

Doctoral Thesis

Mangrove forest management and its influence on forest-dependent communities: A case study in the Sundarbans Mangrove Forest World Heritage and Ramsar Site, Bangladesh

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Dissertation

Management von Mangrovenwäldern und dessen Einfluss auf lokale, forstabhängige gemeinden: Eine Fallstudie der Sundarbans Mangrovenwäldern (Welterbe und Ramsar-Gebiet), Bangladesh

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I herewith declare that I am the sole author of the current thesis and that I have conducted all works connected with the thesis of my own. Furthermore, I declare that I only used those resources that are referenced in the work. All formulations and concepts taken from printed, verbal or online sources – be they word-for-word quotations or corresponding in their meaning – are quoted according to the rules of good scientific conduct and are indicated by footnotes, in the text or other forms of detailed references.

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Vienna, 23 October 2017

Signature:

DEDICATION

This thesis is dedicated to my beloved Parents Sekander Ali and Monowara Begum.
They always take care of my higher studies and research work

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Keywords

Buffer Area, Core Area, Forest Management, Forest Patrolling, Governance, Harvesters, Harvesting, Mangrove, Non-timber forest products, Pirate, Revenue, Royalty.

Abstract

The livelihoods of the majority of the inhabitants of the Sundarbans Mangrove Forest are directly dependent on its natural resources. Non-timber forest products such as fish are a major source of income for these communities and a major source of revenue for the Sundarbans Forest Department. The Department is responsible for the management of the forest, including the harvesting of non-timber forest products and associated revenue collection, and controlling illegal harvesting and the activities of pirates which are increasingly extorting financial gains from the area's fishermen.

This research project explores the current management system of the Sundarbans Mangrove Forest and the impacts on the area's fishermen communities. Under the current forest management system, a fishing ban has been imposed over the core area of the Sundarbans. As a result, approximately 40% of this area's former fishermen are now unemployed and approximately 50% have had to obtain other labor-based employment. The fishermen's previous average annual income from fishing in the core area was approximately EUR 2,625 but this has now fallen to approximately EUR 511. The affected fishermen community and the core area of the Sundarbans subject to the fishing ban have been mapped. The fishing ban areas cover 24 rivers and 4 islands. Identification of these fishing ban areas has been based on the fishermen's indigenous knowledge and past fishing experience in the core area. At present, the fishermen community is facing numerous challenges to their livelihoods. The fishing ban has strained local businesses and resulted in a loss of foreign income to the region. This has affected many fishermen's ability to provide for their children's education and is also adversely impacting the community's religious and other traditional customs.

The research also explores the critical issues that the current forest management raises for the buffer area's fishermen in the Sundarbans Mangrove Forest. These fishermen are in an economically disadvantaged position due to the high costs of unofficial extra royalty payments to the forest revenue collectors, and additional illegal payments that must be made to both the forest patrols and pirates. The Forest Department collects extra unofficial revenue from the buffer area's fishermen that amounts to approximately

EUR 320,349 (EUR 29,916 for BLCs plus EUR 290,433 for royalties) per annum. The forest patrols are also extorting approximately EUR 2.3 million each year in illegal payments from the fishermen, while pirates also receive approximately EUR 2,318 per fisherman each year. The total annual amount illegally obtained from the fishermen by the pirates and forest patrols is approximately EUR 25.61 million. This is approximately 21 times higher than the current annual budget for the Sundarbans Mangrove Forest (Sundarbans Forest, West Division) and approximately 427 times higher than the annual legal revenue collected from the fishermen by the Forest Department. This situation is a major issue in the current management of the Sundarbans Mangrove Forest that is impacting on the livelihoods of the buffer area's fishermen.

The research recommends numerous potential solutions to the problems occurring in the current management of the Sundarbans Mangrove Forest. These include modifying the forest patrols and revenue collection systems to ensure that monitoring and protection activities are more effective and transparent.

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List of Abbreviations

ACF	Assistant Conservator of Forest
BLC	Boat License Certificate
DFO	Divisional Forest Officer
GPS	Global Positioning System
ICTs	Information and Communication Technologies
UNDP	United Nations Development Programme

1 CHAPTER I – INTRODUCTION

1.1 Preface

Bangladesh is the most densely populated country in the world, with more than 1,015 people per km². The country's total population stands at approximately 160 million and its economy is based on agriculture and fisheries (MoEF, 2012; FAO, 2014). Over 75% of the population live in rural areas, and the livelihoods of these people are heavily dependent upon agriculture, fisheries and other forest resources (Akanda, 2005). Bangladesh has almost 11% forested land and only 5% of this is designated as protected areas (FAO, 1998, 2010). The Sundarbans Mangrove Forest is the largest protected area in Bangladesh, encompassing nearly 40% of the country's forested area (DoE, 2015). The Sundarbans is managed by the government as a forest reserve, and it is recognized both as a Ramsar Site and a UNESCO World Heritage Site. The Sundarbans ecosystem supports the livelihoods of about 3.5 million people living in coastal communities who rely on the great variety of fish that the forest provides (Roy, 2009; Roy et al., 2012). The Sundarbans also contributes around 41% of the total revenue obtained from forest management in Bangladesh, generating employment and income opportunities for around 150,000 households (ADB, 1996). Moreover, the average annual revenue obtained from the Sundarbans Mangrove Forest for all types of provisioning services was approximately US\$ 744,000 during each of the financial years between 2001-2002 and 2009-2010 (Uddin et al., 2013).

In many countries, local communities are often excluded from designated protected areas and this can lead to substantial adverse social and ecological impacts. In many cases, the designation of protected areas leads to local communities being displaced from their settlements without alternative work and income. In other cases, the local communities face restrictions on the use of common property resources that were previously available to them for their livelihoods, such as through grazing, fishing or hunting (Pimbert and Pretty, 1995). The participation of affected local communities in the design, establishment and management of protected areas is therefore vital,

particularly to ensure there is a fair and equitable sharing of the benefits among these stakeholders (Lausche, 2011).

In the Sundarbans Mangrove Forest, the Forest Department is responsible for implementing the resource management system. However, this system is very old, being established in 1869 prior to the Sundarbans' declaration as a forest reserve in 1875-76. The Forest Department manages the Sundarbans Forest via a top-down approach where there is an absence of local community involvement in resource management decision-making. This results in the neglect of customary rights and a lack of integration of traditional knowledge regarding forest resource conservation (Tamang, 1994; Hussain, 1994; Roy and Alam, 2012). Such a top-down management approach for protected areas can create social disruption and vulnerabilities in people's livelihoods which in turn affects the cultural heritage of the local community such as through reduced access to traditional resources and rights (Torri, 2011).

Protected areas should play a vital role in the sustainable development and economic well-being of the surrounding local communities. It is important too to receive positive socio-economic feedback from protected areas in establishing proper community rights (McNeely, 2008). However, it is necessary to ensure that a protected area can provide continuing ecological outcomes through community participation (Ezebilo and Mattsson, 2010).

In protected area management, there are seven principles that should bring about good governance. These are legitimacy, transparency, accountability, inclusiveness, fairness, connectivity and resilience (Lockwood, 2010). Hockings et al. (2006) identifies effective governance as a pre-condition for effective management. Moreover, weak governance tends to create ineffective bureaucracies, corruption and inefficient conservation outcomes (McCreless et al., 2013).

1.2 Rationale

Sundarbans is not only a forest but is also represented as a wetland. It is declared as a Ramsar Site which follows an international treaty for the conservation and sustainable use of wetlands. Therefore, the Ramsar Convention's mission provides that the area be used wisely such as a tool for poverty alleviation. Sundarbans is the world largest mangrove forest which provides a variety of ecosystem services. These services can economically benefit coastal and mangrove communities such as in employment opportunities, sources of income, poverty reduction, and social well-being through sustainable management of its resources. The current management of the Sundarbans however is not reflecting this position.

Three (3) pillars — environmental, economic, and social — should be considered to ensure the sustainable management of resources. The existing rules and regulations of the Sundarbans Mangrove Forest prohibit the extraction or harvesting of any kind of forest timber for any purpose, even for economic and commercial purposes. Only non-timber forest products such as fish, honey, and palm leaf are allowed to be harvested for the purpose of revenue collection and to benefit the local community in terms of income. The current Sundarbans Forest Management approach discourages fish harvesting to minimize over-harvesting, illegal tree felling, wildlife poaching, and to protect the forest ecosystem. In this respect, the Sundarbans Forest Department is unable to collect potential revenues from fish harvesting. Unfortunately, this position of discouraging fish harvesting has created an economic and social vulnerability base in the Sundarbans Mangrove Forest and also makes it challenging for the local communities' livelihood, especially in being able to produce income. For the purposes of Sundarbans' forest protection, it is important to ensure the transparency and effectiveness in forest management, governing, and monitoring systems. The approach of discouraging fish harvesting is not the solution for forest protection. It should instead seek to innovate its management approach and establish an equitable and effective monitoring system in governing areas where fishermen can harvest fish as well as run their fish base for economic activities, simultaneously protecting forest resources.

Against this background, the rationale behind this study was to explore the present management and governing system and how it impacts the fishermen in the Sundarbans Mangrove Forest. The major aim was to identify the weaknesses in the present forest protection monitoring and fishing revenue system and suggest ways to improve it.

1.3 Research problems and questions

In the research field surveyed, the following scenarios have been ascertained occurring in the Sundarbans Mangrove Forest. They are as follows:

- Fish harvesting is banned in the core area
- Fishermen are facing unemployment and lacking income
- Fishermen currently have no permission to use engine boats for fishing

The problems identified are the following:

The Forest Department lacks interest in fish harvesting in the Sundarbans Mangrove Forest because fish harvesting is not profitable and creates illegal tree felling, wildlife poaching, and overfishing.

It is hypothesized that some of the problems existing in the current management are creating a barrier in benefiting from fish harvesting and are also unable to protect illegal tree felling, wildlife poaching, and overfishing and harvesting.

The questions raised in this research are the following:

- What are the socioeconomic effects of fishing on the fishermen and their incomes?
- How much revenue of the Forest Department stems from fishing and what is the scope of increasing this revenue?
- What is the outlook of the present forest administrative structure and its functions for the forest and in the management of fish harvesting?

- What does the present system use in patrolling the area and what equipment is being utilized for patrols and monitoring of forest activities?
- Are there any limitations in forest monitoring and the system of revenue collection? What is the current relationship between the fishermen and the Forest Department?

1.4 Objectives of the study

General objective

The general objective of this study is to assess the current forest management and governance system influencing the forest-dependent communities.

Specific objectives

To present the current governance structure that is managing the Sundarbans Mangrove Forest

To explore the current Sundarbans Mangrove Forest management practices

To identify the existing problems in the current management practices

To find the social and economic impact on the forest-dependent communities in the current management system

To analyze the economic benefits from the current fish harvesting management

To recommend a potential management system for Sundarbans

1.5 Limitations of the study

There is a lack of funding in arranging field surveys, transportation, and accommodation costs

A poor transportation system and a remote area in terms of having good travel routes to reach areas as well as difficulties in conducting research and fieldwork for longer periods of time

During a past field survey work conducted in one of the local areas, a local government election campaign was being held; therefore, the people of the local communities were unavailable to be reached in their homes.

2 CHAPTER II - LITERATURE REVIEW

2.1 Importance of mangrove forest

Mangrove forests are increasingly renowned as a vital ecosystem in sustaining the livelihoods of the communities in around the mangrove forest. Mangrove ecosystem can identify as a vast productive area of flora and fauna, unique ecosystem, and important from social, economic and ecological points of view (Spalding et al., 2010).

The mangrove forest supports various fisheries which are dominated by many species of fish, crabs, crustaceans and mollusks. Globally, it is estimated that nearly 80% of fish harvests are directly or indirectly dependent on mangrove and other coastal ecosystems (Kjerfve and Macintosh, 1997). In addition, many indigenous coastal communities' food security is associated with the condition of the mangrove ecosystem (Horwitz et al., 2012).

About 10 million people in tropical and subtropical regions of the world depend on mangrove forests for various timber and non-timber forest products including like medicines, livestock feed and honey. Mangrove forests play a vital role in direct and essential connection between life in the ocean and life on land. Mangroves provide a source of income for the local communities, and perform significant protective functions; absorbing the energy from waves and wind, while also regulating coastal water quality (Gasana and Borobia, 2004).

Mangroves contribute to stabilizing shorelines and reducing the devastating impact of natural calamities such as cyclones and tsunamis. Mangrove forest also provide breeding and nursing grounds for aquatic and pelagic species, and a source of food, fuel and building materials for mangrove communities (Giri et al., 2010).

2.2 Governance of protected areas

Graham et al. (2003, p. 2-3) defined governance as “the interaction among structures, processes and traditions that determine how power and responsibilities are exercised, how decisions are taken, and how citizens or other stakeholders have their say”. Governance is the institution and practice used by stakeholders to create and influence decisions and to exercise authority and responsibility over people (Wilson, 2002). Governance is emerging as a vital element in protected areas management. It involves key parties such as the government, the private sector, and civil society who must ultimately decide who makes and prepares decisions and how they will be implemented through management (Graham et al., 2003). Effective governance for managing protected areas calls for a precise application of principles in legitimacy and voice, direction, performance, accountability, and fairness and rights. Good governance is vital for the successful management of all protected areas across the globe (Borrini-Feyerabend and Hill, 2015). The major function of governance of protected areas is to construct and maintain an environment requiring efficient management (Abrams et al., 2003). However, corruption remains a challenging issue for effective governance. For establishing effective accountability, therefore, it is vital to find ways to minimize corruption (Graham et al., 2003). The quality of governance is associated with the degree in which a protected area meets conservation objectives, contributes to the community’s well-being, and achieves economic, social and environmental goals (Balloffet and Martin, 2007). Smith et al. (2003) illustrates this strong relationship between the quality of governance and the quality of biodiversity conservation.

When the following criteria of the United Nations Development Programme (UNDP) are successfully implemented in a protected areas’ management system, effective governance can be achieved (Graham et al., 2003). The specific criteria are: public participation (all should have a voice in the decision-making process); strategic vision (looking constructively towards the future with consideration of the social, historical, and cultural complication of each condition); consensus orientation (ability to mediate differing interests to reach a broad consensus on what is in the best interest of the

group); responsiveness (when institutions and processes try to serve all stakeholders); effectiveness (ability to realize organizational objectives); efficiency (best use of resources or the potential of producing an effective amount of output using the lowest amount of input); accountability (officials answer to stakeholders on the disposal of their powers and duties, accepting criticism as well as responsibility for failure, incompetence, or deceit and acting on requirements made of them); transparency (sharing and disclosing information and acting in an open approach); equity (just treatment, requiring that similar cases be treated in similar ways); and rule of law (the legal framework of being fair and enforcing impartially) (UNDP, 1997; cf. e.g. Eagles et al., 2011).

2.3 Property rights

Property rights can be defined as the right to use a resource (Alchian and Demsetz, 1973), i.e. how to use a resource which is not necessarily owned by the use (e.g. use rights, ownership, limitations of use). Essentially, when it comes to common pool resources, there are two types of rights that govern; customary rights and legal rights. An individual holds that there are needs or rules that authorize a particular action to be taken in regards to applying a property right. Access is often defined as a property right, but it differs in conditions. Access has been expressed as the right to enter and use common pool resources such as forests (Schlager and Ostrom, 1992) however, Ribot and Peluso (2003,) define it as the ability to receive a benefit from a resource and regard that property right as the right of benefitting from such a resource. According to Bromley (1967), property rights as an instructional arrangement of formation and informal for access and control over the resources and benefits generated thereby. Allen (1991) refers to property rights having to be defined, their use having to be monitored, and the possession of rights having to be enforced.

There are four categories of property rights; namely state property, private property, communal property, and open access (Feeny et al., 1990). Under state property, ownership of resources is managed and controlled by the State. In private property ownership, an individual or a corporation has the privilege of property rights (Bromley,

1991). In a communal or common property right ownership, a specific group of users hold the right and duties of access to the resources (Ostrom, 1986; Bromley, 1991). Finally, in an open access ownership, access is unregulated and open to anyone with undefined property rights related to the resources involved (Feeny et al., 1990).

Property rights play a significant role in the sustainable use of resources and enhance protection of these resources including the conveying of rights (Lyons, 1998; Anderson et al., 2013). Schlager and Ostrom (1992) suggest that in community-based natural resource management, there are four legal rights held by resource users - how a resource can be utilized (e.g. cutting firewood), having the right to be managed (e.g. planting seedlings), having the right to be excluded (determining who else may use the resource), and having the right to be alienated (transferring user rights to others by inheritance, sale, or gift). These bundles of rights are related to geographical and social conditions that provide resource users rights to enter and use such resources. There are also rights in entering, extracting, as well as managing resources when it comes to authorized users; although the right to enter, withdraw, and manage resources is granted by the owners. Owners have a full right to allow one to enter, use, and manage such resources as well as exclude non-members or others from having access to such a resource. An owner also has the right to sell the rights of the resource (Schlager and Ostrom, 1992).

A government can assert the ownership of various natural resources based on the idea that the resource is vital to the country, and the management of that resource has significant environmental and economic implications (Meinzen-Dick and Knox, 2001). However, in many cases, especially in developing countries, the inability or lack of capacity to enforce state property rights as well as regulate resource management has led to an open access of public property which causes over-extraction and depletion of resources (Agrawal and Ostrom, 2001). Many suggestions have been conveyed as to how to overcome specific problems related to property rights such as using certain rights or in regulating long-term tenancy with user groups (Hanna, 1996; Jaramillo and Kelly, 1997). Demsetz (1997) identifies three universal principles, those being:

universality (all scarce resources are owned by someone); exclusivity (property rights are exclusive rights); and transferability (ensuring that resources can be allocated from low to high-yield uses). These principles are significant for the efficiency of property rights.

Efficiency in marine resources allocation occurs when rights of access are allocated so that use provides the maximum value to the community. Resource allocations have a temporal element, in that the amount of resources harvested in any particular period will influence the amount available in the future (FAO, 2000).

2.4 Protected areas management

In protected areas management, it is significant to include sustainable environmental management practices. The protected areas' manager should be able to successfully represent the environmental issues involved, be a leader, and be accountable to all stakeholders. The manager will be accountable for resource utilization and responsible for conservation. All types of protected areas organizations should incorporate the importance of sustainability in their policies as well as the planning and monitoring systems involved in achieving this goal. Moreover, the manager's major functions are to conserve the protected area's biodiversity and cultural heritage values (Graeme et al., 2005). The sustainable management of protected areas needs to simultaneously highlight issues on minimizing greenhouse gas emissions, waste production, and water and energy consumption, as well as maximizing benefits to resource users. It is important that the protected areas manager follows the international environmental treaties, policies, rules, and vision in the management of protected areas (Graeme et al., 2005, p. 270).

The protected areas manager realizes the importance of communities when managing protected areas and also that stakeholders can play a significant role in the management of these protected areas. This combined effort of stakeholders and local communities can bring great benefits to a protected area. These benefits can include the activities of fishing, hunting, grazing, and reed harvesting (Alexander, 2008, p. 42).

A protected area organization essentially follows the policy framework which is based on the international sustainability principle as well as the national and local environmental legislation and policies. Therefore, a protected areas management system would incorporate corporate plans, regional plans, management plans, business plans, and individual operations plans (Graeme et al., 2005, p. 274).

