

Farmed fish value chain development in Bangladesh: Situation analysis and trends



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Farmed fish value chain development in Bangladesh: Situation analysis and trends

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WorldFish

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Abbreviations

ADB	Asian Development Bank
AqDP	Aquaculture Development Project
BADS	Bangladesh Aquaculture Development Society
BARC	Bangladesh Agriculture Research Center
BARD	Bangladesh Rural Development Academy
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BFDC	Bangladesh Fisheries Development Corporation
BFRI	Bangladesh Fisheries Research Institute (also abbreviated FRI)
BIDS	Bangladesh Institute of Development Studies
BRAC	Bangladesh Rural Advancement Committee
BWDB	Bangladesh Water Development Board
CARE	Care (international NGO)
Caritas	Church-based NGO, Caritas is a Latin word means love and charity
CBFM	community-based fisheries management
CBM	community-based management
CBOs	community-based organization
CCRF	code of conduct for responsible fisheries
CEGIS	Centre for Environmental and Geographical Information Systems
CODEC	Community Development Center
CPR	common property resources
DAE	Department of Agricultural Extension

Danida	Danish International Development Assistance
DFID	Department for International Development
DoE	Department of Environment
DoF	Department of Fisheries
ECA	Environment Conservation Act
ECNEC	Executive Committee for the National Economic Council
EIA	environmental impact assessment
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FDEC	Fisheries Development Executive Committee
FFP	Fourth Fisheries Project
FRSS	Fisheries Resource Survey System
FSRFD	Fisheries Sector Review and Future Developments
FTEP	Fisheries Training and Extension Project
FTF AIN	Feed the Future Aquaculture for Income and Nutrition
GDP	gross domestic product
GEF	global environment facility
GIS	geographical information system
GNAEP	Greater Noakhali Aquaculture Extension Project
HACCP	hazard analysis and critical control point
ICLARM	International Centre for Living Aquatic Resources (now WorldFish)
IPM	integrated pest management
IUCN	International Union for Conservation of Nature
LDC	Low-income Developing Country
LEAF	Local Extension Agent for Fisheries
LGED	Local Government Engineering Department
MACH	management of aquatic ecosystems through community husbandry
MAEP	Mymensingh Aquaculture Extension Project

MoA	Ministry of Agriculture
MoEF	Ministry of Environment and Forest
MoFL	Ministry of Fisheries and Livestock
MoL	Ministry of Land
NATP	National Agriculture Training Programme
NCSFA	National Committee for Shrimp and Fish Affairs
NFA	National Fishermen's Association
NFEP	Northwest Fisheries Extension Project
NFP	national fisheries policy
NRMC	Natural Resources Management Council
NWMC	National Water Management Council
OLP-II	Oxbow Lakes Project—phase two
PBAEP	Patuakhali Barguna Aquaculture Extension Project
PL	post larvae
Padakhep	Padakhep Human Development Center (NGO)
Proshika	Human Development Center
PRSP	Poverty Reduction Strategy Paper (also abbreviated iPRSP)
RDA	Rural Development Academy
RDRS	Rangpur Dinajpur Rural Services
SCBRMP	Sunamgonj Community Based Resource Management Project
SUFER	Support for University Fisheries Extension and Research
SWOT	Strengths, Weakness, Opportunities, Threats
T	tonne
TMSS	Tangamara Mohila Shomobay Somity (or Tangamara women cooperative society)
UP	Union Parishad
USAID	United States Agency for International Development
WARPO	Water Resources Planning Organization
WB	World Bank

Glossary of terms

arot	an office, a store, or a warehouse in a marketplace from where arotgars conducts their business.
arotdar	actor in the fish value chain. Arranges or negotiates sales for the sellers on a commission basis. They often act as wholesalers and are a main provider of fisheries credit to fishers / fish farmers.
baor	oxbow lake
beel	deepest part of the floodplain, often with a permanent area of water
char	newly formed island or a point bar formed in a river
dadon	this is a type of loan given to fishers / fish-farmers by arotgars and mohajans (traditional moneylenders) on condition that fish are sold to them only. Sometimes prices are predetermined.
dighi	big pond
faria	intermediaries in the fish value chain who purchase small quantities of fish from fishers / fish farmers far away from the market and carry it to the terminal point and sell it to the arotdar or retailer
gher	area of land enclosed by dikes for shrimp culture
haor	deeply flooded saucer-shaped depression in the northeast region of Bangladesh
hapa	holding net usually used for fish fry
jal	net
jalmohal	fishery leased out by government for revenue
jola	water-body
khas	government land
koyal	people who conduct auctions for arotgars. They offer an initial price of the lot to the assembled buyers. They then announce the prices offered by different buyers in front of auction participants. They repeat the process until the final price is agreed
kua	a ditch or pond dug in a floodplain to concentrate fish as the water level falls (also known as a pagar)
nikari	an informal intermediary who does not own fish but sets a bridge between buyers and sellers and receives commission from farmers and fishers
paiker/ bepari	An intermediary in the fish marketing chain; he often covers the assembly function in the chain, acting as dadondar; depending on the location they are also called a wholesaler or retailer. They are also called bepari.
parishad	council
polder	land enclosed by an embankment
upazila	subdistrict
zamindar	person assigned to collect revenue on behalf of the British government directly from the tenant in Indian subcontinent during British rule. In 1793, the Permanent Settlement Law put forward as an incentive to zamindars, that 'for fair revenue collection, the hereditary tenure of possession is to be the only necessary security'. In fact the zamindars were declared to be the proprietors of the soil.

Executive summary

Objectives

This report evaluates how fish value chains in Bangladesh function. It concentrates on: (i) providing an overview of past trends, the current status and the expected future development of the farmed fish value chain in Bangladesh; and (ii) pinpoints the fundamental challenges and opportunities for the aquaculture sector. The study was carried out to provide information about the present status of fish value chains in Bangladesh and analyse the conditions where growth has been occurring. The results presented were obtained from secondary data from a variety of sources. Key informant interviews were conducted with fish wholesalers, traders and retailers in Dhaka fish markets. The report addresses a number of key areas, and the findings are summarized under the headings below.

National context

In Bangladesh, almost 80% of the population lives in the rural areas, with 54% of them employed in agriculture and the remainder in the rural non-farm sector. The rural economy constitutes a significant component of national gross domestic product (GDP), with agriculture (including crops, livestock, fisheries and forestry) accounting for 21% and the non-farm sector, which is driven primarily by agriculture, for another 33%. Bangladesh is one of the most densely populated countries in the world; more than 150 million people occupy the country's 147,500 km² land area, consuming rice and fish as staple foods. Rice farming is the single most important livelihood for the vast majority of the rural poor. The demand for rice and fish is constantly increasing.

The country's population is growing at a rate of 1.6% per year, increasing by 2.4 million each year. Poverty in Bangladesh is primarily a 'rural phenomenon', with 35% of its rural population classified as poor (BBS 2011). Achieving the Millennium Development Goal (MDG) of halving poverty to 26.5% by 2015 will require a growth rate of at least 4.0% in agriculture and 7.0% in the non-farm sector. Bangladesh's progress in relation to the MDG poverty reduction target is satisfactory (GED 2013).

The **multidimensional poverty index (MPI)** defines multiple deprivations in the same households in terms of education, health and standard of living. According to the most recent data (2007), 57.8% of the population lived in multi-dimensional poverty despite important improvements in some human development indicators over the past three decades. An additional 21.2% were vulnerable to multiple deprivations. The MPI shows that measuring income poverty (the percentage of the population living below purchasing power parity per capita (PPP) USD 1.25 /day) does not present a full picture of poverty. The MPI in Bangladesh is 14.5 percentage points higher than income poverty. This suggests that households living above the income poverty line may suffer deprivations in terms of health, education and other living conditions (UNDP 2013).

The **gender inequality index (GII)** examines gender-based inequalities in three dimensions: reproductive health, empowerment and economic activity. Reproductive health is measured by maternal mortality and adolescent fertility rates. Empowerment is measured by the share of parliamentary seats held by each gender, and achievement at

secondary and higher education by each gender. Economic activity is measured by labour market participation by each gender. The GII shows the loss in human development due to inequalities in male and female achievements in these dimensions. Bangladesh has a GII value of 0.518, ranking it 111 out of 148 countries in 2012 (UNDP 2013). Bangladesh ranks 63 out of 86 countries included in the OECD's 2012 Social Institutions and Gender Index (<http://genderindex.org/country/bangladesh>). This index assesses country performance in five areas related to the enabling environment for social and gender equality: the family code, physical integrity, son bias, resources and entitlements, and civil liberties.

Women's access to resources tends to be lower than men's, including their direct access to and ownership of agricultural land and related productive resources. While there are no laws limiting women's access to public space, in practice the social norms regarding women's mobility place limits on their freedom of movement. This affects the range of occupations and work locations available and acceptable to women, although poverty can drive women and their families to act outside of these prescriptions.

Fisheries resources in Bangladesh

Freshwater aquaculture and coastal aquaculture are both practised in Bangladesh. At present there is no marine aquaculture production. Freshwater aquaculture is comprised mainly of pond aquaculture, particularly the polyculture of a variety of species, including native and exotic major carps, and non-native tilapia and pangasius. Coastal aquaculture is comprised mainly of extensive shrimp farming, but a range of other aquatic products including fish and crabs are also produced on shrimp farms. In the past, people depended mainly on wild fish, but catches have declined due to an increased fishing effort and a range of other anthropogenic pressures. As a result, aquaculture has grown rapidly to fill the gap. As a whole, the fisheries sector is important for Bangladesh's food security and economic growth. Fish production totals 3.26 million tonnes (of which 53% originates from aquaculture), and contributes 4.4% of national GDP and 22.7% of agricultural GDP. Average growth in fisheries output from 2009 to 2012 was 6.22% per annum, of which aquaculture contributed the majority (DoF 2013). Fisheries in Bangladesh are diverse; there are approximately 795 native species of fish and shrimp in freshwater and marine waters. A total of 260 species have been recorded in freshwater; about 200 species are truly freshwater, while the remaining 60 are examples of estuarine and marine species. To date 12 exotic species have been introduced. The livelihoods of more than 1.65 million people (over 11% of the total population) directly depend on fish; of these, 10% are women who are directly involved in the fisheries sector.

Export and import fish

Fish imports and exports to and from Bangladesh are very low. Of the total fish production of the country, about 2.84% is exported (EPB 2013). It is estimated that about 46,800 t of fish are imported (DoF 2013), which is just 1.6% of the total current fish demand of Bangladesh. Exports are to various countries, mainly in Europe, the USA and the Middle East. Of the total export earnings from fish, over 77% is from shrimp—of them *Penaeus monodon* (black tiger shrimp, locally called *bagda*) constitutes about 75% and different types of frozen fish contribute about 20%. *Hilsha* accounts for approximately one-third of these. Shrimp is the second largest export item from Bangladesh after readymade garments. Shrimp farming is a source of employment for an estimated 1.2 million people, of whom, more than 20,000 are women who work on shrimp farms and in processing units.

Household fish consumption and expenditure

Historically Bengali people have a strong preference for fish, which forms an important part of their customs and culture. Almost all households consumed fish at least once a week. Fish is the most important animal food source in Bangladesh, accounting for more than 60% of the total intake. Per capita fish consumption in Bangladesh is now close

to the global average, at 49.5 g/day, or 18.1 kg/year. However, there is a significant difference in fish consumption between rural and urban households. In rural areas, average daily consumption per capita is 45.8 g, while in urban areas it is higher, at 59.9 g (BBS 2011). Average monthly household expenditure on fish consumption is about 13% of total expenditure. Reliable data on intra-household fish consumption patterns is not available.

Fish breeding and Genetics

In Bangladesh, the first artificial breeding program for fish was undertaken in the early 1980s in the district of Jessore, which became the country's first hub for fish seed production and marketing. Since this time, other hatchery hubs have developed in Comilla, Mymensingh and Bogra, and increasing numbers of individual hatcheries have been established in most other districts. However, most of these hatcheries are thought to use inadequate management practices such as inbreeding and use of immature brood. This has resulted in the production of poor quality seed, with negative effects on fitness-related traits such as growth rate, survival and disease resistance. Awareness about the deleterious effects of inbreeding has increased in recent years, based on lessons learned from past experience. Farmers are now more aware of the quality of the source of fingerlings than in the past, and hatcheries are registered under the Fish Seed Act, which included stipulations about the management protocols that hatcheries should follow

The GIFT strain of tilapia (Genetically Improved Farmed Tilapia), was developed through collaborative research initiated by WorldFish during the 1990s. GIFT was developed to enhance production traits of tilapia, a commercially important fish species. Presently, more than 95% of tilapia hatcheries and farms of Bangladesh are growing the GIFT strain, and farmers are reportedly satisfied with the strain, but there are concerns about whether the strain has been adequately maintained.

Fish health and disease control

With the rapid expansion of aquaculture, prevention against fish disease is becoming an increasingly important issue, and disease induced mortality is a serious issue for the fish seed industry. However, diseases are not a major constraint to improving fish production in Bangladesh at present; poor quality of fingerlings due to poor brood selection and inbreeding are a major issue. Cost-effective methods to accurately and quickly detect fish-borne diseases are now available to farmers.

