A study on the development, evolution and efficiency of floodplain aquaculture enterprises in Bangladesh

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List of Abbreviations

BCC	Banker, Charnes, Copper
BDT	Bangladeshi Taka
CCR	Charnes, Cooper and Rhodes
CPR	Common-pool resource
CRS	Constant returns to scale
DEA	Data Envelopment Analysis
DMU	Decision making units
DoF	Department of fishery
DRS	Decreasing returns to scale
FPA	Floodplain aquaculture enterprise
GDP	Gross domestic product
ha	Hectare
IFLA	IFPA with lease-managed aquaculture
IFPA	Independently-formed FPA
IFSA	IFPA with self-managed aquaculture
IRS	Increasing returns to scale
km	Kilometres
MC	Management committee
ME	Mix efficiency
MoF	Ministry of finance
MT	Metric ton
NFPA	NGO-collaborated FPA enterprise
NGO	Non-governmental organization
RTS	Returns to scale
SADP	Second Aquaculture Development Programme
SE	Scale efficiency
SBM	Slack-based measure
TFP	Third Fisheries Projects
UAF	Utilized area of floodplain
VRS	Variable returns to scale

Abstract

While floodplain water-bodies remain the largest source of captured fish in Bangladesh, small-scale and self-organized aquaculture ventures have been found in these water-bodies since the mid-1980s. Although most of the floodplains are used for agricultural purposes in the dry season and composed of private lands, they turn into seasonal water-bodies during the monsoon because of the inundation caused by overflowing of neighbouring rivers. Such a floodplain water-body can be classified as a common-pool resource (CPR) because of its finite aquatic resources, and the potential difficulties of excluding local users due to its usual large geographical size. In Bangladesh, the Daudkandi sub-district of the Comilla district has become an important site for the development of floodplain aquaculture enterprise (FPA) in floodplains composed of private lands. In this area an early FPA was formed by the landowners in 1984 and, since 1996, an NGO, named SHISUK, has been developing more FPAs. While the NGO-collaborated FPAs (NFPAs) have been later expanded into other districts, the landowners of the Daudkandi region continue to form independent FPAs (IFPAs) without any external support. Because of all these expansions over the last three decades, the initial FPA management system, along with later modifications, provides an opportunity to study a new CPR organization and, at the same time, to investigate the important aspects of development, evolution and performance of aquaculture practices in the floodplains of Bangladesh. This study tries to achieve these two purposes.

At first, considering the FPA management system practiced in CPR, we try to theoretically frame the system in terms of the design principles developed by Ostrom (1990), which are frequently used as defining features of long-surviving successful user-managed CPR organizations. We attempt to find the match between the management system of the first NFPA, Pankowri Fisheries Ltd., and Ostrom's design principles. While the management rules of the NFPA match with the design principles, the design principles are not formulated without considering important variables like the cost borne by excluded past users, community's internal power relationships, resource aspect (for instance, private ownership of floodplain lands), etc.

In the next stage, to study the evolution of the management system, fifteen FPAs are selected from five districts to chart the major modifications in organizational and operational aspects after their inceptions. Organization of the FPAs evolves with increased realization of profitability among the landowners. Consequently, they have not only formed new FPAs by themselves but have also tried to confine the management rights and benefits among themselves by excluding the non-landowner participants. Such realization also renders the previous support of the non-landowners unnecessary, as the landowners now are readily willing to take the risk and responsibility of FPA enterprises.

The landowners' prominence is underpinned by the fact of their ownership of lands within the floodplain and, with FPAs being mature, this fact has gradually become more and more significant in determining the access rights to FPAs. Operationally, lease-based management has been introduced where the rights of aquaculture operation are transferred to the lessees from FPA's management committee. This mode of operation is an adaptive response to the problem of lower profits which hurts FPA beneficiaries. In communities where the FPA trend is relatively new, the participation of non-landowners in management still exists and FPA management committee runs the aquaculture operation instead of lessees. It is important to see which direction the involvement of non-landowners will take in the future.

In the final stage, the FPAs are compared in terms of their relative efficiency using non-parametric Data Envelopment Analysis (DEA) methodology. By using production data of year 2015-16, the technical, scale and mix efficiency along with the overall efficiency are measured with the help of three DEA models. Utilized land area, fish feed, stocked fingerlings, wage and salaries are used as inputs, and fish sales are considered as output. While eleven FPAs turn out technically efficient, only six of them show overall efficiency. On average, the NFPAs are more efficient than IFPAs. The results indicate that lease management, which has gradually been adopted by many FPAs, is not necessarily more efficient than self-managed FPAs, since only two lease-managed FPAs show overall efficiency. The approach of intensive use of inputs in many older FPAs' doesn't make them efficient, despite their higher fish yield than relatively newer FPAs—which are performing technically efficient ways with optimal scale and mix. While the lease-based aquaculture operation ensures positive returns for FPA investors, the aquaculture operations by themselves remain unprofitable or inefficient in some instances. Given its linkage with government and academic experts, NGO may play an intermediary role to connect such low-performing aquaculture operations with expert knowledge.

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Chapter 1

Introduction

1.1 Background of floodplain aquaculture in Bangladesh

Floodplains are low-lying lands adjacent to rivers that get inundated during the rainy season due to the overflowing of rivers. Riverine floodplains are known for their contribution to human civilization through development and expansion of agriculture. With the gradual industrialization of the current developed countries, and intensive farming in both developed and developing countries the importance and use of floodplains were also transformed by bringing them under human control (Tockner & Standord, 2002). However, in developing countries, a large part of floodplains is still very important for life and livelihood of rural communities where floodplains remain the subject of natural cycle of inundation and recession (Welcome, 1975; Hoggarth, 1999; Nagabhatla & Sheriff, 2009).

At present, the floodplains of the developing countries are used as a source of fish through capture and culture fisheries besides their use for agriculture, transport, forestry, water abstraction, water drainage, housing, industry, etc. (Hoggarth, 1999). The use of floodplains as source of fish is especially prominent in the countries of South America, Asia and Australia as shown in Figure 1.1. Peterson & Middleton (2010) also reported that Mekong river and its floodplains provide approximately 33%, 32%, 29% and 5% of the total national fish production in Cambodia, Thailand, Vietnam and Laos respectively. In similar way, floodplains provide 25% of national fish in Bangladesh (DoF 2017). In the countries where floodplains are used as a major source of fish, they are mainly used both for capture and culture activities, albeit with varied styles and intensities. For example, while the Paraná River and its floodplain have been used for aquaculture for decades in Argentina (Handisyde, 2013), there were attempts in addition to traditional aquacultural practices to introduce floodplain aquaculture in Cambodia and Vietnam (Joffre and Sheriff, 2011). On the other hand, in Bangladesh, aquaculture in floodplain has became a major trend in recent years as has been attested by the presence of extensive literature on related issues. Floodplain aquaculture is also practiced in China, Mali, India (Nagabhatla & Sheriff, 2009; Joffre and Sheriff, 2011)

Bangladesh is a low-lying South Asian country mainly composed of alluvial deposits borne by three large river systems—Ganga-Padma, Meghna and Jamuna-Brahmaputra—and their branches. This makes most of the lands of the country floodplains as they regularly get inundated during the annual monsoon of June-September. Floodplains compose more than half of the country's land, and contain privately-owned lands, as well as government-owned lands, open rivers, closed perennial water-bodies, etc. Floodplains composed of private lands are mainly used for agricultural purposes during dry season of October to May. On the other hand, government tends to hold rights overs large areas of floodplains because of historical

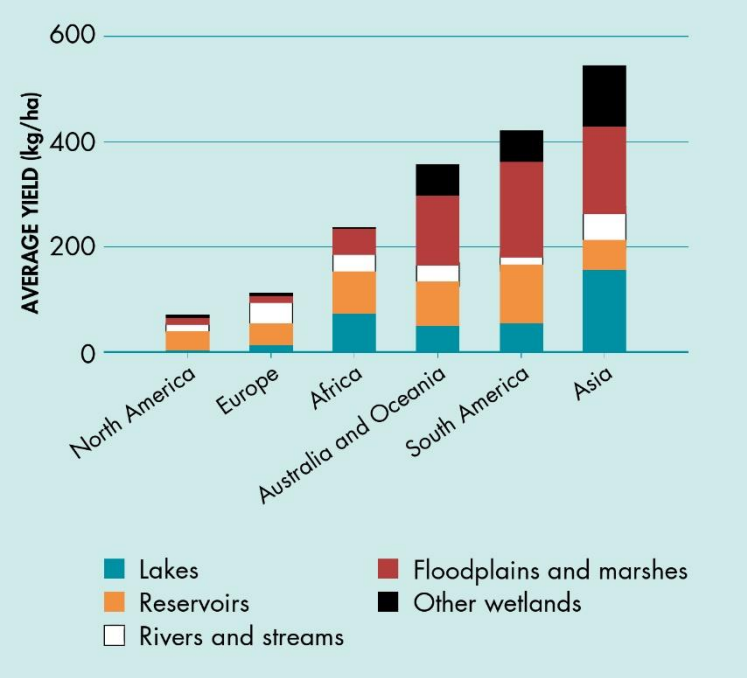


Figure 1.1: Global inland average fish yields by water-body type per annum for year 2014-15. Source: FAO, 2016; p.117.

background of colonialism. In many cases, both government lands and private lands situate side by side and monsoon flooding makes them unified water-body. In some cases, perennial water-body is surrounded by private agricultural lands, while in other areas the whole floodplain is composed of private lands. Regardless of their nature, a floodplain usually becomes a single water-body during the rainy season of June to September by inundating the lands which may be under various types of property rights. This makes a floodplain difficult to use for any culture-based fish production during the monsoon unless some collective arrangement is made among the right-holders of its lands. This is somehow more pertinent to the floodplains that is composed of private lands, as individuals cannot exercise the authority of government agencies in using the flooded lands. Thus, since the flooding makes boundaries among private lands unrecognizable and unusable, and no single landowner[1] legally and practically exercises property rights over a whole water-body, such floodplain water-bodies was mainly used as open access resources during the monsoon, and members of the community used these water-bodies for various purposes.

In Bangladesh, floodplains water-bodies—containing private and public lands—are mainly used as a source of harvesting naturally recruited fish. These seasonal water-bodies are still the single largest source (18.52%) of capture fishery, given their dominant area (69%) they held among the inland open water-bodies (DoF 2017). The usual practice for the government

[1] The number of landowners vary from floodplain to floodplain mainly depending on the areal size of the floodplain.

has been to use floodplain water-bodies—under its management—for earning revenues by leasing them to individual or group who harvest naturally occurred fish from these water-bodies. However, since the late 1980s in selected water-bodies, the government has operated production-enhancement projects based on stocking of fingerlings (Ahmed 1999; Islam 1999). Later studies reported that, at around the same time, a trend of collective fish farming in floodplains was also developed by the landowners who own lands there (Toufique and Gregory 2008). One of the earliest cited case of such collective initiative was to be found in the Daudkandi sub-district of Comilla district where landowners from a small floodplain formed *Dhanuakhola Nagarpar Adarsha Motsha Chash Prokalpo*[2] in their lands in 1984. Interestingly, this initiative was taken as a solution to prolonged water logging caused by contemporary building of flood control infrastructures (CIRDAP 2002).

On the other hand, the general impression gleaned from the fishery sector of the country in the mid-1980s was very bleak. The problems of the sector (e.g., poverty-stricken conditions of fishermen, declining yields from capture fishery, loss of natural fish and their habitat, etc.) were also intricately connected with other concerns like food security (large number of population with increasing need of animal protein) and community development (through ensuring profitable use of large inland water-bodies) (Hossain et al., 1998; Thompson et al., 1999; Alam and Thompson 2001). In simple terms, the challenge was the same as it was around the globe—to increase the fish yield in a sustainable way. From the mid-1980s, different types of reforms were introduced in the fisheries sector in Bangladesh, most of which were targeted toward inland water-bodies. One of the highlights of the reforms was New Fisheries Management Policy (NFMP) of 1986. Side by side various projects were also undertaken to implement new policies and experiments. Some of them, like, Second Aquaculture Development Programme (SADP) and Third Fisheries Projects (TFP) tested stocking-based yield enrichment in floodplains, while others, like Aquaculture Technology Adoption, aimed at expanding aquaculture practices among fishers. In 1996, Community-based Fishery Management (CBFM) programme was initiated with a focus on co-management. In many of these projects (and all CBFM projects), various NGOs worked closely with the community people as providers of management system, organization and/or credit support. Thus, by the middle of 1990s, a general environment existed where, on the one hand, group or collective management of aquaculture enterprises in floodplains could be found, at least in some rudimentary form, and, on the other hand, scopes of partnership between community and extra-community entities (i.e., NGOs) had been opened (Thompson et al., 1998 & 2003; Hossain et al., 2006).

[2] In English, Dhanuakhola Nagarpar Ideal Fish Farming Project

Amid such developments, when an NGO named SHISUK[3] initiated collaborative aquaculture programme in the Daudkandi sub-district, the presence of a moderately successful example of landowners-managed collective aquaculture in floodplain immensely assisted the implementation of the programme. While Dhanuakhola provided a general framework for organizing and managing collective aquaculture, the NGO significantly improved the management system and broadened the scope of its operation and provided necessary example of highly profitable enterprise. The general idea behind this management system is that the landowners of a floodplain collectively invest to initiate aquaculture to bear the costs of the operation (e.g., infrastructure, stocking fingerlings, feed, harvesting cost, etc.), and share returns according to their investment. The principal modifications and improvements that the NGO brought to the management practice included formal share-based investment, separation of dividends paid to investors from land rents paid to landowners, inclusion of non-landowners, better bookkeeping procedures, etc. Thus, by collaborating with the community members of landowners and non-landowners, the NGO assisted to form Pankowri Fisheries Ltd in 1996. The most enduring success of the NGO collaboration has been that it showed that collaborative and collective aquaculture enterprises could be profitable and manageable in larger floodplain water-body. The demonstration of profit and manageability resulted in proliferation of aquaculture enterprises in floodplains through, on the one hand, by landowners' own initiatives, and, on the other, by the NGO collaboration in the Daudkandi and other regions. The rate of spread was so impressive around the Daudkandi region that the management system started to be identified as the Daudkandi model, and SHISUK was credited with the pioneering role in its innovation and spread. Although there are other FPA management systems (Mustafa and Brooks, 2009; Sultana, 2012; Haque et al., 2011; Dey et al. 2013; Khan, 2015), the SHISUK-promoted management system can be called representative FPA management system because of its considerable coverage and common presence among the studies.

However, none of these studies framed the management system from a theoretical perspective, chart the management system's evolution since its development and measured internal efficiency of the aquaculture enterprises adopted this management system. This study aimed to fill these three gaps. Within this study, the term floodplain aquaculture (FPA) is principally used to denote the collective group that is formed for managing aquaculture in floodplain water-bodies. However, depending on the context, it will also indicate to the emerging and distinctive practice of aquaculture in floodplains. Before specifying the objectives of the

[3] *Shikhya, Shastha, Unnayan Karjakram* in Bengali, which can be translated into English as Education, Health and Development Programme.

study more narrowly, the next section briefly reviews the past literatures that led to the formulation of the subject and scope of present study.

1.2 Review of previous studies

Each of the chapter 2, 3 and 4 contains reviews of relevant literatures in their introductory sections. This section is confined to tracing two more general backgrounds of the study. First, the development of stocking practices in floodplains, and second, the emergence of this management system in policy and research literatures.

The fisheries sector of Bangladesh is currently culture dependent. The latest report of Department of Fishery (DoF) for the year 2016-17 highlights the situation by comparing the present condition against the status of fisheries sector in 1983-84, when the contribution of inland capture and culture fisheries to total fish production were 62.59% and 15.53% respectively. By contrast, in 2016-17, inland capture fisheries contribute only 28.14% and inland culture fisheries contributes 56.44% to total fish production. The rest is contributed by marine sources. In terms of economic value, fisheries sector contributed 3.61% in the total GDP[4] of the country for the year 2016-17 (MoF, 2017), although species-wise monetary value is not available in the published reports. Internationally, Bangladesh is the third largest producer of capture fisheries, while in terms of aquaculture it is the fifth largest producer (FAO, 2018).

In overall prominence of aquaculture in terms of domestic production, the role of floodplains of Bangladesh has been gradually improving. As already mentioned the early floodplain stocking projects were conceived in late 1980s and started to implement around the same time or in early 1990s. Two pioneering projects in this regard were SADP (Ahmed 1999) and TFP (Islam 1999). In both these projects, mainly large floodplains under government management were stocked and majority of them also contained proportional perennial water-bodies. Under SADP stocking continued for 1989-96, while under TFP for 1991-97 periods. Both studies also mentioned that after the completion of projects community people started stocking activities on their own on small scale. However, the involvement of community people in both projects were low to moderate as they were implemented mostly in government water-bodies. As a result, Ahmed (1999) reported that fish yield from floodplains was gradually increasing due to artificial stocking since 1989-90 as shown in Figure 1.1. However, such increase was not contributed to aquaculture in annual government report of fishery resources survey system (FRSS) until 2009-10, when, for the first time, FRSS reported the aquaculture production data from seasonal floodplain water-bodies. At present floodplain aquaculture holds immense

[4] The GDP is BDT 19,758 million (USD 250 million)

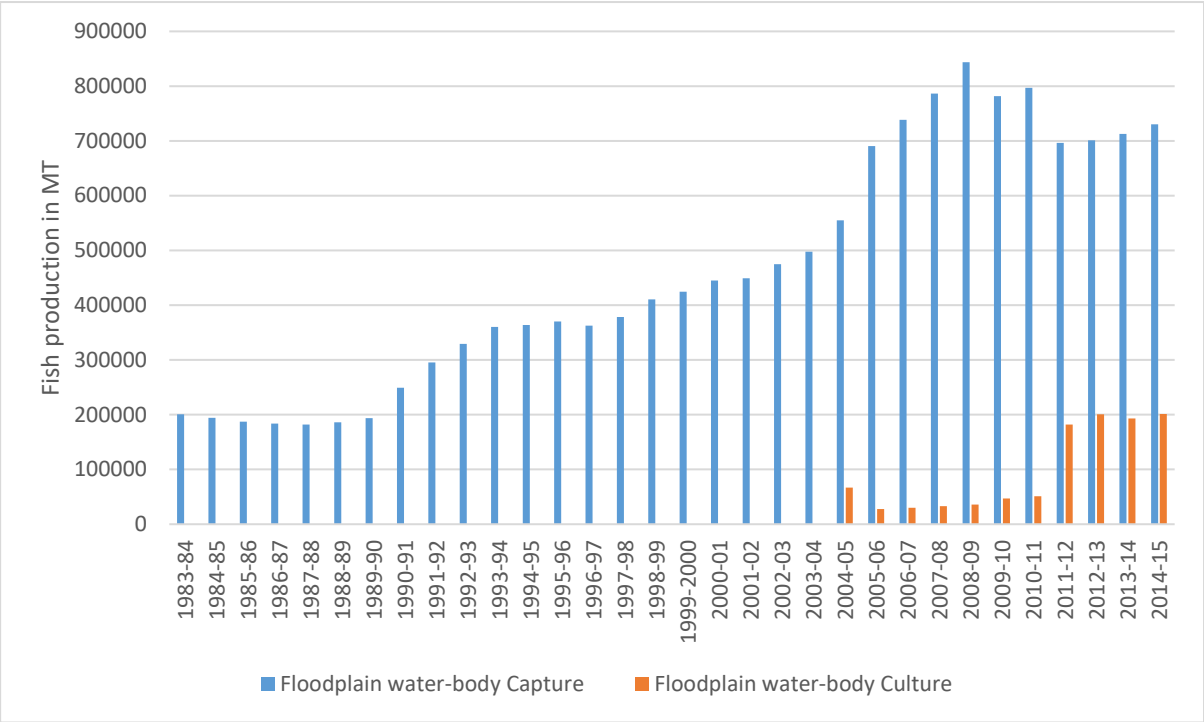


Figure 1.2: Fish yield from floodplain water-bodies (FRSS 2015 & 2017)

possibility as indicated by FRSS 2017 data which showed that the rate of yield from cultured floodplain is 1539 kg/ha while that from capture floodplain fishery is only 276 kg/ha. Table 1.1 shows the major cultured species in the FPA[5].

The stocking of private floodplains was reported in a study (Thompson et al., 2005) conducted on the sustainability of an earlier extension project (1990-93) in Kapasia sub-district. This study claimed that during the project stocking idea was promoted/tested in selected floodplains, where mostly landowners collectively mange the culture operations. However, the continuation of stocking operations was irregular as the collective initiative was marred by intra-group conflicts. It seems that the community users from this area were yet to achieve a manageable model for aquaculture enterprises in their floodplains.

The management system subject to the present study was reported as a solution to the problem of collective organization and management by many studies. One of the early studies was conducted by Centre on Integrated Rural Development for Asia and the Pacific (CIRDAP) in 2002 and mainly focused on Pankowri Fisheries Ltd. This report gave a general picture on the historical development (e.g., building flood control embankments, etc.) that set the necessary context for the development of floodplain aquaculture in the Daudkandi region. At the same time, this study set the tone of later works on the management framework, which were mostly concentrated their efforts on the effects of the aquaculture enterprises formed by adopting this

[5] Major species produced in Bangladesh is presented in Appendix 1.

management framework. CIRDAP study identified several merits (increased fish production, improved soil fertility, income generation, infrastructure development, etc.) of Pankowri Fisheries Ltd., along with some weakness (risks of commercial fish production, exclusion of rural poor and marginal people, capture of benefits by rural elites, among others). All the following studies, until now, mainly elaborated the conclusions of this report. For example, in 2007 Gregory et al. published a study drawing the identical conclusions. This study also raised concern over the loss of diversified naturally occurred fish due to erection of enclosures for controlling the movement of water around the floodplain.

Table 1.1: Species composition of cultured fish production of floodplain water-bodies for year 2016-17

Sl. No.	Species	Total Catch (MT)	(%)
1.	Rui *(Labeo rohita)*	50547	23.45
2.	Catla *(Catla catla)*	22548	10.46
3.	Mrigal *(Cirrhinus cirrhosus)*	23901	11.09
4.	Kalibaus *(Labeo calbasu)*	386	0.18
5.	Bata *(Labeo bata)*	9771	4.53
6.	Ghonia *(Labeo gonius)*	2379	1.10
7.	Silver Carp *(Hypophthalmichthys molitrix)*	34685	16.09
8.	Grass Carp *(Ctenopharyngodon idella)*	11215	5.20
9.	Common Carp *(Cyprinus carpio)*	22038	10.22
10.	Boal/Air/Guizza Air *(Wallago attu/Sperata aor / Sperata seenghala)*	115	0.05
11.	Shol/Gazar/Taki *(Channa striatus/C. marulius/C. punctatus)*	227	0.11
12.	Koi *(Anabas testudineus)*	1332	0.62
13.	Singhi/Magur *(Heteropneustes fossilis/Clarias batrachus)*	45	0.02
14.	Big Prawn (e.g., Galda)	678	0.31
15.	Small Prawn	1063	0.49
16.	Tilapia/Nilotica *(Oreochromis mossambicus/O. niloticus)*	21904	10.16
17.	Sarpunti *(Puntius sarana)*	8103	3.76
18.	Other Inland Fish	4611	2.14
	Total	**215547**	**100.00**

Source: DoF 2017, p 51.

These conclusions were mostly echoed in the study conducted by Toufique and Gregory in 2008. This study elaborated on the theme of exclusion of small scale fishermen and other community members because of turning the open access floodplain water-bodies into a closed-access water-body under collective management of aquaculture enterprises. A comparative study (Mustafa and Brooks, 2009) produced related results by juxtaposing the aquaculture enterprises under this management framework against aquaculture enterprises in other semi-closed water-bodies. This study concluded that while the SHISUK-collaborated aquaculture enterprises had high productivity, their benefits were confined to the landowners of the floodplains and achieved at the cost of bio-diversity loss in terms of reducing the number of naturally recruited fish. Another comparative study (Sultana, 2012) also reached the same types of conclusions. While all these studies mostly reiterated the same conclusions in terms of

weakness of the aquaculture ventures under this management framework (although they concentrated mostly on NGO-collaborated aquaculture enterprises) and, most of them also highlighted the innovative approaches of this management framework.

However, none of them explored the management rules from the any theoretical perspective or charted how the rules and practices under this management have been changed, if ever, over time by the participants. Additionally, these studies overlooked the fact that the management framework adopted by both NGO-collaborated and landowners' self-organized enterprises and, thus, failed to consider internal comparison among them. This study attempts to fill these gaps.

1.3 Purpose of research & research question

The general objective of this study is to identify how this FPA management system fits within the existing theoretical framework of CPR management and, at the same time, to investigate the important aspects of development, evolution and performance of aquaculture enterprises formed adopting this management system. The study tries to answer three following questions:

A. How the rules of this management system match with the design principles identified by Ostrom (1990) as the underlying principles for sustainable common-pool resource (CPR) institutions? The reason for this theoretical framing is that the floodplain water-bodies can be classified as CPRs because of their usual large size which make it difficult to exclude potential beneficiaries and the limited amount of aquatic resources they hold.

B. What kind of changes, if any, in the rules and practices under this general management system, have been introduced over time by the participants? It is a common phenomenon among

CPR literatures that the users of a CPR usually change the rules of their organization and management of resources as they experience new situations, developments and problems.

C. Finally, how these aquaculture enterprises compare against one another in terms of efficiency? The efficiency measurement is necessary to understand the operations of the floodplain aquaculture from practical perspective and to acquire a general understanding about how the efficiencies of the FPAs relate to the management variations.

1.4 Research methods and sites

Each of the chapter 2, 3 and 4 provides a detail methodology used in the collection and analysis of data used in those chapters. In general, all data were collected by conducting extensive field visits in five districts of Bangladesh. The sites were selected on the basis of presence of floodplain aquaculture in the community. As the Daudkandi sub-district was the site where first FPA was established under the focused management system, and witnessed the subsequent proliferation of FPAs, most of the FPAs were selected from this site. The NGO, SHISUK, since early 2010s introduced this FPA management system in other parts of the country. At the time of the study there were four sub-districts, beside Daudkandi, where NGO-collaborated FPAs were found. All FPAs from these sites (Shingra, Harirampur, Nazirpur and Rajapur) were also studied. Overall 15 FPAs were studied from these sites. The primary method employed for data collection was questionnaire-based surveys, interviews and participant observations. Most of the interviews were conducted during the site visits. Follow-up interviews were conducted over phone and e-mail. While qualitative data were collected from extensive interviews and participant observations from site visits, quantitative data were collected from FPAs' official records.

1.5 Organization of the thesis

Chapter 2, 3 and 4 of the thesis deal with the specific research question mentioned in A, B and C respectively of the section 1.3. In Chapter 2, the management system is described at a point when the NGO got already involved in promotion and expansion of FPA by considerably modifying the system that had been developed by the landowners. The application of Ostrom's design principles in this chapter is concentrated on the FPA management system the way it is practiced in the NGO-collaborated FPA, rather than all FPA in general. As such, the term "Daudkandi model" is used in this chapter to denote the management system. The subsequent modifications that were introduced in next two decades in both NGO-collaborated FPAs and landowners self-organized FPAs are articulated in Chapter 3. The efficiency measurements of the same sample set of Chapter 3 are presented in Chapter 4. Chapter 5 concludes the thesis by providing a general conclusion and policy implications of the findings of study.