A protected areas management can have wide implications in actively working in environmental planning and management while meeting the demands of individuals and/or organizations (Rydin, 2003). In addition, the protected areas management it is important to maintenance the activities of partnerships and co-management based work, involving various stakeholders in the management process (Ostorm, 1990; Reeve et al.,2004).

Communities can receive direct benefits from the management of protected areas. Management can, however, be too restrictive in accessing resources and changing the local power structure, social values, and/or behaviors. If that is the case and management strategies are not specific to protected areas and are lacking community involvement due to such a restrictive management structure, this can ultimately create livelihood impacts and conflict between local communities and the managers of protected areas (Coad et al., 2008, p. 31).

A carefully managed protected area can improve the welfare of residents in reducing poverty, increasing developmental benefits to marginalized communities, and conserve biodiversity (WWF, 2008). However, protecting areas of forest can also have disadvantages to communities such as increasing poverty and marginalization, dislocation of communities, and other livelihood impacts (Pimbert and Pretty, 1995).

2.5 Community participation in protected areas management

In recent years, the concept of community participation has emerged as a vital element in policy-making and political philosophy. This participation approach has led to improved relations between different levels of government and between the state and civil society, non-governmental organizations and local communities. Unfortunately, the current management in developing countries still tends to approach forest resource management in the same way that it was introduced by the colonial governments (Burns et al., 1994). Marinoff (1997) suggests that political consciousness is created by decentralization of power to communities which may help in implementing participatory policies involving communities. A participatory approach can develop democracy among communities and generate empowerment in allowing decision-making to all involved (Appelstrand, 2002; Stave, 2002). Maskey et al. (2006) argues that benefiting from common forest resources is determined by the user by the level of participation in forest management activities. Lingani (2011) suggests that the securing of forest user's rights and their being empowered could actually enhance the outcomes of the forest management program. Wainwright and Wehrmeyer (1998) identify local residents' participation as being vital when it comes to community-based conservation. This participatory approach permits communities to regain control over resource management, increase improvement in development activities, and strengthen the decision-making process.

Participation should incorporate all implementation stages of the conservation project including information gathering, decision-making, consulting, initiating action, and its evolution. In conservation planning, a bottom-up participatory approach provides a voice for the communities' which is in contrast to the traditional top-down approach (Wells and Brandon, 1993).

In many cases of protecting nature, the enthusiasm for community-based conservation is underestimated. In creating a successful community-based conservation program, the decentralization of resource management from the central authority to the local communities should be considered. Community-based conservation acts as an important tool in promoting active participation in a conservation program (Hackel,

1999). Although participation in such a program can be diverse in structure, decentralization involving duties toward natural resources should be extended to local residents (Lundy, 1999). Improving the quality of environmental decisions and local plans for ecological management can be ensured through stakeholder participation (Reed, 2008; Brody, 2003). Capacity building and social investment are also necessary in participatory forest management initiatives that are successful in protecting forest resources (Coad et al., 2008, p. 32).

2.6 Background to the establishment of the Sundarbans Mangrove Forest and the ban on fishing in this forest

In the 16th century, the Sundarbans Mangrove Forest was the property of the local King or Zamindar who imposed a levy on the extraction of wood from the forest. During the British period (c. 1700-1947), the proprietary right over the forest was assumed by the Crown. Forests began to be leased to Europeans in 1830. This resulted in the progressive conversion of forests into agricultural land. This practice continued until 1875. A number of prominent British foresters visited the Sundarbans between 1863 and 1874 and succeeded in raising awareness in the colonial administration about the value of the forest. Their recommendations resulted in the introduction of a set of guidelines that initiated the first conservation activities in the forest. (Government of Bangladesh, 2015)

Systematic management of the Sundarbans Mangrove Forest began in the 1860s after the establishment of a Forest Department in Bengal. In 1875-76, the Sundarbans was declared a Reserved Forest under the Forest Act 1865, and in 1879 its management was transferred from the civil district administration to the newly created Forest Management Division which was headquartered at Khulna. (IRG, 2010b). In 1992, the Sundarbans Mangrove Forest was declared the world's 560th Ramsar Wetlands site (Islam and Gnauck, 2009). The UNESCO World Heritage Committee inscribed the Sundarbans of Bangladesh in the World Heritage list in their 21st session in 1997 and

accordingly, the Government of the People's Republic of Bangladesh declared the Sundarbans Mangrove Forest a World Heritage Site in 1999 (Awal, 2014).

In order to conserve the wildlife and biodiversity of the Sundarbans Mangrove Forest, in 1977 the Government of Bangladesh established three Wildlife Sanctuaries (i.e. Sundarban East, Sundarban South and Sundarban West) under the Bangladesh Wildlife Act 1974 (IUCN, 2014). Notified areas within these Wildlife Sanctuaries have particularly high biodiversity values and thereby constitute the core zones of the three gazetted Protected Areas (IRG, 2010b). According to the Bangladesh Wildlife Preservation Act 1974, since 1999 fishing in the three wildlife sanctuaries has been permanently prohibited (banned) (IUCN, 2014).

2.7 The current scenario of Sundarbans Mangrove Forest management

The Sundarbans Mangrove Forest is managed by three wildlife sanctuaries. In a wildlife sanctuary area, it is prohibited to hunt, shoot, or trap wild animals for the purpose of protecting wildlife and other natural resources (Roy and Alam, 2012). For almost 150 years, the Sundarbans Mangrove Forest has been managed by the Bangladesh Forest Department. This mangrove forest is administratively divided into two divisions, namely the Sundarbans West and East Divisions. Divisional Forest Officers are responsible for managing the forest, wildlife sanctuaries and fishery resources (Hussain, 2014). Moreover, the fishery resources of the Sundarbans are controlled by the Forest Department through an allotment of permits allowing fishing. Presently, the Forest Department has a limited capacity to control permit licenses and to monitor fish patterns to reduce over-harvesting and in preventing the harvesting of wild shrimp (Hoq, 2007).

At present, the integrity of the Sundarbans Mangrove Forest is rapidly deteriorating. Flora and fauna diversity and ecosystem functions have declined. Several forest policies and associated laws and management plans have been enacted to protect the forest; however, they have been poorly implemented (Iftekhar and Islam, 2004).

Rahman et al. (2010) identifies three main management failures that are affecting the Sundarbans Mangrove Forest and contributing to its decline. These failures are a lack of skill and training of officials; malfunction of institutions in effectively managing the mangrove resources, conflicting activities and poor planning; and the lack of information related to environmental protection of coastal land-use and its implementation incorporated into the development plan.

The local residents have identified substantial mangrove ecosystem degradation due to the malpractices and corruption of the Forest Department (Roy and Alam, 2012). The Forest Department has pursued various initiatives to conserve the mangrove ecosystem since 1960 to 2001 but has to date been unable to develop and successfully implement a logical management strategy (Islam and Wahab, 2005).

2.8 Fishery resources and fish harvesting in the Sundarbans Mangrove Forest

The Sundarbans Mangrove Forest ecosystem is significant both ecologically and economically as a breeding and nursery area of important fisheries (IRG, 2010a). The Sundarbans is the nursery ground for 90% of the region's commercial fish species and 35% of all the fish species found in the Bay of Bengal (Kamal, 1999). Chantarasri (1994) reported that about 200,000 fishermen were involved in fish harvesting in the Sundarbans Mangrove Forest in 1993, which was approximately 88% of the total population in the Sundarbans region.

The Sundarbans Mangrove Forest fishery harvests can be divided into two categories: inshore harvests and offshore harvests. In 2010 and 2011, approximately 22,000 metric tons (MT) of different varieties of fish were harvested from the Sundarbans Mangrove Forest. This amount was almost double the harvest between 2001 and 2007 (IPAC, 2010; DoF, 2012).

In the Sundarbans Mangrove Forest, fish harvesting is controlled by the Forest

Department. The Forest Department is also responsible for collecting revenues from the fishermen from their fishing activities (Hoq, 2007).

2.9 Wildlife sanctuary areas of the Sundarbans Mangrove Forest

For the purpose of protecting the wildlife habitats and natural resources of the Sundarbans Mangrove Forest, there are now three areas that have been declared as wildlife sanctuaries. These are the Sundarbans West (715 km²), Sundarbans South (370 km²), and Sundarbans East (312 km²) wildlife sanctuaries (Iftekhar and Islam, 2004). These three areas include core zones adjoining the Bay of Bengal where there is a total ban on fishing, while the other area of the Sundarbans is designated as the buffer zone (Figure 2.4).

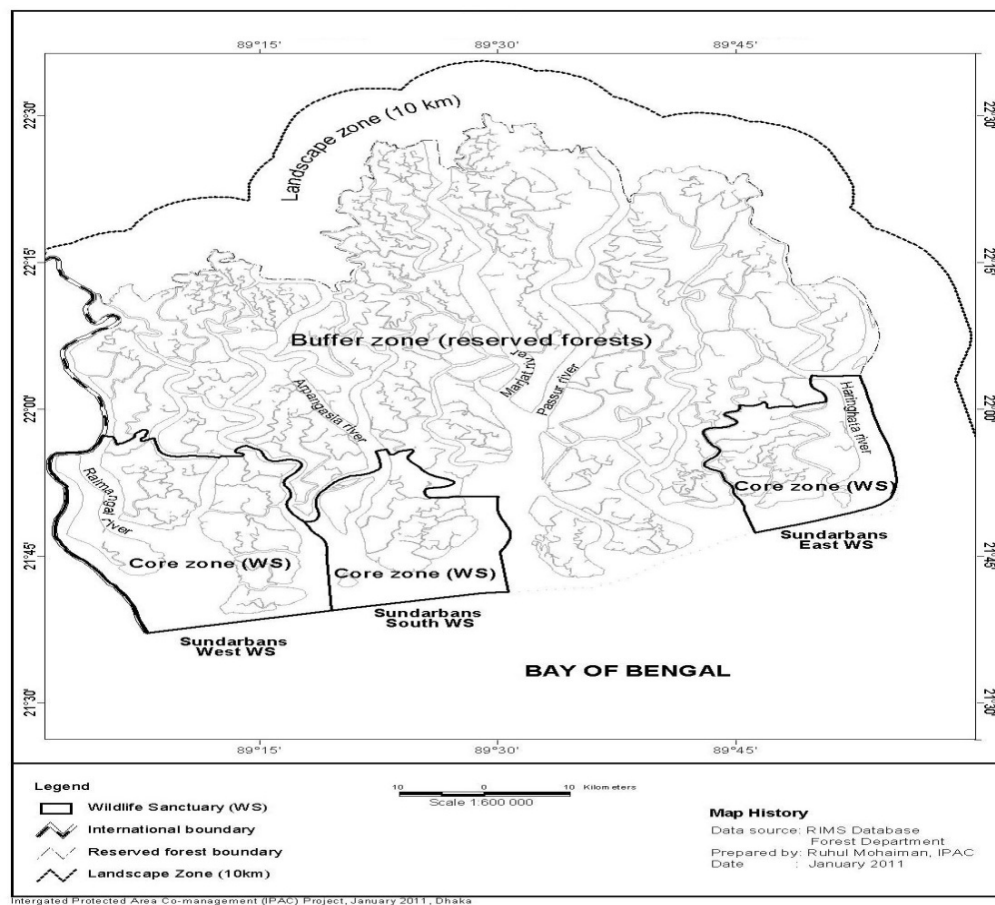


Figure 2.1: Core zones and buffer zones in the Sundarbans Mangrove Forest. (Source: IRG, 2010)

Fish harvesting is permitted in the Buffer Zone. However, fishing has been banned in about 18 canals within the Buffer zone. The Forest Department has proposed the establishment of another wildlife sanctuary in the Sundarbans Mangrove Forest where fishing will not be allowed (IRG, 2010b).

2.10 Information and Communications Technology (ICTs) uses for Improving governance and monitoring

The proper use of Information and Communications Technology (ICTs) can bring a positive result in reducing corruption and improving governance (World Bank, 2007)

Nsita (2010) reported it is proved that ICTs such as internet, mobile phone, and global positioning system (GPS) are playing an important role in promoting transparency and fair governance. Now a day is increasing the use of Information and Communications Technology among the government organization and civil society for improving the transparency and accountability of governance and reducing corruption (Wickberg, 2013).

The technology of drones can also be a helpful tool in managing the conservation of the forest. Various conservation organizations and protected areas authorities worldwide have raised interest in the usage of drones for the purpose of monitoring illegal hunting and poaching (Jaime et al., 2014). Government can therefore benefit from ICTs applications, greater stakeholders' involvement, and increasing transparency (Rametsteiner et al., 2005).

3 CHAPTER III - STUDY AREA

3.1 Location

The Sundarbans Mangrove Forest is located in the extreme south-west corner of Bangladesh between the Baleswar and Harinbhanga Rivers adjoining the Bay of Bengal. The forest is situated in the southern parts of Khulna, Bagerhat and Satkhira Civil Districts lying between latitudes $21^{\circ} 27' 30''$ and $22^{\circ} 30' 00''$ North, and longitudes $89^{\circ} 02' 00''$ and $90^{\circ} 00' 00''$ East. It is bounded in the north by private settlements, in the south by the Bay of Bengal, in the east by the Baleswar River, and in the west by the Harinbhanga, Raimongal and Kalindi Rivers which also form the international border with India. The forest covers 6,017 sq. km of which 4,143 sq. km is land and 1,874 sq. km is water comprising rivers and tidal waterways.

The study was conducted in the selected areas of Koyra in Khulna District and Shamnagar upazillas in Satkhira District (Figure 3.1). The selected areas are located within 5 km of the Sundarbans Mangrove Forest and are part of the Khulna and Shatkhira Forest Range. The Khulna and Satkhira districts are located 35 km and 70 km north, respectively, from the edge of the Sundarbans Mangrove Forest.

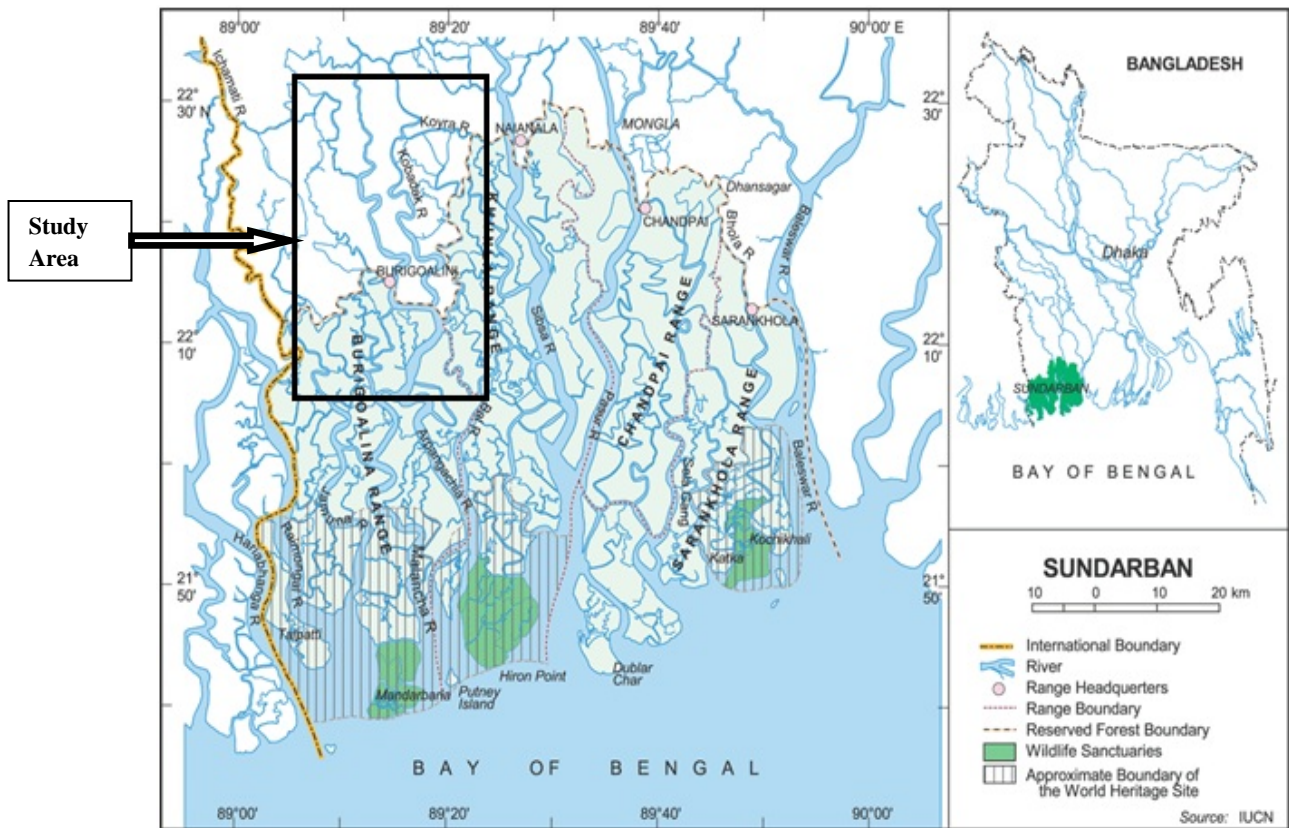


Figure: 3.1 Map of the study area. (Source: IUCN, 2014)

3.2 Climate

The Sundarbans is located south of the tropic of cancer and at the northern limits of the Bay of Bengal, and is categorized as moist tropical forest. The annual average rainfall ranges between 1600 and 2000 mm. The relative humidity is consistently around 80 percent. Temperature ranges from 7.7 C to 38.80 C throughout the year. The climate in the Sundarbans has a marked seasonality between a monsoonal summer and a cool winter. The monsoon season runs from June to September and brings heavy rains under the influence of south-west trade winds, with 75% of the region's annual precipitation occurring during this period. There are occasional thunder storms, cyclones and strong tidal surges during this season. The dry winter season is from November to April and brings infrequent rainfall under the influence of north and northeast winds and cool and sunny weather (IUCN, 2014)

3.3 River systems of the Sundarbans Mangrove Forest

The Sundarbans Mangrove Forest receives water from tributaries of the Padma, Meghna and Jamuna Rivers. The most prominent of these tributaries that pass through the Sundarbans include the Baleswar, Passur, Shibsa, Kobadak, Kholpetua and Kalindi Rivers (see Figure 3.2). These are large tidal rivers that together with their innumerable small channels and creeks all flow southwards into the Bay of Bengal. The total length of the rivers within the Sundarbans Mangrove Forest is approximately 12,000 km. This highlights the density of the Sundarbans' river network.

There is seasonal variation in the level of salinity in the Sundarbans' riversystems, which is inversely proportionate to freshwater supply. The major river systems are quite deep compared to the smaller tidal rivers. For instance, the average depth of the Passur River is about 15m. The rivers and canals are generally shallower in the Sundarbans' northern and southern parts compared to the central part. The duration of ebb tides in the tidal rivers is longer than that of the flood tides. Flows in the smaller cross channels obviously depend on the timing and magnitude of high water in the channels that they connect to.