Fish production and use of feed

The most important cost factor in aquaculture is the cost of feed. The growth of both commercial aquaculture and commercial fish feed production in Bangladesh in the past 10 years has been extremely rapid. Intensive and semi-intensive production of pangasius, tilapia, koi, magur, shing and, in some cases, carps is heavily dependent on the use of pelleted feeds. Total aquaculture feed production was estimated to have reached 1.4 million tonnes in 2014. Most of this is comprised of formulated commercially manufactured feeds, but some on-farm feed production takes place. Semi-intensive and low-intensity carp farming relies mainly on organic and inorganic fertilization, and 'raw' supplementary feeds which are usually agricultural by-products such as rice bran and mustard oil cake. There are approximately 100 feed mills in operation in Bangladesh. Formulated feeds are of variable quality and are considered to represent a major impediment to the growth of the sector. The Feed Act requires registration and licensing for all feed producers, ensuring that the macronutrient content of different categories of feed and raw materials is maintained at optimum levels. However, enforcement of the Act is currently limited.

Knowledge transfer and gender

In Bangladesh, farmers have been working in close cooperation with both the public and private sectors. The public sector provides technologies while the private sector is investing and adopting technologies. A combination of provision of training knowledge and credit from both sectors has enabled both men and women to start fish culture.

Gender issues

Pond aquaculture is an appropriate entry point for empowerment of women; it offers opportunities, particularly for middle-class household women's movements outside the homestead, while for poor women, social restriction working outside has not been followed due to economic imperatives. Several studies indicate women's participation in fish culture is predominantly limited to feeding, fertilizing, applying manure and feeding the ponds. These activities are essential and must be performed routinely every day, but are often considered as part of household activities. Most of the women do not have control over the income derived from this type of work.

Access to credit

Historically, the Bangladesh fisheries sector is highly organized by informal moneylenders, from fish exporters at the top to the fishers at the bottom. The informal money lending is called the *dadon* system—under which operating expenses are advanced to fishers by in return for a monopoly on the right to purchase all fish products. This network is less evident in aquaculture than in fishing, although similar arrangements still prevail in some cases, particularly in shrimp farming. Formal credit is available through public and private commercial banks; national NGOs provide credit to fishers and fish farmers. It has been proposed that a dedicated aquaculture credit fund be established to provide loans with reasonable rates of interest and conditions specially tailored to fit the needs of fish producers and other value chain actors.

Value addition and marketing

The potential for upgrading the activities of fish producers in Bangladesh is considerable due to a number of limitations that currently affect the performance of fish farmers. These include: (i) high levels of competition and participation at each node of the value chain; (ii) lack of institutional organization and coordination among actors at individual value chain nodes; (iii) the exclusion of smallholder fish farmers from higher value markets due to limited access to information; (iv) lack of formal capital appropriate for the fish production system; (v) lack of enforcement of standards and policies to enhance fish production; (vi) widespread use of low quality inputs. At present there are limited prospects for adding value by processing fish, as customarily Bengalis prefer to purchase whole, unprocessed fish.

Food safety

Hygiene is generally poor throughout post-harvest value chains for fresh fish but people in Bangladesh are becoming increasingly concerned about food safety issues such as formalin and pesticide contamination. A variety of pesticides, including DDT, are used in open-air fish drying to protect against flies and other insects. Formalin is commonly used as a preservative to prolong the length of time for which unrefrigerated fish can be sold. Treatment of carps imported from India and Myanmar with formalin is particularly widespread. The Government of Bangladesh has approved the draft Formalin Use Control Act, 2013 to dissuade the misuse of formalin. Awareness raising programs for safe fish marketing have been undertaken involving the market management committees (MMC). Recently, sales of live fish at the city markets have increased, raising public concern about fish safety.



Background

Bangladesh is a small, low-lying country in south Asia, which is bordered by India except for a small border with Myanmar in the southeast of the country on the Bay of Bengal. After the creation of Pakistan in 1947, and a series of movements and uprisings over the next 24 years, Bangladesh achieved its independence from Pakistan in December 1972. After a military coup in 1975, two army generals' dictatorial regimes (1975–1990) followed during which time the country's economic growth rate did not rise above 4% (BBS 1981; 1991). After the fall of the army rule a democratic system returned and opened the door to the world economy. Although the country boasts a growth rate of 6%, inequality is high. About half of Bangladesh's population is employed in agriculture, another important sector for employment and GDP is the service sector.¹ The garment industry is the single most important foreign exchange earner.

Objective of the situational analysis on Bangladesh fish value chain

The main objective of this situation analysis is to review the circumstances in which, and how, the fisheries value chain in Bangladesh operates. This analysis is a systematic collection, and reviews the past and present data to identify and classify the trends, for the effective assessment of the functioning of the fish value chain in Bangladesh.

This analytical report highlights a wider national context for in-depth fish value chain assessments. It: (i) provides an overview of past trends, current status and the likely future directions in fish value chain of Bangladesh, and (ii) pinpoints the primary challenges and opportunities in the enabling environment of the country's fish value chain.

This report is focused on: (i) the production and production systems of fish and shrimp; (ii) the consumption and expenditure of households; (iii) the value addition and marketing system; (iv) the export and import of fish; (v) inputs and services such as fish health, fish genetics, feeds, knowledge systems, access to credit etc. (vi) food safety related to fish; (vii) the competitiveness of the fisheries sector; (viii) value chain governance; (ix) externalities; (x) aquaculture development strategies and activities; (xi) the research and development partnership; and (xii) a review of the opportunities for pro-poor fish value chain development.

Methodology used

This study used primary and secondary data from different sources to generate findings. Data was sourced from: Fisheries Resource Survey System (FRSS) of Department of Fisheries (DoF), report of the Household Income and Expenditure Survey (HIES) of Bangladesh Bureau of Statistics (BBS) and findings of different fisheries projects of DoF, Bangladesh Fisheries Research Institution (BFRI), Local Government Engineering Division (LGED), research papers of Bangladesh Agriculture University's fisheries faculty, Food and Agriculture Organization (FAO) of the United Nations,

1. Source: <http://www.unescap.org/stat/data/syb2009/17-Employment.asp>.

WorldFish research studies, review donor supported project reports of IFAD, Danida, USAID, DFID, World Bank and other development partners in the fisheries sector. Different NGOs, particularly BRAC, experiences of fisheries also provided valuable information.

Key informant interviews were conducted with fish wholesalers, fish selling agents and live fish sellers at Dhaka fish wholesale markets. The finding of this situation analysis will be useful to different stakeholders who are interested in developing a fisheries program in Bangladesh.



The product: Overview of Bangladesh fisheries sector

Bangladesh is one of the poorest and most densely populated countries in the world. More than 150 million people occupy the country's 147,500 km² of area and consume rice and fish as staple foods. Bangladeshi people are popularly referred to as 'Macche-Bhate Bangali' or 'fish and rice makes a Bengali'. Rice farming is the single most important livelihood for the vast majority of the rural poor. The demand for rice and fish is constantly increasing, with the population growing by more than 3 million people each year (BBS2010).

Historically, the country's natural water bodies were stocked during the monsoon through natural spawning. Fish farming had been a traditional practice in ancient India during the era of Hindu rulers before the twelfth century (Gatlin 2010). Many of the kings created ponds and tanks for drinking, bathing and sometimes for small-scale irrigation; these ponds and tanks were used for rearing fish for recreational (not commercial) purposes (FAO 2014).

Bangladesh has extensive and highly diversified fisheries resources. Fish play a crucial role in the diet and nutrition of its people. The fisheries sector has been playing a very significant role and has potential for future development of the agrarian economy of the country. Fishers and fish farmers play a vital role in collecting fishes from natural water bodies and culturing fish in closed and semi-closed water bodies.

This situational analysis of the Bangladesh fish value chain discusses the following aquatic species:

- native Indian carps (rohu, catla, mrigal and others)
- non-native carps (silver carp, common carp, grass carp etc.) and other carps
- tilapia and pangasius,
- catfishes (shing, magur)
- hilsha
- shrimp and prawns

Historically, most of these species (such as hilsha, rohu, catla) are popular with the people of Bangladesh and are accepted as a part of cultural life. Some non-native carps (silver carp), tilapia and pangasius were introduced for commercial culture over the last three decades; and have gained wide acceptance, especially by low-income people for its affordable price.

There are approximately 795 native species of fish and shrimp in the freshwater and marine waters of Bangladesh and 12 exotic species that have been introduced. In addition, there are 10 species of pearl-bearing bivalves, 12 species of edible tortoise and turtle, 15 species of crab and 3 species of lobster (FAO 2008). A total of 260 fish species have been recorded in the freshwaters of Bangladesh (Rahman et al. 2006) and 200 of these are truly freshwater species, while the remainders are examples of estuarine and marine species.



Consumption and expenditures

Per capita consumption and expenditure of fish

Fish is the most important animal source of food in Bangladesh, accounting for more than 60% of total animal protein intake (DoF 2013). BBS households survey 2010 found that in a two-week period, among the surveyed households, more than 98% of them consumed fish at least once/week, and 60% ate fish at least every second day. These figures emphasize the importance of fish in the Bengali diet. Household Income and Expenditure Survey (BBS 2010) shows that per capita per day fish consumption is 49.5 g, national fish consumption trending significantly upward during the period 2000–2010.

Table I shows the monthly total expenditure on major food items against that on fish in different survey years by resident households. In 2010, at national level, monthly expenditure on fish was BDT 827/household, an increase of more than 52% over 2005 and about 63% over 2000. In the last decade (2000–2010), disparity between rural and urban areas in terms of expenditure on fish increased by 3%.

Table I. Share of expenditure on fish among major food items by residence

Year	National		Rural		Urban	
	Total food Expenditure	Exp. on fish (BDT)	Total food Expenditure	Exp. On fish (BDT)	Total food Expenditure	Exp. On fish (BDT)
2010	6031	827	5543	706	7362	1156
2005	3209	394	3023	346	3756	530
2000	2477	309	2300	277	3175	434

Source: BBS (2010).

In 2010, urban households were spending about 39% more on fish than rural households, while the difference was 36% in 2000. Between 2000 and 2010, the share of fish expenditure against the total monthly food expenditure of rural households increased by 61%, while it was about 64% at urban households. The share of rural households' expenditure on fish was somewhat lower in 2005, although their total monthly food expenditure increased by 24% during that period.

Fish consumption patterns across rural and urban households

In 2010, per capita daily fish consumption was 49.5g or 18.1 kg yearly, an increase of 14.95% from 2005. There is a significant difference in fish consumption between rural and urban households. In rural areas, daily fish consumption was 45.8g while in urban areas this was 59.9g (BBS 2010). This was an increase of 13.3% and 17.2% over 2005 for rural and urban households, respectively.

Historically, Bengali people have a strong preference for fish. It is part of their custom and culture. The oldest largest community in this delta zone is Hindu. In Hindu culture and custom, fish plays an important role. Many of their customs have been adopted in the lifestyle of the resident Muslim community. Some of these common customs have been practiced in both rural and urban households.²

Fish consumption patterns across income class

Table 2 shows the monthly expenses on fish consumption in rural areas. In rural areas overall households spent about 51% more in 2010 on fish compared to 2005. The small landholding households increased their share of expenditure on fish in 2010 more, compared to larger landholdings. This is surprising, as BBS households' survey shows that as households' landholding increase, the share of expenditure on meat, poultry, eggs, milk, edible oil and fruits increases (BBS 2010). This suggests that the growth in fish consumption that occurred between 2005 and 2010 was pro-poor.

Table 2. Monthly share on fish expenditure by landholdings in rural areas

Size of land owned (acres)	Monthly average expenditure on major food items (BDT)	% of expenditure on fish 2005	% of expenditure on fish 2010	Change in expenditure on fish 2005–2010 (%)
all HH	5543	12.74	11.46	50.94
landless	4259	12.64	11.29	58.81
0.01–0.04	4314	11.44	10.17	55.81
0.05–0.49	5304	12.82	11.17	53.32
0.50–1.49	5927	12.88	11.24	52.15
1.50–2.49	6804	13.31	12.53	49.35
2.50–7.49	8247	13.38	12.54	49.33
7.50+	11014	15.30	13.61	49.87

Source: BBS (2010).

Fish consumption patterns by gender and age

Data on fish consumption by gender was not available. However, Bengali women and girls usually eat less fish than men or boys; this is the case for other protein-based food items such as eggs, milk, meat etc. According to a focus group discussion with a women fish farming group of Mohespur upazila, Jhinaidah district (organized by BRAC/DoF assisted by IFAD/Danida), this is especially the case for rural middle-class and poor households (Nathan and Apu 1998). Within most poor households, women's diets are less nutritious than those of men, and pregnant and lactating women are more vulnerable to problems caused by poor nutrition. The availability of fish, or the opportunity to purchase better quality food can have significant health impact (Islam 2013).

A survey was carried out in 2004 on fish consumption by a group of students from Bangladesh Agriculture University (BAU) in three villages of Netrokona district and three slums each in both Mymensingh and Dhaka. A number of survey techniques involving participatory qualitative and quantitative elements with 90 households covering different levels of socioeconomic status were conducted. Fish consumption was surveyed four times in the households during the 6-month period using 5-day recall methods. It was found that there was a significant difference among three surveyed areas. The villagers in Netrokona district consumed more fish than the other two slum areas. Slum dwellers in Dhaka consumed slightly more fish than the households of the Mymensingh slum. The head of the households always consumed the most fish, followed by the male children, and the female members consumed the least amount of fish (Mostafaet al.2004).