Chapter 2

The Daudkandi Model of Community Floodplain Aquaculture in Bangladesh: A Case for Ostrom's Design Principles

2.1 Introduction

Floodplain water-bodies are one of the major common-pool resources (CPRs) of Bangladesh (Thompson et al. 1998; Sultana and Thompson 2008). Bangladesh is a delta and most of its 147570 km^2 area (BBS 2011) is mainly composed of alluvial deposits borne by the Ganga-Padma, Meghna and Jamuna-Brahmaputra rivers and their branches. Floodplains constitute more than 55% of the land, and on annual basis from 26000 km^2 to 82000 km^2 of them get inundated in the monsoon and remain so for the next few months. According to Fisheries Statistical Yearbook of Bangladesh 2013–2014 compiled by Fisheries Resources Survey System (FRSS) of Department of Fisheries DoF), Bangladesh has 2.8 million ha of floodplain water-bodies (FRSS 2015). These water-bodies are seasonal in nature and formed by submerging large or small areas of lands during the monsoon. Each of these water-bodies, in the majority of cases, brings privately owned lands of different landowners within it by flooding them, and turns them into a single continuous resource system by practically making the boundaries among the lands unrecognizable and unusable. Therefore, no single landowner legally and practically exercises property rights over a whole floodplain water-body. This reality makes floodplain water-bodies open for surrounding community members, and, as the landowners had no collective aquaculture management system, until recently these water-bodies remained as sources of capture fish, rather than cultured fish.

In this context, floodplain aquaculture (FPA) is a recent development in Bangladesh as such practice was first reported in early 1980s. A WorldFish study (Belton et al. 2011) attributed its introduction to a local non-governmental organization (NGO) named SHISUK. This FPA management system, developed by SHISUK with community collaboration, was started as an independent pilot project without support of any government body in 1996 in the Daudkandi upazila (sub-district) of the Comilla district. The management system later gained popularity as the Daudkandi model of community fishery/aquaculture or FPA regionally and nationally, and henceforth will be mentioned as such or simply as the model in this chapter. The Daudkandi model has been adopted by more than 90 similar FPA projects and companies around Daudkandi upazila (Toufique and Gregory 2008). Sultana (2012) also mentioned that the model received considerable policy attention in the context of an annual 30–100% rise in enclosure-based private seasonal FPAs in subsequent decades in different parts of Bangladesh. Although the model is unique for several reasons, one of its most important features is that it keeps management of the FPA in the hands of community of users. If the fact that floodplains are CPR is considered, management by local users becomes more significant.

However, management of a CPR, even by the community of users, is very delicate and complex because of two characteristics all CPRs share: a) exclusion of appropriators is costly,

meaning it is difficult to deny access to it, and b) the unit of the resource extracted by one appropriator is subtracted from availability for others to extract (Ostrom et al. 1999; Tietenberg and Lewis 2009). These two aspects of CPRs make their management a focus of a long-drawn investigation within and among international agencies and academicians for past few decades (Van Laerhoven and Ostrom 2007; Fennell 2011). In 1954, Gordon expounded in his seminal work a theory of open access fishery commons. Based on this same principle, Hardin (1968) subsequently generalized a tragic consequence of all commons due to the unsustainable nature of exploitation by the users of the commons (Béné 2003). For Hardin, the solution would be to bring the commons under private or state management. However, field data illustrated that both the private property and government management systems have had their failures (Feeny 1994; Feeny et al. 1996; Ostrom et al. 1999). Internationally this led to a search for the commons successfully managed by their users. Data collected from the field presented both successful and unsuccessful user-managed CPRs (Ostrom 2000). By studying both types of CPR institutions, Ostrom developed, in her book Governing the Commons (1990), 'a series of design principles that characterize the configuration of rules that are used' (Ostrom 2000: 40). She defined design principles as an 'element or condition that helps to account for the success of these institutions in sustaining the CPRs and gaining the compliance of generation after generation of appropriators to the rules in use' (Ostrom 1990: 90). According to Ostrom, most long-term CPR institutions are characterized by most of these design principles, whereas the not-so successful institutions 'tend to be characterized by only some of these design principles' and failed institutions 'are characterized by very few of these principles' (Ostrom 2000, p 40).

This study uses these design principles in analysing the Daudkandi model on two grounds. First, Ostrom's design principles can be a good diagnostic framework to study the management rules of the FPAs formed under the Daudkandi model. These principles, through empirical studies, have been found to be the characteristics of successful CPR institutions and may be used for studying such institutions formed by users of resources under various institutional mechanisms. Second, Ostrom argues that a self-governed CPR is one wherein 'major appropriators of the resource, are involved over time in making and adapting rules within collective-choice arenas' and in the modern political economies it is highly usual that 'in a self-governed system, participants make many, but not necessarily all, rules that affect the sustainability of the resource system and its use' (Ostrom 2002: 1317). Initially in the co-management era, primary partners in managing a resource were government and the users, and that regime has been looked into through Ostrom's framework (Gelcich et al. 2006; Yandle 2003 and 2008; Schreiber and Halliday 2013; McClanahan et al. 2015). That clear dichotomy has

changed in subsequent years through various experimentations, and in the case of present study, as will be shown, community users formed the main partnership with the NGO without any government initiative framework for and involvement in managing their resource. The application of Ostrom's design principles in such cases may give an opportunity to understand the various aspects and direction of such emerging partnership.

The chapter is outlined as follows: section 2 reviews the evolution of the management system of open inland water-bodies. Methodology and data collection are outlined in section 3, followed by a summary presentation of the Daudkandi model in section 4. Collected data regarding management rules of the FPA are explored within Ostrom's design principles in section 5. Section 6 concludes the chapter by discussing significant findings and their implications.

2.2 Management of inland open water bodies of Bangladesh and involvement of NGOs

Bangladesh has several types of inland water-bodies: rivers and estuaries, oxbow lakes (boar), permanent or semi-permanent water bodies (beel[6] and hoar[7]), floodplains and marshes. According to FRSS-2015, as shown in Table 2.1, while 83.22% of 3.54 million metric ton national fish production come from inland water-bodies, floodplain water-bodies provide more than 26% of this inland (combining captured and cultured as shown in the shaded rows of Table 2.1) fish yield.

Since the British colonial period, the majority of these inland water-bodies, except privately owned ponds and most floodplains, had been under the government ownership and considered a major source of revenues. In 1950, after the colonial period, the ownership of these water-bodies was brought under the Ministry of Land (MoL). Under the MoL the main mechanism of managing these water-bodies (including government owned floodplains) was a periodic leasing system for one to three years to the highest bidder. After the independence of Bangladesh in 1971 the system remained more or less the same, although different initiatives were taken for adopting a more appropriate fisheries management practice. This system, along with later experiments, faced severe criticisms for failing to sustain biological fisheries resources and ensure economic and social development of small but genuine fishermen through equal distribution of benefits derived from these water-bodies (Hossain et al. 1998; Thompson et al.

[6] Beel a large surface waterbody that accumulates surface runoff water through internal drainage channels. Beels are small saucer-like depressions of a marshy character. Many of the beels dry up in the winter but during the rains expand into broad and shallow sheets of water, which may be described as fresh water lagoons.
[7] Haor is a bowl-shaped large depression. It receives surface runoff water by rivers and other water-bodies, and consequently, a haor becomes very extensive water-body in the monsoon and dries up mostly in the post-monsoon period.

Table 2.1: Sector wise annual fish production

Fisheries Sector	Water Area (Hectare)	Total Production (Metric Ton)	%
A. Inland Fisheries			
a) **Inland Open Water (Capture)**			
1. River & Estuary	853,863	167,373	4.72%
2. Sundarbans	177,770	18,366	0.52%
3. Beel	114,161	88,911	2.51%
4. *Kaptai* Lake	68,800	8,179	0.23%
5. Floodplain	2,595,529	701,330	20.09%
Total Capture	**3,910,053**	**995,805**	**28.07%**
b) **Inland Closed Water (Culture)**			
6. Pond	371,309	1,526,160	43.01%
7. Seasonally cultured water-bodies†	130,488	193,303	5.45%
8. *Baor*	5,488	6,514	0.18%
9. Shrimp/Prawn Farm	275,274	216,447	6.10%
10. Pen culture*	6775	13,054	0.37%
11. Cage culture	7	1,447	0.04%
Total Culture	**789,341**	**1,956,925**	**55.15%**
Total Capture and Cultured Inland Fish	**4,699,394**	**2,952,730**	**83.22%**
B. Marine Fisheries	--------	**W595,385**	**16.78%**
Country Total		**3,548,115**	**100%**

*Pen culture is also a kind of aquaculture conducted in floodplain around the year
†Seasonally cultured water-bodies are paddy field, floodplain, etc. which are under in fish culture
Shaded rows show the contribution of floodplain water-bodies in national fish production
Source: FRSS 2015

1999; Craig et al. .2004; Hossain et al. 2006). To all this were added the problems of feeding a population growing at an ever-increasing rate.

To deal with these problems, in 1986, the New Fisheries Management Policy (NFMP) was devised with a long-term goal of gradually phasing out leasing system by endowing management responsibility for the water-bodies to the DoF of Ministry of Fisheries & Livestock (MoFL) from the MoL (Middendorp et al. 1999; Thompson et al. 1999). The institutional limitations of the DoF and the success stories of various NGOs in many fields led to different types of collaborations between DoF, NGOs and local fishermen, some of which brought significant advances (Hossain et al. 1998). In these projects NGOs were mainly responsible for forming and training of fishermen group, awareness creation, developing management and operational system, and providing credit facilities (Ahmed et al.1992; Ahmed et al.1997). This trend gave the NGOs the opportunity to get involved as partners with fishermen or community members— with or without support of government— in the management of water-bodies in

various roles in different projects. Amid all this development, the NGO SHISUK without any government support developed the Daudkandi model of FPA in collaboration with community people of the Daudkandi sub-district.

2.3 Methodology

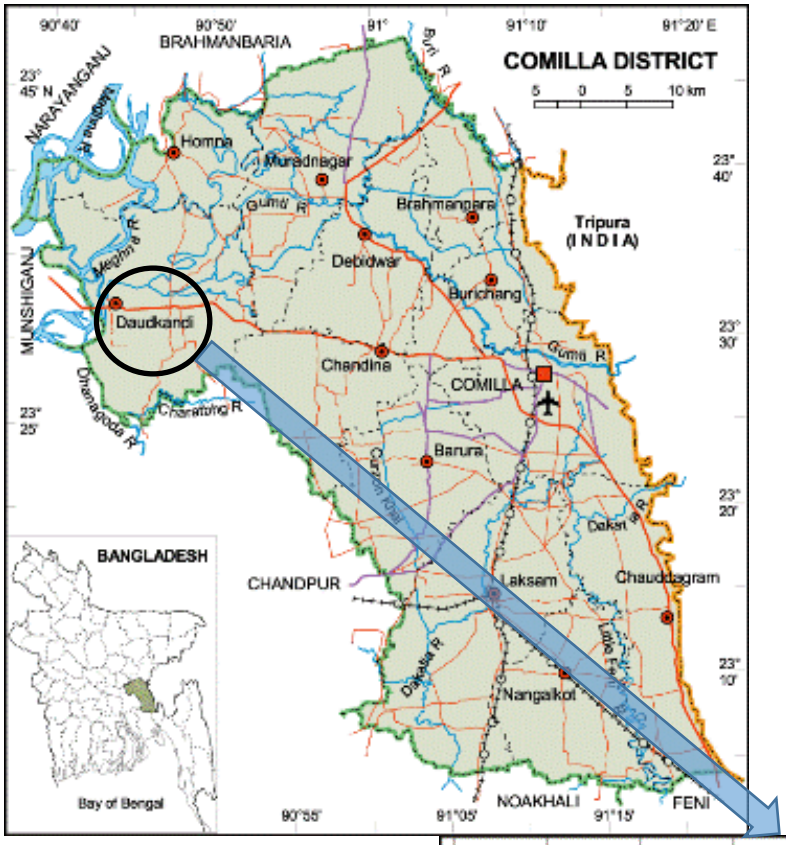
2.3.1. The Site:

The Daudkandi model was adopted initially as a pilot FPA project in 1996 and then formally through Pankowri Fisheries Ltd. in 1997. As Figure 2.1(b) shows, the site is 2.5 kilometres (km) north from Dhaka-Chittagong highway (indicated by red line) and spread through six villages: Charaipara, Hasherkhola, Ataikhloa, Dhanuakhola, Vashkhola and Patch-pukuria of the Elliotgonj union of Daudkandi upazila of Comilla district. Comilla District, as shown in Figure 2.1(a), is of 3085.17 km^2 area and located between 23°02´ and 24°47´ north latitude and between 92°39´ and 91°22´ east longitudes. It is bounded by Brahmanbaria and Narayanganj Districts on the north, Noakhali and Feni Districts on the south, the Tripura state of India on the east and Munshiganj and Chandpur Districts on the west. The population density of the district has increased to 1,712 people (higher than the national average of about 1,015) (BBS 2011) from 1,487 people per km^2 during 2001–2011(Toufique and Gregory 2008).

Because of the low-lying nature of its land, most of which remains under water due to frequent floods, the district long had been recognized as a food deficit area, with its lowest-lying areas growing only rice (BWDB 1994). Farming households, including well-off landowner families, experienced lack of employment, shortages of food, especially during September–November, and the resultant urban migration[8]. Thus, subsistence fishing became the most important occupation to marginal farming households with lack of formal activities.

In 1992 the Bangladesh Water Development Board (BWDB) put an embankment on the Gumti River—the main reason of this recurrent floods—to protect villages from recurrent flooding, and this changed the landscape of the area by enclosing an area about 327 km^2 by a 45.5 km long embankment, including Daudkandi upazila (Toufique and Gregory 2008). As part of Daudkandi upazila, the area surrounding Pankowri Fisheries Ltd. is also part of the larger Meghna-Gumti floodplain and is bordered by the Gumti River on the east, north and west, and a portion by the Daudkandi-Comilla highway on the south. The entire floodplain takes the appearance of a vast water-body during the summer monsoon (June–September) by getting inundated because of its low-lying landmass, which filled with depressions like other low-lying areas of the surrounding upazilas. The low-lying landmass was traditionally cultivated for winter crops, like onions, garlic, pulses and sweet potatoes.

[8] However, the exact number migrated villagers was not reported.



a) Comilla district
(circled area is the Daudkandi upazila)

b) Daudkandi upazila (sub-district)
(circled area is the Elliotgonj union)

Figure 2.1: Research area of the Elliotgonj union (the red line indicates the Dhaka-Chittagong highway)
(*Source:http://www.mapsofbangladesh.com/Comilla_District.phphttp://www.mapsofbangladesh.com/Daudkandi-Upazila.php*)

In other seasons the lands were used for production of rice species locally known as *Aus* (April–August) and *Aman* (April–December). However, this farming was mainly dependent on natural weather and most times production was damaged by excessive rain, floods or sometimes droughts (CIRDAP 2002).

The early attempt—although moderately successful—of utilizing seasonally flooded private lands for aquaculture was made by a group of landowners in Daudkandi upazila in 1988. After construction of the government flood control embankment in the locality, new attempts were made without involvement of any NGO. Most of these attempts failed on account of technical or organizational/financial grounds. Only after introduction of the Pankowri Fisheries project did the area found a sustainable and adoptable successful management system for floodplain aquaculture in the technical, organizational and financial aspects.

2.3.2 Data collection:

Primary data: Data from the field were collected from five field visits conducted during two months of December and January. This period was the fish harvesting period for that particular season. Main methods for obtaining primary data were interviews and participant observations.

Face-to-face interviews with NGO staff who had been involved with the FPA from the beginning until the time of the study were conducted on the basis of structured questionnaire supplemented by non-structured questions. Through these interviews information regarding the development, historical context (which worked as a driving force) prior to the FPA initiative, landowners' mobilization, etc. was collected. FPA staff like the chairman of the Pankowri Fisheries Ltd, programme coordinator of SHISUK, were interviewed to learn about the operational processes, conflict resolution, compensation, dividend distribution mechanism, etc. Other interviewees included shareholders, members of the Board of Directors (BoD), officials of the FPA, and a few general villagers. Depending on the persons and suitability of the occasion, the informal interviews were conducted either during field trips at the community, during directors' gatherings or at the NGO office at Dhaka. SHISUK's interviewed officials included the executive director, programme coordinator, and one FPA-related staff. They were interviewed individually at the Elliotgonj office of the Pankowri Fisheries Ltd. and SHISUK's office in Dhaka. Members of the BoD and shareholders were interviewed when they gathered for FPA meetings, and as such these interviews were conducted at Elliotgonj. General villagers were asked on the basis of unstructured question sets for their perception of the FPA initiative.

Besides interviews, participant observation was used as an additional way of collecting data. The researcher was present at several formal meetings of directors, NGO staff and

shareholders. The decision-making process and participation of landowners in it were observed. The researcher was also present during the harvesting period, and this and other related operations were observed. These observations also supported the information collected from interviews.

Secondary data: Handfuls of quantitative data along with qualitative data about the FPA were collected from official documents, such as FPA manuals and annual reports of SHISUK and Pankowri Fisheries Ltd. Some secondary data about local condition were collected from research materials prepared by other development organizations such as Centre on Integrated Rural Development for Asia and the Pacific (CIRDAP).

2.4 The Daudkandi Model of community FPA

In 1996 SHISUK initiated a pilot project to develop a viable management system of community-governed aquaculture in six villages of the Elliotgonj union. The general people of these villages surrounding the floodplain were not professional fishermen, so before the FPA project they mainly fished only during the rainy season when the floodplain was inundated. With the main objective of utilizing a local underutilized resource through active participation of community members, the project started with around 115 ha (285 acres) of floodplain that turns into a water-body in the monsoon (June–September). The pilot project adopted an innovative mechanism to solve the primary problem of capital. It distributed shares to landowners and other villagers and started the FPA operation. Although initially the shares—each valued Tk. 1000—had only been issued to landowners holding lands in the floodplain, the project soon found that issuing of shares in this way was ineffective to raise required capital. So other households, who didn't own land in the floodplain, were allowed to buy shares, provided that the subscriber must be an inhabitant of any of the surrounding six villages. No individual could buy more than 20 shares.

Eighty percent of shares were distributed to landowners and villagers, and 20% were bought by the initiator NGO, SHISUK. It kept 5% of the shares from its 20% exclusively for less advantaged and impoverished villagers. After its initial two years of success, using the issued shares, the FPA was registered in 1997 as a joint stock company under the Company Act 1994 and named Pankowri Fisheries Ltd. Table 2.2 shows the condition of the FPA after the company was formed. It is evident from the Table 2.2 that not all landowners whose land fell within the selected area of aquaculture invested in the project.

Table 2.2: *Pankawri* Fisheries Limited at a glance

Area	115 hectares (285 acres)
Total land owners	395
Total number of shares	2000
Total number of shareholders	387
Share price	1000 BDT
Share limit	20 shares (1% of total shares)
Community Shares	1600
SHISUK Shares	400 (20%)

(***Source**: Data compiled from official documents of Pankawri Fisheries Ltd.*)

All activities of the FPA have been running in the fashion of a conventional company since its formation as one. Shareholders select a board of directors comprising one chairman, one managing director and nine directors for two years. This board oversees the day-to-day operations run by a group of employed personnel and sometimes form committees for specific management operations[9].

Figure 2.2 shows the flow of initiation, execution and seasonal operation of an FPA under the Daudkandi model. Yellow boxes indicate the inception and development stages and green boxes the annual seasonal operations of an FPA. It is noteworthy that the mobilization of landowners and surrounding community populace of a floodplain water-body and other subsequent stages theoretically can be achieved without the NGO initiative and involvement, given that the community members engage themselves on their own.

The FPA does not own the lands of the floodplain; it simply, in the form of a private limited company, takes lease of lands from landowners for use during the monsoon through a contract which grants it the legal right to use the land in exchange for the lease money. Accordingly, the FPA has to pay lease money to landowners in exchange for using their lands. After deducting all costs but before distributing dividends, this lease money is paid as 27% of initial earning. Then 70% of the net profit is distributed as dividends to shareholders regardless whether landowners or not, and 3% is kept for development of local areas. However, the amount of lease money is directly dependent on the profit the FPA makes every season, and this rate of 27% of earnings before paying dividends remains unchanged as long as the amount of leased asset remains fixed.

[9] The harvested fish in the Pankowri Fisheries Ltd. included Silver Carp (*Hypophthalmichthys molitrix*), Big Head Carp (*Hypophthalmichthys nobilis*), Bata (*Labeo Bata*), Rui (*Labeo rohita*), Tilapia (*Oreochromis mossambicus*), Thai puti (*Barbonymus gonionotus*), Mrigal (*Cirrhinus cirrhosus*), Common carp (*Cyprinus carpio*), Grass carp (*Ctenopharyngodon idella*), Catla (*Catla catla*), Black carp (*Mylopharyngodon piceus*), Pangas (*Pangasius pangasius*), Air (*Sperata aor*), Koi (*Anabas testudineus*), Tengra (various species of *Mystus*) and Shinghi (*Heteropneustes fossilis*). The total volume of fish production was 382 MT.

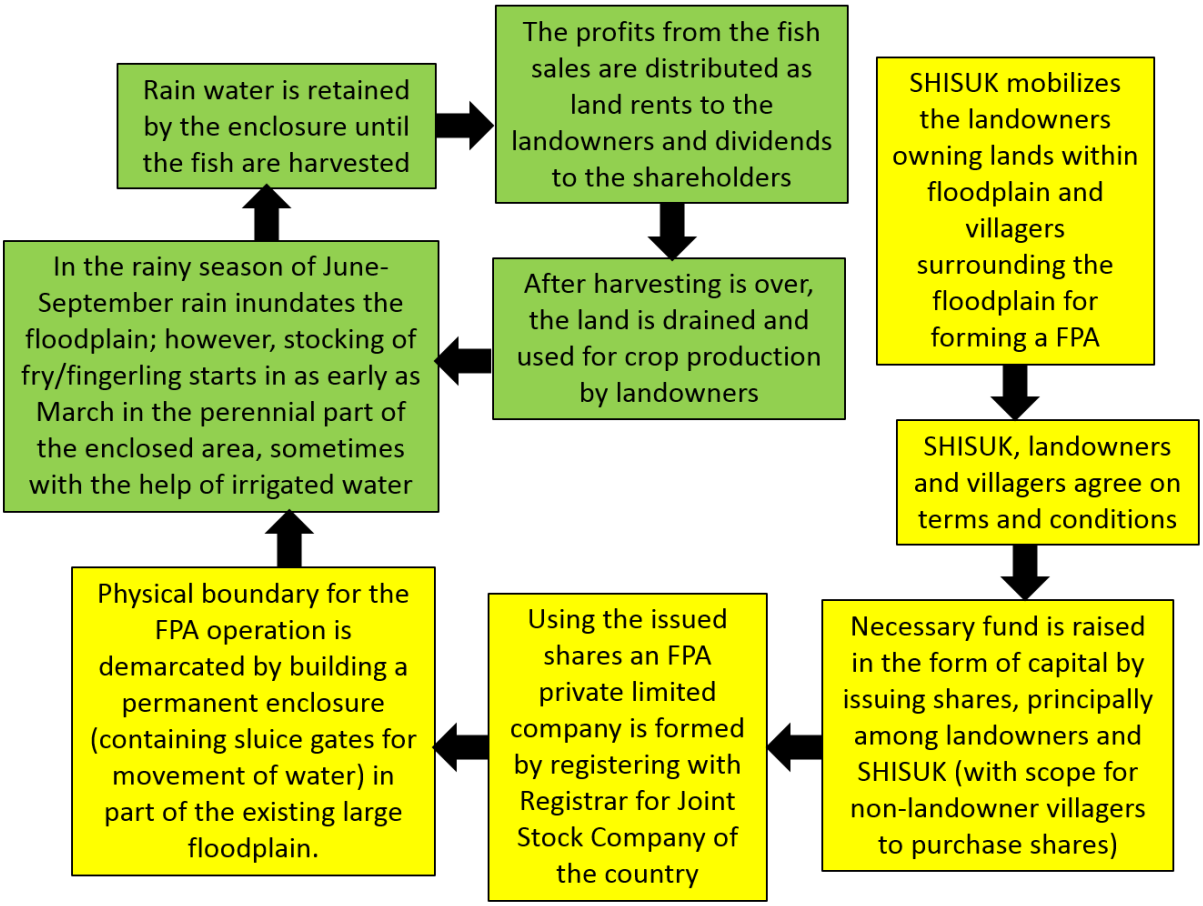


Figure 2.2: Development and operational cycle of FPAs under the Daudkandi model

2.5 Ostrom's design principles and their application in the Daudkandi model

By studying a wide range of long-lived user-managed CPR institutions, Ostrom found that in most cases the resource and the institution survived a long period in spite of the possibility they could be exploited unsustainably by opportunistic individuals (Ostrom 1995). Ostrom, adopting the definition provided by Shepsle (1989), called these CPR institutions robust 'in the sense that they survived for very long periods of time utilizing the same basic rules for adapting to new situations over time' (Ostrom 2000; p 40). As the nature of the resources these institutions govern vary, specific rules applied to one cannot be generalized for other resource systems. However, it is possible to find common principles that characterize successful CPR institutions. Ostrom identifies seven design principles (Table 2.3) that characterize most long-sustained CPR institutions, with an eighth principle for successful governance of larger nested CPRs. This eighth design principle was not applied in the present study, as a single management body runs the FPA under the Daudkandi model, and the FPA is not part of any larger system. In the sections following Table 2.3 the applicability of Ostrom's design principles are detailed in terms of FPA operational rules.

Table 2.3: Design Principles characterized most long-surviving CPR institutions (Ostrom, 2000)

1. Clearly Defined Boundaries
Individuals or households with rights to withdraw resource units from the common-pool resource and the boundaries of the common-pool resource itself are clearly defined.
2. Congruence
A. The distribution of benefits from appropriation rules is roughly proportionate to the costs imposed by provision rules.
B. Appropriation rules restricting time, place, technology, and/or quantity of resource units are related to local conditions.
3. Collective-Choice Arrangements
Most individuals affected by operational rules can participate in modifying operational rules.
4. Monitoring
Monitors, who actively audit common-pool resource conditions and appropriator behavior, are accountable to the appropriators and/or are the appropriators themselves.
5. Graduated Sanctions
Appropriators who violate operational rules are likely to receive graduated sanctions (depending on the seriousness and context of the offence) from other appropriators, from officials accountable to these appropriators, or from both.
6. Conflict-Resolution Mechanisms
Appropriators and their officials have rapid access to low-cost, local arenas to resolve conflict among appropriators or between appropriators and officials.
7. Minimal Recognition of Rights to Organize
The rights of appropriators to devise their own institutions are not challenged by external governmental authorities.
For common-pool resources that are part of larger systems:
8. Nested Enterprises
Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises.

1. Clearly defined boundaries and rightful users of the common pool resources—Individuals or households with rights to withdraw resource units from the common-pool resource and the boundaries of the common-pool resource itself are clearly defined: Geographical or physical boundaries of the resource, as well as the individuals and/or households with rights to withdraw from the resource base, must be clearly defined. Without definitive borders and exclusion of non-investors, local appropriators will risk that 'benefits they produce by their efforts will be reaped by others who do not contribute to these efforts' (Ostrom 1994: 5), or make no sacrifice for enhancing the resource system. Clearly defined boundaries and users will ensure that investors will receive as high a return as they expect and that actions of others will not destroy the FPA.

