Assessing potential interventions to maximize fisheries - water productivity in the Eastern Gangetic Basin (EGB)

Evaluation of Constraints and opportunities for Improvement: context Gorai-Madhumati (GM) sub-basin

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ACRONYMS

AEZ	Agro-Ecological Zone
AIGA	Alternative Income Generating Activities
ASB	Asiatic Society of Bangladesh
BARC	Bangladesh Agricultural Research Council
BBS	Bangladesh Bureau of Statistics
BCAS	Bangladesh Center for Advanced Studies
BEZ	Bio-Ecological Zone
BFDC	Bangladesh Fisheries Development Corporation
BFRI	Bangladesh Fisheries Research Institute
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
CEGIS	Center for Environmental and Geographic Information Services
CBFM	Community Based Fisheries Management
CCRF	Code of Conduct for Responsible Fisheries
CDI	Caritas Development Institute
CPP	Compartmentalized Pilot Project
CPUA	Catch Per Unit Area
CPU(L)A	Catch Per Unit Land Area
CNRS	Center for Natural Resources Studies
DAE	Department of Agricultural Extension
DoE	Department of Environment
DoF	Department of Fisheries
DSAP	Development of Sustainable Aquaculture Project
DFID	Department for International Development
FAP	Flood Action Plan
FCD	Flood Control and Drainage
FCDI	Flood Control Drainage and Irrigation
FFP	Fourth Fisheries Project
FMC	Fisheries Management Committee
FRSS	Fishery Resources Survey System
GDA	Ganges Depended Area
GDP	Gross Domestic Product
GEF	Global Environment Facility
HYV	High Yielding Variety
ICZMP	Integrated Coastal Zone Management Project/Plan

IUCN	International Union for Natural Conservation
IWM	Institute of Water Modeling
IWRM	Integrated Water Resources Management
LGED	Local Government Engineering Division
MoWR	Ministry of Water Resources
MACH	Management of Aquatic resources through Community Husbandry
NGO	Non-Government Organization
NWMP	National Water Management Plan
NWRD	National Water Resources Data-base
NWRC	National Water Resources Council
PRSP	Poverty Reduction Strategy Paper
saciWATERs	South Asian Consortium for Interdisciplinary Water Studies
SRDI	Soil Resources Development Institute
SWAIWRMP	South West Area Integrated Water Resources Management Plan
T. Aman	Transplanted Aman
WARPO	Water Resource Planning Organization (former MPO)
WB	World Bank
WRS	Water Resources System

Definitions/Glossary

Aquaculture: the rearing or culture of aquatic organisms using techniques designed to increase the production of the organisms in question beyond the natural capacity of the environment. The organisms remain property of a natural or legal person throughout the rearing or culture stage, up to, and including harvesting.

Baor: Abandoned course of river (Ox-bow lake)

Beels: Low-lying depressions in the floodplain (small lakes). They may have a permanent character, containing water throughout the year (perennial beels) or dry out completely during a part of the year, usually 4-5 months (seasonal beels).

Biodiversity (biological diversity): the variability amongst living organisms, including the variability within species, between species and of ecosystems.

Cultured Pond: Ponds where culture of fish is practiced under definite production plan. Fingerlings and other inputs are given as per production plan, followed by water and soil management and supplementary feeding.

Culturable Pond: Ponds usually not under planned aquaculture practice; only unplanned stocking or entrance of fingerlings from monsoon spillage are cultured without supplementary feeding nor water/soil management; but may be brought under aquaculture with minor interventions. Some of such ponds mostly remain uncultured due to multi-ownership problems.

Derelict Pond: Ponds or ditches where aquaculture is not possible without major renovations. May not be potential for aquaculture due to physical hindrance like thick vegetation, siltation, pollution, lack of water during dry season, etc.. These ponds are homestead ponds in general and mostly owned by poor households. It is possible to bring them under cultivation and the technological innovation has started and needs to be further strengthened, being a good opportunity for the poor people - mostly the agricultural farmers - to have additional incomes and reduce poverty.

Ecosystem: a community of interdependent organisms that interact within the environment they inhabit. This complex, integrated unit exists in a fine balance, so that even small changes to one part of the system can have knock-on effects on many other components of the system.

Floodplains: Land inundated during the monsoon as a result of rainwater congestion and river flooding. (Floodplains and beels are hydrologically linked and highly dynamic. The National Water Development Plan (WARPO, 1999) states that waterbodies can be classified according to flood extent, depth, duration, timing and connectivity within the water resource system).

Haor: Large low-lying area or depression which becomes a unique large waterbody during rainy season.

Land Type: Former Master Plan Organization (MPO), now named Water Resources Planning Organization (WARPO) defines the land type based on inundation depth like below:

Inundation Depth (cm)	MPO Land type	Water Type	Farmers Classification	Land use during the monsoon
0-30	F0	Dry	Tan Jomi	Sugarcane, Vegetation, T. Aman, HYV
30-90	F1	Dry	Pachot Jomi	T. Aman, Local and HYV
90-180	F2	Floodplain, Seasonal Beel	Dopa Jomi	T. Aman, Local, DW Aman, Fish
>180	F3	Perennial Beel	Beel	DW Aman, Fish

Rivers and canals (*khals)*: Rivers are large natural streams of water, with connecting canals that in some instances feed the *beels* with water.

Table of Contents

List of Figures

List of Tables

Executive Summary

Issues in Bangladesh fisheries and water resources sectors: Bangladesh is a deltaic country with a significant increase in water cover during the wet season; (peak in June – August) amounting to a total of 5.05 million hectares of water area of which 2.83 million are seasonal floodplain water and 2.22 million ha are constituted by rivers, lakes, beels, etc.. The water cover keeps on changing due to a shorter and more intense monsoon period and a decline of freshwater flow throughout the dry period. Out of the 2.22 million ha less than 30% is perennial water (according to expert judgment; hard data is not available). In addition, there is 0.53 million ha of closed water. The amount of perennial as well as seasonal water is under continuous reduction due to natural as well as anthropogenic causes that have deleterious effects on aquatic habitats and a consequent loss in fisheries productivity.

Bangladesh is prone to extreme climate variability which is being aggravated by anthropogenic activities. Among the disasters, flood was found to be devastating, and occurrence of flood was higher in coastal areas than in upper riparian locations. The combined effect of these natural and manmade disasters are reducing water availability, deteriorating wetland habitats and are consequentially having a severe impact on capture fisheries and also notable effects on aquaculture. This dearth of surface water and low flow of rivers is also putting large pressure on the groundwater table as well as allowing salinity intrusion into freshwater habitat. These have been aggravated by the unplanned development water resources infrastructure e.g. Flood Control and Drainage/Irrigation (FCD/I) embankments (more than 12,000 km in length) inside the country and the Farakka barrage at the upstream of the country which has altered the aquatic ecosystem and has reduced water flow downstream into the Gangetic Basin which has drastically reduced the fisheries productivity.

Fisheries are one of the most important sectors in the context of rural economy; it is the only sector that provides the opportunities for open access livelihoods for the rural poor and ultra-poor. In spite of all these negative effects from anthropogenic sources, Bangladesh produces 2.56 million mt of fish annually and contributes to 21% of the total agricultural production. In addition to providing more than 60% of animal protein intake to the nation it is the second most important sector in export earning contributing to about 40 billion Taka annually. It provides employment to 12.5 million people most of which are rural poor and thereby substantially contributing to poverty reduction.

Themes and outputs: In this report we present an analysis of the fisheries water productivity in the Eastern Ganges Basin (EGB) as a sub sector of the broader CPWF Basin Focal Project – Indo-Gangetic Basin, (BFP-IGB) where a maximization of water allocations in this water scarce situation is appraised. The present study has made an endeavour to i) evaluate spatiotemporal variation of water productivity of fisheries and aquaculture in the context of the EGB ii) evaluate fisheries and aquaculture potential throughout the sub basin for different production systems iii) identify the constraints and opportunities of fisheries water productivity for different production systems and aquatic ecosystems iv) identify potential pro-poor and small-scale interventions that maximize fisheries and aquaculture water productivity v) evaluate policy and institutional issues to address fisheries potential identify and evaluate the potential.

The report also captures the policy environment, pro-poor market promotion, strengthened institutions at public, private and grassroots levels through a review of the sectoral policies and an analysis of the policy gaps that need to be addressed to maximize the water-use as well as water access in the total agricultural sector that includes fisheries and aquaculture (generically the natural resources sector) in the EGB of Bangladesh with specific focus on the Gorai-Madhumati (GM) sub-basin.

Study approach: Temporal and spatial variation of catch per unit area (CPUA) were determined based on secondary data (mainly public domain source i.e. the Department of Fisheries (DoF) Fisheries Resource Survey System (FRSS) and some other projects based sources) for open and closed fisheries systems for the 14 districts of the GM sub-basin. A case study was carried out in a sample of three districts - designated upper, middle and lower stream of the sub-basin to obtain primary data on water productivity values and drivers for different capture and culture systems. Fisheries water productivity values were obtained through a semi-quantitative method in an attempt to acquire comparable values for agriculture and aquaculture in a standardized form. Productivity values allowed us to identify the potential determinants of water productivity through questionnaire surveys, focus group discussions (FGD), key informant interview (KII), extensive farm and field visits, and professional and expert judgments.

Many of the drivers of productivity identified apply to all the systems studied while some are system specific. The constraints identified are described below followed by the system specific constraints and possible interventions.

Aquatic Environment: Environmental change was found to have detrimental effects on fish availability. Examples are drought, salinity, turbidity and pollution which caused loss of many species during the last decade. Future studies must factor in the impact of climate change, especially salinity intrusion which has increased due to a reduced flow from upstream and which has already started to aggravate by a rise in sea level.

Marketing: Fish marketing systems were found not to have much impact on fish water productivity when measured in terms of weight. But when converted to monetary values, it became an important issue. Fish farmers are strongly influenced by their output value of products. Respondents perceived that information flow regarding price has much strength in determining fair price for the produce. Marketing issues are also a matter of potential intervention. In semi-closed and closed culture systems strengthening marketing linkages that includes mechanisms to reduce middlemen interception would improve the income of the root level producers. The market channel for the shrimp growers has however advanced because most of the shrimps are targeted for export market.

Openwater - Capture fisheries: Water resources development interventions made through the FCD or FCD/I projects implemented during the late 1960s and early 70s had a negative impact on fish water productivity and biodiversity of open water bodies in almost every case (FAPREF). In this study, respondents however perceived a smaller increase in catch from capture fisheries but could not relate the impacts to project interventions. These may be due to lack of awareness or to the failure of the study to make them conceptualize the larger picture.

Access to open water resources: Access was also found to have a negative impact on fish catch for the poor fishers. Due to a centralized and not pro-poor leasing system, fishers have lost their entitlement. Furthermore it was found that due to lack of capital, poor fisher groups have failed to manage the waterbodies profitably. For this reason, access to credit should be ensured simultaneously to guarantee the rights of poor fishers to open water resources, making the systems more productive and more equitable. It was found that the waterbodies managed by the community based organizations (CBOs) produce better results as the CBOs operate fish sanctuaries and undertake small-scale habitat restoration which is beneficial for the life cycles of fish. These interventions have increased the fishers' income two - three fold (REF?) and at the same time the non-fisher households have also been able to avail of the additional incomes from subsistence fishing.

Closed and semi-closed water – Aquaculture: For semi-closed and closed (pond) culture systems there is a lack of established extension services. Hatchery, nursery and feed mills should be established more evenly throughout the sub-basin as demand for inputs is high throughout but the inputs are mostly available in a concentrated area. Similarly, fish-depots and processing plants should also be established more evenly. Even, government has established - but not made functional - hatcheries and farms that when made operational could help meet the demand. Decentralized seed production could minimize input costs, and training on culture techniques, management, fish fry production and water conservation could increase the production efficiency. For the possible intensification of culture fisheries there should also be reinforcement of marketing systems including fish processing plants, storage depots and export linkages.

Brackishwater aquaculture: Brackishwater aquaculture is mainly constituted by shrimp and prawn. Marine shrimp *Penaeus monodon* (bagda) has been cultivated over the last three decades. Freshwater shrimp *Macrobrachium rorenbergii* (golda) culture is rather complex, does not grow in saline water but in freshwater and needs saline water for larval survival and growth and hence it was not popular during the time people started bagda farming. Now over the decades due to salinity influx into the upper region of the sub-basin both bagda and golda farming are increasingly expanding and farmers are taking up and coping with the climate change with shrimp farming and converting the agricultural lands that have become non-remunerative for rice farming. Shrimp farming have three to four fold higher returns. Bagerhat agricultural lands are suitable for one agricultural crop cycle only that was observed by this team earlier.
One of the constraints to the shrimp culture is threat of major fish killing was disease, especially viral (e.g. WSSV) and fungal infection. Recently WorldFish has developed and provided services to the farmers in assisting virus free PL tested in its laboratory; the technology has been transferred to public as well as private sector institutions.

Adaptations to climate change: In the days to come when present agricultural land uses may become un-suitable for rice or other cereals, then more promotion of shrimp culture to cope with salinity and sea level rise is expected. It may also open opportunities for mariculture of white fish in those areas in near future. Brackishwater fisheries would also be available for capture fisheries. Fisheries can provide scope for adaptations to climate change and the consequent sea level rise as well as salinity intrusion.

Another means of adaptation would be adopting floating agriculture as an integrated measure. Both shrimp culture and coastal aquaculture systems would also require the development of infrastructure and a sustainable marketing channel.

Scope and potential interventions: Interventions to increase the water flow and flushing conditions of the aquatic ecosystems are found to be a win –win situation for achieving an increase in fisheries productivity and have a beneficial impact on the society including the agricultural farmers. The restoration of water bodies through interventions such as re-excavation of beel beds , fish sanctuary establishment and reopening of canals to facilitate fish migration (that also supports water for irrigation to certain extent), consolidate the functions of the water management committee (WMC). To achieve agricultural and fisheries water productivity the community based water sharing systems need to be identified as a basis for far reaching benefits. .

Policy implications: On the policy arena, agricultural policy also needs to be integrated and synchronized with the other natural resource policies e.g. water policy, fisheries policy, and environment policy; those that advocate for mechanisms to enhance ecosystem productivity. Presently there are conflicts among the natural resources sector policies. The present National Agricultural Policy has provided the department of agricultural extension (DAE) to implement minor irrigation projects to claim lands from wetlands for rice culture, particularly the HYV rice which are water hungry crops. Bangladesh rice research institute (BRRI) has produced some less water consuming varieties e.g. BR28, BR29 etc which have by now become popular. There is a need for policy mind-shift and to try to accommodate the policy for a win-win situation that provides that best compromise in maximizing water-use.

Leasing systems of public water need to be more equitable and pro poor, redistributing the benefits that the elites tend to capture; possible interventions and recommendations for improved fisheries productivity of capture fisheries is linked to the change in leasing policy. Currently, this is already being attempted in the new *Jalmohal* (Wetland) Policy 2009 of Bangladesh but it is yet to address the decentralized implementation strategy.

Institutions and governance: Institutional support was found to be an important factor that influences fisheries water productivity. Institutions can introduce new farming practices, demonstrate the proven pro-poor culture technologies, provide technological advice and facilitate the easy supply of inputs e.g. the quality and disease/ virus free fish/shrimp seeds and feeds. Development of the mass-scale fish culture, fish hatchery development, fish fingerling trading in the Jessore district as fish production hotspots and the increased fish production in its impact zone is a clear indication of development of private institutions that have been patronized by the GO and NGO institutions over the last two decades. Majority of the respondents however were not able to relate this to the institutions that are responsible for such activities which recommends strengthening of the extension service providing institutions e.g. the DoF and the NGOs. It may be noted that the WorldFish Center has developed and demonstrated innovative technologies for assisting shrimp farmers to get virus free shrimp post-larvae (PL) and the innovation of decentralized fish seed production and value chain system and this need be transferred to the service providers. Training should move away from standardized programs and should be more oriented to specific systems or real needs of the community

The CBOs developed in the 500+ waterbodies need be consolidated and brought under network (a process in initial stage) to ensure the enhancement in the open-waterbodies of fisheries productivity. It will empower them further to raise their voices at the policy level and influence the necessary changes of the fisheries policy and the Waterbody leasing policy. This practice of the CBOs for community based fisheries management may be extended and introduced in the waterbodies that have been leased out to societies byagencies other than DoF. Good practices and lessons may be transferred by institutional strengthening programs of the relevant organizations under public, private and the grass-roots levels. In addition, the water management committee (WMC) that is composed of public, local government and the community needs to be made functional and responsible for the allocation of water through sluice gates following a guideline that supports dry season irrigation from surface as well as ground water and maintain a minimum level of water in the beels for brood fish stock.

1. Introduction

The fisheries and aquaculture production is directly related to availability of water. Bangladesh is situated at the delta of one of the world's major river systems where there is a vast area of freshwater during summer monsoon amounting to a total of 5.05 million hectares of which 2.83 million is seasonal floodplain water and the rest includes the rivers, lakes, beels etc (DoF, 2009). In addition to this, there are 0.53 million ha of closed water. The amount of perennial and seasonal water is under continuous reduction due to natural as well as anthropogenic causes and fisheries productivity suffers to a great extent during the dry season (peak in February – April). In spite of negative effects of natural as well as manmade causes Bangladesh still produces 2.56 million mt of fish annually that contribute to 21% of the total agricultural production. In addition to providing more than 60% of animal protein to the nation it is the second most important sector in export contributing to about 40 billion Taka annually. It provides employment to 12.5 million people.

A fully functional ecosystem which needs to deliver goods and services to the society in terms of enhanced and sustained natural resource capital, employment creation and food security is dependent on the hydro-morphological conditions of the basin. This multiple use of water resources makes it difficult to optimize agriculture water use particularly during the dry seasons (BCAS, 2006). The competing use of water resources further complicates the situation and in most cases fails to strike a balance between the demand and supply of water among the sectors as well as within the sectors. The changes however have very little to do with the natural events, but are caused to a great extent by the anthropogenic factors of which the water resources development interventions are by far the most mentionable in the case of the catastrophes faced by the Bangladesh fisheries sector.

Changes of habitat ecology source from the changes in water resource systems, particularly the resource development interventions within and outside the country. The unplanned water resource development interventions that have created infrastructures e.g. embankments, river closures, etc. and the construction of the cross boundary Farakka barrage at the upstream of Bangladesh have drastically reduced the water flow and hence the water area which has broadly impacted the aquatic life functions. Bangladesh is situated at the delta of the world's major river system. It shares the downstream water of the major regional river systems (the Ganges-Jamuna-Meghna) with the upstream countries. So there is also a major effect of the changes of the water resource systems on the upstream regional countries and on the aquatic ecosystem of Bangladesh.

The net result is that the supply of renewable water per capita is declining throughout the basins that Bangladesh shares with India (CEGIS, 2002). Reduced water availability in the Ganges-dependent area has affected the southwest region of Bangladesh in a number of ways, including increased saline intrusion, changes to river morphology, and increased environmental hazards, threatening the security of the natural aquatic resources, including the Sundarbans World Heritage Site.

Additionally the water sector infrastructure development activities for flood control, drainage, irrigation and other purposes during the last four decades in Bangladesh has created negative impacts on wetland habitats and fisheries. Over the last 50 years the floodplain areas have been reduced from 9.3 million ha to 2.8 million ha. These have drastically reduced water flow for various purposes and hence migration of fish, and reduced water area for grazing of fish (CEGIS 2002).

The most critical conditions for fish habitat lay in the water depth and water retention capacities of the habitats, most importantly the *beels*, the *baors* (oxbow lakes) and the connecting *khals* (canals) during the dry season, and as a result the over-wintering shelter for parent fish stock have been lost to a great extent. Abstraction of water for irrigation and other purposes, as well as drying of *beels* for annual fish catch have resulted in conversion of many fish habitats into paddy fields and resulted in loss of habitat and in reduction of overall fish catch from the inland open-water system (Ali 1997).

2. Background

2.1. Context and Issues

Aquatic ecosystem functions that naturally enhance fisheries productivity are not optimized in the Eastern Gangetic Basin (EGB) of Bangladesh, rather the natural and manmade activities put hindrances to the optimization of water functions and ecological productivity. This results in lower renewable capacity of the fish stocks and lower level of biodiversity that has gradual deleterious impacts lowering overall fish production in the open water systems. The pond aquaculture has developed momentum over the last few decades in order to cope with the nutritional needs, but that has another dimension to look into from the poverty reduction and social dynamics and it's complimentarily with other agricultural land use patterns. The objective here is to determine what factors or variables are causing this, and identify potential and low-cost opportunities to alleviate the constraints under different socio-economic and institutional dynamics.