2. Pre-marriage functions such as panchini (a function at the bride's house where bridegroom's guardians were invited to finalize the marriage date and other issues), ghaya holud (colourful function arranged at both houses two days before the formal marriage ceremony). On that day the bridegroom-party visits the bride's house with sweets and large fish, usually rohu; coastal area people prefer catla). To date this custom is practiced in both Hindu and Muslim communities. After the wedding, whenever the bride's parents visit the couple's house, they bring gifts which usually include a large fish. On pohela boishak, the first Bangla calendar day, Bengalis like to cook different fish dishes for their family members. In rural areas pond owners undertake harvest on this day, distribute fish to their relatives and neighbours. For the last three decades, eating hilsha on pohela boishak has become an important part of the New Year's festival, especially in urban areas.

Quantitative data on difference of fish consumption between male and female household members are not available. An in-depth study on fish consumption disaggregated by gender is required.

Role of fish in diets

Fish is the most important animal sourced food in the daily diets of Bengali people, contributing over 60% of total intake (BBS 2010). Fish provides a good source of high quality protein and contains many vitamins. It contains energy, protein, fat, cholesterol, vitamin B12, phosphorus, selenium, omega, carbohydrates, calcium and essential amino-acids. The quantity of nutrients differs with type of the fish (Table 3). The protein content of most fish averages 15 to 20%. Fish proteins contain all the essential amino-acids and, like milk, eggs and mammalian meat proteins, have a high biological value (FAO2014b).

Table 3. Share of major food items in total food expenditure 2000, 2005, 2010(%)

Food items	Year		
	2010	2005	2000
Total monthly food expenditure (BDT)	6031	3209	2477
cereals	35.95	39.00	38.02
pulses	2.35	2.65	2.92
fish	23.71	12.24	12.48
meat and eggs	10.31	8.51	8.02
vegetables	7.79	8.38	9.21
milk/milk products	3.02	3.74	3.95
edible oil	4.35	4.25	2.71
condiments/spices	9.99	7.52	7.13
fruits	4.08	3.23	2.97
sugar/molasses	1.06	1.56	1.34
beverages	0.73	0.68	1.97
miscellanies	5.67	8.25	8.29

Source: BBS (2010).

Micronutrient-rich small indigenous fishes fulfil the nutrition demand of poor households, especially in rural areas. A number of fisheries related projects have focused on increasing the production of these species; those fishes are: mola, dela, darkina, chala, chapila, bata etc. (Akhter et al. 2013). Upper-class city people view these fish as delicious food items and recently the supply of these small indigenous species has been increasing in the big city markets of Bangladesh. Although for rural poor these fishes are almost free (they harvest them from ditches and canals, rivers, other open waters etc.), but they are expensive in city markets.

Role of fish in expenditure

Table 3.3 captures the monthly food expenditure pattern that households made in different years. Percentage share of expenditure of major food items is also presented in this table. In the three survey years, the pattern of share in food items is almost similar. Fish makes up the second highest expenditure of the households, after cereals.

In 2010, expenditure on fish was significantly higher than in the two other survey years; it incurred almost a quarter of the monthly expenditure on food items. During this period, fish price had not increased more than other food items. In fact fish price was almost stable during last 10 years or more except for the usual seasonal price rise during the month of Ramadan (holy period for Muslims) and the Bangla calendar month Falgoon (February) when many festivals, marriages, picnics and social gatherings are held.

Toufique and Belton (forthcoming) show in a recent study that between 2000 and 2005:

the real price of farmed fish fell by 9%—more than that of fish from any other source—while the price of inland capture fish fell 2%, despite a contraction in supply per capita of 19%. This suggests that substitution between farmed and inland capture fish took place, with rapidly expanding supply from aquaculture counteracting upward price pressure on inland capture fish.

Changes in preferences for fish

It is important to address the demand for fish for consumption for low-income group households, which is a large, expanding market in the growing economy of Bangladesh. Like other working-class people, a large number of women garment workers who work in the industrial sector have limited time to do housework and cooking. Pangasius and tilapia are popular with them as they are easy to process and cheap to buy, so they can afford to buy fish once or twice a week. Fisheries research has concentrated on developing low-value species that is reflected in the market. Farmers grow improved and fast-growing pangasius, tilapia, bata and koi and their presence in the consumer market has ensured essential nutrition support for low-income groups (Hussain 2010).

Fish gutting and filleting is a complicated job, usually carried out by women. In middle and lower-middle class households' women carry out this task and in upper-class households, domestic women workers carry out the fish processing. Recently, the rapid growth of garment and other industries which employ large numbers of women has created a situation where even domestic workers prefer not to process fish. As a result, fish processors (all male) are found at the markets at every city market. Some supermarkets, shops and fish suppliers began to sell processed fish but this has not yet received much support from customers, because they are unsure about the freshness of processed fish (Ahmed et al. 2012).

Bangladesh imports carp fish from India and Myanmar, which accounts for only 1.1% of total fish consumed (Belton et al. 2011). Fish exporters use formalin to protect them from rotting. Campaigns against formalin use are becoming stronger. With the assistance of concerned government departments and civil society, some markets have been declared 'formalin free' (Kabir and Monir 2013). People have now changed their buying strategy; they buy smaller size carps (less than 1 kg) because imported fishes are usually more than 1.5kg (personal communication from carp importers, Jatrabari, Dhaka).

There are new commercial initiatives of selling live fish as a new product type in fish markets; recently a group of fish sellers have been marketing live large-size carp fish. These are mainly available at big city markets and supermarkets at 60–70% higher than the normal price. Wealthy people buy from these markets as they are assured that the fish are formalin-free. Expansion of large-size live fish markets is limited, as it is not affordable for most people. Recently, fish suppliers have been addressing the demand for live fish from low-income group households, which are a large, expanding market in the growing economy of Bangladesh (Apu and Himel 2013). Findings presented in Table 4 were collected by visiting three retail fish markets of Dhaka during the peak morning and evening selling hours (December 2013). Most of the buyers in the evening were female garments workers and other daily workers.

Table 4. Demand for live or formalin-free fish by size, price and income class

Fish species	Size	Price (BDT/kg)	Buyers categories
pangasius, silver carp, tilapia	5–6 pes/kg	80–100	day labour, garment workers
Thai koi, small roi, catla, mrigal, bata, thai puti, taki	8–10pes/kg	120–150	lower-middle-class households
large-size koi and tilapia, thai puti and local shor puti	Koi 4–5/kg Tilapia 2–3/kg	180–220	middle-class households
roi, catla and mrigal, kalibaush, shol, ayr, boal	1–1.5 kg	250–350	well-off households
large roi, catla and mrigal, kalibaush shol, ayr, boal	2–5kg or more	500–800	well-off households
singh, marur, pabda, gulsha	20–25/kg	400–600	well-off and middle-class households

Source: Personal communication from fish markets at Mirpur, Mohammadpur and Hatirpol, Dhaka

Factors influencing trends in consumption

Recent World Bank data show for 2013 the population growth of Bangladesh to be 1.2%, total urban population is 29% of the total population, and rate of population growth in urban areas 2.9% (World Bank 2014). They show that GDP growth is 6.0%, is inflation 7.5%; and the current GNI per capita (Atlas method) is USD 900 (World Bank 2014). These trends in population growth, increasing income and rapid urbanization will influence food consumption, and particularly in relation to fish as it is the second most popular food item (in terms of expenditure) of Bengali people. The fish production review of Bangladesh shows that the average growth rate was 5.61%, (including imports and

exports), based on the last 10 years of production. This growth has remained stable over the last 10 years. However, in the last four years, the fisheries sector has showed better performance; during this period, average growth was 6.22% (Azad 2013).

Policies in place that influence consumer demand for fish products

In Bangladesh, poverty rates have been declining over the past decade (2000–2010), contributing a significant increase in people's purchasing power and an improvement in their access to basic foods. Aquaculture development is cited in the Bangladesh National Food Policy Plan of Action (2008–2015) as a way of addressing the increasing demand for food. The fish production review of Bangladesh shows that the average growth in the fisheries sector is 5.61% (including imports and exports), which remained stable throughout the past 10 years. This is an important indication of the ability of the sector to provide more protein for the people. Aquaculture has enormous potential in increasing production by adopting improved management. Policies and activities to boost aquaculture production in a sustainable manner for the nutritional security of the people have been initiated.

- A policy of 'repeated stocking and repeated harvesting' has been readily accepted by farmers; they report it to be a more profitable approach than harvesting once or twice yearly.
- Hybrid species of native popular fishes such as koi, sing, bata and crossbreed of carps etc. have been developed by fisheries scientists and researchers.
- Training has been organized for hatchery owners, nursery operators, fry traders and fish farmers for culturing hybrids.
- Technical and credit support for extension of culture of hybrid species throughout the country has been provided.
- Local skilled fisheries extension workers have been developed at village or union level.

Current policy issues on fish consumption

Natural resource management and aquatic biodiversity conservation are intrinsically linked. There are several management tools through which natural resources, including inland open-water fisheries, can be managed. In the long-run, this would have a positive impact on aquaculture. Activities such as: habitat restoration, establishing fish sanctuaries, implementation of the Fisheries Act and regulations, promoting selective gear use, encouraging fish-friendly structures and introducing endangered and threatened species, would all contribute to improving biodiversity via production. The Bangladesh Government has been implementing this strategy through 'Strategy for Conservation and Management of Wetland Biodiversity project' through Department of Fisheries (Sumon et al. 2013).

The impact of long-term trends in climate change is not well understood in the fisheries sector. Fishing-based livelihoods are subjected to a wide range of climate-related variability. From extreme weather events, such as floods, droughts, changes in aquatic ecosystem structure and productivity, to changing patterns and abundance of fish stocks. The Department of Fisheries (DoF) has taken initiatives to address the climate change paradigm through intervening programs such as: habitat restoration; establishment and rehabilitation of fish sanctuaries; introduction of saline tolerant and fast-growing species; expansion of aquaculture technologies suitable for flood/drought prone areas; expansion of cage and pen farming; beel nursery operation; and fingerling stocking programs. Various social safety net programs, such as the introduction of 'Vulnerable Group Feeding' and 'Alternative Income Generating Activities' and distribution of eco-friendly fibre-reinforced plastic boats, awareness and capacity enhancement of different stakeholders was initiated (Alam and Faruk 2013)

DoF has undertaken a research study for establishment of suitable techniques to reduce off-flavour in fish.³ Findings have been disseminated through farmers' training and general campaigns for fish traders and general people. Off-flavour in pangasius and tilapia is a common deterrent in Bangladesh for their marketing in spite of their huge aquaculture potential. It is evidenced that Geosmin and 2-Methylisoborneol (MIB) are responsible for creating off-flavour in fish, which has a negative impact on a large number of consumers. Both chemical analysis and sensory taste testing were undertaken to measure the level of off-flavour in pangasius and tilapia. The efficiency of three treatments—SandFilter, PondPlus and AquaPhoto (soil probiotics) were compared for the improvement of water quality parameters, AquaPhoto showed the best result. Twelve hours depuration technique was found to be useful for farmers (Mahmud et al.2013).

Conclusions regarding likely market growth scenarios

Fish has played a major role in the diet and nutrition of Bangladeshi people for generations. Almost everybody consumes fish at least once a week. It is a part of the Bengali culture. From the point of expenditure, fish is the second most popular food item of Bengali people. Consumption of fish has increased in the last decade (2000–2010). Households' average monthly expenditure on fish has increased by over 60%, although disparity between rural and urban households has widened. Urban households are spending more on fish than in the past. However, the quantity of fish consumed by rural poor households is more than that consumed by similar categories of urban households. This could be because of increased production from aquaculture, low prices at rural markets and free access to inland water bodies such as canals, floodplains, rivers etc.

Government policy is to provide more fish for people; it supports research strategies for improved strain species of native popular fishes. Such strategies include addressing the climate change paradigm through: habitat restoration, establishment of fish sanctuaries, and strengthening of the private sector and extension services.

3. Research conducted by Aquaculture Department, Patuakhali Science and Technology University in collaboration with RFLDC project, Barisal funded by Danida.



Production

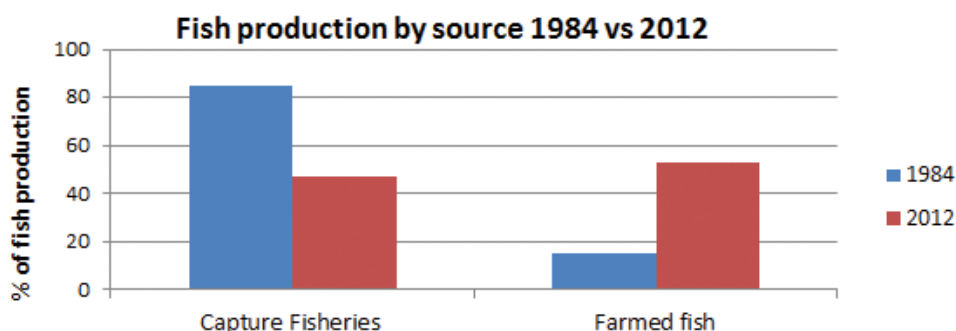
Bangladesh is a densely populated country of 147,570 km², with a population of 150 million people. It has extensive water resources in the form of ponds, natural depressions (haors and beels), lakes, baors, canals, rivers and estuaries, covering an area of 4.56 million ha (DoF 2005).