During the mobilization and development phase, the NGO and landowners came into agreement regarding the use of their lands for the FPA and its boundaries. Then the boundary was drawn by constructing a permanent earthen road on the west side of the floodplain, providing management a definite area to practice aquaculture. The road also works as an embankment and contains sluice gates for movement of water in and out of the enclosed area selected for aquaculture. Thus, part of the existing floodplain water-body was brought under FPA operation and management. The rest of the part remains open to the community members, even during the monsoon period (June-September) as before. The right to use the land for fish

culture and for setting up permanent boundaries is earned through lease contracts and thus is protected by legal mechanism.

The rights of the individuals have been created by issuing shares to landowners of the floodplain and other community members. Thus, non-shareholders were excluded from receiving any direct benefit earned through extraction of resource units, i.e. fish. As a matter of fact, as mentioned, the FPA is run as a private limited company, and this entails that only the management body of the FPA can extract resource units from the FPA. Profits earned from sales of cultured fish are annually distributed as dividends to shareholders. So, it seems both the geographical limit of the FPA fish culture and the rights of users are protected through legal provisions.

2. Congruence between appropriation and provision rules and local conditions—appropriation rules restricting time, place, technology, and/or quantity of resource units are related to local conditions and to provision rules requiring labour, material and/or money: This design principle indicates two levels of congruence or matching. At one level, for the sustenance of a resource system there should be rules and restrictions regarding harvesting patterns, and input provision of labour and other materials. These two types of rules should be congruent with local conditions. In her attempts to broaden and revise design principle, Ostrom (2009) hinted that local conditions may include social, economic, cultural, ecological and ideological characteristics. In the case of the Daudkandi model, the FPA harvests different kinds of fish, but generally harvesting is done in bulk and around the same period, with some variance in schedule, labour amount, technology depending on fish size, type, growth, local weather, market demands etc. Fish are mainly cultivated during seven months of a year, including two-three months of rainy season when floodplain is inundated with rain waters. In dry season when rice is grown, no aquaculture intervention can be conducted. Just after the harvesting of winter (Boro) crop, water supply is ensured within the enclosed part through a canal passes along the aquaculture waterbody containing water from the sluice gates of Gumti embankment. For flooding of the lands, rainwater remains the main source, which depends on regional weather and climate conditions Although the release of fingerlings starts in early March in the small perennial part within the floodplain enclosed for the FPA operation (sometimes by dint of flooding via irrigation system), the ultimate growth of the fish depends on supply of the rain water in the whole enclosed area. Usually water starts to inundate the lands from mid or late June, when rain begins. The harvesting of the fish starts in late September or early October, and, sometimes, based on growth, natural conditions and market demand it continues to late January or early February. After the end of rainy season, some water remains for few weeks and later

water is retained through embankment built around the cultured area. Release of water starts in late December. By shutting the sluice gates water can be retained for extended culture period, but for land preparation for Boro paddy cultivation water cannot usually be held beyond January. So, it seems the FPA is bound to comply with local conditions in doing its business.

At the other level of congruence, there should also be some proportionality and equitability in distribution of benefits and costs derived from the use of the CPR. The shareholders or users basically make two types of contributions. First, they raised the initial necessary capital in the form of purchased shares, and against that now they are entitled to annual benefits as long the FPA continues its business. It also means that no shareholder is allowed to harvest fish on their own. Harvesting decision are made by elected board of directors along with all other decision regarding the management of the FPA. By the same token, no user has to personally contribute in the input or labour supply of the resource system, and here comes the second type of contribution. The company conducts all operational requirements with its earnings, which is basically part of profit that shareholders contribute in the form of retained earnings. In reality, sometimes the FPA collected fund from outside sources. Like other private limited companies, the FPA maintains a core base of experienced and non-experienced employees all around the year to support and implement decisions made at higher management level, though its main operations are conducted in and around the monsoon period for six-seven months. Most of the labour participated in fishing activities are hired only for harvesting period, and varies according to local particularities, e.g. availability, wage, harvesting requirements, etc. Amounts of fingerlings to procure varies depending on cost, maintenance capability of the FPA and local market's supply-demand conditions.

3. Collective choice arrangements- most individuals affected by the operational rules can participate in modifying the operational rules: Shareholders are rightful users of the CPR under the Daudkandi model, and also the directly affected party of any operational rule. Most of these shareholders are also found to be the landowners whose lands fell within the enclosed part of floodplain which has been brought under aquaculture. As already mentioned, the option for collective choice action is that the shareholders will elect a board of directors for design operational rules and run the day to day management of the FPA. This also fulfils the statutory requirement of the Company Act, under which the FPA has been formed, while removing the complexities which may arise from involving large number of shareholders in day-to-day decision-making process.

However, in rural context of closely knitted small community, informal communication plays significant roles in expression of grievances and concerns, and this rural cultural feature is

used by anyone who is affected by any rules implemented by the FPA management. In addition to the members of board of directors, a considerable number of landowner shareholders remains outside the management committee, and for them this type of communication is very important for the movement of water in and out of the enclosed part for agricultural activities. For these ordinary shareholders, the informal communication plays a very significant role, if not in directly modifying, then at least in exerting some influences on modifying operational rules.

4. Monitoring- monitors, who actively audit the common-pool resource conditions and appropriator behaviours, are accountable to the appropriators and/or are appropriator themselves: To manage any CPR successfully over a long period of time, CPR institutions have to develop some sort of monitoring system to maintain appropriate behaviours of the users. In case of Pankowri Fisheries Ltd., the company has salaried employees, along with guards, who look after the overall conditions of the FPA and monitor the behaviours of the shareholders. These monitors are, in turn, to be held accountable for their duties to board of directors and shareholders. Moreover, few directors are sometimes directly assigned to the various responsibilities regarding the FPA, and as such, remain wary of warning signs. Besides, in a rural environment, shareholders show varied degree of vigilance in overseeing whether other shareholders comply with the operational rules or not. Moreover, as the FPA has been registered as a private limited company, it is legally bound to conduct audit by external certified auditors.

5. Graduated sanctions- Appropriators who violate operational rules are likely to receive sanctions (depending on the seriousness and context of the offence) from other appropriators, from officials accountable to these appropriators, or from both: Ostrom put forward some benefits of a system of monitoring and sanctioning when they are implemented together by local users of a CPR as '(1) it stops the infraction from continuing and may return contraband harvest to other appropriators; (2) it conveys information to the offender that someone else in a similar situation is likely to be caught, thus increasing confidence in the level of quasi-voluntary compliance; and (3) it imposes a punishment, most likely in the form of a fine plus loss of reputation for reliability' (Ostrom 1994: 8). In Pankowri Fisheries Ltd., the sanctions for breaching operational rules were adopted at the initiation of the FPA by board of directors with discussion of ordinary shareholders, i.e. the community people. The main breach of rules is confined to the theft of the fish from the cultured area. In this case if the any rule breaker gets caught with fish, then they have to pay a fine equal to the amount of fish with which they get caught multiplied by the numbers of day from releasing the fingerlings to the day they get caught. Moreover, if violator is a shareholder, then they, according to the FPA rule, have to

forfeit their shares. Though this provision seems a bit impractical to be applied at community level.

6. Conflict resolution mechanisms- Appropriators and their officials have rapid access to low-cost local arenas to resolve conflicts among appropriators or between appropriators and officials: As Ostrom says 'in field settings, applying rules always involves discretion and can frequently lead to conflict' (Ostrom 1994: 9). In the case of Pankowri Fisheries Ltd., as well as other FPAs formed adopting the Daudkandi model, there exits several stakeholders in two levels. Within a FPA there exists general shareholder, board of directors and staff, and outside it there are non-shareholder landowners, other community members and local government bodies and their personnel. The disagreements that arise within the FPA are usually dealt through simple mechanisms of bringing grieving parties together and settling issues following organizational rules, priorities, goals etc. of the FPA. When there arises a conflict between the FPA and any member of the community, the first step of the resolution is to hold meeting between the conflicting parties in the presence of board of directors and officials of the FPA; and the traditional village arbitration mechanism is followed to settle the issue. In rural setting of closely knitted society, most conflicts- which may affect many besides the directly engaging parties- are solved through local initiatives without extra-community interventions. If the origin of the conflict is any breach of operational or other rules, within or without the FPA, then the reconciliation is designed to be achieved by sanctioning the rule breaker.

Moreover, the presence and involvement of the NGO in whatever degree also creates reliability on these less expensive local resolutions of any conflict among various types of parties. In any case it was observed that, even when the NGO was engaged in any disagreement, the presence of various stakeholders who work in small and closely knitted scope try to solve any disagreements without causing too much costs.

7. Minimal recognition of rights to organize- The rights of the appropriators to devise their own institutions are not challenged by external governmental authorities: Ostrom mentioned of many inshore fisheries where 'local fishers devise extensive rules defining who can use a fishing ground and what kind of equipment can be used' and in all these cases as long as 'the external governmental officials give at least minimal recognition to the legitimacy of such rules, the fishers themselves may be able to enforce the rules' (Ostrom 1990: 101). In the case of the Daudkandi model, the FPAs, like Pankowri Fisheries Ltd., are turned into legal entities in the form of joint stock private limited companies; and, consequently, their management and operation of fishing business are legally authorized to be devised by the shareholders directly or indirectly rather than by any external government body. The FPAs thus

formed are subject to only two types of external legal bounds: first, the laws which govern the activities of limited companies and, second, the existing fishing laws and regulations which are generally applicable for anyone who are engaging in fishing business in the country. With exception of these two forms of legal bounds, the FPAs are legally independent, recognized, and protected to conduct their business in ways as they deem fit. The issuing of shares ultimately decides who have the rights over the formed FPAs and who do not have any.

In addition to the legal one, government recognitions to conduct fishing activities as per rules and procedures devised by shareholders of Pankowri Fisheries Ltd have been extended through other indirect ways. Such indirect ways of recognitions can be found in the various training provided by the District and Upazila Fishery Officers to the FPA staff, shareholders and villagers without interfering in the rules and regulations devised by the members of the FPA, and in more than one agreements regarding the replication of the model in other floodplains and non-floodplain water bodies

2.6 Discussion and Conclusions

This study tried to look into a specific FPA management system primarily designed by an NGO in collaboration with a community of general villagers in the changed circumstance of overall fisheries management regime in Bangladesh. Because of floodplain water-body's CPR nature, the fitness of model's management rules within Ostrom's design principles has been tested, and it has been found that most of these principles are matched with management rules of the studied FPA under the Daudkandi model. However, as a CPR institution this FPA model is still young in comparison with many long surviving CPR institutions, and its robustness in form of future success and sustainability depends on various factors: for example, its capacity to maintain the legitimacy of the established FPAs within local community through working collaboratively, and its ability to foresee changes and the extent of adaptation to those changes. However, the major findings of this study and few related observations can be made as follows:

1. **Fulfilment of Ostrom's design principles**: For now, the FPA model has been found to follow Ostrom's design principles in its management principles and rules regarding a definite boundary of the physical resource and rightful beneficiaries, an arrangement for collective choice actions for most of the affected parties, a monitoring system, local low cost conflict resolution mechanisms, recognition of external authorities, etc. However, the fulfilment of all these principles—about which none of the users had any previous idea—in field level is an extremely complex ongoing process. The sustainability of a CPR solely in terms of compliance with Ostrom's principles cannot be predicted as there is strong possibility of the presence of external

factors like market demands or resource's various properties (Cox et al. 2010; Schreiber and Halliday 2013). Cox et al. (2010) also mentioned the limitations of Ostrom's principles in considering user community's internal power play. In general, Ostrom's design principles may be used as guidelines to understand the sufficiency of incentives and maturity of social capital at community level; mostly through appraisal of internal institutional aspects, and without considering whole gamut of external factors (Yandle 2003 and 2008; Cox et al. 2010; Trimble and Berkes 2015). Thus, it's needed to consider any external force, like non-authorized users' interest in the FPA, which may hold potential opportunity or threat for the successful continuation of the FPA model.

2. New property rights regime: The management of a CPR through devising new property rights regime always includes various level of redefinition of rights and rules, including exclusion rights (Schlager and Ostrom 1992). The first design principle is about defining these property rights holders and the physical limit of the CPR, where these property rights will be exercised. In the case of Pankowri Fisheries Ltd., under the Daudkandi model, there have been found several critical features in fulfilling this principle.

2.1 First, the CPR of the study is a seasonal floodplain water-body. Part of it was brought under new resource management system by erecting a permanent embankment. Only in the rainy season the new management regime can manage and have control over the enclosed part; and in dry season when there is no water-body the landowners exercise their private property rights over individually hold lands. However, there exists some agreement and collaboration regarding the use of land in dry and wet season so that both parties can practice their rights in respective seasons.

2.2 Second, there are landowners who decided not to be part of new CPR management but hold lands within enclosed area of the FPA, and the relationship these landowners have with the FPA may be proved significant for the performance of the FPA.

These first two features of the FPA—seasonality and usage of lands of non-shareholder landowners—have many potential dynamics and may hold important future implications for governing the CPR under the Daudkandi model. Various dynamics of the relationship between the FPA and landowners can be found in, for example, gaining consent in using lands, or reaching an agreement regarding payment of compensation or release of retained water (so that non-shareholder landowners can conduct their agricultural activities) etc. These dynamics can result into, for example, conflicts among shareholders, landowners or between shareholder and non-shareholders; or higher lease money payment, etc. Thus, the settlement of these dynamics in the replicated FPAs requires further investigations.

2.3 Third, as already mentioned, general populace of the surrounding villages of the studied FAP were not full-time fishermen, and only used to catch fish of subsistence nature. However, the initiation of the aquaculture has put limit on who can benefit from the FPA, for not everyone, even if interested, could afford investing in shares. So, those who were at the bottom of the society, and could not afford share purchase, but previously at least had been able to catch some fish, clearly got excluded from the direct FPA benefits. It is understandable that the exclusion of some past users by modifying property rights might affect these past users. The nature and scope of this exclusion has not been properly studied, though mentioned with emphasis in some studies (Gregory et al. 2007; Toufique and Gregory 2008). At the same time, some general villagers emphasized that the poor section of the community are receiving some trickledown benefits through employment or working as labour at the FPA, and/or engaging in some forward or backward linkage services and supplies, or through overall increased affluence of the community.

However, in the absence of any previous baseline study of the benefits reaped by the poor section of the community, it is impossible to measure how much they have lost in terms of opportunities because of the initiation of the FPA, and make any subsequent comparison between this evident loss of access and any post-FPA benefits. A possible management intervention for the potential floodplain landowners might be to conduct some baseline survey of social, economic conditions of community members in newly planned FPA areas as part of overall project management. It is important for the long-term successful management of a FPA formed under the Daudkandi model to be locally embedded and that embeddedness would be absent if its initiation creates substantial loss for other community members.

On the other hand, on theoretical level, how the costs- now being borne by this community level past users- can be conceived within Ostrom's design principles framework is yet to be explored as these users are left outside the pale of the new group of authorized appropriators. Part of the second design principle is about the proportional equivalence or equitable distribution of costs and benefits among users 'who agree to use the resource according to their agreed-upon rules', not among the excluded ones 'who do not agree to these rules' (Ostrom 2009: 7). However, the exploration of resultant social conditions of the excluded past users and community poor in a closely knitted local setting may shed lights on key issues concerning the maintenance of the FPA's community-level legitimacy, which is important for future sustenance and efficiency of CPR institutions.

3. Matching of overall benefits and cost: The principle of congruence, along with all other design principles, has been elaborated with considerable issues and nuances over the years

since their original formulation in 1990 (Ostrom 2009; Cox et al. 2010). The overall profitability of the FPAs, including Pankowri Fisheries Ltd., under the Daudkandi model was not part of the present inquiry as that has been found to be considerably high in other studies (Gregory et al. 2007; Toufique and Gregory 2008; Mustafa and Brooks 2009). However, the issue of congruence between ecology or biodiversity or overall local environment and the FPA management is something which requires prolonged engagement in the field which was not available for this study.

4. **Distinct features of the Daudkandi model**: The application of Ostrom's principle in this FPA management system involves some challenges, as well as some possibilities, because of several features of the model. The main innovation of the Daudkandi model is a new institutional way of collaboration between landowners of floodplain and surrounding community people so that they can engage themselves in developing aquaculture in a seasonal water-body over which no single individual can hold sway during the rainy season. This institutional way of collaboration has been achieved within the scope of a private limited company where issued shares are not allowed to be exchanged in the stock market and can only be held by specified shareholders (community populace and the NGO). While issuing shares to demarcate right holders from others has not been uncommon at the community level, forming a private limited company with them is new in the context of rural Bangladesh. The issuing of shares among the people of the community also ensured the procurement of initial necessary capital without taking recourse to any external development fund. This specific legal approach also entails some external statutory requirements, like annual audit, for better and transparent management of the resource, and this is also supposed to give the employed personnel a considerable role to play in operational management of the FPA. On the other hand, this is done by the collaborators with an aim to enhance the resource by unlocking potentialities, rather than to solve resource management problems, and without this possibility of enhancement there would have been no promise of collaboration among individual landowners. The landowners have collectively remained the owners and major decision makers of the FPA, though initially they were convened and later have been assisted by an NGO.

The second distinct aspect of the model is the way in which the NGO is involved as a facilitator and partner in managing a FPA. The study found that the NGO assisted the implementation of the FPA project in various ways: staffing, providing organizational support, arranging external credit, establishing networks with local, regional and national government agencies and national and international non-government bodies. It has also been observed that the presence of the NGO created hopes among general villagers and involving parties in

settlement of disputes and disagreements in more credible, smooth and less expensive ways. In the sphere of co-management, many studies have concluded that different levels of competence and distributed decision-making along with multiple stakeholders with multiple relationships (Carlsson and Berkes 2005; Marín and Berkes 2010; Trimble and Berkes 2015).

The NGO's involvement should also be viewed from the perspective of capacity building of the community users; more so in this particular case because of the lack of a professional fisher group prior to the FPA initiative, and the local landowners' lack of experience in commercial fishery or aquaculture. At the same time, capacity building— technical or managerial or institutional—whether as a partner of co-management or sole party of self-management has a temporal dimension. Historically, successful users' managed CPRs are characterized by capable group of users, and their evolving capacity in successful handling of conflicts over resource use. In the case of the Daudkandi model, the very establishment of the FPA indicated that floodplain landowners reached a settlement regarding the use (and other related issues) of the floodplain water-body for fish culture. Moreover, this study (which captures state of the FPA rules at a point of time), found that the FPA has some rules in place to handle newly-raised conflicts of affected parties (Ostrom's design principle 3 and 6). Having these rules is an indication that, at least, at the design level the managers of CPR institution are capable, for the rules were designed on the basis of collaboration rather than one sided imposition of any partner. While the compliance with Ostrom's design principles indicates the capability of CPR institutions, the level of compliance may change for better or worse with passing of time as applications of these principles in cases of co-management institutions is found in several studies (Gelcich et al. 2006; Yandle 2003 and 2008; Schreiber and Halliday 2013). It is important to remember that the involvement of the NGO is theoretically not necessary for the replication of models where landowners and community people themselves come together and workout their collaboration. Thus, on the one hand, continuous research on the evolution, along with other replications, (as a learning process, or at least clear-cut success or failure) of the management system to understand the scope and nature of the NGO-community partnership may shed light on areas and upon variables which are important for its future success as a CPR governance institution. On the other hand, from the institutional capacity perspective, the real test of the Daudkandi model as a CPR institution for floodplain water-bodies will be found in the FPAs where there will be no NGO involvement in management and the community has to do everything itself.

Data for this study was collected from the field through a period of two months, which seems insufficient for capturing the whole gamut of dynamics that lies underneath the management, daily operation and issues regarding long-term sustainable relations between the

resource system and resource units extracted under this particular CPR institutional mechanism. Without long-term and thorough observation, investigations and cross-disciplinary studies, many issues of sustainability and efficiency will remain indecisive. Moreover, the model has been already variously adapted by 90 other FPAs in Daudkandi and its surrounding upazilas; further, in few of these adaptations SHISUK has been directly involved. This scale of expansion and flexible replications may add considerable complexity through customization in each of these replications.

Chapter 3

The evolution of a floodplain aquaculture management system in Bangladesh

3.1 Introduction

The spread of floodplain aquaculture (FPA) is one of the accompanying trends of a countrywide expansion of aquaculture in Bangladesh, which, 1,956,900 tonnes, is the sixth largest producer of cultured fish in the world (FAO, 2016). While the spread of overall aquaculture has been observed since the country's independence in 1971, the trend of aquaculture in seasonal floodplain water-bodies is comparatively new. Although there were reports of a stocking-based rise of harvested fish from floodplains since 1988-89 (Ahmed, 1999; Islam, 1999), numerous studies have reported the recent mainstreaming of the FPA phenomenon (Gregory et al., 2007; Toufique and Gregory, 2008; Belton et al., 2011; Haque et al., 2011; Sultana, 2012). In addition, the Department of Fisheries (DoF) only began publishing FPA data in its annual Fisheries Resource Survey System report in 2011 (FRSS, 2011).

Not surprisingly, the spread of FPA has also witnessed development of several types of FPA practices. Among them, one management system has been regularly featured in various studies—sometimes as the sole focus, sometimes in comparison with other similar practices (Gregory et al., 2007; Toufique and Gregory, 2008; Mustafa and Brooks, 2009; Sultana, 2012; Khan, 2015; Bayazid, 2016). The development of this management system has been attributed to a non-governmental organization (NGO) called SHISUK, and its collaboration with a community of the Daudkandi sub-district in the Comilla district to form an FPA was widely recognized as pioneering. This first NGO-collaborated FPA (NFPA), Pankowri Fisheries Ltd (Pankowri, hereafter), was formed in 1996. While the NGO promotes the management system by referring to it as the Community Enterprise model, it is popularly known as the Daudkandi model of FPA. The profitability of an FPA enterprise, demonstrated by this NFPA, resulted in the proliferation of more than 50 FPAs in the neighbouring communities across a span of two decades. While the NGO promoted and partnered with a few of these FPAs, others were independently formed by landowners from various floodplains. The NGO later expanded their FPA programme in other parts of the country.

However, how this FPA management system evolved over time—in the NFPAs and independently-formed FPAs (IFPAs)—is yet to be adequately explored. Khan (2015) indicated that over the years, some changes have occurred since its first application. Given the common-pool resource (CPR) nature of the floodplain water-bodies, modifications in management system are not unexpected, as Ostrom (1990, p. 58) identified that "appropriators designed basic operational rules, created organizations to undertake the operational management of their CPRs, and modified their rules over time in light of experience according to their own collective-choice and constitutional-choice rules". Identifying and studying such changes will shed light on critical

aspects of the collective management of community resources, such as how users responded to the opportunities opened up through improved use of the resources or solved management problems using their experiences over time (Agrawal, 2001; Olsson et al., 2004; Carlsson et al., 2005; Ostrom, 2007; Berkes, 2009; Armitage et al., 2009; McGinnis and Ostrom, 2014). The purpose of this study is to identify the extent and nature of the modifications—whether uniform or varied, considering the numerous adoptions—made over the last two decades by the participants of the FPAs. By studying organizational and management aspects of FPAs selected from five districts of Bangladesh, this study attempts to articulate those modifications. As this FPA management system was expanded through independent adoptions and NGO-led programmes, the study covers both types of FPAs, with an emphasis on NFPAs.

The article is outlined as follows: section 2 reviews briefly the development of this management system, followed by a brief theoretical framing of collective FPAs in section 3. Methodology and data collection are presented in section 4. Collected data regarding the FPAs are offered in section 5, and their discussion is presented in section 6. Section 7 draws some concluding remarks.

3.2 Proliferation of FPAs by adapting the NGO-promoted management approach

In Bangladesh, 2.8 million ha of water-bodies are formed every year by inundation of floodplains, which is the largest among all inland open water-bodies in the country (FRSS, 2017). Most of these floodplains are composed of private lands, which are mainly used for agricultural purposes during dry seasons. However, because of the historical background of colonialism, the government holds rights over large tracts of floodplains. Regardless of such distinctions, during the monsoon, a floodplain usually becomes a single water-body, connecting lands which are owned by different owners, and sometimes under different property rights regime. Thus, they become unusable for investment-based resource development or extraction unless some collective arrangement is made among rights-holders about all the aspects of any specific uses. This is more pertinent to the water-bodies that are formed by connecting plots of lands separately owned many individuals, because individuals cannot exercise the authority of government agencies when annual flooding makes the boundaries among the lands practically ineffectual. In this study, we will solely concentrate on FPA practices in this latter kind of floodplain water-bodies.

Therefore, an FPA initiative in private floodplains seemed difficult or simply inconceivable to implement because of floodplain water-bodies' seasonally differentiated uses, involvement of various number of landowners, among other reasons. Formation of an FPA would also require considerable investment in infrastructure because of the water-body's nature,

in addition to fish culture related investments. There is also concern over unenforceability of access controls and non-compliance with other rules, which might cause benefits to be appropriated by non-authorized and/or non-investor community members. At the same time, a few scattered initiatives failed due to lack of agreements about and conflicts over sharing costs and benefits, alternative seasonal uses of floodplain lands, etc. (Thompson, 2005). Thus, for a long time, floodplain water-bodies in private lands remained mainly the open access source of capture fishery for neighbouring communities.

An adoptable model of collective and self-organized FPA management must demonstrate that such obstacles can be dealt with, and considerable returns can be generated from aquaculture activities in floodplains. The Community Enterprise model initiated in the Daudkandi sub-district in 1996 was reported to meet these criteria (Gregory et al., 2007; Toufique and Gregory, 2008; Belton et al., 2011b; Khan, 2015).

However, the SHISUK's collaborative attempt to establish an FPA was not the first of its kind in this community. A small group of landowners started an FPA named Dhanuakhola Nagarpar Adarsha Motsha Chash Prokalpo (Dhanuakhola) in a small floodplain of 13.35 ha land in 1984. There had been no other successful FPA in the community until Pankowri was formed in 1996. Nonetheless, the precedent of Dhanuakhola in the community proved important, as SHISUK cited its profitability in motivating the neighbouring landowners to form Pankowri. By forming Pankowri in a larger floodplain, SHISUK modernized and improved upon previous practices, devised ways to solve past difficulties, and expanded the scope of collective FPA enterprises.

Figure 3.1 shows the chronological spread of the FPAs formed under the studied management system. These FPAs were primarily formed in one of two ways. First, following the success of Pankowri, SHISUK formed more NFPAs throughout the 2000s in partnership with community stakeholders in various parts of the Daudkandi region. From the early 2010s, the NGO gradually expanded its FPA programmes in other districts. Second, landowners formed IFPAs by playing leading roles without any NGO involvement. This type of FPAs, formed through flexible application of the NGO-promoted management approach, are very common in the neighbouring communities of the Daudkandi sub-district. The proliferation of IFPAs showed that the development and management of FPAs can happen without the NGO initiative and involvement when community participants successfully engage on their own.