While water is a scarce resource and is under multi-use pressure, agriculture is dominating on the water-use in Bangladesh. In most cases the need for wetland conservation to deliver ecological goods and services is ignored and as a result the ecosystem characteristics have already been altered with devastating impacts on fisheries productivity, and fish stock regeneration capacity. Moreover some agricultural project interventions have claimed lands by converting wetlands into dry-lands suitable for agriculture but have made them unsuitable for fisheries production. Over the last few decades the floodplain areas, which are a good source for subsistence fishing for the rural poor, have been reduced to one-third (ASB, 2003).

Environmental flow conditions have been changed drastically over the last few decades. *Beel* beds which used to serve as the over-wintering fish grounds have been silted up and canals which used to serve as the inter-habitat migration pathway for spawning fish have been hindered. Excessive surface water irrigation from the *beel* beds have resulted in drying of the over-wintering habitats that also stimulates fishing by dewatering. All these events have been evaluated in the paper with evidence of the land-use changes and the fisheries production loss. At the same time, the low productive agricultural lands have been converted into shrimp culture ponds by the local community applying indigenous knowledge and initiative (e.g. Bagerhat district) for subsistence as well as for a more profitable use of the land. The interventions of the agricultural sector for converting fisheries waterbodies into agricultural fields is certainly an agenda for technical as well as policy review. Some of these elements have been captured in this report.

2.2. Objectives and output of the study

The overall objectives of the Indo-Gangetic Basin Focal Project (IGB-BFP) is to conduct a basin-wide analysis of conditions, constraints and opportunities to improve water productivity and enhance agriculture based economy and rural livelihoods including fisheries and aquaculture. The scope for sustainable land use system for longer term interventions that enhance the ecosystem productivity to alleviate poverty through high potential but low-cost interventions is also evaluated.

The knowledge flow shall enable policy-makers and practitioners in the water and related sectors to conceive more clearly the consequences of specific interventions advocated by the project compared to the status quo. The sub-project envisions a series of special studies, appended to the routine monitoring for consolidation of existing practices, which alert us of any negative consequences of our actions and reinforce the potential outcomes of not changing the management strategy.

The specific objectives of the study include the following:

- Analysis of fisheries-water productivity (WP#2) for Eastern Ganges Basin particularly Gorai-Madhumati sub-basin for different capture and culture fisheries systems.
- Undertake a case study on fish productivity and linkages to poverty in the Goari-Madhumati sub-basin in Bangladesh, and provide the fisheries related information for the trade-off analysis between aquaculture and agronomic activities.
- Identify and evaluate suitable physical, economic and institutional interventions (WP#5) for enhancing overall fisheries productivity in Goari-Madhumati sub-basin.
- Implement studies on fisheries institutions (in collaboration with WP 4- Institutional Analysis). This involves carrying out a study on institutional aspects of culture fisheries in the Eastern Ganges basin (GM-sub-basin).

- Develop a methodological framework (WP#3) for analyzing the water productivity of fish in the context of the IGB, here with particular reference to the Gorai-Madhumati sub-basin.

2.3. Study Site

Figure 1 shows the location of the Garai Madhumati sub basin in Bangladesh, and of the Eastern Ganges Basin – the area of study.

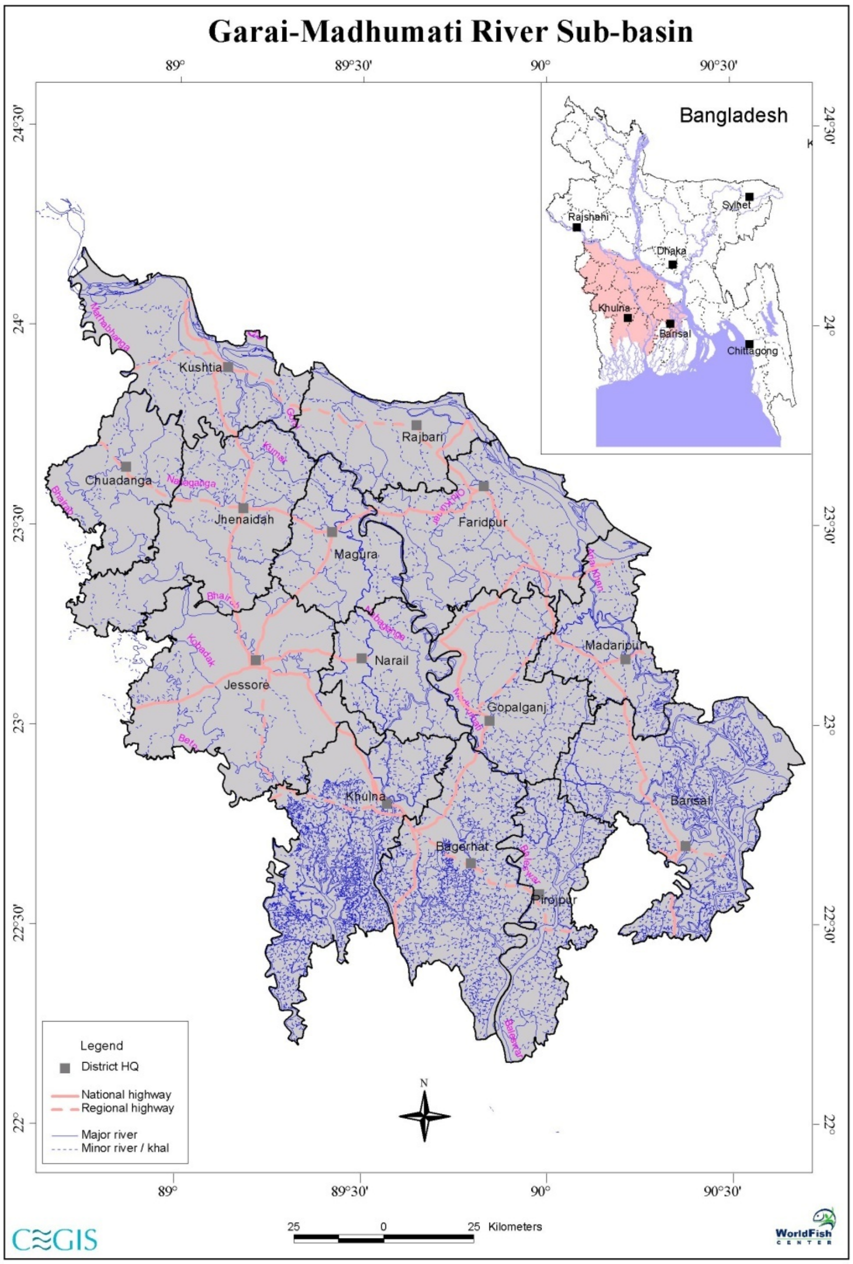


Figure 1: Gorai-Madhumati sub-basin, Bangladesh*.*

3. Methodology

The spatiotemporal analysis findings are based on secondary data are mainly from the FRSS/DoF and the National Water Resources Database (NWRD) databases. This was followed by conducting a case study and extensive field and farm survey at the selected regions (districts) and collated with the expert consultation and professional judgments for necessary interpretation of the results and recommendations. A criteria selection process was initiated to classify the types of data needed to identify changes in the water resources sector and their impact on fisheries and agriculture in order to provide the basis for recommendation for possible pro-poor intervention for fisheries, water and agriculture productivity management and conflict resolution at an economically feasible and socially acceptable manner supported by scientific evidence. To this end multi-criteria analysis process (including the efficient and economic use of water) was used to identify the potential local solutions that would compromise with the best options for adopting either win-win situation actions or tradeoffs.

Frequent sharing were made with the counterpart IWMI scientists (the respective work package leaders) to keep the data and information collection at a level that enables synchronizing the analysis that leads to the results needed for framework development at basin scale and to generate options for adaptations to the changing land types and the need for changing the land-use practices.

3.1. Digital Elevation Models and secondary data analysis

District wise productivity (per unit water area basis) maps based on secondary data and digital elevation models (DEM) have been constructed in order to understand the regional variation in productivity and are presented under the relevant section.

The initial stages of the analysis consisted of evaluating the fish production per area in the EGB districts from secondary data, segregating the data into habitat types for capture fisheries: *beels, baors* and riversand culture systems: cultured ponds, culturable ponds, derelict ponds and shrimp culture. This secondary data on district wise productivity (per unit of area) was used to construct digital elevation models (DEM) in order to understand the regional variation in productivity throughout the area of interest. Once the differences in catch per unit area (CPUA) were determined for the different systems in the different districts, primary data was extracted as described below.

3.2. Case Study

Case study consisted of surveying 960 households (320 households in each of the three 3 districts chosen in the GM sub-basin for the field study: Chuadanga (upstream), Narail (middlestream) and Bagerhat (downstream)). Measures of water productivity by weight and monetary value were obtained together with inquisitive data on productivity constraints and potentials. The systems studied were: semi-open *beels,* rivers, extensive ponds, semi-intensive ponds, intensive ponds, shrimp aquaculture, and integrated systems (IAA and rice fish). This work was done by partner Center for Natural Resource Studies, (CNRS) who also carried out FGDs in the areas. The sampling of districts was purposive, and the criteria for choosing the three districts was based on productivity situation from secondary data, fisher intensity of the district, poverty situation (both caloric and income basis) and hydrological scenario (upstream, downstream and middle districts). The findings for the determination of water productivity are presented throughout as “catch per unit volume” and “Returns (Tk) per unit volume” wherever possible and the identification of drivers and constraints of productivity was facilitated by the results obtained from it.

3.3. On-field observation and farm visit

Field observations and gathering of information were made to different fisheries and aquaculture production systems to enable further analysis of water productivity potentials and the constraints in achieving the potentials and undertake cost- benefit analysis in order to determine the feasible and sustainable options to promote improved livelihoods.

3.4. Expert and professional judgments

Triangulation among the sources and identification of gaps in knowledge and findings were addressed using these tools. Discussions were made with the experts within and outside WorldFish. The WorldFish projects e.g. Decentralized Fish Seed Production, the IPAC study on the lessons learned for best practices in fisheries and wetland management consisting on the establishment and community led management of fish sanctuaries including the restoration of habitats, have been considered where necessary for collation into the win-win situation analysis; here the identified weaknesses that have been subject to overcome also deserve attention.

3.5. Analysis and reporting

After an initial analysis of secondary data on production systems obtaining data as CPUA, and an understanding on patio temporal variation, the case study looked at water productivity of different production systems by obtaining productivity of fisheries by weight and monetary values by volume of water in order to standardize the measure with the water productivity of other crops. A detailed account of the calculations and methods to obtain fisheries water productivity values is addressed in the Methodological Framework in Appendix 1.

Through the review of secondary information, the household survey questionnaire, FGDs, KII and field visits an analysis of constraints and opportunities affecting the fisheries water productivity was done in order to understand the drivers and hindrances of productivity of the EGB to ultimately recommend potential pro-poor interventions for the optimization of fisheries water productivity.

3.6. Limitations of the data

As the field data for the case study was obtained by the enumerators of the sub-contracting NGO then the reliability of the findings depends upon their honesty, sincerity and efficiency in generating the data. Reliability of data is also an issue when interpreting secondary data. The majority of this type of data was found from DoF – FRSS as mentioned previously because it was the only source with complete data for all the sub basin. This data must be also interpreted with caution. Yet some data was not found from secondary sources for some production systems (e.g. IAA, rice fish), and few calculations for IAA and Rice –fish were obtained so these systems' results may not be representative of the basin. Therefore, the findings of the present study are indicative rather than conclusive and should be interpreted with care.

4. Livelihood, Poverty and Socio-economic Status

For a complete understanding of water productivity and its limitations and possibilities, the socio economic status of people living in the EGB region was explored and obtained through secondary data s well as from the field case study. Being aware of their current condition will provide information on their adaptive capacity allowing a more realistic analysis of future interventions.

4.1. Demographic Information of the GM sub basin

The total area of the sub-basin is 27,636 sq.km and had a population of 20.7 million in 2001 (BBS 2006), of whom approximately 40% are literate. Details on district wise area, population and literacy are shown in Table 1 and Figure 2. The majority of land is agricultural and cultivable. There are a considerable number of water areas in the form of *beels, baors*, floodlands, ponds, rivers and canals in the mid and lower part, and a countable amount of fallow land also remains.

Table 1: Area, Population and Literacy rate (Census- 2001, BBS)

District Name	Area (Sq. km)	Total Population	Density (per Sq. km)	HH	HH Size	Literacy Rate (%)
Kushtia	1621.15	1740155	1073	379504	4.57	40.4
Chuadanga	1177.40	1007130	855	225830	4.44	40.9
Jhenaidah	1949.62	1579490	810	333526	4.72	44.7
Rajbari	1118.80	951906				39.8
Magura	1048.61	824311	786	163949	5.02	44.7
Jessore	2570.42	2471554	962	524127	4.67	51.2
Narail	990.23	698447	705	141071	4.94	48.6
Faridpur	2072.72	1756470	847	349458	5.01	40.9
Gopalganj	1489.92	1165273	782	221986	5.24	51.4
Madaripur	1144.96	1146349	1001	231655	4.95	42.4
Khulna	4394.46	2378971	541	499324	4.74	57.8
Bagerhat	3959.11	1549031	391	323505	4.74	58.7
Pirujpur	1307.61	1111068	850	232962	4.77	64.3
Barisal	2790.51	2355967	844	474076	5.0	57.0

The economy of the sub-basin area has an agrarian facet which reflects the national situation as well. A large proportion of the economy comes from fisheries, aquaculture and shrimp and prawn culture. A good number of people are living on labor sale in agriculture and wedge labor and little comes from other sectors like industry. As for occupations, 12.5 million of people are engaged with fisheries, aquaculture and related activities (Figure 2). The protein intake is similar to the national and the major portion of the protein comes from the fish, which is the only source of protein for the poor and marginal people (BBS 2006).

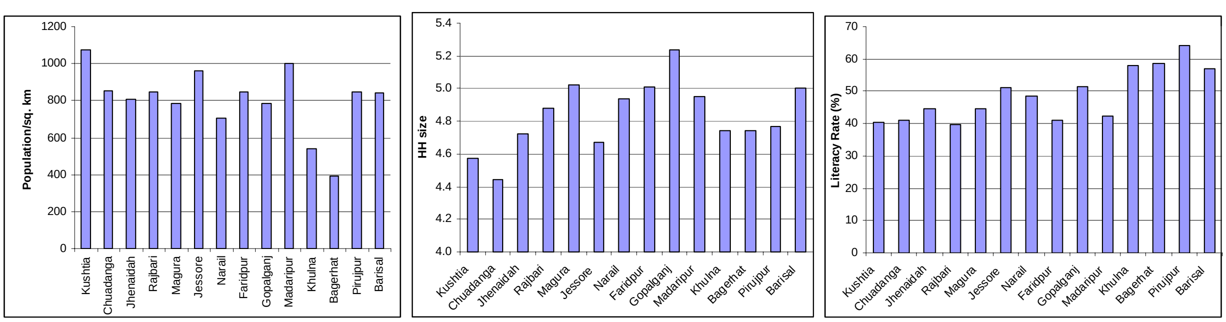


Figure 2: Population, average household size and literacy rate at each of the 14 districts comprising the GM sub basin (adapted from BBS, 2006)

4.2. Occupation

Table 2 shows the basin wide occupation pattern. Fishing involves capture fisheries in open water only. Aquaculture is widespread however it is in most cases a secondary occupation and hence falls under agricultural farmer. Occupation data on fish farming and capture fishing was determined by the purposive sampling of the case study which is mentioned below.

Table 2: District-wise occupational pattern of the Gorai – Modhumati Sub-basin area. (Source: Adapted from BBS, 2006)

Dist name	**Kushtia**	**Rabari**	**Chuadanga**	**Jhenaidah**	**Magura**	**Faridpur**	**Gopalganj**	**Madaripur**	**Jessore**	**Narail**	**Khulna**	**Bagerhat**	**Pirojpur**	**Barisal**
Agriculture	31.5	42.82	40.33	48.14	51.26	42.76	46.37	43.74	39.48	47.6	25.11	36.24	35.3	35.28
Agri-labour	13.9	23.63	28.08	23.17	19	21.67	20.94	24	24.13	18	11.3	18.31	17.05	18.76
Fishing	0	1.25	-	-	1.22	1.47	1.71	-	-	2.08	1.66	3.06	2.68	3.45
wage labourer	4.48	2.94	2.69	2.67	2.53	2.74	1.71	2.96	2.68	2.44	7.15	6.73	5.71	4.16
Handloom	3.58	0	-	-	-	-	-	-	-	-	-	-	-	-
Industry	1.14	0	-	-	-	-	-	-	1.41	1.31	16.38	-	-	-
commerce/business	15.34	11.43	12.69	11.26	9.37	10.63	9.76	9.93	11.99	10.9	-	12.86	16.2	13.89
transport	2.05	2.15	1.91	2	2.45	2.06	1.38	1.31	3.11	2.6	4.09	2.27	1.64	1.72
construction	1.41	1.03	-	-	-	-	1.01	-	-	-	1.53	-	1.28	1.25
service	7.15	6.08	6.08	4.14	6.01	7.16	9.28	6.08	8.66	7.84	18.93	7.58	7.25	10.64
others	9.45	8.67	8.22	8.35	6.92	11.51	6.36	11.98	8.18	7.24	12.22	12.95	12.89	10.85

Samples were selected on the basis of the community engagement with fishing or fish farming along with other occupations they have. It is found that people usually depend on different types of occupations in different seasons or in the same day. Hardly any household was found to live on any single occupation rather they are adapted to a number of agricultural activities including fisheries and/or aquaculture which together make their livelihoods.

From the case study, based on the multiple responses, almost all of the respondents at the three sites depend on other farm based or non-farm based occupation rather than on fishing and fish farming alone (Table 3). In the case of Bagerhat, respondents' dependency on fish farming seems to be the highest among the three districts. This is mainly due to wide spread shrimp culture supported by the hydro-ecology of the area which is now well established.

Table 3: Variation in occupation of the respondents in three districts (percent, in 2009)

Occupation	Chuadanga (%)	Narail(%)	Bagerhat(%)
Fishing	29.00	23.80	24.29
Fish Farming	22.33	26.04	36.72
Other	48.67	50.16	38.98

Further, it is found from the survey that both fishing and fish farming are supplemented by other occupations. When considering household involvement on fishing activities, respondents at Bagerhat district have spent more time on fishing and fish farming than other districts (
Table 4). This is due to their lower land holding capacity in comparison to other districts as well as due to larger availability of water in open waterbodies and culture systems.

Table 4: Respondent's engagement in different occupation (measured in month)

Occupation	Chuadanga	Narail	Bagerhat
Fishing	9	7	11
Fish Farming	11	7	11
Other	12	12	9

4.3. Education

Survey findings reveal that for each site the level of education among fishers is lower than that of fish farmers. None except very little percentage of the total fisher of Chuadanga had completed high school level education (Table 5). Most of the fishers have a primary level education.

Table 5: Variation in level of education of the fishers and fish-farmers

Level of Education	Chuadanga		Narail		Bagerhat	
	Culture (%)	Capture(%)	Culture (%)	Capture (%)	Culture (%)	Capture (%)
No education	27.00	58.60	13.30	24.50	17.50	29.70
Primary Education	20.30	26.40	26.70	44.80	39.20	53.90
High school - below SSC	25.70	11.50	31.10	27.30	32.00	14.10
SSC	16.20	2.90	18.90	3.50	8.80	2.30
HSC and above	10.80	0.60	10.00		2.60	

4.4. Income and poverty

It is found that fishers depend mostly on fishing, while fish farmers are engaged with other agriculture and non-agriculture based activities. For this reason, when calculating fish farmers monthly average earning, income from other occupations was also considered. Again, it is found that respondents of Bagerhat earn more from both fishing and fish farming than in the other two districts (Table 6). This is also supported by their greater engagement with fishing and fish farming. Such deviations are discussed in the later sections of this report.

Table 6: Contribution of different sources in monthly income (BDT) of fishers and fish-farmers

Occupation	Chuadanga	Narail	Bagerhat
Fishing	2,230	1,928	3,118
Fish Farming	1,562	1,112	2,356
Other activities	2,888	5,382	1,684

For Chuadanga and Narail, per capita monthly income of the fisher group is remarkably lower than fish farmer groups (Table 7). It is already mentioned that, fish farmers usually supplement their earnings by other agriculture and non-agriculture based occupations. Their land holding capacity also supports this (Table 9). In the case of Bagerhat, it is found that both groups of fish farmer and fishers depend on aquaculture and fishing more than on other occupation. Moreover, there was no significant difference found in land holding capacity and educational level between the two groups.

Table 7: Variation in per capita monthly income through capture and culture fisheries

System Type	Chuadanga	Narail	Bagerhat
Capture	759.44	975.59	884.03
Culture	979.09	1231.00	834.86

Average monthly income of the households was assessed and compared with upper poverty line income used in Household Income and Expenditure Survey 2005. It is found that poverty rate is higher among the fishers of Chuadanga than fishers of other districts (Table 8). However, no remarkable difference was found between the poverty status of the households based on system type.

