bhattacharya, 2003). Despite a ban on fry collection due to the negative impact of by-catch mortality of many pelagic and non-pelagic species, as many as 50,000 fry collectors or more depend on collection of fry for their livelihood in the Indian Sundarbans (Banerjee & Singh, 1993). Many fry collectors

suffer from gynaecological, skin, or eye problems as a result of long hours spent collecting fry in brackishwater. In a survey administered for this research project in Namkhana Block, 69.41% of the households engaged in fry collection suffer from at least one of the health issues listed above (N=87).

The open access nature of fry collection further marginalizes this group due to intense competition and the dissipation of economic rents. Furthermore, harvesting of adult shrimp by the capture fishery decreases the number of female spawners, which leads to a decrease in abundance of shrimp fry available for collection. Fewer shrimp fry means more effort on the part of fry collectors for the same harvest. In the same survey, 84.88% of households engaged in fry collection indicated a decrease in the abundance of shrimp fry available for collection over the last five years. The majority of these households (61 out of 87 households) blamed fishing trawlers for the decrease in abundance, and some also blamed the problem on an increase in the number of fry collectors (27 out of 87 households). Only two households cited a loss of mangrove coverage for the decrease in abundance of shrimp fry.

Rice farmers can benefit in the short-term from the conversion of their paddies to shrimp aquaculture ponds by way of higher financial returns on shrimp aquaculture. However, they are increasingly dependent on middlemen for inputs, financing, and sale of their product. In addition, fiercer global competition from new shrimp aquaculture producers, coupled with the risk of new viral outbreaks, present farmers with a major risk of decreasing returns or complete crop failure (Hein, 2000, 2002; Neiland *et al*., 2001).

In the Indian Sundarbans, the long-term consequences of converting agricultural land to shrimp ponds is potentially devastating for small scale shrimp farmers, as well as

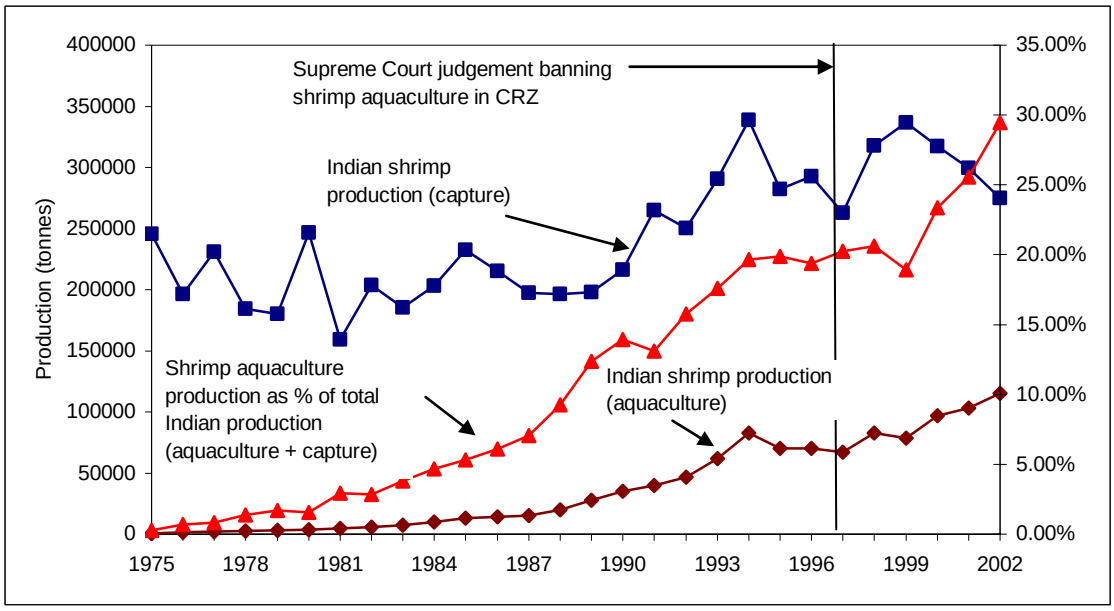
for nearby agricultural farmers and downstream communities. Wide scale land degradation and high rates of abandonment often renders converted land unsuitable for any other use. The risk of disease outbreaks increases with the expansion and intensification of shrimp cultivation, thereby exposing small-scale farmers to potentially catastrophic financial losses. Finally, dependence on middlemen for technical knowledge, supplies and product distribution and marketing leave little room for error. In Thailand, the conversion of rice paddies to shrimp ponds led to an increase in conflict between shrimp farmers and rice farmers due to increasing levels of salinity and other pollutants in surrounding agricultural land, and increasing demand for freshwater for shrimp and rice cultivation (Flaherty *et al*., 1999). Although conflict between shrimp farmers and agricultural farmers is generally at low levels in the Indian Sundarbans, the potential for conflict certainly exists. The low level of conflict is due primarily to the small number of non-traditional shrimp farms operating in the region. Many farmers are engaged in traditional and improved traditional shrimp cultivation, which is environmentally benign (except for the demand for wild shrimp fry to stock their ponds). Even non-traditional shrimp farmers are primarily engaged in extensive shrimp cultivation with low stocking densities, and limited application of technology and chemical inputs. However, salinization of soil and groundwater is a major problem in the Indian Sundarbans for other reasons (Tripathi *et al.*, 2006; United Nations Environment Programme (UNEP), 2004), and any expansion or intensification of shrimp cultivation may further compromise the ability of agricultural farmers to generate sufficient yields of rice from their land. This situation could lead to conflict between shrimp farmers and

agricultural farmers, especially if higher levels of pollution from shrimp pond effluent coincide with increasing salinization of groundwater and agricultural land.

1.3 Background

India has a biologically rich and diverse coastline in excess of 6000 km, covering nine states from Gujarat in the northwest to Kerala and Tamil Nadu in the south, and West Bengal in the northeast. More than 400 million people live along India's coastline, many of whom rely on the natural productivity of the ocean and its coastal zone for their livelihoods (M. Gupta & Fletcher, 2001; Hein, 2000, 2002; Lakshmi & Rajagopalan, 2000). Since 1980, cultivation of brackishwater shrimp has increased from 3,868 tonnes to 114,970 tonnes with a value of $715.4 million in 2002 (Figure 1), and India is now the world's fourth largest producer after China, Thailand, and Indonesia (Food and Agricultural Organization of the United Nations (FAO), 2000).

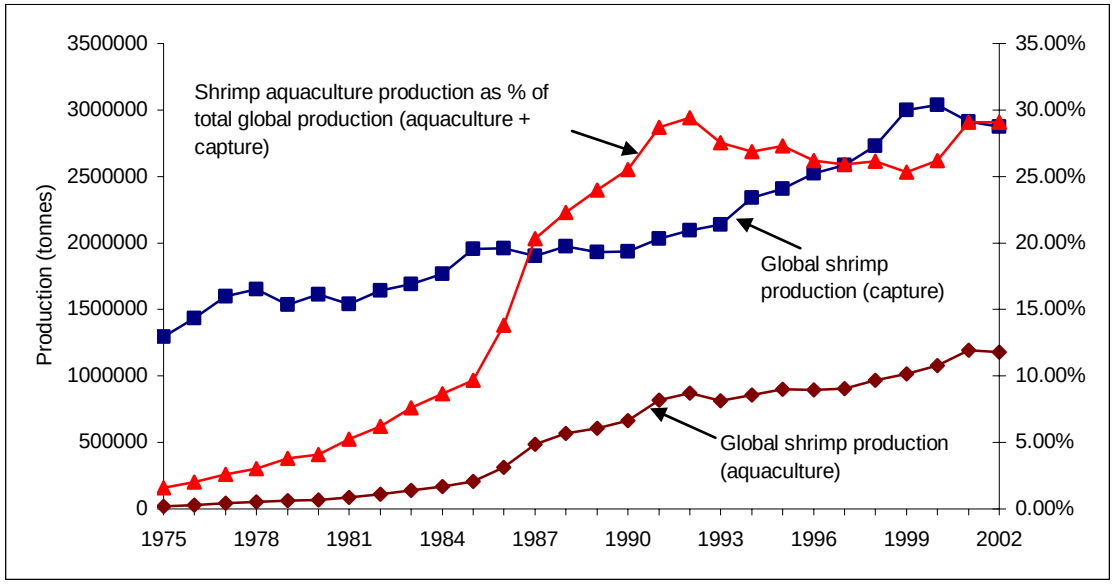
Figure 1: Shrimp production in India (aquaculture & capture), 1975 – 2002



Source: FAO (2000)

Globally, the production of cultured brackishwater shrimp has increased from 69,198 tonnes in 1980 to 1,179,717 tonnes with a value of $6.724 billion in 2002 (Food and Agricultural Organization of the United Nations (FAO), 2000). Since the demand for shrimp in North America, Europe and Japan exploded in the 1980s, the share of cultivated shrimp has increased dramatically from 4.11% to 29.10% of total shrimp production (aquaculture and capture fisheries) (Figure 2). This share is likely to rise even further due to increasing pressures on wild shrimp stocks, coupled with greater competition and higher costs associated with capture fisheries.

Figure 2: Global shrimp production (aquaculture & capture), 1975 – 2002



Source: FAO (2000)

The rapid growth of the shrimp aquaculture industry generates heated debate between proponents and detractors of the industry. Proponents claim that aquaculture is a Blue Revolution, akin to the agricultural Green Revolution started in the mid-1960s. Proponents claim a host of benefits accruing from shrimp aquaculture: a stable and

affordable alternative to declining wild shrimp stocks, which promotes global food security and reduces pressure on remaining wild stocks; economic growth through job creation, regional development, spin-off industries, and foreign exchange earnings; and an opportunity for developing countries to utilize marginal coastal areas (Economist, August 7, 2003; Naylor *et al.*, 2000; Stonich & Bailey, 2000). Proponents also point to the domination of the industry by developing countries, in the tropical zones of Asia and Latin America, as evidence of the economic benefits of shrimp aquaculture.

Its detractors claim a host of negative effects: a decrease in food security; marginalization of the poor and landless; extensive environmental and ecological damage; and transformation of communities from self-sufficiency to labour market dependency for their survival (Boyd & Clay, 1998; Paez-Osuna, 2001a, 2001b; Primavera, 1997a, 1998a; Stonich & Bailey, 2000). This perspective focuses on the negative economic, social, and environmental impacts generated by the rapid and relatively unregulated growth of the industry. However, both groups recognize that shrimp aquaculture raises a number of important questions regarding its contribution to economic growth, the distribution of its benefits and costs, the environmental and ecological impacts, and the extent of public participation.

1.4 Policy Context in India

Shrimp aquaculture is considered by India's central policymakers as an important component of an economic development platform for coastal communities, regions, and the nation as a whole. In the Planning Commission's 10th Five Year Plan (2002 – 2007), the Government of India (GOI) specifically referred to the passing of the Coastal Aquaculture Authority Bill as an important initiative to move the country towards

sustainable aquaculture development (Government of India, 2002). A major goal identified in the 10th Five Year Plan is to increase the country's per capita income, and shrimp aquaculture is an important export sector that generates significant foreign exchange, investment, employment opportunities, and regional growth (Government of India, June 2001). The GOI's emphasis on foreign exchange earnings as an important contributor to economic growth is supported by powerful shrimp aquaculture interests, represented by industry associations such as SEAI (Seafood Exporters Association of India). The GOI has specific objectives to increase shrimp production: increase the area under shrimp cultivation; increase investment in the sector; intensify production through the introduction of commercial shrimp aquaculture techniques and new technologies; minimize disease outbreaks; and increase hatchery production of shrimp fry for the stocking of shrimp ponds.

In India, only 12.98% of total land area suitable for shrimp aquaculture is currently under cultivation (Table 2). The east coast is more suitable than the west coast, and the States of West Bengal, Orissa, Andhra Pradesh, and Tamil Nadu account for approximately 90% of total shrimp aquaculture production (Map 1). In terms of intensity, approximately 90% of shrimp farms are less than two hectares, which is why the GOI and industry players are in favour of intensification. At 405,000 hectares (Ha), West Bengal has the largest potential area available for shrimp aquaculture in the country, yet only 12.33% of this area is currently under cultivation. At 0.60 metric tons (MT) per Ha, it also has one of the lowest productivity rates; consequently, West Bengal offers shrimp farmers an opportunity not only to expand the total area under cultivation, but also to intensify the production of shrimp in existing areas under cultivation.

Table 2: Shrimp production (aquaculture) in India, and State and total potential shrimp aquaculture area under cultivation, 2003 - 2004

State	Production (MT)	Production (share of total)	Area under cultivation (Ha)	SPAC	TPAC	Productivity (MT/Ha/Yr)
Andhra Pradesh	53,124	47.10%	69,638	46.43%	5.84%	0.76
West Bengal	29,714	26.35%	49,925	12.33%	4.19%	0.60
Orissa	12,390	10.99%	12,116	38.34%	1.02%	1.02
Kerala	6,461	5.73%	14,029	21.58%	1.18%	0.46
Tamil Nadu	6,070	5.38%	3,214	5.66%	0.27%	1.89
Karnataka	1,830	1.62%	3,085	38.56%	0.26%	0.59
Gujarat	1,510	1.34%	1,013	0.27%	0.09%	1.49
Maharashta	981	0.87%	615	0.77%	0.05%	1.60
Goa	700	0.62%	963	5.21%	0.08%	0.73
Total	112,780	100.00%	154,600		12.98%	0.73 (Mean)

Note: SPAC: = % of potential land area under cultivation in the State; TPAC: = % of total potential land area under cultivation in India ("potential" refers only to land area suitable for shrimp aquaculture).
Source: Marine Products Export Development Authority (2003-2004)

Map 1: Coastal States of India (for enlarged area see Map 2)

1.5 Scope of Research

This research project focuses on the acceptability of alternative development scenarios to local stakeholders who are directly or indirectly affected by shrimp aquaculture in the Indian Sundarbans[4]. A better understanding of the preferences of local stakeholders will contribute to the development of coherent and effective policies with respect to the sustainability of the shrimp-mangrove system, and the stakeholders that rely on the system for their livelihoods. As it currently stands, policy initiatives for the Indian Sundarbans are largely dictated by regional and national government agents, or influenced by polarized groups for or against shrimp aquaculture. A more participatory approach incorporating the views of local stakeholders is an important step in formulating constructive policies that reflect positive and negative aspects of shrimp aquaculture, in a larger development context for the region.

1.6 Methodological Approach

Stakeholder analysis is the methodological framework used in this research project. The reason for using a stakeholder analysis in the Indian Sundarbans is based on the benefits of an empirically derived management tool, or decision support system (DSS) in the case of the discrete choice experiment (DCE), which is derived from the preferences of local stakeholders. This research project provides policymakers and other stakeholders with an analytical tool (the DSS) to assess alternative management options

[4] The research project is part of a larger project initiated by the Shastri Indo-Canadian Institute (Shastri), under the auspices of the Shastri Applied Research Project (SHARP). The title of the SHARP project is "Assessing Environmental Management Options to Achieve Sustainability in the Shrimp-Mangrove System in the Indian Coastal Zone of the Bay of Bengal". Funded by the Canadian International Development Agency (CIDA), SHARP focuses on policy development for poverty reduction and sustainable development in India.

and development scenarios, with respect to the shrimp-mangrove system and shrimp aquaculture in the Indian Sundarbans. The application of a DCE in this research project is a step forward in the evolution of stakeholder analysis because it allows researchers to quantify the preferences of local stakeholders. The ultimate intention is therefore to provide policymakers and affected stakeholders with a DSS that will help policymakers make better informed decisions regarding the shrimp-mangrove system, and shrimp aquaculture in the Indian Sundarbans. Traditionally, stakeholder analysis has focused primarily on qualitative elements, which limits its effectiveness as a policy tool.

1.7 Limitations

This research project uses participatory methods to elicit the preferences of local stakeholders for different development attributes. The purpose of the research project is not to compare decision-making frameworks, such as top-down versus bottom-up alternatives; instead, it works within the decision-making framework in India; a top-down approach dictated by Union (the Government of India), State (the Government of West Bengal), and Panchayat (local) officials. However, the introduction of participatory methods recognises the importance of local stakeholders to the decision-making process, and these methods serve two purposes: to provide actionable feedback from locally affected stakeholders to decision-makers, and to empower local stakeholders to make their own decisions in a local setting. The latter purpose is achieved through a process of self-education, facilitated by the methods used to elicit the preferences of local stakeholders during the field component of this research project. Interaction with local stakeholders highlighted the fact that they possess significant knowledge about their local environment, and the social and economic challenges facing their communities. Through

the process of individual and group interviews, rapid rural appraisals (RRAs), and administration of the household survey (HS) and DCE, local stakeholders in Namkhana Block are more aware of the challenges and opportunities they face.

Conventional stakeholder analysis generally includes input from all stakeholders interested in the research topic, item, or policy issue. This approach often reflects the *ex post* nature of the analysis, which in many cases involving natural resource use is conflict resolution or conflict management. Such situations necessitate the input of all stakeholders to seek resolution. This research project focuses only on the preferences of local stakeholders (excluding stakeholders involved in the capture fishery) for alternative development scenarios; it does not examine the preferences of outside stakeholders that may have an interest in the development of the Indian Sundarbans (Appendix D: Stakeholders). This focus is possible because the research project is an *ex ante* analysis of the potential problems and prospects facing local stakeholders; it is not based on resolving or managing existing conflicts in the region. From a policy perspective, this research project is meant to facilitate discussion at local, regional, and national levels aimed at improving the living conditions of local stakeholders, and the management of natural resources.

The results and recommendations in this research project are based on a case study. A case study is less representative than a multiple area study, which means that the research project is unable to compare and contrast results from stakeholders in different Blocks in the Indian Sundarbans. Time constraints and logistical challenges regarding the choice of study area may have introduced some bias into the results, especially considering the relative wealth and accessibility of the study area vis-à-vis

more remote areas. A great deal of effort was made to focus on the regional impacts of alternative development scenarios for stakeholders in the Indian Sundarbans, not just the study area in question. This effort was made to mitigate the limits of a case study approach. Respondents were asked to consider the implications of alternative development scenarios for the entire region, and not just for their own household or geographic region.

CHAPTER 2: LITERATURE REVIEW – STAKEHOLDER ANALYSIS

2.1 Introduction

Shrimp aquaculture raises challenging policy and management questions that encompass economic, social, and environmental issues affecting multiple stakeholders on a global scale. Consequently, it has important implications for the application of stakeholder analysis as a theoretical framework, and for the role of local stakeholders in the decision making process in developing countries. However, the global nature of the shrimp aquaculture industry, the separation of production and consumption of shrimp between Southern and Northern countries respectively, and the skewed distribution of the economic, social, and environmental impacts of shrimp aquaculture, mean that many alternative frameworks based on economic, social, political, or development theory can be applied to this broad topic[5]. In this regard, it is possible to view stakeholder analysis as a lens through which economic, social, political, or development practitioners can view the role of various agents, or stakeholders, in a larger context. The purpose of this chapter is to review the application of stakeholder analysis to natural resource and environmental issues, in a developing country context. The specific objectives of this chapter are to define and identify the origins and key characteristics of stakeholder analysis, to review the methodological tools typically used in the execution of a stakeholder analysis, and to discuss the policy implications of an application of

[5] For example, the advent of shrimp aquaculture as a major export industry is supported by neo-liberal economic theory, especially with respect to export-led growth of non-traditional crops (Stonich, 1991).

stakeholder analysis in the context of natural resource and development issues associated with shrimp aquaculture in the Indian Sundarbans.

The first section of this chapter provides a definition of stakeholder analysis and its origins, with specific reference to natural resource and environmental issues. Stakeholder analysis is widely applied in other disciplines, but it is not the author's intention to review these applications. The second section investigates the rationale for conducting a stakeholder analysis, with reference to the complex and multi-use nature of natural resources, and the role externalities and open access conditions play in setting the stage for policy interventions.

2.2 Definition and Key Characteristics of Stakeholder Analysis

Stakeholder analysis is used widely in multiple disciplines, and it is an effective tool for policy analysis and formulation in developing countries (Grimble & Chan, 1995; Grimble & Wellard, 1997). Its application to natural resource uses and conflicts is especially useful in light of the multi-use nature of natural resources, the presence of market failures and externalities associated with natural resource systems, and the wide range of stakeholders directly or indirectly affecting or affected by decisions involving natural resources.

Grimble and Wellard's definition of "stakeholders" is the most applicable in the context of natural resources, and the policy development process in a developing country context:

> Any group of people, organised or unorganised, who share a common interest or stake in a particular issue or system; they can be at any level or position in society, from global, national, and regional concerns down to

> the level of household or intra-household, and be groups of any size or aggregation (1997: 175-176).

In this context, stakeholder (or multi-stakeholder) analysis is best defined as "an approach and procedure for gaining an understanding of a system by means of identifying the key actors or stakeholders in the system, and assessing their respective interests in that system" (Grimble & Chan, 1995: 113). In the context of natural resources, a more specific definition is used by Röling and Wagemakers that limits stakeholders to users and managers of natural resource (1998: 7).

Although stakeholder analysis was only applied to natural resource management and policy development issues in the early 1990s, the framework has its origins in the 1980s, in the field of management sciences (Freeman, 1984; Mason & Mitroff, 1981; Mitroff, 1983). The increasing complexity of business relations in the social sphere, and the consequent need for more modern approaches to business management led to the development of a stakeholder approach to meet these challenges. The role of the corporation as a profit maximizing institution by means of the production and sale of products to third parties increasingly gave way to the role of the corporation as employer, member of wider society, and institution that individuals or groups depend on for their livelihood (Carroll & Buchholtz, 2003). This expansion of the definition of the corporation incorporates not just the direct relationships between the corporation, its stockholders, employees, suppliers, and customers, but also the indirect relationships between the corporation and other stakeholders that affect it, or are affected by it. In this sense, there is a strong link between stakeholder analysis in the fields of management science and natural resource management in the “need to recognize and better deal with the wide range of stakeholders that can affect or be affected by the actions and policies of

policymakers" (Grimble & Chan, 1995: 114-115). The reasons for using a stakeholder analysis are fourfold (Ramirez, 1999):

- to discover existing patterns of interaction by empirical means;
- to improve interventions through analytical assessment;
- to provide policymakers with better management tools;
- to predict conflict.

A number of useful information gathering techniques have been adapted and applied in the context of stakeholder analysis (Grimble & Chan, 1995). The first set of techniques include rapid and participatory rural appraisals (RRA and PRA), which have been adapted from the field of micro-level development research. The RRA method first appeared in the 1970s and 1980s, largely in response to biased perceptions generated by urban professionals visiting rural areas to conduct tourism research, and to the many problems associated with complex questionnaire surveys (Chambers, 1994a, 1994b). By the late 1980s, the RRA method had developed to the point that four classes of RRA were listed by the International Institute for International Development (IIED): participatory RRAs, exploratory RRAs, topical RRAs, and monitoiring RRAs (McCracken *et al.*, 1988). The participatory element of a participatory RRA is reflected in the methods employed to conduct it; namely semi-structured interviews and focus groups (Chambers, 1994c). However, methods only accounts for one of three basic components of a PRA; the other two being behaviour and attitudes (of outsiders), and sharing (knowledge and experience of locals and outsiders). Alternatively, a distinction can be made between a participatory RRA, with an emphasis on the elements which encourage participation by local people, and a PRA, which is focused on initiating a process of participatory

planning, and where local people are the primary actors (Townsley, 1996). The PRA method evolved, in part, from the RRA method, and its application in the development sphere spread quickly in the 1990s[6] (Chambers, 1994b). The difference between the two methods is defined both by the reasons for, and process of, conducting an RRA or a PRA (Table 3). "An RRA is intended for learning by outsiders. A PRA is intended to enable local people to conduct their own analysis, and often to plan and take action" (Chambers, 1994a: 958). The purpose of a PRA is to enable development practitioners, government officials, and different stakeholders to work together to plan and implement appropriate programs (World Bank, 1996).