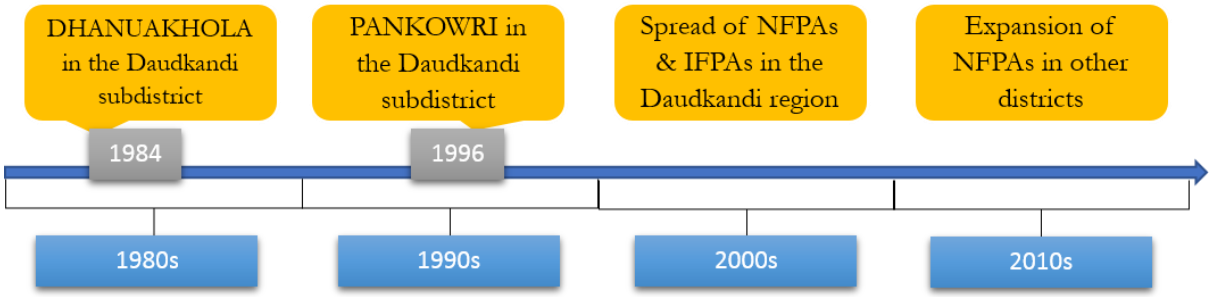


Figure 3.1: Chronological spread of FPAs based on the studied management system

The formation steps and management cycle now generally followed in these FPAs are shown in Figure 3.2. The green boxes depict the seasonal cycle of aquaculture, such as stocking, nurturing, harvesting, etc., in a floodplain water-body once an FPA has been formed. The yellow boxes show the preliminary formation stages of mobilization, reaching agreement, obtaining capital, setting physical boundaries, and forming a management committee. This initiating phase is one-time affair as the FPA formed through these steps manage the aquaculture operation in the designated floodplain every year. However, in the absence of a successful demonstration

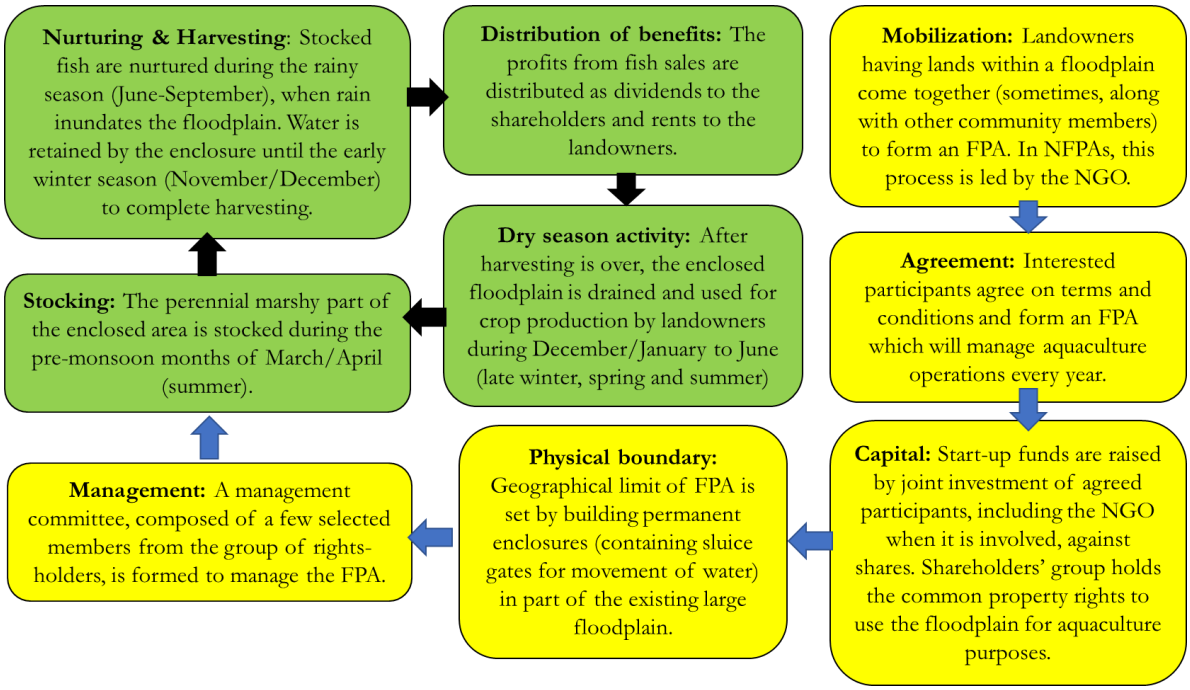


Figure 3.2: FPA formation and management cycle (Yellow boxes indicate the formation stages of FPA and green boxes the annual operations conducted during March-December of every year)
Source: Adapted and modified from Bayazid (2016)

prior to SHISUK's intervention, these preliminary stages were perceived to be more difficult, as shown by the lack of collectively managed FPAs. The green boxes in the Figure 3.2 show the annual cycle of aquaculture operation. After the young fish and fingerlings are collected from the hatcheries and nurseries of community-market and different regional markets, they were released in the perennial marshy parts of the floodplain in March/April period (early summer). In the pre-

monsoon months of May to early June the stocked fish remain in the marshy part and then are moved to inundated floodplain after the arrival of rainy season in the early June. Since release the young fish are nurtured for six to seven months (until September to October) depending on the desired growth of the fish and local conditions. The stocked fish are mainly provided supplementary feed in the floodplains where aquaculture activities are decade old. In the floodplains where aquaculture activities are related recent, the nutritional need of released fish sometimes fulfilled by naturally available feed. By the end of December or early January, harvesting get completed in all FPAs and the floodplain is being prepared by farmers for their agricultural activities.

3.3 Theoretical underpinnings of NGO intervention and collective management of FPAs

SHISUK's intervention to promote FPAs in various parts of the country can be regarded as an extension of conventional co-management practices. In its classic conception, co-management was understood as sharing responsibilities and authority, primarily between central government agencies and local users, in management of a resource (Jentoft, 1989; Berkes et al., 1991; Pomeroy et al., 1997; Carlsson et al., 2005; Beem, 2007). However, through a meta-analysis of co-management interventions in developing countries, Evans et al. (2011, p. 1940) showed that many "co-management projects involve support by independent organizations or non-governmental organizations, in place of the state". This was precisely the role of SHISUK in developing FPAs. The NGO, SHISUK, collaborated with the community in promoting aquaculture practices without any government initiative framework for or involvement in managing FPA enterprises. The involvement of government agencies in similar FPAs occurred only after the trend became popular among landowners. Furthermore, the NGO not only made investments, but also participated in management and day-to-day operations of the FPAs. Therefore, responsibilities and authority were also shared to some extent by community stakeholders (landowners and other shareholders) and the NGO. In contrast, the participation of government agencies was limited to providing financial and technical support, and research collaboration during the project periods in which they collaborated.

In the realm of property rights, there are two aspects regarding the collective management of floodplains for aquaculture operation. One set of property rights determines exclusivity of the owner for benefits and costs accrued by owning and using the resource, along with transferability of these rights through voluntary exchange (Tietenberg and Lewis 2009). Sometimes these rights also authorize the kind of use for the user or user-groups. This type of authorization is more relevant for running FPA operations in floodplains because the same floodplains are used for agricultural production in the dry season. In the collective management

of FPA, a group of rights-holders is formed from the members of the community. This group has the sole right to use the specified floodplain for aquaculture operation. However, the lands within the floodplain are the private property of numerous landowners. Therefore, the collective rights of the group to use the lands for their purpose is obtained by the simple mechanism of rent. Each individual landowner transfers their private property rights to the group for a specified period around the monsoon in exchange for a rent fee. In the dry season, the landowners practise their private property rights by engaging in agricultural activities, mostly rice cultivation.

Another aspect of property rights—consistent with the conceptualization of Schlager and Ostrom (1992)—is related to the bundle of rights, responsibilities, and limitations of the members of the collective group that holds the rights to use the floodplain for aquaculture operations. The rights to the benefits of the aquaculture operation are the basic rights of a member of such a group. These rights are based on the personal investment they made, especially at the beginning of FPA formation. However, the real management and operation of such an FPA is run by a committee composed of a few selected members from the group of rights-holders. This type of management committee (MC) holds the rights to all sorts of collective-choice actions, such as making operational decisions and rules, and operational activities, including harvesting. The rights of ordinary members of the group are limited to benefits according to their investments and sometimes include rights to elect members of the MC. Constitutional-choice actions occurred during the formation of FPAs, and participation in such activities were determined by community members' stakeholding, power relationships, and patterns of the communal decision-making process.

Thus, in collective management of an FPA, common property rights are created for a group of property users, so that they can collectively manage aquaculture operation in floodplain water-bodies. Through the formation of such a group having common property rights, the erstwhile seasonal open access floodplain water-body has been brought under a common property regime. In NFPAs, the NGO is also a common property rights-holder based on its investment, and shares management responsibilities and benefits along with the other shareholders. In all FPAs, irrespective of their formation pattern, the investor rights-holders are now known as shareholders, and those who are selected for managing the FPA affairs are known as directors. Such a management committee is called a board of directors (BoD) or executive committee (EC). These terminologies will be used in this study for simplicity.

3.4 Study sites and Methods

Study sites: The study was conducted on fifteen FPAs, including both IFPAs (five) and NFPAs (ten), so that changes in their organizational and management aspects could be studied side by side. At the time of the study, NFPAs were found in seven districts of Bangladesh. From them, five districts were selected where at least one fully operational FPA was found with records of continuous FPA operations. The sub-districts within these five districts where the FPAs are situated are identified in Figure 3.3. They are Daudkandi (Comilla district), Harirampur (Manikganj district), Shingra (Natore district), Rajapur (Jhalokati district), and Nazirpur (Pirojpur district). In the four sites outside the Daudkandi region, the FPA trend is relatively new. These sites were selected to explore whether there is any difference between the older and newer FPAs in terms of organizational and management practices. It was attempted to select both NFPAs and IFPAs from all sites. However, while more than 50 FPAs—numerous IFPAs, along with six NFPAs—were found to be operational in and around the Daudkandi sub-district, only a few NFPAs that performed continuously through a well-organized institutional scheme were found in the other four sites. As such, eleven FPAs—six NFPAs and five IFPAs—were selected from the Daudkandi region. One NFPA was selected from each of the remaining four sub-districts.

Data collection: The data were primarily collected using interviews based on a structured questionnaire, supplemented during the field visits by non-structured questions asked as the situations required. Two general field visits were conducted. The first visit (April and May of 2016) was conducted when the FPA staff were preparing the floodplain for the approaching monsoon by stocking part of the floodplain with young fish and/or nurturing them. The second field visit (October and November 2016) was made during the harvesting season.

Principal interviewees included FPA staff, directors, some ordinary shareholders and lease holders. Collected data were checked against official documents wherever it was possible. Besides interviews, some participant observations were also conducted by attending the FPA meetings, harvesting sessions, and other official activities (e.g. election of members of the BoD). In addition to FPA staff, NGO staff were also interviewed. The interviewees included NGO staff of each regional office, the FPA programme coordinator, and the executive director. Three types of data were collected. One type of data focused on the formation and development of the FPAs, including information regarding the mobilization of landowners and other community people, infrastructure, initial investment, landowners, and shareholders, among others. Data regarding management included information about aquaculture operations, the decision-making process, and administration rules and practices. The third category of data focused on changes in the management practices over the years.

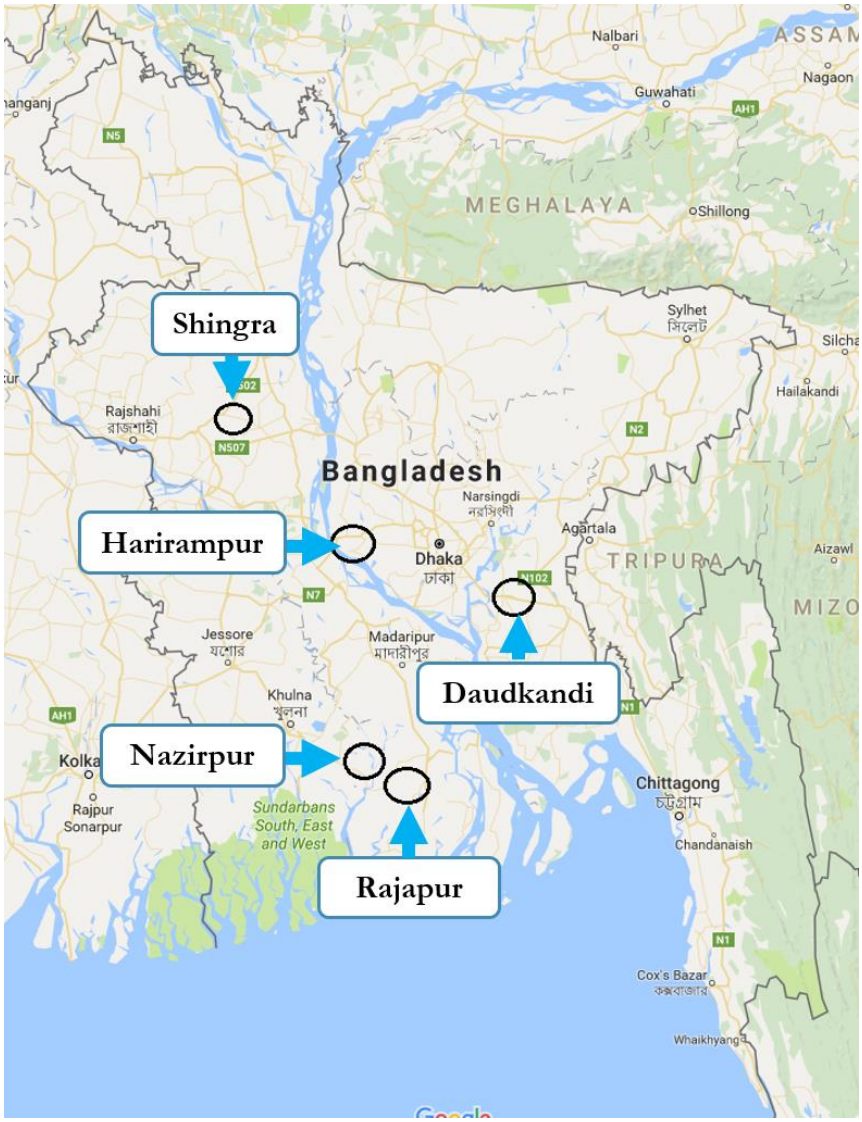


Figure 3.3: Study sites of five the **s**ub-districts (*Source*: https://www.google.co.jp/maps/place/Bangladesh)

3.5 Modifications in organizational and management aspects of FPAs

The studied fifteen FPAs are chronologically shown in Table 3.1, with their shortened names in parentheses[10]. In the Daudkandi region, since the formation Pankowri, SHISUK collaborated with the community in forming Khirai, LKS, Chargram, Shanto, and Proshanto, while landowners established IFPAs such as Charipara, Kushiara, Asia, and Shishir. DKK, Raninagar, UB, and Jhonjhonia were the result of SHISUK's collaboration outside the Daudkandi region and were the earliest NFPAs in their respective communities. These four FPAs were originally formed through various projects where different government development agencies participated as facilitating partners. These agencies provided a portion of the infrastructure cost during the

[10] Fish production related data of these FPAs are shown in Table 4.1.

formation of the FPAs. However, their involvement was confined to the projects' duration, and after that, the FPAs were supposed to function as other NFPAs.

3.5.1 Shareholder composition and its changes in the FPAs over the years

In all FPAs, the investments were made against issued shares, following the practice introduced by SHISUK in 1996. However, this was not the case of Dhanuakhola, which was formed in 1984. Although the participant landowners of this FPA made individual investments like all other FPAs, and divided profits accordingly, the practice of forming FPAs based on investments made against shares was not common at that time. Under share-based investment, a landowner usually makes an investment in proportion to his landholding amount. Thus, the landowner who had more land was entitled to have more shares. However, in Shishir, all landowners made equal investments regardless of landholding amounts. In NFPAs, there was an additional guideline limiting individual shareholding to 20 shares, even if the landholding amount permitted more shares. However, in newer NFPAs (Raninagar, DKK, UB, and Jhonjhonia), the practice of issuing shares in proportion to landholding amounts was not followed. Rather, any shareholder, including non-landowners, who resided in the community could buy a maximum of 20 shares. Nonetheless, such practices were not applicable to the NGO, as it was an extra-community institutional investor. Its share investment was determined at the mobilization phase by negotiating with the community partners, and the common practice was that the NGO would not invest more than 30% of the total share investment.

The composition of shareholders was significantly different between NFPAs and IFPAs (Table 3.1). In the NFPAs, the NGO was the largest single shareholder holding 6.62% (Pankowri) to 30% (Jhonjhonia) of shares. Collectively, landowners were the largest group, holding 92.68% (Pankowri) to 35.22% (Jhonjhonia) of shares. In addition to SHISUK and the landowners, other shareholders were local non-landowners, who could be classified into two categories.

One category consisted of local landless people who did not possess any income-generating land. The older NFPAs (Khirai, LKS, Chargram and Shanto) maintained a specific quota of shares for this category. In this type of quota, one share was endowed to one landless person or household. However, among the more recent NFPAs—DKK, Raninagar, UB, and Jhonjhonia—only Jhonjhonia had such a quota (Table 3.1). These shares were actually allocated from the shares that were bought by the NGO, and the common practice was it endowed up to five percent of its shares to local poor who could not afford purchasing shares. Although SHISUK paid for these shares at the time of the usual investment, these shares were handed

over to the landless after the NGO got back its invested money in the form of dividends earned against these shares.

The other category of non-landowners included local well-off people who did not have any land in the floodplain which was under the FPA's operation but possessed lands in other parts of the community. They included traders and merchants, respected members of the community, elected representatives to local and national government bodies, and ordinary community members. These non-landowner shareholders were known as VIP shareholders.

In the IFPAs, landowners were the major shareholders (Table 3.1). In most IFPAs, non-landowners were not permitted from the very beginning. Very few non-landowner shareholders were found in these FPAs—in Charipara, two neighbouring households; in Kushiara, three local religious institutions; and in Shishir, three non-landowners became shareholders by investing equally like other shareholders.

Table 3.1: **Studied FPAs**

S= SHISUK, LN= local non-landowner who bought shares, LL= landless shareholders who were endowed shares

	Name of the FPAs	FPA type	Year of formation	Locality	Size (ha) of the floodplain	No. of landowners	Composition of shareholders		
							No. of shareholders	Landowner shareholders	Non-landowner shareholders
1.	*Dhanua Khola Nagarpar Adarsha Motsha Chash Prokalpo (Dhanuakhola)*	IFPA	1984	Daudkandi, Comilla	13.23	68	68	68	0
2.	*Pankowri Fisheries Ltd. (Pankowri)*	NFPA	1996	Daudkandi, Comilla	85	420	423	420	3 (1^{S}+2^{LN})
3.	*Charipara Rupali Agro Fisheries (Charipara)*	IFPA	1999	Daudkandi, Comilla	26.71	158	160	158	2^{LL}
4.	*Kushiara Fisheries (Kushiara)*	IFPA	2000	Daudkandi, Comilla	13.35	65	68	65	3^{LL}
5.	*Asia Fisheries (Asia)*	IFPA	2001	Daudkandi, Comilla	170	575	575	575	0
6.	*Khirai Fisheries Ltd. (Khirai)*	NFPA	2003	Daudkandi, Comilla	61	305*	557	437	120 (1^{S}+19^{LN}+100^{LL})
7.	*LKS Fisheries Ltd. (LKS)*	NFPA	2003	Daudkandi, Comilla	46.94	213*	495	359	136 (1^{S}+35^{LN}+100^{LL})
8.	*Chargram Fisheries Ltd. (Chargram)*	NFPA	2004	Daudkandi, Comilla	140	519*	713	573	140 (1^{S}+39^{LN}+100^{LL})
9.	*Shishir Motsha Chash Prokolpa (Shishir)*	IFPA	2004	Daudkandi, Comilla	13.35	34	31	28	3^{LN}
10.	*Proshanto Motsho Prokalpo (Proshanto)*	NFPA	2007	Daudkandi, Comilla	147	828	806	806	0

11. *Shanto Motsho Prokalpo (Shanto)*	NFPA	2007	Daudkandi, Comilla	80.13	474*	850	749	101 (1^{S}+100^{LL})
12. *DKK Bio-Village O Samajik Motsho Prokolpo (DKK)*	NFPA	2012	Harirampur, Manikganj	54.54	195*	497	442	55 (1^{S}+6+48^{LN})
13. *Raninagar Chalan Beel Motsho Community Enterprise (Raninagar)*	NFPA	2013	Singra, Natore	25	86*	262	165	97 (1^{S}+96^{LN})
14. *Uttompur Badurtola Motsho Chash Community Enterprise (UB)*	NFPA	2015	Rajapur, Jhalokati	28.04	117	164	117	47 (1^{S}+46^{LN})
15. *Jhonjhonia SHISUK Community Enterprise (Jhonjhonia)*	NFPA	2015	Nazirpur, Pirozpur	37.39	92	242	65	177 (1^{S}+126^{LN}+50 ^{LL})

(Source: Authors' Survey)

*in these FPAs, the number of landowner shareholders are higher than the number of landowners because some shareholders, who were immediate family members (wives and children) of landowners but who were not officially registered as landowners with the government land management authority, were treated as landowner shareholder since investment against their shares were made by landowners on their behalf

These FPAs were all run by MCs composed of members selected from the shareholders. Given the landowners' overwhelming proportion, only landowner shareholders were permitted to be directors in IFPAs, except for Asia, where three non-landowner directors were found. In these FPAS, MCs were formed through a process of deliberation and negotiation among incumbent and aspirant MC members, and sometimes community leaders. Nonetheless, changes in MCs were irregular and rare in IFPAs. In contrast, in the NFPAs, the general practice was to form a MC for a two-year term by holding an election among shareholders. This practice was regularly followed in all NFPAs of the Daudkandi region, except in Pankowri, where the election was not regular. The basic requirements for both directors and voters were to be landowners and shareholders at the same time, although an exception was found in Pankowri, which had one non-landowner director.

However, differences were found in directors' requirements in the newer NFPAs (DKK, Raninagar, Jhonjhonia, and UB) where non-landowners were found in MCs. Here, the basic requirement to be a member and a voter was to be a shareholder. Nonetheless, like the NFPAs of the Daudkandi region, MCs of these NFPAs were also formed for two years. However, in these newer NFPAs, the number of aspirant candidates were few. Because of this, deliberations and negotiations among the few candidates were preferred to elections for forming a new MC. In addition, the NGO staff stated that an election might cause division and conflict among shareholders, as was experienced sometimes in some of the older NFPAs. Nonetheless, the option of an election was officially still available if deliberation failed or general shareholders preferred elections. It may be noted that the NGO did not have direct voting rights in selecting members of management committees, though it held the position of chairman of the MCs in all NFPAs, except Pankowri.

However, the number and composition of shareholders was not static, and this kind of change had a corresponding impact on the formation of MCs. The composition of shareholders changed in two ways. First, share composition changed when shareholders traded shares among themselves and with non-shareholders. The trading of shares, however, was guided by FPA-specific rules, which determined whether a non-landowner could buy shares or not. In all the IFPAs, no new non-landowners could purchase shares; however, the current non-landowner shareholders (e.g. in Charipara and Shishir) could sell their shares to other landowners. In contrast, the non-landowners could purchase shares of NFPAs, except in Pankowri.

Shareholder composition also changed when FPA management changed shareholding rules or dissolved shares, as was found to happen in the following FPAs over the years:

Pankowri: In the NFPAs, use of the landowners' lands, the participation of SHISUK, and investments were based on a contract or agreement mode at the inception of the FPAs with a valid period of five to ten years. The main reason behind the existence of such a contract was that the NGO was an extra-community participant, and the contract gave the community landowners an assurance that the NGO had no intention of or would not be able to take possession of the property of the landowners in case of default or loss in their collaborative enterprise. Additionally, the contract bound the parties to continue the FPA operation at least for the stipulated period, so that the initial investment costs could be recovered. Finally, the contract gave the NFPA a stable and firm structure for the time being, because within the contract period, no major organizational change was allowed. After expiration of the contract, the landowners might renew the collaboration after reconsidering its terms and conditions, including the nature and extent of involvement of all interested parties.

In Pankowri, as per the contract made at its inception in 1996, shares were issued to any interested member of the community, including non-landowners. Moreover, non-landowners were allowed in the MCs (like Raninagar, Jhonjhonia, or DKK). However, in 2008, after the expiration of the first contract period, the landowners decided to renew their collaboration with the NGO but not with non-landowners. Thus, the non-landowners were forced to sell their shares. At the same time, shares were redistributed according to landholding amounts, and the landowners who had not bought shares at the inception were allowed to buy shares. Moreover, landholding was added as a requirement for directors. Now Pankowri had only two non-landowner shareholders besides SHISUK, and this was an exception to its general rules. Even some of SHISUK's shares were bought back and dissolved by the MC. However, this kind of curtail of SHISUK's shares was not found in any of the other NFPAs.

Kushiara: Like Pankowri, in Kushiara's early years when not all landowners had invested in shares, there was a provision for non-landowners to have shares. However, over subsequent years, such shares were bought back by making changes in its rules, and the landowners who had not previously bought shares were allowed to invest. Moreover, a previous quota of 5% of the shares to be maintained for local landless people was also revoked.

Proshanto: In this FPA, two hundred shares that had been initially planned to be endowed to landless people and that were bought by SHISUK on their behalf were eventually dissolved by the management of the FPA on the grounds that there were no such landless people in the community who could be eligible for such endowment.

Asia: The landless shares (186) were bought back and dissolved.

3.5.2 Emergence of lease-based management of aquaculture operation

In the early 2010s, a practice of lease-based management for the FPAs' aquaculture operations emerged in the Daudkandi region. Through a lease mechanism, an FPA transfers its rights to run aquaculture operations—instead of being managed by the shareholders' representative MC—to lessees in exchange for a lease fee paid to the FPA. Like all FPA activities, this leasing-out process was also administered by the FPA's MC. Table 3.2 shows how the rights and responsibilities were shared between the MC of an FPA and lessees of the aquaculture operation. Through the lease mechanism, a MC's rights to operational activities and related collective-choice actions regarding aquaculture were transferred to a group of lessees. All other rights and responsibilities regarding FPA management remained in the hands of shareholders and their representative MCs.

Table 3.2: Shared rights and responsibilities in FPAs with leased aquaculture operation

Major activities regarding management and operation of FPAs	**Responsible group**	
	Shareholders' appointed MC	Lessee group
Aquaculture operation: stocking, nurturing and harvesting		✓
Collective-choice action regarding aquaculture operation		✓
Dividend distribution to shareholders	✓	
Land rent distribution to individual landowners	✓	
Build/monitor/maintain necessary infrastructure and resource conditions	✓	
Paying compensation for the damage of land and other property of individual landowners/surrounding households	✓	
Decisions about leasing	✓	

(Source: Authors' Survey)

Eight of the eleven studied FPAs in the Daudkandi region were now managing their aquaculture operation through lease-based mechanism. In the light of this observation, we can classify the studied FPAs using the scheme shown in Table 3.3. Besides the categories of NFPAs and IFPAs, the FPAs can be differentiated in relation to the group managing the aquacultural operation, as shown in the columns of Table 3.3. The aquaculture operations of Charipara, Kushiara and Asia, and the more recent NFPAs were found to be managed by shareholder nominated MCs. In 2007, Shishir was the first FPA to adopt a leasing mechanism; however, the mechanism was later significantly formalized by the NFPAs, as discussed in the following paragraphs.