Table 8: Percentage of poor households among the samples

System Type	Chuadanga (%)	Narail (%)	Bagerhat (%)
Culture	27.70	25.56	30.41
Capture	33.33	25.87	27.34

4.5. Land Ownership

According to the result of the survey it was found that, for every site, household based on capture fishery has smaller land holding in comparison to the household based on culture fisheries (Table 9). Most of the fishers owned land less than 0.2 hectare (0.5 acre). This was mainly comprised of homestead land. As a result they have fewer options for other land based occupations. Contrary to this, most of the culture fishery based households, except for Bagerhat, have 0.2 – 1.0 hectares of land. And it is found that, they mainly depend on other agriculture and non-agriculture based occupation.

Table 9: Variation in land ownership among the fishers and fish-farmers

Land holding size	Chuadanga		Narail		Bagerhat	
	Culture (%)	Capture (%)	Culture (%)	Capture (%)	Culture (%)	Capture (%)
<0.02 ha		43.70		17.50	4.60	14.10
0.02-0.20 ha	5.40	39.10	6.10	31.50	62.90	78.10
0.20-60 ha	20.30	12.60	25.00	27.30	29.40	7.00
0.60-1.00 ha	15.50	3.40	20.60	18.20	2.10	0.80
1.00-3.00 ha	45.90	1.10	40.00	5.60	1.00	
3.00 ha +	12.80		8.30			

5. Fisheries Water Productivity in Different Production Systems

An initial description of the systems profiles studied is given below for the differentiation of production systems. Following these descriptions, there is a synthesis of the results from our secondary and primary data on open water systems, culture systems (including IAA and shrimp culture). There is an initial account of results showing geographical variation in Productivity Elevation Models (PEM) and results on spatio-temporal variation data obtained from public organizations and various other projects. Results from the field on upstream to downstream variation for the different systems and water productivity values in *production by volume* and *return (Tk) per volume* are addressed subsequently.

5.1 System Profiles

5.1.1. Capture Fisheries Systems

Capture fisheries cover a variety of habitat types: *beel, baor* and rivers. Beels are the low-lying depressions in the floodplain (small lakes) and may have a permanent character, containing water throughout the year (perennial *beels*) or dry out completely during a part of the year, usually 4-5 months (seasonal *beels*). *Baors* are specifically abandoned river courses; oxbow lakes. During monsoon the *beels* become part of the floodplain fishery which generates opportunities for subsistence fishing as 80% of rural households take part in fishing to contribute to the agricultural income and achieve the daily needs of household expenditure and/or protein supply. Rivers are large natural streams of water, with connecting canals that in some instances feed the *beels* with water.

5.1.2. Culture Fisheries and Integrated Agriculture-Aquaculture Systems

Intensive aquaculture

Intensive aquaculture IS not widespread in the area. The culture systems that were identified as intensive were those in which there is use of supplementary feed, and has high number of cycles per year and stocking density. In this study, fish owners stocked fish fry at least 2-3 times a year. We found these systems to be more densely stocked than other semi or non-intensive systems.

The spread of this system usually depends on the owner's financial capacity and knowledge, although from our study it was found that people were not interested in intensive types of aquaculture despite higher profit when compared to other production systems, because of the complexities faced during profit sharing due to multiple ownership of a single parcel of land.

Semi-intensive

Under semi-intensive systems fish fry is stocked only once annually and generally during the rainy season when there is sufficient stored water. Throughout the period from stocking to harvesting, only very small amount of feed (e.g. cooked rice, rice husks, etc.) is introduced, if any, and fish mainly depend on natural foods found within the system. Harvest occurs before the dry season although the pond is harvested throughout the year especially for consumption. These kind of systems are found abundantly both in Narail and Chuadanga, whereas in the case of Bagerhat, there is a larger mix of semi-intensive and intensive types of culture.

Extensive / Low input aquaculture

Extensive aquaculture is more requires less effort in husbandry of the fish. It is done in the man-made lakes, ponds, closed or semi-enclosed water bodies. Fish chosen for extensive aquaculture are very hardy and often low stocking densities are maintained. Culture species normally grow using natural feed or very small amount of exogenous feed. Carp, tilapia, pangus, and shrimp are the most prominent species of extensive aquaculture. This type of aquaculture has very low negative impacts on the environment, as opposed to extensive aquaculture which destroys natural habitats.

Shrimp Culture

In the study areas of the EGB, especially in the southern areas which are closer to brackish waters, the main types of aquaculture are shrimp culture (both *Galda* and *Bagda*) either in mono or polyculture systems. This can be supported by the abundance of *ghers (Coastal Shrimp farm)* present in the area and the presence of saline water which is suitable for fresh water prawn, *bagda (Macrobrachium)* culture. The determinants that outweigh the scale for landowners to adopt aquaculture techniques are mainly water quality and quantity. However, in the areas where saline water is present, mixed culture with species like carp (which are salt intolerant) are not possible. Moreover, types of fish culture also depend on availability of quality fish fry and the price of fishmeal.

From the study, participants recalled that the usual stocking of *bagda* and *galda* is 10,000 fry of each in a pond of 50 decimal during the month of *Falgun* (February-march). The feed required for a 50 decimal pond is 1.5 kg of fish meal in the first month, 2 kg in the second month and from then on 4 kg per month until harvesting takes place. The shrimp farmers usually provide manufactured meal, snails, egg shells, etc. When farmers opt for mixed culture of shrimp and fish they stock 50-60 kg of carp fry during the months of *Jaisttha-Ashar* (June-July).

Integrated Agriculture Aquaculture

Integrated Agriculture Aquaculture (IAA) is a kind of culture where uses of the land are mutually inclusive and support each other. It is comparatively a new technology introduced in the area. In IAA systems, aquaculture is practiced in ponds with little or no water exchange. There are a number of farming systems which can be regarded as variations on the IAA theme:

- Farms based mainly on dry-land crops and fish culture, sometimes with a small input from poultry or other livestock.
- Wetland crops: Rice and fish culture
- Integrated animal and fish farming e.g. pigs, ducks and poultry farmed together with fish. (e.g. pigs/ duck/ poultry farmed together with aquaculture).

Rice-Fish

Rice-fish culture is an integrated system that is mainly governed by availability of water. Rice is an economically important crop and the integration of fish provides supplemental income/food and if managed adequately can increase the rice yield and reduce the need of fertilizer. Cultivation of fish can be simultaneous with rice or alternate with the crop cultivation.

In every site respondents reported that they prefer rice-fish culture as it is more profitable than other types of land use. All respondents reported that they can harvest at least two crops in the same year. This system needs to provide small amount of food for fish, while doing simultaneous culture. And fish excreta works as biological manure for rice. However there are some disadvantages to it that have not allowed this system to be properly established as an integrated culture system in Bangladesh.

5.2. Variation in Productivity for Capture fisheries in the EGB

Fisheries water productivity has been obtained as catch per unit area (CPUA) from secondary data and calculated as volume using the data collected from the case study. The results for spatio-temporal variation of productivity throughout the basin, and an account of productivity by volume in the three districts studied on the field are explored and discussed below.

5.2.1. *Beel* system

From the temporal variation data from 2002 – 2007 (Figure 3) all fourteen districts have had an overall slight decreasing trend for *beel* productivity. Faridpur shows a notable increase in 2004, although it has decreased since. The other peak regions (Rajbari, Madaripur and Gopalganj) also have a visible decrease. Eventhough Faridpur has been decreasing the spatial variation data shows that currently, Faridpur remains a hotspot for *beel* productivity (Figure 4).

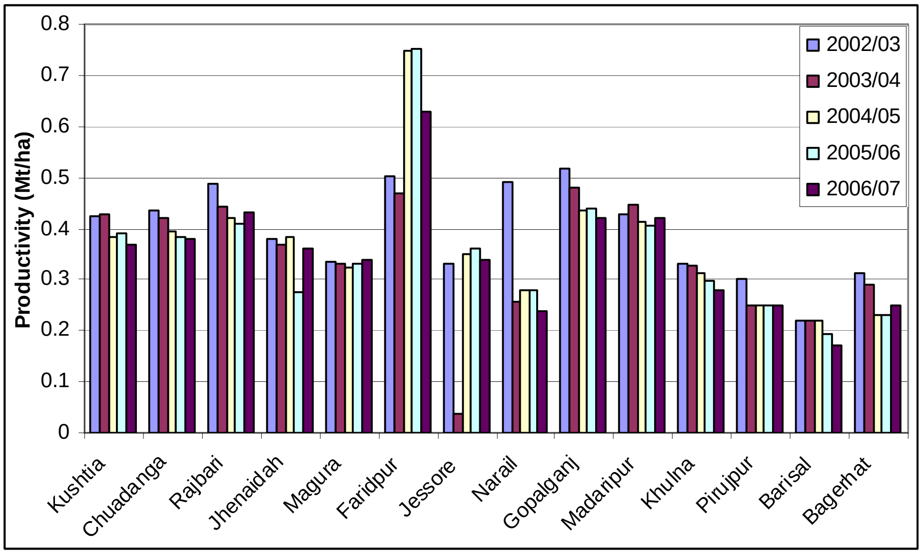


Figure 3: B*eel* fisheries productivity for 14 districts from 2002 - 07. (Source: DoF, FRSS)

Beel fisheries productivity in terms of CPUA has a clear peak in the northeastern part of the sub-basin, especially in Faridpur and followed by Rajbari, Madaripur and Gopalganj. The least productive districts are located in the Southeast, coinciding with the lower part of the Sub-basin which shows a low and decreasing trend (Figure 4).

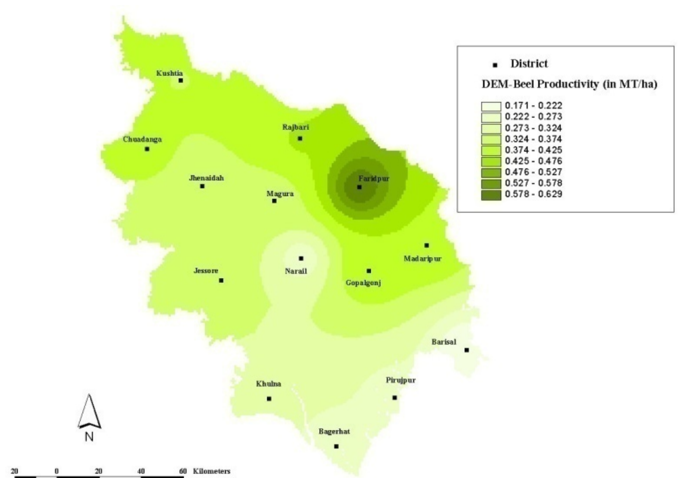


Figure 4*: Spatial variation of Beel fisheries productivity in GM sub-basin.*

Data from primary sources (Table 1) corroborate this trend of decreasing productivity downstream. The productivity by weight and value downstream in Bagerhat's *Badokhali beel* is the lowest, but the species composition is more economically valuable; probably due to the availability of shrimp. However, these results must be cautiously studied as the sample is very low (n=3).

Table 10: Water productivity by weight and value of 3 beels in the case study area.

Districts	Name of the water body	Water Productivity (kg/1000m3)	Water Productivity (BDT/1000m3)
Chuadanga	*Raisar Beel*	21	1,700
Narail	*Guakhola beel*	9.5	760
Bagerhat	*Badokhali beel*	0.6	70

The waterbodies have a lower water flowing condition due to upstream water scarcity and de-linking nature which is one of the causes for the trend. The very high productivity in *beel* fisheries in the northeast is influenced by the Padma (the Ganges and Jamuna confluence). This good connection with the Padma provides a good biological ground, as it facilitates migration, allowing hatchlings to enter the *beels*, it is area of good nursing grounds, and food is also available. The proximity of the Padma ensures good water quality, and can cause water spillage, allowing the formation of *beels* in the area, and ensures that these are mostly perennial, hence allowing production all year round. Seasonal water will increase the beels volume and create floodplains. Further away from the rivers, the productivity in *beels* decreases.

5.2.2. *Baor* (oxbow lake) Ecosystem

The intensity of fish production in *baors* is higher in the northwestern region and gradually decreases towards the south-eastern areas. The highest value is in Chuadanga district, followed by its neighboring district, Kushtia (Figure 5). The high *Baor* productivity hotspot in the north may be as a result of a good management system of the fishery in that area. The southernmost areas (Bagerhat, Pirujpur and Barisal) have no *baors* and hence are not comparable. The visible gradient reflects the pattern of *baor* concentration across the region where zones of higher presence of *baors* translate into a higher intention of culture and better management.

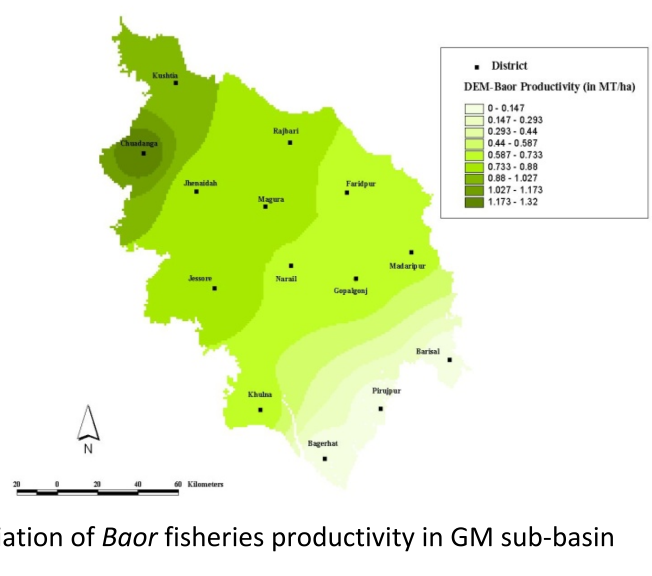


Figure 5: Spatial variation of *Baor* fisheries productivity in GM sub-basin

Baors have higher production values than *beels* overall and produce a larger amount of catch per unit area of water. These habitat types are more manageable semi-closed systems than *beels*, and therefore better established management practices cause a higher production. Faridpur is the only area where productivity in both habitat types is similar. In both cases, it is reasonably high, and this is linked to the proximity of the water bodies and connections through tributaries and distributaries to the river Padma.

Temporal data available was used to compare the differences in management of private and government managed *baors* from 1984 to 1997 (Figure 6). Privately managed and government managed *baors* show that privately managed *baor* productivity increased over time at a much higher rate than government managed *baors*. This data together with the Key Informant Interviews (KII) and expert judgment reveal a weakness in government management of *baors.* However, the overall productivity remains low (<1Mt/ha) due to very traditional practices with common species, compared to other countries, e.g. China and Vietnam who produce approximately 5 to 10 Mt/ha. Replication of private management of *baors* should be attempted by government management as well as taking example from other countries' management tools and technologies, as long as these rely on sustainable practices.

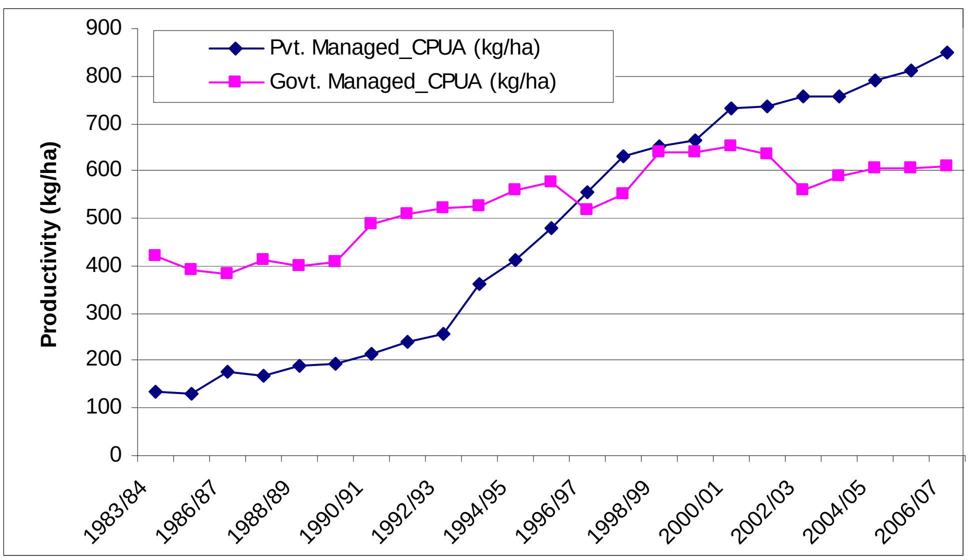


Figure 6: Temporal variation of *baor* productivity in the G-M sub basin.

5.2.3. River system

Data on river area by district was not available, therefore the data consists of production per district area (CPUA of *land*) (Figure 7), which does not provide results that are comparable to other productivity systems nor allows for a comparison among districts as it involves confounding variables, i.e. the area of water in each district will differ from one to another.

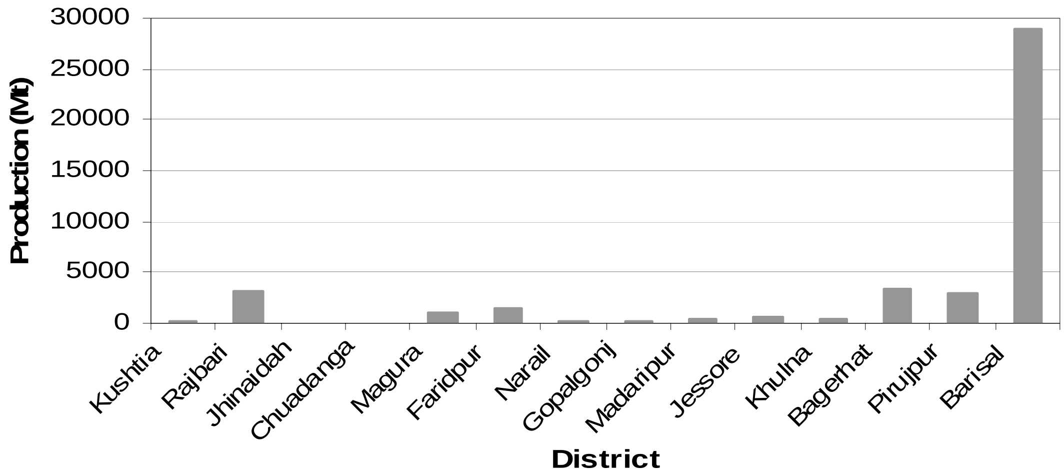


Figure 7: River fisheries production (MT) by district. Source: DoF; FRSS

This data of production by area of land has its peak in the district of Barisal (28,839 MT), followed by Bagerhat, Pirojpur and Rajbari, although their production is about eight times lower. The remaining districts have poor river production of capture fisheries, and the lowest is present in Chuadanga and Jhenaidah (30MT and 40MT respectively).

Table 11: Water productivity by weight and value of 3 river catchments in the case study area.

Districts	**Name of the water body**	**Water Productivity (kg/1000m3)**	**Water Productivity (BDT/1000m3)**
Chuadanga	*Mathavanga* River	26	2,240
Narail	*Nabaganga* River	4.5	540
Bagerhat	*Kulirjorr* River	14.5	1,735

The productivity calculations obtained from field data contrast with the data of production showing Chuadanga to be the most productive out of the three districts studied. This contrasts with the virtually absent production shown in

Table 11: **Water productivity by weight and value of 3 river catchments in the case study area.**

Table 11. The trends vary and show river *Mathavanga* upstream to have the highest productivity by weight and value. This may be due to the composition of fish species, the presence of high valued species, high biodiversity index and water flow upstream. Moving downstream we find a higher productivity (threefold) than midstream. The trend does not continue downstream in *KulirJorr* River, where fishers who usually catch fish also find *galda* and *bagda* shrimp. This is linked to a high biodiversity index, which is at the same time directly related to water availability and environmental flow conditions.

5.3. Variation in Productivity for Culture fisheries and Integrated Agriculture Aquaculture (IAA) in the EGB

According to the definitions of the Department of Fisheries' (DoF), (Government of Bangladesh (GoB)), we have segregated ponds into three types: *Cultured ponds* where the culture practice, including release of fingerlings, supplementary feeding and other necessary inputs, are under a production plan. *Culturable* ponds which are not under planned aquaculture but under traditional practices and where there is scope for bringing the ponds under aquaculture with minor interventions. Lastly, *derelict ponds* which are ponds or ditches where aquaculture is not possible without major interventions. Derelict and culturable ponds by definition are not systems which are currently intended for culture but they do have the potential; hence the inclusion of these systems in the study. They were not studied on the field however the governmental data was addressed to understand their current situation and potential.