Figure 3.2 : River systems of the Sundarbans Mangrove Forest. (Source: IUCN, 2014)

The Sundarbans' major river systems create four estuaries known as Bangra, Kunga, Malancha and Raimangal. The Raimangal River separates the district of the 24 Parganas in India from that of Satkhira District in Bangladesh and divides the Sundarbans' protected forests from its reserved forests. The Raimangal River has a length of 80 km from the Shaheb Khal to the Bay of Bengal. The eastern portion of the Sundarbans is flushed with water from the Ganges River and its tributaries. However, the waters in the western parts of the Sundarbans within Bangladesh territory resemble long arms of the sea rather than rivers as they are subject to strong tidal influences throughout their course. These waters also have much higher levels of salinity compared to the water bodies in the central and eastern parts of the Sundarbans. The Isamati River begins near Halderkahli and meanders over 80 km through the Satkhira forest. The river Arpangassia, formed by the merger of the Kalpatta and the Kobadaker Rivers near Burigoalini, flows southwards for approximately 64 km between the Satkhira forest and the forests of the Khulna Ranges. This river is also called the Barapunga in its lower reaches and is joined by the Malancha River just before reaching the sea. The Sibsa River originates at Deluti from the combination of a number of canals derived from the Kobodakin River to the west and the Bhadderin River to the east. The Sibsa River system is connected with the Arpangassia River by the Hansura and Batlagang Rivers and various other channels. The Bhadder River leaves the Kobadak at Jhikargacha near Jessore, enters the Sundarbans' reserved forest at the northern end of Sutarkhali and traverses another 40 km before merging with the Sibsa River. The Rupsa-Passur River flows through the middle part of the Sundarbans. This river originates from waters received from the Gorai River via the Nabaganga, Bhairab and Atrai Rivers. At approximately 146 km long, the Baleswar River system mainly receives its waters from the Padma-Arial Khan system and partly from the Gorai River. This major river flows along the eastern boundary of the Sundarbans. The freshwater flow from the Madhumati-Baleswar River system maintains a low salinity level in the eastern Sundarbans (IUCN, 2014).

3.4 Local communities of the Sundarbans Mangrove Forest

A large number of communities live in close proximity to the Sundarbans Mangrove Forest. These communities are located to the Sundarbans' north and east, in an area called the Sundarbans Impact Zone (SIZ). Within the SIZ, there is an estimated population of 3.5 million people. The livelihoods of most of these people are dependent, to varying degrees, upon their traditional uses of the Sundarbans' forest and fisheries resources (Hossain and Kabir, 2006).

4 CHAPTER IV – METHOD

4.1 Research design

Figure 4.1 depicts the research design. The use of questionnaires and semi-structured interviews allowed for the collection of data from a large and varied group of households. Following completion of the questionnaires and interviews, the collected data was processed, analyzed and interpreted.

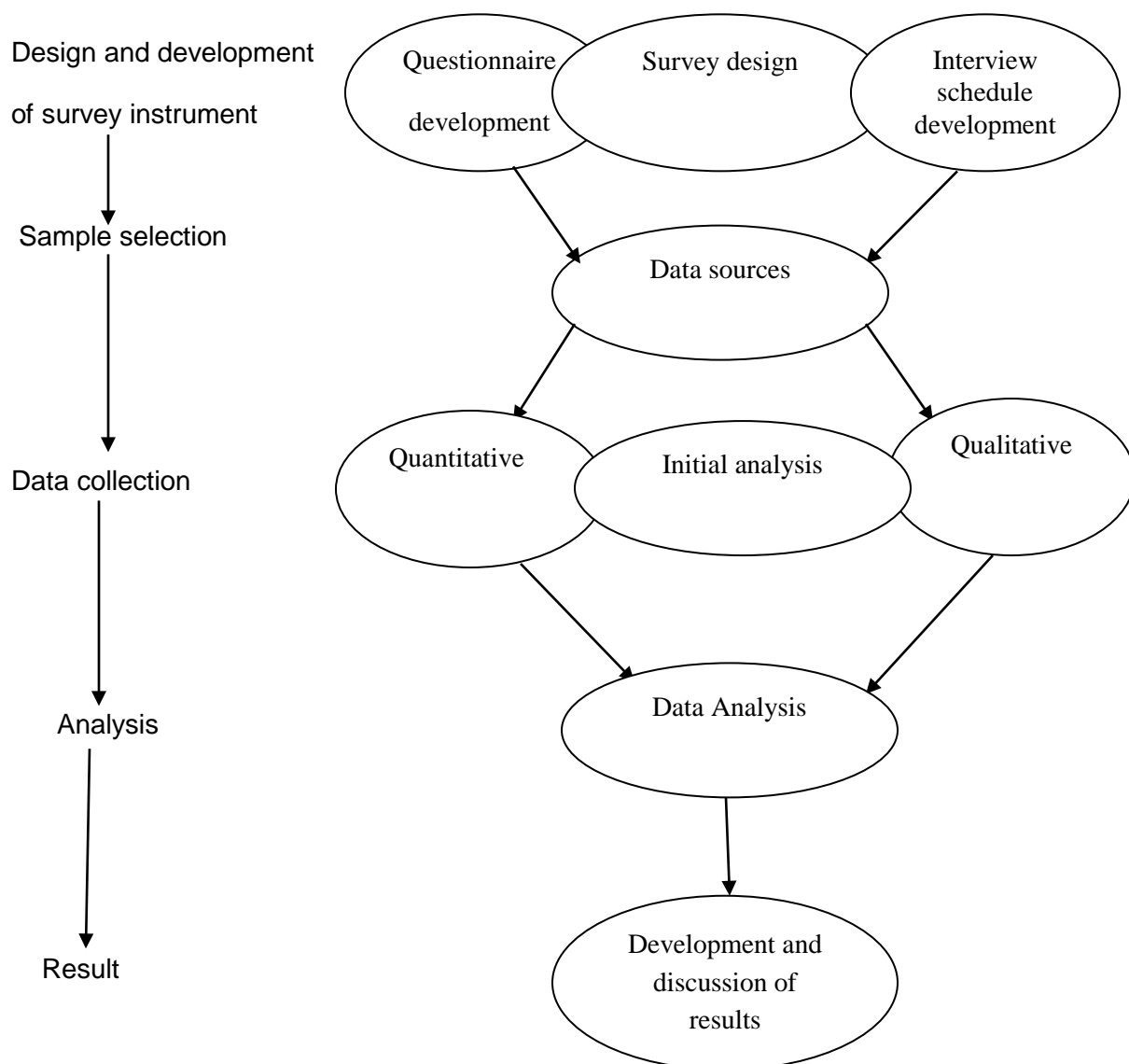


Figure 4.1: Summary of the research design.

4.2 Selection of villages

The selection of surveyed villages was based on their proximity to the core protected area (of the Sundarbans Mangrove Forest) and their dependency on Sundarbans' resources. The selected villages and their Unions are outlined in Table 4.1.

Table 4.1: Surveyed villages in Khulna and Satkhira Districts.

Study Area		Total Number of Household in the village	Sample Size (i.e. surveyed households)
Village	Union		
Pathor Khali	Uttar bathkashi	200	45
Boro Bari	Uttar bathkashi	220	35
Koyra No.4	Koyra	410	45
Koyra No.6	Koyra	240	40
Gobra	Koyra	190	40
Gata Khali	Koyra	200	35
Modinabad	Koyra	240	44
Munshiganj	Munshiganj	190	40
Chakla	Protab nagar	180	30
	Total	2,070	354

4.3 Data collection techniques

4.3.1 Reconnaissance survey

Prior to data collection, a reconnaissance survey was undertaken in the study area. This survey involved observations of and discussions with the local people to acquire some basic understanding and ideas about their mangrove forest management activities and to inform them of the study's objectives. The reconnaissance survey was therefore important for better understanding the existing environmental, socio-economic and cultural conditions of the study area and to inform the development of the questionnaire and interview schedule.

4.3.2 Questionnaire preparation and testing

A draft questionnaire was developed based on the study's objectives and information obtained from the reconnaissance survey. This questionnaire was pilot-tested in a fishing community at Gobra Village to ensure it was effective in obtaining the data necessary to fulfill the study's objectives. Amendments were made (including deleting some questions and adding others) before the final questionnaire was prepared.

4.3.3 Household questionnaire survey

The study's primary data was obtained through household surveys. Village households were randomly selected for participation in the survey. The surveys involved interviewing household members using the questionnaire as a guide to ensure all aspects of the study's objectives were addressed. Figures 4.2 and 4.3 show fisherman in two different villages (Munshiganj and Pathor Khali) participating in a household interview. A total of 354 households were surveyed. Direct questioning and different scales were used to obtain information about interviewee age, occupation, place of employment, amount of products harvested from the mangrove forest, revenue payments and income. Using the questionnaire as a guide ensured consistency in the data collection process for each household.



Figure 4.2: Household interview in Munshiganj Village.(Source: M. Shariful Islam, 2016)



Figure 4.3: Household interview in Pathor Khali Village. (Source: M. Shariful Islam, 2016)

4.3.4 Focus group discussions

Two focus group discussions were held with fishermen selected from the community. Each group discussion involved 10 people from 9 villages, and two of these focus group discussions were undertaken. The discussions used a semi-structured questionnaire as a guide and a checklist to ensure important topics were addressed. Figure 4.4 shows a

group of fishermen who participated in a focus group discussion. The aim of the discussions were to map the harvesting areas of the mangrove forest and to collect both quantitative and qualitative data about the amount of fish being harvested, revenue payments, other harvesting expenses, incomes and harvesting problems encountered by the fishermen.



Figure 4.4: Focus group interview with fishermen group. (Source: M. Shariful Islam, 2016)

4.3.5 Key informant interviews

Interviews were conducted with key informants from different administrative units of the Sundarbans Forest Department. For each key informant interview, a semi-structured questionnaire was used to guide the interview. The key informants included 2 Forest Rangers responsible for 2 different Forest Station offices under 2 different Sundarbans Forest Ranges (see figures 4.5 and 4.6), 2 Assistant Conservators of Forest, 2 Forest Guards and 1 Forester. The interviews sought to collect data about current forest management issues, administrative units, manpower for forest management activities, the revenue collection system, forest patrolling activities, non-timber forest product harvesting, and forest budget issues.



Figure 4.5: Interview a Forest Ranger at Kashiabad Forest Station.

(Source: M. Shariful Islam, 2016)



Figure 4.6: Interview a Forest Ranger at Burigoalini Forest Station.

(Source: M. Shariful Islam, 2016)

4.3.6 Direct observations

The field-based observations involved systematically walking through the villages with the study's interviewees and other informants including forest resource harvesters while observing their activities, asking questions, and seeking solutions to the problems they faced. These direct observations were therefore a very useful method for understanding the actual conditions on the ground.

4.3.7 Secondary data collection

Secondary data used for the study included relevant papers and reports obtained from international journals and internet searching, and statistical information, reports and maps collected from various Government departments and non-government organizations (NGOs). These sources included the Department of Forest (DoF) at Dhaka, the Sundarbans Forest Division office at Khulna and Seminar library of Urban and Rural Planning Discipline.

4.4 Data processing and analysis

The collected data was processed, analyzed and interpreted to generate the study's results. All of the collected data was firstly transferred to a master sheet to facilitate tabulation. The data was analyzed and interpreted results presented using tabular and graphical summaries. The final report has been systematically prepared using the MS Word and MS Excel programs.

5 CHAPTER V - RESULTS

5.1 Household Respondents

A total of 354 household interviews were conducted in 9 villages located within the Sundarbans Mangrove Forest (Table 5.1). The survey found there were two types of fishermen households– core area harvesting fishermen household and buffer area harvesting fishermen household. The total number of respondents in the core area harvesting fishermen household was 125.

Table 5.1: Details of the household respondents in the surveyed villages.

Villages	Household respondents					
	Respondents (Households of core area harvesting Fishermen)			Respondents (Households of buffer area harvesting Fishermen)		
	Male	Female	Total	Male	Female	Total
Pathor Khali	7	4	11	32	2	34
Boro Bari	3	2	5	29	1	30
Koyra No.4	5	5	10	34	1	35
Koyra No.6	5	3	8	30	2	32
Gobra	20	14	34	6	0	6
Gata Khali	10	4	14	19	2	21
Modinabad	4	3	7	36	1	37
Munshiganj	9	3	12	28	0	28
Chakla	15	9	24	6	0	6
Total	78	47	125	220	9	229
Percentages of core and buffer area harvesting hudehold	35.3%			64.7%		

Source: Field Survey, 2016

Among these, the male and female respondents were 78 and 47, respectively. On the other hand, the buffer area harvesting fishermen household respondents numbered at 229.. The male and female respondents were 220 and 9, respectively. Approximately 35% of the surveyed fishermen households were core area fishermen while approximately 65% were buffer area fishermen.

The majority (i.e. 55%) of the respondents were less than 45 years of age, while most (i.e. 35%) were aged 35-44 and 30% were aged between 45 and 54 (Table 5.2). Only 3% were older than 65.

Table 5.2: Age of household respondents.

Age of Household Respondents (year)				
25-34	35-44	45-54	55-64	65-74
20%	35%	30%	12%	3%

Source: Field Survey 2016

5.2 Impacts of the fishing ban on the fishermen communities in the core area of the Sundarbans Mangrove Forest

5.2.1 Past and present fish harvesting permission scenarios

Before 1996, the communities of the Sundarbans Mangrove Forest had rights of access to the core and buffer areas for fish harvesting and for generating income through fishing. At that time, fishermen were permitted to use boats both with and without engines for harvesting and transporting fish. The Sundarbans Forest Department was responsible for granting entrance permits and Boat License Certificates (BLCs) that allowed fishermen to harvest fish in both the buffer and core areas. The BLCs were able to be renewed each year. The fishermen were allowed to harvest fish in both the core and buffer areas throughout all 12 months of the year. Each fisherman's boat received 4 entrance permits a month, with each permit being valid for 7 days.

Since 1996 however, the fishermen in the Sundarbans have not been granted entrance permits or BLCs for boats both with and without engines for harvesting fish in the core area. This is a result of the Sundarbans Forest Department establishing three wildlife sanctuaries in the Sundarbans Mangrove Forest adjacent to the Bay of Bengal. The establishment of these wildlife sanctuaries has been upheld under the Bangladesh Wildlife Preservation Act of 1974. The sanctuaries include "Wildlife Sanctuary East", "Wildlife Sanctuary West" and "Wildlife Sanctuary South". These areas have now been designated as the core area of the Sundarbans Mangrove Forest where fishermen are no longer allowed to harvest fish. Thus, the fishermen are now only granted entrance permits and BLCs for harvesting fish in the buffer area. Additionally, the core area fishermen did not receive any compensation for the fishing ban being imposed over their former fishing grounds.

Since 2015, harvesting in buffer area is only permitted by issuing BLCs for boats without an engine, and boats with engines are no longer allowed for harvesting in Sundarbans Mangrove Forest. In the period 1996 to 2014 when fishing permission for boats with engines was granted in the buffer area, many core area fishermen were also illegally harvesting fish from the core area using boats with engines despite fishing ban. Now,

the core area fishermen can no longer illegally harvest fish from the core area due to ban on engine boats. This is because harvesting fish in the core area requires engine boats, due to it being located a long distance away from the fishermen's homes and the associated difficulty with transporting harvested fish such a long distance.

There is currently a significant number of former core area fishermen that now have no income from fishing and are unemployed. Some of these former fishermen have obtained low-income labor-based employment. This reduction in fishing-based businesses has had an adverse impact on the fishermen's livelihoods. Table 5.3 outlines some of the major changes that have occurred for the fishermen due to the fishing ban in the core area of the Sundarbans Mangrove Forest.

Table 5.3: Major changes due to the fishing ban in the core area of the Sundarbans.

Changed situations	Before fishing ban in the core area	After fishing ban in the core area
Average annual fish extraction per fisherman	approximately 140 Quintals (1 Quintal equal to 100 Kg)	No fish harvesting allowed
Average annual income from fishing per fisherman	approximately EUR 2,625	No income from fishing
Average annual revenue paid per fisherman	approximately EUR 855.68	No core area fishing revenue paid to the Forest Department

Source: Field Survey, 2016

5.2.2 Major problems faced in the core area of the Sundarbans due to a fishing ban

A focus group discussion identified numerous problems due to a fishing ban imposed on the core area of the Sundarbans Mangrove Forest (see Figure 5.1).

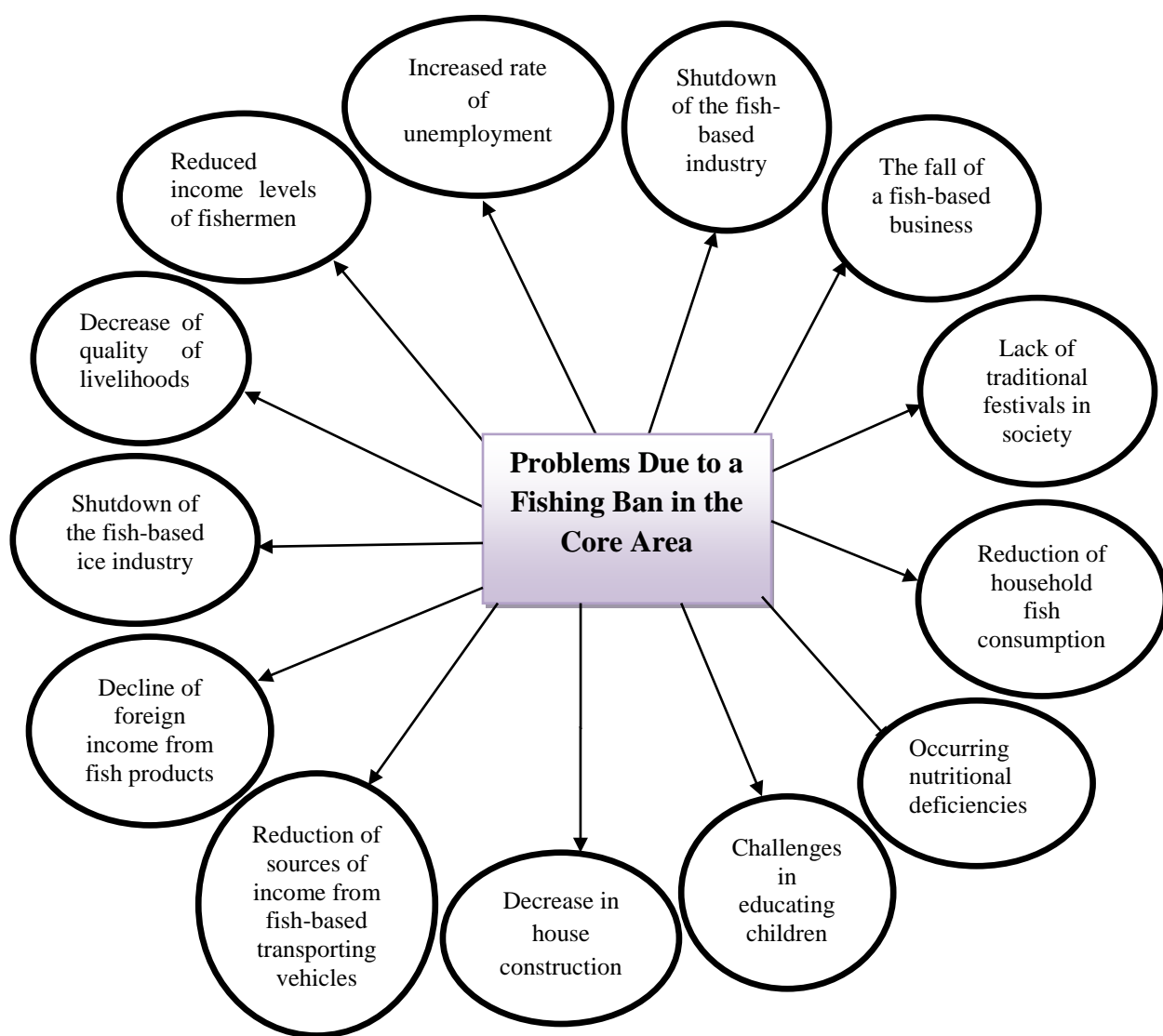


Figure 5.1: Problems due to a fishing ban in the core area of the Sundarbans Mangrove Forest.