Table 3: Differences between an RRA and a PRA

RRA	PRA
Focused on needs of development workers and agencies *(extract information)*	Focus of PRA decided by communities *(facilitate sharing)*
Priority is the efficient use of time and achievement of objectives *(rapid and cost effective)*	Final product used mainly by community *(community-oriented)*
Communication and learning tools used to help outsiders analyse conditions and understand local people *(data analysis and policy prescriptions)*	Enables communities to make demands on development agencies and institutions *(empowerment)*
Focus of RRA decided by outsiders *(top-down)*	Closely linked to action or intervention, and requiring availability of support for decisions, and conclusions reached by communities based on results of the PRA *(bottom-up)*

Based on Townsley (1996)

The second set of techniques is based on seven principals or approaches developed from the management science literature (Mason & Mitroff, 1981; Mitroff, 1983). These approaches were developed to aid policymakers identify stakeholders, and

[6] Five streams are identified by Chambers as sources and parallels to PRA: activist participatory research; agroecosystem analysis; applied anthropology; filed research on farming systems; and rapid rural appraisal (1994b: 954).

three of these approaches are particularly relevant to stakeholder identification in the context of natural resource management (Grimble & Chan, 1995). The three approaches are the reputational, focal group, and demographic. The reputational approach is based on asking knowledgeable or important members of a community to identify stakeholders groups. The focal group approach is based on interviews with one or more stakeholders, which often leads to the identification of other groups that have a stake in the use of natural resources. The demographic approach is based on pre-defined criteria or categories, which are used to identify different stakeholders.

2.3 Rationale for Stakeholder Analysis

The application of stakeholder analysis is an important development in the formulation of polices concerning natural resources and local stakeholders. There are two primary reasons to justify the use of stakeholder analysis in the general context of natural resources and the policy development process in developing countries:

> Stakeholder analysis can be justified on the basis of the limitations and weaknesses of conventional methods used in policy and project assessment and design in dealing with stakeholder interests. The application of stakeholder analysis to natural resource management can also be justified in terms of why it is particularly relevant to natural resource and environmental issues, as opposed to other issues (Grimble & Chan, 1995: 115).

Conventional economic methods of measuring the welfare effects of environmental and social policies include cost benefit analysis (CBA), and total economic value (TEV). These approaches boil a project or policy initiative down to a singe numerical value, rarely with any consideration of the distribution of costs and benefits between different stakeholders, or of the perception of different stakeholders

regarding the nature of the problem they face (Grimble & Wellard, 1997; Jenkins, 1999). Consequently, certain stakeholders may not cooperate with the implementation of a project or policy, which often leads to its failure despite a positive internal rate of return for the project or policy. Jenkins (1999) proposes an integration of financial, economic, and distributive analysis into CBA to mitigate this outcome. This approach, he argues, forces development projects and policymakers to identify stakeholders, determine whether or not they stand to gain from the project's implementation, and to address the concerns of those stakeholders that do not stand to gain from the project or policy's implementation (Jenkins, 1999). This approach is still rooted in a top-down, financial and economic evaluation of a project or policy's success or failure. Even if it is possible to weight potential financial benefits and costs accruing to different stakeholders, it is difficult to measure, in financial and economic terms, the distribution of benefits and costs of the economic, social, and environmental externalities associated with the project or policy. This is especially true in the case of natural resources, where market failures and non-market, negative externalities are often present.

Five characteristics make stakeholder analysis particular effective in the management of natural resources, and the policy development process in a developing country context (Grimble *et al.*, 1994; Grimble & Wellard, 1997):

- environmental problems are often dominated by natural and physical systems (such as watersheds, forest ecosystems, coastlines, etc.) that cut across geographic borders (different communities, villages, towns, etc.), as well as across economic, social, and political institutions. Consequently, environmental issues involve a wide range of stakeholders including national, regional, and local governments, commercial

interests, and local communities and individual stakeholders that rely on natural resources for their livelihoods;

- the impacts of environmental problems affect a wide range of stakeholders at local, regional, national, and sometimes international levels. These effects are the externalities associated with the use, consumption, or extraction of environmental services and natural resources. The costs associated with negative externalities, such as pollution from aquaculture farms released into public canals, are predominantly borne not by those who generate them, but by other users of natural resources. Rarely in the case of environmental problems are these costs internalized due to the difficulty of measuring, valuing or regulating these externalities. In contrast, many of the benefits accruing from ecological or environmental systems are non-market goods or services, and hence difficult to measure. An example of these goods and services is the biological productivity of mangrove forests, which benefits fishers, and the capacity of mangrove forests to store carbon, and protect coastal communities from storms and erosion;
- natural resources are often common or public goods, which makes it difficult to control access or extraction by different stakeholders, and leads to inefficient and unsustainable outcomes;
- natural resources are subtractable, which leads to potential conflict between stakeholders in the present, as well as in the future. These temporal trade-offs have important implications for the rate of consumption or use of the resource for one purpose or another;

- the multiple uses of natural resources are often incompatible, or mutually exclusive. For example, mangrove land converted to agricultural land limits the ability of wood collectors to generate a livelihood, and the conversion of agricultural land to shrimp ponds is often irreversible due to extreme degradation of the land. These trade-offs require careful analysis, especially when considering temporal effects or potentially irreversible damage.

Stakeholder analysis is thus most usefully applied in situations where there are negative externalities, unclear property rights, different levels of stakeholders with divergent interests, and where trade-offs regarding natural resources need to be addressed at the policy level.

The application of stakeholder analysis is particularly relevant in the case of shrimp aquaculture because of the wide range of economic, social, and environmental impacts on different stakeholders in different geographic areas, and because the debate about the benefits and costs associated with shrimp aquaculture is increasingly polarized in the academic literature, and in the policy arena. The debate is seen as mutually exclusive, focusing only on the negative or positive impacts of shrimp aquaculture, depending on the point of view of the author or policymaker. Unfortunately, the specific nature of the benefits or costs associated with shrimp aquaculture, and its impact on local stakeholders in specific geographic locations, is missing from many analyses. In India, for example, the experiences of local stakeholders in Tamil Nadu are significantly different from those of stakeholders in the Indian Sundarbans in West Bengal. Local resistance to shrimp aquaculture in Tamil Nadu ultimately went all the way to the Supreme Court of India, whereas as in the Sundarbans, local farmers have practised a

traditional form of shrimp cultivation for a long time. Without proper identification of the stakeholders, the economic, social and environmental conditions, and careful analysis of the trade-offs experienced by different stakeholders in different geographic locations, policymakers run the risk of implementing top-down policies aimed at promoting or curbing shrimp aquaculture, with potentially disastrous consequences. Regrettably, stakeholder analysis is too often applied after the implementation of policies that generate conflict between different stakeholders at local, regional, or national levels. Stakeholder analysis is widely applied to cases requiring conflict resolution, whereas in many cases an early application of stakeholder analysis may have led to conflict avoidance. However, this pre-emptive approach is not always applicable in the case of natural resource management, as described by Hjortso *et al*. (2005) in their application of rapid stakeholder and conflict assessment methodologies to a case of mangrove forest conservation in Vietnam[7]:

> We have argued that users of people-centred approaches must recognize that power and social conflict are inherently part of resource management. Traditional stakeholder analysis, therefore, must be integrated with conflict assessment focused on subject, relationship, and procedure (2005: 154).

The implication of this approach is that local stakeholders are generally unable to resolve the trade-offs associated with the use of natural resources, and that this inability will ultimately lead to conflict. However, the imposition of externally devised management policies is often to blame for the emergence of conflict in the first place; hence the need for stakeholder analysis to help identify and resolve problems associated

[7] This case is the Damdoi Forest Enterprise, which has some similarities to the case in the Indian Sundarbans. In both cases, mangrove forests and shrimp aquaculture exist in close proximity, and multiple stakeholders depend on the natural ecosystem for their livelihoods.

with these policies. This approach is best summarised by the second of Lewis's (1996) reasons for conflict regarding the use of natural resources in or near protected areas[8]:

> (1) The perceived incompatibility of meeting local peoples resource needs and at the same time protecting nature; and (2) lack of involving local people and others who care about the land and nature in planning and decision-making processes concerning such resources (Hjortso *et al*., 2005: 149).

Unlike other cases in Tamil Nadu and Damdoi Forest in Vietnam, conflict over the use of natural resources is not the basis for stakeholder analysis in this research project in the Indian Sundarbans, especially since most stakeholders agree that protection of mangrove forests is of paramount importance to all local stakeholders because of the protection it provides against cyclones and soil erosion. Rather, the identification and description of local stakeholders, the analysis of the trade-offs they currently face, or may face in the future if shrimp aquaculture expands into agricultural land, and the examination of alternative development scenarios, are the driving force for conducting a stakeholder analysis. There is little doubt, however, that potential for conflict exists if shrimp aquaculture expands and intensifies through the introduction of outside commercial interests, and advanced cultivation methods. At the national level, the Coastal Aquaculture Authority Act (2005) broadens the power of the Coastal Aquaculture Authority to manage aquaculture operations in the coastal zone, despite the existence of environmental laws regulating activity in these zones, and the Supreme Court order banning shrimp aquaculture within 500 metres of the high tide line. In the Indian Sundarbans, shrimp farmers are local, use low intensity shrimp cultivation

[8] The author was unable to cite the original source; however, it is cited in the paper by (Hjortso *et al*., 2005).

techniques, and they indicate a high preference for mangrove forest expansion, which is counter to the perception that shrimp farming and mangrove forests are mutually exclusive. The real potential for conflict has more to do with the expansion of commercial shrimp aquaculture by outsiders; this encroachment may have far-reaching consequences for the environment, as well for economic sustainability and social equity in the Indian Sundarbans.

CHAPTER 3: APPROACH AND METHODS

3.1 Introduction

The research findings regarding stakeholders in this project are based on a multi-method approach using qualitative and survey-based information collected during the pre-testing and data collection phases of the project. The multi-method approach is often used to combine qualitative information into the quantitative data collection process (Ragin *et al.*, 2004). In this project, qualitative information was collected in the first stage of the data collection process, the pre-testing phase, with important implications for subsequent phases and data analysis. The use of qualitative information was critical to the proper identification of stakeholders, variables, and attributes for the household survey (HS) and discrete choice experiment (DCE). In this regard, the multi-method approach is essential to the proper implementation and analysis of a DCE, especially when participatory stakeholder analysis is the underlying theoretical and methodological framework. Participatory stakeholder analysis is based on the role stakeholders play in identifying variables and attributes, not just their response to a HS or DCE. The multi-method approach also sharpened the focus of the research on an *ex ante* evaluation of alternative development scenarios for the Indian Sundarbans, versus the more traditional *ex post* evaluation of conflict between different stakeholders arising from well established shrimp aquaculture activities in other parts of India, Asia, and Latin America.

Qualitative research techniques were used to identify the following key elements of the research project during the pre-testing phase: stakeholders directly or indirectly

affected by shrimp aquaculture; the socio-economic impacts of shrimp aquaculture on different stakeholders; the trade-offs between different stakeholders with respect to alternative anthropogenic uses of the shrimp-mangrove system; and suitable attributes for the DCE. Quantitative data in the form of a HS was used to describe and analyze both representative and targeted stakeholders, as well as to segment different stakeholders in the analysis phase of the DCE.

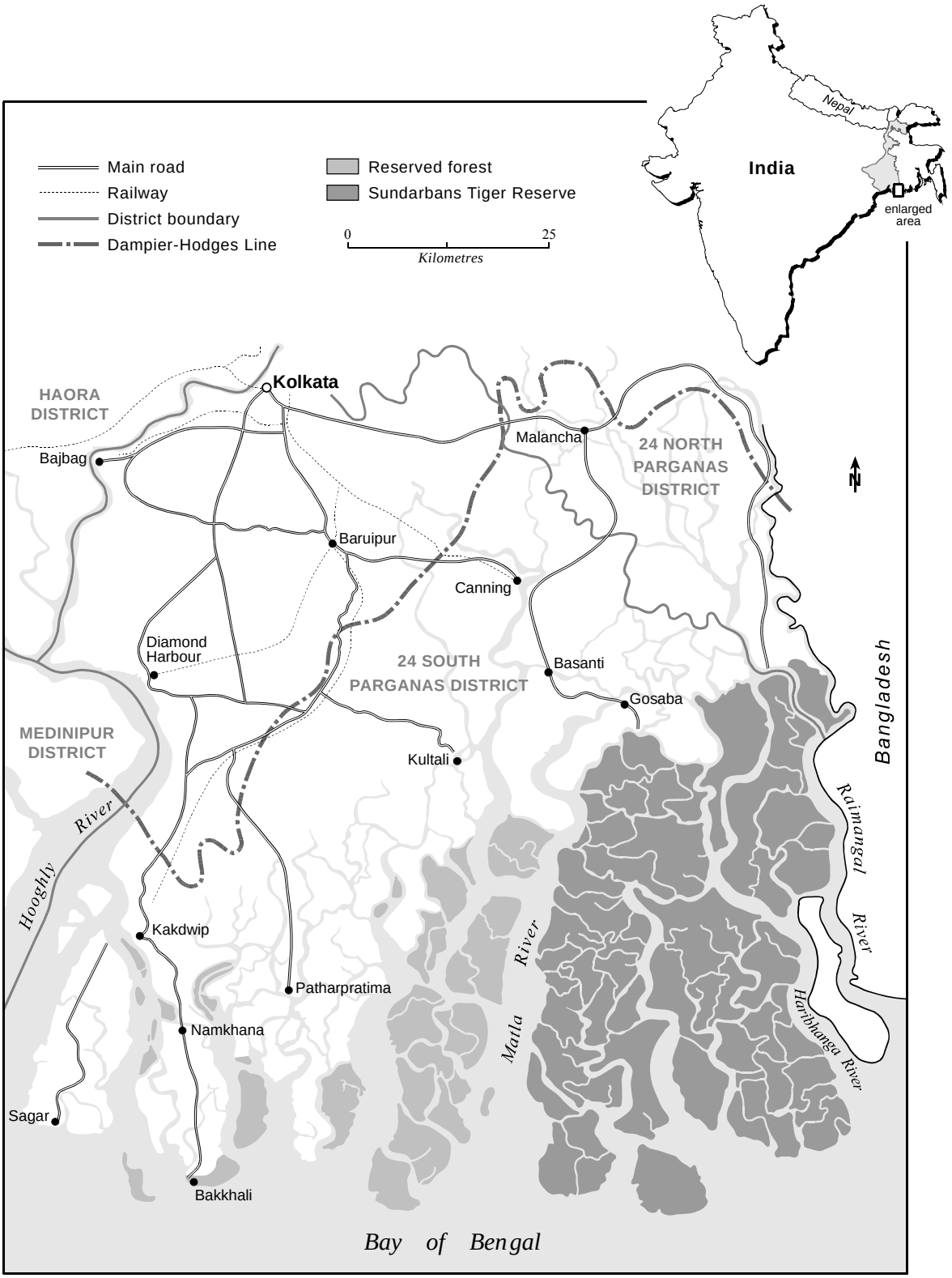
3.2 Site Selection and Description

The Sundarbans is the largest contiguous area of mangrove forests in the world, forming an integral part of the delta region at the mouth of the Ganges, Brahmaputra and Meghna rivers along the Bay of Bengal (Map 2). It covers approximately 10,000 km^2 of forest and water, which is shared between India (40%) and Bangladesh (60%) The Indian share is comprised of 4,260 km^2 of reserved forest, which is managed by the Sundarbans Tiger Reserve (2,600 km^2), and the 24 Parganas South Forest Division (1,660 km^2). An additional 5,400 km^2 of inhabited, non-forest area exists on the north and north-western fringe of the mangrove forest in India. This inhabited area is also referred to as the Sundarbans region, bringing the total Sundarbans area to 9,660 km^2 on the Indian side. It is bordered on the west by the Hooghly river, on the east by the Raimangal river, on the south by the Bay of Bengal, and on the north by the Dampier-Hodges line[9]. The Indian Sundarbans was declared a Global Biosphere Reserve by UNESCO in December 2001.

[9] The Dampier-Hodges line is an imaginary line between Kakdwip and Basirhat in 24 Parganas South and North districts respectively, and it indicates the northern-most limits of estuarine zone affected by tidal activity.

The entire Indian Sundarbans lies within the State of West Bengal, primarily in the district of 24 Parganas South, with a small portion in the district of 24 Parganas North. The Indian Sundarbans covers 19 Blocks: 13 in 24 Parganas South, and 6 in 24 Parganas North. The geographic constraints of the research area presented a number of challenges with respect to the implementation of the HS and DCE. The first challenge was to identify locations where all relevant local stakeholders groups were present. The second challenge was to identify locations within reasonable travel time from Kolkata. Out of the 19 Blocks in the Indian Sundarbans, Namkhana Block was selected for the survey and household experiment. Bakkhali is located on the southern tip of Namkhana Block, 132 km from Kolkata, and it served as the base for the pre-testing phase of the research project from January – March, 2005. As of the 2001 GOI census (Government of India, 2001), West Bengal had a population of 80.1 million people, and 24 Parganas South had a population of 6.9 million (5.8 in rural areas and 1.1 in urban areas). Namkhana Block had a population of 160,627 and is considered rural.

Map 2: Indian Sundarbans (24 Parganas South and North)



3.3 Identifying Stakeholders

As discussed in Chapter 2, the RRA, reputational, focal group, and demographic techniques were all used to identify and elicit information from different stakeholders in Namkhana Block. The RRA, reputational, and focal group techniques are qualitative approaches, while the demographic technique is a survey based approach.

The list of stakeholders that have a stake in the management and development of the Indian Sundarbans is long. The list includes a diverse range of interested groups include international agencies, non governmental organizations, national, state, and local governments, commercial and industrial interests, and regional and local communities (Appendix D: Stakeholders). Consequently, the Indian Sundarbans presents policymakers with multiple and often conflicting demands from different stakeholders. In most cases, the power to influence policymakers lies in the hands of international, national, and regional or state stakeholders[10].

3.4 Qualitative Methods

An RRA method was used to identify different stakeholders, and to select attributes for the DCE based on the stakeholders' perspectives. Informal interviews and focal groups were conducted with households from different stakeholders, as well as with small groups from different communities, ranging in size from 3 – 20 persons. The interviews were conducted with randomly selected representatives of the following key stakeholders: fry collectors, shrimp farmers, and agricultural farmers (Appendix E:

[10] Evidence of this power is clear from the establishment of the world heritage site and biosphere reserve in the Indian Sundarbans, the international and national efforts to save the Bengal tiger through the establishment of the Sundarbans National Park, and the establishment of the Sundarban Development Board (SDB), by the West Bengal government, to manage development in the region.

Interviews). The focal group interviews were generally comprised of members from different stakeholders, although some of the group interviews were with fry collectors only.

3.5 Survey Based Methods

Random and targeted HSs were used to collect quantitative data for the key stakeholders. Since a random sample did not guarantee sufficient representation of any particular stakeholder group, as some groups were quite small, the sampling was split into two distinct groups: a random sample (296 households) and two separate samples targeted at shrimp fry collectors, and shrimp farmers/potential shrimp farmers (52 and 48 households respectively). The random sample is representative of the two villages surveyed in Namkhana Block, Chondinpiri North and Debnagar, and the targeted samples sufficiently augment the sample size of the two crucial stakeholder groups for the DCE. The questionnaire was the same for all the surveys (Appendix F: HS and DCE).

Approximately 400 cases were required to generate sufficient representation of the key stakeholders (396 were ultimately used for data analysis purposes). Surveying this many households necessitated a well organized team of local field investigators (FIs) familiar with the research area. It also required the assistance of the Sundarban Development Board, and locally elected officials (Appendix G: Letter of Cooperation). Implementation of the HS faced two constraints:

- seasonal – all surveys has to be completed by May due to the onset of extreme heat and monsoon conditions;

- human resources – there were a limited number of FI who met the qualifications required to conduct accurate surveys. In addition, conducting a DCE requires thorough preparation and a good grasp of the material, which requires a fairly high level of understanding. A training workshop was held in Bakkhali to train the FIs.

3.5.1 Sampling plan

The sampling plan for the random and targeted samples was based on the selection of a representative Block, Namkhana, within the district of 24 Parganas South. There are seven Panchayats within Namkhana Block, and approximately 5-7 villages within in each Panchayat. One village in Horipur Panchayat, and one village in Namkhana Panchayat (Appendix H: Sampling and Implementation Plan) were selected based on the following criteria:

- representation of stakeholders (shrimp and polyculture farmers; paddy, vegetable and betel farmers; shrimp fry collectors; fishermen);
- potential for shrimp farming;
- presence of recent or ongoing conversion of agricultural land/polyculture area for the purpose of shrimp farming;
- proximity to mangroves;
- proximity to brackishwater source;
- presence of technical assistance for shrimp farming.

3.6 Discrete Choice Experiment (DCE)

3.6.1 General approach

A discrete choice experiment[11] (DCE) is a stated preference technique where respondents are asked to evaluate hypothetical scenarios, as opposed to the researcher modelling actual behaviour (i.e. revealed preference methods). For the purpose of implementing a DCE, two separate components are required: a statistical design plan to create the hypothetical scenarios, which have combinations of policy or outcome attributes; and a statistical method to analyse the responses (Louviere *et al.*, 2000). The most commonly used statistical method of analysis is the multinomial logit (MNL) model, which is based on the behavioural assumptions of random utility theory (McFadden, 1974). This kind of choice modelling based on random utility theory originated in transportation research, and has been applied extensively in the fields of applied decision making and market research (Adamowicz *et al.*, 1994). While originally the method was used to model actual behaviour (i.e. revealed preferences), when the choice behaviour is based on the evaluation of hypothetical profiles or choice sets, it is referred to as stated preference research, or stated choice research if two or more profiles are presented in one choice set (Louviere *et al*., 2000; Louviere & Woodworth, 1983). In each of these choice sets, the respondent is presented with two or more alternative scenarios (one of which often involves maintaining the *status quo*), and is required to indicate his/her preference for one of the alternatives, assuming these are the only alternatives available to him/her.

[11] The literature may refer to a discrete choice model, or choice model, or choice based conjoint or contingent choice model; some of these terms lead to confusion because the distinction between stated or revealed preference or choice model becomes indistinguishable.

Each alternative is described in terms of a number of attributes. For each attribute, there are multiple levels that describe the attribute, and usually these attribute levels are varied in each choice set according to an orthogonal statistical plan[12]. By aggregating the responses from all respondents, it is possible to derive part worth utility functions for each attribute. These part worth utilities demonstrate the importance of various attribute levels to the choice selection of an individual.

To calculate efficient part worth utilities, a DCE study must be designed to ensure orthogonality of attribute levels both within and between alternatives. A full factorial design, in which all main effects and interactions are orthogonal (i.e. independent), represents one extreme for a design plan that a researcher could employ for a choice experiment. However, full factorial design plans require individuals to evaluate an unrealistic number of choice sets, even in cases where the total number of attributes is small. Therefore, researchers typically compromise the ability of a design plan to estimate all interactions by selecting a design plan that requires only a reasonable number of choice sets to be evaluated. A fractional factorial design plan is one such plan that reduces the size of full factorial designs. A variety of fractional factorial design plans exist that range from orthogonal estimation of main effects without any interactions, to plans that permit various degrees of orthogonal main effects and interaction effects to be estimated (Louviere *et al*., 2000).

[12] In an orthogonal design, the attribute levels are uncorrelated with any other attributes, thus ensuring that the part worth utilities measure only the intended attribute and are not confounded with other attributes.

3.6.2 Theoretical background

The theoretical basis for stated choice research lies in random utility theory in which a person's utility from a particular site or experience is described by the following utility function, sometimes referred to as a conditional indirect utility function:

$$U_{in} = V_{in} + \varepsilon_{in} . \qquad (1)$$

The utility gained by person *n* from alternative *i* is made up of an objective or deterministic and observable component (*V*) and a random, unobservable component (ε) (Adamowicz *et al.*, 1998; Adamowicz *et al.*, 1994). The unobservable component, often referred to as a random error component, is commonly assumed to be Type I or Gumbel distributed and to be independently and identically distributed (McFadden, 1974). A result of this assumption is that a DCE must be independent of irrelevant alternatives (IIA), meaning that "the ratio of choice probability for any two alternatives is unaffected by addition or deletion of alternatives" (Carson *et al.*, 1994: 354). In simpler terms, the IIA requires that alternatives are independent.

The observable component of utility (V) can be expanded as follows:

$$V_{in} = \mathrm{ASC}_i + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k \qquad (2)$$

where the ASC_i is an alternative-specific constant that represents the "mean effect of the unobserved factors in the error terms for each alternative" (Blamey *et al.*, 1999: 341). Furthermore, β_1 is the coefficient for the first attribute, and X_1 is the level for the first attribute, and there are a total of *k* attributes.