5.3.1. Freshwater Pond Habitats

Culturable ponds

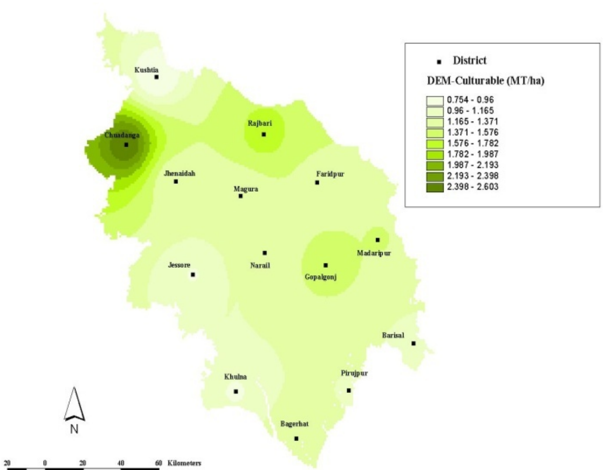


Figure 8: Productivity Elevation Model (PEM) of the culturable ponds in the EGB

Figure 8 shows the distribution of productivity (CPUA) in the fourteen districts of the EGB. There is a focus of high productivity in the northwest which can reflect a better management practice. One of the areas of lowest productivity in the southwest is Jessore which has well established extension services, fisheries research institute bodies, as well as nurseries and hatcheries. Therefore that area has facilities for culture, hence waterbodies will be already under full management. Khulna, the neighbouring district also has low productivity of culturable, due to its proximity to Jessore. The other area of low productivity is in the north, but the reasons vary as water scarcity is a driver in this area.

Derelict ponds

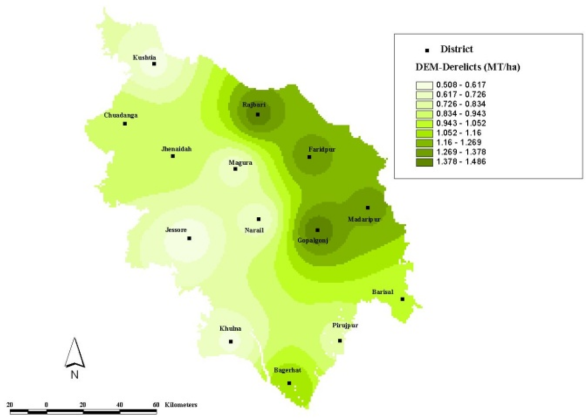


Figure 9: Productivity Elevation Model (PEM) of the derelict ponds in the EGB

Derelict ponds are notably more productive along the area adjacent to the river that passes by the northeastern part of the river. Figure 9 shows the high productivity intensity at Rajbari, Faridpur, Gopalganj and Madaripur. There is a noticeable gradient of derelict pond productivity from the northeast towards the southwest, where Kushtua, Jessore and Khulna have the lowest values.

The confluence of the tributaries of the main rivers in the northeast clearly coincides with the productive derelict areas, where river bank erosion may provoke the formation of the derelict ponds. The proximity of the river causes the high water availability by tidal influence which has two effects: a high natural stocking due to the river proximity and overflow of the river into the ponds.

Cultured ponds

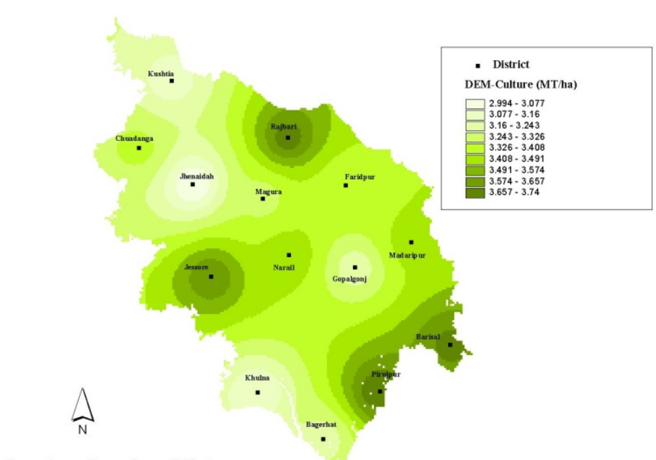


Figure 10: Productivity Elevation Model (PEM) of the cultured ponds in the EGB

Three foci of high and low productivity can be found when looking at Figure 10. The three high productivity points are in the north (Rajbari), west (Jessore) and northeast (districts of Pirujpur and Barisal). These hotspots represent a range of productivity drivers. In Jessore there are well established extension services and seed availability due to set up of hatcheries. The north is an advantageous ecological zone due to the proximity of the productive Padma River, and the southern regions near the coastal belt take advantage of the salinity gradients to develop the profitable shrimp industry and extend the aquaculture practices.

The temporal variation of aquaculture productivity (i.e. average of cultured, culturable and derelict ponds) for the fourteen districts, Jessore and Khulna stand out with the highest values, whereas Pirujpur, Gopalganj and Faridpur are on the lower end (Figure 11). Jessore has had a slight decrease with time, opposite to Khulna. Field results represent the year 2009, therefore it is not comparable to the temporal data considering the high variability between years.

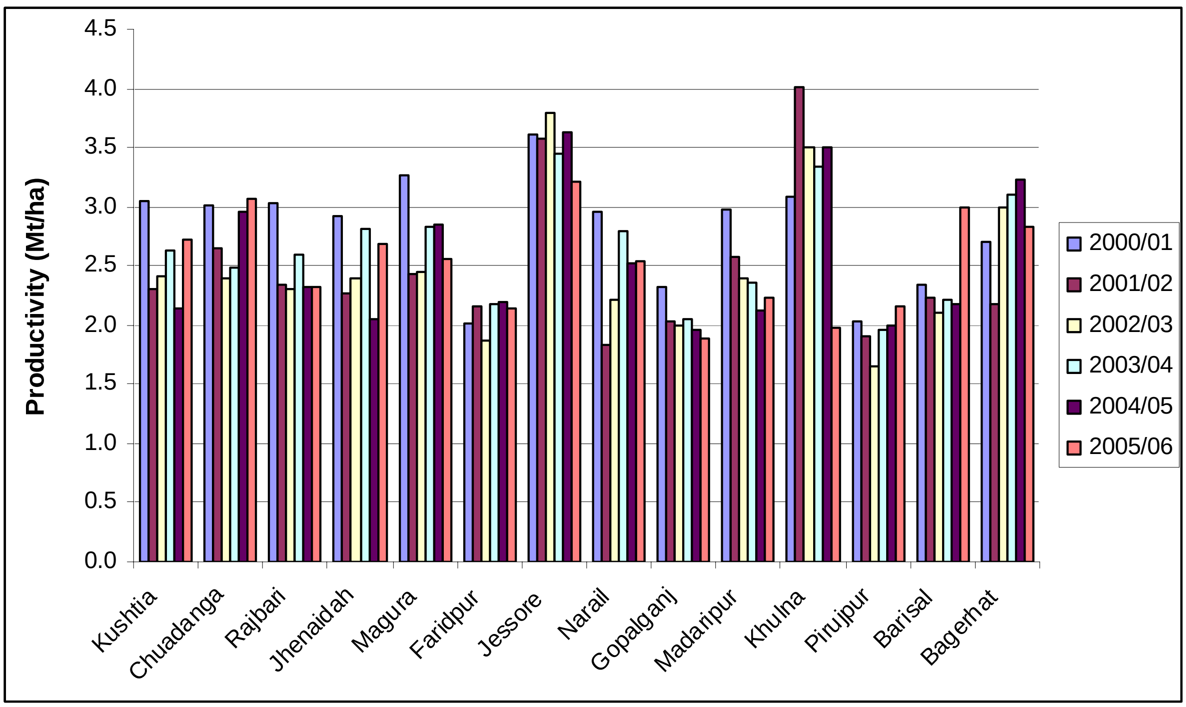


Figure 11: Temporal feature of average aquaculture productivity in GM sub-basin.

Culture of fish in ponds can be categorized into three subtypes: intensive, semi-intensive and extensive (low input). Water productivity of intensive fish culture is however not presented as their presence was rare (only some practiced in Bagerhat) and their standard deviation was high and not conclusive. It can be said that intensive culture is still in experimental phase and in true sense, there is no culture practice of intensive nature in general in this sub-basin. This is related to the institutional developments and the capital investment and the risk of environmental disaster that exists if the management is not optimal.

Table 12: Water productivity by weight and value of extensive and semi intensive fish culture systems in the case study area

District	N	System Type	Productivity ($Kg/1000m^3$)	Productivity ($tk/1000m^3$)
Chuadanga	14	Extensive	45 ± 23	3,715 ± 1,894
	116	Semi intensive	205 ± 104	16,083 ± 7,652
Narail	41	Extensive	53 ± 36	6,261 ± 4,086
	92	Semi intensive	138 ± 71	14,235 ± 12,009
Bagerhat	94	Extensive	32 ± 24	9,808 ± 6,611
	20	Semi-intensive	88 ± 53	15,895 ± 9,231

It is shown in Table 12 that the production of extensive fish culture systems was low for all districts compared to intensive or semi-intensive culture systems. In case of semi-intensive systems, production value of Chuadanga district reveals the highest among three districts. It was also found that when measuring productivity in monetary value, the patterns differ from those of productivity by weight. This is due to two reasons; the species cultured and/or the vigor of the marketing system.

Differences in aquaculture productivity by weight have several causes. Already mentioned are the well established private hatchery zone and seed dissemination system in Jessore that facilitates production, from which neighbouring districts also benefit. Research Institutions (e.g. BFRI), local government and NGOs are also well established which have yielded benefits to the farmers in knowledge diffusion and production capacity enhancement, spreading aquaculture activities on small as well as commercial scale.

Geographical aspects, such as soil quality and the water retention period differ across the districts and affects aquaculture productivity as well. Water availability is a major factor affecting the sub basin, and an example is found in th North-western part of the sub-basin (e.g. Kushtia) where its low productivity is mainly due to a shorter water availability period.

5.3.2. Shrimp farm productivity

Figure 12 presents exclusively the productivity values of shrimp and prawn ponds from 2001 to 2006. Values of shrimp and prawn byproducts (from finfish culture) are not considered in these estimates. The traditionally established shrimp farming regions of Bagerhat and Khulna have shown a steady and high productivity while there is no visible trend in the other areas of the sub basin. Their neighboring districts, especially Narail, Gopalganj and Jessore, have had an increase in productivity since 2002 that has remained steady. Narail had an exceptional increase in production which coincides with the implementation of a water management project; south west area integrated water resource management project (SWAIWRMP) which facilitates culture fisheries including shrimp farming within the small scale water resources project boundary whose previous objective was rice cultivation intensification.

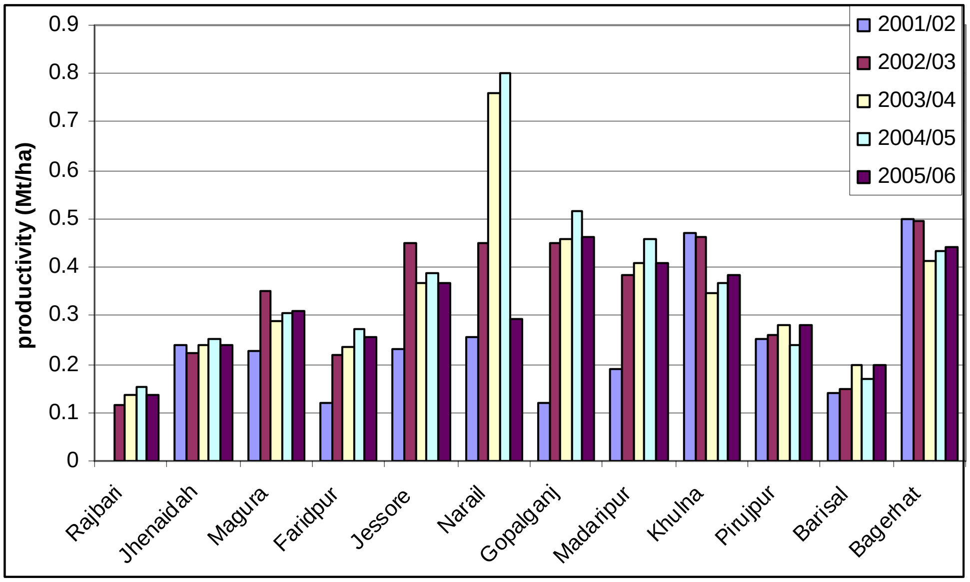


Figure 12: Temporal variation of shrimp/prawn productivity across the G-M sub basin

Shrimp farming was only found in two of the three districts studied - the two most downstream. This coincides with the temporal patterns discussed. Chuadanga situated upstream had intensive aquaculture but not shrimp aquaculture, and Bagerhat, on the coastal zone also had a nursery that was included in the case study.

Table 13: Water productivity by weight and value of shrimp culture in the case study area.

District	N	System Type	Productivity ($Kg/1000m^3$)	Productivity ($tk/1000m^3$)
Chuadanga	7	Intensive	323 ± 176	19,918 ± 13,967
	1	Shrimp (Bagda) Culture	68	34,136
Narail	38	Shrimp (Galda) Culture	41 ± 8	13,532 ± 10,601
	15	Shrimp (Bagda) Culture	22 ± 2.7	8,529 ± 6,072
	14	Shrimp (Galda) Culture	19 ± 3.3	15,168 ± 8,095
Bagerhat	1	Nursery	50.10	10,025

The district of Bagerhat in the coastal zone is a favourable area for shrimp culture with a higher salinity which is beneficial for shrimp farming. The district of Narail however, has a higher production by weight, and a larger number of samples studied due to higher availability. This practice is relatively newer in Narail than in Bagarhat and it is also significantly less profitable at Narail. Table 13 shows that roughly double production by weight in Narail give approximately the same profit in monetary terms. This can be a result of the adequate marketing system establishment of *galda* culture in Bagerhat and of the flaws in marketing dynamics suffered in newly developed shrimp culture in Narail.

5.3.3. IAA

From the case study, the most productive integrated system was found to be rice-fish systems (especially in Chuadanga), which reveals the highest output by weight and profit (Table 14).

Table 14: Water productivity by weight and value of rice-fish and IAA systems in the case study area.

District	N	System Type	Productivity ($Kg/1000m^3$)	Productivity ($tk/1000m^3$)
Chuadanga	11	Rice-Fish	297.00±216.00	20301.00±11325.00
Narail	1	IAA (Fish product)	92.00	6929.00
	7	Rice-Fish (Fish-product)	76.00±62.00	4988.00±2876.00
Bagerhat	16	IAA	54.00±49.00	12906.00±7684.00
	34	Rice-Fish	33.00±30.00	8066.00±710.00

However it is not a widespread culture system in the basin. This may be due to the risk faced as almost half of the systems where rice was cultivated together with fish were flooded - except in Chuadanga that falls in the upstream. Rice-fish systems of Chuadanga reveal exceptionally large value. Such variation in production is mainly due to composition of species produced. Farmers of Chuadanga have produced carp species whereas in Narail and Bagerhat, farmers have produced carp species with fresh water prawn (*golda*) that made a noticeable difference in achieving higher productive use of land and water and hence added value in the production.

IAA has been widely adopted downstream, however, only one case was found middle stream, and none upstream in Chuadanga, where rice-fish proves to be a very productive and profitable option for integrated systems.

5.3.4. Comparison between culture systems

Figure 13 shows a comparison between the systems studied through the field study. In terms of productivity by weight, the upstream district of Chuadanga has high productivity for semi intensive, intensive and rice-fish culture. These reflect in the profits gained by these systems, which are also considerably higher. However, the sample size must always be considered: Chuadanga semi-intensive (n=116), rice-fish (n=11) and intensive (n=7), as well as the already mentioned high standard deviation found for the small sample of intensive ponds. The productivity by weight obtained in Chuadanga is considerably higher in contrast to the other districts, but when compared in monetary terms (Figure 14), the profits from half the production by weight at Bagerhat gives about the same profit. This indicates a well established market system and cultivation of highly valuable species. In Bagerhat the profit from all systems is higher compared to other districts. This again corroborates the successful market dynamics comprised by the benefits from international market linkages, availability of fish processing plants and of input materials.

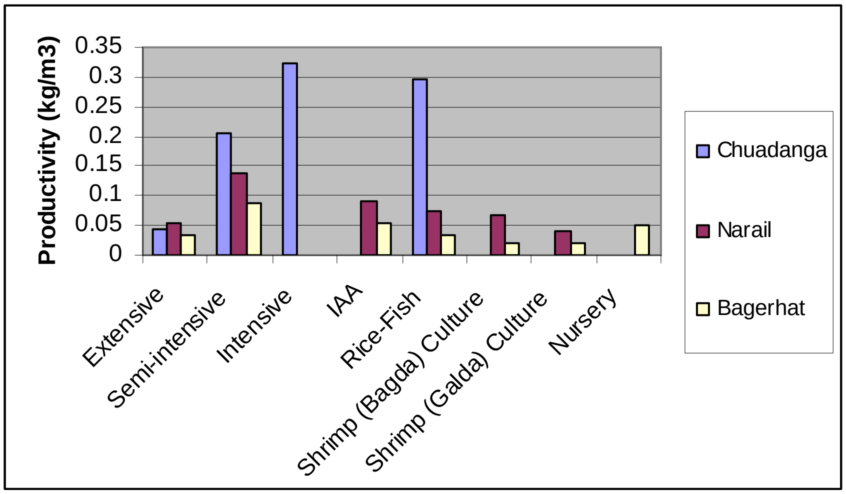


Figure 13: Productivity of the systems by district (measured in kg/m^3)

The monetary returns illustrated in Figure 14, show shrimp as the most valuable product. However this is restricted to higher investment and to downstream areas where the salinity of water is suitable for its growth. Rice-fish shows profitability upstream at Chuadanga. The case study looked exclusively at the fisheries water productivity, but it must be noted that integrated approaches such as Rice-Fish and IAA involve agricultural product too, which has not been included in these calculations, and therefore the results obtained only demonstrate part of its potential productivity.

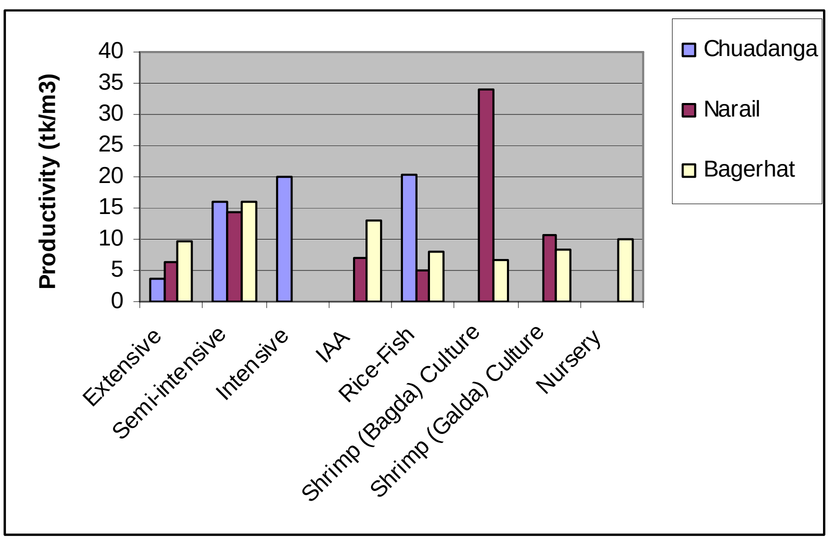


Figure 14: Productivity of the systems by district (measured in Tk/m^3)

5.4. Hot spots for fisheries systems in the G-M sub basin

The fish water productivity spatio-temporal variation analysis using DoF data for the fourteen districts in the sub basin have indicated four identifiable "hot spots" for capture and culture fisheries (Figure 15). Field data was collated to validate the information as there are some risks involved in making an analysis based on FRSS data alone. These are supported by the findings from our primary data analysis, where the exploratory study on Chuadanga, Narail and Bagerhat confirm these observations. The mentioned "hot spots" are described below:

- The North-Eastern part of the GM sub-basin is the hotspot for *beel* systems,
- The North-Western side is concentrated for *baor* (ox-bow lake) productivity,
- The South-Western side is specifically favorable for pond aquaculture and shrimp farming, and
- The coastal zone of the sub basin and its nearby districts has highest productivity for shrimp and prawn.

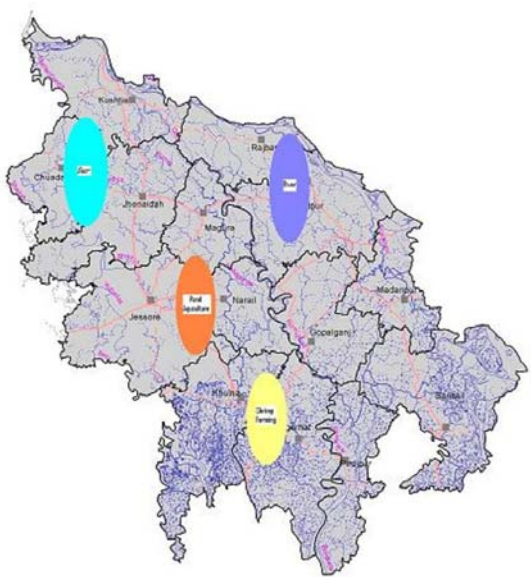


Figure 15: Productivity hotspots in the EGB.
Blue: *Baor* hotspot
Violet: River
Orange: pond aquaculture
Yellow: Shrimp farming

6. Constraints affecting the productivity of different systems

6.1. Threats to productivity

The factors listed here are those which cause the systems to be unproductive Fisheries productivity in the context of the EGB faces an array of hindrances as the surveys, FGDs and key informant interviews have shown. Below are some of the important factors, where in many cases the limitations are beyond the control of the land poor rural people.