(Source: Field Survey, 2016)

The problems facing the fishermen of the Sundarbans include increasing rates of unemployment, reductions in income levels, damaged fish-based businesses and industry, and deteriorating quality of their livelihoods. These problems are impacting the personal lives of the fishermen and their families. For example, they can impact their children's futures by limiting their access to education.

5.2.3 The Sundarbans Mangrove Forest fishing ban areas as mapped by the fishermen group

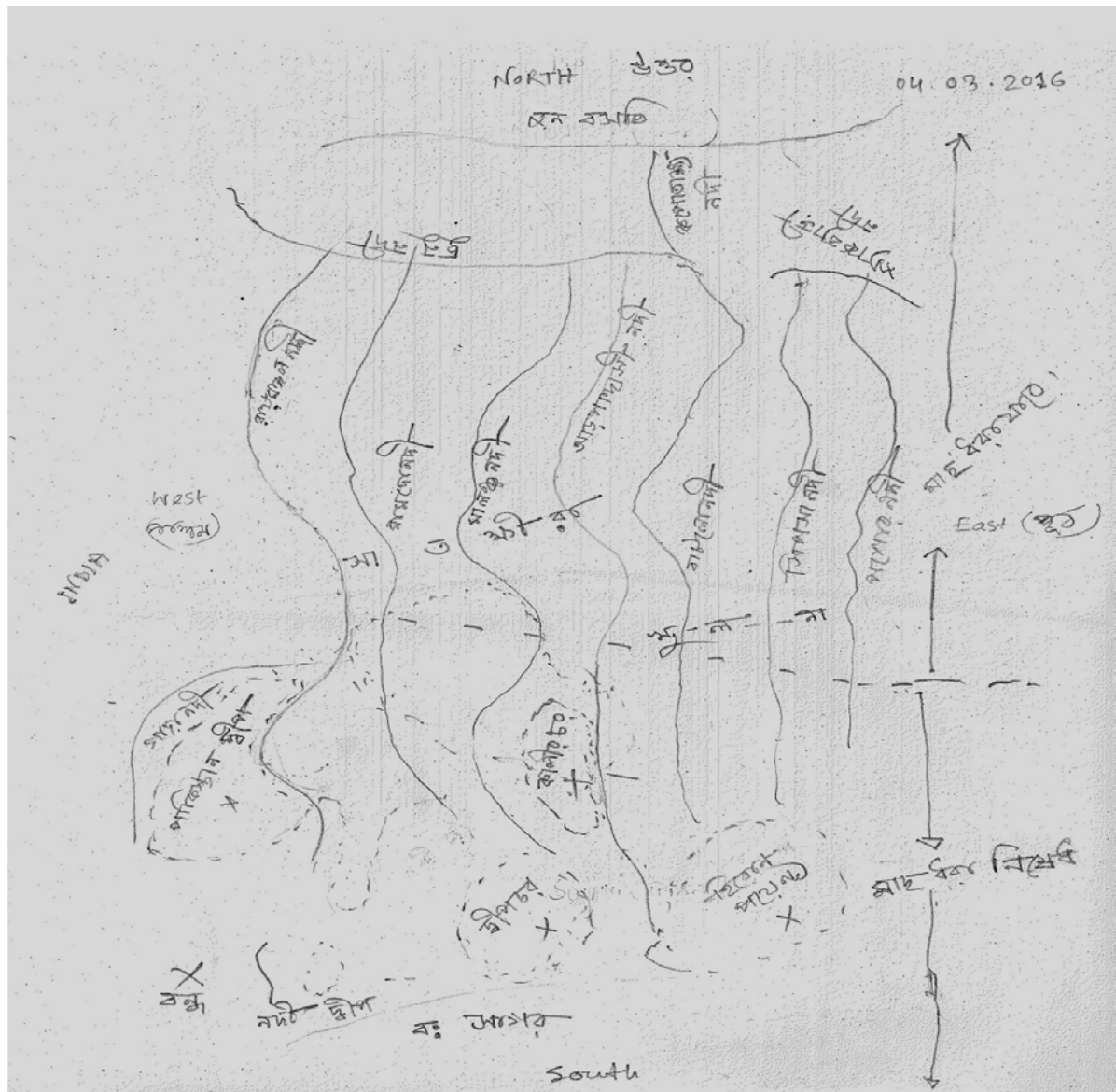


Figure 5.2: The fishing ban area (core area) and the fishing permit area (buffer area) mapped by the fishermen group. (Source: Field Survey, 2016)

The Fishermen Group includes participants from 4 different villages who have assisted in the drawing of the map shown in figure 5.3. The map was based on the group's indigenous knowledge of the area along with their extensive fishing experience, both in the core and buffer areas of the Sundarbans Mangrove Forest. The rivers and islands included in the map are written in the local language. The 7 major rivers in the Sundarbans area are identified: namely the Posur, Sipsa, Batlo, Arpangashi, Maloncho, Mamdo and Rai Mongol Rivers. The map also indicates which parts of these rivers are banned from fishing.



Figure 5.3: The fishermen group's mapping of Sundarbans banned and permitted areas of fishing. (Source: M. Shariful Islam, 2016)

In the map, the fishermen have shown that the southern portion, close to the sea, is an area banned from fishing while the northern portion which is close to the local inhabitants is an area where fishing is permitted. The Fishermen Group also drew the 4 islands involved: namely Hiron Point, Kalirchor, Deep chor and Pakistan Deep. The fishermen were previously able to harvest fish from the waters surrounding these islands but these areas are now included in the fishing ban. As seen from the map, these are significant areas that are now banned from fishing.

5.2.4 Rivers and islands in the Sundarbans Mangrove Forest affected by the fishing ban

During the focus group discussion, the Fishermen Group mentioned the names of all the rivers and islands involved in the fishing ban area. These are listed in Table 5.4.

Table 5.4: Names of the rivers and islands affected by the ban.

	Khulna Forest Range		Satkhira Forest Range
1	Balir Gang (River)	1	Agunjala (River)
2	Boro chees khali (River)	2	Baila (River)
3	Bundo (River)	3	Chamta (River)
4	Chanda Bonia (River)	4	Deep chor (Island)
5	Choto chees Khali (River)	5	Elisamari (River)
6	Dobaki (River)	6	Holda bunia (River)
7	Hiron Point (Island)	7	JolGata (River)
8	Kaga (River)	8	Kalki Bari (River)
9	Kajuria (River)	9	Kaman daga (River)
10	Kalirchor (Island)	10	Khajur Dana (River)
11	Kawrasuti (River)	11	Lotabari (River)
12	Kola Tola (River)	12	Pakistan Deep (Island)
		13	Puspokati (River)
		14	Mandarbari (River)
		15	Matia (River)
		16	Taltoli (River)

Source: Field Survey, 2016

The fishermen have identified a total of 28 affected rivers and islands in 2 forest ranges (the Khulna and Satkhira Forest Ranges). Among these, there are 24 rivers and 4 islands. In the Khulna Forest Range, the Fishermen Group has identified a total of twelve (12) regions banned from fishing which includes 10 rivers and 2 islands. In the Satkhira Forest Range, the Fishermen Group has identified sixteen (16) regions banned from fishing which includes 14 rivers and 2 islands.

5.2.5 Impact on occupations affected by the fishing ban in the core area of the Sundarbans Mangrove Forest

i. The current occupational status of the fishermen from the core area

Due to the fishing ban in the core area of the Sundarbans Mangrove Forest, a significant number of core area's fishermen (about 50%) have had to change their occupation (Figure 5.4). The ban has also created a high level of unemployment among the fishermen from the core area. About 40% of these fishermen are now unemployed and only around 10% of the area's fishermen have access to the buffer areas where fishing is still allowed.

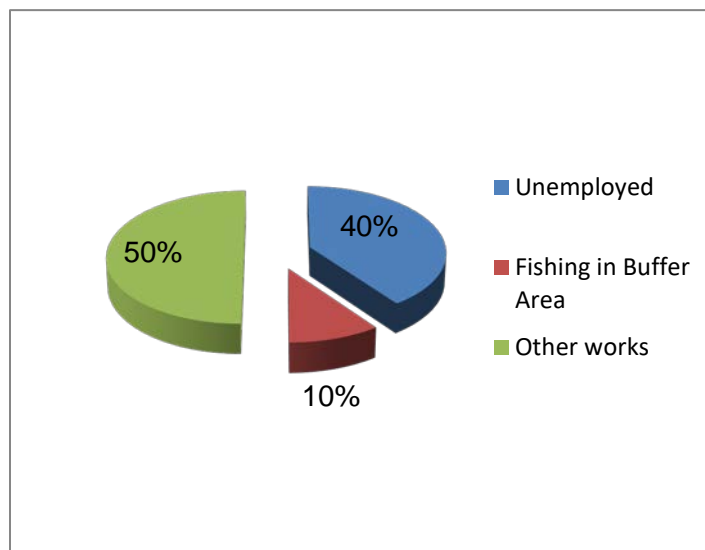


Figure 5.4: The current work situation of the fishermen impacted by the fishing ban in the core area. (Source: Field Survey, 2016)

ii. Other employment categories and percentages

The core area's fishermen are now involved in five different types of employment as seen in Figure 5.5 below. Most (approximately 65%) have switched to labor force employment. This includes employment as soil cutters (30%), brick field workers (20%) and agricultural laborers (15%). Other types of employment are as rickshaw and van vehicle drivers (30%) and various roles in other small businesses (5%).

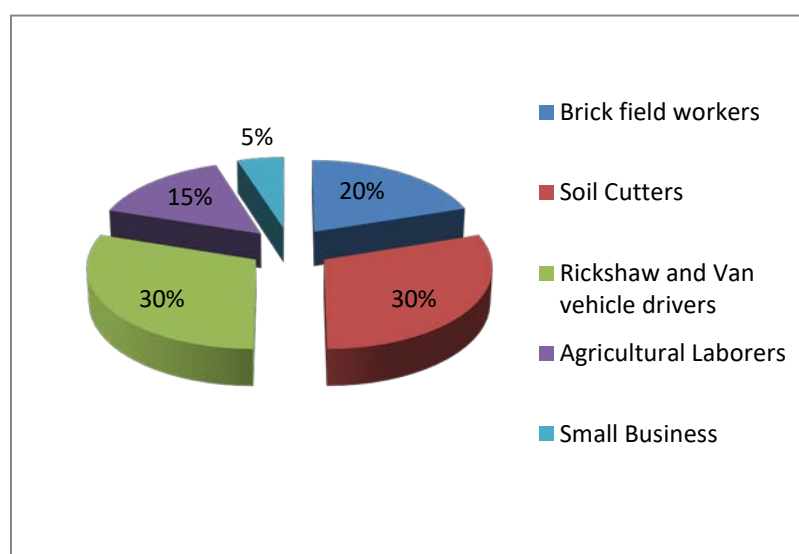


Figure 5.5: Current types of employment that core area fisherman have had to branch into.

(Source: Field Survey, 2016)

iii. Present employment opportunities of the core area fishermen

Table 5.5 outlines the employment conditions for the occupations the fishermen are now involved in. Brick field workers and rickshaw and van vehicle drivers have an opportunity to work for an average of 6 months per year; soil cutters for 5 months per year (Table 5.5); and agricultural laborers for 3 months per year. In contrast, occupations in both small business and fishing in the buffer areas have an opportunity to work 12 months per year.

Table 5.5: Present occupational conditions

Occupation	Opportunities to work (months per year)	Occupation Area
Brick field workers	6 months	Outside from own districts (urban area)
Soil cutters	5 Months	Outside from own districts (urban area)
Rickshaw and van vehicle drivers	6 Months	Own and outside districts (urban area)
Agricultural laborers	3 months	Own district
Small business	12 months	Own district
Fishing in the buffer area	12 months	Own district

Source: Field Survey, 2016

Employment as brick field workers, soil cutters and rickshaw and van vehicle drivers allows the fishermen to work in both their own districts and outside of these areas. Employment as an agricultural laborer, in small business and through fishing in the buffer area allows the fishermen to work solely in their own districts. With half of the available occupations requiring work outside of the fishermen's home districts, workers are having to live separately from their families during the months of employment. The fishing ban in the core area has therefore influenced the fishermen's migration patterns from their villages to urban areas.

5.2.6 Impact on incomes due to the fishing ban in the core area of the Sundarbans Mangrove Forest

Figure 5.6 outlines the annual incomes of the core area's fishermen in their present occupations compared to their previous annual income from fishing in the core area. The fishermen's present average annual income across all types of occupations is approximately EUR 511 while their previous average annual income from fishing was approximately EUR 2,625. Their previous annual average income was more than 5 times higher than their present annual average income across all types of occupations. The agricultural laborers are particularly worse off, with their previous annual average income (EUR 2,045) being approximately 9 times higher than their present annual average income.

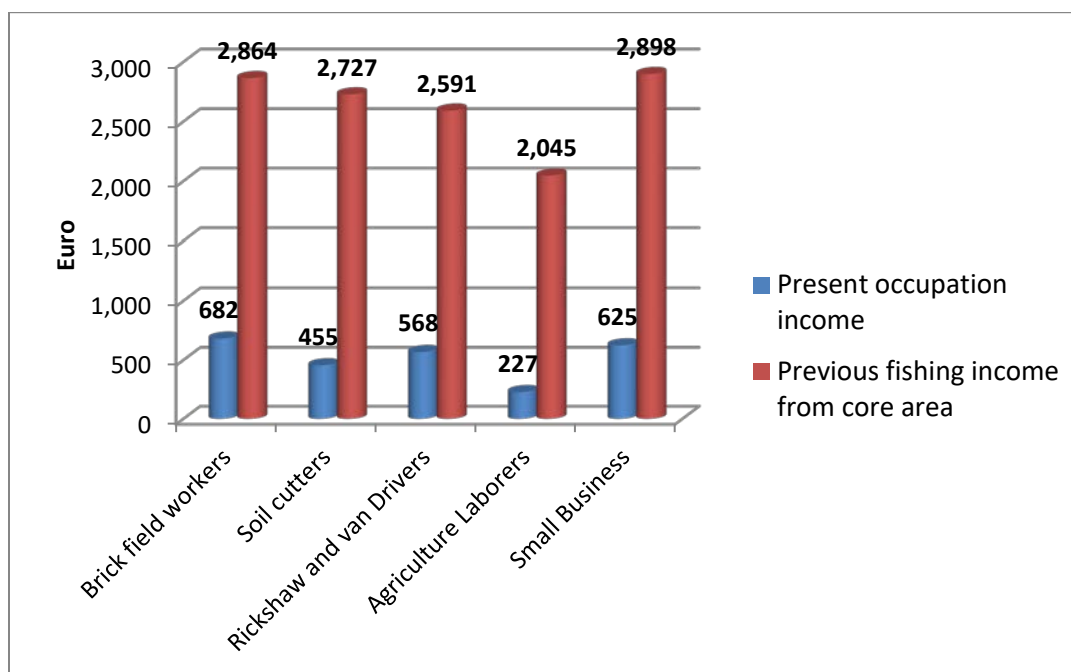


Figure 5.6: Impact on annual income due to the fishing ban in the core area.

(Source: Field Survey, 2016)

(Note: Conversion from local currency (Bangladeshi Taka, BDT) based on exchange rates of February 2016).

5.2.7 Fishing ban affecting villages in the core area of the Sundarbans Mangrove Forest

Nine villages have been affected by the fishing ban in the core area of the Sundarbans Mangrove Forest. Table 5.6 illustrates the number of households in each village and the percentage of the total households in each village that have been directly affected by the fishing ban. Of all the villages, Gobra and Chakla are the most affected (with approximately 85% and 80% of households affected, respectively). On the other hand, the villages of Modinabad and Boro Bari have the lowest percentage of affected households at 15% and 14%, respectively. In total, 125 fishermen households reported they were directly affected by the fishing ban in the core area of the Sundarbans Mangrove Forest.

Table 5.6: Numbers and percentages of village households affected by the fishing ban in the core area.

Village	Number of affected households	Percentage of affected households
Gobra	34	85%
Chakla	24	80%
Gata Khali	14	40%
Munshiganj	12	30%
Pathor Khali	11	25%
Koyra No.4	10	22%
Koyra No.6	8	20%
Modinabad	7	15%
Boro Bari	5	14%
	Total: 125	

Source: Field Survey, 2016

5.3 Comparison between the buffer and core areas of the Sundarbans Mangrove Forest where fish extraction takes place

5.3.1 Fish extraction in the buffer and core areas

Figure 5.7 compares the annual quantity of fish extracted per fisherman from the buffer and the core areas of the Sundarbans Mangrove Forest. For the buffer area, the annual average fish extraction per fisherman is approximately 32.4 Quintals. This compares with an annual average fish extraction (before fishing was banned in the core area) per fisherman in the core area of approximately 140 Quintals. The annual average fish extraction in the core area was therefore approximately 4 times higher than in the buffer area. Figure 5.8 shows the type of boat usually used by fishermen for harvesting fish from the buffer area of the Sundarbans Mangrove Forest.

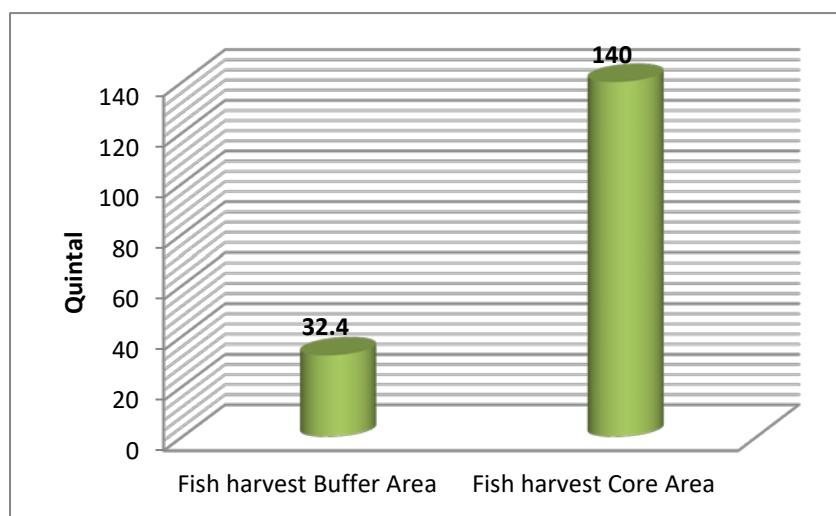


Figure 5.7: The comparison of the annual fish extraction in the buffer and core areas.

(Source: Field Survey 2016)

(Note: 1 quintal equals 100 Kg)



Figure 5.8: Boat used for fishing in the buffer area. (Source: M. Shariful Islam, 2016)

5.3.2 Fishing Income in the buffer and core areas

Figure 5.9 shows a fisherman's annual average income from fishing in the buffer compared to fishing in the core area. A fisherman's average annual income from fishing in the buffer areas is approximately EUR 1,477 while it is approximately EUR 2,625 from fishing in the core area. The income of fishermen in the core area was nearly 2 times higher than those fishing in the buffer area.