Table 3.3: Classification of sample FPAs based on management of aquaculture operations

	Shareholders' representative MCs	Lessee group
IFPAs	*Asia*	*Dhanuakhola*
	Charipara	*Shishir*
	Kushiara	
NFPAs	*DKK*	*Chargram*
	Jhonjhonia	*Khirai*
	Raninager	*LKS*
	UB	*Pankowri*
		Proshanto
		Shanto

Note: IFPAs=Independently formed FPAs; NFPAs=NGO-collaborated FPAs

Table 3.4 contains lease related information of the FPAs that adopted the system. It shows adoption year of the lease-based practice, tenure of the lease contract, number of members of the current lessee group, etc. In addition, it shows the nature of the stakeholding relationships of the lessees, as discussed in the following section.

How the leasing system works: The aquaculture operation was leased at the beginning of each monsoon before stocking of the floodplain started. The preferred method of leasing was decided upon by directors of the FPA on behalf of the shareholders. Two methods were common among the FPAs. In the method followed by all NFPAs, a lease circular was distributed in the community. Following the announcement, interested groups of lessees submitted their proposals to the MCs. Through a process of open bidding in the presence of directors, shareholders, and NGO staff, the highest bidder was selected from the proposals submitted. Sometimes this selection was done in a sealed-bid manner. After the selection, a contract was signed with the selected lessee group. This contract stated, among other terms, the tenure of the lease, mode of lease payment, geographical limit of the aquaculture operation, and rights and responsibilities of the parties. Another method of leasing involved a non-public and more informal search for a suitable lessee through personal communications of the directors of the FPA. After the leasing trend became popular, many lessees emerged in the Daudkandi region who engaged in this type of leasing ventures. The directors sometimes communicated with familiar lessees of their communities, and reached an agreement through less formal processes. This type of practice was found in Dhanuakhola. A variation of non-public leasing involved internal selection from interested directors of the FPA itself. Subsequently one or more directors leased the aquaculture operation from the MC. In Shishir, one interested director leased the aquaculture operation, and then managed it with the help of external lessees of his choice.

Income for the FPA: The main purpose of an FPA was to generate income by running aquaculture operations in the floodplain. As the FPA was not to engage in this operation after transferring its rights to the lessee group, the lease fee it earned from this transfer to lessees became its sole income. This income was distributed as rent to the landowners, as dividends to the shareholders, as salaries to directors and other regular and irregular staff. It was also used for repair and maintenance of the floodplain and infrastructures, and paying compensation for any damage the aquaculture operation caused. The lease fee was usually paid to the FPA in equal instalments at the beginning of each aquaculture season, if the aquaculture operation was leased for more than one season.

The lessee group: Every lessee group had a leader with whom the lease contract was formally made. A lessee group was organized in the same fashion as an FPA. Its members invested differently and shared returns accordingly, like the shareholders of the FPAs. However, lessee groups contained far fewer investors than the FPAs, as can be seen from the fact that the largest lessee group had 22 members (Table 3.4), while the smallest FPA had 31 shareholders (Table 3.1). Moreover, participation in the lessee group was informal, flexible, and usually limited to the lease period. Nonetheless, there were lessee groups that had formal names and constant core members for managing the group's various lease operations in different FPAs. In any case, the FPAs were found to have no significant prerequisite regarding manner of formation or number of members of lessee groups.

However, internally the lessee groups had varied members. One important point of variation emanated from the stakeholding relationships that the lessees had with the leasing FPA, in addition to being lessees. Based on these stakeholding relationships, the lessees can be separated into two categories:

a) In each FPA there are lessees who had additional and direct stakeholding relationships with the leasing FPA as shareholders or directors. This category could be termed as insider lessees.

b) In contrast, there were lessees who had no stake in the leasing FPA as shareholders or directors. This group can be called outsider lessees. The insider and outsider lessees are shown in Table 3.4. The outsider lessees are indicated by LI, while others are insider lessees.

The nature of these stakeholding relationships is presented in Table 3.4. The table shows that many of the outsider lessees were actually directors or shareholders of other neighbouring FPAs. Different lessee groups had different characteristics in terms of stakeholding in the FPAs, which can be seen in the last row of the Table 3.4 showing the percentage of lessees with any additional stake in any FPAs besides lease-holding. Most lessees had FPA related experience in

one way or another. In addition, the table also shows information on lessees who were locally prominent traders of aquaculture inputs, such as fish feed, fertilizer, and fingerlings.

Table 3.4: FPAs with leased aquaculture operations and the status of lessees in terms of their stakes in the FPAs

Insider lessees, who were also authorized members of the leasing FPA, are indicated as: D= incumbent director, D^P= past director, S=shareholder. Outsider lessees, who were not authorized participants of the leasing FPA, are indicated by 'LI'. The stakeholding relations of the lessees with any other studied FPA are indicated in parentheses as: D^O= director of another FPA, D^{PO}= past director of another FPA, LM=lessee in another FPA, S^O= shareholder of another FPA. Lessees who were engaged in an aquaculture related trade is indicated by 'T' in square brackets. The shaded cells indicate the lessees with any additional stakeholding relations in any studied FPA.

		FPA							
		Shishir	**Shanto**	**Proshanto**	**LKS**	**Chargram**	**Khirai**	**Pankowri**	**Dhanuakhola**
1.	**Lease period (years)**	3	2	2	2	2	2	1	2
2.	**Lease management started in**	2007	2011-12	2011-12	2012-13	2012-13	2013-14	2015-16	2015-16
3.	**Members of Lessee Group**	4	18	19	9	22	18	19	10
4.	**Lessees' relations with FPAs**	D [T]	D	S (D^O)	D^P (S^O, LM)	S* (D^O, LM) [T]	S	S [T]	D
		LI	D	D^P	D^P	D [T]	S	S [T]	D
		LI (D^{PO})	S (D^O)	S	S	D	S	D (LM)	D (D^O, LM)
		LI (S^O)	S (D^O)	S	S	D	S (LM)	S	D
			S	D^P	S	S	S	S (LM)	D
			D^P	D^P	S (D^{PO})	S (D^P, LM)	S	S	LI (S^O)
			LI (D^O)	D^P	LI	S, D^P	S	D (LM)	LI
			LI (D^O)	S	LI (D^O)	S (LM)	D	S (LM)	LI
			LI (D^{PO})	S	LI (D^O)	S	S	S (LM)	LI [T]
			LI (D^O)	D		LI (D^O, LM) [T]	D	D (LM)	LI (LM)
			LI	S		LI	S [T]	S	
			LI (D^O)	LI		LI (D^O)	S	S (LM)	
			LI	LI		LI (D^O)	LI (S^O, D^O)	LI (LM)	
			LI (D^O)	LI		LI (D^{PO})	LI (LM)	LI (LM)	
			LI	LI		LI (D^O)	LI (D^O)	LI (LM)	
			LI	LI		LI	LI	LI (LM)	
			LI (D^O, LM) [T]	LI		LI (D^O, LM)	LI	LI [T]	
			LI (D^O, LM) [T]	LI		LI [T]	LI	LI	
				LI		LI		LI	
						LI			
						LI			
						LI			
5.	**Percentage (%) of lessees with additional stakes in any FPA†**	75	77.78	57.89	88.89	68.18	83.33	84.21	70

(Source: Authors' Survey)

*Only non-landowner shareholder found among the lessees.

†For each FPA, calculated from the total number of lessees who are authorized member of any studied FPAs (number of shaded cells) divided by the total number of lessees.

3.6 Discussion

3.6.2 Participation of non-landowner shareholders

In all types of FPAs, the landowners were the principal and common stakeholders. This is understandable, given that they privately owned the lands within which the FPA operations were conducted. However, non-landowners were also present in all types of FPAs in varied proportions, with important differences in rationale and methods of their inclusion. Below we provide the principle reasons for non-landowner participation:

2.1 **Obtaining the necessary capital**: In many FPAs—especially in the early ones—a portion of landowners were sceptical about the profitability of the FPAs and did not make share investment at the time of the FPA formation. These landowners were satisfied with any rent earnings they would receive in exchange for lowing their lands to be used by the FPAs. This was the case because, before the initiation of the FPAs, most landowners had left the floodplains largely unused during the monsoon, and they had earned little, if any, income from their lands in that season. Thus, when the prospect of income from the flooded lands occurred through the formation of the FPA, they were happy to receive rent income without the additional risk of making an investment in the venture. At that time, affluent non-landowners who were ready to take the risk and make the investment were offered shares freely. As we have shown, such participation was mainly seen in the NFPAs, since these FPAs generally followed an inclusive principle by not confining shares to any specific group, such as landowners, when they were initially issued.

2.2 **Securing support, rule enforcement and leadership**: The group of affluent non-landowner shareholders sometimes included community leaders, locally well-respected persons, or people of political professions, and other potential key community members, such as non-landowners living on contiguous lands of a floodplain. This kind of involvement can be understood from two perspectives found in CPR theories. First, within the institutional model of social-ecological system (SES), as formulated by Anderies et al. (2004), these members of the community could be viewed as providers of 'public infrastructure' in the sense that their inclusion could facilitate enforcement of rules. The idea is that their involvement would ensure compliance with rules by participants (shareholders, directors, and landowners) and non-participant members of the community, such as by not poaching, along with quick, effective, and lasting resolution of any conflict. This perception was also reflected in the term 'VIP shares' by which such non-landowner shares were known among the FPAs. In addition, this type of inclusion would also guarantee these key non-landowners'

commitment to comply with the rules of the FPA as participants and beneficiaries. The inclusion of neighbouring non-landowners was also found in IFPAs.

Second, the roles played by locally influential people can be perceived from their leadership status within the community (Olsson et al., 2007; Gutiérrez et al., 2011; Stöhr et al., 2014). In our study, we found that the participation—in the form of token endorsement to being a member of the regular decision-making body—of the community leaders and/or locally respected people provided the legitimizing foundation through their approval and support for the FPA initiatives. Moreover, some non-landowners were cited as possessing important managerial skills, demonstrating personal commitment, and taking direct responsibility for the functioning of the FPAs. Few of these non-landowners ultimately bought lands within the floodplain to further strengthen and legitimize their involvement. It was reported that, in the earlier years of NFPAs, critical leadership roles regarding motivational support, guidance, and commitment were provided by both landowners and non-landowners. This kind of involvement was especially found in the NFPAs, because the NGO itself is an extra-community entity.

2.3 **Poverty alleviation**: Landless community people were included to make the FPA initiative socially more beneficial[11]. While the presence of landless community members was almost non-existent in the IFPAs at the time of the study (Table 3.1), in NFPAs their endowment-based inclusion was reported to mainly depend on their presence in the community and ability to invest in shares. In most of the NFPAs where there was no landless quota, and in Proshanto where planned allocation of such shares was ultimately cancelled, official staff reported that, in their communities, there were no ultra-poor landless people who could not afford to buy shares. As these shares were endowed by the NGO from its own shares, we asked whether it conducted any survey to get information about local landless people before allocation of such shares. It became apparent that the NGO made its allocation decision upon information provided by the community leaders and landowners at the time of formation of the FPA or by the directors of the FPA rather than on any kind of survey. Therefore, the inclusion of local poor largely depended on how they were represented or reported by the community leaders or local members of the FPA management.

The first two points explained why shares were not issued in proportion to landholding amounts and why non-landowners were found in MCs of Raninager, Jhonjhonia, and DKK, or even in

[11] Not having income-generating land is traditionally considered within a community as an indicator of poverty. This indicator was also considered by the NGO when it distributed some of its shares for alleviating local poverty.

Pankowri in its early years. Interestingly, while the participation—and subsequent exclusion in Pankowri—of the affluent non-landowners in the MCs was observed in some FPAs, this had never been the case for the landless shareholders as they had never been members of MC in any FPA. Our observations from the field indicated that, to some extent, the absence of the landless in decision-making process was caused by the fact that the inclusion of the landless people was based on endowment rather than on their active involvement in and support for the FPAs and/or on their socioeconomic importance within community. It should be noted in this connection that, although the NGO allocated shares to local poor in many communities, it didn't make any attempt to include these people in the MC. While it was difficult to predict the outcome of such attempts in their absence, the NGO perceived its share endowment more as financial assistance similar to social safety net support rather than as empowerment programme for the ultra-poor. In addition, participation of the landless was impossible in many FPAs as no type of non-landowner was authorised to become member of the MCs in these FPAs.

However, arrangements for non-landowners' participation were not permanent, as we have seen in Pankowri or Kushiara, where non-landowners were eventually excluded. The reason for this change could be found in the growing realization among landowners of the profitability of FPA enterprises. This realization was expressed in the unanimous responses of the interviewees about the increase in fish yield and resultant increase in income from the FPAs over the years. This enhanced realization can also be easily appreciated from the expansion of the FPAs, and the ways access rules were modified. On one hand, only the prospect of a lucrative return motivated the landowners to collectively start aquaculture in their lands. At the same time, many landowners who had not previously bought shares ultimately became eager to obtain a share of the rising profits. Thus, the early role of the non-landowners as investors in an FPA became unnecessary, as the landowners themselves were now keen to invest in this profitable venture. In the IFPAs, the landowners as principal organizers were not usually willing to include non-landowners unless their inclusion helped the functioning of FPA management (as mentioned above); in a few IFPAs, like Kushiara, where non-landowners were involved, they were asked to leave. This was also observed in NFPA such as Pankowri.

The exclusion of non-landowners indicated the attempt to confine the benefits to as few people as possible. In some FPAs, this resulted in concentration of shares among only the landowners whose claims to participation and benefits would be rather difficult to ignore because of their ownership of the lands of the floodplains. Consequently, landownership within the floodplain—which has always been an important determinant for user's access rights in the FPA because of the private ownership of lands within floodplains—ultimately became the most

important factor in gaining access rights and making legitimate claims to benefits of the FPAs. Only those non-landowners who were too important to exclude remained as shareholders, such as national-level political figures or highly influential community members. Thus, in Pankowri and Kushiara, all this resulted in inclusion of erstwhile non-shareholder landowners and exclusion of non-landowner shareholders.

The heightened realization of profitability also resulted in cancellation of shares that had been endowed to the landless, as was found in Asia and Kushiara. Regarding landless shares, a few FPA staff members—both from IFPAs and NFPAs—complained that some landless shareholders had sold their shares when they faced financial difficulties, and thus made the provision to provide support for them by endowing shares pointless. Although the efficacy of earnings from only one share in alleviating poverty of a landless poor household may be questioned, it should be mentioned that in NFPAs, most landless shareholders kept their shares. This is supported by the observation that the number of landless shareholders remained the same in these FPAs over the years. However, in the NFPAs, trading of endowed landless shares was not permitted, and if any landless shareholder traded his endowed share, that share would be cancelled. Thus, although a few FPA staff suggested that trading of landless shares occurred, they had no documented record of such trading since no shareholders ever reported any such transaction. Whatever may be the case, in the context of a prevailing tendency to confine profit among as few people as possible, selling of shares by landless shareholders prompted some FPAs' managements to dissolve landless shares.

In addition, an understanding also common among landowners was that non-landowners' participation might have negative impact on the FPA and on their property. This was because, as the non-landowners did not have any ownership stake in the floodplain, their participation in management might result in irresponsible operational decisions, and thus might damage lands, neighbouring houses, the related infrastructure, or disrupt the seasonally alternative use of the floodplains, among other concerns. The absence of non-landowners in the IFPAs from the beginning indicated that such concerns had been always there in some degree. Nevertheless, it is possible that these concerns were accentuated by the FPAs' rising profitability and consequent increased profit consciousness.

However, in most NFPAs—Khirai, LKS, Chargram, and Shanto—the inclusion of non-shareholder landowners was slow and gradual, and did not result in exclusion of any non-landowners. This non-exclusion can be explained through three observations. First, these FPAs were formed a few years after the formation of Pankowri, and by that time the profitability of the FPAs was clearly demonstrated. Thus, from the beginning, most of landowners bought

shares in these FPAs and only a few were left out for personal reasons, such as absence of the household chief or disputes over land ownership, etc. Second, the non-landowners (besides the local landless) shareholders were mostly local elites whose involvement was more of a token endorsement than any real involvement in the FPAs' management. In addition, even if any non-landowners wanted to participate in the FPAs' management, such involvement was institutionally impossible as no non-landowner was allowed to be a member of an MC or a voter for selecting such members, according to the FPAs' rules. No non-landowner MC member was found in any of these FPAs. It is noteworthy that, unlike the first NFPA Pankowri, where non-landowners were initially allowed as members of a MC, in the following FPAs, the landowners' exclusive rights to the MC was in effect from the very beginning. This change in rules attested the landowners' increased readiness to participate in FPA ventures and heightened realization of profitability from them.

Finally, the continued participation of landless shareholders in these IFPAs indicated that this was caused by the presence of the NGO in these FPAs. Nonetheless, the interviewed directors of these FPAs expressed no objection against the continued sharing of benefits by non-landowners. Some held the view that since these non-landowners lived around the cultured water-body, their inclusion would bring about their assistance, support, and compliance with FPA rules as beneficiaries of the enterprise.

Nonetheless, even in these NFPAs, the number of landowner shareholders were reported to increase over time. This increase mainly resulted from the FPAs' rules regarding election of members of the MCs. On one hand, since only landholders of a specified amount of land could compete in such elections in these FPAs, it was reported that a few non-landowners bought or acquired lands through inheritance to become members of MCs. Having the required amount of land in one's own name was important, because parents' land could not be used for voting or candidacy purposes. However, since transaction of shares was allowed in these FPAs, acquiring shares was cited to be easier than acquiring land. On the other hand, as the voter was also required to be a landowner and shareholder, some candidates bequeathed the required amount of land and shares—which was very small—to his lawful inheritor to increase his number of votes. Every voter was important, because MC members were separately elected from each of the villages that surrounded a floodplain. Thus, in each village, the actual number of voters was not many. It was reported by FPA staff that they had to frequently update their official records for these new landowners and shareholders before elections.

Therefore, it became evident that there was a gradual increase of the proportion of landowners in shareholder composition in the studied FPAs of the Daudkandi region. With the

increased realization among landowners of profitability, the support of non-landowners became redundant and their sharing of benefits was perceived as an unwelcome extraction of benefits by outsiders at the expense of landowners' more rightful claims. The idea of non-landowners' involvement, especially the affluent ones, was now generally perceived by landowners as a meddling attempt, because access rights to FPAs were now being legitimized in terms of landownership more than they were at the beginning of the FPA trend. Even for the NGO, the priority in the Daudkandi region was to keep the landless. Interestingly, the involvement of the NGO was also viewed by a few landowners as unnecessary. SHISUK's share reduction and removal from MCs' chairmanship in Pankowri were the result of a few landowners' opposition to its continued involvement in the FPA.

However, a few interesting exceptions were found in the landowners' general attitudes toward non-landowners in those FPAs where the latter group was excluded or not allowed at all. In Asia and Pankowri, exceptions were made to the general rule to include non-landowner directors in MCs. Moreover, these non-landowners were found to not even be shareholders. In the case of Pankowri, we learned that such an exemption which was made for one non-landowner was attributable to his power relations within the community. This exception to organizational rules stood in sharp contrast to other NFPAs, where aspirant non-landowners were found to abide by the rules and bought or obtained land through inheritance to fulfil the landholding requirement of a director. This indicates that, in some cases, the community's internal dynamics of power relationships could be a direct determinant of the inclusion (and possibly the exclusion) of non-landowners, along with their type and continuity as participants. Such inclusion or exclusion ultimately translated into facilitation or contestation of the enforceability of the rules and functioning of FPAs in the community. For NFPAs, this signified that SHISUK's role in maintaining the NFPA's organizational integrity was also shaped by such community power dynamics.

3.6.2 The innovation of lease management and rise of professional lessees

During the last two decades in the Daudkandi sub-district, the shareholders and directors of the FPAs experienced many difficulties. Topping the list was unsatisfactory profits or outright losses, leading to lower than expected or no dividends or land rents. In this respect, there were frequent mentions of various issues surrounding the management committees' handling of FPA affairs. These included complaints about inefficient management of aquaculture operations by the MCs, lack of cooperation and mistrust among the directors, along with typical allegations of financial embezzlements, among others. The transfer of the FPA's income generating function,

aquaculture operation, through leasing mechanisms to lessees was innovated by the participants of the FPAs as a solution to these problems.

Many interviewees reported that the primary reason for transferring the management risk and responsibility to a lessee group through lease management was to solve two major problems the FPAs were facing. First, the problem of lower profit or loss was solved through the lease mechanism because, under this mechanism, the lease fee became the income of the FPA instead of sales revenue from fish generated by aquaculture, upon which its profit previously depended. Moreover, the lease fee was riskless, because an FPA earned it without engaging in aquaculture operations, and thus without making any of the usual operational expenditures related to such operations.

At the same time, since the challenge of managing aquaculture was transferred to the lessees, and how they managed that operation had no impact on the income of the FPA, this solved the second major problem hurting the income of an FPA resulting from any mismanagement of aquaculture operations by the responsible management group. In Table 3.4 we showed that many of the lessees (58% to 84%) were in fact, one way or another, related to the FPAs. Many respondents expressed the opinion that, under the lease-based system, the lessees—whether they were directors in the new role of lessees or any other outsider lessees—could hardly afford mismanagement of aquaculture operations, since the stakes for the few lessees were personal and high. The lessees ran the aquaculture operation by making considerable personal investments rather than managing irresponsibly the investments made by the shareholders of the FPAs.

The interviewed lessees were found to be motivated to take risks to make an investment in leasing aquaculture operations and mentioned the prospect of profits from such ventures as motivations behind such involvement. Thus, the lessees could be viewed as a new type of fishermen whose involvement in aquaculture was of entrepreneurial nature. This was despite the fact that most of them had little or no experience in fish farming before the introduction of FPAs in their communities. However, as we have shown in Table 3.4, many lessees were either insiders of relevant FPAs or stakeholders of other FPAs, and gathered years of fish farming experience through managing the FPAs as directors. A few also cited their experiences in managing private pond aquacultures. More importantly, they were now aware of the profitability of aquaculture enterprises in floodplains. While as FPA directors they could still earn remuneration for their services, those who were involved in leasing reported that they made higher income from higher investments. In addition, when someone managed the aquaculture operation as a director of an FPA, the losses as well as profits of the FPA were shared among all

shareholders, and the portion of their personal loss or gain was not large. There was also mention of additional income in the form of commissions as the result of large scale and/or continuous purchase of aquaculture inputs from suppliers. Since this income was only accessible to those who were making decisions and managing the aquaculture operations, the directors in their roles of lessees could still benefit from such income.

The size of the lessee group was usually small (Table 3.4), and corresponded to the average size of MCs. Like the members of the MCs, the lessees were responsible for decisions about stocking, harvesting, managing, and other aspects of the aquaculture operations. Nonetheless, the extent of their involvement was greater than the usual managerial role of members of MCs because it was based on their considerably higher investment and resultant higher personal commitment to aquaculture operations. Some lessees were also found to manually participate in harvesting and other fish culture activities alongside the employed staff and labourers, like any other fishermen, as a part of direct monitoring.

At the same time, many lessees also held leases in FPAs of neighbouring communities as members of the same or different lessee groups. For example, the lessee group of the Dhanuakhola FPA was found to manage several other FPAs. Thus, over time, there emerged a class of professional lessees who worked as investor-managers, and were specialized in the management of lease-based aquaculture activities. It can also be said that the rise of these professional lessees and lease-based management of FPAs' aquaculture operations were two mutually reinforcing developments.

However, growth of aquaculture related professions was not limited to lessees, as the spread of FPAs was accompanied by the rise of various input suppliers and output forwarders in the Daudkandi sub-district (Gregory et al., 2007; Toufique and Gregory, 2008). In the other four sites, the FPA trend was too new to have resulted in the growth of such professions.

When the staff and shareholders of Charipara, Asia, and Kushiara were asked why they did not adopt lease-based management of aquaculture operations, they responded that they were continuously making profits and the landowning shareholders were happy with their management. While we did not collect any time series information on revenues of these FPAs, a glance at the FPA profits for the season 2015-16 showed that these three were among the eight FPAs which did make profit in that season.

3.7 Concluding remarks

This study aimed to trace the major organizational and management modifications that were introduced by participants of the FPAs as they experienced altered incentives and new challenges in the process of their continuous collective attempts. In the course of the study, the NGO

SHISUK's contribution in the development of FPAs in the Daudkandi region and the recent spread of the trend in other parts of Bangladesh was corroborated. However, after SHISUK's intervention in the Daudkandi region, the expansion of FPAs was boosted by a trend of bottom-up adoption, where landowners formed FPAs to collectively manage aquaculture in their lands. Although the NGO remained as a non-landowner institutional partner in the NFPAs, it was the landowners—either as principal participants or sole organizers—who played the major role in subsequent evolution of FPA management and organizational practices. While the landowners were always the most important participants in these FPAs because of their ownership of the lands of the floodplains, this aspect gradually transformed into the most important factor in determining users' rights in some FPAs.

This transformation has important implications for CPR theories. For example, within the SES framework (McGinnis and Ostrom, 2014; Ostrom 2007, 2009) this feature of private ownership of floodplain lands can be perceived as a component of a Governance System (GS), or even as a component of a Resource System (RS), because this private property regime was not directly used to govern the collective use of the floodplains. Nonetheless, this feature has an important impact on the collective action situations regarding FPAs, as shown in this study. Regardless of within which first tier of the SES framework we place this feature of the studied floodplains, our findings indicate that the significance of this feature as a determining factor of actors' behaviours, and therefore, of outcomes, increased over time. This suggests that the importance of a variable in the governance of CPR can be changed over time as a result of the modified perception of a variable and its use among actors. In addition, this finding reiterates the continuous challenge of 'developing methods for studying the evolution of action situations over time' (Ostrom, 2011: p. 23).

The participants introduced changes in the FPAs' organizational composition and management practices in light of what they experienced and learned over the years. In this process of experiential and experimental learning-by-doing, the NGO has also been a partner. These two—adaptive management and the linkage characteristics of co-management—are the basic components of adaptive co-management (ACM) (Plummer et al., 2012). However, whether the modifications that were implemented in the FPAs can be called ACM depends on whether they meet the core components, features, and necessary conditions for an ACM (e.g. Plummer et al., 2013) or how they compare with an ACM-based assessment of natural resource management (e.g. Stöhr et al., 2014). Such evaluations can be made in future studies methodologically built on ACM frameworks. Nonetheless, lease-based management was an adaptive development because it was innovated by shareholders to solve the problems of financial performance. Thus, to some

degree, the FPAs evolved through participants' capacity to respond adaptively in the face of challenges they experienced. Although our study found that most, but not all, interviewed shareholders were happy with the outcomes of lease-based management, the question whether the lease mechanism led to effective and efficient financial and non-financial management of aquaculture operation requires further inquiry.

Meanwhile, as illustrated in this study, many later developments regarding FPAs were responses—such as the proliferation of FPAs in the Daudkandi region, and landowners' attempts to become rights-holders or concentrate among themselves the increasing flow of benefits—that resulted from modified incentives brought about by the community's integration with the market (cf. Pender and Scherr, 1999; Agrawal, 2001; Gebremedhin et al., 2004; Tucker et al., 2007; Cinner et al., 2012). In the case of the present study, the community's integration with markets through development of FPAs occurred with the help of the NGO. Although its involvement was not limited to that role, since it has been continuously shaping the management of the FPAs and governance of the floodplain water-bodies, its capacity in these roles is to some extent determined by the dynamics of a community's internal power relationships, as can be seen from the example of Pankowri. Thus, an important area to be explored in future research can be the dynamics of communal power relationships and their impact on the governance of floodplains and management of their uses.