Water resource development interventions

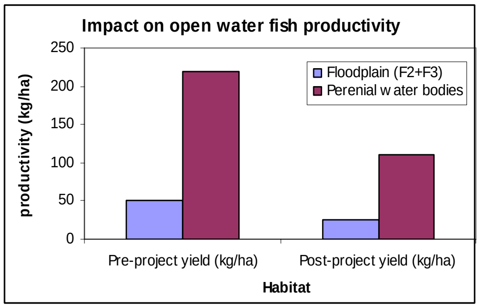
Based on secondary analysis, some projects were found to be detrimental to open water fisheries (e.g. SSWRDP). For example, flood control and drainage and/ or irrigation (FCD/I) interventions have caused a reduction of water area and volume (floodplain area reduced from 9.3 million ha to 2.8 million ha over four decades), hampered the migration and spawning of aquatic organisms, increased siltation of *beel* beds reducing and eliminating overwintering shelters. These project interventions have also caused delinking of the rivers and together with the draining *beels* for irrigation purposes, it caused changes in land type as well as wetland contamination through agro-chemicals and pesticide.

People however, perceive the issue differently. Respondents in Chuadanga faced difficulties in recalling about any water resource development intervention in the area. According to them most of the interventions were routine development activities and do not have any negative impact on natural water flow. This is considered by the professional judgment as an ignorance of the fishers who are also agricultural farmers. Also, the interventions of the water sector were in favour of growing paddy which is socially considered positive interventions. They tend to value fish as less important for annual food security.

Respondents of Bagerhat complained that water has become more saline than before. Tidal water splashes diurnally into the *beel* and other waterbodies in the coastal area which is important for the shrimp culture. However, this salinity is unfavorable for the production of many fish species. Furthermore, due to the low return from the saline water and disaster struck ponds, waterbodies have become stagnant and left unused. These are then transformed into unproductive water resources. Climate change and its effects on increased disaster severity (as already witnessed with *Sidr* and *Ayla*) will aggravate this matter.

Respondents of Narail complained that, construction of embankments is hampering natural water flow. They also accused the polders that have been built downstream of increasing tidal height. It has become 1-2 feet higher than before.

The dewatering of *beels* is also one of the water resource interventions. It can create vulnerable, disastrous and critical ecological conditions and rapid siltation can raise *beel* beds and alter and disrupt the connectivity of the beels with the rivers and floodplains. Effects of hese projects are seen in Figure 16 where the change in land type is unfavorable to fisheries productivity. The feeding and breeding habitat and migratory routes for small and large native species of fish are also disrupted and the conversion of land use from fisheries to agriculture also leads to intensification of agriculture practices (HYV) which are likely to increase the use of agrochemical and pesticides which are especially a threat to local fish stocks.



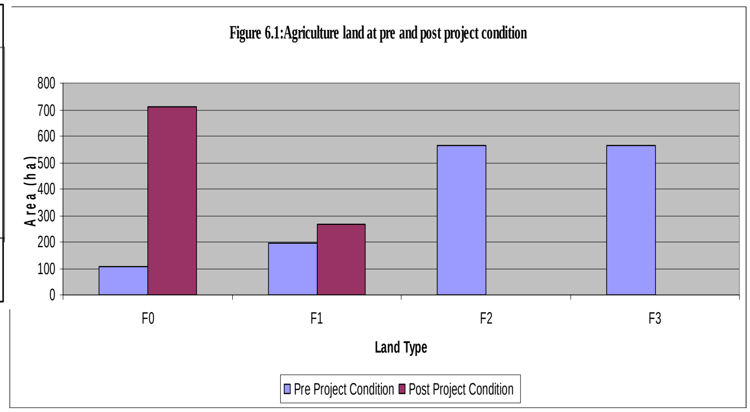


Figure 16: Land type changes due to agricultural land encroachment.

Climate and land use change

Drought has become severe over the decades and its frequency and duration has been increasing. Fishers of Narail district reported a drought that has prolonged from mid-March to mid-June. For the same site and for the same year farmers reported that drought has prolonged from the 2nd week of April to the 1st week of June. This may be due to irrigation of paddy fields that resulted in less water available for the fishers to catch fish.

In case of Bagerhat, fishers and fish farmer's responses agreed on length of drought and its severity. According to them, drought generally starts from Mid-February to Mid-April. But for the last year it has prolonged for one more month. Salinity in water is also increasing. It is observed mainly in Bagerhat and Narail. Being situated adjacent to the coast, inhabitants described salinity during dry season as intolerable.

According to CEGIS professionals, sea level is rising at the rate of 5mm/yr over the last 30 yrs. About 20 million people will be displaced by the next 20 -30 yrs. Salinity intrusion and flooding are major phenomena. The professional observations and perceptions suggest that in the near future the present economic activities may not remain suitable and the community will need to change the land-use practice. This needs to be estimated and projected and the adaptation measures need be thought of from now. Here brackish water fisheries and marine culture may offer opportunities for alternative measures for agro-economic activities for survival

Environmental Flow changes

Water flow in river measured in terms of water depth has been reduced during the last decades, due to various causes and the situation tends to become worse during the dry season. In case of Chuadanga, participants reported a minimum depth of water in most *beels* including *Raisar Beel*. This must have had detrimental effects on the life cycle of some aquatic species, particularly in the overwintering shelter of the spawning fish stock. These are supposed to undergo spawning migration in the pre-monsoon but the route of migration is obstructed resulting in lower spawning efficiency which leads to lower natural fisheries regeneration capacity and hence can lead to overfishing as the fish stock will be reduced and the fishers will be easily catching these from a smaller volume of water.

Access to water

Access to water resources was assessed on the basis of leasing method of open waterbodies. In addition to this, the effectiveness of the methods was also assessed. Participants reported that they are well aware of prevailing leasing method of open water in the area. According to them, it was practiced to lease out the open water to the poor fishers through project based initiatives. But recently this method is not followed by the responsible department. Figure 17 shows the leasing entitlement of the fishers where it is visible that poor fisher don't have leasing right to open waters. The recent revision of the waterbody leasing policy has added another dimension to the effect that the law makers of the respective constituencies would advice on the fishers' groups to get the leasing right that is viewed as opening a window for restricted access of the real fishers in the waterbodies. This needs to be reviewed and made pro-poor. Water sector was reported to be the most prone to corruption (TIB 2008) having water resources under elite capture.

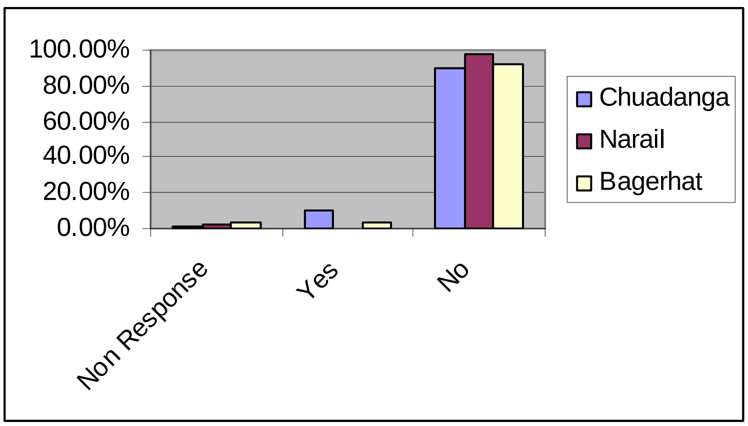


Figure 17: Leasing rights of the fishers in different parts of the basin

Another problem is that currently some influential people in the localities have enlisted themselves as fishers though they are not actually fisher by profession. As a matter of fact, with this fraudulent activity supported by their illegal influence, they have been managing to grab the entitlement of leasing rights. In some cases, responsible fishery officers are supposedly also involved with such activities. Fishers of Bagerhat district have cited an example: A 1 km long canal that was created from an embankment along *badokhali beel* where carp fires and eggs had been hatching, was taken over by district fisheries officer for providing access to the adjacent openwater to real fishers but some elites grabbed the leasing right and restricted the poor fishers from fishing. They are the ultimate losers.

It is interesting that; despite scarcity of water and obvious constraints and problems faced by the poor fishers, dwellers have reported that they didn't engage in any type of conflict. This may happen due to their social bondage or their powerlessness to be part of any conflict. This contradicts with data shown on Figure 19 where it is shown that concerned fishers have complained to the pertinent department but failed almost all the time. Figure 18 shows that local influential people, lease holders and fishers of adjacent villages cause the greatest difficulties.

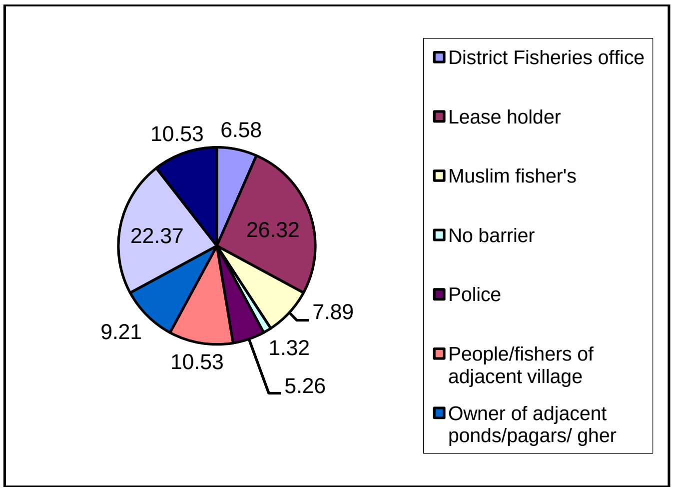


Figure 18: Barriers imposed by different actors (%)

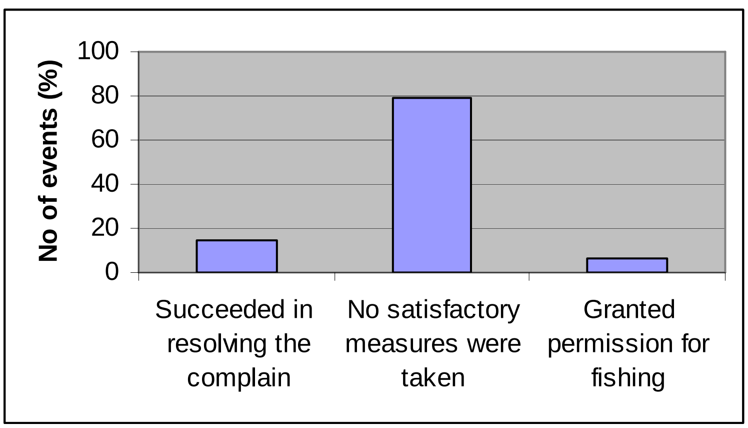


Figure 19: Status of complain resolution

When further asked to identify the reasons for any restrictions suffered, most answers were related to the lease owner putting restriction on fishing in the waterbody which is after all his legal right. Other reasons behind the restrictions suffered are reflected in Figure 20.

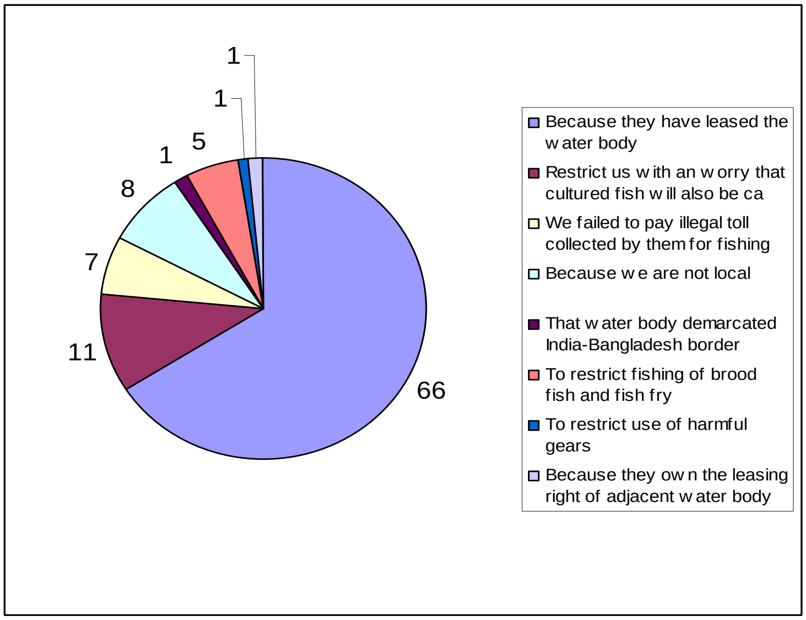


Figure 20: Causes of restriction of use of waterbodies

6.2. Causes for water productivity variations and future constraints

Fisheries productivity was analyzed in 14 districts of *Gorai-Madhumati* sub-basin in Bangladesh. *Beel* and *Baor* productivity were compared within the habitat and between habitats. Similar differences were noticed in the case of aquaculture productivity as well. These differences are attributed to hydrological aspects such as proximity to Padma river, salinity, soil water retention, pollution, water diversion, delinkage, siltation and institutional aspects such as access, ownership, policies, extension services and past project interventions.

If we compare the productivity values of the systems, in general, with the basin location, it can be found that, productivity values for Chuadanga district is higher than that of Narail and Bagerhat. To explore the issue, the status of occurrence of disaster in the area was assessed. In 2008 almost half of the systems of Narail and two thirds of the systems of Bagerhat were affected by different kinds of disaster. Storm surge associated with devastating cyclone Sidr has caused the system to be overtopped. As a result most of the stocked fishes escaped.

Respondents were asked about the causes that make them decide to go for fish culture rather than other uses. Most of them (around 50%) explained fish culture is more profitable than other types of land use. A substantial percentage of respondents reported that fish culture is easier to administer, besides they have inherited the tradition from their ancestors. Results are summarized in Figure 21.

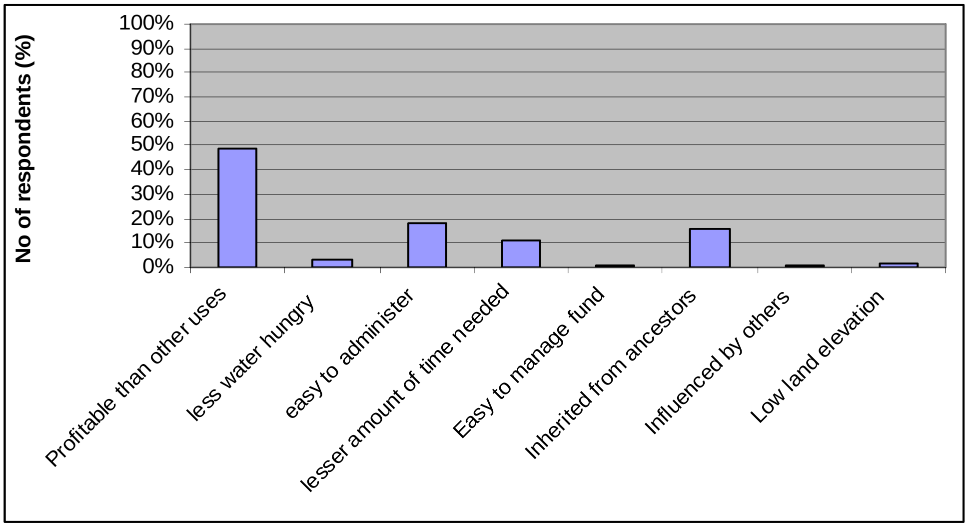


Figure 21: Reasons why farmers chose fish culture over other land use

Table 15 summarizes the main factors affecting production of fish culture according to respondents from the case study. The farmers consider the main factors affecting the production to be scarcity of water, suitability of the pond (i.e. area and cleanliness), quality of the fingerlings, proneness of fish to disease, and the high fish feed price and lack of training. Downstream, issues on temperature and salinity increase were also raised.

Table 15: Barriers of fish culture

Name of the district	Barriers of fish culture
Chuadanga	- Scarcity of water
Narail	-High price of fish meal - Scarcity of quality fingerlings - Disease proneness - Lack of training
Bagerhat	- Increase in salinity - Increase in temperature

6.2.1. Constraints for capture fisheries

Constraints for capture fisheries systems throughout the GM sub basin have been identified through extensive farm & field visits, focus group discussion, and professional & expert judgment.

Starting with the physical barriers, the transformations of land type have decreased the availability of water and hence the productivity of waterbodies. Examples of these land type transformations are the agricultural intensification programs where rice production is enhanced, and the flood protection embankments which cause connectivity loss, affecting the migration routes of fish, spawning, etc. These programs do not assess their impact on fisheries appropriately and also are the root for environmental degradation. Industrial waste disposal and agro-chemical pollution of water is another factor impoverishing the quality of the water and reducing productivity. Another physical barrier is the unsuitable infrastructure of the area and lack of transportation facilities. These pose a serious hindrance to the marketing dynamics. Market chains also present obstacles. The interference of middlemen and the lack of knowledge on market prices restrict the gains of the fishers.

Management practices are not adequately applied or inexistent. There is a lack of adoption of good practices and sustainable management measures at large and illegal and destructive fishing and overfishing in non-leased areas of openwater system - particularly in the rivers, tributaries and floodplains – reduce the availability of produce and the sustainability of fisheries. This lack of management, coupled with lack of coordination and insufficient capital, pose constraints to the optimal potential productivity. However, it has been seen that those who are under Community Based Organization (CBO) networks have been able to sustain benefits. An adequate management of the open water fisheries has been constrained by the presence of influential parties who intercept the management cycle and the potential gains of fishermen, who are at the same time virtually hijacked

During the field observations with local institutions, a deficiency of skilled manpower and professionals in the extension service agencies was witnessed. There was not enough labor force from the institutions dealing with fisheries issues which weakens the support fishers receive. Lacking that support means lacking conflict resolution support too, therefore conflicts for property rights for land and water that arise in floodplain areas that are divided into private and public water are not resolved adequately, and pose threat to productivity as well.

Present leasing systems of waterbodies lead to a tragedy of the commons, indirectly encouraging the exploitation of resources leading to destructive fishing methods, dewatering of waterbodies and other environmentally threatening fishing practices. The effect of such leasing system has been noticed and the new draft of Wetland Policy, 2009 of Bangladesh addresses this matter, although it has not yet been formalized. However, there is still a lack of policy regarding sustainable environmentally friendly and pro-poor fish culture management.

6.2.2. Constraints for closed and semi-closed culture fishery

Similarly, constrains for semi-closed and closed culture fishery were identified. The marketing system flaws, unsuitable infrastructure and transportation facilities affect culture fisheries as they do capture fisheries. In this case, there are also technological constraints. There is a lack in practice of environmentally friendly and sustainable technologies for fish stock conservation which is not addressed in the national policies and also a lack of availability of quality seed, feed product, fertilizers and other fish culture materials.

With respect to institutional constraints, culture fisheries suffer many hindrances at different levels. The inheritance of ponds cause multi ownership of waterbodies, and this leads to conflicts between owners. This impedes the optimization of production of that culture system. Institutional support through credit and financial assistance is insufficient; hence those not economically solvent face a strict limitation. Again, leasing systems are an issue, as government ponds do not offer equal opportunities for fishermen. Mortgage requirements for leasing go against poorest fishers who do not own property and there is scope for elites to capture the benefits. At the local level, there is the already mentioned deficiency of skilled manpower. This causes insufficiency in extension services through support and through training, which is essential for the enhancement of productivity, but which is lacking at many locations.

6.2.3. Constraints for shrimp farming and coastal aquaculture

Some of the constraints suffered by shrimp farming are similar to capture and culture fisheries. Its productivity is also affected by the insufficient capital, the lack of coordination and management instruments among the fishers, the unsuitable infrastructure and transportation facilities, and the weak market linkages. However, shrimp farming also faces other limitations due to its characteristics of coastal aquaculture.

Shrimp farming will be more productive with saline water but agricultural crops are hampered by salinity. There is a lack of proper land zoning –although policy for it is being drafted - and in some cases shrimp farmers will take advantage of this black hole to settle their saline ponds in their area of choice. This creates great conflicts between shrimp farmers and rice farmers, because the salinity of the shrimp ponds intrudes into the agricultural land, hampering rice production. This issue has not been tackled in the policy and hence will remain conflictive. The poorest farmers are unsupported and the conflicts will be solved through social power.

6.2.4. Constraints for IAA and rice-fish

Even though integrated agriculture aquaculture (IAA) and rice-fish systems contribute to a more efficient use of water by producing agricultural and fisheries products, their limitations are several, which have been identified through household survey, farm visit and expert judgment. Only one case of IAA as found throughout the case study in middlestream (Narail). All integrated systems were rice-fish.