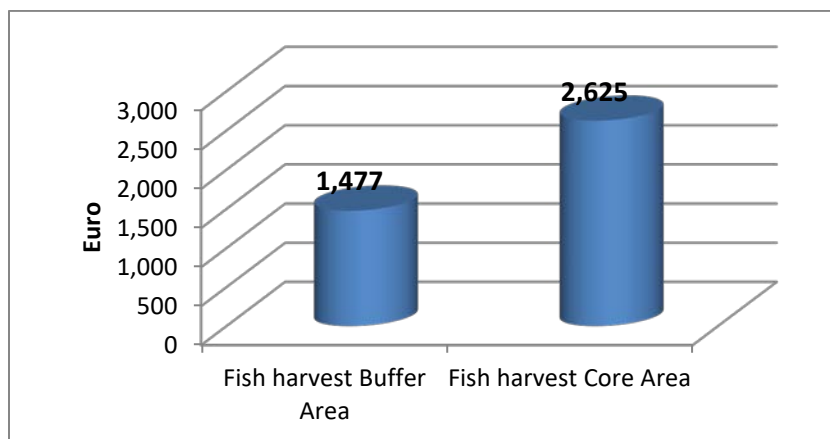


Figure 5.9: Comparison of the annual income from fishing in the buffer and core areas, per fisherman. (Source: Field Survey 2016)

Figure 5.10 shows a type of boat that fishermen used for harvesting fish from the core area of Sundarbans Mangrove Forest. The size of the core area's harvesting boats is bigger than the boats used in the buffer area.



Figure 5.10: Boat used in the core area fishing. (Source: M. Shariful Islam, 2016)

5.3.3 Buffer and core area revenue payments for fish extraction

Figure 5.11 shows a fisherman's average annual revenue payments from fishing in the buffer area compared to fishing in the core area.

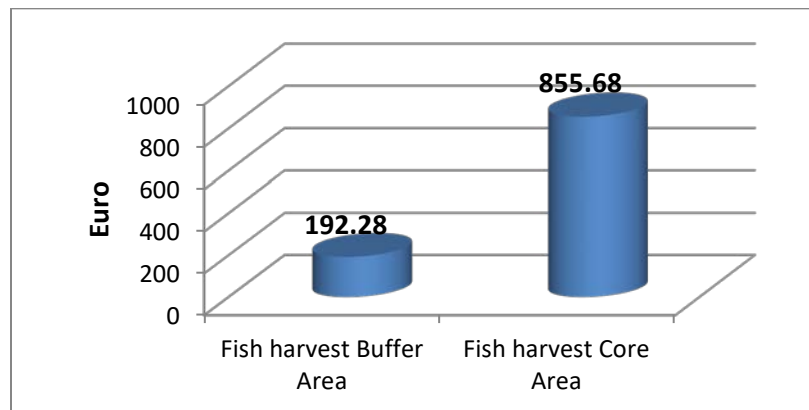


Figure 5.11: A comparison of the annual revenue payment per fisherman in the core and buffer areas. (Source: Field Survey 2016)

A fisherman's annual average revenue from fishing in the buffer area is approximately EUR 192, while it is approximately EUR 855 from fishing in the core area. The revenue payment to fishermen in the core area was approximately 4 times higher than the payment to the fishermen in the buffer area.

5.4 Sundarbans Mangrove Forest Management

5.4.1 The current number of personnel at the Sundarbans Mangrove Forest

The Sundarbans Forest Division (the East and West Divisions) consists 5 different administrative positions working for the Sundarbans Mangrove Forest Management (Table 5.7). These positions are Divisional Forest Officer (DFO), Assistant Conservator of Forest (ACF), Forest Ranger (FR), Forester and Forest Guard (FG). For the management of the Sundarbans Mangrove Forest, there is a total of 293 administrative personnel. Of these, 2 persons are employed as DFOs, 6 are employed as ACFs, 21 as FRs, 86 as Foresters and 178 as FGs.

Table 5.7: The current number of personnel for Sundarbans Forest management.

Administrative Personnel	Number
Divisional Forest Officer (DFO)	2
Assistant Conservator of Forest (ACF)	6
Forest Ranger (FR)	21
Forester	86
Forest Guard (FG)	178
Total	293

Source: Field Survey 2016

5.4.2 Forest patrol tools utilized in the Sundarbans Mangrove Forest

i. Defense tools for patrolling the forest

Forest patrol activities in the Sundarbans Forest (West Division) involve the use of 6 different defense tools (i.e. rifles, SLR, China rifles, guns, and six shooters). Table 5.8 outlines the number of each of these tools held by the West Forest Division. There is a total of 635 defense tools and the majority of these are rifles (322).

Table 5.8: Defense tools for patrolling the Sundarbans, West Forest Division.

Defense tools	Quantity
Rifle (303)	322
SLR	103
China Rifle	130
Gun/Bonduk	63
Six shooter	6
Total	635

Source: Field Survey 2016

ii. Watercraft used for patrolling the forest

The Sundarbans West Forest Division uses 3 different types of watercraft for patrolling activities. These are Speed Boats/Cabin Cruisers, Launch Boats and Toller Boats. Table 5.9 outlines the number of each of these watercraft held by the West Forest Division. Toller boats are by far the most commonly used watercraft for patrolling the Sundarbans West Forest Division.

Table 5.9: Watercraft used in the Sundarbans, West Forest Division.

Name of Aqua Engine Boat	Quantity
Speed boat/cabin cruiser	10
Launch Boat	6
Toller Boat	50
Total	65

Source: Field Survey 2016

5.4.3 Administrative units in the Sundarbans Mangrove Forest

Figure 5.12 presents the administrative units of the Sundarbans Forest Department. The figure illustrates the administrative powers of the Sundarbans Forest Department from the highest to the lowest levels.

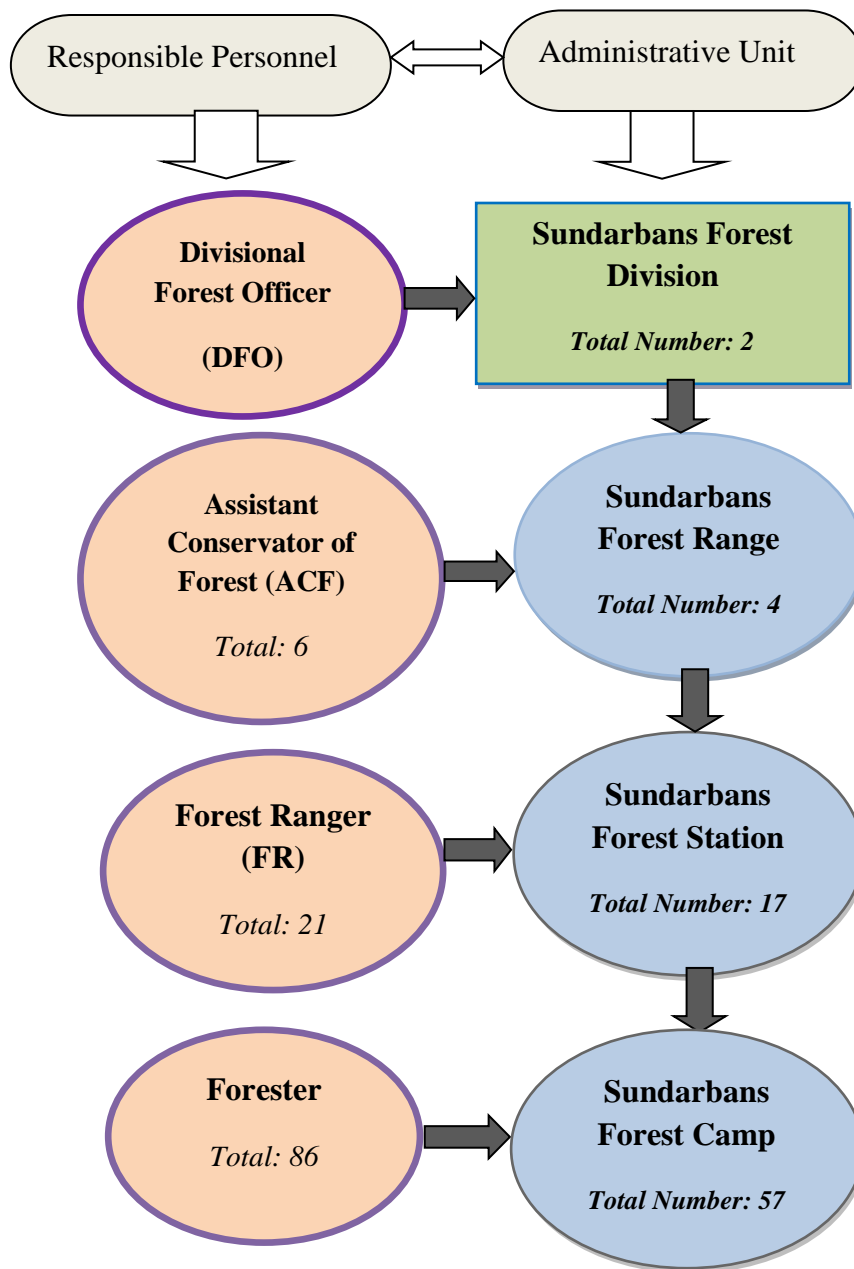


Figure 5.12: Administrative units of the Sundarbans Forest Department.
(Source: Drawn by M. Shariful Islam, 2016, based on field survey, 2016)

The Sundarbans Forest Division is the highest administrative unit, followed by the Forest Range, the Forest Station and the Forest Camp. Two such offices for Forest

Division and Forest Station are shown in Figures 5.13 and 5.14 respectively. The DFO is responsible for the Sundarbans Forest Division, the ACF is responsible for the Forest Range, the FR is responsible for the Forest Station and the Forester is the responsible authority in the Forest Camp. The total number of Forest Divisions and Forest Ranges stand at 2 and 4 respectively.



*Figure 5.13: Sundarbans Forest West Division office.
(Source: M. Shariful Islam, 2016)*



*Figure 5.14: Sundarbans Forest Station office,
Kashiabad. (Source: M. Shariful Islam, 2016)*

5.4.4 Sundarbans Forest administrative arrangement for Khulna Range

Figure 5.15 depicts the administrative arrangements for the Khulna Forest Range in the Sundarbans. This arrangement involves Forest Stations and their associated Patrol Camps. Within the Khulna Forest Range area, there are 5 Forest Stations (i.e. Baniakhali Station, Kashiabad Station, Kala bogi Station, Sutarkhali Station, Nolian Station). Kashiabad Station, Kala bogi Station and Nolian Station each have four (4) patrol camps while Baniakhali Station and Sutarkhali Station each have 2 patrol camps.

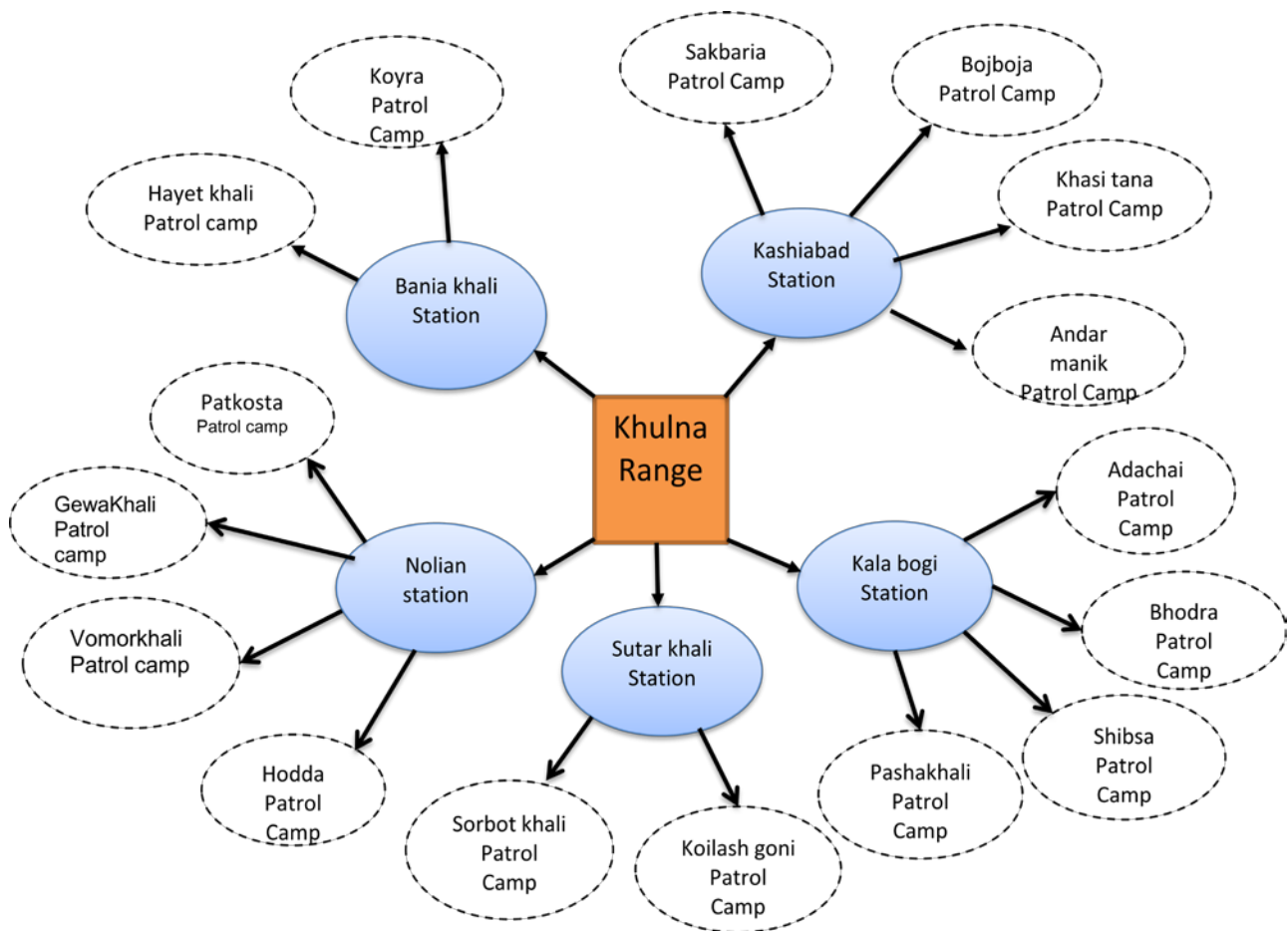


Figure 5.15: Administrative arrangement for the management of the Sundarbans Forest, Khulna Forest Range. (Source: Drawn by M. Shariful Islam, 2016, based on field survey, 2016)

5.4.5 The Sundarbans Mangrove Forest resource management

The study found that the Sundarbans Forest Management operates on the basis of three forest resources (i.e. timber species, non-timber products and wildlife) (Figure 5.16). The hierarchy of forest administrative units works together to ensure the forest and its resources are well-managed.

The Sundarbans Forest Department manages the mangrove forest's timber species based on the regulations under the Bangladesh Forest Act of 1927. This management

includes the prohibition of felling, cutting and damaging of timber species in the Sundarbans Mangrove Forest. The Forest Department controls illegal felling and other damage to protected timber species through regular patrols and punishments for infringements including fines, arrest and jail sentences.

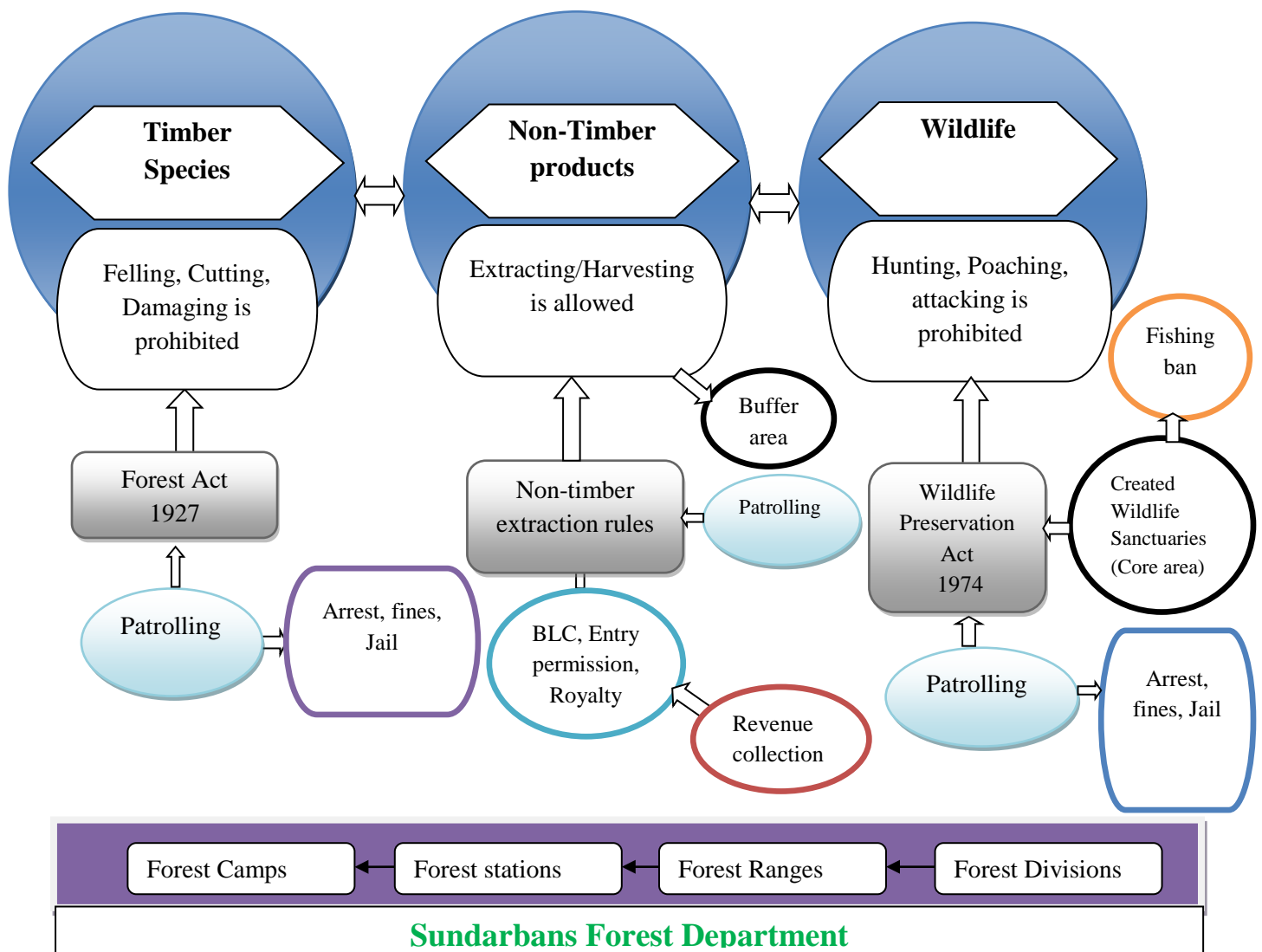


Figure 5.16: Diagram of the overall current forest management system for the Sundarbans Mangrove Forest. (Source: Drawn by M. Shariful Islam, 2016, based on field survey, 2016)

The extraction of non-timber forest products (i.e. fish, crab, honey, and palm leaf) is allowed in the buffer area of the Sundarbans Mangrove Forest but it must be done in accordance with the Forest Department's extraction rules. Forest patrol activities seek to ensure any extraction follows these rules. The Forest Department has also prepared a revenue system for the extraction of non-timber forest products. A Boat License Certificate (BLC), entrance permission and royalties are the major sources of revenue collection for extracting non-timber products from the forest.