Of the five studied sites, no other site showed developments like those that were observed in the Daudkandi region. These developments, including lease-based management of aquaculture and the rise of professional lessees, were the results of more than two decades of FPA expansion in and around the Daudkandi region. Although the interviewees from the other four sites reported few aquaculture initiatives besides the NFPAs, their number, level of fish production, revenues, and community participation have yet to reach what we observed in the Daudkandi region. Nonetheless, the direction of the FPA evolution in these regions should be carefully examined in the particular context of expanding FPA trends and the overall context of community-based CPR management.

In any case, the introduction of aquaculture in seasonal floodplain water-bodies is an altered way of using existing resources. This altered way entails not only new management practices underpinned by newly defined property rights-holders, but also new levels of involvement from the rights-holders. Enhanced use of the floodplain to obtain higher yield requires a higher degree of involvement from the authorized and contributing users. In the context of heightened awareness of profitability of FPA enterprises, the twofold challenge for the future will be, first, how the local poor or marginal community members can claim or

maintain endowed claims over time of benefits for which they made no contribution, and second, how the benefits from FPAs can be made more wide-ranging through continued inclusion of non-landowners.

Chapter 4

Measuring efficiency of collective floodplain aquaculture enterprises of Bangladesh using Data Envelopment Analysis

4.1 Introduction

Bangladesh has experienced a gradual rise in aquaculture in seasonal floodplain water-bodies in the last two decades. This trend began attracting the attention of academia and policymakers since the late 2000s (Gregory et al., 2007; Toufique and Gregory, 2008; Belton et al., 2011; Haque et al., 2011; Sultana, 2012; Joffre and Sheriff, 2011; Dey et al., 2005, 2013; FRSS 2013, Bayazid, 2016), although studies have reported the simple stocking-based rise of harvested fish from floodplains since 1988–89 (Ahmed, 1999; Islam, 1999). While floodplains contain the largest area of inland waterbodies, at 2.8 million ha, only 140,000 ha of this is currently under aquaculture practice (FRSS, 2017). However, given the comparatively recent introduction of cultured practices, and that they exist in only 5% of the total floodplain area, the yield from this portion is impressive, at around 23% of the total yield from floodplain water-bodies. Thus, it has become an important sector for food security in Bangladesh.

In terms of property rights, the floodplains of Bangladesh can be divided broadly into two categories: 1) floodplains that are fully or mostly owned by various government bodies, and 2) floodplains that are primarily composed of privately-owned lands of numerous landowners. Although seasonal aquaculture is found in both categories of floodplains, the recent emergence of the trend is centred more around the second category of floodplains. A common practice to initiate and manage an aquaculture in such a floodplain is to form a collective body, mainly composed of landowners who make the necessary investment to implement aquaculture in the floodplain water-body. We use the term *floodplain aquaculture (FPA)* to identify this kind of collective body. In many cases, FPAs also include interested non-landowner participants, both from within and outside the community.

An early system of FPA organization and management was developed in the Daudkandi sub-district of the Comilla district when landowners of a floodplain formed an FPA named *Dhanuakhola Nagarpar Adarsha Motsha Chash Prokalpo (Dhanuakhola)* in 1984. However, the FPA trend gained significant momentum in this region since the formation of the FPA *Pankowri Fisheries Ltd* in 1996, where an NGO, named SHISUK, first participated along the community participants. Through its participation, the NGO also modernized the earlier management system and demonstrated its successful application in larger water-bodies involving large number of stakeholders. Because of such role this management system was frequently associated with SHISUK in many previous studies (Gregory et al., 2007; Toufique and Gregory, 2008; Belton et al., 2011; Khan 2015; Dey et al. 2013). In any case, SHISUK gradually expanded its FPA programme by forming more NGO-collaborated FPAs (NFPAs), first in the Daudkandi region and then in other parts of the country. In the Daudkandi region, freshly motivated by the success

of NFPAs, landowners of the neighbouring floodplains formed many independent FPAs (IFPAs), like Dhanuakhola, without support or involvement of any NGO or government agency. As a result of these expansions over the three decades, significant internal variations now can be observed in terms of organizational and operational aspects within the original management framework (Bayazid et al., 2018).

The purpose of this study is to measure the relative efficiency of such FPAs which, despite being formed adopting a similar management framework, now show important internal variations. In addition to measuring efficiency of aquaculture operations of these FPAs, which has not been done before, the study may indicate whether any specific variation show more efficient outcomes than others. This may shed light on relations between the FPAs' internal variations and current performances. Thus, it may also provide directions for the future improvements. Previously, a handful of studies (Mustafa and Brooks, 2009; Akter et al., 2015) compared the performance of various seasonal aquaculture enterprises, including FPAs of this management approach. However, these studies mainly compared aquaculture practices found in different kind of floodplains with different management approaches. The same is true of the study conducted by Sultana (2012), where the author compared several enclosure-based aquaculture management systems. In contrast, on one hand, we compare aquaculture practiced in the same type of water body, namely, floodplains composed of privately owned lands. On the other hand, the selected aquaculture enterprises are related to one another in the sense that they evolved from the same organizational and management core; that is, landowner-centred collective management. Moreover, when previous studies compared FPAs of this management framework, they ignored IFPAs and solely concentrated on NFPAs. In contrast, we try to maintain a representativeness by including FPAs of organizational and operational variations that flourished over time under a general management framework.

In addition, in this study, we introduce the Data Envelopment Analysis (DEA) for measuring the technical, scale and mix efficiency of selected FPAs. DEA is a non-parametric approach developed by Charnes, Cooper, and Rhodes (1978) as an alternative to conventional efficiency-measurement techniques, which place some restrictions on calculating total factor productivity and are usually used to identify average, rather than the best performers. In contrast, DEA measures the relative efficiency of various entities—called decision-making units (DMUs)—engaging in the same kind of operations and provides considerable computational flexibility and ease, along with broader scope for analysis.

The application of DEA for studying the efficiency of aquaculture has become popular during the last two decades (Iliyasu et al., 2014; Sharma and Leung, 2003). Studies range from

those on standard economic or technical efficiency (e.g. Sharma et al., 1999) to time series analyses (Asche et al., 2013) and combinations of DEA and other techniques (Vázquez-Rowe et al., 2010; Iliyasu et al., 2016). With regard to Bangladesh, existing DEA studies include species-oriented analyses (Alam and Jahan, 2008; Alam, 2011), farm-based measurements (Arjumanara et al., 2004) and evaluating the potential of emerging practices (Ahmed et al., 2011).

The next section briefly introduces the organizational and management aspects of the studied FPAs. Section 3 describes the slack-based DEA methodology used in this study and is followed by a description of the data collection process in section 4. The results of the efficiency measurements and related analyses are presented in section 5. Section 6 concludes the paper.

4.2 Collective management of aquaculture in floodplains

Several types of aquaculture practices are found in the floodplains of Bangladesh and, among them, the common form consists of the rotational use of the floodplains for rice and fish production (Dey et al., 2013). In this mode, fish culture is limited to seven or eight months around the monsoon when the floodplain turns into a single water-body. In the dry season, when the individually-held plots of lands within a floodplain can be clearly demarcated, landowners usually use their lands for production of crops, predominantly rice. In the most common way of organizing such rotational rice-fish production system, privately managed rice production in the dry season is followed by collective fish culture in the monsoon season. The collective body holds the rights to conduct fish culture in the floodplain water-body during a stipulated period around the monsoon.

The selected FPAs are one type of such collective body. In terms of organization, the common features of these FPAs are that (1) they are mainly composed of landowners of the floodplains, and (2) the basic contribution that all participants must make is to invest to initiate fish culture operation. When non-landowners from the community—who do not own any land in the cultured floodplain and are more common in NFPAs—participate in FPAs, they also have to make such investment to create the basis of their participation. This is also true for the extra-community non-governmental organization (NGO), SHISUK—the only one that is found as a participant in some FPAs—since, like all other landowner and non-landowner participants, SHISUK also invested in the FPA shares. An FPA formed this way holds the collective rights to fish culture operation and, usually pay land rent[12] to each landowner in exchange of transferring their private property rights to the FPA.

[12] Payment of land rent is practiced in all FPAs, except one (Dhanuakhola). However, the mode of payment of land rent seems non-conventional. Although it is paid to the landowners because of their ownership of lands, it is not paid in advance to the landowners and does not depend on any rate fixed at the beginning of fish culture operation.

It should be noted that, the initial involvement of SHISUK mainly resulted from its role in promoting FPAs in the related communities. Although the inclusion of such non-landowner and involvement of NGOs are not uncommon in other floodplain aquaculture systems, their modes of involvement are varied in different management systems ((Dey et al. 2003 & 2005; Joffre et al. 2011). In this study, we concentrate on the management system where the NGO participates by making investment like all other participants. To the best of our knowledge, SHISUK is the only NGO who participated in this manner.

In terms of management, each FPA forms a management committee from its shareholders to make decisions about and oversee all kinds of FPA functions, including fish culture operations. In NFPAs, SHISUK also acts as a member of the management committee. Such a management committee holds the sole rights over the harvesting of fish and no shareholder is permanent to harvest from the cultured water-body. The operational pattern of fish farming followed by these management committees are almost identical, since all FPAs conducted culture activities around the monsoon in same type of floodplains. This process is presented in Figure 4.1. Some infrastructural development or modification of the floodplain under aquaculture has been made before the inception of an FPA enterprise. This includes the construction of permanent earthen embankments and roads along the borders of the floodplain to control the flow of water and to transport inputs and outputs. After these preliminary steps are completed, the fish farming process follows the usual pattern of stocking, nurturing and

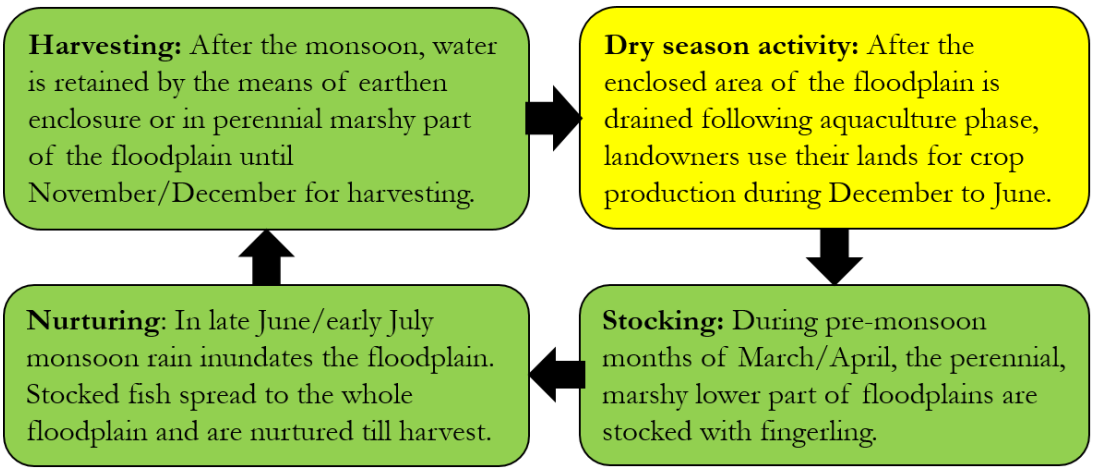


Figure 4.1: Annual cycle of aquaculture and agriculture in floodplain (adapted from Bayazid 2016, p862)

Rather, it is paid as a portion of net return or profit and calculated as percentage of profit. Thus, its payment is contingent upon the making of profit. If an FPA cannot make profit it does not pay land rent to the landowners. In the early years of their operations, when many FPAs failed to make profit, such land rent was not paid to landowners. However, as most of the FPAs are now profitable, land rent is paid to all landowners regardless of being a participant or not of the FPAs. It may be added that, this way of paying land rent from the profit might affect the management of aquaculture operation in the same manner as does the possibility of earning dividend from profit.

harvesting (Figure 4.1). After harvesting net return or profit was distributed among shareholders as dividends and as land rent among landowners.

However, despite following a similar approach for organizing and managing their activities, some important variations can also be found among these FPAs that have emerged over the years. In a previous study Bayazid et al. (2018) mentioned of two most important variations. First, with respect to organizational composition, we already mentioned the most obvious types, namely NFPAs and IFPA, that resulted from the involvement of the NGO, SHISUK, as an important stakeholder in some FPAs.

Second type of variation is found in terms of the mode of managing aquaculture operations. Typically, the management committee of an FPA oversee all aspects of aquaculture operations and make related decisions. However, in some FPAs, a lease-based management of aquaculture operation has been developed. In lease-based management, the FPA's management committee, as the representative of investors, transfers their rights of managing the aquaculture operation to a group of lessees in exchange for a transfer fee. The aquaculture operation is usually leased for more than one season (e.g. for two to three years). It is worth mentioning that the lease-based mechanism was developed as a solution to the persistently low performance or losses in some FPAs. Today, many FPAs (both IFPAs and NFPAs) have adopted the lease-managed mechanism, while others continue a self-managed operation. In this study, in addition to measuring efficiency of FPAs of this management system, we try to see whether (1) the involvement of NGO have any positive impact on efficiency, and (2) lease-based operations are more efficient than self-managed operations.

4.3 Methodology: Data Envelopment Analysis

DEA is used to measure the efficiency of target DMUs by establishing a frontier surface that contains the efficient DMUs and envelops the inefficient one (Cooper et al., 2007) through mathematical and linear programming. Inspired by Farrell's seminal work (1957), Charnes et al. (1978, 1981) developed the first DEA model, known as the CCR (Charnes-Cooper-Rhodes), to consider total factor productivity by including multiple inputs and outputs into an efficiency calculation. DEA identifies the best DMUs and measures the relative efficiency of others with reference to the best ones. In this study, to draw a comprehensive picture of efficiency of FPAs, we use three DEA models, namely CCR, Banker-Charnes-Cooper (BCC) and slack-based measure (SBM), which are briefly described as follows.

The CCR model for measuring technical efficiency: Technical efficiency (TE) measures the extent to which a DMU produces the maximum feasible output from a given set of

inputs, or uses the minimum level of inputs to produce a given level of output. The most common DEA model that is used to measure TE is CCR. The usual linear programming (LP) formula for measuring CCR efficiency θ is as follows:

$$(CCR_{LP}) \max_{v,u} \theta = uy_o$$

subject to $vx_o=1$

$vX \geq uY$

$u \geq 0$, $v \geq 0$. (1)

where x_o and y_o are the input vector and output vector, respectively, and v and u represent vectors of input weights and output weights. The constraints are set such that the value of θ ranges from 0 to 1. If the objective value θ^* is 1 for the target DMU, then it is efficient, otherwise it is inefficient. The CCR score shows the input minimization rate in an input-oriented model, or the output augmentation rate in an output-oriented model. Figure 4.2 shows a simple representation of the CCR frontier as a straight line from the origin for eight DMUs (A, B, C, D, E, F, G and H) with one input and one output. Here, H is the only efficient DMU, since it is located on the CCR frontier. It is the failure to reach the frontier that makes other DMUs inefficient. The CCR model assumes a technology which is operating at constant returns to scale (CRS). Thus, in a CCR model, consideration of the best performance in terms of returns to scale (RTS) is already embedded, and CCR-efficient DMUs are also scale efficient (Coelli et al., 2005).

Variable returns to scale and the BCC model: To incorporate variable returns to scale (VRS) characteristic of the production technology, Banker et al. (1984) proposed the BCC model by separating the simultaneous measurement of technical and scale efficiencies in the CCR model. This model which produces pure technical efficiency (PTE) can be represented as follows:

$$(BCC_D) \max_{v,u} \theta_B = uy_o - u_0$$

subject to $vx_o=1$

$vX \geq uY - u_0$

$u \geq 0$, $v \geq 0$, where u_0 free of sign. (2)

Here, u_0 can be used to identity the RTS nature of the DMUs, that is, whether they are increasing returns to scale (IRS), decreasing returns to scale (DRS), or constant returns to scale (CRS). The BCC frontier is piece-wise linear as shown in the dashed connected lines of Figure 4.2. While, as in the CCR model, the BCC score ranges from 0 to 1, the BCC frontier contains more efficient DMUs than the CCR frontier because of former's VRS assumption.

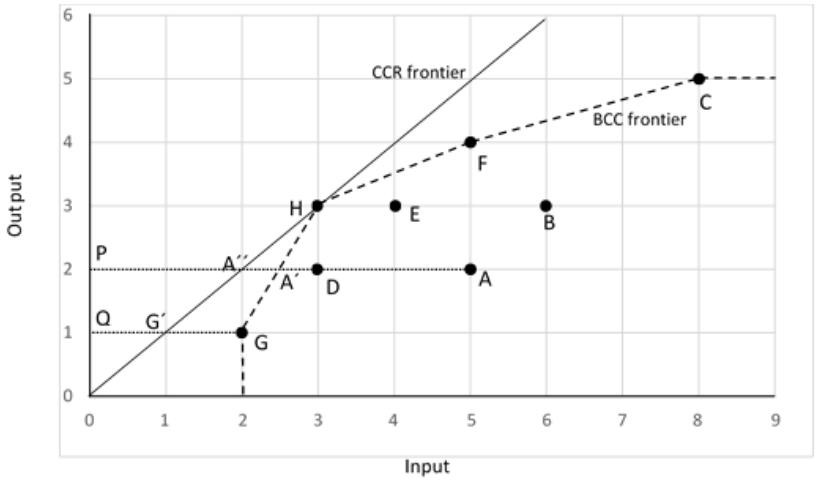


Figure 4.2: CCR and BCC frontiers for eight DMUs (A, B, C, D, E, F, G and H)

Scale efficiency from CCR and BCC scores: Scale efficiency (SE) measures whether a DMU performs at the optimal scale level. Because of the separation of the technical and scale aspects of efficiency, SE of a DMU can be calculated as the ratio of its CCR efficiency (CCR_θ) to its BCC efficiency (BCC_θ):

$$SE = CCR_\theta / BCC_\theta \tag{3}$$

Like CCR and BCC, the SE score cannot be greater than 1. A DMU can be efficient in terms of PTE by being BCC-efficient but not CCR-efficient because of its scale inefficiency. Because of this, CCR-efficiency is also known as global TE.

Slack-based measure (SBM) and mix efficiency: When DMUs use multiple inputs (or produce multiple outputs) in a mix, like the example in Figure 4.3 with two inputs for one output, inefficiency can originate from the way they are mixed. CCR and BCC do not directly calculate such mix or non-radial inefficiency, even though a technically (radial) efficient DMU may use excessive inputs or have output shortfall. For example, in Figure 4.3, U can be technically efficient by reaching U', but can reach T only by removing excess input. Such excesses or shortfalls are known as slacks and can be measured by several DEA models. In our study, we use the SBM for non-radial efficiency (Tone, 2001). The SBM model can be defined as follows:

$$\text{(SBM)} \min_{\lambda, s^-, s^+} \rho = \frac{1 - \frac{1}{m}\sum_{i=1}^{m} s_i^- / x_{io}}{1 + \frac{1}{s}\sum_{r=1}^{s} s_r^+ / y_{ro}}$$

Subject to $x_o = X\lambda + s^-$

$y_o = Y\lambda - s^+$

$$\lambda \geq 0,\ s^- \geq 0,\ s^+ \geq 0 \tag{4}$$

Like CCR and BCC efficiency, the SBM efficiency score ρ^* ranges from 0 to 1. When a DMU has no input slacks (s^-) and/or output slacks (s^+), then the DMU has an efficiency score

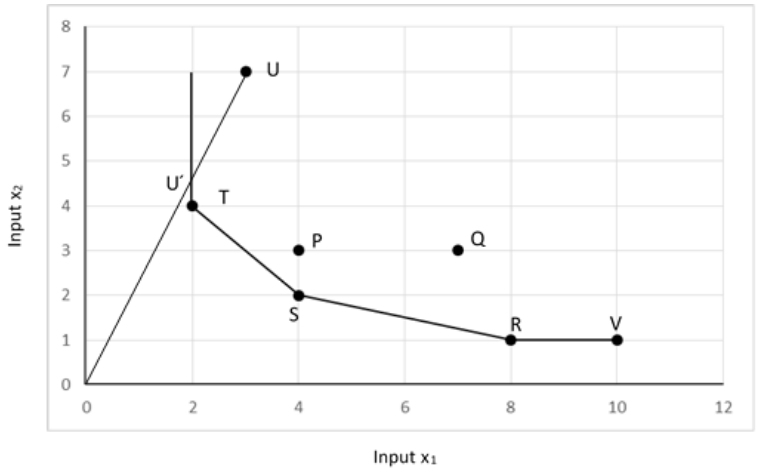


Figure 4.3: Mix Efficiency of seven DMUs (P, Q, R, S, T, U and V)

of 1. Moreover, SBM scores incorporate the mix efficiency (ME) with CCR efficiency. Thus, ME can be measured as,

$$ME = SBM_{\rho}/CCR_{\theta} \tag{5}$$

where $SBM_{\rho}$is the slack-based efficiency score and CCR_{θ} is the CCR efficiency score. From this we can derive

$SBM_{\rho} = ME \times CCR_{\theta}$, and from (5)

$$SBM_{\rho} = ME \times SE \times BCC_{\theta}. \tag{6}$$

Thus, SBM can be decomposed conveniently into the measurement of ME, SE and PTE and be used as an indicator of overall efficiency.

4.4 Data, and input and output specifications

For measuring the efficiency of FPAs with the focused management system, we selected 15 FPAs from the five sub-districts of Bangladesh. They are the Daudkandi (Comilla district), Harirampur (Manikganj district), Shingra (Natore district), Rajapur (Jhalokati district) and Nazirpur (Pirojpur district) sub-districts. While the Daudkandi region has well established association with this management system, selection of the other sites was based upon the presence of NFPA in a community. This is because the NGO has been engaged in introducing this management system in different parts of the country since 2010s. At the time of this study, NFPAs were found in seven sub-districts, including Daudkandi. Of these, five were selected where at least one continuously operational FPA was found.

Although we attempted to select both NFPAs and IFPAs from all sites to maintain representativeness, outside Daudkandi, this management system is relatively new. Thus, while more than 50 FPAs (numerous IFPAs and six NFPAs) are reported to be operational in and

around the Daudkandi sub-district, in the other four sites only NFPAs are found to perform continuously using a well-organized institutional scheme. As a result, 11 FPAs (six NFPAs and five IFPAs) were selected from the Daudkandi region, and one NFPA from each of the other four sub-districts was selected based on the information provided by the NGO.

In the Daudkandi region, with the help of local SHISUK staff, contacts with NFPAs were established and all six operational NFPAs were surveyed. Later, the assistance of NGO staff was also taken in identifying and selecting IFPAs from this region. Such assistance was sought after for several reasons. First, there is a lack of any comprehensive and up to date database of the operational FPAs in this region. The government database was old and unreliable. Second, given the fact that the local NGO staff maintain relations with other FPAs, it was assumed that the IFPA respondents would feel more comfortable about the surveys and thus be confident and ready to share information, if they were approached by the NGO staff. From the surveyed IFPAs, five were selected from which complete relevant data was able to be collected.

In Table 4.1, 15 selected FPAs are listed chronologically by year of formation, along with their shortened names in the parentheses which are used in this paper for the sake of convenience. In final sample, we tried to include at least more than one FPA of each variation described in section 2. We included 10 NFPAs and five IFPAs. In terms of mode of managing aquaculture operations seven FPAs followed self-management, eight lease-based management. While all NFPAs from the Daudkandi region have adopted lease-based management of aquaculture, those from other four sites reminded under self-management. Among the five IFPAs, found only from the Daudkandi region, three followed self-managed, while the other two adopted lease-based aquaculture operations.

Fish production data of the FPAs were collected from their official account records for the year 2015–16 by conducting two field visits during April–May and October–November of 2016 in the five selected sites. An FPA-specific questionnaire was developed for data collection, supplemented by non-structured questions, which were asked as needed during the field visits.

Table 4.1 shows the four inputs and one output that are included in efficiency measurement of selected FPAs. Inputs were primarily selected on the basic of their share in total cost. Most cost-incurred items are fish feed, fingerlings and salaries and wages paid to the regular and non-regular workforce. All FPAs also use some common type of fertilizers to grow natural fish feed, along with lime, and other chemical products, like medicines for fish diseases, etc. These are bundled together with usual fish feed in 'feed and others'. These three inputs are measured in monetary units of Bangladeshi Taka (BDT; BDT 80.50=US$ 1). On average, they

together incurred more than 80% of total cost of the FPAs, while, individually, feed and others 48%, fingerlings 18% and wages and salaries 18%. In addition to these inputs, to consider the contribution of land in fish culture, utilized area of floodplain (UAF) within which an aquaculture operation is confined is considered as an input[13]. In all FPAs, the selected inputs are standard inputs.

Other important outlays for the FPAs include the repair and maintenance of the aquaculture related infrastructures built in and around the utilized area of floodplain, as well as compensation paid to neighbouring households for damages caused by the aquaculture operations. However, a large portion of such expenses is the result of the floodplain's geographical features, rather than the capability of the management. At the same time, although important in terms of aquaculture operations, these items individually incurred very small portion of total cost. For example, for repair and maintenance of infrastructure the FPAs expended, on average, 1% of total cost. Thus, we do not consider such outlays as inputs.

Fish sales in BDT are considered as the single output of the FPAs. All FPAs were found to follow the strategy of 'commoditized bulk production' (Hernandez et al., 2017) by culturing an almost identical mix of fish species, dominated by carp along with some introduced species, like tilapia. The relatively newer FPAs harvested some naturally recruited fish. However, in comparison to stocked fish, their contribution to sales revenue is very small and no additional feed or other input was supplied for them.

Under the lease-based management, the lessee-group manages the aquaculture operation in the same fashion as that the management committee of an FPA does. Moreover, the collective rights over the aquaculture operation in the relevant floodplain ultimately belong to the FPA which leases its rights to the lessees for a specified period. Thus, even though the lessee-group manages the aquaculture mostly independent from the FPA's management committee, we subsume lessee-managed operation within the boundary of the FPA. Finally, even when the aquaculture operation is leased, the FPA's management committee remains responsible for the repair and maintenance of the infrastructure. It finances such expenditures from the payment it receives from the lessees. The rest of the lease payment is used to meet administrative expenses. The residual amount is distributed as a return among the investor-members of the FPA, and as land rent to the landowners. However, as is the usual practice, the land rent is paid only after

[13] It may seem that land rent which is paid to the landowners in most FPAs can be considered as an input for calculating land's contribution in fish production. However, as we mentioned in note 2, land rent is paid after fish sales are completed, and only if profits can be generated from these fish sales. In the FPA (Uttompur) which failed to make profit, we did not find payment of any land rent. However, in such an FPA land's contribution in fish production remains. Thus, land rent cannot represent land's contribution in fish production

paying all other expenses. Thus, the rationale for not including the land rent as an input or an output remains valid for FPAs which adopted lease-based operation.