As for other aquaculture and open water systems, water quality and use of pesticides are again an issue, as well as the market system establishment and the difficulties in transportation which hinder the survival of the seed stock. A good understanding of these technologies is necessary for an adequate water management given that appropriate levels of water must be maintained for the systems simultaneously managed. In the case of rice fish, for example, another constraint is the potential reduction of rice yield. One of the benefits and potentials of rice fish systems is the increased rice yield compared to a rice-only system. However, a lack of knowledge and training may lead to an early stocking of large fingerlings before the rice is well established, which can cause a decrease in rice yield.

7. Institutional Dynamics of Fishery in the GM sub-basin

Institutional arrangements also play an important role on productivity. Exceptionally high productivity in aquaculture is linked principally with the institutional developments, whereby there is a huge presence of GO and NGO institutions in that area. Strong institutional arrangements also involve a well established seed dissemination system and hatchery, where fish seeds are easily and cheaply available. This creates a buffer area. A good example of this is the district of Jessore. Also, Faridpur has high proportion of productivity in *baor* as well as *beel* fisheries, which may be seen as an institutional issue to the effect that DoF has an extensive donor assisted effort in the area over the last decade. On the other hand, a weak institutional set up may lead to lower productivity. This is the case in most of the areas, with few exceptions, as low productivity is mostly due to the existence of multiple ownership or ownership conflicts.

The institutional dynamism can be segregated broadly under 3 categories i.e.

(i) Public Initiations e.g. DoF, Bangladesh Fisheries Research Institute (BFRI), Bangladesh Fish Development Corporation (BFDC), Department of Agricultural Extension (DAE), Public bank etc.

(ii) Private institutions including NGOs e.g. Private hatchery, nursery, farm, processing plant, credit facilitate NGOs etc.

(iii) Community level/Local Institutions e.g. Water Management Cooperative Association (WMCA), Community Based Organizations (CBO), Resource management Organization (RMO), different associations etc.

These institutions can follow several frameworks with a range of activities for fisheries and aquaculture development. These could be segregated also into three categories:

(i) Research and Technology Innovations
- Developing technologies, carrying out feasibility studies, producing manuals for culture technique or management aspects, etc.

(ii) Technology transfer and adoption
- Training on culture techniques and better management practices, consultation for the improvement of technology dissemination, initialize the commercialization of proven technologies, e.g. shrimp farming systems, etc.

(iii) Technology Impact assessment
- Impact of technologies on bio-physical environment socio-economic aspects, etc.

In Bangladesh, the premier institution for fisheries technology development is ‘Bangladesh Fisheries Research Institute (BFRI)’. This institute has pioneered and developed many technologies in the field of fish breeding and seed production, fish culture (mono and poly-culture, pen culture, cage culture, shrimp culture crop rotation of shrimp and fish culture), Integrated farming (IAA, chicken-fish, duck-fish, rice-fish), management and policy formulation and biotechnology. On the other hand DoF's strength has mainly focused on extension services, farming practices, hatchery operations and conservation through Districts and Upazila Fisheries offices. Bangladesh Fisheries Development Corporation (BFDC) is engaged with marketing and fisheries development function.

From primary data collected with different tools it was found that people approached different agencies for different reasons. These are shown in Figure 22 where there is a representation of the number of people approaching different service delivery agencies. It is found that, among the agencies, people went to Upazila parishad most, but circumstantially, as almost half went to have relief materials after SIDR. Among other agencies only around 10% people went to Fisheries and Agricultural office for different purposes.

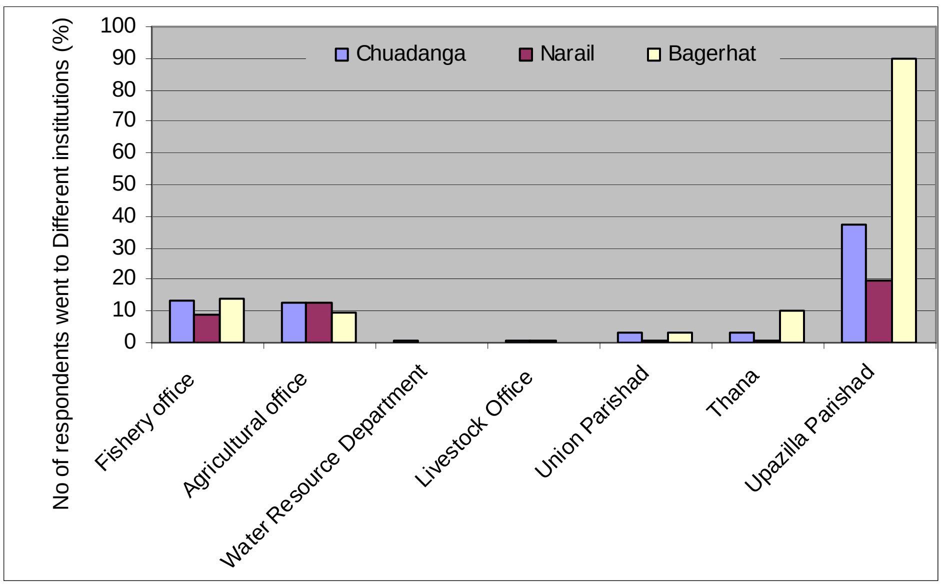


Figure 22: Percentage of respondents that visited different institutions

Participants identified the institutions from where they receive services. They have rated the institutions based on the range and effectiveness of the services received on a scale of 1-5, where 5 means active and 1 denotes to extremely poor. FGD results are shown below (Table 16)

Table 16: Efficiency of the institutions based on participants response

Name of the institutions	Chuadanga		Narail		Bagerhat	
	Fisher	Fish-Farmers	Fisher	Fish-Farmers	Fisher	Fish-Farmers
Fishery Office	Moderate	Moderate-Active	Fair	Active	Active	Active
Agricultural Office	Moderate	Moderate-Active	Fair	Moderate	Active	Active
Upazila Parishad	Moderate	Moderate-Active	-	-	-	-
Thana	Fair	Moderate	-	-	Moderate	Moderate
Union Parishad	Active	Active	Fair	Moderate	Active	Active

NGO	-	-	-	-	Active	Active
Water Development Board	Extremely poor	Extremely poor	-	-	Active	Active
Other Projects	Moderate	-	-	-	-	-
Other private organization	-	-	-	Active	-	-

People approached fisheries office for different purposes e.g. training, fertilizer, conflict resolution, etc. that also represents the services delivered by the institution from the perspective of receivers. The two major services were to receive training (45% of respondents) and 30% went for technical suggestion for aquaculture. However, the institutions visited should have scope for service improvement, as Figure 23 shows that respondents were significantly dissatisfied with problem resolution.

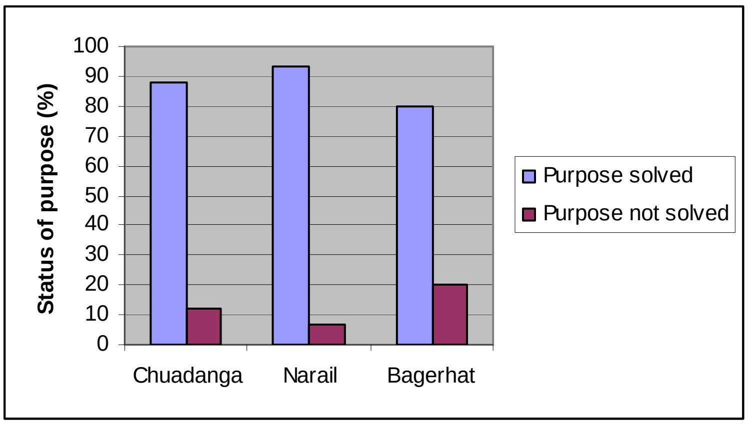


Figure 23: Status of fulfillments with institutions

For accessing credit e.g. sources, collateral, etc. most of the respondents approached NGOs for credit. They also use bank credits, and *mohajon* (moneylender) credit. These are characterized by higher interest rates.

Respondents reported various constraints to access institutional loan. With respect to NGO credit disbursement, the interest rates are high and there is at times requirements to provide a deposit in the form of assets to the credit institution which in the case of poor farmers is not possible, and therefore they miss their access to credit. The limitations faced by farmers with public financial institutions (i.e. banks) are the demand of an additional and unrecorded amount of money for the disbursement of the loan requested. The lack of timeliness also results in a constraint, as the money required by for example, fish farmers, will be essential for a specific time when stock must begin.

8. Intervention analysis

8.1. Lessons learnt from interventions of previous projects

To search the options for future improvement, the study tried to identify the implemented and ongoing activities throughout the sub-basin. This has been done through studying project interventions across the sub basin and learning from their successes, problems and limitations, for future scalability. The study considered the major projects under implementation in the sub-basin as well as already completed projects regarding fisheries, agriculture and water resources in the study area.

The analyses identified two possible future courses of action which could involve adopting the identified beneficial interventions for under-managed areas, and follow on by scaling up these interventions to presently under-managed production systems.

Community Based Fisheries Management (CBFM), 2002-2006:
The primary purpose was to improve the livelihoods of the poor fishers through their participation in fisheries management and for ensuring equitable distribution of benefits and acquire sustainable fisheries resources and more particularly to reestablish the lost ownership. The management system had a community participation approach through the formation of CBOs (Community based organizations) and the interventions used were establishment of fish sanctuary and where necessary undertaking habitat restoration and introduce closed seasons, control and removal of destructive fishing gears and stocking of native indigenous carps.
These interventions were proved to be very much potential in increasing fish abundance, biodiversity and fisheries yields through augmentation of the renewable capacity of the fish stocks.

Fourth Fisheries Project (FFP), December 1999 – June 2006:
Another public sector (DoF implemented) project following up on CBFM, replicated the approach and also added a new dimension by including culture fisheries. Technology dissemination and training was provided to fish farmers in order to reach to a broader public. LEAF (local extension agent for fisheries) approach of the FFP was a good lesson that helped decentralized extension services at a very effective but low cost.

Habitat restoration and fish sanctuary development through community participation has proven to be a very effective measure for enhancing ecosystem productivity and regeneration of fish stocks that provides two to three fold benefits in terms of fish production for the real fishers as well as delivering additional subsistence fishing opportunities for the general villagers including agricultural farmers for their additional income from fishing for sustainable livelihoods.

Management of Aquatic Resources through Community Husbandry (MACH) project - 1998-2008.

MACH project was implemented by the DoF with support from USAID which have demonstrated that establishment of fish sanctuary with community participation and habitat restoration generates multifold fisheries production that reaches to the commons in addition to the fishers. This project, although not implemented in the GM sub-basin area, has demonstrated that providing and community based operating of endowment fund helps the CBOs to sustain and continues to follow the good practices in fisheries management including the maintenance of the fish sanctuaries. Thus the agricultural farmers are also getting additional income from fishing. This project captured the concept of wetland and all living resources therein including the water edible plants and overall biodiversity enhancement. It was proved to be also effective to restore the ecosystems that also provide easy access to the water plats as food for the poor.

Recommendation Domain Project: Development and status of freshwater aquaculture in Bangladesh, December 1999 – June 2006:

This project assessed the suitability of areas in Bangladesh for aquaculture considering factors like water availability, soil type, market mechanisms and other inputs with geographical differences. The output of this project was a suitability map for aquaculture considering different variables and developed a software package; SAQUA which serves as a decision tool for aquaculture initiatives.

Study on Impact of Sanctuary on Fish Production and Biodiversity:, 2006-2007:

This study's purpose was to evaluate the performance of different types of sanctuaries (permanent, seasonal, closure) under different development projects and assess their problem and constrains through two main indicators: productivity and biodiversity. Most of the sanctuaries performed very well, especially the permanent types with regards to both indicators. Failure was rare, but the few cases were not due to the sanctuaries' physical establishment but due to the conflicts within the managing body e.g. CBOs, and with external influential people.

Development Intervention on Wetlands, Its Resources and Livelihoods of People, 2006:

This study, carried out in only two *beels* within the GM sub basin, assesses the impact of water related development interventions on wetlands resources (flora, fauna and ecological resources) and livelihoods as well as learning about wetland resource management from indigenous knowledge. This learning refers to the need for awareness of the local community of the need for ecosystem management which they can easily adapt in day to day practices for increased biodiversity and hence enhanced livelihoods.

Gorai-River Restoration Project (GRRP), 1998 – 2001:

This project helped restore the *Gorai*-River to ensure fresh water flow in the wet season and augment this flow during the dry season. The broad interventional approach was focused on dredging during the 3 successive years for a set number of months as well as doing an environmental monitoring program for a year round impact analysis. The potential impacts were increased water flow and water level that facilitates fish migration and movement and the restoration of the freshwater species habitat by protecting these from salinity intrusion through increasing freshwater flow.

South West Area Integrated Water Resources Management Plan (SWAIWRMP) 2004-05:
The purpose of this broad planning project was to ensure the implementation of IWRM (Integrated Water Resource Management) in every sector, i.e. agricultural, fisheries, environmental, riparian vegetation, etc. for the whole of the south western region. It has attempted to demonstrate the benefits of IWRM in all the natural resources sectors.

Small Scale Water Resources Development Sector Projects (SSWRDSP) 1998-ongoing:
This project was set up to increase sustainable income in agricultural production and income of small farm holders through agricultural intensification, more specifically, rice through claiming more land from wetlands. The impact of this project, before the establishment of WAIWRMP was an increase in rice yields but was detrimental to open water fisheries and environmental preservation.

8.2 Potential Opportunities

Opportunities are those factors that have the potential to promote the improvement of fisheries productivity but that have not yet been grabbed and acted upon. From the results obtained from the case study, the secondary information, and especially the thorough field studies, group discussions and expert judgments, opportunities for improving the fisheries-water productivity in the Gorai-Madhumati Basin have been identified and classified into the following categories, i.e. capture fisheries, semi closed and closed culture, shrimp culture, coastal aquaculture and integrated systems such as rife fish

8.2.1. Opportunities for capture fisheries

The results from the field showed that the water availability period in middle and downstream are longer than upstream, which infers that upstream would be benefited from higher water availability. Institutional opportunities involve the segregation of judiciary and executive bodies of government which has facilitated the more direct supervision of fishery related laws and legislation, hence encouraging greater support to fishers. Similarly, the new "*Jalmohal* (wetland) policy 2009" if approved will have a pro-poor focus considering the reforms on leasing systems and access to open water resources, giving high priority to capture fishers. However, even though there are additional clauses empowering fisher groups, they still do not possess the power or support to implement this new policy. This policy needs to be reviewed, according to some experts (Workshop recommendations on Good practices in fisheries management DoF, 2009).

8.2.2. Opportunities for semi-closed and closed culture fisheries

When considering semi-closed and closed culture fisheries systems a physical opportunity arises from the fact that almost every household unit has a pond in middle stream. This is great productivity potential if these are used purposely. From the field visits, two other opportunities were identified related to institutions. Educated youth are engaging with aquaculture due to a change in mentality and view of the system and young professional fisheries officers are willing to take challenges and get involved in future improvements if they are given the possibility, although unfortunately it is not always facilitated by the system.

8.2.3. Opportunities for shrimp farming and coastal aquaculture

There exists an opportunity to attempt resolving the conflict described in section 6.2.3 on land zoning as the Integrated Coastal Zone Management Plan (ICZMP) has drafted the coastal land zoning policy, which will facilitate the proper zoning system in coastal region. ICZMP may allocate specific zones for shrimp culture and others for rice cultivation with respect to area suitability. Shrimp policy has also been drafted which may is expected to open new opportunities for pro-poor shrimp fisheries as well as pro-poor shrimp culture. Technological opportunities for mariculture are also present in the coastal areas where shrimp culture exists, such as seaweed and mussel culture. Adoption of other technologies involving shrimp culture could be integrated shrimp farming and rice-fish culture which can pose novel opportunities in the area of shrimp culture and coastal aquaculture.

8.2.4. Opportunities for and rice-fish

Integrated systems such as rice fish have an efficient use of water as agricultural and fisheries products are derived from the same water allocation. Also, given the right timing and adequate management, rice yields of rice-fish can be higher than rice-only systems and have the potential to conserve water; a valuable attribute during water scarce times. Other opportunities facilitating their adoption are the low risk it poses in comparison to other systems by not being too costly and not requiring loan support, and the little time involvement it requires, which permits the famer to undertake other income generating activities or improve on existing ones.

8.2.5. Potential strategies identified

The potential plans to mitigate the negative impacts that inland capture fisheries have on the environment and vice versa are presented below.

- Encourage advocacy and lobbying by influential institutions and NGOs for the conservation and protection of the resource to ensure awareness and compliance with policies.
- Develop systems to improve the quality and quantity of information on national wetland ecosystems which will enable the improved planning and management of wetlands.
- Develop an inventory of key fisheries and conservation areas detailing their extent and quality and support the conservation of these critical habitats, especially dry season

wetlands, through the declaration of national sanctuaries or areas of critical ecological importance.

- Enhance collaboration between national and international institutions for the implementation of relevant treaties and conventions.
- DoF and relevant agencies and institutions should provide guidelines and information support to the Department of the Environment to ensure that regulations against pollution of water bodies from different sources including the agricultural fertilizers and pesticides are fully enforced through field based technical support.
- Improve local institutional capacity in wetland and ecosystem management and take-up action plan for consolidation and institutionalization of the CBOs; in particular provide support to develop national CBO network.
- Develop ecosystem approaches to conserve the integrity of wetlands and prevent loss of habitat through loss of dry season water and sedimentation
- Ensure local regulations and good practices to support the conservation of wetlands by the community; develop mass scale awareness for natural resource conservation including the school programs.
- Ensure people's participation in the management of the ecosystem and the natural resources and continuation of the rights on the wetlands with good linkages with the line agencies e.g. DoF and the local administration and the local government (LG) bodies.

8.3. Scope for Improvement of fisheries water productivity

From the information collated from the variety of sources used, there is visible scope for the improvement of fisheries water productivity in the EGB. These are summarized below. The newly evolved culture systems of IAA and Rice-Fish could enhance the Fisheries-WP in the EGB.

- For intensified pond culture and shrimp farming, the use of quality seeds was identified as a key aspect for optimizing productivity.
- Decentralized fish seed production and marketing system was identified as a good tool for utilizing the aquaculture potential given the water access and availability
- Culture cycle rotation, especially Rice-Fish cultivation, is a potential future intervention. In the case of rice fish, depending on availability of land and water there could be alternate rice and fish, and at times simultaneous culture. For shrimp production, it would involve cycles of shrimp growth alternating following cycles with the growth of other fish species.
- Rice fish offers the possibility of water storage in trenches for supplementary irrigation at critical cultivation points for rain fed rice.
- Community based resource management, community based *beel* and *baor* management, habitat restoration, natural stocking for recruitment and sanctuary establishment are all potential management practices for ensuring and improving capture fisheries productivity.

- Quality fish-seed, nursing and seed decentralization farming technology and improved marketing dynamics can ensure and improve water productivity of pond aquaculture
- Cage culture, seaweed and mussel culture in the coastal region pose an opportunity for improving coastal water productivity.
- Technologies for IAA such as rice-fish and duck-chicken-fish would be improved and strengthened with the development of extension services related to these culture practices.

9. Potential interventions for improving productivity

Barriers and opportunity for culture and capture fisheries vary along the basin and intervention should be system specific; different for culture and capture fisheries. For technologies, such as IAA and Rice-Fish that have been innovated by advanced institutions (WorldFish, BFRI for example) and introduced recently by the relevant extension institutions and NGOs with support from the concerned authorities, intervention should focus on extension services, applicability and up take of the technologies. The proposed interventions are grouped under three categories – physical, technological and institutional interventions – for culture fisheries, capture fisheries and IAA. In the farm based technology extension initiatives the LEAF concept developed under the Fourth Fisheries project (FFP – DoF) may be considered as a good extension tool to reach the poor farmers at the grassroots level; particularly to those areas and to those communities who live in remote areas where GO as well as NGO services are very hard to reach.

Descriptions for culture and capture fisheries interventions are provided in this section, and matrices (matrix 1 to 3) for the interventions suggested for capture, aquaculture and integrated summarize the interventions identified for capture, culture and integrated systems.

9.1. Interventions for Capture Fisheries

With an aim of restoring fish diversity and production in open water bodies Government has been enforcing some laws e.g. Fish ban in certain period of the year (closed season during breeding period), restriction on using harmful fishing gears, restriction on fishing with fine meshed nets to protect fish under certain size, restriction on fishing by dewatering, etc.. Enforcement of such laws and regulation without alternative livelihoods (AIGAs) may affect livelihoods of fisher. In case of non-availability of AIGAs and in case the matter needs urgent attention the fishers may be compensated by the government. Most of the fishers of Chuadanga and Bagerhat agreed to have compensation measures (Figure 24) at the varying payment levels shown in Figure 25.