An individual will choose alternative *i* over alternative *j* if and only if $U_{in} > U_{jn}$. Thus, the probability that person *n* will choose alternative *i* over alternative *j* is given by the equation:

$$\text{Prob}(i|C) = \text{Prob}\{V_{in} + \varepsilon_{in} > V_{jn} + \varepsilon_{jn}; \forall j \in C\} \qquad (3)$$

where *C* is the complete set of all possible sites from which the individual can choose. Since the ε term is assumed to be Gumbel-distributed, the probability of choosing alternative *i* can be calculated by the equation (McFadden, 1974):

$$\text{Prob}(i) = \frac{\exp^{v_i}}{\sum_{j \in C} \exp^{v_j}} \qquad (4)$$

which represents the standard form of the MNL model.

3.6.3 Design of DCE for Namkhana Block

The HS was used to administer the DCE. The attributes and their associated levels were identified through a series of discussions with experts, and numerous individual and group interviews in the field (Appendix E: Interviews). The attributes were described to respondents during the survey (Appendix F: HS and DCE), and were also represented in graphical form (Figure 3).

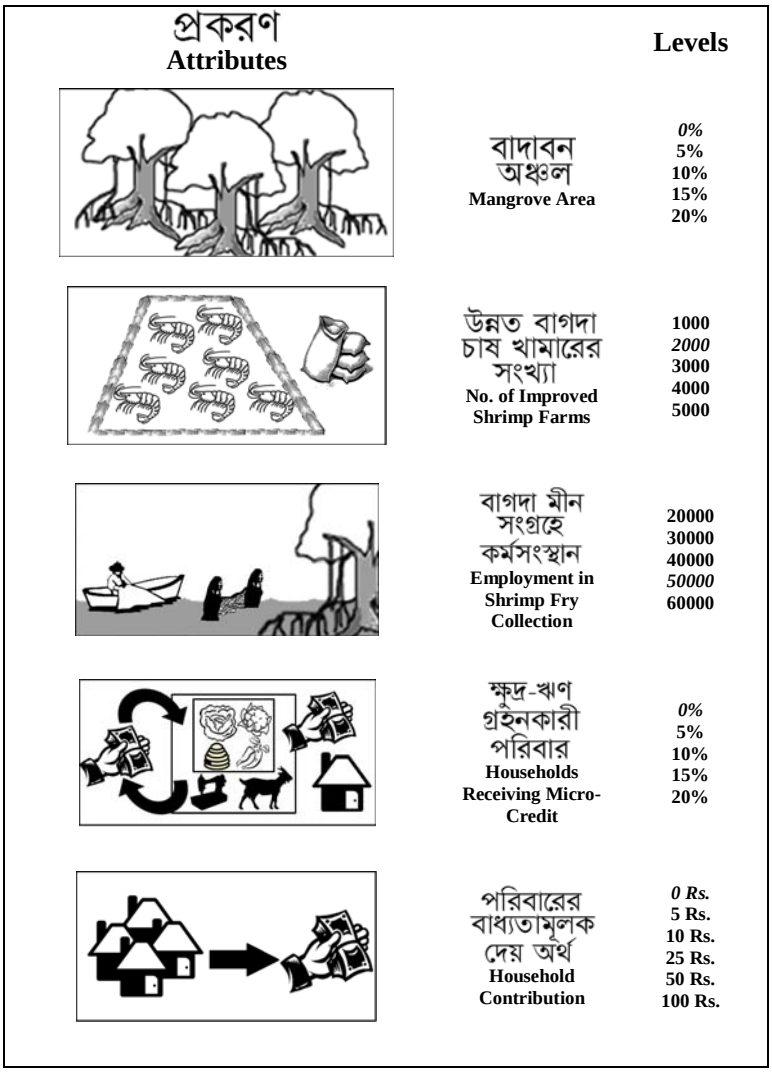
The attributes reflect key environmental and economic components, in the context of this research project, which were identified by different stakeholders during the pre-testing phase (Appendix I: DCE Pre-test Results). Mangrove coverage is fundamental to the survival of many floral and faunal species in the Indian Sundarbans. Mangrove coverage protects communities from the devastating effects of storms and cyclones in the region, and also from land erosion caused by river action in the Sundarbans delta. The

number of shrimp farms and the number of fry collection jobs reflect the economic importance of shrimp aquaculture. Mangrove forests have been cleared in many other countries in Asia and Latin America to make way for shrimp farms, which effectively documents a trade-off of mangrove coverage (an environmental attribute) in favour of shrimp aquaculture (economic attributes represented through the number of shrimp farms and fry collection jobs). Many households in the Indian Sundarbans are focused on subsistence production to meet their daily needs; therefore, access to credit is an important initiative to help these households generate an income. Access to micro-credit also offers households an opportunity to diversify their source of income, especially in the case of households dependent on fry collection, which is regarded as a job of last resort. The household payment attribute is a payment vehicle which represent a household's willingness to contribute towards the development of the Sundarbans through a capital fund, and can be used for valuation purposes (Bennett & Blamey, 2001; Hanley *et al.*, 2001; Hanley *et al.*, 1998).

The DCE is comprised of choice sets made up of three different choice profiles, which were presented to respondents: "Option 1", "Option 2", and the "Current Situation" (Appendix J: Sample of DCE Choice Card). The three choice profiles are based on the attributes described earlier in this section. For each choice set the attribute levels for Options 1 and 2 vary so that no two choice sets are alike. Options 1 and 2 represent hypothetical scenarios, whereas the current situation (Current Situation) represent the *status quo*, and is always the same for each choice set. Since each attribute is independent of the other attributes, the combination of levels for Options 1 and 2 are randomly generated within the experimental design parameters. Respondents were asked

to choose one of the three choice profiles (Option 1, Option 2, or Current Situation) for each of the choice sets presented to them (a "None of the Above" alternative was also available).

Figure 3: List of attributes and levels (Current Situation in italics) for DCE



Creating choice profiles from five attributes with five levels each amounts to a 5^5 factorial design. A fractional factorial representation of a resolution III main effects design requires 40 replications (Addelman, 1962). Given the fact that the data were

collected as part of the HS, each respondent was shown only five choice sets, and the total of 40 choice sets were divided into ten survey versions[13]. The DCE study involved mostly illiterate or semi-literate rural residents; therefore, the choice sets were created in the Bengali language, as well as with pictographs to convey the meaning of each attribute and its respective level (Figure 3). Since all the attributes were specified as numeric variables, it is possible to represent each level graphically on a vertical sliding bar. Each choice set was printed on a separate sheet of paper, and each version of the DCE (i.e. five choice sets) was printed on the same coloured paper to avoid confusion. Each book of ten versions of five choice sets (i.e. 50 choice sets in total) was bound in a spiral binder for multiple use. This administration of a DCE is novel, and it is an effective method for collecting multivariate trade-off information from rural populations in developing countries (Rasid & Haider, 2003).

[13] The first choice set was the same for each version, and this choice set was used to familiarize the respondent with the choice experiment format. Results for the first choice set were not analysed, leaving four choice sets per respondent for analysis purposes.

CHAPTER 4: IDENTIFICATION AND DESCRIPTION OF STAKEHOLDERS

4.1 Introduction

Based on the findings of the field research conducted in Namkhana Block, the principle stakeholders are segmented into two groups for the purpose of analysis: shrimp fry collectors (Fry Collectors), and current or potential shrimp farmers (Shrimp Farmers). A third stakeholder group comprises those households whose primary activities do not include fry collection or shrimp farming (Others). Based on the random sample of 296 households in Namkhana Block, 35 households are engaged in fry collection (11.8%), 84 households are currently engaged or plan to engage in shrimp farming (28.4%), and 177 households are engaged primarily in agricultural farming including rice, vegetable, and betel cultivation (59.8%). The random sample is representative of two villages, Chondinpiri North and Debnagar.

Analysis of data in sections 4.2 – 4.6 is based on combined data from the random sample (N=296), and targeted samples of Fry Collectors (N=52) and Shrimp Farmers (N=48). The total number of sample points (random and targeted samples) for each stakeholder group is 87 Fry Collectors, 132 Shrimp Farmers, and 177 Others (Total N=396). An important clarification is necessary regarding the classification of Shrimp Farmers: only six of these households in the random sample recorded any income from shrimp farming in the preceding 12 months (N=84), and only seven of these households in the combined random and targeted samples recorded any income from shrimp farming

in the last 12 months (N=132). The relevance of these findings is important because it indicates how few households currently generate any income from shrimp farming, versus the number of households that are interested to start cultivating shrimp in the next five years. Many of the households interested in shrimp farming focus on the higher profit margins associated with shrimp cultivation; however, many of the households not interested in shrimp farming are fearful of viral outbreaks (especially white spot), and the financial risks associated with the activity. For the purposes of this research project, the households currently engaged in shrimp farming, and the households that plan to engage in shrimp farming are classified into one stakeholder group: Shrimp Farmers[14].

4.2 Shrimp Fry Collectors (N=87)

There is a clear difference between the relative wealth of different stakeholders: Fry Collectors are the least wealthy, and Shrimp Farmers are the wealthiest[15] (Table 4). The divergence in wealth between these two stakeholders makes intuitive sense given that fry collection is a job of last resort, and shrimp farming requires relatively large amounts of capital. In terms of measures of dispersion for the WI, all three stakeholders exhibit positive skewness, with Fry Collectors exhibiting the highest skewness. This

[14] The primary reasons for this classification is based on three realities: there are too few current shrimp farmers to analyze independently; current shrimp farmers and households interested in shrimp farming have a collective stake in the activity, and the *ex ante* nature of this research project with respect to shrimp farming requires a clearer understanding of the dynamics of this stakeholder group as it potentially grows.

[15] Measures of wealth are based on a Wealth Index (WI), which is a numeric variable, generated using three variables from the HS: number of adult members of the household (over 15 years of age); area of agricultural land, polyculture ponds, and shrimp ponds owned by the household (in *bighas*); and the number of cattle owned by the household. The WI is a broader based method to categorise households than an income index, and is akin to an asset based index: adult members of the household are a source of labour, and land and cattle are capital.
WI = (no. of adults (over 15 years of age) + owned land (*bighas*) + no. of cattle) / highest score for (no. of adults (over 15 years of age) + owned land (*bighas*) + no. of cattle). The WI ranges from 0 to 1, although there is no score of 0 for any of the households. The score of 1 represents the "wealthiest" household based on the WI.
A *bigha* = 3283 m^2

implies that sample points for all stakeholders are stacked towards the lower end of the WI, which is confirmed by the median statistic for each stakeholder group (Table 4). A comparison of the means of the WI for each stakeholder group indicates that Shrimp Farmers are significantly different (and wealthier) than Fry Collectors and Others.

Table 4: Mean Wealth Index (WI) of stakeholders

	Median	Mean	Lower bound	Upper bound
Fry Collectors (N=87)	0.153	0.190	0.160	0.219
Shrimp Farmers (N=132)	0.284	0.314	0.285	0.344
Others (N=177)	0.191	0.219	0.198	0.239

Note: lower and upper bounds based on a 95% confidence interval for the mean. Total N=396.
Note: mean WI for Fry Collectors and Others is significantly lower than mean WI for Shrimp Farmers. Results are based on two-sided tests assuming equal variances (0.05 significance level). Tests are adjusted for all pairwise comparisons within a row of each innermost subtable using the Bonferroni correction.
Generated using SPSS (2004)
Source: SHARP HS and DCE

Fry Collectors fall into the lowest income bracket, and as a group are the most marginalized in terms of job opportunities, access to land, or alternative sources of income generation (Table 5). The mean income of Fry Collectors and Others is significantly different (and lower) than that of Shrimp Farmers. The mean income of Fry Collectors appears much lower than the mean income of Others, but the difference is not statistically significant. The mean proportion of income generated from fry collection in the last 12 months is 40.25% for Fry Collectors (34.86% and 45.64% are the respective lower and upper bounds based on a 95% confidence interval for the mean, N=87).

Table 5: Mean income (Rs.) of stakeholders

	Mean	Lower bound	Upper bound
Fry Collectors (N=87)	18,497.70	14,512.74	22,842.66
Shrimp Farmers (N=132)	50,642.23	42,274.14	59,010.33
Others (N=175)	28,910.55	22,920.86	34,900.24

Note: lower and upper bounds based on a 95% confidence interval for the mean. Total N=394 (2 non-responses).
Note: mean household income for Fry Collectors and Others is significantly lower than mean income for Shrimp Farmers. Results are based on two-sided tests assuming equal variances (0.05 significance level). Tests are adjusted for all pairwise comparisons within a row of each innermost subtable using the Bonferroni correction.
Generated using SPSS (2004)
Source: SHARP HS and DCE

Despite a ban on fry collection due to the negative impact of by-catch mortality of many species, as many as 50,000 fry collectors or more depend on collection of fry for their livelihood in the Indian Sundarbans (Banerjee & Singh, 1993). Fry collection jobs are usually filled by women and children, and many suffer from gynaecological, skin, or eye problems as a result of long hours spent collecting fry in brackishwater. Survey results indicate that 69.41% of Fry Collectors suffer from at least one of the health issues listed above, 59.77% of Fry Collectors are dependent on local markets to sell their catch, and 40.23% are dependent on middlemen (N=87). None of the Fry Collectors sell their catch directly to shrimp farms.

The vast majority of Fry Collectors (84.88%), indicated that there had been a decrease in the abundance of fry available for collection over the last five years. Many of them (61 out of 87 households) blamed fishing trawlers for the decrease in the abundance of available fry, and some also blamed the problem on an increase in the number of Fry Collectors (27 out of 87 households). Only two households cited a loss of mangrove coverage for the decrease in abundance of fry.

4.3 Shrimp Farmers (N=132)

Shrimp Farmers in the Indian Sundarbans are almost exclusively from the area (95% are from the District of 24 Parganas South), and the mean number of generations their households have been in the District is 2.21, as compared to 2.19 generations for Fry Collectors, and 2.14 generations for Others. Of the 5% of Shrimp Farmers who came from outside of 24 Parganas South, all are from the neighbouring District of Midnapur. This situations differs from other States in India, as well as other countries in Asia and Latin America, where shrimp farms are often owned and/or operated by outsiders, which can lead to conflict between different stakeholders. However, the situation in the Indian Sundarbans does not imply that distributional issues are not important, given that the mean income of Shrimp Farmers is significantly higher than Fry Collectors and Others (Table 5). As noted in section 4.1, very few Shrimp Farmers actually generate any income from shrimp farming. In the last 10 years, only 12 of 130 Shrimp Farmers converted agricultural land to shrimp ponds, and only six of 130 converted polyculture pond area to shrimp ponds (N=130, two non-response). The mean area of agricultural land converted was 1.79 *bighas* (0.83 *bighas* and 2.75 *bighas* are the respective lower and upper bounds based on a 95% confidence interval for the mean, N=12). The mean area of polyculture pond area converted was 5.4 *bighas*, but the relatively small number of sample points, coupled with a high variance render this figure difficult to interpret. It is possible to conclude that only a small fraction of Shrimp Farmers are actually engaged in shrimp cultivation at present.

Shrimp Farmers are wealthier than the other stakeholders (Table 4). Access to wealth in the form of land, labour and capital is crucial for any household planning to

cultivate shrimp. The majority of Shrimp Farmers (83.84%) are "Likely" or "Very Likely" to convert some portion of their agriculture land or polyculture pond area in the next five years. A total of 123 (94.62%) Shrimp Farmers indicated that they are close enough to a source of brackishwater for shrimp farming, and 7 (5.38%) indicated they were not close enough. The mean distance for Shrimp Farmers close enough to a source of brackishwater is 202 meters (157 meters and 246 meters are the respective lower and upper bounds based on a 95% confidence interval for the mean, N=122, 1 non-response). The mean distance for Shrimp Farmers who considered themselves to be too far from a source of brackishwater is 1,157 meters (393 meters and 1,921 meters are the respective lower and upper bounds based on a 95% confidence interval for the mean, N=7).

4.4 Others (N=177)

The data for the Others stakeholder groups is segmented into three Wealth sub-segments, based on the WI. The Wealth segments are split evenly based on three percentiles: High Wealth (N=58), Medium Wealth (N=62), and Low Wealth (N=57)[16].

The Others group is comprised primarily of agricultural farmers engaged in rice cultivation, betel production, and vegetable production. Polyculture production is widespread as well, mainly for subsistence purposes. However, in terms of income generation, 49.1% of households in the Low Wealth segment, 21.3% in the Medium Wealth segment, and 17.5% in the High Wealth segment did not generate any income from agricultural production in the last 12 months (N=175, 2 non-responses). This

[16] The Wealth sub-segments are segmented based on the WI. The ranges for the three categories "High Wealth", "Medium Wealth", and "Low Wealth" are:
$\text{Low Wealth} \leq 0.136612; 0.136612 < \text{Medium Wealth} < 0.240438; \text{High Wealth} \geq 0.240438$
As the three percentiles indicate, the distribution is skewed towards the lower end of the WI range.

implies that a large portion of the Low Wealth segment have no access to land, or produce agricultural produce for subsistence purposes only. The balance of income is generated from other activities, including wage labour. For the remaining households that generated some income from agricultural production, the mean percentage share of income from agricultural production increases with Wealth level (Table 6).

Table 6: Percentage of total income (Rs.) derived from agricultural production (Others)

	Mean	Lower bound	Upper bound
Low Wealth (N=29)	45.7%	34.5%	56.9%
Medium Wealth (N=48)	52.1%	42.7%	61.4%
High Wealth (N=47)	64.3%	53.7%	74.9%
Overall (N=124)	55.2%	49.2%	61.2%

Note: lower and upper bounds based on a 95% confidence interval for the mean. Total N=124.
Note: results are based only on households that generate at least some income from agricultural production.
Generated using SPSS (2004)
Source: SHARP HS and DCE

A relationship exists between total income and the Wealth segments for the Others stakeholder group. The mean income of the Low Wealth segment is lower than that of the Medium and High Wealth segments, and the mean income of the Medium Wealth segment is lower than that of High Wealth segment (Table 7). However, a comparison of the means indicates that only the income of the High Wealth segment is significantly different (and higher) than that of the Low and Medium Wealth segments. The mean income of the Low Wealth segment is not statistically different from the mean income of the Medium Wealth segment.

Table 7: Average income (Rs.) of Wealth segments (Others)

	Mean	Lower bound	Upper bound
Low Wealth (N=57)	14,907.89	11,108.38	18,707.41
Medium Wealth (N=61)	21,081.64	15,546.05	26,617.23
High Wealth (N=57)	51,291.51	35,535.72	67,047.30

Note: Lower and upper bounds based on a 95% confidence interval for the mean. Total N=175 (2 non-responses).
Note: mean income of the Low and Medium Wealth segments is significantly lower than the mean income for the High Wealth segment. Results are based on two-sided tests assuming equal variances (0.05 significance level). Tests are adjusted for all pairwise comparisons within a row of each innermost subtable using the Bonferroni correction.
Generated using SPSS (2004)
Source: SHARP HS and DCE

Shrimp Farmers and the Others High Wealth segment are in similar income brackets (Tables 5 & 7), and this Wealth segment is potentially the most suitable group to consider shrimp farming in the future based on access to land, labour, and capital. In addition, 67.2% of the High Wealth segment indicate they are close enough to a source of brackishwater for shrimp farming[17]. However, the entire Others stakeholder group is defined by its explicit independence from fry collection and shrimp farming activities: 88.96% are "Very unlikely", and 11.04% are "More unlikely than likely" to convert any agricultural land or polyculture pond area into shrimp ponds in the next five years (N=163, 14 non-responses). Therefore, it is important to investigate the reasons why this stakeholder group is not interested in shrimp farming. Across all three Wealth segments, "Lack of household funds/credit" and "Financial risk" are the dominant reasons why this group does not plan to convert any agricultural land or polyculture pond area into shrimp

[17] The mean distance for High Wealth households close enough to a source of brackishwater is 352 meters (245 meters and 458 meters are the respective lower and upper bounds based on a 95% confidence interval for the mean, N=39). The mean distance for High Wealth households not close enough to a source of brackishwater is 634 meters (407 meters and 861 meters are the respective lower and upper bounds based on a 95% confidence interval for the mean, N=19).

ponds in the next five years[18] (Table 8). This implies that Shrimp Farmers that do plan to convert agricultural land or polyculture pond area into shrimp ponds, in the next five years, have access to funds and are more willing to take financial risks.

Table 8: Ranking of reasons for not converting agricultural land/polyculture pond area into shrimp ponds in the next five years (Others)

Reason	Ranking mean[a]	Lower bound	Upper bound	Responses	% of total N
1. Lack of household funds/credit	1.90	1.68	2.21	131	74.01%
2. Financial risk	1.85	1.67	2.03	116	65.54%
3. Risk of disease	3.58	3.23	3.92	64	36.16%
4. Lack of access to brackishwater	2.73	2.33	3.13	63	35.59%
5. Lack of technical knowledge	3.20	2.90	3.51	59	33.33%
6. Not interested	3.32	2.78	3.86	50	28.25%
7. Other	1.69	1.39	1.98	32	18.08%
8. Government regulations	5.74	5.23	6.25	23	12.99%

[a] Ranking based on 1 as highest rank and 8 as lowest rank.
Note: lower and upper bounds based on a 95% confidence interval for the mean. Total N=177.
Generated using SPSS (2004)
Source: SHARP HS and DCE

4.5 Attitudinal Information

Eight attitudinal questions were included in the HS regarding the effects of shrimp aquaculture and fry collection on the environment, and the importance of mangrove coverage. These questions were posed as statements, and respondents indicated their attitudes on a scale from "Strongly Agree" through "Strongly Disagree". The results illustrate a number of important findings (Table 9):

[18] There is no statistical difference between the mean rankings when compared across all three Wealth segments

- all stakeholders strongly agree that mangrove forests mitigate the destructive force of natural disasters, that these forests should be preserved, and that mangrove forests are important in terms of their biologically productive capacity;
- all stakeholders strongly disagree that local households should get more access to mangrove forests to collect forest products;
- all stakeholders agree that they are concerned about the conversion of paddy land to shrimp ponds. Interestingly, Fry Collectors are more concerned than Others about the conversion of paddy land to shrimp ponds, and Shrimp Farmers are in the middle;
- all stakeholders quite strongly agree that damage or correction costs associated with the negative effects of shrimp farming on the environment should be borne by Shrimp Farmers. As expected, Fry Collectors and Others agree more strongly with this statement than Shrimp Farmers;
- all stakeholders are fairly neutral, or slightly agree with the idea of more community based shrimp farming on leased or community land;
- all stakeholders agree that fry collection has a negative impact on the environment in terms of fish stocks, and damage to embankments. Shrimp Farmers and Others agree more strongly with these statements than Fry Collectors.

The response to these questions indicate a keen understanding of the importance of environmental variables in the lives of all stakeholders in the Indian Sundarbans.

Table 9: Mean response (and comparison of means) to statements regarding the effects of shrimp aquaculture and fry collection on the environment, and the importance of mangrove coverage in the Indian Sundarbans

Statement	Fry Collectors (N=87) (A)	Shrimp Farmers (N=132) (B)	Others (N=175) (C)
1. I am concerned about the conversion of paddy land to shrimp farms.	2.28 (2.02 - 2.54)	2.42 (2.22 – 2.61)	2.71 (2.52 – 2.89) A
2. If shrimp farming has negative effects on the environment, shrimp farmers should pay for any damages or correction.	1.51 (1.39 – 1.62)	1.78 (1.65 – 1.91) A C	1.53 (1.44 – 1.62)
3. There should be more community managed or cooperative shrimp farms on leased or common land.	2.77 (2.49 – 3.05)	2.90 (2.67 – 3.13)	2.77 (2.57 – 2.98)
4. Some kinds of fish and shrimp are more abundant when there are mangrove forests nearby.	1.66 (1.53 – 1.78)	1.51 (1.39 – 1.63)	1.59 (1.47 – 1.71)
5. Mangrove forests mitigate the destructive force of natural disasters (flooding, cyclones, waves, etc.) and should be preserved.	1.15 (1.07 – 1.23)	1.11 (1.06 – 1.17)	1.07 (1.03 – 1.11)
6. Villagers' access to mangrove forests to collect forest products (fuelwood, honey, building materials, etc.) should be increased.	4.61 (4.41 – 4.81)	4.78 (4.68 – 4.88)	4.62 (4.50 – 4.74)
7. Shrimp fry collection decreases the number of fish available for fishers to capture.	2.30 (2.07 – 2.53) B C	1.76 (1.66 – 1.86)	1.71 (1.63 – 1.79)
8. I am concerned about the damage to the embankments caused by shrimp fry collectors.	2.08 (1.88 – 2.28) B C	1.71 (1.62 – 1.80)	1.71 (1.60 – 1.81)

Note: responses based on 1=Strongly Agree, 2=Agree, 3=Neutral, 4=Disagree, 5=Strongly Disagree. Figures in parentheses are the lower and upper bounds based on a 95% confidence interval for the mean. Total N=394 (2 non-responses).
Note: results of the comparison of column means are based on two-sided tests assuming equal variances (0.05 significance level). For each significant pair, the key of the smaller category (**A**, **B**, or **C**) appears under the category with larger mean. Tests are adjusted for all pairwise comparisons within a row of each innermost subtable using the Bonferroni correction.
Generated using SPSS (2004)
Source: SHARP HS and DCE

CHAPTER 5: DCE - RESULTS AND DISCUSSION

5.1 Introduction

The results of the DCE are discussed in this chapter. The DCE data are segmented into the same three stakeholder groups for analysis purposes: Fry Collectors, Shrimp Farmers, and Others. The Others group is also segmented into the same three Wealth sub-segments used in Chapter 4. Section 5.2 presents the results of the MNL model, and section 5.3 is a detailed discussion of the results and their implications for each of the attributes used in the DCE.