Table 4.1: Inputs and outputs of compared FPAs

	FPA Name	Year of formation	Location	Inputs				Output
				UAF* (ha)	Fingerling (Million BDT)	Feed & others (Million BDT)	Salaries (Million BDT)	Fish sales (Million BDT)
1.	Dhanua Khola Nagarpar Adarsha Motsha Chash Prokalpo (Dhanuakhola)	1984	Daudkandi, Comilla	13.23	1.767	4.287	0.328	8.174
2.	Pankowri Fisheries Ltd. (Pankowri)	1996	Daudkandi, Comilla	85	6.265	17.698	3.751	37.835
3.	Charipara Rupali Agro-fisheries (Charipara)	1999	Daudkandi, Comilla	26.71	1.906	5.933	1.291	10.584
4.	Kushiara Fisheries (Kushiara)	2000	Daudkandi, Comilla	13.35	1.387	15.598	3.633	25.849
5.	Asia Fisheries (Asia)	2001	Daudkandi, Comilla	170	7.709	15.125	5.638	35.206
6.	Khirai Fisheries Ltd. (Khirai)	2003	Daudkandi, Comilla	61	3.048	13.040	3.605	23.638
7.	LKS Fisheries Ltd. (LKS)	2003	Daudkandi, Comilla	46.94	1.214	8.477	2.601	13.736

8.	Chargram Fisheries Ltd. (Chargram)	2004	Daudkandi, Comilla	140	3.018	12.858	4.874	32.304
9.	Shishir Motsha Chash Prokolpa (Shishir)	2004	Daudkandi, Comilla	13.35	0.994	5.377	1.329	6.668
10.	Proshanto Motsho Prokalpo (Proshanto)	2007	Daudkandi, Comilla	147	4.165	14.002	4.723	33.058
11.	Shanto Motsho Prokalpo (Shanto)	2007	Daudkandi, Comilla	80.13	2.117	11.189	3.642	26.725
12.	DKK Bio-Village O Samajik Motsho Prokolpo (DKK)	2012	Harirampur, Manikganj	54.54	0.207	1.081	0.956	2.925
13.	Raninagar Chalan Beel Motsho Community Enterprise (Raninagar)	2013	Singra, Natore	25	1.091	1.685	0.386	5.934
14.	Uttompur Badurtola Motsho Chash Community Enterprise (Uttompur)	2015	Rajapur, Jhalokati	28.04	0.050	0.101	0.084	0.150
15.	Jhonjhonia SHISUK Community Enterprise (Jhonjhonia)	2015	Nazirpur, Pirozpur	37.39	0.726	0.023	0.206	1.465
	Mean			62.78	2.3776	8.4315	2.4697	17.6167
	Maximum			170	7.7089	17.698	5.6379	37.8353
	Minimum			13.23	0.0495	0.0225	0.0844	0.14957
	Standard deviation			50.06	2.1137	5.9660	1.8490	13.0413

*UAF= utilized area of floodplain

4.5 Results And discussion

4.5.1 Input-oriented efficiency scores of FPAs

The input-oriented DEA analysis is shown in Table 4.2. It contains five types of efficiency scores—pure or local technical (BCC-I), scale of operation (SE-I), global technical (CCR-I), input mix (ME-I), and overall efficiency (SBM-I). Among the 15 studied FPAs, six are overall efficient. The scores are discussed in detail as follows.

BCC, SE and CCR performances: The average BCC-I score is 0.96, with 11 efficient FPAs. This suggests that most of the FPAs are performing well in terms of achieving pure technical potential. Among the BCC-I inefficient FPAs, Proshanto is very close to the efficient score of 1, while LKS has the lowest BCC score. Three FPAs score below the mean BCC-I score.

However, considering the CCR-I results (with an average of 89% efficiency score), we can see that a few FPAs (like Uttompur and Shishir), that are BCC-efficient, have very poor CCR scores. The BCC-efficiency of Uttompur may be due to its utilization of the least amount of inputs (e.g. fingerling, etc.). Among the CCR-I inefficient FPAs, six score lower than the mean. We already mentioned that the difference between the CCR and BCC scores originate from scale efficiency. The scale efficiency scores of the FPAs that are BCC-efficient, but not CCR-efficient, are the same as their CCR-I scores. Therefore, these FPAs can become CCR-efficient by removing scale inefficiency. Using the returns to scale characteristics of the FPAs, derived from the BCC-I calculations, it can be suggested that Pankowri, Asia, and Chargram can decrease the size of their operations, while Shishir and Uttompur (which have the lowest scale and technical efficiency scores) can increase the size of their operations to become scale and technical efficient. On average, the FPAs are 91% scale efficient, with four FPAs showing below-average scores. This suggests that, on average, the FPAs are more efficient in pure technical performances than they are in terms of scale performance. This is usual, given the BCC model's scale-flexible assumptions. Charipara, Khirai, LKS, and Proshanto are inefficient in both pure and global technical categories. It can be seen from Table 4.2 that, except for Proshanto, other three have better scale optimization than technical performances. This implies that to improve their efficiency they should concentrate on management and operational efficiency, while Proshanto needs to focus on the size of its operations.

Overall (SBM-I) and mix (ME) efficiency: In keeping with DEA principles, the average of SBM-I scores are the lowest (77%) among all types of efficiency scores, because to calculate overall efficiency SBM-I scores combine other efficiency scores (Table 4.2). Of the nine

overall inefficient FPAs, seven score lower than the mean SBM-I score. Here, Uttompur has the lowest score.

On one hand, the SBM-I scores reflect the presence of slacks in inputs and measure the slacks that should be eradicated by inefficient FPAs to reach the efficient frontier. Table 4.3 shows the required percentage decrease of each input obtained from the SBM-I model. As expected, FPAs with the lowest SBM-I scores has the highest percentage of slacks to decrease. Table 4.3 shows that the FPAs have the largest amount of slacks in land use. Interestingly, land is also the most difficult input to decrease, given the infrastructures developed around the UAF. Large amount of the slacks in UAF indicates that the FPAs can achieve the same level of fish production with considerably less land. Next to UAF, stocked fingerling and wages and salaries (paid against labour and staff) have the largest slacks. Although, feed is the largest input in monetary terms in most FPAs, it has the smallest amount of slacks.

On the other hand, SBM-I scores can be decomposed, primarily into technical (CCR-I) and mix (ME-I) efficiency scores. Using (5), we obtained mix efficiency scores of the FPAs with an average of 89.83% (Table 4.2). Here, six FPAs have lower than average scores. Among the overall inefficient FPAs, some (Charipara, Asia, Shishir, Proshanto and Uttompur) have lower technical efficiency scores than mix efficiency scores, while others (Pankowri, Khirai, LKS, and Chargram) have lower mix efficiency scores. Thus, these FPAs can focus accordingly to improve their overall efficiency.

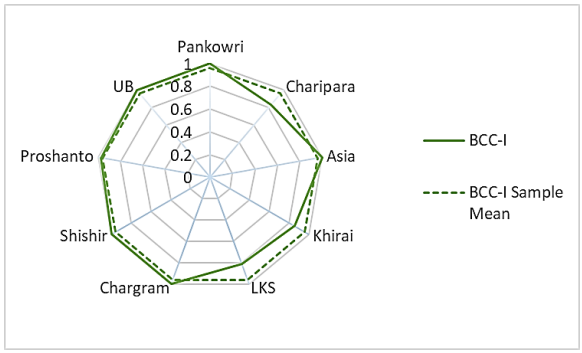
Finally, from (6), the scores of the nine overall (SBM) inefficient FPAs can be decomposed into their technical (BCC), scale (SE), and mix (ME) sources. This is shown in Figure 4.4, along with the mean BBC-I, SE-I, and ME-I scores. This figure shows that while many FPAs perform well in pure technical terms (panel A), their relatively low scale and mix efficiency scores contribute to their overall inefficiency which results in poor SBM-I scores (panel D). Furthermore, the figure shows that of the nine inefficient FPAs, six have above average scale efficiency scores and three (Pankowri, Charipara, and Chargram) are very close to being efficient (panel B). However, in the case of the mix efficiency scores (panel C), only three FPAs have above average scores and none of them are close to an efficiency score of 1. This implies that, most inefficient FPAs fare better in maintaining the size of their aquaculture operations than balancing a commensurate mix of the inputs to run those operations.

Table 4.2: Input-oriented efficiency scores of the FPAs

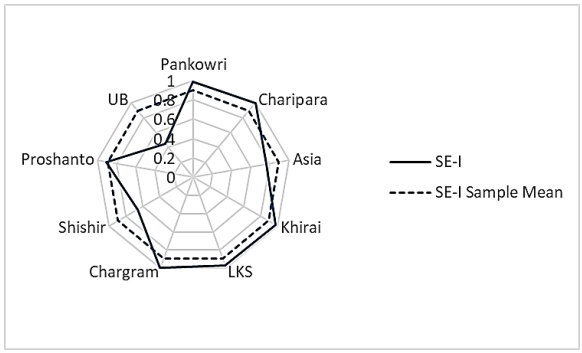
FPAs	Organization composition	Mode of aquaculture operation	RTS	BCC-I	SE-I	CCR-I	ME-I	SBM-I
Dhanuakhola	IFPA	Lease-managed	CRS	1	1	1	1	1
Pankowri	NFPA	Lease-managed	DRS	1	0.9818	0.9818	0.9388	0.9217
Charipara	IFPA	Self-managed	DRS	0.8348	0.9992	0.8341	0.8628	0.7197
Kushiara	IFPA	Self-managed	CRS	1	1	1	1	1
Asia	IFPA	Self-managed	DRS	1	0.7652	0.7652	0.8866	0.6784
Khirai	NFPA	Lease-managed	DRS	0.8559	0.9800	0.8388	0.8506	0.7135
LKS	NFPA	Lease-managed	IRS	0.8106	0.9695	0.7859	0.7885	0.6197
Chargram	NFPA	Lease-managed	DRS	1	0.9960	0.9960	0.9436	0.9398
Shishir	IFPA	Lease-managed	IRS	1	0.6617	0.6617	0.7825	0.5178
Proshanto	NFPA	Lease-managed	DRS	0.9753	0.9076	0.8852	0.9144	0.8094
Shanto	NFPA	Lease-managed	CRS	1	1	1	1	1
DKK	NFPA	Self-managed	CRS	1	1	1	1	1
Raninagar	NFPA	Self-managed	CRS	1	1	1	1	1
Uttompur	NFPA	Self-managed	IRS	1	0.4517	0.4517	0.6159	0.2782
Jhonjhonia	NFPA	Self-managed	CRS	1	1	1	1	1
Geometric Mean				0.9626	0.8960	0.8626	0.8983	0.7749
Maximum				1	1	1	1	1
Minimum				0.8106	0.4517	0.4517	0.6159	0.2782
Standard deviation				0.0688	0.1626	0.1619	0.1115	0.2212

Table 4.3: Input slacks of the FPA operation from SBM-I scores (required percentage decrease of each inputs is shown in brackets)

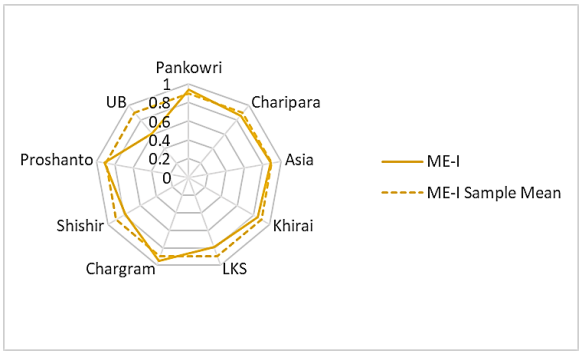
FPAs	**UAF (ha)**	**Fingerling (Million BDT)**	**Feed & others (Million BDT)**	**Wage and salaries (Million BDT)**
Dhanuakhola	0	0	0	0
Pankowri	5.245 (6.17%)	1.577 (25.16%)	0	0
Charipara	15.784 (59.09%)	1.01 (53.02%)	0	0
Kushiara	0	0	0	0
Asia	81 (47.64%)	3.32 (43.12%)	0	2.13 (37.87%)
Khirai	34.62 (56.75%)	1.28 (41.99%)	0	0.57 (15.85%)
LKS	39.84 (84.88%)	0.48 (39.26%)	0.19 (2.21%)	0.67 (25.76%)
Chargram	17.91 (12.79%)	0	0	0.55 (11.28%)
Shishir	9.90 (74.20%)	0.64 (64.00%)	1.35 (25.16%)	0.39 (29.49%)
Proshanto	50.06 (34.05%)	1.57 (37.67%)	0	0.21 (4.53%)
Shanto	0	0	0	0
DKK	0	0	0	0
Raninagar	0	0	0	0
Uttompur	27.41 (97.75%)	0.02 (44.52%)	0.06 (57.96%)	0.075 (88.46%)
Jhonjhonia	0	0	0	0
Mean	18.79 (31.57%)	0.66 (23.52%)	0.11 (5.69%)	0.31 (14.22%)



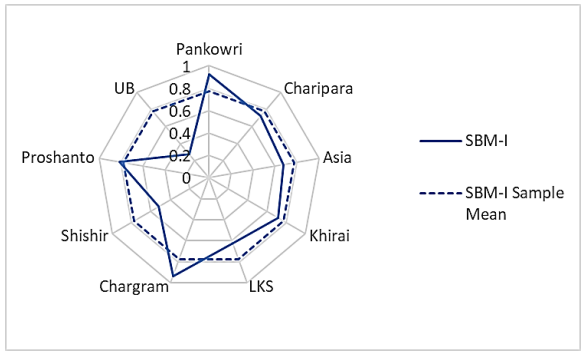
Panel A. BCC-I



Panel B. SE-I



Panel C. ME-I



Panel D. SBM-I

Figure 4.4: Decomposition of SBM-I scores of inefficient FPAs into BCC-I, SE-I and ME-I scores (broken lines indicate mean score of each category of DEA results)

The returns to scale features of the FPAs are shown in Figure 4.5. All six CCR-efficient FPAs—also overall efficient—show constant returns to scale characteristics (as per DEA principles). Among the inefficient FPAs, six show decreasing returns to scale and three increasing returns to scale characteristics. This means that most of the inefficient FPAs are performing at a supra-optimal scale. On the other hand, the increasing returns to scale characters of three FPAs, that also have the lowest overall efficiency scores, suggest that they are performing at a sub-optimal level.

If the utilized land area (UAF) of each FPA is considered as an indicator of its size, then it can be seen that FPAs with decreasing returns to scale have the highest mean UAF in comparison with the FPAs showing constant and increasing returns to scale. This is shown in Figure 4.6, along with the sample mean of the UAF. This simply indicates that, among the inefficient FPAs, the number of relatively larger FPAs is higher than the number of smaller

FPAs. Indeed, out of the six overall efficient FPAs, only Shanto has more UAF than the sample average. Note that there are five FPAs with a higher UAF than the sample mean.

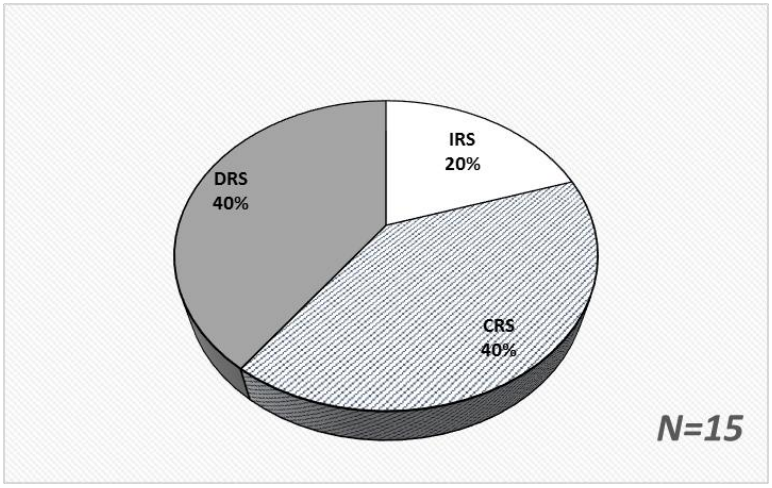


Figure 4.5: Returns to scale characteristics of studied FPAs (CRS= constant returns to scale, DRS= decreasing returns to scale, IRS= increasing returns to scale)

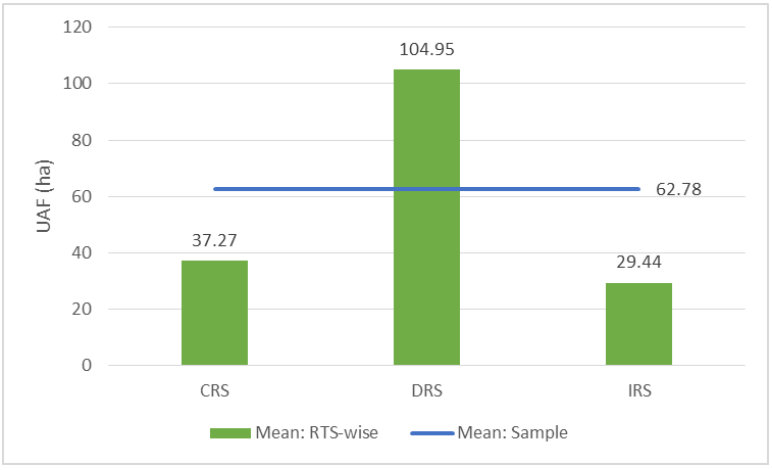


Figure 4.6: Mean land size of FPAs in terms of RTS characteristics

Internal comparisons of the FPAs: This section will briefly present the FPAs performance in terms of variations in the organizational composition and mode of aquaculture management outlined in section 2.

Table 4.4 shows the mean efficiency scores (percentage) of NFPAs and IFPAs against those of the sample. These scores are plotted in Figure 4.7. While both groups score similarly in terms of pure technical and mix efficiency, IFPAs have lower scores in scale efficiency than NFPAs. This lower score ultimately leads to their lower than average overall efficiency score (SBM) of 75.96%. In addition, NFPAs also have more efficient units (four) than IFPAs (two). However, Uttompur with the lowest efficiency score of 27.82% is an NFPA. Probably because of this unit the standard deviations of NFPAs are usually higher than those of IFPAs. Regarding

IFPAs, it should be noted that, their lower number of efficient units may result from their relatively smaller presence in the sample (five IFPAs to 10 NFPAs) due to their absence outside Daudkandi region.

Table 4.4: Comparisons of mean efficiency scores between NFPAs and IFPAs with standard deviation (sd) in parenthesis

	Mean efficiency (%) NFPAs (sd) N=10	**Mean efficiency (%) IFPAs (sd) N=5**	**Mean efficiency (%) Sample (sd) N=15**
BCC	96.17 (7.03)	96.45 (7.39)	96.26 (6.88)
SE	90.80 (17)	87.26 (16.10)	89.60 (16.26)
CCR	87.32 (17.43)	84.16 (14.82)	86.26 (16.19)
ME	89.63 (12.42)	90.25 (9.38)	89.83 (11.15)
SBM	78.27 (23.54)	75.96 (21.18)	77.49 (22.12)

If we draw a comparison between NFPAs and IFPAs of the Daudkandi region, where the IFPAs (five units) have more comparable presence against NFAPs (six units), we can see that IFPAs fare better with respect to number of efficient units—two IFPAs in contrast to only one NFPA. Despite this, on average, NFPAs (average score 82.27%) of this site are better than IFPAs (average score 75.96%). This is caused by the individual scores of FPAs. While the inefficient IFPAs (Asia, Charipara and Shishir) of this site score lower than the sample mean, three inefficient NFPAs (Chargram, Pankowri and Proshanto), out of five, score above the sample average. Thus, it seemed that although IFPAs of the Daudkandi region have more efficient units, the inefficient units perform significantly poor in our sample.

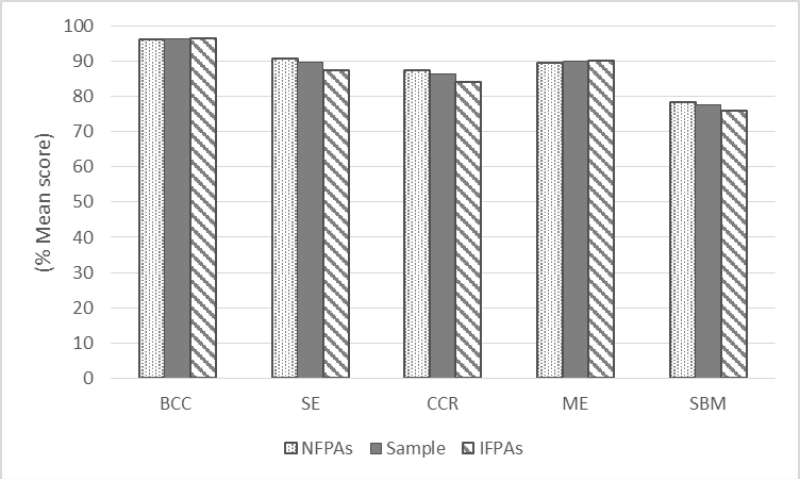


Figure 4.7: Mean efficiency scores (%) of NFPAs, the sample & IFPAs

DEA results also reveal some additional aspects of efficiency within NFPAs, of which all operational units are included in this study. First, out of ten NFPAs in our sample, six are located in the Daudkandi region. In addition, they are also older and larger in terms of fish production than NFPAs of other four sites. However, in our DEA analysis, except Shanto, all NFPAs from the Daudkandi region turn out to be inefficient. By contrast, although we found only one NFPA in each of the other four sites, except Uttompur, other NFPAs show overall efficiency.

Second, using DEA results we can evaluate the role of NGO in efficient performance of the NFPAs. We have seen that in Daudkandi, out of six NFPAs, only one is overall efficient. Thus, even with above average overall scores (82.27%), it is difficult to claim that the participation of NGO results in efficiency in these NFPAs. In addition, the aquaculture operations of NFPAs of the Daudkandi are lease-managed. Under lease arrangement, the FPAs' management committee has almost no control over the aquaculture operation, since its management was transferred to lessee-group. Thus, the NGO, as a member of the FPA management committee, has also very small, if any, control over aquaculture operations. Therefore, while the poor average and individual BCC (Table 4.2) scores of these NFPAs suggest that the problems lie with the management and operational aspects of aquaculture, they are more likely to be found with the lessees who are now responsible for the aquaculture operations.

On the other hand, out of four NFPAs outside Daudkandi, three are overall efficient. All these NFPAs are self-managed, and thus the involvement of the NGO is more direct in managing their fish culture operations, since they are managed by FPA management committee. Moreover, since these NFPAs are relatively new, and therefore its local management committee members were supposedly less experienced, the NGO—having two decades of experience in aquaculture—seemingly provides necessary and important guidelines in managing aquaculture operations, which might contribute in efficient management of aquaculture operation. From this analysis it can be said that while the role of the NGO may be important in the early years of an FPA in terms of providing necessary guideline, it may not be enough in ensuring continuous efficiency of aquaculture operation. It might also be that now the NGO is more experienced and capable in managing aquaculture operations in collaboration with community partners. However, without further research into the nature and extent of NGO involvement in NFPAs, its relationship with FPA efficiency cannot be properly understood.

The IFPAs show less internal variability in terms of DEA results than NFPAs, as can be found in their standard deviations (Table 4.4). Moreover, since all the IFPAs are from the Daudkandi region, the geographical variations in results that are found in the NFPAs, cannot be

observed in IFPAs. However, in future study, this can be remedied with more focus on and increased number of IFPAs, which were usually overlooked in previous studies.

The comparison between the self-managed and lease-based aquaculture operations in terms of average scores is shown in Table 4.5 and Figure 4.8. The DEA results show that the self- managed aquaculture operations are better at pure technical efficiency, while lease-based operations are better at scale efficiency. In terms of mix efficiency, their performance is similar. On average, lease-based operations have better overall efficiency scores than self-managed operations, which also have lower than average scores. This is despite the result that, four of the six efficient FPAs are self-managed, while two are lease-managed. The reason for such results can be found if we consider the individual scores of FPAs. While the inefficient self-managed FPAs (Asia, Charipara and Uttompur) scored lower than the sample mean, there were inefficient lease-based operations (Chargram, Pankowri and Proshanto) which scored well above the mean but nonetheless failed to reach the efficiency. At the same time, Uttompur which is the most inefficient FPA has self-managed operation. Like NFPAs, because of this FPA, self-managed FPAs show higher spread of data with higher standard deviations than lease-managed FPAs.

Lease-based FPAs are only found in the Daudkandi region. Among them, two are overall efficient, although their number in the sample is considerably higher than self-managed FPAs (eight against three) in this site. From this it may be assumed that, with more self-managed FPAs in sample, more efficient units might have been found. However, we were reported by the interviewees from this site that nowadays most of the FPAs manage their aquaculture operations under lease-based mechanism, and more are adopting this mode. In spite of reported popularity, the DEA results indicate that lease-based aquaculture operations are not necessarily efficient, since most of lease-based operations remained overall inefficient. Although NGO played leading role in promoting lease-based management of aquaculture in NFPAs of the Daudkandi region, NFPAs outside this site are self-managed. From DEA results self-management can be justified because most of the FPAs outside Daudkandi are efficient. However, in all these sites the FPA trend is relatively new and continuation of self-managed operations or adoption of lease-based operation depend on future performance of these FPAs, among other factors.

4.5.2 Output-oriented efficiency scores of FPAs

The scores of output-oriented DEA measurements (Table 4.6) are almost identical to the input-oriented scores. All the efficient and inefficient FPAs of the input-oriented models maintain their status in the output-oriented results. The returns to scale characteristics are also the same. However, in the BCC-O model, the inefficient FPAs display slight differences. This suggests

that, given the variable returns to scale feature of BCC model, a few FPAs show minor variations between input utilization and output production. These FPAs (Charipara, Khirai, LKS, and Proshanto) also display slightly different SE-O scores from their SE-I scores, while all other FPAs score identically in both cases. In keeping with DEA principles, CCR-O scores are the same as the CCR-I scores. However, all FPAs have a score of unity in their ME-O scores—indicating no mix inefficiency—because there is only one output (fish sales). By the same token, the SBM-O scores are identical to the CCR-O scores. This indicates that, in the case of single-output-producing DMUs, like the studied FPAs, the SBM-O scores reflect only the technical efficiency. Because of these minor differences, the findings from the input-oriented results remain valid for the output-oriented analysis. Thus, we do not repeat them here.