Apart from this, participants of FGD emphasized on leasing out the water bodies by focused project and NGO. They have appreciation for the leasing out methods practiced by the CBFM-2 and the FFP projects. They are also aware about short leasing period and the consequent lower outputs. According to them leasing period should be increased to a minimum of 5 years. This has the reference of the waterbodies leased out to private leaseholders or to the youth groups without the community based fisheries management (CBFM) concept and program support. The waterbodies transferred by the land ministry to CBOs through DoF has longer and renewable lease period with certain conditions. These conditions encourage the beneficiaries to maintain and manage the waterbodies efficiently and effectively that ensures higher yield in fish production from the managed waterbodies compared to the unmanaged or under-managed ones. Here one of conditions is that the *beels* or cross section of the tributaries can never be dried out, rather than maintaining a minimum level of water.

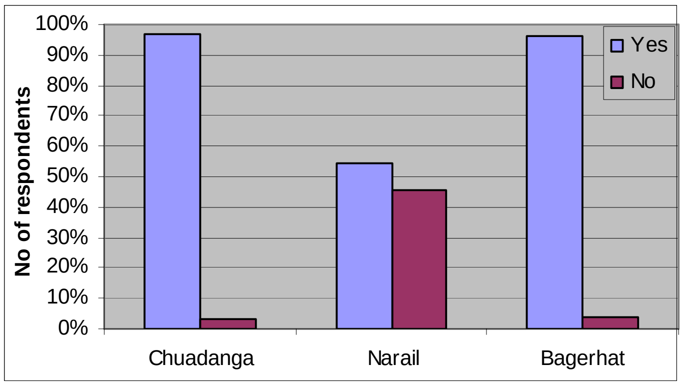


Figure 24: Agreement regarding fishing ban

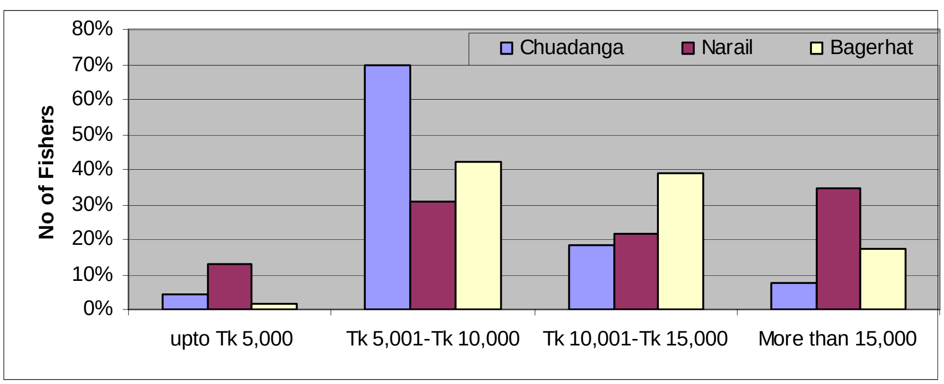


Figure 25: Minimum amount (BDT) demanded by the fisher to stop fishing

Their disagreement with the fishing ban was mainly caused due to mistrust among fishers on authority, and lack of knowledge on financial benefits that may derive from conservation (Figure 26). On the other hand the fisher has no alternative for livelihoods where the conservation call is bound to fail. Conservation financing mechanism needs to be developed in order to uphold the community to exercise good practices. So AIGAs or subsidy support for the ban (closed fishing) period has to be identified and introduced. Expansion of the CBFM approach of management would be the ideal one that encompasses the sense of ownership and responsibility of the fishers as well as other beneficiary groups to exercise all good practices such as refrain from using destructive fishing gears and methods, obey closed season establish and maintain sanctuaries and where necessary undertake community based habitat restoration programs e.g. excavation or re-excavation of canals to connect *beels* with rivers/floodplains and facilitate spawning and overwintering migration of fish.

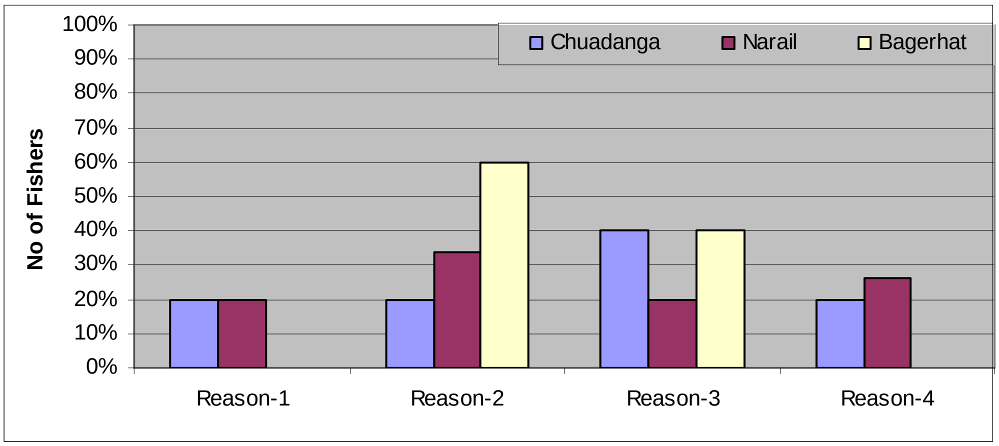


Figure 26: Reasons of non-agreement with fishing ban

I am opposed to such economic approaches = Reason-1
I do not trust the payment authority = Reason-2
I do not know how much money to ask = Reason-3
I do not believe about sufficient reimbursement = Reason-4

Fishers were asked about their interest to attend in a hypothetical discussion regarding water management that might be beneficial for them. In each district they are highly interested to join such discussion as shown in Figure 27 that clearly reveals their awareness about rights and self-respect. They seemed to be aware of the harmful effect of agro-chemical pesticides but they have no alternatives in hand to stop this. In this case the IPM (integrated pest management) method needs to be addressed as it has proven to be effective but does not have adequate technological extension. Department of Fisheries (DoF) and the Department of Environment (DoE) can lead on it while the agriculture extension department (DAE) may not take extra hurdle to do this.

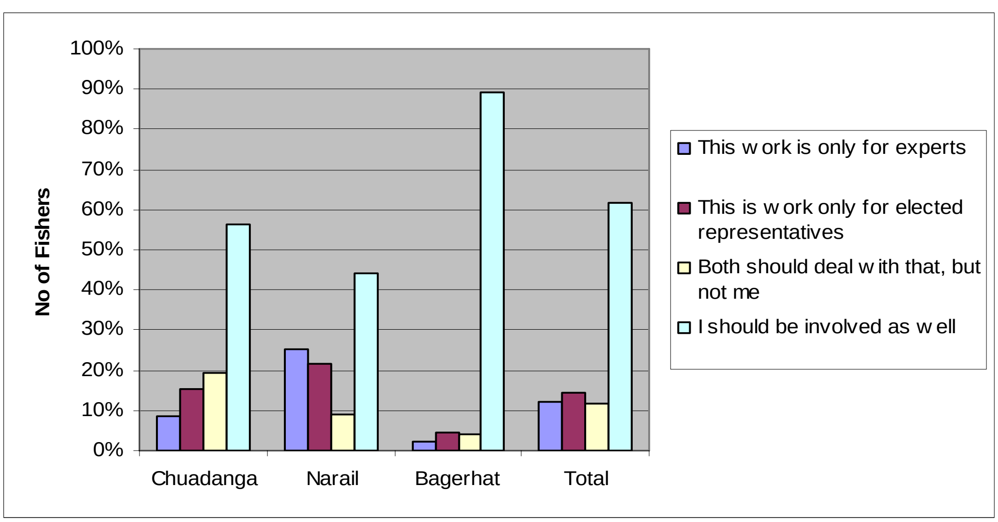


Figure 27: Affected fisher's interest to participate in discussion regarding water management

Participants were asked for physical and technological interventions and in case of capture fishery, very negligible variation is observed among different districts. Interventions proposed by fishers of different districts were concerned with the need of governmental implication in order to stop excess use of pesticides in agricultural field, and the use of harmful gears and illegal methods. Improvement of water availability should be ensured by effective management of sluice gate and new technologies could be introduced for jute retting as traditional method causes water to pollute.

Water sector intervention for habitat restoration may be an option at costly level, but pro-poor restoration work including the establishment of sanctuaries that have high potential impact need to be carefully developed and introduced as has been done in over 500 waterbodies through project interventions for co-management. These programs were successful in yielding benefits for a wider community not only fishers but general villagers many of which gained higher income in addition to agricultural activities through engaging themselves in subsistence fishing.

Now the rural community is aware that fishing by dewatering and abstraction of water below optimum level in the *beel* would be harmful, but where the waterbody is not under CBO management control this has been found to work but the awareness and motivation have washed out along with the hunger.

In some cases the local people were found to have good practical knowledge of the combination of livelihood activities in order to enhance income from the given area of land and water but some organizational and technical assistance must provide support to access institutional credits. Institutional as well as governance mechanism packaged with such initiatives would not only help the community to improve their economic condition rather this perception of the community may be taken as an advantage by the authority and development institutions to introduce good practices in the society for long term outputs and sustainability.

Matrix 1: **Proposed intervention for Capture Fisheries**

	Constraints	intervention			opportunity
		physical	technological	institutional	
Bagerhat	Food scarcity	Government. can supply food through VGF cards, rations or subsidies Using the empty homestead spaces to plant fruit trees to help survival during sever food crisis	Grow crops that can be stored and grown throughout the year		
	Water scarcity	Infrastructure for rainwater harvesting Excavating canals and drains to reach water to the fields		Training the farmers on water conservation and management practices	
Chuadanga	Pesticides in the agricultural lands nearby pollute waterbodies	• Using biofertilizers; training participants so that using organic fertilizers do not interrupt fish culture		Avoiding pesticide usage in the fields Raising awareness among the farmers about the disadvantage of using pesticides	Water is not polluted naturally • Water in the waterbodies are freshwater; not saline
	Water scarcity	Water storage in the local ponds throughout the year	▪ Rainwater harvesting	Ensuring access to sufficient water	
	Agricultural practices near the beels	▪ Banks of the *beels* should be elevated so as to protect fish	Avoid pollution of *beels* from agricultural activities are		

			nearby by encouraging the use of organic manures		
	Sedimentation in beels create fish habitat scarcity	Waterbodies need to be excavated Canals should be connected with the rivers so that fish can travel easily Over extraction of natural resources must be prevented to ensure fish habitat		Raiser *beel* should be kept open Commercial leasing of water bodies must not damage the waterbody by clearing it Community based participation is essential for natural resource management and required training should be arranged	Fish disease in beels is rare
Narail	During the month of *Kartik-Ashwin*, jute retting pollutes water reducing fish productivity		▪ Alternative ways should be used	Jute retting in open water should be prevented	
	Using Behundi, current nets to catch fish irrespective of size and reproduction stage reduces fish		Using harmful instruments must be stopped	Fishermen should be made aware of the rules and regulations of catching fish ▪ Fishermen should be encouraged in having	

	productivity			secondary livelihoods	
	Excessive use of Charpattar	Its use have to be stopped			

9.2. Interventions for Culture Fisheries

When participants were asked for their ideas on possible interventions, issues on water availability, fish disease, and fish feed, conflicts and market functions arose. Water availability during dry season should be ensured by installing deep tube well as a measure of both short and long term intervention. With an aim of fish disease prevention, good quality fingerlings should be provided and it should be ensured that farmers get experts suggestions for every aspect of their farming practices. They asked for a certain amount of loan to start with and for training. Government may increase its extension service and diversify its training subjects.

Farmers also complained that, price of fish meal has been increasing day by day. Government should take initiative to sell fish meal in a reduced or subsidized price. Respondents of Bagerhat asked to provide emergency water transportation through plastic pump to their farm from adjacent river. In addition, for better managing the conflicts they have proposed to form a 'sluice gate operation committee' by ensuring involvement of fishers, fish farmers and farmers.

Market related interventions were also important for both fishers and fish farmers, but the lack of knowledge of market price remains a problem, therefore providing access to daily market price would be helpful. According to participants such an initiative will help them to make well informed decision on how to obtain a better price. The ideas proposed to solve this are shown in Figure 28, where most of them reported that communication with storage owner and fish traders will be of worth as well as effective direct consultation.

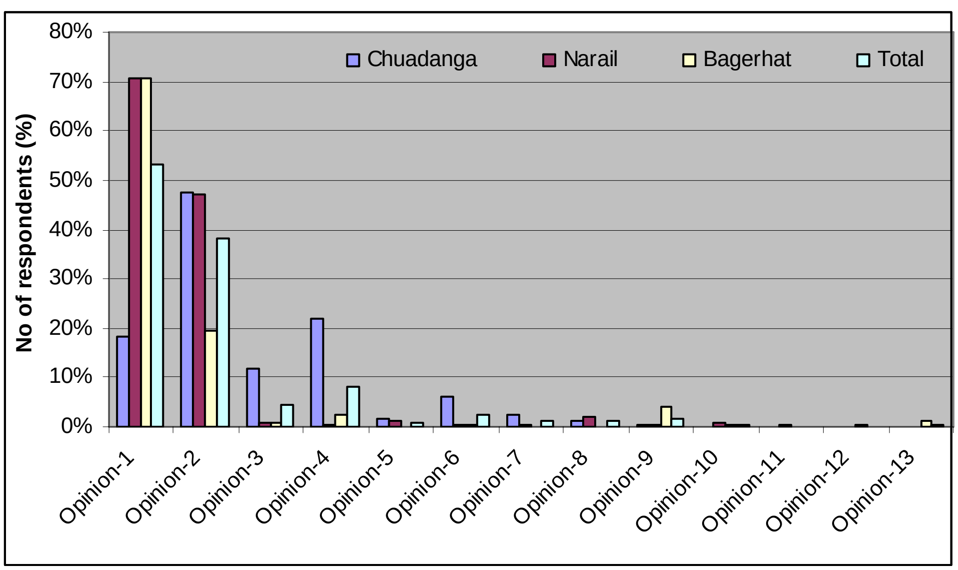
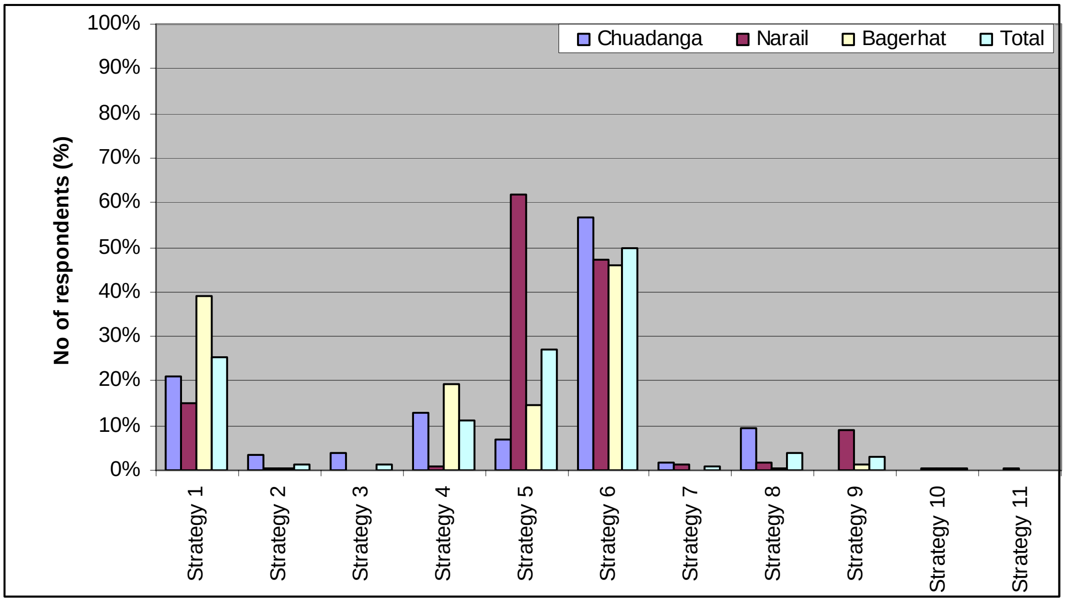


Figure 28: Opinion of the respondents regarding daily market price



Strategy 1=	One can collect price information from storage
Strategy 2=	Those, who goes to market regularly, might be consulted
Strategy 3=	Not necessary
Strategy 4=	From villagers/local fishers
Strategy 5=	Storage owner, depot owner and fish traders can be communicated
Strategy 6=	Storage owner and fish traders should be communicated through mobile phone
Strategy 7=	Fish farmers should be consulted
Strategy 8=	Don't have any idea
Strategy 9=	By regular selling in market
Strategy 10=	By selling fish to different buyers
Strategy 11=	Price related information should be broadcasted in radio and TV

Figure 29: Strategies to know daily market price

Matrix 2: **Proposed intervention for Culture Fisheries**

	constraints	intervention			opportunity
		Physical	technological	institutional	
	Crisis for good quality fish fries	Distribution of good quality fish fries through local fisheries departments of the Government		Awareness raising among people not to catch mother fish Involve and encourage local in raising fish fries Training them on the skills of raising fish fries	
	Scarcity of irrigation on time	Infrastructure for rainwater harvesting Excavating canals and drains to reach water to the fields		Training the farmers on water conservation and management practices	
	Food scarcity		Grow crops that can be stored / grown throughout the year ▪ Using the empty homestead spaces to plant fruit trees to help survival during sever food crisis		
	Water scarcity	Infrastructure for rainwater harvesting Excavating canals and		Training the farmers on water conservation and management practices	

		drains to reach water to the fields			
	No permanent fish depot in Srighat bazar	▪ Constructing a permanent depot			ce available

9.3. Interventions for Integrated Aquaculture Agriculture and Rice-Fish

Matrix 3: Proposed intervention for IAA and Rice-Fish culture

	Constraints	intervention			opportunity
		physical	technological	institutional	
Narail	During the floods, bunds collapse releasing fishes into the open; fish productivity falls	Bunds in the field have to be strengthened so that fish cannot get out in the floods or during heavy rainfall	Fish fries will have to be increased at local level	People can be trained on the flood-risk free measures for protection and fish cultivation in the rice-fields	Fish are high in demand
	Bazar is situated far from the village making fish transportation difficult; often these get rotten	Transportations to carry fish from the village can be accommodated	▪ Cost of transportation can be raised through co-operative society		Fish are high in demand Roads are carpeted
	Water scarcity	Construction of water storage structures Rainwater harvesting	Integrated use of groundwater and surface water ▪ Training people on water management		
	Increased temperature may kill fish	Regular monitoring of water temperature	Tree plantation around water bodies that give shade on water Using water hyacinth or other aquatic plants to keep water cool and give fish shelter		

Narail	Low fish fry production making these costly to buy		▪ Fish fries will have to be increased at local level	People can be trained on how to raise fish fry	▪ Fish fry are high in demand
	Water crisis during *Chaitra- Baishakh*		Withdrawal of water with machines	▪ Integrated use of groundwater and surface water	Since the river is nearby the *chitra* and *Nabaganga* river, water is available
	Polluted water in the rice field kills fish	Chemical fertilizer should not be used	Taking measures to prevent water pollution in the rice field	▪ People can be trained on how to culture fish in the rice field	People have interest to grow both rice and fish-cultivation
Bagerhat	No local business for fish fry			training local fish fry businessmen ▪ providing credit through NGO	Fish fries are high in demand
	Water crisis during *Falgun-Chaitra*	▪ Canal excavation			More fish fries can be cultured
	No training available on paddy-fish culture			▪ fish culture training through NGOs	People will be encouraged to raise fish fry
	Scarcity of good quality fish fries	▪ Arrangement for good quality fish fry			Good quality fish fry will be available

9.4. Summary of Intervention Potentials for Improving Fisheries Water Productivity

Based on our extensive field visit, specific group discussion and professional and expert judgment, the following have been identified as possible interventions for capture/open water fisheries system throughout the GM sub-basin.

- Develop more fish sanctuaries followed by habitat restoration, which have wider beneficial impact on fisheries productivity
- Conservation of natural breeding habitats, and sanctuary development and management
- Leasing system of public water need to be changed to enhance productivity and sustainable fisheries. This is already being attempted in the new Wetland Policy 2009 to take a pro-poor and decentralized implementation system including the provision of longer term duration of leasing and that have to follow the CBFM guidelines.
- Move away from standardized training programs to demand oriented ones which focus on specific systems or community needs.
- Agriculture policy needs to be integrated and synchronized with the other natural resource policies e.g. water policy, fisheries policy, environment policy; those which advocate for mechanisms to enhance ecosystem productivity for both fisheries and other aquatic natural resources in order to maximize water use as well as fit the society and in particular all the households in a multi-livelihoods combination that is socially more acceptable
- Agricultural farmers better chose producing rice as these are non-perishable and can be stored during the year round as food support. In similar ways community cold storage system for storing fish may be examined to be an alternative, as fish has a higher value of production per drop of water compared to rice. Farmers are very much aware of that but there are issues that need to be dealt with to improve the conditions in a community friendly way.