There are two types of aquaculture being carried out in Bangladesh: freshwater and coastal aquaculture; currently there is no marine aquaculture production. Freshwater aquaculture comprises mainly of pond aquaculture, especially the polyculture of both native and exotic species. Coastal aquaculture is comprised mainly of shrimp farming.

Historically, people depended mainly on natural waters for fish supplies, but people began to culture fish in enclosed waters because of declining catches of wild fish due to an increased fishing effort by the growing population and the effects of environmental degradation. The polyculture of major and exotic carps and monoculture of pangasius, Nile tilapia and, to some extent, catfish are the most widely practiced culture systems in Bangladesh. Three Indian major carps, *Labeo rohita*, *Catla* and *Cirrhinus mrigala* and one exotic carp, *Hypophthalmichthys molitrix* (silver carp) now account for more than 78% of total pond production (DoF 2013).

Bangladesh has huge inland water resources with a wide range of natural variations. The share of inland capture fisheries has markedly declined over the last three decades mainly due to resource degradation. Figure 1 shows the fish production scenario by sources: capture and culture fisheries, 1984 vs. 2012. In 1984, the contribution of capture and culture fisheries to total fish production were 85% and 15%, respectively; whereas in 2012, capture fisheries contributed 47%, while culture fisheries contributed 53% to total production.

Figure 1. Share of fish production by production source, 1984 vs. 2012.



Source: DoF (2012).

Systems of production

In Bangladesh, it was anticipated that carp polyculture at the individual smallholder level had the greatest potential for intensive culture systems, using fertilizers, supplemental feeding and improved management practices (Gupta and Acosta 2004). By the end of the 1990s, government and private donors began to focus their support on smallholder

projects to intensify aquaculture production.⁴ But in reality, most of the expansion in production has taken place as a result of intensive commercial aquaculture, not through intensification of homestead ponds (Belton et al. 2011). Current annual average fish production using pond culture has reached 3615 kg/ha (DoF 2012).

Farmed fish is produced in the following systems in Bangladesh: pond culture (homestead and commercial), seasonal floodplain aquaculture, rice–fish culture, cage culture, and gher culture (shrimp/prawn in coastal areas). Freshwater pond farming has been at different stages of fish culture, it depends on the level of investment and the knowledge of fish culture. Table 5 shows the different systems of pond fish farming which have been practiced in Bangladesh (FAO 2014a). ‘Numerous projects have promoted simple improved management strategies, such as regular application of fertilizers and feeds, and the stocking of fish species in combinations and stocking densities designed to move the production system from extensive to semi-intensive’ (Belton et al. 2011).

Table 5. Descriptions of freshwater pond farming systems in Bangladesh

Farming systems	Farming practices
extensive	Stocking with 3 Indian major carp species, no fertilization and feeding.
improved extensive	Stocking with 3 Indian major and 3 exotic (silver, common and grass) carps, irregular use of fertilization (mostly cow dung) but without feeding. Silver barb is also occasionally stocked.
semi-intensive	Stocking with 3 Indian major and 3 exotic carps or monoculture of striped catfish. Regular use of fertilizer (both organic and inorganic) with occasional use of supplemental feed consisting of rice bran and oil cakes. Silver barb is generally stocked as well as freshwater prawn and Nile tilapia.
intensive	Monoculture of striped catfish, tilapia, koi, shing, magur. Regular feeding with commercially manufactured pellet diet.

Source: FAO (2014a).

Production from freshwater pond farms using different pond farming systems

Table 6 shows the fish production status of 2013 from ponds adopting different production systems. High intensive culture methods have been practiced mainly by commercial large fish producing farms, covering an area of about 11,400 ha (less than 1% of total pond area); average production is about 19t/ha. These water bodies are mainly located at Mymensingh (Trihal upazila), Dhaka (Saver upazila), Natore and Comilla districts. Dominant culture species are pangasius and koi. Saver and Natore mainly supply live fish to Dhaka city markets. However, most of the pond farming production of the country is generated from semi-intensive systems, contributing over 46% of the country’s annual fish production from pond culture, and covering about 60% of the total pond farming area. Average production is over 2.8t/ha. This indicates that there are immense opportunities for increasing production from ponds using improved technology and with financial support, especially for low-income households.

Table 6. Fish production in ponds by system

Pond culture method	Production range (t/ha)	Area (ha)	Production (t)	Productivity (t/ha)	% of production
extensive	<1.5	50,193	65,014	1.295	5.84
semi-intensive	1.5–4	219,307	621,525	2.834	46.30
intensive	4–10	88,806	439,181	4.945	32.72
highly intensive	>10	11,399	215,352	18.892	16.05
derelict ponds*		1,604	1,210	0.754	0.09
total		371,309	1,542,282	3.615	100.00

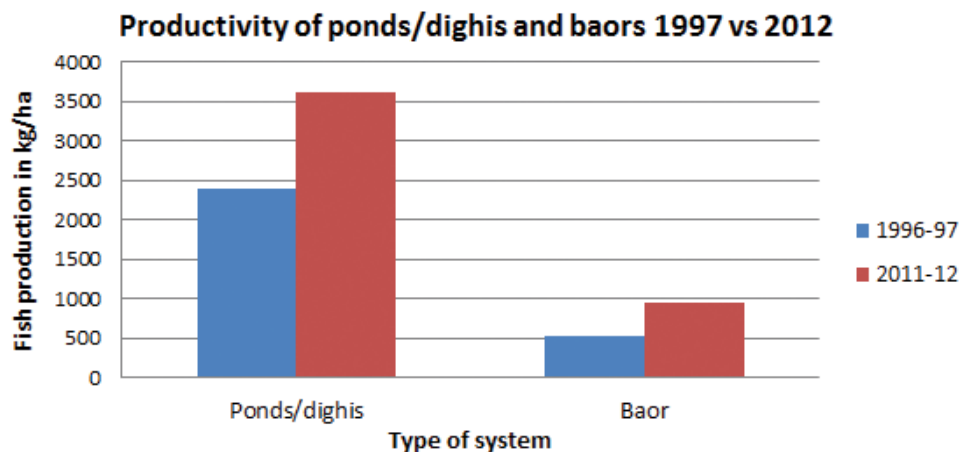
Source: DoF (2012). Note: These ponds are completely dry in the winter season (Nov–Feb).

4 . IFAD supported AqDP in the southwest part of the country; Danida supported projects in Mymensingh, Patuakhali, Bargun and Greater Noakhali; World Bank supported Fourth Fisheries Project in the remaining districts of the country.

Fish production from pond/dighis and baors

Figure 2 shows the improvement of fish production from ponds/dighis and baors in 1997–2012. Since 1990, fish production has been increasing; the current rate of increase is 6.54% (DoF 2012).

Figure 2. Productivity of different types of production systems, 1997 vs. 2012.



Source: DoF (2012).

In Bangladesh, there are 146,890 ha of ponds and dighis and 5488 ha of oxbow lakes (baors). In 1996–97, average fish production in ponds and dighis was about 2400 kg/ha and in baors it was 540 kg/ha. In 2012, after 15 years, fish production has increased to 50.6% and 75% from ponds/dighis and baors, respectively.

Fish production in these water bodies could increase further through the adoption of improved culture methods. The following issues are important in increasing fish production using modern technologies.

- Appropriate studies are required to assess the impact of exotic fish on our native species and the environment. Only those exotic fish that show positive results would be promoted for culture.
- Union-based demonstration farms need to be established with the assistance of the private sector, for the dissemination of aquaculture technologies.
- Female participation in fish culture and marketing must be enhanced. Women’s role in the fish value chain should be properly defined (Apu and Himel 2013).

Production volumes status and trends

Table 7 shows the volume of fish production from the last 12 years by sector. Inland culture fisheries has increased by 62%, while in-capture fisheries increased by 30%. Of the total inland culture fisheries production of 2012, pond aquaculture contributes about 78%, followed by shrimp (11.4%) and seasonally cultured water bodies (10.6%). Of the total catch from inland capture fisheries, production from floodplains contributes 73%, followed by catch from rivers and estuaries (15%) and beels (9%).

Table 7. Sector-wise fish production in Bangladesh, 2000 vs. 2012

Sector of fish production	Production (t) 2000	Production (t) 2012	Increase in production (t) 2000–2012	Change in production 2000–2012 (%)
Inland capture	670,465 (40.4%)	957,095 (29.3%)	286,630	+42.75
Inland culture	657,120 (39.6%)	1,726,067 (52.9%)	1,068,947	+162.67
Marine fisheries	333,799 (20.1%)	578,620 (17.7%)	244,821	+73.34
Total production	1,661,384	3,261,782	1,600,398	+69.33

Source: DoF (2012).

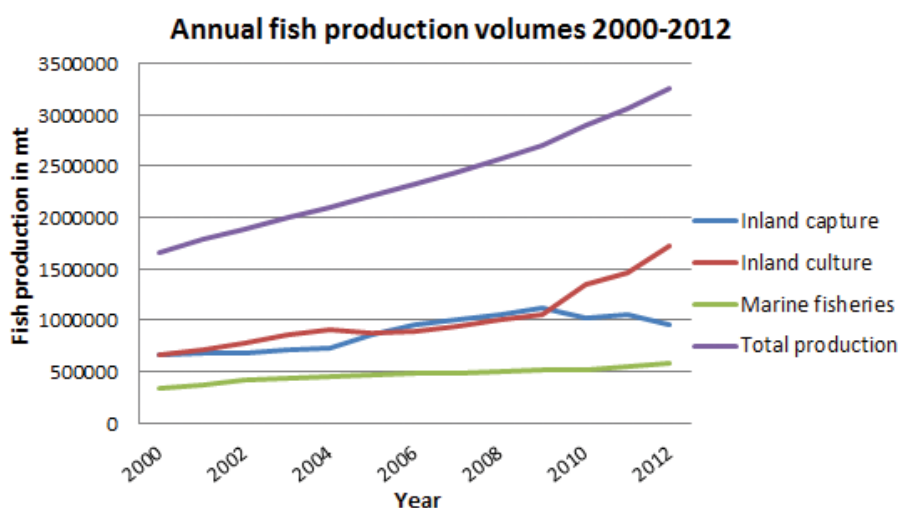
Although floodplains have been contributing significantly in capture fisheries but since 2009 showing a decline in catch, which could be of converting huge floodplain area in to season cultured water body.⁵ Catch from rivers and estuaries was dominated by six principal rivers⁶ (about 79% of the total catch from rivers and estuary); lower Meghna alone contributes about 69% of the total catch from river and estuary. The total catch of hilsha (346,512 t) contributes 33% to the annual catch of inland capture fisheries and 66% to marine fisheries (DoF 2013). As much as 60% of the hilsha in the world are harvested from the rivers and estuaries of Bangladesh (Roy and Habib 2013).

In Bangladesh, inland pond culture accounted for almost 86% of the total recorded aquaculture production (Belton et al. 2011). Pond aquaculture is dominated by production of carps. Pond culture is commonly practiced all over the country while *gher* culture and seasonal floodplain aquaculture are limited to a few districts. In Bangladesh, generally carps are considered high sale products that are afforded by only upper and middle class people. However, price of non-native carps are comparatively lower, of them silver carp is cheaper. Apart from that, the two most important species cultured in ponds are tilapia and pangasius. These species are cheaper, lower middle class and poor people have easy access to these fishes. Current average pond production is about 3.62 t/ha (DoF 2013). Production of commercial semi-intensive and intensive fish farm (species: pangasius, Nile tilapia, koi etc.) is very high; smaller farms produce an average of 40 t/ha, while larger farms obtain yields as high as 60–70 t/ha (Edwards and Hossain 2010).

Shrimp and prawn production in *ghers*⁷ take place in south and southwestern Bangladesh. For commercial shrimp culture, the country mainly depends on black tiger shrimp or bagdha (*Penaeus monodon*) and sweet water Goldha shrimp (*Macrobrachium rosenbergii*). Currently shrimp production has increased to 196,306 t (713 kg/ha). Moreover, shrimp harvested directly from seawater has also increased. Shrimp is one of the important export items of Bangladesh; it contributes 80% of the total export earning of the fisheries subsector (EPB 2011). The shrimp sector is expanding and provides economic opportunities for those controlling each node of the value chain, in addition to numerous lower value livelihood opportunities for the rural poor, who are the overwhelming majority of value chain participants (Belton et al. 2011).

Figure 3 shows the trend of annual fish production by sectors during the period of 2000–2012. Since 2009, growth in culture fisheries has been increasing, although there has been a decline in capture fisheries since then. In 2009 and 2012, annual production from culture fisheries increased by 38.4%, while capture fisheries declined by 17.4%.

Figure 3. Trends in annual fish production volumes by sector, 2000–2012.



Source: DoF (2012).