Wildlife is also managed in the Sundarbans Mangrove Forest. This management is based on the Bangladesh Wildlife Preservation Act 1974 and is focused on wildlife protection. To protect the wildlife of the Sundarbans, regular patrol activities are undertaken by the Forest Department and fines, arrests and incarceration are applied as needed to curtail abuses. In addition, the Forest Department has also created wildlife sanctuaries including in the core area where fishing is banned.

5.4.6 Non-timber forest product harvesting management and revenue collection

Table 5.10 presents details of the management system for the harvesting of non-timber forest products (i.e. fish, crab, honey, and palm leaf) from the Sundarbans Mangrove Forest. This includes details of the revenue collection and permit systems, and the harvesting seasons. The non-timber forest product revenues are collected from harvesters through the BLCs, forest entrance or harvest permission fees and royalties. The BLCs are issued for each harvester for a one-year period and can be renewed yearly. Figure 5.17 shows a fisherman entrance permission document issued by a Forest Station Unit.

Table 5.10: The current management and revenue collection system in the Sundarbans in relation to the harvesting of non-timber forest products.

Non-Timber Forest Products	Revenue collection			Permitted persons per boat	Monthly permission for entrance to the forest for harvesting (Each Boat with BLC)	Months of allowable harvesting (seasons)	Permission For Harvesting (Total months per year)
	BLC (Boat License Certificate) Fee per annum (for 10 Quintals measure Boat)	Entrance/Permission Fee (Per person)	Royalty (Per person per permission)				
Fish	0.06 €+ VAT 15%	0.08 €+ VAT 15% For 7 days	Per person for 19.60 kg 0.71 €+ 15% VAT	2-6	4 times	January-December	12 months
Crab	0.06 €+ VAT 15%	0.07 €+ VAT 15% For 7 Days	Per person for 19.60 kg 0.71 €+15% VAT	2-4	4 times	March-December	10 months
Honey	0.06 €+ VAT 15%	No entry fee	For 0.75 Quintal 8.52 €+ 15% VAT For 30 days	6-12	1 time	April-June	2.5 months
Palm leaf (GolPata)	0.09 €+ VAT 15%	No Entry Fee	For 1 Quintal 0.28 €+ 15% VAT	5-7	1 time	Nov-March	5 months

Source: Field Survey, 2016

The BLC fee is measured on the basis of the size of the boat. The entrance fee is collected from each person occupying a boat and the royalty fee is collected on the basis of the amount of harvested products procured, as permitted. Figure 5.18 shows the Forest Station Unit is collecting revenue (Royalty) from a fisherman that officially records in paper.

For the purpose of managing the harvesting of non-timber forest products, the Forest Department maintains their own framework on issues of revenue payments, permitting authorization to persons and issuing permits for a specified time whether monthly or seasonally (stated by a particular month of the year).

In the case of fish harvesting, the revenue comprises the BLC fee of EUR 0.06 plus 15% VAT for 10 Quintal measurements per boat, the entrance fee per person of EUR 0.08 plus 15% VAT for 7 days, and the harvesting royalties per person which equates to 19.60 kg of harvested products at EUR 0.71 plus 15% VAT. Two to six (2-6) people per boat are permitted for fish harvesting. In addition, each boat is granted permission to harvest fish 4 times a month. Fish harvesting is allowed from January to December (a total of 12 months) each year.

Figure 5.17: Fishing entrance permission document.
(Source: M. Shariful Islam, 2016)

Figure 5.18: Royalty collection document.
(Source: M. Shariful Islam, 2016)

In the case of crab harvesting, the revenue comprises the BLC fee of EUR 0.06 plus 15% VAT for 10 Quintal measurements per boat, the entrance fee per person of EUR

0.07 plus 15 VAT for 7 days, and the harvesting royalties per person which equate to 19.60 Kg weight of harvested products EUR 0.71 plus 15% VAT. Two to six (2-6) people per boat are permitted for crab harvesting. For each boat, crab harvesting is allowed 4 times per month between March and December (a total of 10 months) each year.

In the case of honey extraction, the revenue comprises the BLC fee of EUR 0.06 plus 15% VAT for 10 Quintal measurements per boat and the harvesting royalty which equates to EUR 8.52 plus 15% VAT for up to 0.75 Quintals for 30 days. There is no entrance fee for honey harvesting. Six to twelve (6-12) people per boat are permitted for honey harvesting. Honey extraction is permitted once per month per boat and only during the months of April to mid-June (a total of 2.5 months) each year.

For palm leaf harvesting, the revenue comprises the BLC fee of EUR 0.09 plus 15% VAT for 10 Quintal measurements per boat and the harvesting royalty which equates to EUR 0.28 plus 15% VAT per Quintal. There is also no entrance fee for palm leaf harvesting. Five to seven (5-7) people per boat are permitted for palm leaf harvesting. Palm leaf harvesting is permitted once per month per boat between the months of November and March (a total of 5 months) each year.

5.4.7 Revenue collection and patrol functions for the Sundarbans Mangrove Forest

i. Revenue collection functions for the Sundarbans Mangrove Forest

Figure 5.19 illustrates the overall non-timber forest product revenue collection function for the Sundarbans Mangrove Forest. The Forest Station is responsible for collecting revenues from the harvesting of non-timber forest products.

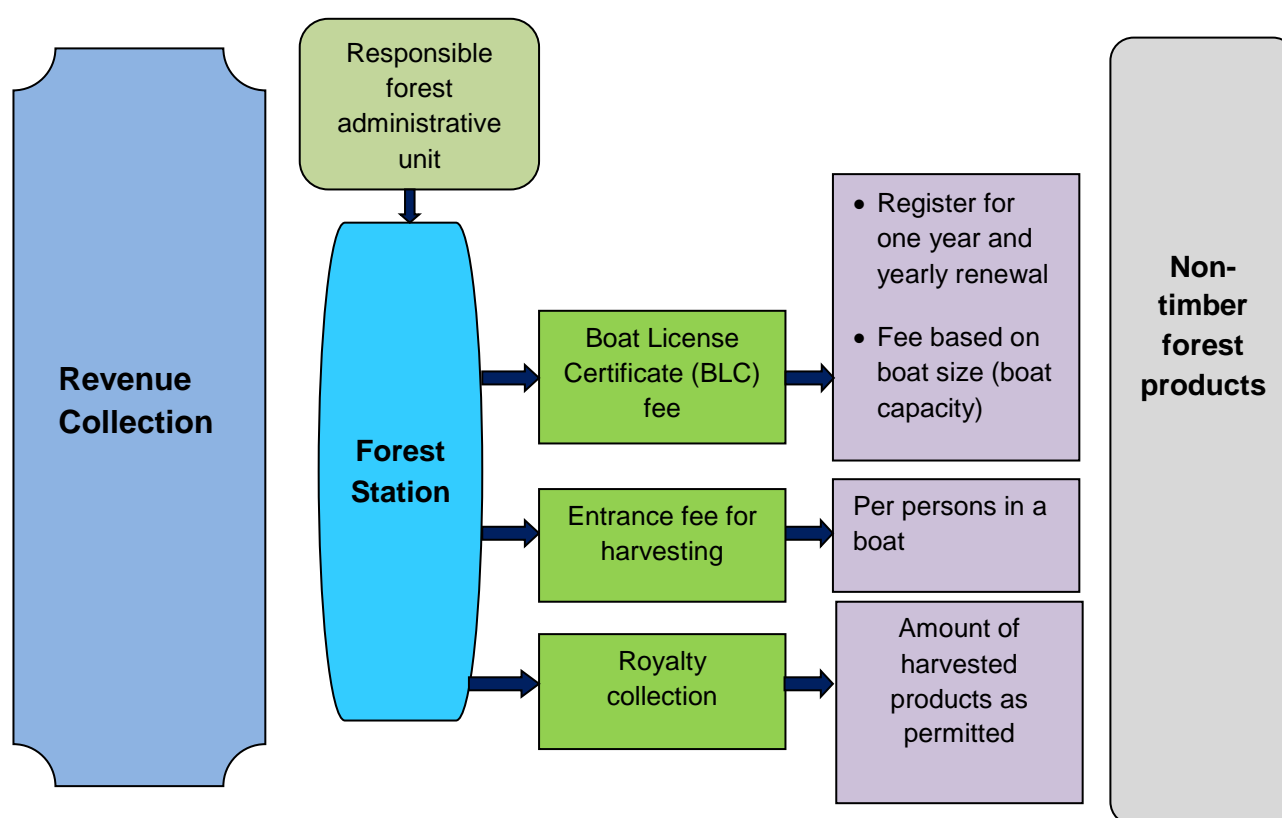


Figure 5.19: Current overall revenue collection functions for non-timber forest products in the Sundarbans Mangrove Forest. (Source: Drawn by M. Shariful Islam, 2016, based on field survey, 2016)

The non-timber forest products revenue collection comes from three sources which are from the Boat License Certificate (BLC), entrance or permission fee for harvesting, and royalties from harvesting products.

ii. Patrol functions of the Sundarbans Mangrove Forest

Figure 5.20 shows the overall patrol functions of the Sundarbans Forest Department for the Sundarbans Mangrove Forest.

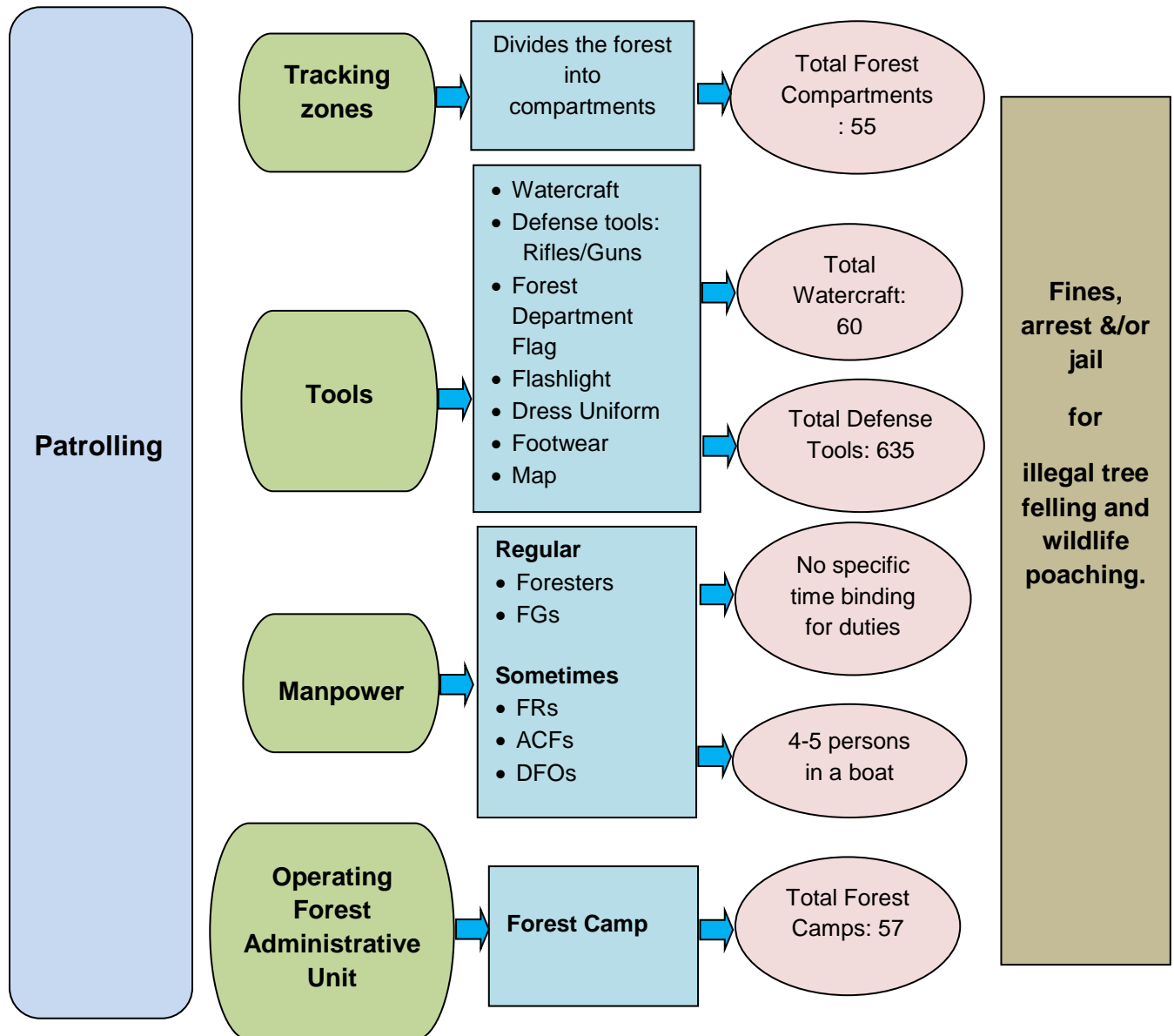


Figure 5.20: Current patrol functions in the Sundarbans Mangrove Forest.

(Source: Drawn by M. Shariful Islam, 2016, based on field survey, 2016)

To patrol the mangrove forest, the Forest Department has divided the entire forest area into 55 compartments. The Forest Department uses various tools (i.e. watercraft, rifles, flags, uniforms, proper footwear, flashlights and maps) to ensure efficiency in its patrolling operations throughout the compartments. The watercraft and defense tools are particularly important items for patrolling the forest. The FGs and Foresters work together in their patrols using the watercraft. The FRs, ACFs and DFOs also occasionally join the FGs and Foresters in the patrolling activities. A patrol group usually consists of four to five (4-5) persons. The Forest Camp is the Administrative Unit that leads patrols of the forest. There is a total of about 57 Forest Camps that work in the Sundarbans Mangrove Forest for the purpose of patrolling the forest.

5.4.8 Irregularities in revenue collection under the current management of the Sundarbans Mangrove Forest

i. Fee collection scenarios in obtaining a boat license certificate

The study found irregularities in the current fish harvesting management system regarding revenue collection for obtaining a BLC. Table 5.11 shows the extra unofficial amounts received by revenue collectors from the buffer area's fishermen at the Sundarbans Forest Station Unit. The average extra unofficial amount collected per year per fisherman for a BLC is approximately EUR 5.95. The total average annual extra unofficial revenue collected for BLCs from all buffer area's fishermen at the Sundarbans Forest Station is approximately EUR 29,916. In Figure 5.21, a fisherman is showing his BLC permit document, which includes official payments for the BLC.

Table 5.11: The extra money collected for boat License certificates in the Sundarbans Forest, west division.

The average annual payment per fisherman for a BLC for a 20-35 Quintal measure boat (EUR)	The annual revenue for a BLC per fisherman according to the official rules of the Forest Department (for a 20-35 Quintals measure boat) (EUR)			The average annual Extra unofficial payment for a BLC per fisherman to the Forest Station Unit (EUR)	Total BLCs issued (for fish and crab harvesting) 2014-2015.	Total average annual extra unofficial payments to the Forest Station Unit for BLCs(for fish and crab harvesting) (EUR)
	Minimum	Maximum	Average			
6.14	0.13	0.26	0.19	5.95	5,028	29,916.60

Source: Field Survey, 2016



Figure 5.21: Fisherman with a Boat License Certificate. (Source: M. Shariful Islam, 2016)

ii. Royalty collection scenarios

The study also found irregularities regarding the collection of royalties for fish harvesting in the Sundarbans Mangrove Forest. Table 5.12 shows the extra unofficial amounts received by revenue collectors from the buffer area's fishermen for royalties at the Sundarbans Forest Station Unit. The average extra unofficial amount collected per year per fisherman for royalties is approximately EUR 6.57. The total annual average extra unofficial revenue collected for royalties (for fish and crab harvesting) from all buffer area's fishermen in the Sundarbans, West Division is approximately EUR 290,433.

Table 5.12: The extra money collected for royalties at the Sundarbans Forest, West Division.

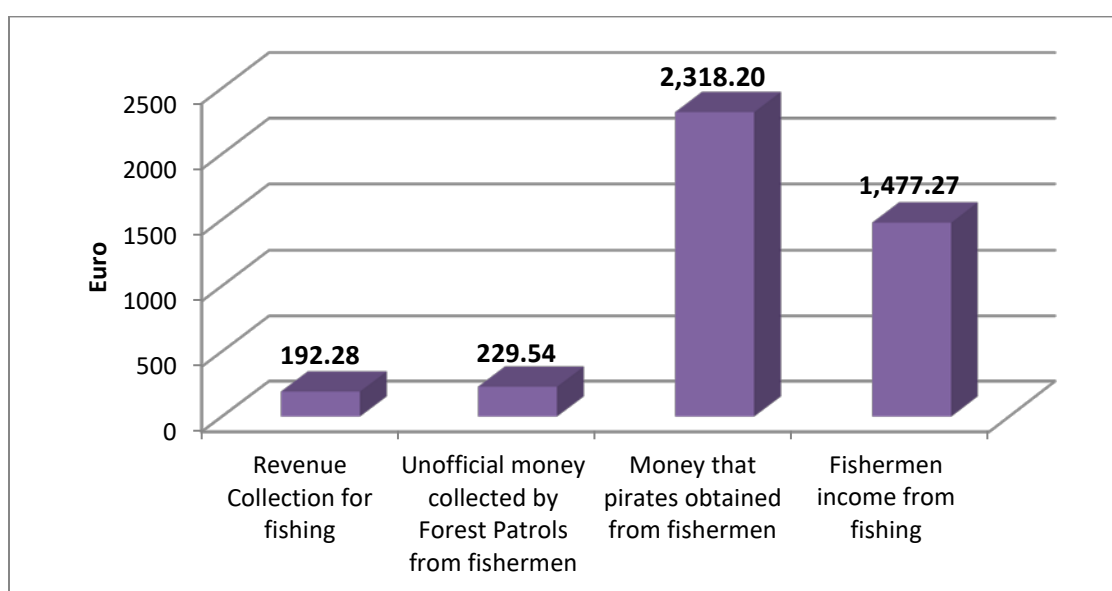
The average royalty payment per fisherman per permission for the harvesting of 19.60 kg of fish/crab (EUR)	The royalty payment per fisherman per permission for the harvesting of 19.60 kg of fish/crab according to the Forest Department's official rules (EUR)	The average extra unofficial royalty payment (for fish and crab harvesting) to the Forest Station Unit per fisherman per permission (EUR)	Total permissions issued (for fish including crab harvesting) 2014-2015	Total annual average extra unofficial royalty payments (for fish and crab harvesting) to the Forest Station Unit from all fisherman (EUR)
7.39	0.82	6.57	44,206	290,433.42

Source: Field Survey, 2016

5.4.9 Fishing in the buffer area under the current management system

The study found that in addition to the Forest Department's collection of official revenue and unofficial extra payments from the buffer area's fishermen, pirates are also collecting payments from the fishermen. The Sundarbans Forest Department's annual average official revenue collection from each fisherman (i.e. for BLC, entrance or permission fees and royalties) is approximately EUR 192.28 (Figure 5.22). The annual

unofficial amount collected (being without a receipt) per fisherman by the forest patrols is approximately EUR 229.54. Pirates receive an annual average of approximately EUR 2,318 from each fisherman. Each fisherman's annual average income from fishing in the buffer area is approximately EUR 1,477.27. Therefore, the annual amount being received by pirates from each fisherman is approximately double their annual average income. This shows that the unofficial payments collected by the forest patrols and pirates is far higher than the official revenue collected from each fisherman.