5.2 Results

The choice profiles in the DCE experiment were composed of discrete attribute levels. However, all the attribute levels were numeric, which allows for linear and quadratic estimation of the parameters. The MNL parameter coefficients, their standard errors, p-values, and model statistics for the whole model, and also for each of the stakeholder groups and Wealth segments are presented in this section (Tables 10 & 11).

The R^2 statistic for each of the six models (Whole Model, Fry Collectors, Shrimp Farmers, and Others Low Wealth, Medium Wealth, High Wealth) indicates an excellent goodness of fit. The estimates of the parameter coefficients are generally consistent with intuitive expectations for each of the attributes, and each attribute has at least one significant parameter estimate.

Table 10: DCE results for the Whole Model (unsegmented), Fry Collectors and Shrimp Farmers

Attributes		Whole Model (N=396)			Fry Collectors (N=87)			Shrimp Farmers (N=132)		
		Coeff	SE	(p)	Coeff	SE	(p)	Coeff	SE	(p)
Intercept		3.21	0.20	0.00	3.59	0.51	0.00	3.10	0.34	0.00
Mangrove	Linear	0.55	0.03	0.00	0.60	0.07	0.00	0.66	0.06	0.00
	Quadrtic	-0.16	0.03	0.00	-0.08	0.06	0.16	-0.19	0.05	0.00
Shrimp farms	Linear	0.35	0.03	0.00	0.30	0.07	0.00	0.55	0.07	0.00
	Quadrtic	-0.08	0.03	0.02	-0.03	0.07	0.65	-0.14	0.06	0.02
Fry collectors	Linear	-0.02	0.03	0.62	0.18	0.07	0.02	0.00	0.06	0.97
	Quadrtic	-0.02	0.03	0.46	0.04	0.06	0.53	-0.04	0.06	0.45
Loans	Linear	0.30	0.03	0.00	0.30	0.07	0.00	0.37	0.06	0.00
	Quadrtic	-0.13	0.03	0.00	-0.21	0.05	0.00	-0.13	0.05	0.01
Payment	Linear	0.03	0.01	0.01	0.02	0.02	0.40	0.02	0.02	0.23
	Quadrtic	-0.00	0.00	0.00	0.00	0.00	0.66	0.00	0.00	0.02
Model statistics	R^2			0.514			0.531			0.581
	R^2 adj.			0465			0.484			0.539
	Log likelihood (0)			-1062.387			-223.535			-306.564

Significant coefficients are presented in bold.
Generated using NLOGIT 3.0 (Green, 2003)

Table 11: DCE results for Wealth segments (Others)

Attributes		Low Wealth (N=57)			Med Wealth (N=62)			High Wealth (N=58)		
		Coeff	SE	(p)	Coeff	SE	(p)	Coeff	SE	(p)
Intercept		2.63	0.42	0.00	3.25	0.51	0.00	3.85	0.71	0.00
Mangrove	Linear	0.58	0.08	0.00	0.57	0.08	0.00	0.33	0.07	0.00
	Quadrtic	-0.26	0.07	0.00	-0.17	0.06	0.01	-0.12	0.06	0.05
Shrimp farms	Linear	0.41	0.09	0.00	0.08	0.08	0.31	0.28	0.08	0.00
	Quadrtic	-0.13	0.08	0.12	0.03	0.08	0.68	-0.09	0.08	0.24
Fry collectors	Linear	-0.12	0.09	0.17	-0.12	0.08	0.14	-0.06	0.08	0.41
	Quadrtic	-0.12	0.08	0.10	-0.02	0.07	0.77	0.02	0.07	0.72
Loans	Linear	0.19	0.08	0.01	0.43	0.08	0.00	0.22	0.07	0.00
	Quadrtic	-0.10	0.06	0.14	-0.07	0.06	0.31	-0.18	0.07	0.01
Payment	Linear	0.02	0.03	0.44	0.02	0.03	0.47	0.07	0.03	0.01
	Quadrtic	-0.01	0.00	0.09	-0.01	0.00	0.08	-0.01	0.00	0.00
Model statistics	R^2			0.497			0.504			0.474
	R^2 adj.			0.446			0.454			0.421
	Log likelihood (0)			-159.139			-167.800			-169.240

Generated using NLOGIT 3.0 (Green, 2003)

5.3 Discussion

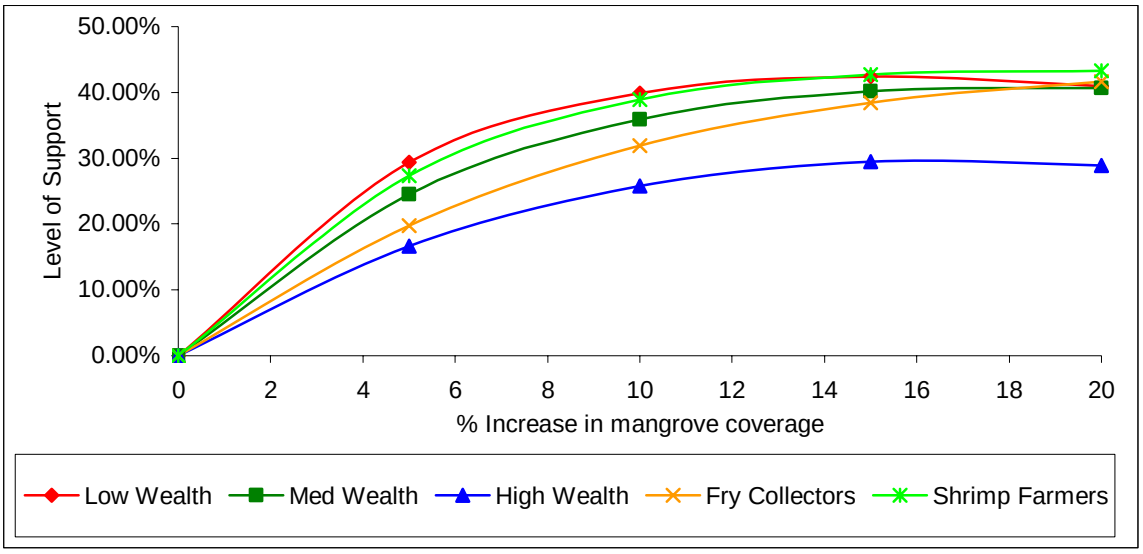
The following sections describe the results of the DCE for each attribute. Graphical representations are also included for easier interpretation of the results. The Y-axis in each figure represents the respective level of support (or relative market share) associated with a respective level in the X-axis for each attribute. The remaining attributes are all set to the Current Situation level; therefore, at the Current Situation level the support for any one of these is exactly 50%. The plots of each graph pass through zero at the Current Situation level for each attribute. For example, if mangrove coverage is increased by 5% from the Current Situation (0% in the case of mangrove coverage), holding all other attributes constant at Current Situation levels, then the change in level of

support for such a policy is reflected on the Y-axis. In this regard, the change of support can be interpreted as a sensitivity analysis for each attribute. The sensitivity analysis is based on a comparison between the Current Situation and a series of scenarios that change only one attribute level at the time, holding all other attribute levels constant.

5.3.1 Mangrove coverage

The linear coefficient for mangrove coverage is positive and significant ($p \leq 0.05$) for all stakeholders and Others Wealth segments, ranging from 0.33 for the High Wealth segment, to 0.66 for Shrimp Farmers. The linear coefficient for mangrove coverage is also the most sensitive linear coefficient across all five attributes for all stakeholders and segments. The quadratic coefficient is negative and significant for Shrimp Farmers and all Others Wealth segments; it is not significant for Fry Collectors. Clearly, there is a high preference for an increase in mangrove coverage relative to the Current Situation (0% increase in mangrove coverage) (Figure 4).

Figure 4: Preference for mangrove coverage



The implications of these results are profound. Firstly, there is uniform preference for an increase in mangrove coverage across all stakeholders and segments[19]. The only notable exception is the lower preference for an increase in mangrove coverage expressed by the High Wealth segment. This segment is less dependent on the protection of mangroves, but they still recognize the importance of mangrove coverage to the overall biophysical health of the region. Secondly, these results rebut the notion that shrimp farming and mangrove coverage are mutually exclusive, with specific reference to the Indian Sundarbans[20]. Shrimp Farmers value mangrove coverage more than any other group or segment. The reasons for this apparent contradiction are relatively intuitive: mangroves are an important source of protection from erosion, and other damage caused annually by cyclonic activity; many Shrimp Farmers are aware of the link between mangrove coverage and biodiversity; and mangrove forests are protected by law in the Indian Sundarbans. In most cases, shrimp farms are in close proximity to the river system and brackishwater canals, hence the importance of protection against natural elements. Furthermore, Shrimp Farmers are from the Indian Sundarbans, and do not have a short-term view of their activities in the region.

The negative quadratic coefficient for mangrove coverage indicates diminishing returns as mangrove coverage increases by more than 15%. As mangrove coverage increases significantly (15% or more), productive agricultural land and residences will be

[19] The DCE was administered a few months after the Asian tsunami. Although this event devastated the east coast of India, the Indian Sundarbans experienced minimal loss of life or damage to property. In interviews, local stakeholders described the onset of rising levels and ripples in surrounding sweetwater ponds, but no adverse effects. Only one person died in West Bengal as a result of the tsunami (Subramanian, 2005). Based on these interviews, it is the author's opinion that this event did not have any significant impact on the results of the DCE. Seasonal cyclonic activity and soil erosion are far more significant events affecting local stakeholders.

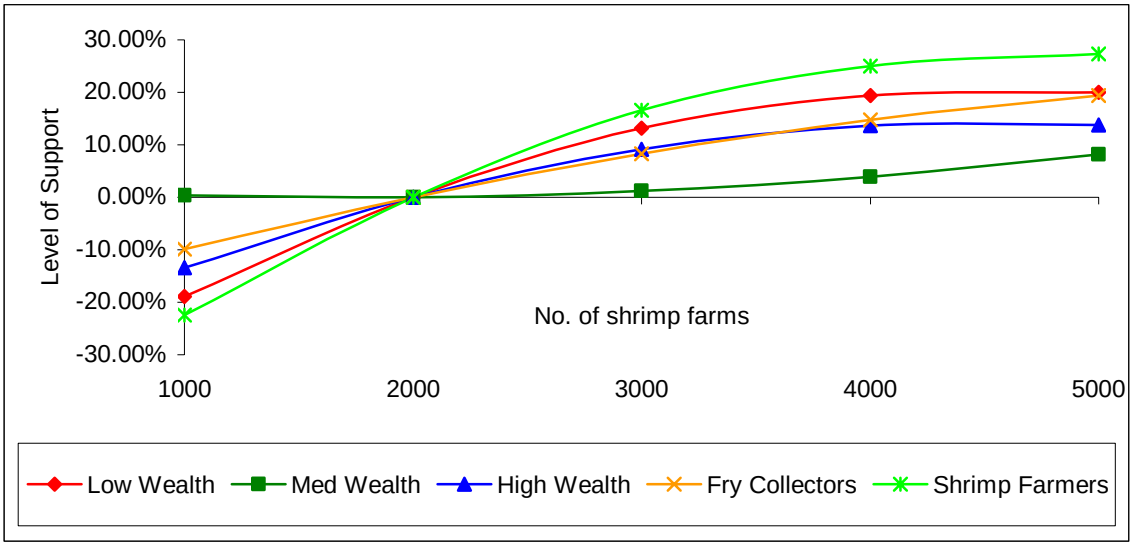
[20] In other States in India, and in other countries in Asia and Latin America, mangroves are often cleared to make way for commercial shrimp farms.

compromised, to the detriment of local farmers and residents. In addition, the protective capacity of mangroves is based on its "front-line" presence (i.e. along the shoreline and canal banks) (Danielsen et al., 2005).

5.3.2 Number of shrimp farms

It is estimated that there are approximately 2000 – 5000 shrimp farms in the Indian Sundarbans[21]. The perception of shrimp farming in the Indian Sundarbans is positive, and all stakeholders and Others Wealth segments expressed a preference for more shrimp farms, and a negative preference for less shrimp farms (Figure 5).

Figure 5: Preference for number of shrimp farms



The linear coefficient for number of shrimp farms is positive for all stakeholders and Others Wealth segments, ranging from 0.08 for the Medium Wealth segment, to 0.55

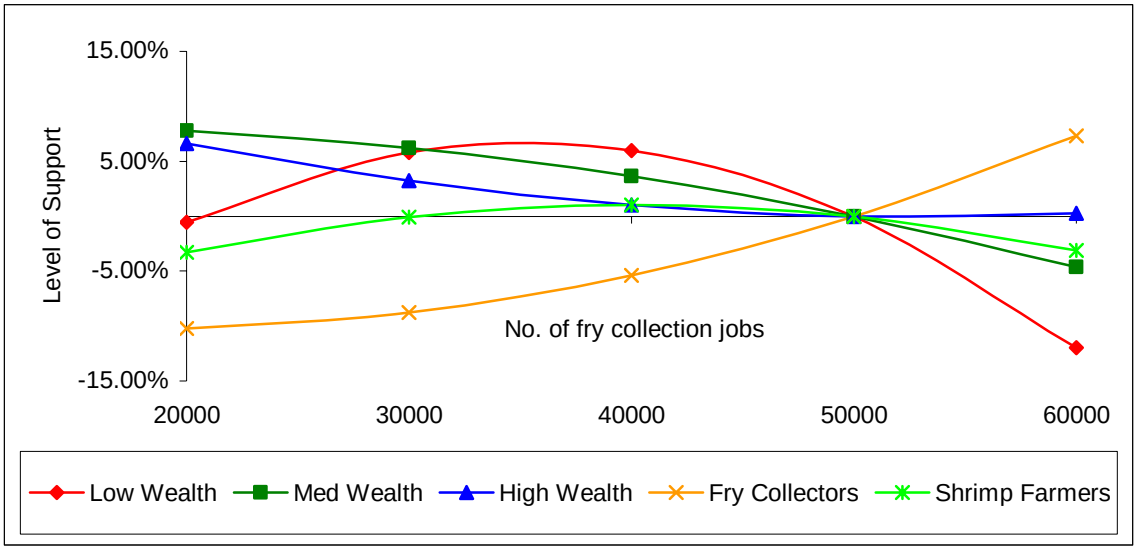
[21] Estimate based on interviews with Mr. Kamal Nayak, a shrimp aquaculture technician working in Namkhana. The figure of 2000 was chosen to represent the Current Situation in the DCE.

for the Shrimp Farmers. The linear coefficient of 0.08 for the Medium Wealth segment is not significant. The quadratic coefficient is significant only for Shrimp Farmers, and the negative coefficient of -0.14 may seem surprising; however, the advent of too many shrimp farms may lead to an increase in competition between Shrimp Farmers, as well as an increase in the risk of disease outbreaks. The positive coefficient for the number of shrimp farms across Fry Collectors and Shrimp Farmers, and two of the Others Wealth segments, has important implications. Fry Collectors are in favour of more shrimp farms because of a potential increase in demand for fry. This may be a misperception on the part of Fry Collectors since most Shrimp Farmers prefer to stock their ponds with hatchery fry, because of the lower risk of disease outbreaks. Nevertheless, an increase in the number of shrimp farms may also increase the possibility of alternative jobs opportunities associated with this activity. On the whole, shrimp farming is perceived as having a positive impact on economic development in the Indian Sundarbans, without compromising environmental conditions.

5.3.3 Number of shrimp fry collection jobs

The perception of fry collection as job of last resort is reinforced by the indifference shown towards this activity by Shrimp Farmers, and all Others Wealth segments (Figure 6). The only significant coefficient for this attribute is for Fry Collectors themselves (coefficient of 0.18), which is to be expected. All Others Wealth segments indicated a preference (although statistically insignificant) for fewer fry collection jobs. Even Shrimp Farmers are not adverse to fewer fry collection jobs, which is congruent with their preference for hatchery fry instead of wild fry to stock their ponds.

Figure 6: Preference for number of fry collection jobs



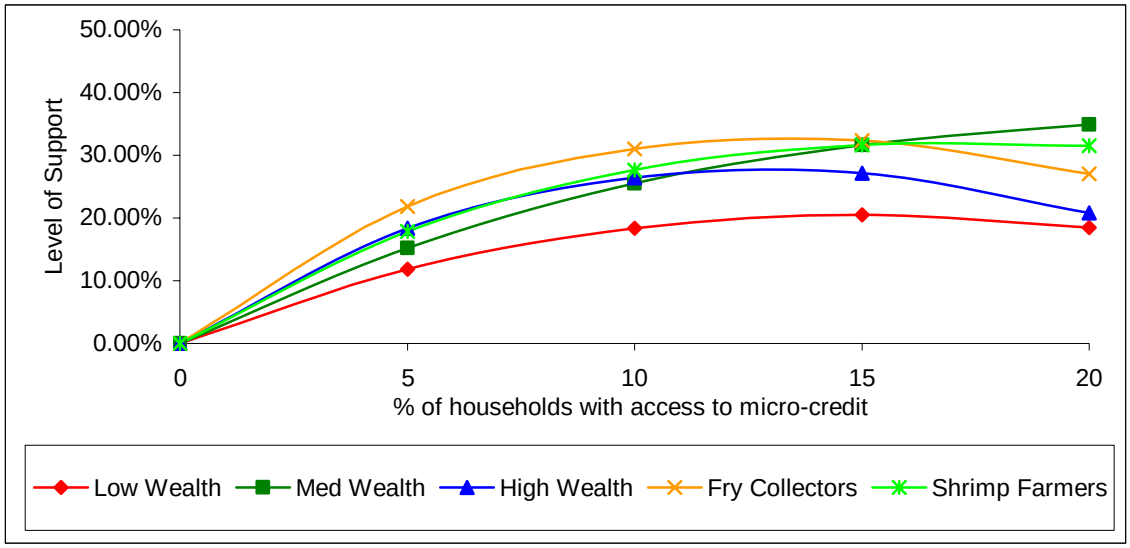
There are two important implications to consider from these results: first, Fry Collectors are a marginal group, and are hence vulnerable to further marginalization if the ban on fry collection is enforced: second, fry collection is not preferred by other stakeholders, and finding alternatives to fry collection should be an important priority, especially in light of the health and environmental problems associated with fry collection.

5.3.4 Access to micro-credit

Access to micro-credit to develop alternative sources of income is an important factor to help poor households emerge from the poverty trap. Coefficients for all stakeholders and segments were positive, and significant for this attribute, ranging from 0.19 for the Low Wealth segment, to 0.43 for the Medium Wealth segment. The quadratic coefficient is negative for all stakeholders and Wealth segments, but is only significant for Fry Collectors, and the High Wealth segment. The disparity between the

coefficients for Low and Medium Wealth segments is somewhat puzzling, since access to loans is aimed at all households. The expectation is that the Low Wealth segment would most prefer access to loans compared to the other groups; however, this is not the case (Figure 7).

Figure 7: Preference for access to micro-credit

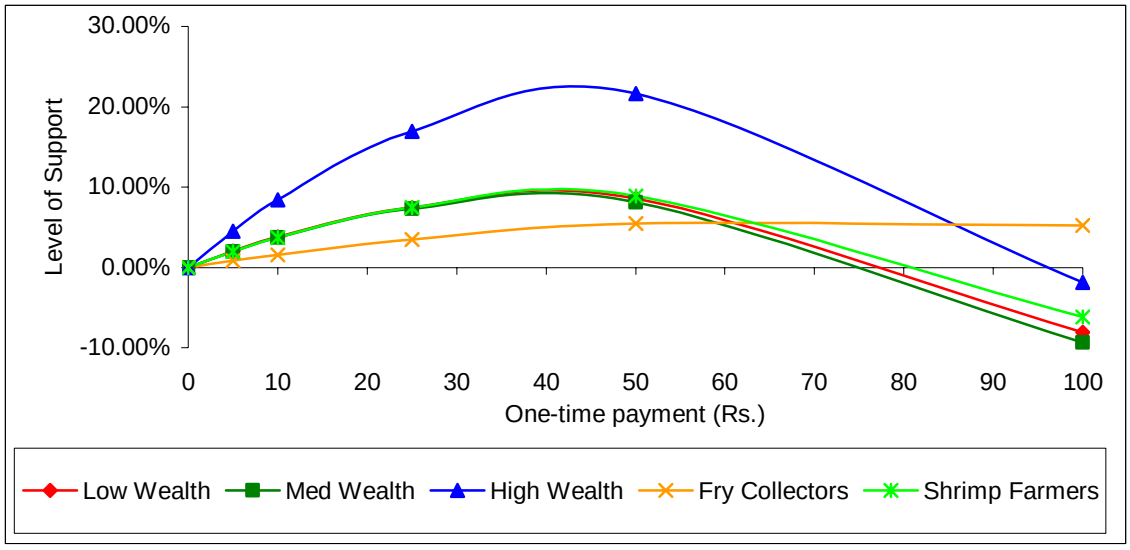


The reasons for this apparent anomaly are not clear, but it may be that households in the Low Wealth segment perceive micro-credit as a very risky prospect, especially if they are unable to repay the loan. This reason could potentially apply to Fry Collectors as well; however, their preference to move out of fry collection might outweigh the perceived risks. The Medium Wealth segment may be more willing to take the financial risks associated with a loan, and may also perceive themselves as having the most to gain from access to micro-credit loans. The difference between these two groups highlights the possibility that poverty trap characteristics still apply to the very poorest households, even in the case of access to micro-credit loans.

5.3.5 Payment vehicle

The payment vehicle is a measure of households' willingness to contribute into an independent Sundarbans Fund focused on improving the livelihoods of all residents in the region. The purpose of the payment vehicle is to determine what different households are willing to contribute towards the fund. The coefficients are positive for all stakeholders, and range from 0.02 for Fry Collectors, Shrimp Farmers, and Low and Medium Wealth segments, to 0.07 for the High Wealth segment. Only the coefficient for the High Wealth segment is significant. These results indicate the relatively low priority given to this attribute compared to other attributes. It is important to note that the quadratic term is negative and significant only for the High Wealth segment, which indicates a reluctance to contribute more than approximately 50 Rs. into the fund (Figure 8).

Figure 8: Preference for one-time payment



CHAPTER 6: ANALYSIS OF POTENTIAL DEVELOPMENT SCENARIOS

6.1 Description of Scenarios

Four hypothetical scenarios were developed to analyse the preferences of the different stakeholders and Others Wealth segments. The characteristics of each scenario are listed in sections 6.1.1 through 6.1.4, and the attribute levels and preference profiles for each of the scenarios are discussed in section 6.2.

6.1.1 Scenario 1: Current situation

The Current Situation scenario is based on conditions as they currently exist in the Indian Sundarbans with respect to the five attributes listed in Section 3.6.3. The characteristics of this scenario are:

- mangrove coverage remains at current levels;
- the number of shrimp farms and the number of fry collectors remain at their current levels (2000 shrimp farms and 50,000 fry collectors);
- no access to micro credit; and no contribution to the Sundarbans Fund.