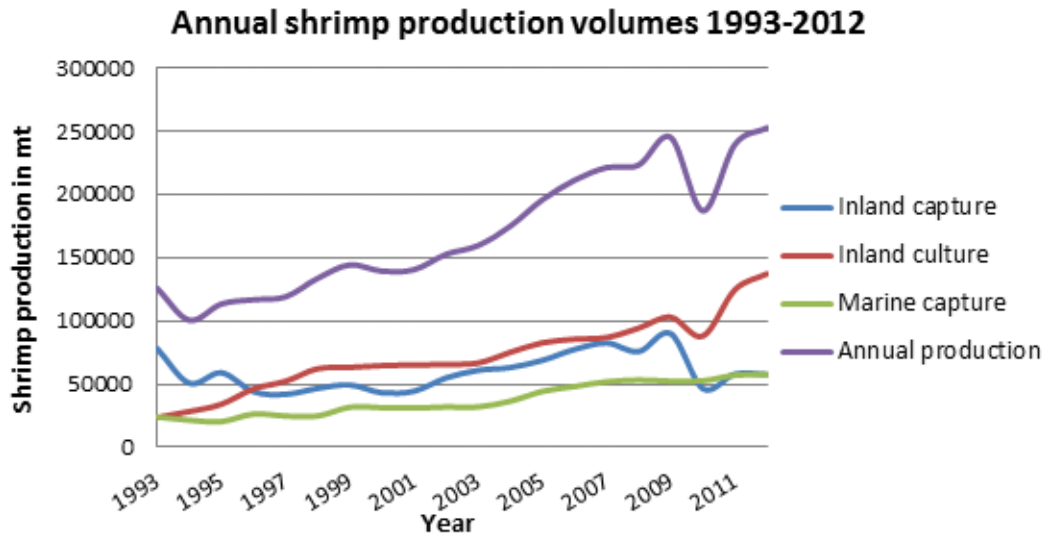
5. Recently 122,026 ha (or over 4% of the total floodplain area) is converted into seasonal cultured waterbodies for modern aquaculture systems, i.e. the total area of 'seasonal cultured water bodies'.

6. Lower Meghna, upper Meghna, lower Padma, upper Padma, Jamuna and Brahmaputra.

7. Shrimp and prawn production in Bangladesh mainly takes place in converted rice fields known as *ghers*. These *ghers* are usually connected with estuaries and canals by sluice gates, which allow farmers to manage the flow of brackish or tidal water.

Figure 4 shows shrimp production during 1987–2012 in Bangladesh from different sources of capture and culture. Bangladesh has not yet introduced marine shrimp culture. Growth of inland shrimp culture increased from 1994. It was however in decline during 2009–2010 because Bangladesh shrimp processing companies did not export as they did not comply with the international quality standards. Shrimp capture showed the most fluctuations, while the marine catch showed an increasing trend although it was relatively low.

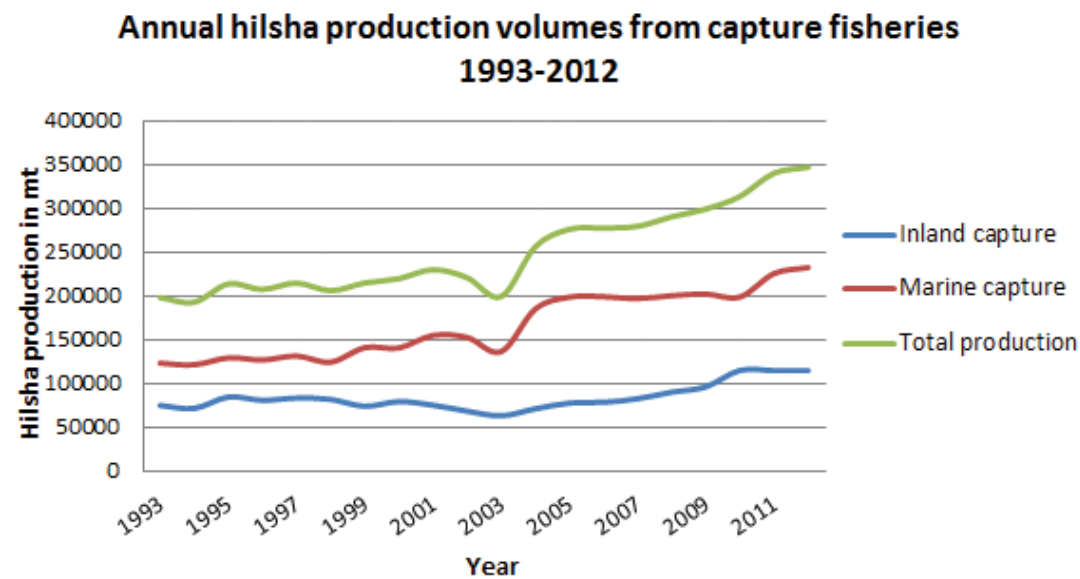
Figure 4. Year-wise shrimp production by different sources in Bangladesh, 1987–2012.



Source: DoF (2012).

Figure 5 shows annual hilsha catch from inland and marine sources from 1987 to 2012. The marine catch of hilsha was always higher than the inland catch, except during 1989–1991. However, the marine catch declined during 2002–2003, and has been achieving steady growth to date, which is significant for the country’s hilsha production. Since 2008, the inland catch has increased. This could be due to a number of initiatives motivating professional hilsha fishers, and preventing them from catching juvenile hilsha (*jatka*) in the peak breeding season.

Figure 5. Annual hilsha production in Bangladesh, 1993–2012.



Source: DoF (2012).

Structure of the production node of different systems

Table 8 shows the value chain node of inland culture fisheries, excluding shrimp and prawn culture. Of the total carp hatcheries, 81 have been operated by the government, with annual hatchling production of 9222 kg, contributing only 1.4%.

Table 8. Overview of the carp sector in Bangladesh

Production node of cultured carp fisheries	Number/size/volume
Number of carp hatcheries	983
Annual carp hatchling production (artificial)	6,46,936 kg
Annual carp hatchling production (natural)	4093 kg
Number of carp nurseries	9452
Annual fingerling production from of nurseries	9.6 billion
Total area of culture fisheries (pond+baor+seasonal floodplain)	498,823 ha
Annual total production of cultured fisheries *	1,529,761 t

Source: DoF (2012).

Note: *87.7% from pond, 12% from seasonal water bodies and 0.3% from lakes.

Of the total annual carp hatchling production, hatchling from natural sources is only 0.63%. Private hatcheries are the main actor for culture fisheries. About 88% of culture fisheries production comes from pond culture, which is about 47% of annual fish production of the country.

Table 9 shows the value chain node of the production of shrimp and prawn farms. Of the total number of shrimp/prawn hatcheries, 17 were operated by the government, with annual production of 0.3 million post larva (PL), while collection from natural source contributing 8.7%. Of the total shrimp/prawn production, about 53% is from black tiger shrimp (*Penaeus monodon*, locally known as *bagda*) or freshwater prawn (*Macrobrachium rosenbergii*, locally known as *golda*) and about 32% is comprised of carp and other fishes. Of the total shrimp production of the country (2012), over 54% is produced from shrimp farms, as opposed to 20% in 1987.

Table 9. Overview of the farmed shrimp/prawn sector in Bangladesh

Production node of shrimp/prawn farms	Shrimp/prawn
Number of bagda hatcheries	61
Annual PL (post larva) production of bagda	8,200 million PL
Number of golda hatcheries	70
Annual PL (post larva) production of golda	1,250 million
Annual PL collection from natural source	900 million
Total area shrimp/prawn farms	275,232 ha
Annual total production of the farms*	196,306 t

Source: DoF (2012).

Note: *of the total production 30% is bagda, 23% golda, 15% other shrimp/prawn and 32% from other fish.

Table 10 presents the details of the annual fish production by sector, inland culture, inland capture and marine fisheries of 2012; and Figure 6 shows the productivity of different types of water bodies by culture and capture fisheries.

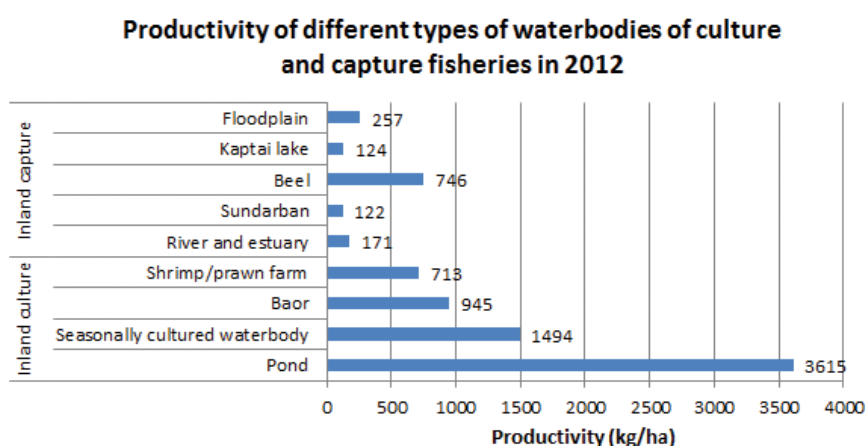
Table 10. Sector-wise annual fish production in Bangladesh, 2012

Sector of fisheries	Water area(ha)	Total production(t)	Production(kg/ha)
Inland fisheries			
Inland closed water (culture)			
Pond	371,309	1,342,282	3615
Seasonal cultured water body	122,026	182,293	1,494
Baor	5488	5186	945
Shrimp/prawn farm	275,232	196,306	713
Cultured fisheries total	774,055	1,726,067(52.92%)	
Inland open water body(capture)			

Sector of fisheries	Water area(ha)	Total production(t)	Production(kg/ha)
River and estuary	853,863	145,613	171
Sundarban	177,700	21,610	122
Beel	114,161	85,208	746
Kaptai lake	68,800	8537	124
Floodplain	2,710,766	696,127	257
Capture fisheries total	3,925,290	957,095(29.34%)	
Inland fisheries total	4,699,345	2,683,162(82.26%)	
Marine fisheries			
Industrial (trawl)		73,386	
Artisan		505,234	
Marine fisheries total	166,000 km ²	578,620(17.74%)	
Country Total		3,261,782	

Source: DoF (2012).

Figure 6. Productivity of water bodies—culture and capture in Bangladesh, 2012.



Source: DoF (2012).

Employment in fisheries production

Table 11 shows the employment in fisheries sectors, culture and capture fisheries (including marine). It is estimated that the entire fisheries sector⁸ supports livelihoods of more than 16 million people (about 11% of the total population), directly and indirectly, including: carp hatcheries, nurseries, fingerling traders, fish farmers, shrimp farmers, workers in shrimp processing units, PL collectors, fish traders, wholesalers, transport workers, fish exporters, service providers and fishers of capture fisheries (Azad 2013). About 92% of them were employed in the aquaculture subsector, of which, just 6% were involved in the shrimp sector, which included farmers, traders and processors.

Table 11. Employment in the fisheries sector

Employment in fisheries by sector	Number
Total employment in the fisheries sector	16,013,000
Total employment in aquaculture	14,697,000
Fish farmers	13,864,000
Shrimp farmers	833,000
Total employment in capture fisheries	1,316,000
Inland capture fisheries	800,000
Marine capture fisheries	516,000

Source: DoF (2013).

8. Person involved in production, processing, marketing, transport workers and service providers.

Of the total employed in capture fisheries (over 1.32 million), about 39% are engaged in marine fisheries. It is reported that about 0.5 million traditional hilsha fishers' livelihoods (38% of the total capture fisheries employment) directly depend on the hilsha catch (DoF 2012). More than 2.5 million people directly depend on hilsha through transporting, marketing, net and boat making, and exporting (Roy and Habib 2013).

Gender in aquaculture value chains

In Bangladesh, much of the visible work is carried out by men in both aquaculture and capture fisheries. Female participation is almost absent in large aquaculture government and privately owned farms or fish hatcheries. These commercial aquaculture farmers are generally some distance from the homestead, which limits the scope of female participation. In the mid-1990s, groups of women were encouraged to participate in fish culture in homestead ponds with the support of NGOs and some private entrepreneurs. However, several studies indicate that: 'women's sphere of participation in fish culture is restricted to feeding and fertilizing ponds' (Barman 2001). It has also been reported that 32 homestead hatcheries in Jessore city are producing huge volumes of hybrid magur and koi fry, and all the work is undertaken by family members, mainly women and girls (Apu and Himel 2013). It is likely that these types of initiatives may be found in other parts of the country.

In 1994, under an initiative by IFAD and Danida, the government transferred newly excavated ponds on government land in the vicinity of the lakes to women under the Oxbow Lakes project (OLP-II); and granted user rights to women, as part of the government's overall policy of promoting gender equality. Women were given user rights to the ponds, which were renewable for a period of 10–50 years at a time. A study conducted in 1998, just after completion of the project, noted that women took up most functions, except for harvesting fish and working as night guards. It was encouraging to note that the women were able to interact confidently with officials and traders. The women who managed the ponds were from poor families, and many of them were single, abandoned by their husbands, or widows. In 2002 post-project visits found that there was intense conflict over control of the ponds, which had become profitable enterprises. Some women's groups were compelled to lease out the ponds to locally influential people. In most cases, in 2002, women only received BDT 1000/year for leasing the ponds, while the net income from carrying out fish culture on these ponds would have been BDT 4000/pond per year. In 2008 it was found that, in some villages, women had been able to regain some ground. Women did not renew the lease to local elites, and either operated the pond jointly or assigned it to one of the group members. Taking back their fish culture doubled or tripled their income, compared to leasing out the pond. However, women still faced problems in establishing their user rights over the ponds allotted to them by the government (Nathan and Apu 1998; 2002; 2007).

Although accurate data on the number of females participating in the aquaculture sector are not available, women are known to dominate the following sectors: processing factories, homestead pond culture; shrimp PL collection from rivers and coastal areas; soil preparation and dike repair of shrimp ghers. Apart from these activities, women undertake most of the work in dried and salted fish processing.