Tentative interventions for semi-closed and closed (pond) culture systems are:

- Community based fish culture and management in large open and semi closed water-bodies
- Hatchery, nursery and feed mills should be established more evenly throughout the sub-basin as demand for inputs is high throughout but mostly available in a concentrated area. Furthermore, government has established - but non functional - hatcheries and farms that if made functional again could help meet the demand.
- Fish-depots and processing plants should also be facilitated more evenly across the sub basin as its demand grows from downstream to upstream, whereas the supply is concentrated down to middle stream.

- Strengthening marketing linkages would improve the root level producers and at the same time reduce middlemen interception.
- Decentralized fish seed technology extension can minimize input costs for production and improve local communities livelihood
- Extension services should be strengthened up to union level by increasing sufficient skilled manpower

For the shrimp and coastal aquaculture:

- These culture systems should develop into more sustainable and environmentally friendly technologies
- Ensure quality of fingerling and post larvae by guaranteeing the availability of high quality and high yielding variety of brood.
- Extension services should be strengthened up to union level by increasing sufficient skilled manpower
- Due to the industrialized nature of shrimp farming, the facilitation of credit support could benefit those interested in farming.
- Introducing salt tolerant varieties will provide adaptation measures for the coastal regions experiencing salt intrusion, which is predicted to increase with the changing climate. Deep water rice variety along with fish (as suggested in the FAP-17 study report) seems to be the best win-win option.
- Rice – fish can also serve to a small-scale with additional input to technological adaptations.
- One option suggested in FAP-17 and FAP-20 is to develop more water gates and fish ladders for long distance migration
- Adopt floating agriculture
- Shrimp farm registration to avoid management conflicts
- Development of infrastructure and sustainable marketing channel

9.5. Policy implications to fisheries and water productivity and optimization of land-use

Water management projects have significant impacts on aquatic biodiversity and fisheries. Often, these impacts are inadequately defined in the policy documents and these impacts are inadequately recognized by decision-makers. The wetland environments of Bangladesh are extremely complex in nature and their understanding requires further investigative capacity and knowledge of the behavioral functions and impacts in order to add value to existing community-led approaches in the fisheries and agricultural sectors.

While rationalization of the water use will adopt sound planning and design principles to ensure that technical, social, and environmental considerations are respected, it will also have an overriding focus on developing sustainable systems for operating and maintaining infrastructure, including strengthening the involvement of local stakeholders and local government institutions in all stages of the implementation process. In addition, the rehabilitation design needs to accommodate potential future climate change. The nation, particularly the line agencies should develop strategies for climate resilient fisheries and aquaculture. In the face of climate change aquaculture may provide solution to cope with the agriculture linked livelihoods when the present land-use will be forced to change.

The National Water Management Plan envisages some fundamental changes in the institutional framework in the future. The Department of Fisheries, operating through NGOs and local government, could be responsible for overseeing the fisheries management aspects, which would include the maintenance of minimum water levels, development of community management organizations, and development of fish sanctuaries, closed fishing seasons, and other aspects of community fisheries management, such as alternative income generation. It has linkage to cross boundary water flow and sharing issues, and demands adequate persuasion to implementation of Ganges Water Treaty.

The identified indigenous interventions would better sustain if the indigenous knowledge so far explored in the fisheries sector was taken as lessons for research and action while planning for land-use rationalization and alternative livelihoods policy panning particularly in the face of climate change. It needs emphasis here that the climate change and climate variability induced issues in agricultural land-use could probably be better addressed where a majority of the impacted livelihoods could be replaced to a large extent by the improved management of the fisheries and aquaculture (WorldFish News Letter, 2006). In this case Ministry of Fisheries and Livestock (MoFL) and DoF would therefore need take proactive actions to accommodate the requirement for the climate resilient fisheries and aquaculture through negotiations with WARPO/MoWR while reviewing the national fisheries policy in the near future; as it is understood that in the light of the findings and the recommendations of the National Fisheries Strategy 2006 the line ministry has plan to update the National Fisheries Policy 1998.

It may be noted here that in an overall vision the policy still bears positive dimension and very few parameters that could be considered conflicting with the strategy, but there might be lacking scope for improvement in holistic land-use and/or water and ecosystem based management of fisheries. In this connection the observation of the IGB-BFP team need be shared with all stakeholders and be critically examined in order to grasp the water related issues in the fisheries sector in particular while a win-win situation with the other sectors should be the target in a national agricultural GDP growth context.

9.6. Observation of IGB-BFP WorldFish – Bangladesh:

1. Increased use of organic manure is not largely in practice and specific action plan under this agenda is absent. This should be addressed more effectively
2. Supplementary irrigation policy during droughts is a direct conflict with the fisheries policies and objectives. This need be synchronized.
3. It is necessary to review these policies to identify the conflicts with the fisheries and aquatic resources; with particular references to the conversion of wetlands into dry-land to claim for pure agriculture dependence on the cost benefit analysis for this conversion which the present study finds fatal for the future food security.
4. The present view appreciates that fisheries is also an area of agriculture, the policy document has not made any relevance with the other sectors, such as fisheries, forestry, etc..
5. The Agriculture land-use appears to have centered within the agriculture sub-sector only. It does not provide any scope for examining land suitability for other areas of agriculture e.g. fisheries. It needs national level review to make an ecosystem based development plan of actions within the natural resources sector particularly those that depend more on water.
6. Coordination is meant to be between agricultural line agencies and the NGO institution and private sector, not only with other related GO agencies.
7. The land-use suitability may have to be looked over the future in time line and address the agricultural/aquaculture changes for coping with the climate change and climate variability as the expected longer time periods of inundated land and salinity intrusion will pose future threats to agro-economic land-use changes and land-use patterns.
8. This is seen as an important consideration from the water-use context; that further demands shift in mind-set in planning for agro-based economy. IGB-BFP program needs to oversee the future needs through circumstantial evidences that has started to impact in the economy and the livelihoods
9. .Climate change should be considered; Advance measures need to be explored and adaptation processes need to be considered in the action plan The land use pattern is predicted to change, sea level to rise and salinity to intrude freshwater. These can cause the present agricultural economic activities to be unavailable making particularly the brackish water aquaculture may become a major coping strategy for the future.
10. The agenda should also include research on the short duration and /or early maturation of HYV or indigenous varieties of rice that can be harvested before the new monsoon water enters the floodplain in order to change the present system of submersible embankments in some part of the Ganges basin. These restrict greatly the entry of the gravid fishes into floodplain in time and has a negative impact on the natural fish recruitment and regeneration process, which has been identifies as a major cause of loss of per capita fish production from the floodplain and hence an adverse impact on food security.

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APPENDIX 1

Methodological Framework

Water scarcity is an issue of concern especially under this changing climate we are facing. Capture and culture fisheries are vulnerable to water availability; therefore we must understand what factors are the drivers that optimize product per drop of water. This methodological framework aims to facilitate the construction of a replicable approach to evaluate fisheries water productivity to a large scale. This is approach measures of water productivity by volume and value for capture and culture systems as well as ii) the tools and methods required for water productivity analysis where the drivers of water productivity in fisheries are evaluated. This provides the basis for finding potential interventions for the optimization of fisheries water productivity in the area of study.

The analysis was done through a household survey questionnaire from a sample of households covering a variety of production systems and districts to estimate values on water productivity considering volume and catch from each waterbody in both weight and monetary value.

Water productivity by volume has been used to determine the water consumption of crops. However, due to the non consumptive nature of fish, measurements by volume (as opposed to per area) have been a challenge so far in fisheries as we can see in the literature (Nguyen-Khoa *et. al.* 2008). Water productivity of crops has been considered in agriculture, seeking ways of optimizing water use. Fish must also be regarded as another crop and should thus be included in the water productivity analysis in a standardized form with respect to other crops. Given the difficulties of measuring non consumptive use of water in fisheries, the connotations different systems pose and the large area studied, the estimation of water productivity of open water fisheries and aquaculture systems were done with a practical and simplified semi-quantitative approach described further on.

Study Area

The study area of the project consisted of the Eastern Ganges Basin (EGB) as a sub basin of the Indo Gangetic Basin. This is the area of the IGB in Bangladesh, which borders with the Padma – the confluence of three rivers which has a direct effect on the areas' water productivity due to its provision of water availability. The water flow from upstream will affect the lowerstream of the basin where a variety of capture and culture fisheries systems are present and of interest.

Production Systems

The production systems studied in the EGB are the following:

Capture

Beels: Low-lying depressions in the floodplain (small lakes). They may have a permanent character, containing water throughout the year (perennial beels) or dry out completely during a part of the year, usually 4-5 months (seasonal beels). During monsoon the beels become part of the floodplain.

River: A large natural stream of water larger than a creek. These may be flooded during monsoon season, creating connectivity between the river and other waterbodies.

Culture

Intensive aquaculture: Pond systems where there supplementary feed is used and there is higher stocking density than in other culture systems. In this study, fish owners with intensive systems stocked fish fry at least 2-3 times per year.

Semi-intensive: Ponds where fish fry is stocked only once annually and generally during the rainy season when there is sufficient stored water. Throughout the period from stocking to harvesting very small amount of feed (e.g. cooked rice, rice husks, etc.) is introduced if any, and fish mainly depend on natural foods found within the system. Harvest occurs before the dry season although the pond is harvested throughout the year especially for consumption.

Low input/ Extensive aquaculture: Extensive aquaculture requires less effort put into the husbandry of the fish. Extensive aquaculture is done in the man-made lakes, ponds, closed or semi-enclosed water bodies. Fish chosen for extensive aquaculture are very hard and often less stocking densities are maintained. Culture species normally grow using natural feed or very small amount of exogenous feed. Carp, tilapia, pangus, and shrimp are the most prominent species of extensive aquaculture. Extensive aquaculture facilities have very low negative impacts on the environment especially newly adopted culture practices in semi-closed water bodies and floodplain as well. Natural habitats are destroyed in the development of man-made ponds used for extensive aquaculture. The production and productivity are ultimate far less than semi-intensive and intensive culture system.

Shrimp Culture: In this context define mono or polyculture systems of tiger shrimp (*bagda*) culture (*Paneaus monodon*) and freshwater prawn *golda* (*Macrobrachium rosenbergii*). This is supported by the abundance of *ghers* (Coastal Shrimp farm) present in the area and the presence of saline water which is suitable for fresh water prawn culture. The determinants that outweigh the scale for landowners to adopt aquaculture techniques are mainly water quality and quantity. However, in the areas where saline water is present, mixed culture with species like carp (which are salt intolerant) are not possible.

Rice-Fish: Rice-fish culture is an integrated system that is mainly governed by availability of water. Rice is an economically important crop and the integration of fish provides supplemental income/food and if managed adequately can increase the rice yield and reduce the need of fertilizer. Cultivation of fish can be simultaneous with rice or alternate with the crop cultivation. Although there are some disadvantages to it that have not allowed this system to be properly established as an integrated culture system in Bangladesh.

Integrated Agriculture Aquaculture: Integrated Agriculture Aquaculture (IAA) is a kind of culture where, uses of the land are mutually inclusive and supports each other. It is comparatively a new technology introduced in the area. In IAA systems, aquaculture is practiced in ponds with little or no water exchange. There are a number of farming systems which can be regarded as variations on the IAA theme:

- Farms based mainly on dry-land crops and fish culture, sometimes with a small input from poultry or other livestock.
- Wetland crops: Rice and fish culture
- Integrated animal and fish farming e.g. pigs, ducks, poultry farmed together with fish. (e.g. pigs/ duck/ poultry farmed together with aquaculture).

Sampling Design

Initially, the area is divided into Districts – or whatever is the division of area in the given zone. Secondary data on productivity measures should be collected for each district, which in fisheries is usually found as catch per unit area (CPUA) not by volume as this study intends. The initial analysis of secondary data provides a basis for the purposive sampling used. In the case of our study secondary data from Department of Fisheries (DoF – FRSS) on productivity of beels, baors and cultured ponds was collected by district. With this data it is possible to address the hotspots of fisheries water productivity in the area and is a suitable basis for the first broader scale sampling.

Large scale sampling:
Purposive sampling was used where a proportionate sample of households would be picked which included all the systems of interest. A sample size of 1,000 households was chosen as a valid representation of seven systems (*beel*, river, intensive aquaculture, semi-intensive aquaculture, extensive/low input aquaculture, shrimp culture, and integrated culture). The following were considered:

- Total households per district
- Fisher households per district
- Catch per unit area for capture systems
- Catch per unit area for culture systems

Total household per district and fisher household per district were used to obtain a *fisher intensity* value:

$$fisher\ intensity_{capture} = \frac{capture\ fisher\ household}{total\ household}$$

$$fisher\ intensity_{culture} = \frac{culture\ fisher\ household}{total\ household}$$

Having obtained the *fisher intensity* per district the capture and culture CPUA for the systems was divided by their respective intensity factor in order to obtain an indicative figure of the production with relation to fisher specific population in the district.

$$production\ intesity_{capture} = \frac{CPUA_{capture}}{fisher\ intensity_{capture}}$$
$$production\ intesity_{culture} = \frac{CPUA_{culture}}{fisher\ intensity_{culture}}$$

The criteria for the large scale sampling were based on production intensity, daily caloric intake (DCI) values and poverty headcount index. Large scale sampling of three areas were chosen considering the following:

- High, medium and low production intensities
- Upper, middle and lower stream basin areas
- And to ensure that the poorest areas were covered districts with lower DCI (Direct Calorie Intake) and higher HCI (Head Count Index) were considered.

Small scale sampling:
The three selected districts were comprised of 16 upazillas (subdistricts). Among these, three – one at each district- were selected on the basis of abundance of the systems of interest and on information availability. Local Fisheries officers were consulted for sampling. Further selection was done using the same criteria to choose three unions (smaller division than upazilla) under the three selected upazilas. The fisheries production systems were identified at the selected sites and a list of household members per area selected was created. *Proportionate* sampling of households is advised because the number of systems found were not equal (e.g. few cases of IAA and many of extensive aquaculture), and not all systems exist in all sites (e.g. shrimp farming was not present upstream).

For the more in depth approach of the case study, after field reconnaissance was completed in the three districts, the systems found were identified and described in detail to ensure uniformity among different sites, and help the researcher minimize human bias in data collection. This also helps the researcher compare between the productivity of same systems situated in different location of the basin and facilitate the identification of factors that are responsible for productivity variation among different systems within a certain location.

Data collection and analysis

Literature review allowed the extraction of relevant secondary information on fisheries water productivity by area (in CPUA) to initially understand the variation throughout the basin to permit the sampling described above. A **household survey questionnaire** was developed after consultation with experts from fisheries, water resource management, hydrology and data analysis backgrounds and was field tested. Data for water productivity calculations can be obtained from this questionnaire. **FGD**s cover the common gaps of information for all systems. The number of participants was constrained to 6-8 only for easy administering and in depth data extraction.

Water Productivity Analysis

Water productivity is defined by the Comprehensive assessment of Water Management in agriculture as the 'ratio of net benefits from crop, forestry, fishery, livestock and mixed agricultural systems to the amount of water required to produce those benefits' (CWMA, 2007).

Molden (1997) stated that water use can be non-consumptive when benefits are derived from an intended use without depleting water. Thus he identified fish water use as a non-consumptive one.

Nguyen-Khoa. S *et a.l* (2008) has modified the framework, proposed by Molden (1997) and adapted by Peden *et al.* (2007) and simplified as:

$PW_s = P_{fish} / (I_{gross} - I_{net})$

Where, PW_s=Water storage productivity, P_{fish}= fish productivity, I= Inflow.

The process of water depletion by the crop is therefore negligible in fish production. Based on the above simplification and modification, it was assumed that water volume remains the same for the whole production year and it has been calculated as an average of the water volume during dry season (October – April) and wet/monsoon season (May – September). Despite the assumption, some system owner might let water enter the waterbody by deliberately pumping water. This is also considered in the calculation (Z) and is added to calculate the total volume of water used by the fishery system. However, water loss through evaporation and seepage was not captured.

Culture and capture fisheries had slightly different calculations for their systems. The data required for it was obtained through the household survey questionnaire – in sections B1 and B2 found at the end of thisframework.

For **culture systems** the volume of the systems must be estimated first:

X = Water volume of dry period = width + breadth + $depth_{dry}$

Y= Water volume of wet period = width + breadth + $depth_{wet}$

With these volumes, a unique volume representing the volume of water maintained in the system throughout the year (Q) was calculated using the following equation:

$[(Xt_1 + Yt_2)/2] + Z = Q$..(1)

Where,

t_n = No of months

Z = Additional volume of water, that owner allowed to enter (i.e. pumped in).

Once the average annual volume of water maintained in the system was estimated (Q), the water productivity by weight (A) could be calculated with equation 2, and productivity in monetary terms (B) could be calculated with equation 3.

$P/Q = A$..(2)

$I/Q=B$..(3)

Where,

Q= Volume of water maintained in the system throughout the year.

P= Amount of production measured in kg

A=Water productivity of the system measured in kg/m^3

I= Equal price of the total fish production.

B= Water productivity of the system measured in Tk/m^3

To estimate water productivity of the system in kg (A), Average catch per person per day was multiplied by the average number of people who catch fish in that certain water body (certain reach, in case of river). Production in monetary terms (B) was calculated similarly.

For **capture systems** the volume of the systems was initially estimated as shown below with the data obtained from the questionnaire. For rivers, catchments were considered, having a fixed area determined by the on-field study.

X = Water volume of dry period = $width_{dry}$ + $breadth_{dry}$ + $depth_{dry}$

Y= Water volume of wet period = $width_{wet}$ + $breadth_{wet}$ + $depth_{wet}$

In this case width and breadth measurements of the system had to be considered different for wet and dry season as the surface area is highly variable with season.

With these volumes, a similar procedure was followed as for culture fisheries, except that parameter z (additional volume of water added by the owner) was not included given that open water fisheries do not have external input from pumping. A unique volume representing the volume of water maintained in the system throughout the year (Q) was calculated using the following equation:

$[(Xt_1 + Yt_2)/2] = Q$..(1)

As for culture fisheries, once the average annual volume of water maintained in the system was estimated (Q), the water productivity by weight (A) could be calculated with equation 2, and productivity in monetary terms (B) could be calculated with equation 3.

$P/Q = A$...(2)

$I/Q=B$...(3)

Where,

Q= Volume of water maintained in the system throughout the year.

P= Amount of production measured in kg

A=Water productivity of the system measured in kg/m^3

I= Equal price of the total fish production.

B= Water productivity of the system measured in Tk/m^3

Limitations

In this study, a large area was sampled which posed several challenges to calculate water productivity in all the systems. For example, fish production data was collected year wise. Production data would be better estimated if collected for each cycle and calculated with the water volume of each cycle. Having a cycle based or monthly measurement would be beneficial for calculating Z; the amount water pumped into the culture systems. In addition, fish production in both weight and monetary values varies also on the basis of species cultured, which could also be considered during analysis.

Accounting for gradual water changes throughout the year would allow a better estimation of water productivity. The inclusion of such measurements interferes with the efficiency of the task and was hence not carried out. However, it is advised to attempt such measurements for case specifics where sample size is small.

Two issues raised during the study were the higher presence of fishers in seasons when fish are more available and that average catch largely depends on the pattern of fishing (group fishing, fishing through dewatering, etc) and gear used. Where possible, and if applicable, these should be integrated in the analysis of fisheries water productivity.

Scalability and recommendations

For broad scale analyses the two step approach suggested using the tools and methods described above can provide a thorough analysis of fisheries water productivity in a given area of study. The water productivity estimations are challenging and accuracy is difficult compared to agricultural estimations of water productivity, especially due to the non consumptive nature and the unintentional inflow and outflow of water from the system. If more accurate water productivity by volume is required then a case specific experimental design should be followed, as shown in Allah, *et. al.,* 2009**.** In such case the parameters of water flow and water level variation would be specified. This approach was not followed in our methodology due to the large sample size and the need to use a practical and simplified approach.

Similar kind of studies could be conducted in other basins with some corrections based on basin characteristics and management practices. For example, in calculating water volume, seasonal variation should be incorporated cautiously. For this study, respondents reported water depth variation only for two seasons: wet and dry, however this may not apply for other basins. We also observed that productivity varies on the basis of the species cultured or captured. This has not been considered in the analysis, but species variation could be a parameter to consider in analyses.

Another important factor to depict the trend of productivity along a basin is to have data collected for several years. It is also favourable to obtain data for a regular year (absence of extreme events e.g. flood or drought of a very high magnitude). This study collected data for the year 2008, which followed a devastating Cyclone Sidr a year earlier, therefore people had to invest more on repairing and rehabilitating activities.

Fisheries water productivity analyses are very case specific and exact values are difficult when the scope of work encompasses a large study area. This methodological framework provides the tools and information required to facilitate the replication of such study, however it must be cautiously used as water productivity estimations are complex and drivers of productivity are variable with location