6.1.2 Scenario 2: High growth strategy for commercial shrimp aquaculture

The push to increase production of shrimp through aquaculture is most prevalent at the national level, as evidenced by the recent passing of the Coastal Aquaculture Authority Act (2005) by the GOI. This Act essentially increases the scope for shrimp aquaculture along the coast (The Hindu, January 17, 2006; The Hindu Business Line,

May 11, 2005). The high growth (High Growth) Scenario reflects the potential for a substantial increase in production with the following characteristics:

- growth is driven primarily by commercial interests along the entire shrimp production chain (farm inputs, technology, exports, etc.);
- consistent with the Coastal Aquaculture Authority Act (2005), which implies a larger role for commercial operators in West Bengal, an area currently dominated by traditional, and small scale shrimp farmers;
- production within the CRZ, which would have a significant impact on the environment and on local stakeholders in the Indian Sundarbans;
- the maximum number of shrimp farms in the DCE (5000), with high levels of hatchery production to supply new and existing farms[22];
- relatively small increase in fry collectors (to 60,000) to pick up the residual increase in demand not met by hatchery supply;
- no change in mangrove area, which would require enforcement of existing laws that forbids any damage to mangrove forests; no access to micro credit; and no contribution to the Sundarbans Fund.

6.1.3 Scenario 3 (a and b): Enforcement of ban on shrimp aquaculture and fry collection in CRZ

Resistance to the Coastal Aquaculture Authority Act (2005) is substantial in India, and many local and some regional government departments, civil groups, and NGOs feel that shrimp aquaculture is detrimental to the environment, and also to local communities

[22] The size of additional shrimp farms is assumed to be the same as the size of existing shrimp farms for the purposes of the High Growth scenario.

(The Hindu, September 11, 2005). These groups advocate enforcement of the Supreme Court judgement banning shrimp aquaculture in the CRZ. In the Indian Sundarbans, fry collection is also banned due to the negative impact on mangrove habitat and pelagic and non-pelagic juvenile stocks. The enforcement (Enforcement) scenarios (3a and 3b) reflect the characteristics of a strong enforcement approach to shrimp aquaculture and fry collection:

- emphasis on enforcing the bans on non-traditional shrimp aquaculture and fry collection;
- reduction in the number of illegal shrimp farms, and in the number of fry collectors (to 1000 shrimp farms and 20,000 fry collectors);
- two variations (a and b) include a 0% increase in mangrove coverage (3a), as well as a 5% increase in mangrove coverage (3b). Both Enforcement scenarios are possible given that there are social forestry programs in the Indian Sundarbans; however, plans for future social forestry programs are not known at the time of writing this research project;
- no access to micro credit; and no contribution to the Sundarbans Fund.

6.1.4 Scenario 4: Sustainable development scenario

The sustainable development (Sustainable Development) scenario recognizes the economic importance of shrimp aquaculture and fry collection to local stakeholders in the Indian Sundarbans. However, it also recognizes the potential for substantial environmental damage as a result of uncontrolled shrimp cultivation and fry collection. In both cases, the key to a sustainable development path takes into account the trade-offs between environmental and economic considerations for poor and marginalized

stakeholders. Fry Collectors are the poorest and most marginalized stakeholder group in the Indian Sundarbans, and their livelihood depends on one of the most environmentally destructive activities in the region. In this respect, it is fundamentally important to offer them (as well as other stakeholders) alternative income generating opportunities, while simultaneously educating them about sustainable fry harvesting practices.

Whilst the majority of households across all stakeholders and Wealth segments are in favour of shrimp farming because of its perceived economic benefits, few households were aware of the potentially catastrophic environmental impacts of shrimp farming. The reason for this lack of awareness is that there is little sign of direct environmental damage from shrimp farming in the Indian Sundarbans, to date. There are relatively few non-traditional shrimp farms in the region; almost all the farms are extensive or marginally semi-intensive in terms of technology, feed supplements, and pesticides, etc. [23]; and almost all the farms are owned by small-scale, local agricultural farmers who converted some of their marginal land to shrimp ponds.

The Sustainable Development strategy is based on the following characteristics:

- increasing investment in social forestry programs or community based mangrove programs, in line with the preferences of all stakeholders groups for more mangrove coverage (an increase of 5%);
- emphasis on economic diversification, along with continued operation of exiting traditional and improved traditional shrimp farms;

[23] The productivity of shrimp farms in West Bengal was 0.60 metric tonnes per hectare per year (Mt/Ha/Yr) in 2003-2004, which is below the average for India at 0.73 Mt/Ha/Yr. Tamil Nadu had the highest productivity at 1.89 Mt/Ha/Yr, and Kerala had the lowest productivity at 0.49 Mt/Ha/Yr (Table 2).

- greater community participation in planning, ownership, and operation of existing shrimp ponds. Community participation will help minimize the negative environmental impacts of shrimp farming, and also lead to a more equitable distribution of the risks and benefits across all stakeholders;
- maintain the same number of relatively low-intensity, non-traditional, locally owned and operated shrimp farms (currently 2000 farms);
- reduce the number of fry collectors by half (to 25,000), promote greater awareness of the importance of mangrove habitat, and create a best-practices approach to minimize by-catch mortality;
- develop a micro-credit scheme to help all stakeholders generate income from alternative sources, especially fry collectors and potential shrimp farmers;
- one-off payment of 100 Rs. into the Sundarbans Fund.

6.2 Discussion of Preference Profiles for Scenarios 1 - 4

The preference profiles for each of the four scenarios described above are discussed in this section (Table 12). The preferences of each stakeholder group (represented as a market share) for each scenario are based on a comparison with the Current Situation (Scenario 1). In most cases, the preferences of all stakeholders reflect a desire for change from the Current Situation. The only limited exception is the Enforcement scenario (3a), which involves a high degree of enforcement of the ban on shrimp farming in the CRZ, and the ban on fry collection, without any increase in mangrove coverage. The Current Situation is preferred in this case over the Enforcement scenario (3a) by the Low Wealth segment, Fry Collectors, and Shrimp Farmers. Both the Medium and High Wealth segments preferred this option to the Current Situation.

Table 12: List of attribute levels and market share profiles for scenarios 1 -4

Attributes/Levels	Scen. 1	Scen. 2	Scen. 3a	Scen. 3b	Scen. 4
Mangrove coverage	0%	0%	0%	5%	5%
No. of shrimp farms	2000	5000	1000	1000	2000
No. of fry collection jobs	50,000	60,000	20,000	20,000	25,000
Household access to loans	0%	0%	0%	0%	15%
Payment vehicle (Rs.)	0	0	0	0	100
Market Share					
Others Low Wealth	*50%*	*59.07%*	*30.84%*	*63.24%*	*88.49%*
Others Med Wealth	*50%*	*58.89%*	*63.26%*	*83.43%*	*93.61%*
Others High Wealth	*50%*	*74.45%*	*55.23%*	*71.11%*	*92.54%*
Fry Collectors	*50%*	*81.48%*	*39.02%*	*59.62%*	*92.84%*
Shrimp Farmers	*50%*	*74.47%*	*24.41%*	*52.47%*	*91.56%*

Note: the market share for each scenario is based on a comparison with the Current Situation. Therefore, in scenario 1 (which is the Current Situation), the split between the two choices (Scenario 1 or Current Situation) is equal.

The High Growth (Scenario 2) and Sustainable Development (Scenario 4) scenarios are significantly preferred over the Current Situation (Scenario 1), and both scenarios present alternative options for development of the Indian Sundarbans. The Sustainable Development scenario is the most preferred option over the Current Situation, as compared to the High Growth scenario over the Current Situation.

6.3 Comparison of the DCE Scenarios

In this section, the comparisons between different combinations of the four hypothetical scenarios replicate the format of the choice sets presented to respondents in the DCE (based on Option A, Option B, Current Situation, or None of the Above). In the three sets of comparisons discussed in this section (Sections 6.3.1 – 6.3.3), the hypothetical scenarios (Scenarios 1 – 4) replace Options A and B used in the DCE.

6.3.1 Comparison 1: High growth (Scenario 2), enforcement (Scenarios 3a and 3b), and current situation (Scenario 1)

There are two important results from the comparison of the High Growth and Enforcement (3a) scenarios, and the Current Situation (Table 13). The first result is the fairly uniform preference of stakeholders (except the Medium Wealth segment) for the High Growth scenario over the Enforcement (3a) scenario, and the Current Situation. However, the preference profiles of the Low and Medium Wealth segments are marginal, and the relatively high market share for the option "None of the Above" reflects a high degree of dissatisfaction with all three scenarios. The marginal preferences of the Low and Medium Wealth segments reflect the fact that more shrimp farms and fry collection jobs would only benefit them indirectly, although the Low Wealth segment may see some wage labour opportunities associated with more shrimp farms.

Table 13: Comparative results 1(a)

Attribute	Scen. 2	Scen. 3a	Current	None
Mangrove %	0	0	0	
Farms	5000	1000	2000	
Fry Collecting Jobs	60,000	20,000	50,000	
% Households with Loans	0	0	0	
Annual Payment	0	0	0	
Market Share				
Others Low Wealth	***37.11%***	*11.46%*	*25.95%*	*25.47%*
Others Med Wealth	*27.79%*	***33.41%***	*24.02%*	*14.78%*
Others High Wealth	***47.40%***	*20.07%*	*26.69%*	*5.84%*
Fry Collectors	***62.49%***	*9.09%*	*20.58%*	*7.84%*
Shrimp Farmers	***55.67%***	*6.16%*	*18.52%*	*19.65%*

The second result is the high preference expressed for the High Growth scenario by Fry Collectors, Shrimp Farmers, and the High Wealth segment. Intuitively, this makes sense since Fry Collectors and Shrimp Farmers benefit from greater demand for their products. The High Wealth segment may be supportive of the High Growth since these are the households with the most land and labour, and therefore stand to gain from greater commercial activity. There is an important caveat regarding the perceived benefits associated with the High Growth scenario for Shrimp Farmers and Fry Collectors: an increase in commercial shrimp aquaculture may force existing Shrimp Farmers out of business, and greater demand for hatchery fry may also reduce the demand for wild fry in the long run.

Enforcement scenario 3b includes a 5% increase in mangrove coverage absent in Enforcement scenario 3a, which changes the results of the comparison (Table 14).

Table 14: Comparative results 1(b)

Attribute	Scen. 2	Scen. 3b	Current	None
Mangrove %	0	5	0	
Farms	5000	1000	2000	
Fry Collecting Jobs	60,000	20,000	50,000	
% Households with Loans	0	0	0	
Annual Payment	0	0	0	
Market Share				
Others Low Wealth	*27.95%*	***33.31%***	*19.55%*	*19.19%*
Others Med Wealth	*16.92%*	***59.46%***	*14.62%*	*9.00%*
Others High Wealth	***39.51%***	*33.37%*	*22.25%*	*4.87%*
Fry Collectors	***55.85%***	*18.75%*	*18.40%*	*7.00%*
Shrimp Farmers	***48.45%***	*18.34%*	*16.11%*	*17.10%*

The significance of this change is substantial since it reverses the results towards the Enforcement scenario (3b) for the Others Low and Medium Wealth segments (especially the Medium Wealth segment), and renders the preference for the Others High Wealth segment more marginal. The key issue is the high preference expressed by all stakeholders for the mangrove attribute, which seems to compensate to some degree the negative economic impact of enforcing the bans on shrimp farming and fry collection. However, Fry Collectors and Shrimp Farmers remain in favour of the High Growth scenario, despite the increase in mangrove coverage under the Enforcement scenario (3b).

6.3.2 Comparison 2: Enforcement (Scenarios 3a and 3b), sustainable development (Scenario 4), and current situation (Scenario 1)

In comparisons between both Enforcement scenarios (3a and 3b), the Sustainable Development scenario, and the Current Situation, the Sustainable Development scenario is clearly preferred by all stakeholders and Others Wealth segments (Tables 15 and 16).

Table 15: Comparative results 2(a)

Attribute	Scen. 3a	Scen. 4	Current	None
Mangrove %	0	5	0	
Farms	1000	2000	2000	
Fry Collecting Jobs	20,000	25,000	50,000	
% Households with Loans	0	15	0	
Annual Payment	0	100	0	
Market Share				
Others Low Wealth	*4.40%*	***75.86%***	*9.96%*	*9.78%*
Others Med Wealth	*9.37%*	***79.75%***	*6.74%*	*4.14%*
Others High Wealth	*7.89%*	***79.31%***	*10.50%*	*2.30%*
Fry Collectors	*4.10%*	***83.08%***	*9.28%*	*3.53%*
Shrimp Farmers	*2.45%*	***82.36%***	*7.37%*	*7.82%*

Table 16: Comparative results 2(b)

Attribute	Scen. 3b	Scen. 4	Current	None
Mangrove %	5	5	0	
Farms	1000	2000	2000	
Fry Collecting Jobs	20,000	25,000	50,000	
% Households with Loans	0	15	0	
Annual Payment	0	100	0	
Market Share				
Others Low Wealth	*15.08%*	***67.39%***	*8.85%*	*8.69%*
Others Med Wealth	*23.21%*	***67.57%***	*5.71%*	*3.51%*
Others High Wealth	*14.60%*	***73.54%***	*9.73%*	*2.13%*
Fry Collectors	*8.98%*	***78.86%***	*8.81%*	*3.35%*
Shrimp Farmers	*7.92%*	***77.75%***	*6.96%*	*7.38%*

Apart from these intuitive results for Fry Collectors and Shrimp Farmers, the results also indicate the preference of the Others Wealth segments for a sustainable development strategy that includes some shrimp farming, and there is little support for enforcing the bans on shrimp farming and fry collection from these segments. It is important to note that the absence of conflict between stakeholders is based primarily on three factors: shrimp farming is conducted on a small-scale by local farmers, the total area under shrimp cultivation is relatively small, and the absorptive capacity of the natural ecosystem does not appear to be compromised by effluents emitted from shrimp farms into the brackishwater canals. The advent of commercial shrimp farming could rapidly change this situation, especially if commercial shrimp farms displace local farmers, employ semi-intensive and intensive cultivation technologies (i.e. non-traditional techniques), and pollution and damage to surrounding agricultural farms becomes more pronounced.

6.3.3 Comparison 3: High growth (Scenario 2), sustainable development (Scenario 4), and current situation (Scenario 1)

In India, the comparison between the High Growth and Sustainable Development scenarios is the most applicable in terms of the current debate at local, regional, and national levels regarding the growth of commercial shrimp aquaculture versus a more sustainable alternative that incorporates socio-economic and environmental impacts on local communities. This research project is unique in that it provides a quantitative indication of local stakeholder preferences regarding these two development scenarios in the Indian Sundarbans. The results of this comparison are extremely significant: all stakeholders overwhelmingly indicate a preference for the Sustainable Development scenario over the High Growth scenario, and the Current Situation (Table 17).

Table 17: Comparative results 3

Attribute	Scen. 2	Scen. 4	Current	None
Mangrove %	0	5	0	
Farms	5000	2000	2000	
Fry Collecting Jobs	60,000	25,000	50,000	
% Households with Loans	0	15	0	
Annual Payment	0	100	0	
Market Share				
Others Low Wealth	*12.97%*	***69.06%***	*9.07%*	*8.90%*
Others Med Wealth	*7.92%*	***81.03%***	*6.84%*	*4.21%*
Others High Wealth	*16.83%*	***71.61%***	*9.48%*	*2.08%*
Fry Collectors	*22.71%*	***66.96%***	*7.48%*	*2.85%*
Shrimp Farmers	*18.51%*	***68.80%***	*6.16%*	*6.53%*

The fact that the market shares range from 66.96% for Fry Collectors to 81.03% for the Medium Wealth segment is clear evidence that these stakeholders are looking for

a balanced, sustainable, and diversified development approach, and that they are willing to contribute towards achieving this goal. The importance of an increase in mangrove coverage, coupled with access to micro-credit loans is further evidence of the need for both environmental and socio-economic considerations.

CHAPTER 7: POLICY IMPLICATIONS AND RECOMMENDATIONS

Policy implications and recommendations arising from this research project must take into account the larger policy debate regarding the benefits and costs of shrimp aquaculture in India. The existence of laws limiting development (including aquaculture) in the CRZ, the 1996 Supreme Court judgement banning shrimp aquaculture within 500 meters from the high-tide line, and the recent passing of the Coastal Aquaculture Authority Act (2005), present policymakers in India with conflicting options to enforce or encourage shrimp aquaculture. The Coastal Aquaculture Authority Act (2005) places regulatory responsibility for aquaculture in the hands of the Coastal Aquaculture Authority, which dilutes the ability of relevant State governments to effectively integrate the management of coastal zones. The Act effectively ends the moratorium on the development of commercial shrimp aquaculture along the coast of India, and it will potentially lead to an increase in commercial activity as financing and insurance options become available to commercial shrimp aquaculture operators (The Hindu Business Line, May 11, 2005).

7.1 Policy Implications for Shrimp Aquaculture in India

Sustainable development implies a long-term horizon, which is often in conflict with the reality of short-term political goals and objectives in many developed and developing countries. Future generations are not represented in the decision-making process, and an emphasis on reaping benefits in the present is especially pressing in any

developing country context (Ascher and Healy 1990). Furthermore, government institutions have few incentives to focus on long-terms goals; budgets are allocated annually, and evaluations are based on specific criteria or measurements (Table 18).

Table 18: Characteristics of GOI's policymaking process and requisites for pursuing sustainable development

Characteristics of policymaking in India	Sustainable development needs not served by policymaking in India
Short-time horizon	Emphasis on *long-term* net benefits
Lack of long-term accountability for shrimp aquaculture activities	Incentives to focus on *long-term sustainability*
Functional fragmentation within GOI regarding natural resource use and management	Analytic comprehensiveness to assess *net* benefits Coordination to balance activities to maximize net benefits and ensure sustainability
Focus of development planning on economic benefits only	Emphasis on *long-term* net benefits Analytic comprehensiveness to assess full range of *net* benefits
Centralization	Adaptiveness Micro-level knowledge to ensure sustainability Coevolution of local social systems Participation

Based on Ascher & Healy (1990)

Given the high degree of functional fragmentation across different government institutions responsible for specific activities, scant attention is paid to the evaluation of natural resource management policies using sustainable development criteria. The centralization of decision-making aggregates policymakers' perceived view of the common interest across the entire nation. This process does not take into account the specific nature of local natural resource uses, conditions, and knowledge, or the social institutions that manage them. The conversion of mangrove forests, often considered as wastelands by central governments, is a good example of how detrimental this perception

can be to local and regional communities, especially in light of the devastating impact of the tsunami on December 26, 2004.

The problems highlighted by the Supreme Court case clearly identify the discrepancy between the policymaking process in India, with respect to shrimp aquaculture in the CRZ, and the policymaking process required for sustainable development (Table 18). The case highlights the conflict between the expansion of commercial shrimp aquaculture, and the needs of local communities that rely on coastal resources for their livelihoods. The Supreme Court case gives policymakers important insights into the social, environmental, and economic effects of commercial shrimp aquaculture in the CRZ of India. It establishes a precedent for the valuation of environmental services provided by coastal ecosystems, and the costs associated with consuming or damaging those resources. Most importantly, for this research project, it reinforces the importance of incorporating the views, knowledge, and needs of local stakeholders in formulating policies that contribute to sustainable development. It is important to recognize that shrimp aquaculture is an important activity that generates significant foreign exchange revenues, employment, and regional development along India's coast. However, the lack of local participation in the policy decision-making process, the polarized positions of proponents and detractors of the industry, and the flawed regulatory and institutional approach to managing coastal resources in India, presents the GOI with enormous policy development challenges.

Reforming the process requires the involvement of central, state, regional, and local levels of government to formulate effective and enforceable policies (M. Gupta & Fletcher, 2001; Noronha, 2004). Government ministries and institutions need to

approach commercial shrimp aquaculture using an integrated approach within existing institutional frameworks. These institutional frameworks exist at all levels of government from the Coastal Aquaculture Authority and the National Coastal Zone Management Authority (NCZMA) at the national level, to the Costal Zone Management Authorites (CZMAs) at the state level, and the Sundarban Development Board (SDB) and Panchayat system at the local level, in West Bengal. Transforming the policymaking process in India is not an easy task, and it will require the cooperation of the GOI to decentralize a degree of decision-making authority to lower levels. However, the benefits of transforming the current process are potentially significant:

- participation of local and regional users of natural resources;
- local conflict resolution mechanisms;
- solutions to local and regional problems generated at the local level;
- greater degree of regulatory buy-in and enforcement.

From a regulatory perspective, the Environment Protection Act (1986) covers a number of important social, environmental, and economic considerations in the context of sustainable development in the CRZ. The Coastal Aquaculture Authority Act (2005) will likely limit the effectiveness of these regulations, setting a dangerous precedent for other industrial developments in the CRZ. Policymakers in India need to carefully weigh the short-term benefits associated with an expansion of commercial shrimp aquaculture against the social, environmental, and economic costs associated with this activity in the medium and long-terms.

7.2 Adoption of a Sustainable Development Strategy for the Indian Sundarbans

Shrimp aquaculture in the Indian Sundarbans is characterized by low intensity or traditional forms of cultivation, and relatively few shrimp farms, most of which are small, dispersed, and locally owned. There is also a high level of awareness of the importance of mangrove forests to all the communities in the region. The potential for large scale commercial shrimp aquaculture is high in West Bengal. Unfortunately, the consequences of unfettered commercial aquaculture development are well documented in other States in India, as well as in other countries in Asia and Latin America. Consequently, recommendations in this research project are based on balancing the needs of local stakeholders, some of whom plan to be shrimp farmers, against the potential consequences of large-scale commercial development.

The recommendation of this research project is to adopt a sustainable development strategy for the Indian Sundarbans. This strategy should incorporate the broad goals derived from the attributes used in the DCE:

- increase mangrove coverage;
- limit the number of non-traditional shrimp farms;
- gradually reduce the number of fry collectors;
- introduce a micro-credit scheme to assist households generate alternative sources of income;
- promote a regional Sundarbans Fund to facilitate economic and social development.

The purpose of these goals is achieve a sustainable development trajectory that minimises the negative environmental impacts of shrimp farming, provides a more even

distribution of the economic benefits of shrimp farming between local stakeholders, and develops alternative opportunities for income generation, especially for fry collectors. Specific objectives for these attributes are needed to achieve these goals.

7.2.1 Objective set 1: Increase mangrove coverage

Based on the DCE, local stakeholders indicate that mangrove coverage is the most important attribute. All stakeholders desire an increase in mangrove coverage, a potent reminder of the crucial role mangroves play in protecting local communities from the devastating effects of seasonal cyclones and storms, and the effects of soil erosion. These indirect and external benefits accruing from mangrove forests far outweigh the direct benefits accruing to local stakeholders through the collection of firewood, timber, medicines, etc. The evidence for this is clear, based on the limited access local stakeholders have to protected forests. Furthermore, data collected during the HS indicate that only a minority of local stakeholders in Namkhana Block access (legally or illegally) mangrove forests to collect firewood, timber, medicines, etc. Consequently, the need to increase and protect mangrove forests in the Indian Sundarbans is of paramount importance. To achieve this objective, local stakeholders, Panchayat leaders, and regional and national governments should expand social forestry programs in the region. The Joint Mangrove Management (JMM) project, which was initiated by the MS Swaminathan Research Foundation (MSSRF), is a good example of the effectiveness of such a strategy, and could serve as a prototype for the Indian Sundarbans (M. S. Swaminathan Research Foundation (MSSRF), 2005) (Appendix K: Joint Mangrove Management Project).

7.2.2 Objective set 2: Limit the number of shrimp farms

Based on the DCE, local stakeholders express a preference for more non-traditional shrimp farms in the Indian Sundarbans. The explanation for the apparent contradiction between the preferences expressed by local stakeholders for more mangrove coverage, and more non-traditional shrimp farms is relatively straightforward. Firstly, mangrove forests are generally not the primary source of land for new shrimp farms; instead it is agricultural land. Secondly, the preference for more shrimp farms is based on the perception that shrimp aquaculture is more lucrative than rice farming, or other forms of non-cash crop agriculture. This perception is partly true given that the relative price for shrimp is significantly higher than rice, but the risks associated with shrimp cultivation are far higher, especially in light of the threat of disease outbreaks. Furthermore, substantial upfront investment is required to start a commercially viable shrimp farm, and only a few local farmers have access to such capital. Thirdly, the relatively small number of non-traditional shrimp farms in the Indian Sundarbans has limited the potential for conflict between different stakeholders, and the negative externalities associated with commercial shrimp aquaculture. Consequently, there is potential for a limited number of non-traditional shrimp farms to exist within a Sustainable Development scenario. However, there are a number of serious challenges for local stakeholders regarding the growth of non-traditional shrimp aquaculture in the Indian Sundarbans. The first challenge is the regulation of non-traditional shrimp farms in terms of environmental impacts, and the second challenge relates to the socio-economic impacts on local stakeholders.