Shrimp value chains

Women are excluded from the most profitable activities in the shrimp value chain because of gender norms, such as their lack of assets and capital, restrictions on their spatial mobility and their inability to interact with other chain actors.⁹ On the other hand, poor women and girls are active at the bottom of the shrimp value chain in large numbers. In common with women in other global value chains, the informality of Bangladeshi women's employment in the shrimp sector means they are especially vulnerable to changes imposed by upstream actors. Belton et al. (2011: 31) state: 'it is unclear whether the greater employment opportunities for rural women associated with shrimp aquaculture have empowered them, have exposed them to new forms of exploitation, or both.' This ambiguity is reflected in the studies reviewed here.

9. The remainder of this section is directly derived from a 2013 literature review: Terry (2013).

Our priority is to improve the terms of the employment of women in shrimp processing factories so they can derive more benefit from the value chain. This might be achieved through ‘top-down’ and ‘bottom-up’ strategies, although there is ambivalence in the literature regarding the outcomes of quality standards and certification. Female fry fishers need help to leave the value chain and find other livelihoods.

In the literature on the shrimp value chain, the focus is on actors in terms of their individual participation in the chain (for instance as workers), without illuminating other aspects of their identity, their social relationships and how these shape their involvement. In Bolwig et al.’s (2010) words, the literature does not focus enough attention on the horizontal social dimensions of the shrimp value chain.

Homestead pond aquaculture

Women make significant contributions to managing homestead ponds, and there is a positive association between their involvement and higher productivity. There is evidence that household fish consumption is higher in places where the ponds are being operated by women, although there is a noticeable lack of gender-disaggregated data on fish consumption.

Despite the benefits which come from women’s participation in aquaculture, it is still much lower than men’s, because of the socio-cultural context. While women’s involvement in managing homestead ponds has given them a stronger voice in household decisions, their empowerment has been limited. A common view emerging from the literature is that small-scale aquaculture is suitable for women because ‘it is largely a homestead-based activity that integrates well with prevailing cultural norms’ (Jahan et al. 2010, 492). In other words, aquaculture is often seen as an entry point for supporting women’s empowerment precisely *because* it does not challenge gender norms. While this approach has had some successes, it has not facilitated strategic transformation in rural women’s status, for instance through enabling married women to control, or at least to have an equal say in, productive assets such as ponds. Without such a change, it is likely that gains in productivity and nutrition will remain limited. In this scenario, the expansion of commercial aquaculture with decent work opportunities for women might be a more effective way to improve food security and support women’s empowerment, than a continued focus on developing homestead aquaculture.

Knowledge gaps on gender and aquaculture value chains

Terry’s (2013) literature review identified some excellent and insightful studies. However the literature it reviewed was only a small subset of a much larger body of studies and project evaluations that do not disaggregate data by gender. This represents a wasted opportunity for building knowledge of the gender ramifications of aquaculture in Bangladesh. Gender academics, program practitioners and activists need to continue to advocate for gender disaggregation in research as a matter of course, crosscutting other variables such as wealth rank and household headship. The lack of up-to-date gender-sensitive research is even more marked than it may seem at first glance, because it is common for recently published studies to be based on data collected from several years ago. Moreover, several studies which have a gender perspective fail to aggregate women according to axes of difference such as household headship. Given the scale of the Bangladesh aquaculture sector, its potential for expansion and its strategic importance for national food security and exports, the scarcity of rigorous research with a strong gender perspective, especially on the issues of consumption and nutrition, is a serious problem.

In the shrimp sector, there is a pressing need to update research on female fry fishers and workers in processing factories. There are several important research questions that should be pursued.

How are the associated trends of declining shrimp-fry stocks, and moves to using hatchery-produced fry, affecting female fry fishers and their families’ food and nutrition security? Is the reported decline in the availability of snails for feed likely to have a significant impact on women’s employment?

What are the gender-specific issues that affect girl and boy children involved in fry fishing and processing factories?

- What, if any, efforts are being made (either by government agencies or NGOs) to help female fry fishers find alternative livelihoods or to assist women in processing factories to have a voice with management? Are there any success stories that can serve as models?
- What standards and certification schemes include gender and employment issues? What can be learned from the Natural and organic shrimp scheme and other certification schemes about using value chain governance mechanisms to improve women's participation and benefits?
- Many female workers in processing factories have come from other parts of the country. What combinations of 'push factors', 'pull factors' and individual agency have brought them into the sector? How does their employment affect their intra-household relations and vice versa?

The priority research questions for inland aquaculture for household and domestic consumption are outlined below.

- What factors prevent women from harvesting cultivated fish? What strategies (i.e. the development of appropriate technologies) could be used to overcome these barriers and enhance women's benefits?
- To what extent do women and girls benefit from increased fish consumption compared to men and boys, particularly in cases where aquaculture increases their workload and thus their nutrient requirements? What are the reasons underlying any gender differences in fish consumption and nutrition within households and what factors influence any variations?
- Are there examples of women controlling productive resources related to aquaculture in Bangladesh? What lessons can be learned from these examples?
- Are there any examples of the gender division of labour being modified in communities in order to enable women to participate in aquaculture, or as a result of their participation? What can be learned from these experiences?
- What are the costs to women for their participation in aquaculture, for instance in terms of other livelihood opportunities lost, higher workload and fatigue, lack of childcare, reduced social interactions, leisure time and sleep?
- Why do the findings on the effects of women's empowerment vary in different studies? There is a need for studies with robust comparative designs to illuminate this point.
- What are the likely gender outcomes, in terms of opportunities and costs to women, of expanding commercial aquaculture?

It is hoped that this guidance will help to develop a research agenda with the ultimate aim of ensuring that the gender gap in terms of benefits from aquaculture in Bangladesh is reduced.

Factors that have influenced trends in production

The growth of the hatchery sector and the availability of formulated feeds are the key factors that have influenced fish production. The Government and the private sector have been implementing the following strategies that have generated positive impacts on the production of fish.

The scientists of Bangladesh Fisheries Research Institute (BFRI) have developed hybrid species. Priority was given to culture-based fisheries converted from floodplains which have already shown encouraging results.

Intensive training was organized for male and female members of the pond operating households. Priority has been given to homestead ponds, most of those had been previously used for fish culture.

Introduction of community-based management for seasonal floodplain fisheries although new, and implemented in different parts of the country has proved to be successful in maintaining the biodiversity of the natural resource.

A long-term strategy plan has been developed for the fisheries sector of Bangladesh indicating the importance of this sector for employment creation and nutrition support.

Policies in place that influence production

In the past decade, the Government of Bangladesh implemented a number of fisheries development projects that support and encourage commercial fisheries in seasonal cultured water bodies converted from floodplains. Significant improvement has already been made in enhancing fish production from inland culture fisheries. During 2002–2006, Jessore hatcheries (southwest region) faced a serious crisis of inbreeding to keep themselves in the market. The Fisheries Policy was introduced in 2010 to require registration of fish hatcheries on an annual renewal from DoF for maintenance of quality seed production and management.

The Government of Bangladesh has given priority to improving the biological management of fisheries to restrict the declination of resources and enhance production. This involves hands-on training, combined with technical assistance at farmers' level and includes a policy to strengthen research in introduction of hybrid and improved species in culture fisheries suitable for the local environment.

The government has quickly responded to the climate change paradigm by intervening in habitat restoration, establishing fish sanctuaries, introducing saline tolerant species and expanding pen and cage culture to increase fisheries production. Emphasis has been given to technical training for aquaculture for pond-owning households, with special attention aimed at women members of targeted families. Farmers in the fisheries sector are calling for a better policy that helps them get access to affordable credit from commercial banks and micro-finance institutions (Golzar et al. 2012).

Floodplain capture fisheries are mostly seasonal. The seasonal flooding of river floodplains, and their lakes (beels), are the most important factors in determining river fish production. Many people live along and around rivers and floodplains. When inundated, the plain contains a rich mixture of habitats that provide shelter, breeding, nursery and feeding sites for a variety of fish species. For example in Bangladesh, fishers target fish when these enter flooded plains at the beginning of the floods to spawn. After the retreat of the floodwaters, the residual waters on floodplains are heavily fished. The fishing is usually indiscriminate, with the removal of all fish, which is over exploitation of natural resources. That is why fishers living in the vicinity of the water bodies need to be involved in their management (Hoggarth et al. 1996).

In 2009, the government approved a water body management policy, which focuses on the floodplains of the country. The policy ensures that all water bodies are managed by fishers. Establishment of fish sanctuaries by fishers facilitates integrated natural resource management and conserves biodiversity, which would revive extinct native species. The government has set a target of an increase of 20% in floodplain fishers' income by 2015.

Current policy issues under debate regarding development of fish production

In Bangladesh, aquaculture is increasing massive, yet open water resources are largely ignored by development planners and their partners. The stakeholders in the fisheries sector aim to achieve direct cost/benefits from fish, and aquaculture is the best option for investment. Large areas of wetlands such as beels, floodplains etc. are being converted into lakes or ponds that downgrade the natural resource and change its characteristics; causing an imbalance in the ecosystem. How do we prioritize immediate production increases by expanding aquaculture, when it might place biodiversity at risk? Moreover, the culture of exotic species such as tilapia, pangasius etc. in wetland areas destroys the natural habitat of small indigenous species, degrades biodiversity of the wetland and hampers the livelihoods of the fishers' communities living in their vicinity.

Appropriate policies for aquaculture practices protecting the wetland biodiversity are essential. Interestingly, there are no policies for preserving the biodiversity of running waters, rivers and other water bodies, with the exception of auction policy for exploiting fisheries resources. The initiatives undertaken for participatory management of open waters have largely resulted in enhancing the catch; conservation of biodiversity has not been prioritized by participating communities. A well-balanced policy to enhance fish production in wetlands is required.

Implications of fish production trends in the value chain

Fish production is among the priority areas of the National Food Policy Capacity Strengthening Program of Bangladesh. Fish farming has emerged as one of the most promising enterprises in the fish value chain. In the last two decades, the government and development partners for culture fisheries have contributed substantially to fish farming. In recent years capture fisheries have shown a declining trend, with a modest growth in marine fisheries. As a result, promotion of culture-based fisheries and large-scale stocking of floodplains and beels (lakes) that previously sustained the capture fisheries was planned. Currently, aquaculture is providing more than half of the country's fish production. Government policies have been supportive to increase aquaculture, which has immense potential to enhance its production in the future.

Bangladesh is also trying to maximize benefits from capture fisheries, now that they are in decline. Its policy is to ensure a satisfactory level of equity in distribution of benefits and protection of the ecosystems. Climate change could have affected capture fisheries production. As a result, there have been a number of activities undertaken to enhance production such as habitat restoration, establishment fish sanctuaries, introduction of endangered and threatened species etc.

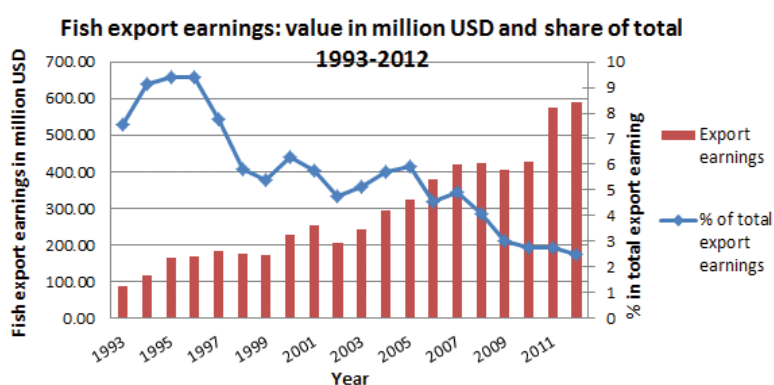
The culture and capture fisheries sectors of Bangladesh has a male-dominated workforce. Women's participation is restricted to homestead pond farming, shrimp PL collection from rivers, fish drying process and net making and repair. Women's work is mostly unacknowledged and is considered to be part of housework and is unpaid. Women empowerment in the fisheries sector is an area that deserves the attention of policy makers and planners.



Imports and exports

Both fish imports and exports in Bangladesh are very low. Of the total fish production of the country, approximately 97% is marketed internally for domestic consumption while the remaining 2.84% is exported (EPB 2013). It is estimated that about 46,800 t of fish is imported (DoF 2013), which is 1.6% of the total current fish demand of the country. Bangladesh's fish export earnings grew from an estimated about USD 7000 million in 1993 to about USD 47,040 million in 2012, of which shrimp and hilsha are the major export earners of fish.

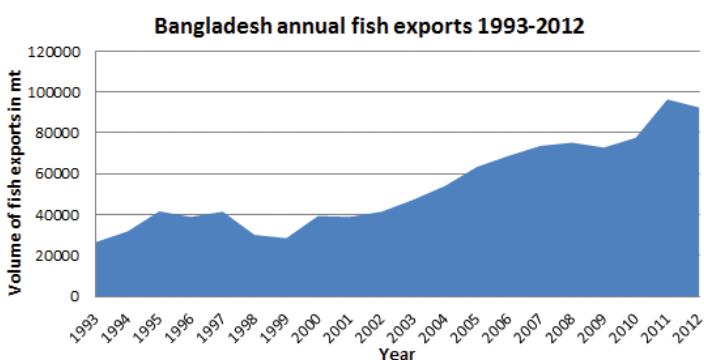
Figure 7. Value of total fish export earnings and share in total export, 1993–2012.



Source: DoF (2013).