*Figure 5.22: The present scenario for fishing in the buffer area.
(Source: Field Survey 2016)*

5.4.10 A Comparison of the annual payments received from the fishermen by pirates vs. the forest department patrols in the Sundarbans, west forest division.

i. Money that pirates receive from the fishermen

Table 5.13 outlines details of the payments that pirates obtain from the buffer area's fishermen. Pirates in the Sundarbans Mangrove Forest are using illegal force to extract a very large amount of money (approximately EUR 23.31 Million) from the fishermen.

Table 5.13: Details of payments to pirates by fishermen in the Sundarbans, West Forest Division (Fiscal Year 2014-2015).

Total number of BLCs issued for fishing	Average number of fisherman per boat paying money to pirates	The annual average payment per fisherman to the pirates	The annual total payment to pirates
5,028	2	2,318.20 Euro	23.31 Million Euro

Source: Field Survey, 2016

ii. Money that the forest patrols receive from the fishermen

Table 5.14 outlines details of the unofficially payments (i.e. without a receipt) that the Forest Patrols obtain from the buffer area's fishermen. The Forest Patrols are illegally obtaining a total of approximately EUR 2.3 Million each year from fishermen in the Sundarbans Mangrove Forest.

Table 5.14: Details of payments to the Forest Patrols by fishermen in Sundarbans, West Forest Division, (Fiscal Year 2014-2015).

Total number of BLCs issued for fishing	Average number of fisherman per boat paying money to the Forest Patrols	The annual average unofficially payment per fisherman to the Forest Patrols	The annual total unofficially payment to the Forest Patrols
5,028	2	229.54 Euro	2.3 Million Euro

Source: Field Survey, 2016

5.4.11 The annual budget and amount received from the fishermen by the Sundarbans Forest, West Division

Figure 5.23 compares the Forest Department's annual budget with the buffer area fishermen's annual expenses for official revenues and other unofficial payments to the Forest patrols and pirates. The amount the Forest Patrols receive in unofficial payments from the fishermen in the Sundarbans Forest, West Division is approximately double the Department's annual budget and approximately 38 times more than the revenue received through official payments. The amount that pirates obtain from the fishermen is approximately 19 times higher than the total annual budget of the Sundarbans Forest, West Division. Overall, the Forest Patrols and pirates are illegally taking a massive amount of money (i.e. approximately EUR 25.61 Million) from the buffer area's fishermen each year. This is clearly having a large impact on the incomes and livelihoods of the fishermen in the Sundarbans Mangrove Forest. Figure 5.24 shows some of the buffer area's fishermen and the fishing net they use.

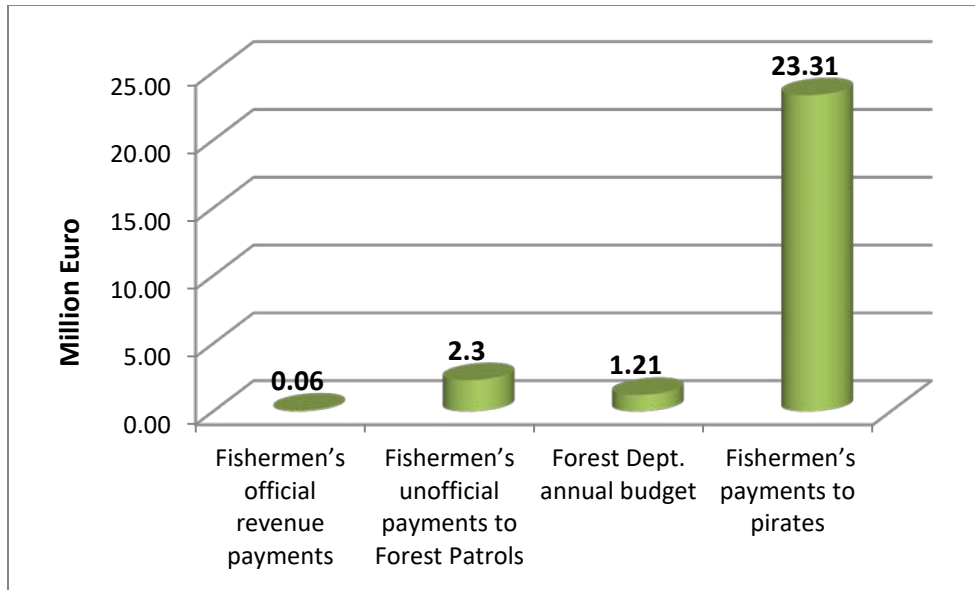


Figure 5.23: Comparison of the Sundarbans Forest Department's annual budget with the buffer area fishermen's annual expenses in official and unofficial payments (2014-2015).

(Source: Field Survey, 2016)

Note: Conversion from local currency (Bangladeshi Taka, BDT) based on exchange rates of February 2016.



Figure 5.24: Fishermen in the Sundarbans Mangrove Forest. (Source: M. Shariful Islam, 2016)

5.5 The current revenues and patrolling structure and their weakness

5.5.1 Weakness in the current revenue collection and system of patrolling the Sundarbans Mangrove Forest

Some weaknesses have been found in the current revenue collection, forest patrolling, and monitoring system in the Sundarbans Mangrove Forest. These are outlined in Table 5.15.

Table 5.15: Weakness of the present revenue collection and forest patrolling system in the Sundarbans Mangrove Forest.

Revenue collection system		Forest Patrolling	
Weakness	Occurring	Weakness	Occurring
The revenue collection system is manual. The revenue collection data is written and recorded by hand on paper.	<ul style="list-style-type: none"> • Lack of transparency in the revenue collection system • Possibility of damage to the revenue data. • Inability to share revenue data with all Forest Station Units 	Limits manpower for patrolling activities in large areas of the Sundarbans which consist of 55 forest compartments.	<ul style="list-style-type: none"> • Weak patrol activities.
The Forest Station Units are not providing any official revenue payment receipts to fish harvesters; therefore, fishermen are not getting their annual revenue payment receipts from the Forest Department.	<ul style="list-style-type: none"> • Lack of transparency in the revenue collection system. • The Forest Stations are collecting extra money from the fishermen during revenue collection. 	During low tide periods, the Forest Station Units are not able to patrol the inner part of the mangrove forest with boats (Note: The Sundarbans Mangrove Forest has the characteristic of low and high tides each day).	<ul style="list-style-type: none"> • Inability to patrol and monitor the forest during the low tide period.
A weight measuring machine is not used at the Forest Station Units and as a result, fish revenue is collected without the actual weight of harvested fish.	<ul style="list-style-type: none"> • Inefficient revenue measurement system. • Possibility of overfishing. 	Difficulties controlling illegal fish harvesters, tree cutters, and wildlife poachers using boat patrols only; limited monitoring of forest patrols.	<ul style="list-style-type: none"> • Illegal fishing, tree cutting, and wildlife poaching

--		Fishermen are often harvesting fish without permission.	<ul style="list-style-type: none"> • Losing revenue • Overfishing and illegal fishing is occurring.
--	--	Under the current fish harvesting management, fishermen boats do not have identification numbers or plates.	<ul style="list-style-type: none"> • Difficulties in identifying boats used in fish harvesting, whether they are legal or illegal. • Illegal fish harvesting is occurring.
--	--	Monitoring of patrolling duties are with an attendance sheet.	<ul style="list-style-type: none"> • Poor monitoring of patrols while on duty in the mangroves.

Sources: Field survey, 2016

5.5.2 The current non–timber harvesting revenue collection system and forest patrolling structure in the Sundarbans Mangrove Forest

The present revenue collection system in the Sundarbans Forest Station is done manually where revenue is recorded on paper by hand (Figure 5.25). This system has its limitations when revenue data needs to be shared among all the administrative units. There is therefore a lack of transparency in the current non-timber forest harvesting revenue collection system. These revenue system harvesters are not getting their annual revenue payment receipt documents from the Forest Stations. The current revenue system used by the Forest Station Unit also does not use weights in measuring the weight of the harvested fish. This creates discrepancies in the revenue collection system. The current structure (Figure 5.25) uses a boat to patrol the forest and to monitor illegal tree felling and harvesting, wildlife poaching, and to fight piracy. This system apparently has some weaknesses. The present forest patrol system should therefore be upgraded and strengthened to ensure successful patrolling of the mangrove forest.

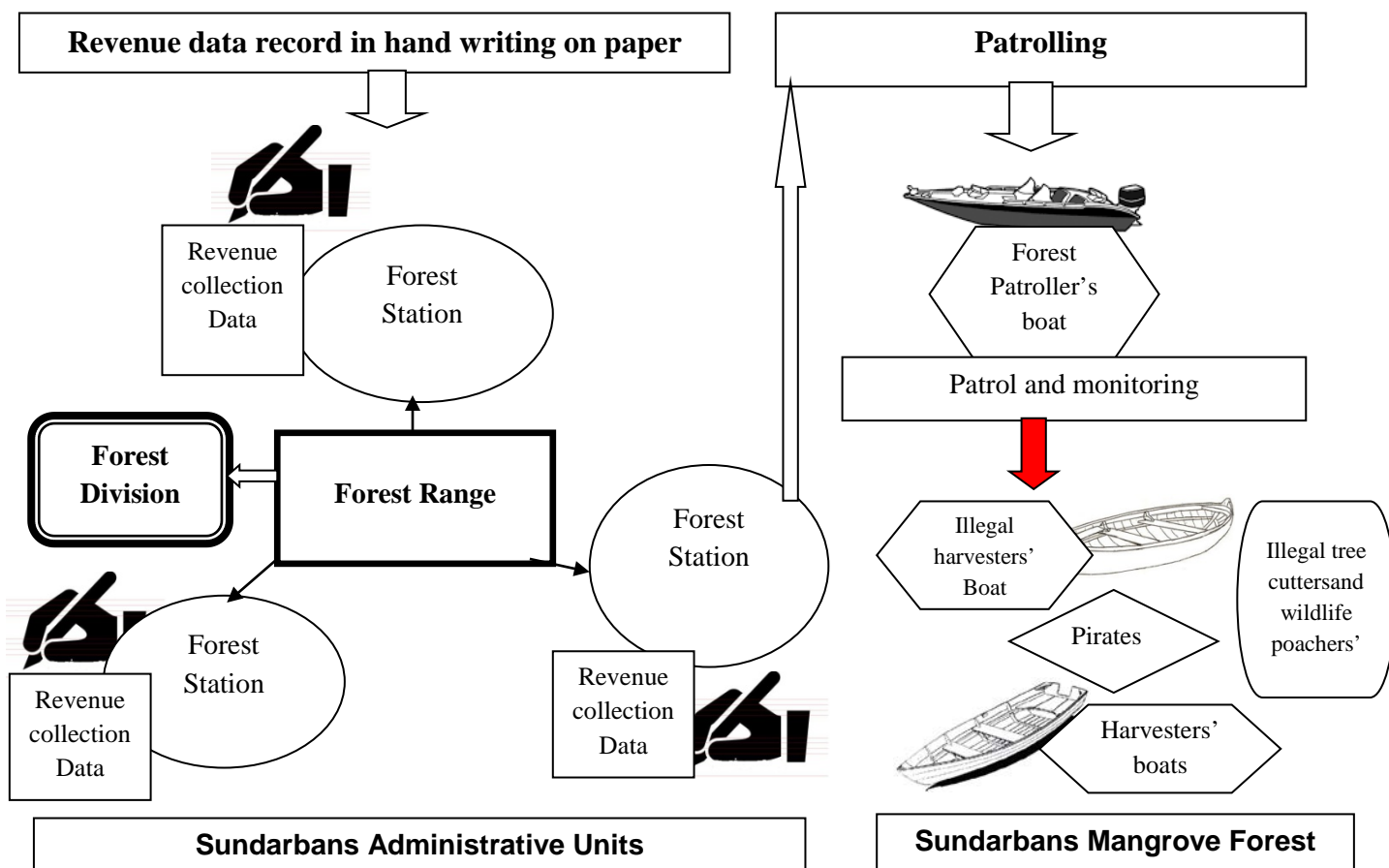


Figure 5.25: The current non–timber harvesting revenue collection and patrolling structure of the Sundarbans Mangrove Forest. (Source: Drawn by M. Shariful Islam, 2016, based on field survey, 2016)

For this reason, the current patrolling structure needs to be modified. Suggestions have been made to include innovative technologies (drones, GPS, and a helicopter) in patrolling and monitoring of activities.

5.5.3 Proposed model modifying the current non–timber harvesting revenue collection system and forest patrol structure of Sundarbans Mangrove Forest

The modified proposed structure (Figure 5.26) can be helpful in solving the current weaknesses (see table 5.15) and improve revenue collection and the system of patrolling the forest.

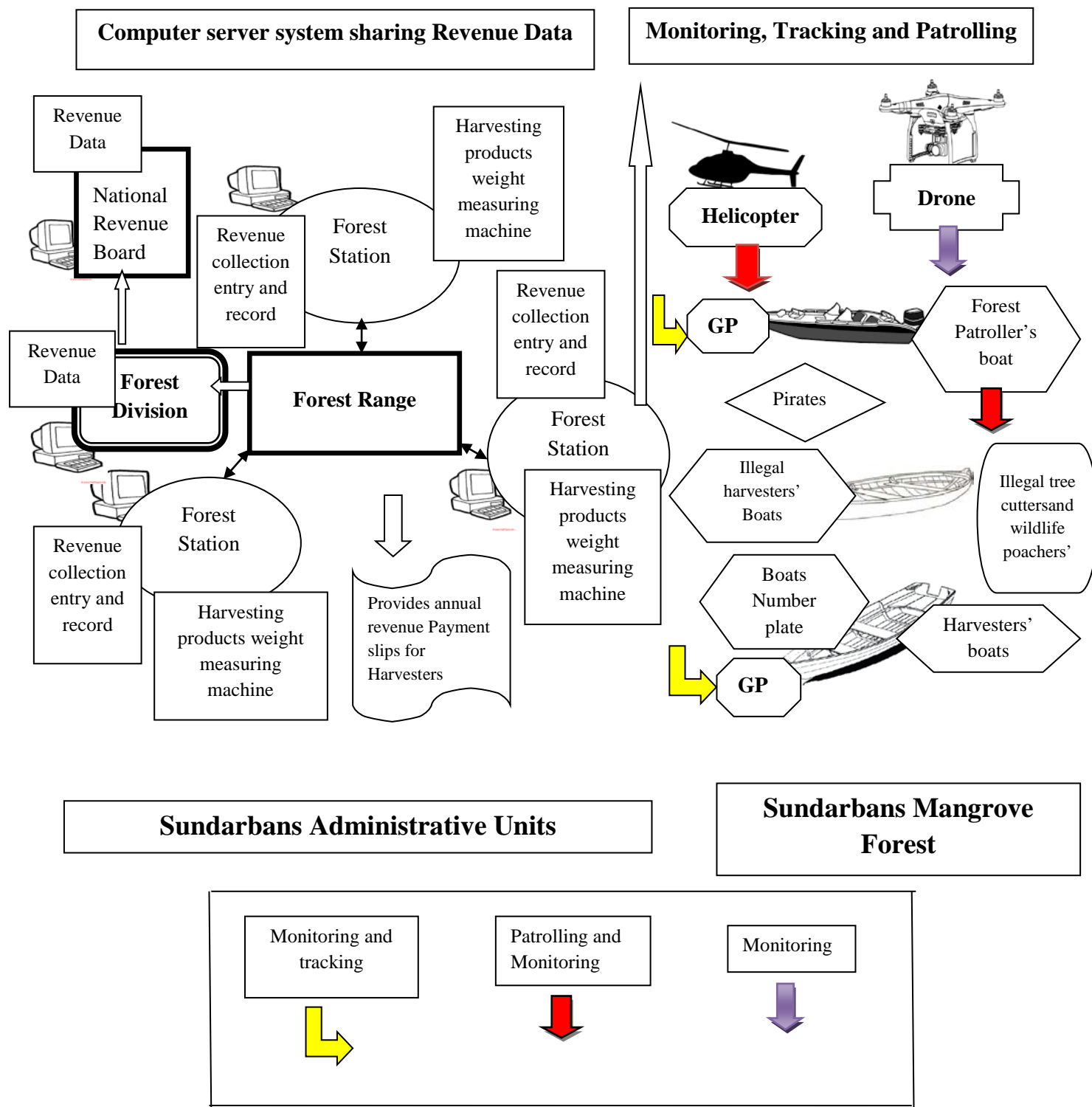


Figure 5.26: Modifications in the current non-timber harvesting revenue collection system and forest patrolling structure of the Sundarbans Mangrove Forest. (Source: Drawn by M. Shariful Islam, 2016, adapted from figure 5.25, 2016)

The modification in the current non–timber harvesting revenue collection system and forest patrolling structure will be helpful for the transparency in the revenue collection system and in strengthening the monitoring and controlling of illegal overharvesting of fish as well as protecting the illegal tree felling and wildlife poaching.

This model introduces a digital system (computer server system) of revenue payment entry (harvesting permission fees, BLC, and royalty collections) and the possibility of sharing information on revenue collection among all Forest Department Administrative Units and the National Board of Revenue (Authority of Revenue) for ensuring the transparency and accountability of revenue collection. This would also be helpful in illuminating the extra money being collected from the fishermen in regards to revenue collection. In addition, the digital (computer) data entry system would allow the fishermen to receive an official annual revenue document, such as a receipt, showing payment.

This model also introduces a weight measurement machine for all Forest Station Units in measuring the weight of fish harvested. This would be useful in collecting accurate data (according to actual weight) in revenues from the fishermen and would be helpful in protecting over-harvesting of fish.

In addition, the Forest Station Units would be able to use a helicopter for the purpose of patrolling and monitoring activities in the forest. This would include using drone(s) which would be ideal for monitoring over-harvesting, illegal cutting of trees, illegal wildlife poaching, and pirate activities. This would be an effective way to monitor and limit forest manpower. A GPS system can also be used in monitoring and tracking of harvester's boats as well as their activities. In addition, this would allow a glimpse into the legal fish harvesting practices of the fishermen. A GPS system can also be used for monitoring of patrol duties (forest patrol boats). To identify a fishermen's boat, a number plate can be implemented for each fishermen's boat. This would allow for a clear identification of the boat that has a legal permit versus one that is fishing illegally.

5.6 Weaknesses in the fishermen's motivations and participation in the decision-making process

The survey identified gaps in the relationship between the fishermen and the Forest Department in terms of their motivation for conservation efforts in the Sundarbans and their participation in the decision-making process. Under the present management system, there is a lack of collaborative research to support an improved understanding and management of the mangrove forest resource, particularly regarding fisheries inventories and socioeconomic analyses of fishermen communities. Table 5.16 outlines weaknesses in the fish harvester's motivations and participation in the current management of the Sundarbans Mangrove Forest.

Table 5.16: Current weakness in motivation, participation and research work.

Weaknesses in conservation motivation, participation in decision-making, and research	Recommendations
<ul style="list-style-type: none"> ▪ The administrative unit of the Sundarbans Forest Station plays only one role with harvesters- granting harvesting permissions and collecting revenue. Fish harvesters unfortunately lack knowledge of forest conservation, harvesting rules, and forest law. ▪ A lack of participation by fishermen in the decision-making process about fish harvesting issues in the Sundarbans. ▪ A lack of research on the fisheries and forest resources and the socioeconomic impact of the fishing ban on communities. 	<ul style="list-style-type: none"> ▪ Include a team to motivate and train the staff of the Sundarbans Forest Station. This team could also work to raise the fish harvesters' awareness and knowledge of forest conservation, harvesting rules and forest law. This would help to improve relations between the Forest Department and the harvesters, and change the harvesters' attitudes towards mangrove conservation, and thereby help to reduce over-harvesting, illegal felling and wildlife poaching. ▪ Involve the fishermen in the decision-making process. ▪ Incorporate a research team into the Sundarbans Forest Division to undertake a fisheries and forest resource inventory and investigate the socioeconomic impacts of the fishing ban.