The Supreme Court ruling banning shrimp aquaculture in certain CRZ areas is a top-down regulatory approach that is difficult to enforce, and the recent passing of the Coastal Aquaculture Authority Act (2005) has also changed the GOI's approach to shrimp aquaculture in the CRZ. An opportunity exists for the GOI, through the newly constituted Coastal Aquaculture Authority, to review supplementary approaches to regulatory regimes, including economic instruments such as taxes, charges, and fees (Anantanasuwong, 2000). A number of such alternative approaches were proposed to cope with the rapid growth in shrimp aquaculture and its negative environmental impacts in Thailand, some of which may be applicable in West Bengal (Appendix L: Regulatory Regimes and Economic Instuments).

Limiting the harmful effects of the negative environmental impacts associated with commercial shrimp aquaculture can be achieved through the implementation of regulations, fees, taxes, or charges in West Bengal. However, the growth in commercial shrimp aquaculture would still likely result in negative social and distributional consequences for local communities in the Indian Sundarbans. This outcome is not part of the Sustainable Development scenario preferred by local stakeholders in the Indian Sundarbans. It is imperative to find suitable alternatives to the growth in commercial shrimp aquaculture that focus not only on environmental concerns, but also on economic and social concerns. One approach is to encourage the growth of group farming practices for sustainable aquaculture. The broad objectives of group farming are twofold (Srinath *et al.*, 2000):

- increase the financial benefits to group farmers and reduce the environmental impacts of shrimp cultivation through improved access to information, technology, and better

cultivation methods, access to credit, financial assistance, and marketing channels, development of leadership and entrepreneurial abilities, improved social cohesion and planning.

- increase the participation and organization of marginal stakeholders, including women and poorer farmers, to achieve a more equitable distribution of the benefits from shrimp aquaculture for participating stakeholders.

A group farming project was successfully implemented between 1993 – 1996, in Chellanam, in the State of Kerala (Srinath *et al*., 2000). Certain aspects of this project are transferable to the Indian Sundarbans because of the similar nature of shrimp cultivation techniques, especially the prevalence of paddy-cum-prawn cultivation, and the dominance of small-scale farmers in the region.

7.2.3 Objective set 3: Access to micro-credit, and education of fry collectors

Access to micro-credit for alternative income generating opportunities is an important attribute, one that was rated highly by all local stakeholders in the DCE. This finding reinforces the need for incentives to help local stakeholders generate income from alternative sources. This finding is especially important for Fry Collectors since they face the highest burden if the number of fry collectors is reduced under the Sustainable Development scenario, or if the ban on fry collection is enforced by the West Bengal government. Fry Collectors also face a potential decline in demand for wild fry, especially in light of the spread of white spot and other diseases, the expansion of non-traditional methods of shrimp cultivation, and easier access to hatchery fry for all shrimp farmers in the Indian Sundarbans. Establishing a regional fund to finance various development activities, including a micro-credit scheme, and mangrove conservation and

restoration projects is one approach to help Fry Collectors and other local stakeholders develop alternative sources of income[24].

Fry Collectors have limited knowledge of the relationship between mangrove coverage, shrimp fry abundance, sustainable harvest practices, and by-catch mortality (Sarkar & Bhattacharya, 2003). They are also ignorant of distribution and marketing strategies, and a large group of them rely on middle-men to carry out these activities. Educating Fry Collectors, and other local stakeholders about the environmental impact of their activities is an important component of a sustainable development approach. Sarkar and Bhattacharya (2003) have initiated a mass awareness campaign to mitigate these negative effects generated by natural resource users in the Indian Sundarbans (Appendix M: Mass Awareness Campaign).

The campaign proposed by Sarkar and Bhattacharya (2003) to better educate shrimp fry collectors and other marginalized stakeholders is an important component of a Sustainable Development scenario that may improve harvesting practices. However, apart from the initiative to establish breeding "hotspots" for tiger prawn, these initiatives are largely voluntary, which may not be sufficient to help Fry Collectors switch to alternative income generating activities. Limiting the total number of fry collectors is as important as educating them about better harvesting techniques. Limiting the number of fry collectors can be achieved through an individual licensing system, or through a community-managed system that provides access to different groups of fry collectors in rotation. In this way, more marginal fry collectors have a greater incentive to enrol in programs that provide training for alternative income generating opportunities. Once

[24] This fund is referred to as the "Sundarbans Development Fund" in the DCE.

training programs are completed, access to micro-credit would further provide trainees with seed capital to initiate new income generating activities. Some of these activities include culture fisheries, mushroom cultivation, apiculture, eco-tourism, and other non-conventional uses of the coastal zone (Sarkar & Bhattacharya, 2003).

CHAPTER 8: CONCLUSION

The Indian Sundarbans has experienced significant changes in a relatively short period of time, especially by Indian standards. Its remoteness, wildness, and exposure to fierce natural elements ensured its preservation for many centuries. The focus on India, and especially Calcutta, by the British East India Company from 1690 onwards, and the establishment of the city as the colonial capital in 1772, significantly changed this perception of the Indian Sundarbans as a wild and remote wasteland. Soaring demand for timber, land, and food led to large-scale migrations into the area, and massive exploitation of its natural resources. Today, the Indian Sundarbans is recognized as one of the most unique ecosystems in the world, subject to national and international conservation efforts. It is also a very fragile system, subject to up-stream river dynamics resulting in high levels of siltation, and salinization of water and land. Increasing levels of pollution from Kolkata, and exploding population growth on the coast has put pressure on marine resources, and fuelled a drive for local development.

The region now faces another threat, the expansion of commercial shrimp aquaculture under the auspices of the Coastal Aquaculture Authority Act (2005). Commercial aquaculture operators are very interested in developing this region due to the abundance of brackishwater, and the existence of marginal agricultural land on the coast. Many local households also believe that shrimp aquaculture may hold the promise of greater economic prosperity. By diversifying out of low margin activities such as rice, vegetable, or polyculture cultivation, these households hope to improve their standard of

living. The moratorium on commercial shrimp aquaculture along India's coastline, stemming from the Supreme Court ruling in 1996, has allowed local farmers and landowners in the Indian Sundarbans to gradually convert some of their property into dedicated shrimp ponds. By doing so, they have avoided large-scale conversion of mangroves and agricultural land into shrimp ponds; a devastating reality in many other parts of India, Asia, and Latin America. This gradual process has also ensured that a larger share of the benefits of small-scale shrimp cultivation accrue primarily to local inhabitants, as opposed to large-scale outside operators. However, the outbreak of white spot disease, in the mid 1990s, did have significant financial consequences for many shrimp farmers. Furthermore, the dependence of local communities on mangrove coverage for protection against storms and erosion has meant that little or no mangrove coverage has been converted for the purposes of shrimp aquaculture. The advent of commercial shrimp aquaculture may have a significant, and negative impact on this delicate balance.

This research project unambiguously highlights the preference of all local stakeholders for a Sustainable Development scenario that is in stark contrast to a High Growth, commercially oriented development scenario. Despite the relative absence of negative externalities associated with shrimp aquaculture in the Indian Sundarbans, local stakeholders are still aware of the importance of a balanced and sustainable approach to development in the region. In many respects this is not surprising; local stakeholders are acutely aware of their fragile existence, and their need for economic development and prosperity is carefully weighed against their knowledge of local conditions and environmental realities. Nevertheless, a large proportion of local stakeholders require

development assistance focused on generating alternative sources of income. This fact is especially true for Fry Collectors who currently face intolerable working conditions, but who may also face displacement or loss of employment due to declining shrimp stocks, or a switch by Shrimp Farmers to hatchery fry.

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APPENDICES

Appendix A: Definition of Shrimp Farming Systems

Shrimp farming systems are based on a number of factors: area under cultivation, pond construction and drainage; dedicated or multiple-use ponds; number of harvests per year; stocking density, and stocking method (hatchery or wild seed); application of technologies to aerate ponds, feed shrimp, and prevent outbreaks of disease.

Table 19: Shrimp Farming Systems

Shrimp Farming System	Main Characteristics[a]	Stocking Density (fry/m^2)[b]
Traditional aquaculture	A variety of polyculture systems with miscellaneous fish and a small component of shrimps. Ponds are naturally stocked with no control over quality/quantity. Average production is low and ranges from 200-500 kg/Ha/year (mixed sizes and species). Most well-known of these systems are the *bheries* system of West Bengal and the paddy-cum aquaculture systems of Kerala, Goa, and Karnataka.	< 5
Improved traditional	Traditional ponds stocked with shrimp seed. Most of the limitations remain: the entrance of predators and competitors, insufficient pond depths, and full dependence on natural food in the ponds. Overall yields increase to some 300-600 kg/Ha/year, with one third of the crop being shrimps.	5 - 7
Extensive	Extensive systems are usually square ponds with excavated walls some 1.5 to 2 meters in height. Water is generally supplied by pumping from canals or creeks. Stocking rates are 2–5/m^2, with one or two crops a year. The farmers use pond-side prepared feed from clams, fishmeal, oilcake, etc. Crop yields are in the range of 300-700 kg/Ha/year, with large variations among the different ponds.	7 – 14
Modified extensive	Laid out as extensive systems, but involving pond preparation with tilling, liming, and fertilization and application of higher stocking densities, of the order of 5-10/m^2. Farmers often use a combination of local feeds and locally produced or imported pellet feeds. One or two crops of 600-1100 kg/Ha/year are harvested.	N/A
Semi-intensive	The ponds are 0.25-1.0 Ha in size, with regular supply and drainage canals and controlled water exchange. Stocking densities are 15–30/ m^2. Imported pellet feeds are used, and application of drugs and chemicals is common. Average yields of semi-intensive farms in India are about 2200 kg/Ha/year, with an average of 1.2 to 1.5 crops a year.	15 – 19
Intensive	The ponds are 0.25–0.50 Ha in size, with four aerators per pond and a central drainage system to remove accumulated sludge. Management practices, including salinity manipulation, are as for semi-intensive systems, but with a stocking density of 30-80/ m^2. Yields of over 8000 kg/Ha/year are possible, but the average yield in India is about 4500 kg/Ha/year, with 1.6 crops per year.	≥ 20

Source: [a] ADB/NACA (1998), Hein (2002)
Source: [b] Gupta *et al*. (2005)

Appendix B: Land Conversion in West Bengal

Land conversion has occurred for over 200 years in the Sundarbans of India and Bangladesh. Historically, a trade-off existed between forests for timber and fuelwood versus the clearing of land for paddy fields. Demand for rice to feed growing populations in India and Bangladesh led to wide scale conversion of forests in 24 Parganas District in India, and Khulna and Backerganj Districts in Bangladesh. Between 1880 and 1980, cultivated land expanded by 6,210 km^2 (an increase of 49%), and wetlands shrank by 5,765 km^2 (a decrease of 45%) in these areas (Richards & Flint, 1990). In the 1870s, colonial administrators recognized the potential impact of unfettered land conversion on forest land and timber supply, especially regarding the *sundari* forests in the Sundarbans of India and Bangladesh. In response, Reserved Forests and Protected Forests were established, and by 1890, 4,095 km^2 of Reserved Forests existed in Khulna District, and 4,480 km^2 of Protected Forests existed in 24 Parganas District (Richards & Flint, 1990). The amount of Protected Forests remained constant between 1890 and 1930 in 24 Parganas District. This area was administered by the Forest Department, representing approximately 60% of the Sundarbans area in the district, and after Partition, this area became the West Bengal Sundarbans Forest Reserve.

Appendix C: Shrimp Aquaculture in Thailand

Initially, mangrove forests along Thailand's coast were converted to shrimp ponds, which had devastating environmental effects for coastal communities and fishers (Barraclough & Finger-Stich, 1996; Primavera, 1998a, 1998b). Increasing international demand for shrimp, coupled with a decrease in the availability of coastal areas for shrimp cultivation, and improved techniques to cultivate shrimp in low salinity environments, pushed shrimp farm operators into prime agricultural areas in Thailand in the 1990s (Flaherty *et al*., 1999). The conversion of rice paddies into shrimp ponds led to a number of environmental problems: conversion and degradation of existing agricultural land; an increase in salinity levels of freshwater and surrounding agricultural land; pollution from shrimp pond effluents; and increasing competition for freshwater. All of these environmental impacts are derived from the existence of short, medium, and long term negative externalities associated with shrimp cultivation. The conversion and degradation of agricultural land is unregulated with no requirement for rehabilitation of land after shrimp cultivation operations cease; increasing salinity levels of freshwater and surrounding agricultural land, and pollution from pond effluents are a direct result of the shrimp cultivation process; and increasing competition for water (which is "free" for farmers in Thailand) is due to the fact that shrimp cultivation requires more freshwater than rice farming. Consequently, the Thai government banned inland shrimp cultivation in 1998, but enforcement remains a contentious issue (Flaherty *et al*., 1999).

Appendix D: Stakeholders

Table 20: Stakeholder interests in the Indian Sundarbans (macro to micro level)

Institutional level	Stakeholders	Interest
Global, international, and wider society	UNESCO; international environmental and conservation organizations; foreign governments; donor institutions; commercial and industrial groups; academic institutions; future generations	Biosphere reserve; conservation of wetland and tiger habitat; border security (Bangladesh); regional development; aquaculture, property development, and tourism; resource extraction; research
National	GOI; Supreme Court of India; Sahara Group (Indian conglomerate); SEAI (Seafood Exporters Association of India); other commercial and industrial groups	Coastal zone management; regional economic development; exports and foreign exchange earnings; aquaculture, property development, and tourism; resource extraction
State/Regional	West Bengal government departments: Environment and Forests, Commerce, Fisheries; SDB (Sundarban Development Board), etc.; academic research institutions; regional communities	Political and institutional infrastructure; regional planning and development; resource and environmental management; research; livelihood generation and food production
Local off-site	Fishers; local government officials; fishing, farming, and transport related groups, local NGOs	Fish productivity in Bay of Bengal; management & enforcement of laws and regulations; provision of business and other services;
Local on-site	Panchayat leaders, agricultural farmers, shrimp farmers, fry collectors, fishers, etc.;	Political power; livelihood generation; protection of resources; access to common resources

Based on Grimble *et al*. (1994)

Appendix E: Interviews

Interview 1: Fry Collector

Date: January 25, 2005
Place: Ramganga, Patharpratima Block
Gender: Female

The interviewee started collecting fry 10 – 12 years ago. During this period the number of fry collectors has decreased in her area, due mainly to a decrease in the number of fry. Trawlers, which indiscriminately harvest all species, are primarily responsible for the decrease in the abundance of fry. Although women have traditionally been involved in fry collection, their numbers are decreasing due health hazards. Most of the fry are distributed via middlemen, who fix the price. The fry pass through two or three levels before they reach their final market. Fry collection is carried out on foot and by boat by men and women. Collecting by boat does increase the harvest, but operating boats is more expensive due to fuel, net, and boat costs. Bycatch levels are in the order of 50%, most of which is discarded on the bank of the river. Most of the collection is done over a six month period in the winter. During this period the interviewee collects 5 days/week, based on tidal activity (collection takes place during low tide). Fry collection is a localized activity, carried out only by people from the immediate area.

The price of fry varies considerably based on seasons, with prices ranging from Rs. 300/1000 fry – Rs. 1000/1000 fry. Demand for fry is highest in March – April, which coincides with the shrimp farming season (April – June, and September – January). The number of shrimp farms has decreased in the area due to viral outbreaks, and the falling price of shrimp.

The interviewee does not want her children to collect fry, especially since it is very hard work, and the risk of health problems is high. The interviewee has eye problems due to the bright glare off the water during collection.

Interview 2: Shrimp Farmer

Date: January 25, 2005
Place: Ramganga, Patharpratima Block
Gender: Male

The interviewee has two ponds (0.75 *bighas* and 1 *bigha*). He started cultivating shrimp four years ago, prior to that he cultivated only sweetwater fish. He decided to switch to shrimp cultivation for two reasons: higher profitability, and access to technical expertise from the local shrimp farming technicians. However, he is constantly concerned about the risk of viral outbreaks (white spot), which is why he only cultivates tiger prawns for three months in a year; however, if the threat of white spot disease were eradicated he would like to cultivate more tiger prawns by converting his sweetewater ponds to dedicated shrimp ponds. He now practices seasonal polyculture: for three months (March – May) he cultivates tiger prawns (brakishwater), and for the remaining nine months he cultivates sweetwater fish. He has three pumps to pump out the brackishwater at the end of the tiger prawn season.

The yield of shrimp varies, and in the 2003/2004 season the interviewee harvested 280 kg. He is expecting 425 kg in the 2004/2005 season. He uses wild shrimp fry to stock his pond, and other inputs include lime, feed, and medicines (but only in the first year). The stocking density of his pond is approximately 4.25 fry/m^2 (14,000 fry/3300 m^2) and the mortality is approximately 50%. Although the supply of wild fry from local collectors is adequate (at approximately Rs. 300/1000 fry), he would like to stock his pond with fry from hatcheries, which would reduce the mortality rate. Water and waste from the pond is discharged into the local canal system, which is linked to the sea. According to the interviewee, the water discharged from his pond does not lead to salinization of soil and sweetwater resources near his farm.

Interview 3: Other (Farmer)

Date: January 25, 2005
Place: Ramganga, Patharpratima Block
Gender: Male

The interviewee cultivates approximately 18 *bighas* of land. Crops under cultivation are rice (2 crops – summer and winter), vegetables, and sunflowers. He employs four labourers year round, and he generates an income of Rs. 1200 – Rs. 1500 per month. None of his land is leased out.

The interviewee does not want to convert any of his land into shrimp ponds. The risk of viral outbreaks is high, and therefore the risk is not acceptable. He would be interested in cultivating shrimp if viral outbreaks were not a problem, mainly because shrimp aquaculture is export-oriented, and more profitable.

According to the interviewee, unemployment is a problem in the Indian Sundarbans. In terms of employment, agriculture employs more labourers, but shrimp cultivation requires more man hours. Some labourers working in both sectors, and wages are approximately the same. Fry collection is a good way to avoid unemployment, but the income is low and the work hazardous (collectors can be attacked by crocodiles and sharks, and there are many health problems associated with fry collection on foot).

Interview 4: Shrimp Farmer

Date: January 29, 2005
Place: Debnagar, Namkhana Block
Gender: Male

Interviewee is also a teacher, and he started cultivating shrimp one year ago. He is also engaged in polyculture cultivation, and prior to that he was an agricultural farmer.

The interviewee cultivates at least one tiger prawn cycle a year, starting in April (additional cycles are dependent on conditions). After harvesting the tiger prawn, he drains his pond of brackishwater, and cultivates scampi (sweetwater). His pond in Debnagar is small (0.18 *bighas*), but he has additional land on Sagar island (27 *bighas*) that he plans to convert to shrimp ponds. The land in Sargar is currently used for cultivating rice, but shrimp cultivation is much more lucrative (shrimp cultivation generates 10 times as much revenue as rice cultivation on the same piece of land). He received permission from the local Panchayat to cultivate shrimp on Sagar island (licensing is required, but not enforced). He does not want to convert his agricultural land in Debnagar because he needs it for agricultural produce.

The stocking density for his pond is 20 fry/m^2, and he plans to increase this to 25 fry/m^2 by using aerators. He is a semi-intensive shrimp farmer, and his fry are supplied from hatcheries in Andhra Pradesh (through Charoen Pokphand, a Thai multinational operating in India), at Rs. 500/1000 fry. He also receives technical assistance from the shrimp aquaculture technician based in Namkhana town (representing IFB Agro Industries Ltd.). The stocking density for his pond was 15 fry/m^2 prior to assistance from the technician (he also had problems with viruses prior to the technician's assistance). He also sells his crop to the technician. The interviewee is concerned about the noise pollution as a result of shrimp cultivation, and the discharge of effluent into the canals. Access to credit is the biggest obstacle that limits the number of people engaged in shrimp cultivation; however, the feed and fertilizer suppliers do give shrimp farmers access to credit.

Interview 5: Group Interview

Date: January 29, 2005
Place: Debnagar, Namkhana Block
Gender: 11 Males, 2 Females

20% of the adult group is engaged in fry collection, and 80% are engaged in agricultural farming (with some fishing related activity as well). Both the women are engaged in fry collection, but it is bad for their health. The farmers have generally increased the production of vegetables and decreased rice production. Most farmers also have sweetwater polyculture ponds. Betel production is a good alternative, but it is expensive to convert to betel production (costs increase by 90%). Funding is sometimes available through the community or the cooperative bank. The group is not interested in shrimp farming because of the risks associated with viral outbreaks; however, shrimp aquaculture is potentially good for the village. The group does not believe there are other problems associated with shrimp aquaculture.

There are no self-help groups for women, and the two women in this group would like access to credit and training for alternative income development schemes. They would like to do something other than fry collection, if it generates more income. The men in the group were genrally supportive of self-help groups for women.

Interview 6: Other (Farmer)

Date: January 29, 2005
Place: Debnagar, Namkhana Block
Gender: Male

The interviewee is engaged in agricultural production (rice) and polyculture cultivation on the same land (paddi-cum-polyculture system). He cultivates some shrimp as part of his polyculture operation, but only using traditional methods (he collects the fry himself and stocks his fields after the rice harvest). He would like to switch all his land, which is ideally suited for shrimp cultivation (within 300 ft of a source of brackishwater), to shrimp ponds. However, the cost is too high, and he will also require more labour. He also has no experience cultivating shrimp (except for the traditional method), and he has not been visited by the shrimp aquaculture technician. His village is supportive of shrimp aquaculture, and he does not see any other problems with it, except the cost. No member of his family is engaged in fry collection for income generating purposes.

Interview 7: Shrimp Farmer

Date: January 29, 2005
Place: Debnagar, Namkhana Block
Gender: Male

The interviewee switched some of his land (3 *bighas*) to shrimp ponds a year ago. He switched because his rice yields were falling due to rising salinity levels (casued by his proximity to the brackishwater canal). He was introduced to shrimp aquauculture by the technician from IFB Agro Industries Ltd., who provides technical expertise and input. He was also motivated by higher profit margins from shrimp cultivation. He has built a weir system, and he plans to convert more of his land to shrimp ponds when he gets a license, and more investment capital. He has pumps and 18 aerators, and he hires two family members and one labourer for three months to help with shrimp cultivation. Two years ago all his land (8 *bighas*) was used for agricultural purposes (rice and vegetables). The license cost will be Rs. 350 per year for all 8 *bighas*, and the license is issued by Benfish (West Bengal Fisheries Department), and he plans to convert the remaining 5 *bighas* into shrimp ponds. He is concerned about the risk of viral outbreaks (white spot), and other diseases that could compromise the health of his crop.

In his first year the interviewee stocked his ponds with hatchery fry from Andhra Pradesh (55,000 fry/3 *bighas*). Only 18,000 survived, and their health was compromised by the outbreak of a "thinning" disease. He was expecting an average weight of 45 grams/tigher prawn, but only got 22 grams/tiger prawn. The stocking density of his ponds will be 14 fry/m^2 (extensive/semi-intensive).

The interviewee received financing from his own savings, and the cooperative bank (at 12% per annum). He also received credit from the feed financier. He is satisfied with the price he gets for his crop, but he would like a hatchery supplier closer to his operations. He did not feel that a local hatchery would threaten the jobs of fry collectors because they don't sell their harvest locally. Shrimp aquaculture is good for the village and will increase per capita income.

Interview 8: Technician (IFB Agro Industries Ltd.)

Date: January 29, 2005
Place: Namkhana, Namkhana Block
Gender: Male

IFB Agro Industries Ltd. (IFB) is part of a large Indian conglomerate. It supplies fertilizer and feed inputs to farmers, and is also a major exporter of marine products, including tiger prawn. IFB and Charoen Pokphand (CP) are working together to promote shrimp aquaculture in the Indian Sundarbans, with the support of the West Bengal government and local officals (except the Sundarban Development Board). CP is a multi-national supplier of shrimp aquaculture inputs, and IFB has local manpower and global distribution channels for marine products. In 2002/2003 there were two IFB technicians in Namkhana Block, and in 2005 there are four. The focus of the technicians is to help traditional polyculture farmers upgrade to semi-intensive shrimp cultivation techniques, and also to help agricultural farmers convert paddy land into shrimp ponds. Other feed/input suppliers are Avanti Feeds Ltd., and Higashi Maru Feeds (India) Ltd.