Private companies in Bangladesh have been exporting fish to different countries in different forms such as frozen shrimp/prawn, live fish, frozen fish, chilled and dry fish, salted/dehydrated fish, crab/eel, shark fin/fish maws, among others. Of the total export earnings from fish, over 77% is from shrimp—of them *P. monodon* constitutes about 75% and different types frozen fish contributes for about 20%—and of them about 31% is hilsha. Shrimp is the second largest export item from Bangladesh after ready-made garments. Bangladesh has exported a small volume of live fish since 2006, but it has experienced a decline since 2009. Figure 8 shows the trend in exported fish from 1993 to 2012.

Figure 8. Annual fish exports from Bangladesh in t, 1993–2012.



Source: DoF (2013).

Factors influencing import and export trends

With the increase of per capita income, upper- and middle-class people can now regularly consume high-value large fishes. Recently, imported rohi and catla have been served at ordinary restaurants where middle-class people are the main customers. Imported carps are cheaper than locally produced fish because they are treated with formalin for transportation. They have created a good market for sale at festivals and at restaurants, where formalin contamination is being ignored. Bangladesh exports mainly shrimp and hilsha, both of which are in demand in the world market for their quality and taste. Fish exporting is increasing, with the growth in non-resident Bangladeshis (NRB) who are the main buyers, particularly of hilsha. Freshwater shrimp is preferred by all consumers in the West for its quality, for which they are willing to pay more.

Niche markets

The market for live fish is expanding in urban areas mainly in the big cities. Better-off consumers in urban areas are willing to pay a premium for live carps which they know are pesticide-free; most of these live fish farms have been developed in the waters around the big cities. Many of the buyers are on holiday and visit these farms to buy live fish as part of their pleasure trips. Large numbers of small fish traders sell fish in early morning markets along the roadsides of the big cities (they sit for 2–3 hours). They collect fish, vegetables and other commodities directly from wholesale markets. Fish cutters are also found at these roadside markets. Morning markets are becoming popular, as prices are comparatively cheap because traders do not have to pay tolls for using the roads. A large number of women buyers regularly visit these roadside markets because of their cleanliness, their proximity to their homes and the fact that they are less crowded (The Daily Jugantar 2013). Very few women visit formal markets. Recently there has been a growing trend for live fish to be sold at morning markets and supermarkets; this is limited to wealthier buyers due to price increases. Other niche markets include ethnic markets in Europe, USA and East Asia and Arabic countries where consumers (including migrant Bangladeshis) buy imported frozen hilsha, organic shrimp, organic vegetable and other products.

Informal vs. formal trade

The amount of fish that have been mentioned for exporting is from the formal trade. Accurate informal trade data is difficult to find, but the general perception of the market players is that the informal trade is 'much higher than that of formal export trading' (personal communication with a group of fish exporters of Jessore district, September 2013). Records of formal export trade are based on the government's revenue earnings. Huge quantities of chitol, magur and pangasius fingerlings are exported to India. Although a large number of households' livelihoods depend on this process, which is openly done, it is an example of informal export trade. Hilsha and dry fish (especially chapa, shutki and dry sea fish) are other important fish products in the informal export market. A study on the volume of exported fish from Bangladesh is needed (Apu and Himel 2013).

Policy of export and import of fish

The Bangladesh Government's policy on fish imports and exports is limited. Interestingly, there is nothing said on fish imports, and it is not mentioned in National Fisheries Policy 1998 or in the fisheries subsector strategies. Initiatives have so far taken place on an ad hoc basis. DoF-operated Fisheries Resources Survey System (FRSS) has not kept any statistical information on fish imports, but they have fish exports data. Although the National Fisheries Policy 1998 gave a visionary statement on fish exports (presented in the box below) it has not been followed up by fisheries subsector strategies developed in 2006, except for a shrimp strategy (see box below).

Bangladesh Fisheries Policy

National Fisheries Policy 1998 expressed regarding fish exports:

- The government will encourage and provide facilities to the private sector engaged in fish and shrimp export as 100% exportable commodities.
- To increase earning through fish export, the views of the private sector and export-related associations or organizations will be given priority consideration.

Shrimp export issues in shrimp substrategy, (DoF 2006):

- The government shall only issue export licenses to those processing plants and exporting companies which can comply with international food laws.
- Shrimp produce will only be licensed for export following the issue of a quality certificate from Department of Fisheries.
- The government shall withdraw export licenses from processing plants and exporting companies that fail to meet importing country regulations.

Recent policy for importing shrimp from India:

- Apart from that government decided to import shrimp from India. The commerce ministry on 3 October 2012 in a circular conditionally allowed the import of shrimp in defiance of the fisheries ministry's proposal for a complete ban on import of such items for development of the country's shrimp industry, as Bangladesh enjoys duty-free facilities for fish export to the European Union. The commerce ministry has allowed the import of shrimp only through Mongla Port as there is a risk of smuggling of the food item through the land port.

Major policy issues under debate

A major policy debate on Bangladesh fish exports and imports is largely centred on two species: hilsha and shrimp. Bangladesh people do not wish to export hilsha to India (West Bengal state) or any other country. For the first time formal hilsha export was banned for one month during peak harvesting by the army-backed caretaker government of 2007–2008. Thereafter it was not continued until 2011. Again a ban was imposed from 2012 by the government, which may have been in protest against West Bengal State Government who refused to give Bangladesh a fair share of water on Tista River. The newspaper cutting presented in the box below would tell how important hilsha is for the Bengalis of West Bengal. Over time, the ban on harvesting and marketing of *jatka* (juvenile hilsha below 15 cm) by the government has largely become accepted by fishers, due to promotion of alternative livelihood activities for hilsha fishers' households.

Surprisingly, hilsha has always been exported at a lower price than for sale in local markets; which is why at some stage during peak hilsha season due to poor supply at local markets, prices soared. For the first time hilsha exports were stopped by the government in 2008 although only 3% of the hilsha was formally exported. Subsequently, the export price for hilsha was fixed by grading the size. Before, there was no standard export price of hilsha, and as a result opportunities were presented for manipulation of invoices and smuggling money out of the country. Government is planning to withdraw the ban on hilsha export soon at the request of India, re-fixing the standard export price. However, the Fish Export Association wanted to keep the previous rates (*The Daily Jugantor*, 7 February 2014)

Shrimp is important for Bangladesh; it contributes 80% of its export earnings (DoF 2013). Bangladesh produces 4.2% of global shrimp production (FAO 2002). Policy debates on shrimp concentrate on maintaining quality assurance according to the standard of international buyers. Currently, shrimp export farms are exporting safe shrimp by monitoring sanitary and phytosanitary (SPS) measures to meet the demands of importing countries. Department

of Fisheries is responsible for certification of shrimp products, before exporting to the European Union and other countries; it certifies traceability, microbiological aspects and ensures that the product is free from chemical pollution.

Before the intervention of commercial shrimp cultivation, people living in the shrimp farming areas depended mostly on the cultivation of food grains. Shrimp has replaced rice as the main crop. Initially in the early 1980s, the influence of the external large shrimp farmers created a difficult situation in coastal areas, as the inhabitants became hostages to the whims of the socially powerful shrimp farmers (Begum and Alam 2002). However, gradually, the small landowners organized themselves and have been participating in shrimp farming by forming cooperatives. This has improved their livelihoods and helped to reduce social tensions. Shrimp farming has been associated with a number of social and environmental issues and the industry has to manage the trade-off between the economic gain and the negative social and environmental consequences (Rahman et al. 2006).

Recently, the government has allowed the import of shrimp, particularly from India, putting the country's export-oriented shrimp industry in jeopardy, according to the Fish Exporters' Association. They want Bangladesh to be a largely exporting country, not an importing country, even if being an exporter is written in the policy (Rahman 2012).

Implication of fish export and import for the value chain

Although Bangladesh imports or exports very little fish in terms of volume, this has a significant impact on the economic, social and employment sector. Importing carps from India and Myanmar has contributed to improved accessibility of fish for low-income households, compared to those being farmed locally.

Shrimp on the other hand is mainly produced for exports and the shrimp industry is a major source of employment and income in Bangladesh. Over 1.2 million people work in the shrimp value chain and depend on it solely for their livelihoods. Over 20,000 women have been working in shrimp farms and processing units (Belton et al 2011). From this perspective, the Bangladesh Government's policy of importing shrimp from India is a serious concern. The commerce ministry's circular for importing shrimp from India to support local demand has generated serious criticism. The Fisheries Ministry fears a fall in shrimp exports if the government allows imports from India, which could be of poor quality and may be exported illegally through Bangladesh. The fisheries ministry¹⁰ requested the Secretary of the Commerce Ministry to ban shrimp imports on the grounds that Bangladesh might lose the GSP (Generalized System of Preference) facility in the European Union for export of its fish. In view of the situation of the export chain of shrimp, indicating the various stakeholders' roles in the entire production and export chain of the shrimp industry of Bangladesh must be carried out.

Inputs and services: Fish health

Structure of animal health sector: Role of the public and private sector.

Veterinary services in the subcontinent started in 1795 for the treatment of horses in the British cavalry and during the British regime this service was gradually extended to subdivisional level for livestock conservation (FAO 2003). In 1947, after the division of the subcontinent, the departmental headquarters was moved from India (Calcutta) to Bangladesh (Comilla district). At that time, Comilla was well-known as a centre for fish culture in large tanks by *zamindars*¹¹ and wealthier families. After several reorganizations of the veterinary service department it became the Department of Livestock Services, Bangladesh with its central office in Dhaka. This government department plays a vital role in maintaining the animal health of the country but it has no responsibility for fish health and disease control.

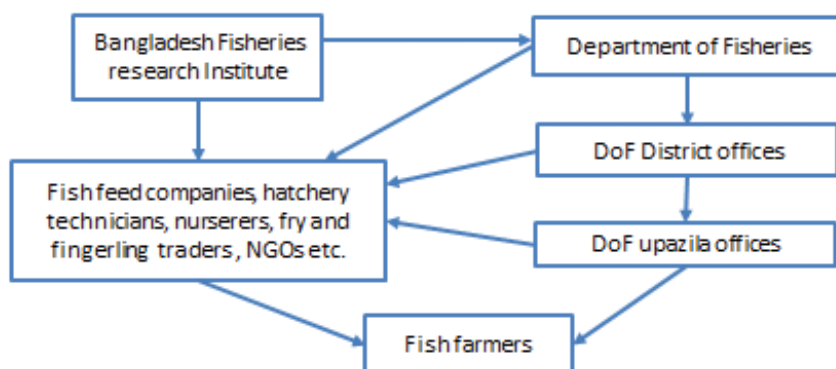
10. Fisheries ministry sent a request letter to commerce ministry on September 20, 2012

11. A zamindar is assigned to collect revenue on behalf of the British government directly from the tenant in Indian subcontinent during British rule. In 1793, the Permanent Settlement Law put forward as an incentive to zamindars, that 'for fair revenue collection, the heredity tenure of possession is to be the only necessary security'. In fact the zamindars were declared to be the proprietors of the soil.

The Department of Fisheries was first established in the undivided Bengal of British India in 1942 with a view to improve fish culture in ponds and lakes. This changed the role of the East Bengal Fisheries Company, which was first established in 1908 by the British Government to export fish to England (DoF 1992). Fish health was not a concern at that stage and there was an absence of technical expertise in the organization. By the late 1970s and early 1980s, progress was made in this area, when a number of young fisheries scientists graduated from Bangladesh Agriculture University (BAU) and joined the department. Later, Bangladesh Fisheries Research Institute (BFRI) formed with the aim of managing fish health and carrying out induced breeding, and their findings have been disseminated through Department of Fisheries. Over the last few decades, fish health has become an important technical issue while carrying out induced breeding of Indian major carp species.

Fish feed companies have also played an important extension role in fish health care. Since 2003, the Animal Health Companies Association of Bangladesh (AHCAB) has been active in the animal industry (poultry, cattle, fish and shrimp). Fish feed companies, hatchery technicians; trained fingerling nurseries and traders have been playing a vital role at fish farmers' level. The structure of the operation of the fish health sector is given below (Figure 9).

Figure 9. Structure of the fish health sector of Bangladesh.



Major disease constraints

Recent research work (Hossain et al. 2011) was conducted from July 2008 to June 2009 to investigate the intensity of infestation of parasites in freshwater fishes and the impact of fish diseases on fish production in the northern region of Bangladesh. The possibility of outbreak of diseases due to deterioration in environmental factors of water bodies was included in this study. The diseases identified are: ulcer diseases, EUS (epizootic ulcerative syndrome), ichthyophthiriasis, trichodiniasis, chilodoneliasis, myxoboliasis, dactylogyrosis, gyrodactylosis, argulosis, pernicious anaemia, red spot disease, red pest of freshwater eel, mouth fungus, branchiomycosis, abdominal dropsy and Whirling disease. The infestations occurred more frequently in young fishes than in adults. Physicochemical parameters have a significant combined effect on the deterioration of water quality and on fish diseases. Gills were the most affected sites and parasites damaged gill filaments by rupturing blood capillaries, causing necrosis, coagulation and haemorrhage. The study revealed the prevalence of different organisms in fishes, which are potential pathogens for them. Fishes were infested by parasites and other pathogens.

From the study, it was observed that the parasites, bacteria and fungus were the most important pathogens to cause outbreaks of diseases. It was also observed that there was a direct relation between disease outbreak among fishes and environmental factors. Low alkalinity reduces the buffer capacity of water and badly affects the pond ecosystem, which in turn causes stress to the fish, which are more susceptible to diseases. Low aquatic environmental temperature reduces metabolic activities of fish, which makes them more susceptible during the winter period to parasitic infection.