Sources: Field survey, 2016

5.7 Fuel wood harvesting issues in the Sundarbans Mangrove Forest

The study found that despite being illegal, approximately 99% of the fishermen harvested fuel wood (live and dead) from the Sundarbans Mangrove Forest. The fishermen commonly stated they undertook this illegal harvesting because there was a lack of alternative fuel wood sources for household uses, particularly for cooking. In this situation, Forest Patrol staffs are unofficially receiving payments from the fishermen for the harvested fuel wood. Table 5.17 outlines the current scenario of fuel wood use and harvesting by fishermen and recommendations for minimizing the resultant problems.

Table 5.17: Fuel wood scenarios in the Sundarbans Mangrove Forest.

Scenario	Result	Recommendations
<ul style="list-style-type: none"> Fuel wood is used by approximately 80% of the households. Fuel wood and cow dung is used by approximately 12% of the households. Fuel wood, cow dung and straw is used by approximately 8% of the households. Alternative fuel (for cooking) is not available in the local areas of the Sundarbans Mangrove Forest. The Forest Department declared that the harvesting of fuel wood (live or dead) from the Sundarbans Mangrove Forest is prohibited. 	<ul style="list-style-type: none"> Approximately 99% of the fishermen carry fuel wood in their boats along with the harvested fish. The Forest Department's patrols are collected unofficial money from the fishermen for carrying fuel wood in their boats. If the fishermen refuse to pay, they are deemed as illegal wood harvesters. As a result, 99% of the fishermen are bound to unofficial payments to the forest patrols. 	<ul style="list-style-type: none"> An alternative and cheaper fuel (for cooking) should be introduced in the communities. Allow a certain amount of dry or dead wood to be harvested. This can be monitored by the Forest Station Unit. Governmental and non-governmental organizations can take the initiative to supply alternative fuel wood and other energy sources to the Sundarbans' local communities (e.g. Biogas plant, solar energy) to solve the fuel wood crisis.

Source: Field Survey, 2016

5.8 Major Problems with the current management of the Sundarbans Mangrove Forest

The survey found numerous problems with the current management of the Sundarbans Mangrove Forest. Table 5.18 outlines details of the key problems and recommendations for their resolution.

Table 5.18: Major problems with the current management of the Sundarbans Mangrove Forest.

Problems	Details	Management recommendations
Pirates	<ul style="list-style-type: none"> ▪ Pirates forcefully profit from the fishermen. ▪ Large amounts of money are illegally obtained by pirates. 	<ul style="list-style-type: none"> ▪ There is a need for cooperation between the Defense Ministry and the Forest Department to eradicate piracy. ▪ Need commitment and support from local governments and political leaders to eradicate piracy. ▪ Create public awareness and media responsibility. ▪ Use drone technology and helicopters to detect the pirates' positions inside the forest.
Revenue	<ul style="list-style-type: none"> ▪ Revenue collection corruption is occurring (forest stations are profiting from the fishermen). ▪ Lack of equity and transparency in the revenue collection system. ▪ Harvesters are dissatisfied with the current revenue collection system. 	<ul style="list-style-type: none"> ▪ In all Forest Stations, establish a computer-based data entry system to document revenue collection from all harvesters. This system should be shared with the Sundarbans Forest Department, the Ministry of Forests and the Ministry of Finance. ▪ Ensure delivery of an official revenue payment slip (receipt) to every harvester. ▪ Install a GPS device in every patrol boat to track its monitoring of harvesting practices. ▪ Install boat number plates on each harvesters' boat and keep updated records of these number plates. ▪ Ensure all harvested products on the harvesters' boats are weighed and that this becomes a mandatory practice completed at the Forest Station checkpoints. ▪ Harvesters' royalty fees should be fixed according to

		<p>the weight of their actual harvested products.</p> <ul style="list-style-type: none"> ▪ A revenue monitoring board should be implemented (jointly with the Bangladesh Revenue Board and the Forest Department) to monitor revenue collections from the harvesting of non-timber forest products and hear complaints from harvesters about revenue issues. ▪ Revenue charges could be increased following consultation with the harvesters.
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Problems	Details	Management Recommendations
Patrolling	<ul style="list-style-type: none"> ▪ Insufficient monitoring of patrolling duties. ▪ Limited manpower and the large number of rivers, tributaries and canals in the Sundarbans makes effective patrolling difficult. ▪ Limited manpower and defense tools makes controlling pirates difficult. ▪ Forest Patrols collecting unofficial fuel wood harvesting payments from fishermen. 	<ul style="list-style-type: none"> ▪ GPS devices installed in all patrol boats so their patrolling activities can be monitored. ▪ GPS devices installed in all harvester's boats to monitor their activities. ▪ Usage of helicopters and drones for patrolling, including to detect pirates and illegal harvesters. ▪ Design new policies for fuel wood harvesting.

Reduction of fish harvesting area	<ul style="list-style-type: none"> ▪ Fishing ban in the core area is creating adverse socioeconomic impacts on local communities. ▪ Substantial losses of income for fishermen and revenue for the government. ▪ Increased unemployment among former fishermen. 	<ul style="list-style-type: none"> ▪ Allowing fish harvesting in the core area at specified times of the year. ▪ Socioeconomic impacts should be considered before declaring an area banned from fishing.
Lack of Scientific Management	<ul style="list-style-type: none"> ▪ Potential for forest fires, and pest and disease impacts on tree species. ▪ Poor decisions made in the management of non-timber forest product harvesting. ▪ Risk of forest loss and degradation. 	<ul style="list-style-type: none"> ▪ A zoning management system, and appropriate silviculture and fire management should be implemented. ▪ A detailed forest resource inventory and development of an appropriate policy and strategy for sustainable forest resource management. ▪ Increase the manpower and professionalism of the Sundarbans Forest Department. ▪ Incorporate a scientific research team into the Sundarbans Forest Department to guide sustainable forest resource management.

Source: Field Survey, 2016

6 CHAPTER VI-DISCUSSION

This study has found that a fishing ban in the core area of the Sundarbans Mangrove Forest has had a significant impact on the core area's fishermen communities. Approximately 40% of the core area's former fishermen are now unemployed and approximately 50% have obtained other labor-based employment (Figure 5.4). The core area fishermen's annual average income from fishing was EUR 2,625. Presently, their annual average income from other employment is EUR 511 (Figure 5.6). The core area fishermen's previous annual income was 5 times higher than their present income. In addition, most of the fishermen's new occupations are located outside of their local areas in the Sundarbans (Table 5.5), meaning they are now often separated from their families during the working months. Other consequences due to the fishing ban in the core area are failing fish-based industries, reductions in household fish consumption and associated increased nutritional deficiencies among family members, difficulties in paying for children's education, an inability of fishermen households to rebuild their homes, and families not being able to engage in community festivals (Figure 5.1). The fishing ban in the core area is creating negative socioeconomic and cultural impacts on fishing communities.

Fish harvesting in the core area of the Sundarbans was far better than in the buffer area in terms of the amount of fish caught and resultant income for fishermen and revenue for the Forest Department. The annual average fish extraction per fisherman in the core area was approximately 140 Quintals, while in the buffer area it is approximately 32.4 Quintals (Figure 5.7). Annual fish extraction in the core area was therefore 5 times higher than in the buffer area. Average annual income per fisherman when fishing in the core area was approximately EUR 2,625 (Figure 5.9), while in the buffer area it is approximately EUR 1,477. The core area fisherman's annual income was therefore nearly double that of what is gained in the buffer area. The core area fisherman made an average payment of EUR 855.68 per year in revenue to the Forest Department (Figure 5.11). However, in the buffer area, this payment is approximately EUR 192.28. The Forest Department was therefore collecting approximately double the amount of fishing revenue from the core area than they are now collecting from the buffer area.

This analysis shows that fishing in the core area has the ability to generate greater economic benefits than the buffer area.

The current Sundarbans Mangrove Forest Management structure includes functions geared toward the protection of timber species and wildlife, and revenue collection from non-timber forest products (i.e. fish, crab, honey and palm leaf). Through forest patrol activities, the Forest Department protects the timber species and wildlife from illegal tree cutters and wildlife poachers (Figure 5.16). The Forest Department also collects revenue from non-timber forest harvesters in the way of a Boat License Certificate (BLC), harvesting permits and royalties. However, the current management systems lacking a scientific basis, specifically regarding appropriate silvicultural practices, pest and disease control, fire management, forest regeneration (natural and planted) and zoning.

The current revenue management system for the Sundarbans Mangrove Forest has each of the buffer area's fisherman paying an extra unofficial amount of EUR 5.95 per annum to the Forest Department's revenue collectors for a BLC (Table 5.11). The annual BLC unofficial fees for all fishermen (Sundarbans, West Division) amounts to EUR 29,916. In terms of royalties, each of the buffer area's fishermen pays an extra unofficial amount of EUR 6.57 for a single fishing permit for 7 days (Table 5.12), which for all of the fishermen amounts to approximately EUR 290,433 per annum. Therefore, in addition to their official revenue collections, the Forest Department also collects extra unofficial payments from the fishermen that amount to approximately EUR 320,349 per annum.

The forest patrols and pirates are also illegally extorting money from the buffer area's fishermen in the Sundarbans Mangrove Forest (West Division). The pirates obtain approximately EUR 23.31 million annually and the forest patrols obtain approximately EUR 2.3 million annually (Figure 5.23). This indicates that fishermen are giving their hard-earned incomes to revenue collectors, pirates, and forest patrols. The total amount of illegal payments (approximately EUR 25.61 Million) is having a significant impact on the fishermen's incomes and it is approximately 21 times higher than the annual budget

(approximately EUR 1.21 Million) of the Sundarbans Mangrove Forest (Sundarbans, West Division). In contrast, the Forest Department receives only EUR 0.06 million per annum in legally-obtained fishing of revenue. This situation highlights a serious weakness in the current management of the Sundarbans Mangrove Forest.

Despite the serious issues with the current revenue collection system for the Sundarbans Mangrove Forest, there are opportunities for increasing revenue and enhancing the Sundarbans Forest Department and its management activities. Firstly and most importantly, piracy and corruption within the Forest Department must be eradicated. Due to the above-mentioned problems, the fishermen's income has been significantly reduced and the economic benefits have been lost in the communities as well as the Forest Department.

With limited forest manpower and having only traditional patrolling tools (boats and guns) to manage a large area of the mangrove forest, the Sundarbans is difficult to manage when it comes to fish harvesting and controlling overfishing, illegal tree felling, and wildlife poaching. Innovative and modern technologies (drones and GPS) can help to solve these problems. A computer server system can also be useful for transparency in the revenue collection system.

A research team should be set up in the current management structure of the Sundarbans Mangrove Forest where fishermen are involved in the decision-making process. This would ensure that benefits are received from fishing and that the negative socioeconomic impact on the fishing communities is minimized.

Using technology geared toward forest protection along with an improved revenue system would improve forest protection and provide for a transparency in the harvesting system. It would also allow the fishermen and their communities to feel a responsibility toward forest protection, and create an opportunity to harvest fish in the core area of the Sundarbans without a harmful impact. This scenario would ultimately improve the livelihood of the communities, contribute to the local economy, and improve forest revenues from fishing resources

7 CHAPTER VII - CONCLUSION AND RECOMMENDATION

7.1 Conclusion

The Sundarbans Forest Department has been unable to control the activities of pirates in the mangrove forests. There is also a lack of transparency in the Department's forest patrols and associated revenue collection processes. As a result, corruption ensues. In addition, there have been deficiencies in the Department's management of fish harvesting and its decision-making regarding socioeconomic outcomes for the local fishermen.

Current management of the Sundarbans Mangrove Forest results in the forest patrols and pirates illegally obtaining a large amount of money (i.e. EUR 25.61 Million) from the buffer area's fishermen each year. This seriously impacts on the fishermen's rightful income from fish harvesting. Clearly, a new approach is needed to prevent this exploitation. The Forest Department currently has adequate manpower to effectively manage the Sundarbans Mangrove Forest; however, it lacks the modern equipment and technology that would help to improve its management functions. The Department also does not have the necessary cooperation of the communities. These circumstances have allowed illegal harvesting, over-harvesting (i.e. fish, crabs, timber and other non-timber forest products) and pirate activity to be common throughout the mangrove forests. The Sundarbans Forest Department requires an appropriate budget which would allow for the purchase of modern equipment and technology. Such equipment and technology would enable the Department to design and implement a more efficient and transparent forest patrolling and revenue collection system to eradicate the illegal collection of money from fishermen by the forest patrols, revenue collectors and pirates. Achieving this will require political commitment including Defense Ministry cooperation. Moreover, an equitable and transparent revenue collection system will be essential for establishing trust and cooperation with the local communities. Eradicating the illegal collection of money from the fishermen would substantially raise their incomes, thereby helping to improve their livelihoods but also providing a basis for the Department to increase their legal fishing revenue collection (i.e. royalties). This additional revenue

could then be utilized to facilitate the Department's improved management of the Sundarbans forest. Such management requires appropriate silviculture and fire management, increased and modernized forest patrolling including via the use of drones, GPS and helicopters, and the eradication of overfishing, illegal tree felling, wildlife poaching, and the extortion activities of forest patrols, revenue collectors and pirates. Future management of the Sundarbans Mangrove Forest should also include greater participation by the forest-dependent communities in decision-making and management activities so as to increase their motivation and responsibility for more effective conservation of the forest and fisheries resources.

The current use of a fishing ban in the core area of the Sundarbans has created significant adverse socioeconomic impacts for the fishermen communities. Livelihoods have been seriously affected. For example, fishing-related businesses have closed or face viability challenges and many (approximately 40%) of the core area's former fishermen are now unemployed. Many of these people now have to migrate to urban areas for work and also face great difficulties in having their children properly educated. While the current management of the Sundarbans Mangrove Forest seeks to protect the forest and fisheries resources, there needs to be greater consideration of the socioeconomic impacts of the management strategy to ensure the continued well-being of the local communities. .

Without improved governance of the Sundarbans Mangrove Forest, the use of a fishing ban for conservation outcomes will not be beneficial to the well-being of the community. With improved governance and re-granting the community with fish and other forest product harvesting rights in parts of the core area, community food security, employment and livelihood development opportunities will also improve. If effectively managed, this would also facilitate beneficial conservation outcomes. The Forest Department should therefore develop a comprehensive plan for the long-term sustainable environmental, cultural and socioeconomic management of the Sundarbans Mangrove Forest.

For improved community and forest conservation benefits for generations to come, the above-mentioned recommendations should be implemented without delay. It is also

urgent that a scientific research team is established within the Forest Department to improve knowledge and ongoing monitoring of the Sundarbans' forest and fishery resources and the socioeconomic conditions and trends of the area's forest-dependent communities.

7.2 Recommendations

The current management of the Sundarbans mangrove forest lacks transparency in the revenue and harvesting system, lacks cooperation between the Forest Department and the forest harvesters, and lacks community involvement in the decision-making process. It also has been unable to create motivation toward responsibility in the conservation efforts of Sundarbans. The current management system also has an absence in scientific activities for resource management and decision-making. In addition, except for traditional boats and guns, the Forest Department has no other technology for patrolling the forest.

It is essential that an analysis and research is made into the scientific management of forest resources as well as on a socioeconomic level. The Forest Department should encourage fishermen's motivation in conservation efforts and help involve the communities in participating in the decision-making process. It should also introduce modern technology to improve patrols and the monitoring of the forest in its harvesting. This analysis of the current research activities, especially in view of the recommendations of the on-going research trends, recommends these meaningful and timely endeavors to be implemented to further efforts in the development of the mangrove forest of the Sundarbans:

- The technology of using GPS for tracking each harvester's boat and having mandatory identification number plates on all boats. This would ensure better monitoring and transparency of harvesting activities in the forest.
- It is difficult to regularly patrol 6,017 sq km of the Sundarbans which consists of 55 compartments (tracking zones) and this with limited manpower (21 Rangers and 86 Foresters). Modern technology should be introduced in the form of GPS, drones, and a helicopter that could more effectively patrol activities in the Sundarbans Mangrove Forest.

- A computer server system should be set up along with a software program at each Forest Station Administrative Unit which should include all harvesters' data on their revenue amounts (BLC, royalties, and permission fees), number of harvesting permissions received, and the amount of harvested products. This Forest Station server would be shared by the Sundarbans Forest Division, the Forest Department, the Ministry of Environment, and the Forest and National Board of Revenue Office.

- It should be ensured that every harvester will personally receive their harvesting revenue payment receipt and be provided a digital or Smart BLC (Boat License Certificate) card.

- Social and economic consideration should be taken into account when it comes to decision-making, whether to allow or ban a particular area from fish harvesting in the Sundarbans Mangrove Forest.

- Local governments and the national Ministry of Environment and Forests in Bangladesh have a responsibility to maintain security of the fisheries resource and the livelihoods of the country's fishermen. Hence, there is an urgent need for these authorities to display a political commitment to stamping out the illegal activities of pirates in the Sundarbans Mangrove Forest. These authorities should work in partnership with members of Parliament and opposition parties, and fishermen groups from local villages to highlight the problems with pirates operating in the Sundarbans Mangrove Forest. Such a partnership could involve public forums or the formation of a committee to develop initiatives to tackle the pirate problem. There is a particular need to ensure that the politicians are not supporting pirates (by providing funding, weapons and other tools) or profiting from their activities, and to promptly expel from political parties any members found to be engaging in these activities. There is also a need to raise awareness among the country's politicians and local communities of the detrimental effects that pirates are having on the local fisheries industry. This could help to reduce

the numbers of new pirate recruits. The committee should also play a leading role in encouraging pirates to cease their illegal activities by supporting them to obtain acceptable employment and make a positive contribution to society. The media also has an important social responsibility to play here as they have the power to better inform and educate the community about the negative impacts of pirate activities on the Sundarbans' fishermen and the economy of local communities.

- It is urgent to consider the core area fishermen's adverse socioeconomic impact due to a fishing ban in the core area.
- Decision-making in the Sundarbans Mangrove Forest Management should be considered with all stakeholders (research institutes, forest harvesters, GOs, NGOs, and the local community organizations). The opinions and scientific analysis of the social, economic, and environmental impacts need to be considered including decision-making in resources management.
- The present management system allows any fisherman from any village to receive permission to harvest from any Forest Station Unit. The present system should be changed with a specific village of the fisherman receiving the harvesting permit and paying the revenue at the specific Forest Station Unit. Every station should have a computer server based on revenue payment data as well as the ability to share its data via a shared computer system. Every Forest Station should deliver the annual revenue payment in a receipt form to all fishermen involved.
- The present harvesting management has no system for measuring actual weight of harvested products brought in by the fishermen. The Forest Department does not physically measure the weight of harvested products brought in. The Forest Department should set up an appropriate weight measurement machine in every

Forest Station Unit for ensuring proper weight measurements of the harvested products. The Forest Department should collect revenues and royalties according to the actual weight of harvested products.

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