Local farmers face many obstacles: limited access to financing; absence of fry hatcheries in West Bengal; limited technical knowledge of advanced cultivation techniques; and poor infrastructure and transport options for input supply and export distribution. Only 10% of total potential shrimp output is currently produced in West Bengal, and IFB would like to see that level reach 25% - 30% within two years. There is also a need to develop local hatcheries, but there is little government support for that, and companies are reluctant to set up operations in West Bengal. Although there is currently not enough demand for hatchery fry, there is good reason to set up local hatcheries to meet future demand. Shrimp production has grown by 20% - 40% over the last five years. In the Indian Sundarbans, 60% of shrimp farmers use traditional/improved traditional cultivation techniques, 10% use extensive techniques, 20% use semi-intensive techniques, and 10% use intensive techniques. The Supreme Court ruling in 1996 slowed the development of commercial shrimp aquaculture developments, which typically use semi-intensive or intensive cultivation techniques.

Interview 9: Shrimp Farmer

Date: January 30, 2005
Place: Madanganj, Namkhana Block
Gender: Male

The interviewee is located near a large channel of the Sundarbans delta, close to a small area of mangrove forest planted by the social forestry program. He started cultivating shrimp eight years ago, using wild fry. Three years ago he switched to hatchery fry. He now has five shrimp ponds on land he bought from an abandoned brick making site next to the channel (the land was not suitable for rice cultivation). There are paddy fields adjacent to his ponds. IFB supplies him with feed for his shrimp ponds, and he is financed by a local financier who buys his crop from him. He uses the proceeds from his crop to pay IFB for the feed. Eight years ago the price for tiger prawn was higher than today.

The stocking density of his ponds is 20-25 fry/m^2 (intensive). He has a license to cultivate shrimp (Rs. 100/0.33 *bighas*), and he received permission to dig his ponds from the local panchayat. He does not think the government should charge higher license fees, even if they improve services to shrimp farmers, such as training. He feels the government should be helping more anyway, and that the Sundarbans Development Board does not provide any assistance to shrimp farmers. IFB provides more assistance than the government.

Agricultural farmers are not interested to cultivate shrimp because they do not have the technical knowledge. He has received no complaints from local farmers about his shrimp ponds in terms of environmental damage. The Indian Sundarbans region has a big problem regarding economic development, and there is no training, credit, or opportunities for local farmers to help diversify their sources of income. Furthermore, the fisheries sector is a problem because the government has managed it very badly, and most of the fishing industry is controlled by a few operators.

Interview 10: Shrimp Farmer

Date: January 30, 2005
Place: Darignagur, Namkhana Block
Gender: Male

The interviewee is located near a large channel of the Sundarbans delta, opposite a mangrove forest on the other side of the channel. He has 20 *bighas* of land, and he cultivates shrimp (last three years) and rice, and produces betel (last 10 years). 80% of his land is used for rice cultivation, 5% for betel production, 2.5% for vegetables, 2.5% for a general use pond (sweetwater), and the remaining 10% for his house. He cultivates shrimp on 4 *bighas* of land leased from a farmer (previously sweetwater ponds). He is the first person in his village to cultivate shrimp, and he started because of the higher profit margin from shrimp cultivation. The idea to cultivate shrimp came form the shrimp aquaculture technician from Kontai (representing IFB and CP). He decided to lease the land because it would have cost too much to convert his agricultural land into shrimp ponds. Other farmers are interested in shrimp aquaculture, but they face capital constraints.

The stocking density of his ponds is 20 fry/m^2 (intensive), and he stocks his ponds with hatchery fry from Andhra Pradesh. The mortality rate of wild fry is 40%, whereas the mortality rate of hatchery fry is only 20% - 30%. He stocks his ponds with approximately 150,000 fry. He cultivates shrimp from March – August (he avoids the monsoon season because the shrimp are smaller during that period). He employs 2 labourers from his village for four months a year, and he uses pumps and aerators. His feed and medicine is supplied by Avanti Feeds Ltd. and IFB, and he is finanaced through a loan. He sells his crop to MMC Exports Ltd. (a competitor of IFB), through a representative that comes from Kolkata. He currently gets Rs. 7.5/gram, but he is not happy with the price (he would prefer Rs. 10/gram). There is currently low demand for shrimp, and he is not worried that more shrimp farmers in the Indian Sundarbans will depress prices further. He would like to see more shrimp farms in the area, but financing is a problem for local farmers. Shrimp aquaculture is good for the village, and he would like to see a local cooperative to help local shrimp farmers get better prices for their crop.

Interview 11: Group Interview

Date: January 30, 2005
Place: Darignagur, Namkhana Block
Gender: 15 Males, 13 Females

This area is comprised of approximately 150 households, 80% of which are poor. Only 20% of the households are in "OK" condition. Most members of the community survive on wage labour working on agricultural farms. The average landholding is 0.5 – 1.5 *bighas* per household.

Most members of the group were involved in fry collection by boat or on foot. Many fry collectors who collect by boat operate for up to 11 months a year, with a break at the end of the monsoon period. The best season for collection is March – August, and fry are most abundant during the monsoon period. During the winter season the abundance is very low. The fry collectors who collect on foot generally catch much less than those who collect from a boat, but the cost is much less. A boat costs approximately Rs. 4000, and then there is the net, bamboo poles, and other equipment.

There has been a five-fold increase in the number of collectors over the last five years. At the same time, there has been a large decrease (50%) in the abundance of fry due to trawlers that capture the spawners. Overall, the demand for fry has stayed the same, and most of the fry collected are distributed through the wholesale market. Fry collection is an open-access activity in the rivers and along the shore. Most collectors are local because it is too expensive to travel to other areas to collect fry. However, collectors do sometimes come from other areas. In terms of optimal collection sites, the group did not think that there was a discernable relationship between mangroves and fry abundance.

In terms of access to credit, a micro-credit scheme is available for self-help groups, organized by the Integrated Child Development Scheme (ICDS). The scheme does not work well because the repayment terms are too onerous: better credit terms may help. Many members of the group are interested in alternative income generating opportunities, such as poultry or livestock rearing. There are no employment opportunities associated with shrimp aquaculture, and there are only five or six shrimp farms in the area. Almost everybody is employed someway in agricultural activities. It

would be good for the village if there was more shrimp aquaculture, and there would be more jobs opportunities. The group would prefer to work on shrimp farms rather than on agricultural farms. The fry collectors would like to sell their fry directly to shrimp farms, but would ultimately prefer to work on shrimp farms as paid labourers. They are concerned about hatcheries, and they would prefer it if local shrimp farms buy wild fry from them.

Interview 12: Other (Farmer)

Date: January 30, 2005
Place: Darignagur, Namkhana Block
Gender: Male

The interviewee has 2.5 *bighas* of land, all of which is used for agricultural production. His family works on the land cultivating rice (one crop per year), and he also has 0.25 *bighas* of land under betel cultivation (started five years ago). Betel production is profitabile, but prices for betel have dropped, along with prices for vegetables. He does not know why the prices have dropped. He did not receive any training to cultivate betel, and he financed it through his own savings. He only has one crop a year, but he is satisfied with the current production. He rice yields have increased over the last five years, so he has no problem with the productivity of the soil.

The interviewee's land is better suited for shrimp aquaculture, and he is interested to convert his land to shrimp ponds, especially since the profit margin is good. However, shrimp farming is risky, and the price of shrimp is falling. He also does not have access to financing or credit to convert his land to shrimp ponds. Shrimp aquaculture is potentially good for the village if it is done properly (i.e. under proper technical supervision). Training should be provided by private companies because the government is too inefficient in the delivery of services.

The interviewee is aware of the importance of mangroves to limit the impact of soil erosion, and to protect area residents from storms.

Interview 13: Shrimp Farmer

Date: February 4, 2005
Place: Shibrampur, Namkhana Block
Gender: Male

Interviewee chose the "Current Situation" for the DCE during the pre-testing phase. Mangrove coverage is a very important attribute for him, and he also believes that infrastructure items should be included as an attribute as well.

The interviewee indicated that 5% - 10% of the total area under shrimp cultivation in the Indian Sundarbans is non-traditional. The average size of a shrimp farm is 0.5 – 1 Ha.

Interview 14: Fry Collector

Date: February 5, 2005
Place: Narangonj, Namkhana Block
Gender: Male

The interviewee has 0.5 *bighas* of leased land, which he uses to grow vegetables. He has experienced erosion of the soil around his land, which has limited his ability to convert any of his land to shrimp ponds. He is also unable to convert his land to shrimp ponds because he does not have access to financing, and he is also reluctant to convert any land to shrimp ponds because of the risk of viral outbreaks.

The interviewee collects shrimp fry on foot, and he collects throughout the year, 5 days per week. He also has a boat, which is used by his son to collect fry as well. There has been a decrease in the abundance of fry, but he does not know why this has occurred.

Interview 15: Group Interview

Date: February 5, 2005
Place: Narangonj, Namkhana Block
Gender: Male & Female (numbers unknown)

The group could not agree on an average number of fry collected on a daily/weekly basis during the different seasons because the range is so large. The number of fry collected by boat versus on foot ranges from 2 – 20 times as many fry by boat.

Two members of the group chose the "Current Situation" for the DCE during the pre-testing phase. They did so because the mangrove coverage was greater than the other options, there were more shrimp farms and more fry collection jobs. According to these members of the group, there is a positive correlation between mangrove coverage and shrimp abundance. They were satisfied with the list of attributes, although they did want more employment related attributes on the list.

Appendix F: HS and DCE

Date:	Interviewer:	Village No:	Household No:	CE Block:

ASSESSING ENVIRONMENTAL MANAGEMENT OPTIONS TO ACHIEVE SUSTAINABILITY IN THE SHRIMP-MANGROVE SYSTEM IN THE INDIAN COASTAL ZONE OF THE BAY OF BENGAL

SHARP PROJECT – HOUSELHOLD SURVEY / CHOICE EXPERIMENT QUESTIONNAIRE

HOW TO USE THIS INTERVIEW PROTOCOL

Notes and remarks are [**BOLD AND CONTAINED IN SQUARE BRACKETS AND UPPER CASE**]. These are for your information.

Text marked in **lower case and bold** is for you to "read" to the respondent, but try not to read this protocol word for word. Just try to capture the main ideas within your own natural style of speaking.

INTRODUCTION

[ASK TO SPEAK TO THE HEAD OF HOUSEHOLD (AN ADULT OVER THE AGE OF 21).]

Hello, my name is _____. We are conducting a survey with local residents about shrimp farming in the Indian Sundarbans. We would like to know your personal opinions about the environmental, social and economic impacts of shrimp farming, and the value of the natural resources in your area. This survey is part of a collaborative research project between Simon Fraser University, in Canada, and Jadavpur University and Burdwan University, in India. Everything that you tell us will be kept strictly confidential.

If you could lend me about one hour of your time, we would really value your input. Would you be willing to participate at this time?

[IF YES, CONTINUE SURVEY]
[IF NO, THEN ASK IF IT WOULD BE MORE CONVENIENT TO COME BACK AT ANOTHER TIME]
[IF YES, ARRANGE A MUTUALLY AGREEABLE TIME]
[IF NO, THANK SINCERELY AND END INTERVIEW]

Thank you for agreeing to participate. Where would you like to complete the survey?

Before we start, I would like you to know that your participation is entirely voluntary and that you may choose not to participate at any time. As a reminder, any information that you provide will be kept strictly confidential. The study results will be presented only as summaries in which no personal information is used.

START SURVEY

In the first part of the survey, I will read each question to you. Please listen carefully to the questions and try to answer them as accurately as possible.

[IF THE RESPONDENT WANTS TO READ THE QUESTIONS WITH YOU, LET THEM]

A. IDENTIFICATION DATA & DEMOGRAPHIC INFORMATION

A.1. Name of panchayat/village: _____

A.2. Name of location: _____

A.3. Name of the respondent: _____

A.4. Gender of the respondent: Male □ Female □

A.5. Age of the respondent: _____Years

A.6. Have you been surveyed with respect to shrimp farming in the last 12 months? Yes □ No □

A.7. Is the respondent head of the household? Yes □ **[GO TO A.9.]** No □ **[GO TO A.8.]**

A.8. If not head of the household, what is the relationship to head of the household?

_____

A.9. Can the respondent read? Yes □ No □

A.10. Can the respondent write? Yes □ No □

A.11. Year of formal schooling completed: _____Years

A.12. Number of family members in the household: _____ People

Category	Reside in household	Reside elsewhere more than 6 months continuously in a year
Male (15 years and over)		
Female (15 years and over)		
Children (14 years and younger)		

A.13. Was the respondent born in this district **[24 PARGANAS SOUTH]**? Yes □ **[GO TO A.14.]**
No □ [**GO TO A.15.]**

A.14. How many generations has the respondent's family lived in this district?
_____ Generations **[GO TO A.16.]**

A.15. If not from this district, which district is the respondent from?
_____

A.16. Type of home and number owned:

Type of house	Owned	Other	Roof type 1=thatch, 2=tile, 3=tin 4=asbestos, 5 = concrete
Hut			
Kacha			
Paka			
Other			

B. LAND HOLDING & PRODUCTION INFORMATION

B.1. Please complete the following information regarding the household's landholdings:

Land Characteristics	Type	Owned (Bighas)		Leased in (Bighas)	Other (Bighas)
		Own cultivation	Leased out		
B.1.1. Agricultural land	Irrigated				
	Non-irrigated				
B.1.2. Aquaculture land	Polyculture pond				
	Shrimp pond (brackishwater)				
B.1.3. Other land (please specify)					

[IF THE HOUSEHOLD HAS NO OWNED, LEASED IN, OR OTHER LAND IN B.1. GO TO B.14.]

[COMPLETE B.2. – B.12. ONLY IF AGRICULTURAL LAND, AQUACULTURE LAND, OR OTHER LAND IS OWNED BY THE HOUSEHOLD IN B.1. FOR ALL OTHERS GO TO B.13.]

B.2. Has there been a change in the salinity of the soil on the respondent's agricultural land in the last 10 years?
Increased □ **[GO TO B.3.]** Decreased □ **[GO TO B.4.]** No change □ **[GO TO B.4.]** Don't know □ **[GO TO B.4.]**

B.3. What does the respondent think is the cause of the increase in soil salinity on the respondent's agricultural land in the last 10 years?
Canal water ingress □ Loss of mangroves □ Embankment erosion □ Other □
Don't know □ *(please specify)*_____

B.4. Is the respondent close enough to a source of brackishwater **[CANAL/RIVER/ESTUARY, ETC.]** to practise shrimp farming? Yes □ No □ Don't know □

B.5. How far is the closest source of brackishwater? _____ Meters

B.6. Has the household converted any agricultural land to shrimp pond area for the purpose of shrimp farming in the last 10 years? Yes □ How much land _____ Bighas No □
Stocking density _____ fry/m^2

B.7. Has the household converted any polyculture pond area to shrimp pond area for the purpose of shrimp farming in the last 10 years?Yes □ How much pond area _____ Bighas No □
Stocking density _____ fry/m^2

[IF "YES" TO B.6. AND/OR B.7. GO TO B.8. IF "NO" TO B.6. AND B.7. GO TO B.9.]

B.8. What are the reasons for converting land/ponds to shrimp pond area for the purpose of shrimp farming **[MORE THAN ONE REASON IS ACCEPTABLE]**? Please rank the reasons **[1=MOST IMPORTANT]**.

Reason		Rank	Reason		Rank
Decreasing yields from agricultural land and/or polyculture pond area	□		Access to credit for shrimp farming	□	
Lower labour cost than agriculture and/or polyculture	□		Higher profit margin from shrimp farming	□	
Access to technical advice for shrimp farming	□		Other *(please specify)*	□	

B.9. How likely is it that the household will convert any agricultural land and/or polyculture pond area to shrimp pond area for the purpose of shrimp farming in the next 5 years?

Very likely □ **[GO TO B.10.]** More likely than unlikely □ **[GO TO B.10.]**

More unlikely than likely □ **[GO TO B.12.]** Very unlikely □ **[GO TO B.12.]**

B.10. How much agricultural land and/or polyculture pond area will the household convert?

_____ Bighas

B.11. What will the stocking density be of the converted agricultural land and/or polyculture pond area?

5-14 fry/m^2 (traditional/extensive) □ **[GO TO B.13.]** 15-19 fry/m^2 (semi-intensive) □ **[GO TO B.13.]** 20 fry/m^2 and up (intensive) **[GO TO B.13.]** Don't know □ **[GO TO B.13.]**

B.12. Why is the household **"More unlikely than likely"** or **"Very unlikely"** to convert agricultural land and/or polyculture pond area to shrimp pond area for the purpose of shrimp farming in the next 5 years **[MORE THAN ONE REASON IS ACCEPTABLE]**? Please rank the responses **[1=MOST IMPORTANT]**.

Reason		**Rank**	**Reason**		**Rank**
Lack of household funds or access to credit	□		Government regulations	□	
Financial risk	□		Lack of technical knowledge or access to technician	□	
Lack of access to brackishwater source	□		Not interested	□	
Risk of disease in shrimp	□		Other *(please specify)*	□	

B.13. Please fill out the following household production information for the last 12 months (agriculture only).

Type	Production in last 12 months (Quintals)			Total income from amount sold (Rupees)
	Total produced (Quintals/Leafs)	Amount sold (Quintals/Leafs)	Amount consumed from own production (Quintals)	
Rice (Quintals)				
Betel (Leafs)				
Vegetables				
Other *(please specify)*				

B.14. How much rice did the household purchase in the last 12 months? _____Quintals

B.15. Does the household own any livestock? Yes □ **[GO TO B.16.]** No □ **[GO TO C.1.]**

B.16. Please fill out the following livestock information:

Livestock	Number owned
B.16.1. Cattle	
B.16.2. Goat/Sheep	
B.16.3. Poultry/Ducks	
B.16.4. Other (please specify)	

C. OTHER LIVELIHOOD & INCOME GENERATION

C.1. Please fill out the following livelihood and income generation information for the last 12 months **[MAKE SURE YOU ACCOUNT FOR <u>EACH</u> ADULT MEMBER OF THE HOUSEHOLD 15 YEARS OR OLDER. MAKE SURE YOU ACCOUNT FOR <u>ALL</u> THEIR ACTIVITIES, SINCE ADULT MEMBERS OF THE HOUSEHOLD MAY BE INVOLVED IN MORE THAN ONE ACTIVITY]**:

Type	Activity	Respondent	No. of other household members participating	Total income to household in last 12 months (Rupees)
C.1.1. Agriculture related	Farm labour	☐		
C.1.2. Aquaculture related	Shrimp farming	☐		
	Shrimp fry collection (by boat)	☐		
	Shrimp fry collection (on foot)	☐		
	Polyculture pond farming	☐		
	Aquaculture labour	☐		
	Mixed-use farming (polyculture component)	☐		
C.1.3. Fishing related	Artisanal fishing	☐		
	Industrial fishing	☐		
	Fishing labour	☐		
	Other fishing related *(please specify)*	☐		
C.1.4. Remittances	**Refer to A.12.**	☐		
C.1.5. Other	Landowner (rental income)	☐		
	Shopkeeper/Merchant/Trader	☐		
	General wage labour	☐		
	Government related	☐		
	Pension	☐		
	Transport related	☐		
	Other *(please specify)*	☐		

[IF SHRIMP FRY COLLECTION CHECKED IN C.1.2., COMPLETE SECTION D.]

D. SHRIMP FRY COLLECTION DATA & INFORMATION

D.1. Please complete the following information about household fry collection by boat **[IF APPLICABLE]**:

Season	No. of boats	Total no. of days per week (all boats)	Total no. of fry collected per week (all boats)
D.1.1. Pre-monsoon (Mar – June)			
D.1.2. Monsoon (July – Oct)			
D.1.3. Post-monsoon (Nov – Feb)			

D.2. Please complete the following information about household fry collection on foot **[IF APPLICABLE]**:

Season	No. of people	Total no. of days per week (all persons)	Total no. of fry collected per week (all persons)
D.2.1. Pre-monsoon (Mar – June)			
D.2.2. Monsoon (July – Oct)			
D.2.3. Post-monsoon (Nov – Feb)			

D.3. Has the number of shrimp fry collectors changed in the last 5 years?

Increased □ Decreased □ No change □ Don't know □

D.4. Has there been a change in the abundance of shrimp fry in the last 5 years?

Increase in abundance □ **[GO TO D.6.]** Decrease in abundance □ **[GO TO D.5.]**

No change □ **[GO TO D.6.]** Don't know □ **[GO TO D.6.]**

D.5. What does the respondent think is the cause of the decrease in abundance of shrimp fry **[MORE THAN ONE CATEGORY IS ACCEPTABLE]**?

Too many fry collectors □ Offshore trawlers □ Loss of mangroves □

Other □ *(please specify)*_____

D.6. Is there any by-catch when shrimp fry are collected? Yes □ **[GO TO D.7.]** No □ **[GO TO D.8.]**

D.7. What happens to the by-catch?

Thrown back into the water alive □ Discarded on shore as waste □ Other □ *(please specify)*_____

D.8. How are the shrimp fry sold?

Local market □ Middleman/agent □ Directly to shrimp farms □

Other □ *(please specify)*_____

D.9. Do any member(s) of the household have health problems they believe may be caused by shrimp fry collecting?

Yes □ **[GO TO D.10.]** No □ **[GO TO E.1.]** Don't know □ **[GO TO E.1.]**

D.10. What types of health problems do any member(s) of the household experience **[MORE THAN ONE CATEGORY IS ACCEPTABLE]**?

Skin □ Eyes □ Gynaecological □ Other □ *(please specify)*_____

E. NATURAL RESOURCE USE

E.1. How far is the closest mangrove forest on foot or by boat? _____ Meters

E.2. In the past, did any members of the household use mangrove forests for subsistence or income generation purposes?

Yes □ **[GO TO E.3.]** No □ **[GO TO E.4.]**

E.3. For what purposes did members of the household use mangrove forests in the past **[MORE THAN ONE CATEGORY IS ACCEPTABLE]**?

Use	Subsistence	Income generation
E.3.1. Biomass fuel	□	□
E.3.2. Building material	□	□
E.3.3. Food	□	□
E.3.4. Medicine	□	□
E.3.5. Other (please specify)	□	□

E.4. Do any members of the household currently use mangrove forests for subsistence or income generation purposes?

Yes □ **[GO TO E.5.]** No □ **[GO TO E.6.]**

E.5. For what purposes do members of the household currently use mangrove forests **[MORE THAN ONE CATEGORY IS ACCEPTABLE]**?

Use	Subsistence	Income generation
E.5.1. Biomass fuel	□	□
E.5.2. Building material	□	□
E.5.3. Food	□	□
E.5.4. Medicine	□	□
E.5.5. Other (please specify)	□	□

E.6. Has the area covered by mangrove forests changed near the respondent's village in the last 10 years?

Increased □ Decreased □ No change □ Don't know □

E.7. Is there a social forestry program near the respondent's village? Yes □ **[GO TO E.8.]**
No □ **[GO TO E.9.]**

E.8. What impact has the social forestry program had on your household?

Many benefits □ Some benefits □ No effect □ Somewhat harmful □
Very harmful □ Don't know □

E.9. Overall, what impact has the protection of mangrove forests had on your household **[E.G. FOREST RESERVE, WILDLIFE SANTUARIES, ETC.]**?

Many benefits □ Some benefits □ No effect □ Somewhat harmful □
Very harmful □ Don't know □

E.10. Does the household get its potable water from a borehole/hand-pump?

Yes □ **[GO TO E.11.]** No □ **[GO TO E.13.]**

E.11. Has there been a change in salinity of the potable water from the borehole in the last 10 years?

Increased □ **[GO TO E.12.]** Decreased □ **[GO TO E.13.]** No change □ **[GO TO E.13.]** Don't know □ **[GO TO E.13.]**

E.12. What does the respondent think is the cause of the increase in potable water salinity?

Canal water ingress □ Loss of mangroves □ Embankment erosion □ Other □
Don't know □ *(please specify)*_____

E.13. Has there been a change in the level of competition between different natural resources users in the area in the last 10 years? **[GIVE EXAMPLES, E.G. BETWEEN SHRIMP FRY COLLECTORS, FISHERMEN, AGRICULTURAL FARMERS, SHRIMP FARMERS, ETC.]**

Increased □ **[GO TO E.14.]** Decreased □ **[GO TO F.]** No change □ **[GO TO F.]**
Don't know □ **[GO TO F.]**

E.14. What does the respondent think is the source of the increase in competition between different natural resource users **[MORE THAN ONE CATEGORY IS ACCEPTABLE]**? Please rank the responses **[1=MOST IMPORTANT]**.