Table 4.5: Comparisons of mean efficiency scores between self-managed and lease-based aquaculture operation with standard deviation (sd) in parenthesis

	Mean efficiency (%) Self-managed (sd) N= 7	**Mean efficiency (%) lease-based (sd) N=8**	**Mean efficiency (%) Sample (sd) N=15**
BCC	97.45 (6.24)	95.23 (7.67)	96.26 (6.88)
SE	85.91 (21.13)	92.97 (11.53)	89.60 (16.26)
CCR	83.72 (20.60)	88.54 (12.50)	86.26 (16.19)
ME	89.81 (14.24)	89.86 (8.64)	89.83 (11.15)
SBM	75.19 (27.47)	79.56 (18.21)	77.49 (22.12)

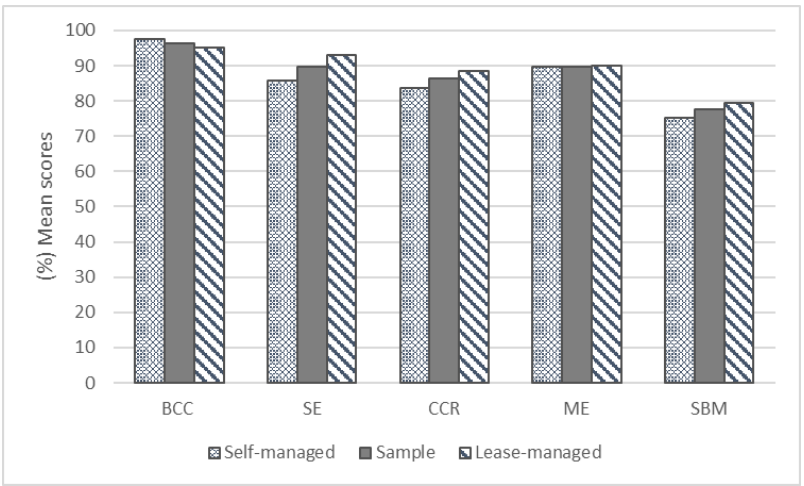


Figure 4.8: Mean efficiency scores (%) of Self-managed, the sample & Lease-managed

Table 4.6: Output oriented efficiency scores of the FPAs

FPAs	Organization Composition	Mode of Aquaculture Operation	RTS	BCC-O	SE-O	CCR-O	ME-O	SBM-O
Dhanuakhola	IFPA	Lease-managed	CRS	1	1	1	1	1
Pankowri	NFPA	Lease-managed	DRS	1	0.9818	0.9818	1	0.9818
Charipara	IFPA	Self-managed	DRS	0.8379	0.9955	0.8341	1	0.8341
Kushiara	IFPA	Self-managed	CRS	1	1	1	1	1
Asia	IFPA	Self-managed	DRS	1	0.7652	0.7652	1	0.7652
Khirai	NFPA	Lease-managed	DRS	0.8580	0.9776	0.8388	1	0.8388
LKS	NFPA	Lease-managed	IRS	0.7919	0.9924	0.7859	1	0.7859
Chargram	NFPA	Lease-managed	DRS	1	0.9960	0.996	1	0.996
Shishir	IFPA	Lease-managed	IRS	1	0.6617	0.6617	1	0.6617
Proshanto	NFPA	Lease-managed	DRS	0.9827	0.9008	0.8852	1	0.8852
Shanto	NFPA	Lease-managed	CRS	1	1	1	1	1
DKK	NFPA	Self-managed	CRS	1	1	1	1	1
Raninagar	NFPA	Self-managed	CRS	1	1	1	1	1
Uttompur	NFPA	Self-managed	IRS	1	0.4517	0.4517	1	0.4517
Jhonjhonia	NFPA	Self-managed	CRS	1	1	1	1	1
Geometric Mean				0.9620	0.8966	0.8626	1	0.8626
Maximum				1	1	1	1	1
Minimum				0.7979	0.4517	0.4517	1	0.4517
Standard deviation				0.0714	0.1631	0.1619	1	0.1619

4.5.3 Geographical distribution of efficient FPAs

In addition to the above findings, some further observations can be made regarding the geographical distribution of the efficient FPAs. Although we selected 11 FPAs from the Daudkandi region, considering the high concentration of FPAs in this region, only three of them show overall efficiency. In contrast, of four FPAs selected outside of the Daudkandi region, three show overall efficient scores. Although the size of fish production is significantly large in

the FPAs of the Daudkandi region, they are not efficient in their production. It is clear from our analysis that their inefficiency can be attributed to all three areas of performance—technical, scale, and mix. The technical inefficiency of the FPAs of the Daudkandi region is a little surprising, given their relatively longer experience in aquaculture operations than that of FPAs in the other regions. The DEA results also suggest that these FPAs use more inputs than they need to produce a given level of output, or that they fail to reach the efficient level of output using their inputs. In terms of returns to scale, the existence of decreasing returns in these FPAs may not be completely unexpected, given their attempts to continuously increase the rate of fish production over the years, which resulted in oversized operations. However, the intensive nature of FPAs has been found to be a common concern in previous studies (Mustafa and Brooks, 2009; Sultana, 2012).

A possible factor that may cause efficiency of FPAs outside the Daudkandi region is their age. Since these FPAs are relatively new, they are yet to face the kind of pressure that is faced by the older FPA to maintain annual growth of fish yield. In addition, competition is also low, since there are few FPAs in these sites. This pressure to improve fish yield might lead the older FPAs to use increasing amounts of inputs beyond the level of optimal scale, or to disproportionately increase some inputs in the input mix. In either case such extensive use of inputs didn't result in proportionate output level. In addition, some newer FPAs, like Jhonjhonia, reported that they have input advantages regarding feed, because the floodplain contained sufficient natural feed supply and they did not need a larger amount of supplementary feed. Others reported that there are considerable number of naturally recruited fish, which are not found in the most extensive aquaculture of the Daudkandi region.

4.5.4 Additional possible factors explaining inefficiency

We already mentioned some possible factors, like the role of NGOs as an experienced partner, intensive use of inputs, age of FPAs, etc., that may contribute in the efficiency outcomes of the FPAs. Although further exploration of factors that contributed to the inefficiencies of the FPAs was beyond the scope of the current study, some comments can be made in light of our observations during the field visits.

Among the FPAs, Uttompur show the lowest overall score. We found that this resulted from the loss of stocked fish during the mid-monsoon of 2015 when floods damaged the embankments that kept the fish within the enclosed area of the floodplain. As a result, a large number of stocked fish were released from the enclosed area. Although such damages caused by flood are not observed in other studied FPAs (where the floodplains are protected by strong earthen embankments), the loss of fish stock due to flood and the related importance of flood

pattern and water management infrastructure are cited as important determinants in performance of floodplain aquaculture (Dey et al., 2005; Joffre and Sheriff 2011). It may be noted that Uttompur is also a very new FPA as it was established in 2015. Therefore, the lack of experience of its management committee in terms of predicting and taking necessary precaution against floods, like building strong embankment, may be attributable for such loss. Although the NGO is a partner in this FPA, the failure to predict and prepare for such incident suggests that it may not familiar with all relevant geographical features of this floodplain.

As the studied FPAs are involved in seasonal fish culture operation, period for fish growth, size, density and timing of released fingerlings, quality and quantity of feed and fertilizer, among others, are also of vital importance in determining efficiency of culture activities (Ahmed & Garnett 2011; Dey et al., 2005; Joffre and Sheriff 2011). The FPAs utilize longer nurture period, released larger fingerlings, as was also common in other floodplain aquaculture (Joffre and Sheriff 2011), and are mostly dependent on supplementary feed. However, day to day operationalization of such practices might vary among FPAs depending on the differences in managerial capacity, styles, technical expertise of managers, along with financial strength of FPA or lessees, price, availability of quality inputs. With respect to stocking and feeding practices, some interviewed managers from the Daudkandi region mentioned that overstocking and overfeeding are now increasingly practiced by many managers and cause inefficiency in many FPAs.

At the same time, some managers also cited lack of fish culture related technical knowledge and experience among many managers as possible cause of lower efficiency. We found this especially relevant in terms of lease-based management of aquaculture. The lessee-group is usually selected through a bidding process, where the highest bidder obtains the lease. This process does not ensure the managerial or technical quality or experience of the lessee, but rather the highest transfer payment to FPAs. Thus, any member of local community with entrepreneurial drive and know-how of financing enterprises can now take lease of aquaculture operations regardless of their fish farming competence and experience. In few lease-based operations, we were reported that the chief lessee who was supposed to oversee the aquaculture operation remained absence due to his obligation in other professional areas. Since many of lessees are also prominent local traders and merchants, such phenomena are not unusual. Moreover, aquaculture operation is usually leased for two to three years. Such a short-term perspective may not be enough to make the aquaculture operation efficient, as we observed during the field visits that, many lease-based operations failed to make any profit in the first year of their tenure. At the same time, it was reported that by the interviewees that with increasing

popularity of lease-based management, many previously better-performing self-managed FPAs are now adopting lease-based operations.

In a few cases, especially IFPAs, we found that the management committees remained unchanged for long time. In absence of changes, inefficiencies and negligence may result in management. We also found deficiencies in keeping adequate records (e.g. simple lapses in book keeping consistencies) resulted in the loss of fish-sales data in one FPA. Finally, a common phenomenon across all FPAs is the lack of specialized learning, professional training and background about aquaculture in general and floodplain aquaculture in particular among the participants. Most participants acquire working knowledge through a learning-by-doing process. Like most of the ordinary shareholders, the members of the management committees were previously neither fishermen nor fish farmers by profession.

Thus, in the main, inefficiencies can be attributed to factors, like negligence on the part of the responsible party (e.g. lessees or members of the management committee), inexperienced management (e.g. leasing the aquaculture operation to a lessee-group with little experience in management). However, given the complex process aquaculture management which involves collective action of many stakeholders, there remain other factors the exploration which is out of the scope of present study. Such factors need to be identified and analysed to fully understand their causal relationships with efficiency outcomes.

4.6 Conclusions

In this study we measured efficiency of collective floodplain aquaculture enterprises that were formed by adopting a similar organizational and management approach. The organizational commonalities can be found in the greater presence of landowners as the participants, and investment-based participation requirement for all members. The management similarities emanated from the role of management committee who preserve the rights to decide upon all aspects and perform all functions related to fish culture operation. Such rights include, but not limited to, the sole control over harvesting. However, within these similarities, we also found two important variations, in some studied FPAs, in terms of (1) organizational composition that resulted from the investment-based participation of the NGO, SHISUK, and (2) mode of managing aquaculture operation that resulted from transferring fish culture rights to lessees by the management committee of FPAs. Thus, we also tried to see whether FPAs with any specific organizational composition and/or management mode showed more efficient performance than other organization type or mode. At the same time, given the role of the NGO in developing this management system, we included all NGO-collaborated FPAs (NFPAs) that were operational at the time of study. While previous studies associated this management system

solely with Daudkandi region, we included newer NFPAs from other parts of the country—as an indication that the management system has undergone expansion—to examine how these relatively newer FPAs perform. However, the number of NFPAs outside the Daudkandi region is still very small to conclude any widespread trend. Thus, in the sample we considered the existing organizational and operational management variations, geographical distribution, different age and the role of NGO within the studied management system.

We also introduced DEA methodology to measure efficiency of the FPAs of this management system. While a few of our findings corroborated those of previous non-DEA studies, through our analysis we have identified areas and sources of inefficiencies that could not have been identified without applying the DEA models. Our analysis found six FPAs to be efficient in technical, scale and mix categories, thus also overall efficient, out of 15 FPAs selected from five districts. In our sample, NFPAs performed better with four efficient units and better average overall efficiency scores of 78.27% than independent FPAs (IFPAs) with two efficient units and overall efficiency scores of 75.96%. However, the number of NFPAs is also higher in our sample due to the total absence of IFPAs outside the Daudkandi region. In this site, interestingly, we found two efficient IFPAs (out of five) in contrast to only one efficient NFPA (out of six). However, out of four NFPAs from four other sites, three turned out as efficient. Although the role of NGO seemed important in efficient performance of relatively newer NFPAs of other sites, its role appeared minor in NFPAs of Daudkandi due to their lease-based management of aquaculture operations. With respect to FPAs adopting lease-based operations, we found them having, on average, better overall efficiency scores of 79.56% but only two efficient units, while self-managed FPAs had lower than average score of 75.19% but four efficient units. From such results it is not clear whether lease-based mode of aquaculture operation is better than self-managed operations in ensuring efficiency. Thus, from the DEA results, it was not possible to establish any straightforward relation between a particular variations—namely organizational composition and mode managing aquaculture operations, and efficiency of aquaculture operations. It should also be noted that, given small sample size, any valid statistical correlation between these internal variations and efficiency is also not possible using the DEA results.

One limitation of DEA methodology is that it requires standardized inputs and outputs across all DMUs. Therefore, any specific input which may be of minor significance for most of the DMUs but be the source of inefficiency in one or two FPAs cannot be included in DEA application. At the same time, the numbers of inputs also impact the efficiency results, especially in cases where sample size is small, as was of this study.

From the inefficiency sources found in DEA analysis, some obvious remedies for inefficiencies can be assumed. The large slacks in UAF may be reduced by allocating the excess area for another use, preferably rice cultivation, the potential for this has been emphasized in some studies (Ahmed et al., 2011). While technically inefficient lease-based operations should focus on improving the managerial and operational aspects by finding better lessees with good track records, the FPAs with a supra-optimal scale should operate at optimal returns to scale. The NGO may play an important role in informing the community practitioners about scale or mix efficiency aspects of aquaculture operations. The local offices of government fishery agencies may also play similar roles.

Given the protein linkage, albeit not necessarily micronutrient linkage (Belton and Thilsted, 2014; Bogard et al., 2015), and the mitigating role of aquaculture in the wake of the sharp decline in capture fishery (Belton et al., 2014), along with FPAs being one of the fastest growing aquaculture niches, it may be time for the government to consider efficiency-related aspects—in addition to the usual growth-related emphasis—in its policy formulation. In addition, aquaculture in rice fields also reported to contribute positively in rice productivity in Bangladesh (Joffre and Sheriff 2011) and in the Daudkandi region by Gregory et al. (2007). However, both these reports are based on anecdotal information provided by farmers. At the same time, dealing with inefficiencies may result in better management of the environment as Asche et al. (2009) reported that technical inefficiencies in aquaculture practices can affect the overall environment. Nonetheless, any policy should be judicious enough not to be too restrictive on any specific sector as recommended by Hernandez et al. (2017), acknowledging the indirect roles of government policies in the overall growth of the aquaculture sector in Bangladesh.

It may be noted that, although we used the data from the financial reports of the FPAs, we found that, except one, no other FPAs conducted any external auditing of their reports. The practice of external auditing will increase the reliability of the financial reports and bring the reporting practices in line with accepted accounting practices. In addition, and more importantly, making such audited reports easily available to all ordinary shareholders will increase trust and confidence among them, and make them informed about their investment and its outcomes, since most of them do not usually participate in management of the FPA operation. In addition, such audited reports will also assist any external interested party, like government, development agencies, researchers, among others, to learn reliability about the various aspects of the FPAs and develop cooperation and collaboration with them.

While a few of our findings corroborated those of previous non-DEA studies, through our analysis we have identified areas and sources of inefficiencies that could not have been identified without applying the DEA models. Although small, our sample included all sites where this management system was found, the oldest and newest FPAs and considered internal variations in terms of organizational composition and modes of aquaculture operation, role of NGO. Nonetheless, given the small sample size confined to a particular FPA management system, we remain cautious in claiming that the results are representative of the country-wide trend of FPAs. Not only are there various types of fisheries and aquaculture enterprises practiced in various floodplains with different management approaches, but there is also involvement of many NGOs providing diverse types of assistance in many of them (Dey et al., 2013; Haque et al., 2011; Khan 2015; Sultana, 2012; Thompson et al., 2003 & 2005). To gain a country-wide perspective of the efficiency of fish production from floodplains, it is necessary to conduct a nationwide representative study, since different management approaches may effect different outcomes. Nonetheless, this study remains valid for the studied management system, providing a framework for and highlighting aspects to be investigated in future research on FPAs in Bangladesh at a national level.

Chapter 5
General discussion and conclusion

5.1 Overall findings considering three studies

This study tried to answer three questions stipulated in the Chapter 1. In the Chapter 2, 3, and 4, those three questions were respectively addressed.

Dealing with the first question, the second chapter demonstrated that, while the participants—within and without community—adopted rules that matched with Ostrom's design principles, they did it without any awareness of the existence of such principles. This observation attests to the significance of these principles in collective governance of CPR and answered the first question posed in the introductory section. However, as already mentioned, one of the limitations of the design principles has been surfaced through the study is their inadequate consideration regarding the exclusion of past users and the effects such exclusion on the continuity of the CPR institutions. This issue has become significant while the second answer was dealt in the third chapter. At the same time, the matching of the FPA rules with Ostrom's design principles basically indicate the presence of rules, rather than their application. Moreover, it is noteworthy that, FPA management system as a CPR organization is considerably different from other CPR management system. The FPA management system is relatively new, while many of CPR organizations which were studied to formulate the design principles were considerably older, some were centuries old (Ostrom, 1990). On the other hand, while previously many CPR organizations were mainly formed by the community users of resources, in the case of studied FPA, the NGO played significant roles in formation and designing, at least, the initial rules.

The findings of the Chapter 3, which dealt with the second question, highlight the fact that, although the first reported FPA was formed as an experimental solution to an emergent problem as well as to evaluate whether this problematic condition could be turned into beneficial one, the later FPAs were mostly driven by entrepreneurial motives. The transformative power of such motives, in addition to the experiences of the participants over the years through profit-oriented fish farming, resulted into the modifications introduced in the management and organizational practices. This kind of changes have some important implications for the theoretical framework used in the study.

Combination of the results of the Chapter 2 with that of Chapter 3 indicate that, in many FPAs exclusion of potential and actual participants occurred in two phases. The first type is common to all FPAs and occurred when the open access floodplain water-body is transformed into a common property through the investment of willing and, thus, authorized individuals. The second phase of exclusion is observed in some FPAs when the organization rules of these FPAs have been modified to exclude most non-landowner shareholders. This latter exclusion is based

on the fact of private ownership of floodplain lands than any other factors. However, the design principles are inadequately formulated to consider this kind of unique feature. In the case of the FPAs, the aquaculture initiatives are collective and can be treated within CPR framework, but the lands that constitute the floodplain are private properties. As this study shows, this specific kind of property-rights has affected the organization and management of this CPR institution.

The Chapter 4 which presented the efficiency comparison of studied FPAs, show that while the participants innovated lease-based management of aquaculture operation as a solution to lower returns to their investments, this innovation only solved half of the problem. While, through lease management the shareholders of the FPAs have been actually able to ensure positive returns on their investments, the inefficiencies that lie in the management of aquaculture operation have not been eradicated—they were just transferred to the lease-managements. Decade-old FPAs, both IFPAs and NFPAs, of the Daudkandi region struggled as they tried to maintain higher profitability every year, and the use of extra inputs may ensure profitability but caused inefficiency in these FPAs. The transfer of aquaculture-related responsibilities from the FPA management committee to the lessees also considerably decreased the role of the NGO in lease-adopted FPAs. Interestingly, in the recently formed NFPAs where the NGO is very active showed better efficiency.

In general, this study shows that a bottom-up CPR management framework can be adopted through a flexible, extended and modified application for co-management of natural resources. As a result, collective (landowners-managed) and co-management (NGO-community collaboration) now exist side by side in governing the same type of floodplain water-bodies. The participation of the NGO as an almost equal partner vis-a-vis the community members in the co-management of the FPAs is an important departure from the conventional trend of involvement of NGOs in other fisheries or aquaculture development programmes. Similar conclusion can also be extended regarding the general scope of the management of CPRs. Additionally, through the adaption of the original management system and its further expansion in other areas the original bottom-up system has been used in a top-down process, where the NGO has acted as extra-community development agent. Nonetheless, the roles of the NGO and the community participants did not remain the same over time, and their changing roles shaped the direction the FPAs took in later years in terms of organization, management and performance.

5.2 Policy implications for local and global context

A. At a global level it has been long accepted that governments do not make all important decisions regarding governance and management of natural resources any more

(Armitage et al., 2012). This study indicates how a new mechanism formulated outside public policy intervention arena became popular over time in managing a specific use of a natural resource. However, the issues pertaining to management entered the larger scope of governance when the effects of managing a resource in a particular fashion start to be felt by larger society. Historically, such effects always arise in management of natural resources. Additionally, governance issues become also relevant when goal-oriented, effective and efficient management of natural resource is desired. To include such aspects in their decision-making process entails the practitioners and managers—within and without community—to perceive their interaction with natural resource through lens of governance, rather than only as users seeking higher returns from a resource. This is more so in the cases—like those of present study—of market-oriented hybrid management of resources where there has been a trend of equalizing efficient management with highest level of resource extraction (Lemos and Agrawal, 2006). To achieve this goal, it is imperative to instil an understanding among the ordinary users about the significance of their actions and decisions in terms of governance of natural resources.

B. At the same time, it is clear from this study that the level of government involvement has been noticeably low in governance of private floodplains. It can be gathered from the fact that Bangladesh doesn't have any overarching management framework for floodplains. Given the continuing spread of aquaculture enterprises in floodplain water-bodies for over three decades, government fishery agencies can ensure the optimum use of these resources with judiciously formulated policy framework. Moreover, such policy may promote the sustainable use of not only floodplains but also the other aquatic resources of floodplains. A related gap is also felt in the lack of any complete survey of FPAs in non-government floodplains, whereas there can be found elaborate records and policies regarding the management of government water-bodies. Although in later NFPAs government has been participated as provider of initial financial support, but such supports have not been found in IFPAs. While the government has always an important stakeholder in fishery sector, it can assist collaboration among researcher and practitioners and also learn from practitioners when they developed their own management system.

C. The study points out that even with a moderately successful FPA since early 1980s, the community failed to further their success by establishing more profitable FPAs on their own, until an NGO got involved in and demonstrated further possibilities. It seems that

the example of considerably profitable and manageable FPA made a significant difference. However, the involvement of NGOs in social and economic development has been a common trend in developing country. The present study indicates an ambivalent perception about the NGO involvement in community development process. This mix reaction is also common in many other cases and among members of local and national communities. The FPA situations give a unique scenario where both NGO-collaborated and self-managed cases exist side by side. Such conditions may be used to conduct inquiries from social capital and relations perspective to into questions like why community tend to fail solve their problems so many times or why the involvement of NGOs fail to create trust and cooperation among involving parties where they are directly involved. An important question that remains to be answered in the future is the continuation of NFPA in case the NGO ceases to be an active partner.

D. Finally, the most important relevance of any aquaculture is about the human development aspects, namely food security and economic prosperity, in the face of dwindling natural sources of fish on a global scale. Within Bangladesh, given the increasing area of floodplains that turn into water-bodies every year, aquaculture practices in floodplain truly hold great prospect for enhancing fish production and improving lives of millions in the rural areas. In terms of aquaculture, Bangladesh is now positioned in sixth place among countries engaged in fish farming activities (FAO 2016). The expanding trend of aquaculture in floodplain can be the niche to be exploited for increasing both global and national contribution of the country.

5.3 Limitations of the study and future directions of the FPA research

There are different types of FPAs practiced in private floodplains around Bangladesh, as sporadically surfaced in different studies and media reports. However, it is difficult to say why they are yet to be featured extensively in related literatures. One probable reason may be found in the fact that before the involvement of the NGO, the FPAs production amount and management pattern was not at the level to draw enough attention even in the Daudkandi region. It has been shown in this study as the production level of FPAs outside the Daudkandi region are yet to achieve the level that was found in this region. All this led to confinement of the scope of this study around the NFPA related communities and, to some extent, a disproportionate emphasis on NFPAs. This is also because the record keepings are more continuous and consistent in the NFPAs. Moreover, the NGO has been more interested, thus more cooperative and open, in letting external researcher inquire about their functions and operations.

On the other hand, this study dealt with the management aspects of the FPAs. However, a few crucial aspects remained outside the scope of this study, especially the biodiversity and ecological aspects, which requires extensive time to investigate. At the same time, the biophysical production condition in terms of input-output relation, not in monetary terms, is not really analysed. Also, there is a concern of water pollution when intensive aquaculture is conducted.

In light of these limitations of the present study, a comprehensive study of the FPAs formed and managed in all parts of the country should be the next stage of broadening the scope of FPA research. At the same time, future studies should separately focus on multiple variable that affect the management of CPRs. While, this study has introduced the application of a popular CPR theoretical framework in FPAs in Bangladesh, the theoretical scope for studying CPRs has continued to expand with the development and application of frameworks like Institutional analysis and development (IAD) or social ecological systems (SECs). The application of such frameworks in future studies will give a comprehensive direction as they combine the social and natural aspects of resource management to obtain a better understanding.

The trend of FPAs has been continuously expanding over the last few decades. However, this doesn't ascertain that the established FPAs will continue their operation perpetually. A handful of FPAs have been reported to stop or become irregular in their operations for various reasons. This issue has been also reported in previous studies in other parts of the country. One of the reasons behind the prominence of the FPAs under studied management framework in research literatures has been their continuous operation. Nonetheless, there were failed attempts even when the NGO was involved. To obtain a better perspective on the future direction of the FPA trend, both in general and in particular, these failed attempts should be studied along the successful ones.

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Appendix:

Species/Group-wise Annual Fish Production in Inland and Marine Fisheries 2016-17

Table: Species/Group-wise Annual Fish Production in Inland and Marine Fisheries 2016-17

Sl. No.	Species/Group	Inland Fisheries (MT)	Marine Fisheries (MT)	Total (MT)	%
1.	Major Carp[a]	811,588	0	811,588	19.63
2.	Other Carp[b]	100,730	0	100,730	2.44
3.	Exotic Carp[c]	409,801	0	409,801	9.91
4.	Pangas (Cat Fish)	510,097	0	510,097	12.34
5.	Other Cat Fish[d]	66,646	0	66,646	1.61
6.	Snake Head[e]	72,991	0	72,991	1.77
7.	Live Fish[f]	h127,120	0	127,120	3.07
8.	Tilapia	370,017	0	370,017	8.95
9.	Other Inland fish[i]	598,923	0	598,923	14.49
10.	Hilsha/Illish *(Tenualosa ilisha)*	217,469	278,948	496,417	12.01
11.	Shrimp/Prawn	197,155[g]	49,619[h]	246,774	5.97
12.	Crab	14,421	0	14,421	0.35
13.	Sardine *(Sardinella fimbriata)*	0	48,704	48,704	1.18
14.	Bombay Duck (*Harpondon nehereu.*	0	69,230	69,230	1.67
15.	Indian Salmon (*Polydactylus indicus*	0	775	775	0.02
16.	Pomfret (*Rup/ Hail/ Foli Chanda*)	0	10,686	10,686	0.26
17.	Jew Fish (*Poa, Lambu, Kaladatina* etc.)	0	33,768	33,768	0.82
18.	Sea Cat Fish (*Tachysurus spp.)*	0	8,424	8,424	0.20
19.	Shark/ Skate / Ray	0	4,495	4,495	0.11
20.	Other Marine Fish[j]	0	132,827	132,827	3.21
Total catch		**3,496,958 (84.58%)**	**637,476 (15.42%)**	**4,134,434**	100.00

Source: DoF, 2017, p. 16

a. **Major Carp**- Rui (*Labeo rohita*), Catla (*Catla catla*), Mrigal (*Cirrhinus cirrhosus*)
b. **Other Carp**- Kalibaus (*Labeo calbasu*), Bata (*Labeo bata*), Ghonia (*Labeo gonius*)
c. **Exotic carp**- Silver Carp (*Hypophthalmichthys molitrix*), Grass Carp (*Ctenopharyngodon idella*), Common Carp (*Cyprinus carpio*), Mirror Carp (*Cyprinus carpio* var. *specularis*), Big Head Carp (*Hypophthalmichthys nobilis*), Black Carp (*Mylopharyngodon piceus*)
d. **Other Cat Fish**- Boal (*Wallago attu*), Air (*Sperata aor*), Silon (*Silonia silondia*), Rita (*Rita rita*)
e. **Snake Head**- Shol (*Channa striatus*), Gazar (*C. marulius*), Taki (*C. punctatus*))
f. **Live Fish**- Koi (*Anabas testudineus*), Singhi (*Heteropneustes fossilis*), Magur (*Clarias batrachus*)
g. Galda (*Macrobrachium rosenbergii*) and other Inland prawn/shrimp
h. Bagda (*Penaeus monodon*) and other coastal/marine prawn/shrimp
i. Includes all other fishes except those mentioned above.
j. Includes all other fishes except those mentioned above.