Reason		Rank	Reason		Rank
Population growth	□		Limited access to resources	□	
Decline in availability of resources	□		Other *(please specify)*	□	

F. CHOICE EXPERIMENT SECTION FOR SHRIMP-MANGROVE SURVEY

We are now near the end of the survey. I think that you will find the next section particularly interesting, because you will have an opportunity to choose between different possible options for development in the Indian Sundarbans.

[!!!CRITICAL!!! IT IS ABSOLUTELY ESSENTIAL THAT YOU USE THE CORRECT VERSION OF THE CHOICE SETS. IF THE CORRECT SET IS NOT USED, WE WILL NOT BE ABLE TO ANALYSE THE RESULTS AT ALL!!! DOUBLE CHECK THAT THE VERSION OF THE CHOICE SET YOU SELECT MATCHES THE VERSION NUMBER CONTAINED IN THE SURVEY YOU ARE USING]

Most people agree that to improve the conditions of people living in the Sundarbans more economic development is needed. One development alternative is shrimp farming using improved methods (feed supplements, higher stocking rates, year round production, etc.), as opposed to traditional methods involving some form of polyculture. Improved shrimp farming increases the incomes of shrimp farmers and also creates employment for shrimp fry collectors, hatchery workers, wage earners, input suppliers, etc. However, in other regions where improved shrimp farming is practised on a large scale, there have been detrimental environmental effects. These include the destruction of mangroves and/or the conversion of land for shrimp pond construction, land degradation, pollution, and salinization of groundwater and soil.

I will now show you a card that presents different activities that are associated with improving the conditions of people living in the Sundarbans. Most of these activities require some form of funding. Since funds for development are limited, only a portion of these activities could be undertaken.

[INTERVIEWER: HAND RESPONDENT THE CARD WITH 5 ATTRIBUTES AND EXPLAIN EACH ATTRIBUTE]

- **Mangrove forest area near villages – Protection and replanting programs (social forestry) can increase the area of mangroves near villages. Increases in mangrove area could range from 0% to 20% of the current level.**

- **Number of improved shrimp farms - Limiting the maximum number of shrimp farms can help reduce the negative impacts associated with improved shrimp farming. The number of improved shrimp farms range from 1000 to 5000.**

- **Employment in shrimp fry collection - By investing in hatcheries to increase the supply of shrimp seed, the number of shrimp fry collectors is likely to decline. Employment in shrimp fry collection ranges from 20,000 to 60,000.**

- **Credit for income generation activities - Micro-credit programs with modest repayment conditions would be made available to households for income generating activities, such as small-scale cash crop production, honey production, mushroom cultivation, purchase of livestock, etc. The share of households receiving credit assistance ranges from 0% to 20%.**

- **Household contribution – Most development funding would come from outside sources (e.g. government development funds, private investments, development projects, etc.). A small, one-time contribution would come from local households (through panchayat payments, house tax, etc.). Assume that these contributions from local households are made into a separate fund controlled by a specially formed NGO or community group. The contributions would NOT go into general government revenues. The one-time household payment ranges from Rs 0 to Rs 100.**

[INTERVIEWER: HAND RESPONDENT THE CHOICE CARD BUNDLE, WITH THE FIRST CARD ON TOP. RECORD THE COLOUR OF THE BUNDLE, AND COMPLETE THE RESPONSES IN THE SPACE BELOW.]

Card colour

Blue (block 1) □	Pink (block 2) □	Green (block 3) □
Yellow (block 4) □	White (block 5) □	
Blue (block 6) □	Pink (block 7) □	Green (block 8) □
Yellow (block 9) □	White (block 10) □	

Now I want you to examine these approaches in more detail. Each card describes a scenario of management approaches for mangroves and shrimp farming; each approach may be more or less favourable for you. On each card, there is the current situation, and two possible other scenarios. You will need to look at the levels in each option and consider the trade-offs carefully. Here are several cards depicting pairs of scenarios with different amounts of each option.

QUESTION:

F.1. Please select your most preferred option. You may select Scenario 1, Scenario 2, the Current Situation, or you may tell us that 'None of these is acceptable' to you.

	Option 1	Option 2	Status Quo	None of these options is acceptable
F.1.1. Card 1	□	□	□	□
F.1.2. Card 2	□	□	□	□
F.1.3. Card 3	□	□	□	□
F.1.4. Card 4	□	□	□	□
F.1.5. Card 5	□	□	□	□

G. ATTITUDINAL INFORMATION

G.1. Please ask the respondent to answer the following questions about their attitude towards shrimp aquaculture, environmental conditions, social conditions, and government policy.

Statements	Opinion					
	Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**	**Don't know**
G.1.1. I am concerned about the conversion of paddy land to shrimp farms.	□	□	□	□	□	□
G.1.2. If shrimp farming has negative effects on the environment, shrimp farmers should pay for any damages or correction.	□	□	□	□	□	□
G.1.3. There should be more community managed or cooperative shrimp farms on leased or common land.	□	□	□	□	□	□
G.1.4. Some kinds of fish and shrimp are more abundant when there are mangrove forests nearby.	□	□	□	□	□	□
G.1.5. Mangrove forests mitigate the destructive force of natural disasters (flooding, cyclones, waves, etc.) and should be preserved.	□	□	□	□	□	□
G.1.6. Villagers' access to mangrove forests to collect forest products (fuelwood, honey, building materials, etc.) should be increased.	□	□	□	□	□	□
G.1.7. Shrimp fry collection decreases the number of fish available for fishers to capture.	□	□	□	□	□	□
G.1.8. I am concerned about the damage to the embankments caused by shrimp fry collectors.	□	□	□	□	□	□

H. HOUSEHOLD AWARENESS/PARTICIPATION/SOCIAL CAPITAL

I would like to ask you some questions about your village and your involvement in your village.

H.1. Most communities have a number of clubs or societies. How many voluntary community groups, clubs or societies do you regularly participate in?_____
_____ **[GIVE EXAMPLES, E.G. SELF-HELP GROUPS, ETC.]**

[IF "NONE" GO TO H.3.]

H.2. Are you on a management or organising committee for any of these groups? Yes □
No □

H.3. Overall, how would you rate the performance of the groups in which you participate?
Very poor □ Poor □ Neutral □ Satisfactory □
Very satisfactory □

H.4. How many informal village events have you attended in the last 12 months?
_____ Events (e.g. traditional dances, jatra, cricket/soccer, village meetings, birth/marriage/funeral ceremonies, etc.).

H.5. Do you feel most people within the village can be trusted?
Almost no-one □ A few people □ Most people □ Almost everyone □

H.6. Have you attended any religious festivals in the last 12 months that required you to travel outside the village?
Yes □ How many have you attended _____ Religious festivals No □

H.7. When you travel outside the village, do you feel most people you encounter can be trusted?
Almost no-one □ A few people □ Most people □ Almost everyone □

H.8. Generally, do you participate in new community projects that are initiated in your village?
Never □ Rarely □ Sometimes □ Usually □ Always □

Appendix G: Letter of Cooperation

SUNDARBAN DEVELOPMENT BOARD
DEPARTMENT OF SUNDARBAN AFFAIRS
GOVERNMENT OF WEST BENGAL
Mayukh Bhavan (1st Floor), Bidhannagar
Kolkata-700 091
Phone : 2337-1102, 2337-1052, 2334-8195, 2337-4252 (Ph. & Fax)

Ref. No 391(2)/PA/SDB/2M-19/01(II) Dated .....

To

1. The Sabhapati,
   Namkhana/Patharpratima/Sagar/Kakdwip
   Panchayat Samity.

2. BLock Development Officer,
   Namkhana/Patharpratima/Sagar/Kakdwip

Sub: Assistance in providing information/data to the Investigating Team of Global Change Programme of Jadavpur University, Kolkata in connection with Project "Assessing Environmental Management Options in the Shrimp Mangrove System of Indian-Coastal Zone of Bay of Bengal."

Sir,

I am enclosing a copy of letter on the captioned subject which speaks for itself.

You are requested to extend necessary cooperation to the team in the interest of the research project.

Enclo: As stated.

Yours faithfully,

(D P Jana)
Member Secretary &
Project Director

Global Change Programme
Jadavpur University
Kolkata - 700 032, INDIA

Dated 27/01/2005

To,
The Director
Sundarbans Development Board.
Kolkata - 35,

Dear Sir,

As principal Investigator for the Project Entitled "Assessing Environmental Management Options in the Shrimp Mangrove System of Indian-Coastal zone of Bay of Bengal" which is in collaboration with Jadavpur University, Kolkata and Simon Fraser University, I would like request you to provide us with assistance in our field work. We would need support from the Block Development Officers (BDOs) to get a list of households in villages for Statistical sampling purposes. Our study area involves the Namkhana, Pathapratima, Sagar and the Kakdwip Blocks. All information shall be used for research purposes only.

Co-operation at the Panchayat level would be extremely helpful in this regard. A letter from your office would help us carry out research work more effectively.

Thanking You.

[redacted]

JOYASHREE ROY
Chief-Co. Investigator.

Yours Sincerely,

[redacted]

(DUNCAN KNOWLER)
Principal Investigator, SHARP

Appendix H: Sampling and Implementation Plan

In order to randomly sample households in each village, household lists for Chondinpiri North and Debnagar were generated by the respective Panchayat offices of Horipur and Namkhana (Table 21).

Table 21: Random sample

Panchayat/Village	Namkhana Block, 24 Parganas South	
	No. of households	Household sample size (15%)
Horipur/Chondinpiri North	829	124
Namkhana/Debnagar	1116	167
Total	1945	291

The targeted samples of fry collectors and shrimp farmers/potential shrimp farmers (approximately 100 households in total) augment the number of fry collectors and shrimp farmers/potential shrimp farmers captured by the random sample, which ensured sufficient stakeholder sample sizes for statistical analysis (Table 22). Households for these targeted samples were selected from the villages surveyed in Horipur and Namkhana Panchayats, subject to the presence of these targeted stakeholders in each village. However, households surveyed during the random sample were not selected for the targeted samples to avoid double counting. All randomly selected households for the random sample were eliminated from the list of possible households for the targeted samples.

Table 22: Targeted samples

Panchayat/Village	Namkhana Block, 24 Parganas South		
	Fry collectors	Shrimp farmers	Total
Horipur/Chondinpiri North	20	20	40
Namkhana/Debnagar	30	30	60
Total	50	50	100

To complete the random sample and targeted samples in the timeframe required, the workload was split into two teams, based on the following sampling implementation plan:

- team 1 comprised of 3 FI - this team was responsible for completing 102 targeted HSs of shrimp fry collectors and shrimp farmers/potential shrimp farmers. Each FI was required to complete 34 HS/CE;
- team 2 comprised of 7 FI - this team was responsible for completing 294 randomly selected HSs in Chondinpiri North and Debnagar. Each FI was required to complete 42 HS/CE.

A detailed breakdown of the sampling implementation plan for teams 1 and 2 is presented in this Appendix (Tables 23 – 25). The household numbers in each FI column for the random sample correspond to the numbers on the household list supplied by the Panchayat offices in Horipur and Namkhana Blocks. Each FI also has "extra" randomly selected households to choose from, in the event they are unable interview certain households from the original list.

Table 23: Targeted samples: Chondinpiri North and Debnagar (team 1)

	FI 1	FI 2	FI 3
CHONDINPIRI NORTH			
Fry Collectors	7	7	7
Shrimp farmers/potential shrimp farmers	7	7	7
Total Chondinpiri North	**14**	**14**	**14**
DEBNAGAR			
Fry Collectors	10	10	10
Shrimp farmers/potential shrimp farmers	10	10	10
Total Debnagar	**20**	**20**	**20**
GRAND TOTAL	**34**	**34**	**34**
Total no. of surveys	**102**		

Table 24: Random sample: Chondinpiri North (team 2)

Survey No.	HS No. - Fl 4	HS No. - Fl 5	HS No. - Fl 6	HS No. - Fl 7	HS No. - Fl 8	HS No. - Fl 9	HS No. - Fl 10
1	10	149	276	394	506	617	729
2	19	150	278	395	515	619	733
3	21	151	279	408	519	624	740
4	23	152	287	410	522	628	744
5	33	158	288	411	524	629	745
6	34	163	290	413	526	632	750
7	36	175	291	420	527	638	754
8	38	182	293	422	531	642	755
9	39	183	295	424	536	643	757
10	49	184	309	427	542	644	760
11	55	190	311	432	549	652	761
12	58	203	317	436	554	660	767
13	59	205	326	437	557	661	769
14	64	212	328	438	562	664	773
15	68	215	331	442	565	671	778
16	73	216	332	445	568	673	784
17	78	221	336	449	571	674	787
18	87	224	337	452	575	675	789
No. (contd)	Extras - Fl 4	Extras - Fl 5	Extras - Fl 6	Extras - Fl 7	Extras - Fl 8	Extras - Fl 9	Extras - Fl 10
19	89	225	342	455	587	681	790
20	93	229	344	462	588	685	791
21	99	235	350	467	593	686	795
22	100	236	357	469	595	687	797
23	102	243	359	473	596	690	801
24	111	249	360	474	601	702	802
25	112	256	364	475	602	708	804
26	116	259	375	476	603	718	815
27	135	261	382	480	607	720	817
28	136	262	383	483	609	722	823
29	142	267	384	494	613	723	824
30	145	270	387	504	616	724	829
Total no. of surveys		126					

Table 25: Random sample: Debnagar (team 2)

Survey No.	HS No. - Fl 4	HS No. - Fl 5	HS No. - Fl 6	HS No. - Fl 7	HS No. - Fl 8	HS No. - Fl 9	HS No. - Fl 10
1	3	173	337	465	649	797	992
2	8	181	340	478	656	799	1004
3	10	190	345	497	661	802	1005
4	11	191	346	499	663	805	1009
5	12	200	347	500	664	809	1015
6	16	203	348	502	672	810	1027
7	22	212	356	519	673	822	1032
8	34	216	357	522	675	823	1033
9	41	218	360	527	682	830	1034
10	47	224	361	541	690	844	1038
11	48	226	367	545	698	850	1048
12	52	227	371	548	699	851	1053
13	54	233	382	553	713	860	1055
14	57	235	384	557	715	862	1056
15	58	242	387	561	719	867	1057
16	78	243	391	568	720	873	1058
17	82	246	394	570	722	881	1064
18	84	247	405	578	726	883	1069
19	86	251	406	581	736	884	1073
20	88	252	407	584	743	892	1075
21	91	256	411	585	747	913	1078
22	102	257	419	592	749	918	1079
23	104	264	421	595	753	922	1080
24	113	289	423	598	757	924	1084
No. (contd)	Extras - Fl 4	Extras - Fl 5	Extras - Fl 6	Extras - Fl 7	Extras - Fl 8	Extras - Fl 9	Extras - Fl 10
25	114	297	427	600	761	931	1087
26	119	302	428	604	765	938	1088
27	120	305	436	609	766	942	1091
28	127	306	437	611	769	945	1093
29	133	310	444	613	774	947	1094
30	136	311	447	615	777	954	1098
31	145	312	448	619	778	955	1099
32	159	318	449	621	785	959	1101
33	160	327	458	622	788	966	1105
34	164	332	460	630	790	980	1111
35	167	334	464	633	794	984	1112
Total no. of surveys		168					

Appendix I: DCE Pre-test Results

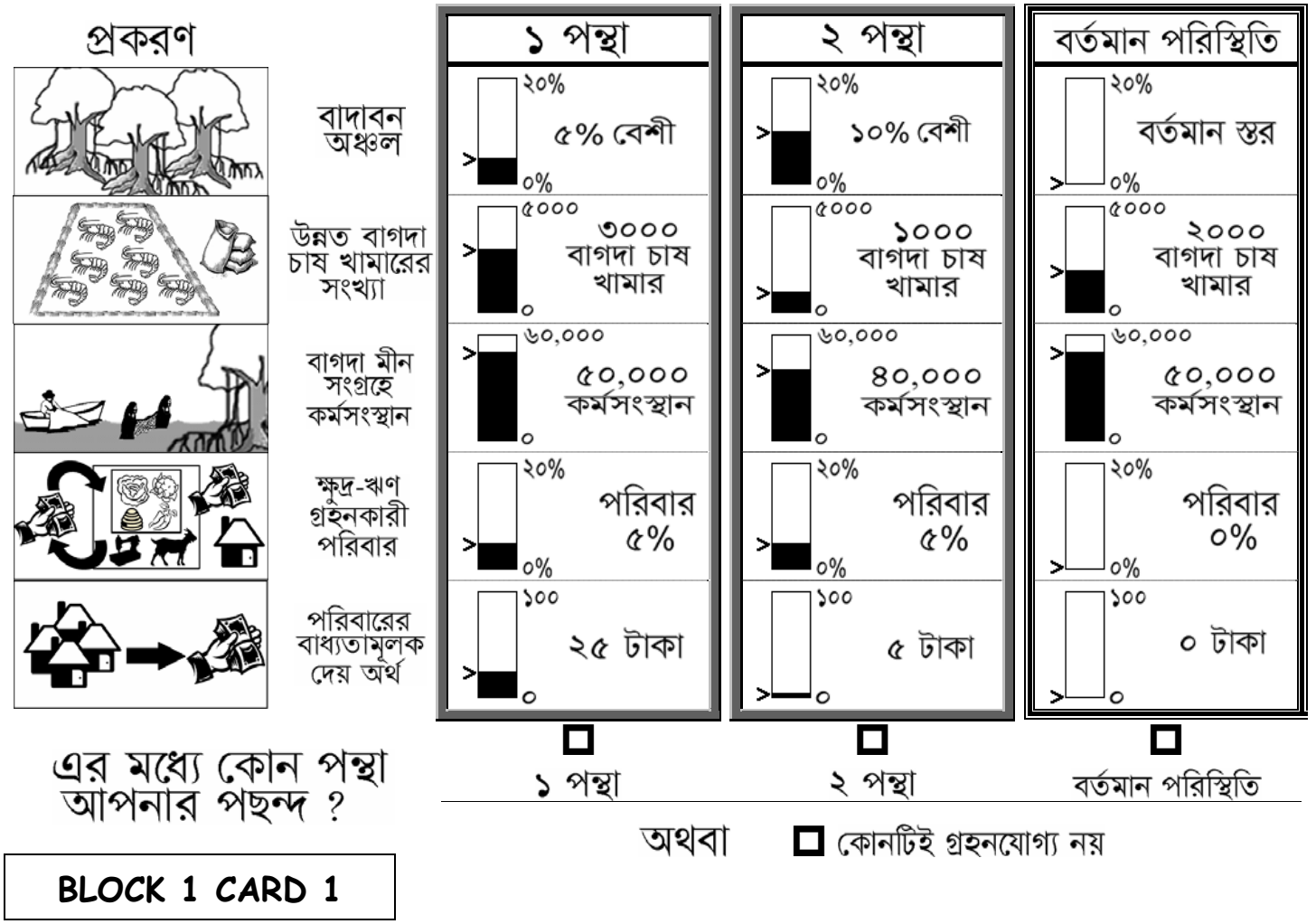
The five attributes used in the final pre-testing phase of the field research component of the project are presented below (Table 26). During this phase, eight HSs and DCEs were conducted in Namkhana Block. Respondents were asked to rank, in order of priority, the relative importance of each attribute in the DCE. Six out of the eight respondents completed the ranking exercise.

Table 26: Ranking of attributes in the DCE (pre-test phase)

	Mangrove coverage	No. improved shrimp farms	Employment in shrimp fry collection	Access to credit	Household contribution[a]
Respondent A	1	4	3	2	5 (Rs. 4)
Respondent B	1	2	5	3	4 (N/A)
Respondent C	N/A	N/A	N/A	N/A	N/A (N/A)
Respondent D	N/A	N/A	N/A	N/A	N/A (Rs. 50 – 100)
Respondent E	1	5	2	3	4 (Rs. 10)
Respondent F	1	2	4	3	5 (Rs. 25)
Respondent G	1	3	5	3	4 (Rs. 15)
Respondent H	2	1	5	3	4 (Rs. 100)
Mean ranking[b]	1.17 (0.74 – 1.60)	2.83 1.29 – 4.38)	4.00 (2.67 – 5.33)	2.67 (2.12 – 3.21)	4.33 (3.79 – 4.88)

Note: ranking based on 1 as highest rank and 5 as lowest rank.
[a] Figures in parentheses represent amount each respondent was willing to contribute towards a Sundarbans Fund, on behalf of the household.
[b] Figures in parentheses are the lower and upper bounds based on a 95% confidence interval for the mean. N=6 (2 non-responses).
Generated using SPSS (2004)

Appendix J: Sample of DCE choice card



BLOCK 1 CARD 1

Appendix K: Joint Mangrove Management Project

For more than 15 years, MSSRF has promoted the protection and restoration of mangrove forests along the coast of India. A very successful project is the Joint Mangrove Management project, which involves collaboration between State Forest Departments and local communities. It is supported by the India-Canada Environment Facility, and the Canadian International Development Agency (CIDA) (India-Canada Environment Facility (ICEF), 2005). This project focuses on science-based, community-centered, and process-oriented methods to restore and protect mangrove forests. MSSRF follows a three pronged strategy to achieve its JMM project goals: conserve and regenerate mangrove forests in the States of Tamil Nadu, Andhra Pradesh, Orissa, and West Bengal; boost participation of a diverse range of stakeholders in conservation projects and management decisions though education, training and policy support; and help in the identification and transfer of salt tolerant genes from mangrove species to other crops (M. S. Swaminathan Research Foundation (MSSRF), 2005).

JMM projects have regenerated 1,447 hectares of degraded mangrove forest areas, and over 12,000 hectares of mangrove forests have been protected by local communities in over 40 villages (India-Canada Environment Facility (ICEF), 2005). Over 6.3 million seedlings have been planted with survival rates between 75% - 80%. Many village level institutions have been created for JMM projects, and over 5,000 families are members of these institutions. 193 self-help groups have also been established to implement alternative income generating activities associated with JMM projects.

Appendix L: Regulatory Regimes and Economic Instruments

The rapid growth of shrimp aquaculture in Thailand has had many detrimental economic, social, and environmental impacts. In response, a number of regulatory and regimes and economic instruments have been proposed to deal with the impact of shrimp aquaculture:

- a fee on water discharged from ponds, and the establishment of an earmarked fund; a tax on shrimp exports; and charges on land-use outside of designated shrimp aquaculture zones (Patmasiriwat, 1997).
- differentiated price permits according to the stocking density of shrimp ponds, and the type of water system (Duraiappah & Israngkura, 1999). This approach allows a regulatory authority, the Coastal Aquaculture Authority in India's case, to limit the total number of farms within specified geographic boundaries, and to set the price of the permit based on farm management practices and soil characteristics (i.e. the price of the permit is based on location characteristics and technical properties). The permit system has two advantages over a tax regime: it addresses the environmental problems of pollution, and soil salinization on land converted to shrimp ponds and surrounding agricultural land; and it addresses the problem of uncontrolled expansion of shrimp farms through limits on the absolute number of farms in specified geographic areas (Anantanasuwong, 2000).
- a combination of economic instruments has also been proposed to mitigate the negative impacts of shrimp aquaculture, and to redirect the proceeds towards more sustainable development activities (AEA Technology *et al.*, 2001). These instruments include a permit fee with proceeds earmarked for information exchange and better

reporting between shrimp farm operators and regulatory authorities; scaled access charges to avoid damage to mangroves through enhanced decision-making regarding the location of shrimp farms; environmental performance bonds to limit the extent of abandonment of degraded shrimp farms; pollution charges on effluent discharged into waterways; fines for non-compliance of environmental and regulatory standards; and the establishment of a fund to improve shrimp aquaculture technology and rehabilitate damage caused by shrimp farming.

Appendix M: Mass Awareness Campaign

The mass awareness campaign is targeted primarily at fry collectors and other marginalized groups, and it focuses on achieving six specific objectives (Sarkar & Bhattacharya, 2003: 263-264):

- more precise recognition of the environmental components of the dynamic ecosystem in the Indian Sundarbans;
- a better understanding of the linkages between environmental components and changing stock patterns;
- establishment of alternative livelihood generating programs based on eco-friendly activities. These programs are to be established in such a way that marginalized households are not further impoverished;
- motivate natural resource users to embrace conservation of natural resources;
- identify breeding "hotspots" for tiger prawn, and enact laws to prohibit exploitation of these broods;
- establish a monitoring program to help improve the overall health of coastal waters in the Indian Sundarbans.