Another study conducted by BFRI 2008 on fish diseases in Bangladesh shows deep concern that the introduction of viral diseases in semi-intensive farms has become a serious issue. Habitat destruction, use of insecticides, and the introduction of diseases such as epizootic ulcerative syndrome (EUS) have become important issues for inland aquaculture.

With the expansion of aquaculture, the outbreak of disease, especially in coastal farming areas has become a major issue, as there are no vaccines for any of the fish diseases. However, there is a need to disseminate information on the potential consequences of an outbreak of fish diseases and for disease control strategies. Currently, the only measures of control in culture fisheries are compulsory harvest of all fish, which is only possible for ponds and small lakes.

Trends in morbidity and mortality

In Bangladesh, prevention against fish disease has become an important issue, with the widespread and uncontrolled expansion of aquaculture. Fish, like other animals, are prone to a variety of diseases. In particular disease induced mortality is a serious issue for the fish seed industry. Like other animals, the immune system of fish plays a vital role in preventing diseases. The immature immune systems of young fish make them more susceptible to infectious disease.

There is no documented information on fish mortality, or information about what percentages of total production loss are due to mortality by species. Our assumption is that about 5–10% fish mortality of stocking fish in the case of aquaculture. After the 1990s, there was no severe fish mortality due to disease. A severe outbreak of epizootic ulcerative syndrome (EUS) occurred in 1988–89 after a countrywide flood. To date no severe disease outbreak has been reported (Faruk 2011).

Major fish mortality (cultured fish) occurred due to poor management and oxygen depletion, high stocking density, malnutrition and poor water quality. Other fish mortality was related to bacterial disease (especially in the case of tilapia and koi); and tail and fin rot disease due to fungus, gill disease etc. Shrimp are severely and frequently affected by different types of viral diseases in coastal areas. Common fish diseases in hatcheries and in early rearing systems are caused by: protozoan ciliates, myxosporodians, worms, opportunistic bacteria and fungi.

Although diseases are not the major constraints for improving fish production in Bangladesh, farmers are increasingly becoming aware of the quality of the source of fingerlings and feed quality. Several service providers for quality fish culture, who are also responsible for fish disease control, are available in all the districts and subdistricts (*upazila*) of Bangladesh. These include: government Department of Fisheries, Fisheries Research Institute, fisheries faculties in different universities; and donor-supported projects, including WorldFish implemented projects.

It is noteworthy that hatchery technicians, fingerling vendors, local successful farmers¹² and feed sellers, often help fish farmers to prevent the outbreak of disease. According to farmers, their presence at village level is reassuring; they can contact the relevant person for advice if there is any occurrence of disease or if there is poor growth of stocked fingerlings. They provide these services voluntarily and provide direct access to the relevant information and technology, even in remote areas.

Sales/imports of veterinary pharmaceuticals

The veterinary pharmaceuticals companies that have been contributing significantly to aquaculture expansion are: Excellence Chemical Company; S. R. A. Trading; Surjavita Agro Complex Ltd.; Unique Groups; Bangladesh Rural and Agriculture Ventures Ltd.; Khaja Goribe Newoz Agro Feed Ltd.; City Group Industries; Kazi Enterprise; Combine System Ltd.; Dhaka Chemicals; Chowdhury Trading; Technology Bazar; The Sun International; and S. S. Trade International.

In the last five years, fish feed use in Bangladesh has increased significantly, with an estimate of one million tonnes of commercially formulated pelleted feed produced and about 0.4 million tonnes of feeds produced by micro-and small enterprises at village level. Feeding of fish with formulated diets has contributed to increased production of pangasius,

12. Many of these farmers at village level have received advance training on fish culture and disease management from Department of Fisheries and have received a water quality test kit-box; they are called local extension agents for fisheries (LEAF). They work on a voluntary basis and maintain close links with the upazila office of DoF.

Nile tilapia, climbing perch, major carps and others. Value chains have been developed in association with the growth of the formulated feed industry and now widely connect feed suppliers with farmers. However remote farmers still lack access to formulated feed (Mamun-Ur-Rashidet al.2013).

Policies influencing access and use of fish health services

The National Fisheries Policy (1998) or the Fisheries Sub-strategies (2006) did not prioritize fish health; it gave emphasize to: (i) hatchery produced quality fish seed; and (ii) safe feed preparation for fish. Unlike other animal health care issues, preventive measures are the best way of taking care of fish health.

The expansion of aquaculture has been dramatic, but it has largely been unregulated. Poor quality of fingerlings due to poor brood selection in breeding and in hybridization has reduced the growth potential of many species. This has serious health consequences for any fingerlings that might find their way into the wild, either through stocking or unintentionally during floods. As a result, a policy of hatchery registration to comply with a basic set of criteria in the long-run would improve fish growth and health.

Assurance of the quality of manufactured feed so far has been dependent on the enforcement of government regulations of The Feed Act which involves: registration and licensing for all feed producers; providing quality monitoring, regulating feed packaging and storage; and inspection of feed mills for compliance with standards. However, there is a responsibility on producers to ensure that their produced feed meets the quality standard set by the Department of Fisheries in collaboration with the feed industries. This is self-certification or quality assurance that an association can impose on its members and a qualified private organization could be nominated by the association for this purpose.

Practical and cost-effective methods that are currently available to help farmers to detect fish-borne diseases quickly and accurately are not yet in use in Bangladesh. These easy-to-use practices for safe and healthy production of catfish and shrimp are already widely used in India, Thailand and Vietnam. Six Asian governments, including Bangladesh, will soon be taking up these methods to improve fish health management services in response to the growing awareness of the need for better fish disease control in aquaculture. It is hoped that these techniques will have a major impact (RIU 2010).



Inputs and services: Fish breeding and genetics

Structure of the fish-seed sector

In Bangladesh, fish seed comes from two sources: natural breeding and artificial breeding. Up to the mid-1980s, with the inception of artificial breeding sources of natural spawn, the only way of collecting fish seed was from natural water bodies. However, with the dependence on artificial breeding in the past 30 years, natural fish seed now contributes to less than 1% of the total demand of the country. But these small volumes of fish seed are the lifeline of the country's brood fish— the main source for artificial breeding; this interdependence is largely the structure of fish seed sector of Bangladesh. Similar situations have been common in the shrimp sector; currently more than 90% of PL is hatchery produced.

Carp and barbs

Several exotic fish species have been introduced in Bangladesh but such introductions have not been properly recorded since 1960. There are at least 13 species of carps and other species under six genera which live in the Halda and Padma-Brahmaputra river system. Of these species, eight species of carps and barbs are used for artificial seed production in hatcheries. Breeding techniques have been developed for the other five species: shingi, koi, golsha, pabda and magur (Hussain and Mazid 2001). The existence of more than 866 carp seed producing hatcheries has been reported in Bangladesh. These hatcheries have been producing seed since the 1970s. Some 607,380 kg spawn are reportedly produced annually (DoF 2012).

In Bangladesh, Jessore was renowned for its quality carp fry and fingerlings reared from spawns from the wild since the early nineteenth century. The mortality of spawns, fries and fingerlings is low in this area because of local climatic and natural characteristics. Hence, some people in fishers' villages in the southern part of Jessore city took up the fingerling rearing business. The first artificial breeding program was carried out in the early 1980s in the villages of Chanchra, Kazipur, Bhaturia and Barmanpara. Thereafter, with the initiative of a group of local young entrepreneurs and supported by Department of Fisheries and Fisheries Research Institutes, Jessore became the country's centre for fish seed production and marketing.

Due to the quick return on investment and large revenue, there was a rapid boom of carp hatcheries during the latter part of the 1990s. To increase the rate of revenue earning, hatcheries began to ignore the quality of fish seed and began to adopt bad practices such as inbreeding and breeding from immature broods. These practices resulted in negative effects on fitness-related traits such as growth rate, survival and disease resistance. Negligence about inbreeding effect has largely been under control due to past negative experiences, not because of regulatory control.

About 10 years ago northern Bangladesh was a vital market for Jessore hatcheries, with approximately 50% of the seeds marketed in northern zone districts—Rajshahi, Rangpur, Natore, Chapai Nababgonj, Nowgha etc. However, with the promotion of DoF and private initiatives, this region is now self-sufficient in producing fingerlings, and marketing to other parts of the country. As a result, Jessore hatchery owners concentrate on marketing to mostly southern saline prone areas where growing fry is difficult (Apu and Himel 2013).

Over the last decade, with the emergence of fish hatcheries all over the country, the monopoly of Jessore hatcheries has been eroded. The biggest supply market was at Rajshahi-Natore, which has now become self-sufficient in fish seed production, it has emerged as a strong competitor of Jessore in the domestic market. Recently developed hatcheries at Mymensingh and Barisal have gained potential to meet about half of the seed local demands (Apu and Himel 2013).

Tilapia

The GIFT (Genetic Improvement of Farmed Tilapias) program was a collaborative research program implemented by WorldFish. It has responded to the challenges that the developing world faces regarding food security and malnutrition. During the last two decades there have been increased efforts to enhance production traits of commercially important aquatic animal species by genetic means. It is generally recognized that the collaborative program on GIFT has encouraged the development of several other tilapia and carp breeding programs that now exist in numerous developing countries (Ponzoniet al. 2010).

GIFT fish in Bangladesh are in the care of Bangladesh Fisheries Research Institute (BFRI) and BRAC Center (non-government organization). After 1997, BFRI found that after several generations of selections, inbreeding became apparent in the selected population, which led to poor growth performance of GIFT fish. To overcome the inbreeding problem, a new batch of GIFT arrived in 2005. The breeding program for this stock followed family selection protocols to avoid inbreeding depression that was experienced with the previous batch. They were subsequently tagged with Passive Integrated Transponder (PIT) tags and communally reared in an earthen pond (1000m²). In 2009, 0.5 million GIFT fry were disseminated to 48 tilapia hatcheries across Bangladesh. GIFT fish have become very popular and well accepted by farmers across the country. Presently, more than 95% of tilapia hatcheries and farms are growing the GIFT strain. Farmers are reportedly happy with the fish that they produce from the GIFT strain. In the meantime, approximately 150–160 million mono-sex fry have been produced by the hatcheries and sold to farmers (Ponzoniet al.2010).

BRAC serves the fish farming community in rural Bangladesh. They received GIFT fry from WorldFish in 2008 and stocked the fry in different ponds for the production of the first generation. The breeding scheme practiced by BRAC is cohort mating. In order to dissemination of GIFT production, BRAC plans to establish new hatcheries at Comilla, Bogra, and Khulna. They hope that by having these additional hatcheries the production will be able to meet the demands from the grow-out farmers.

Other species

The formal responsibility of aquaculture genetic is primarily with the public sector, including the regulatory authority of Department of Fisheries. BFRI have undertaken several researches on the reasons of genetic deterioration of aquaculture of the country, which helped to initiate action plans for increasing aquaculture production. A number of government run projects introduced genetically improved species such as Tilapia, pangasius, pabda, gulisha, koi, singh, bata etc. that are suitable for local environment with consideration of local people's acceptance.

If we look at the other side, in the private sector a good number of hatcheries have been undertaking research on fish genetic sector. Their curiosity to learn and concern for improving the country's aquaculture situation is remarkable. The reason is not simply for money, which is a logical consequence anyway. There is no doubt that the private sector has been playing the key role (especially in Jessore district based hatcheries). They have been collaborating with BFRI research activities and played a major role transferring research results to farming systems. As a result these hatchery owners are respected in the country.

Bangladesh has also initiated selective breeding work on *catla* for genetic improvement. For this, catla were collected from different river systems and genetic characterization is being carried out by applying electrophoresis and morphological methods. Research on genome manipulation is being carried out and successful induction of meiotic and mitotic gynogenesis was achieved at the Fisheries Research Institute, Mymensingh.

Shrimp

In Bangladesh commercial shrimp culture largely depends on *Penaeus monodon* and *Macrobrachium rosenbergii*. Out of 62 species of shrimp, there are a total of 10 families that are found in floodplains, rivers and estuaries, and marine waters. Shrimp and prawn production in Bangladesh takes place mainly in converted rice fields, known as *ghers*. Freshwater prawn farming first started in the southwest region during the early 1970; a few well-off local farmers in the Fakirhat area of Bagerhat district began to experiment with stocking prawn post-larvae in carp ponds, where prawns were grown along with carps (Mazid 1994).

Currently most shrimp culture are carried out in *ghers* on land protected from the sea by polders (very high dikes), which are connected with estuaries and canals by sluice gates that allow farmers to manage the flow of brackish or tidal water. During February to April, tidal waters carry shrimp post larvae (PL) in to *ghers* at high tide. These are trapped inside the *gher* by bamboo barriers placed at the *ghers*. This method of shrimp culture trapping wild seed is practiced in the initial stages of Bangladesh shrimp culture, which has been largely replaced by artificial stocking of PL, either collected from the wild or produced in hatcheries. Similarly, prawns PL are collected from both natural sources and hatcheries (Belton et al. 2011). However, shrimp *ghers* are now mostly depending on hatchery produced PL. Although *gher* farming is primarily for shrimp and prawn, but in practice farmers often stock white fish in the system with changes of salinity levels (Ahmed et al. 2002).

Efforts to improve fish breeding and genetics

Investigations show that hatchery produced seed in Bangladesh has many problems associated with it. Deterioration of hatchery breed stocks as indicated by retarded growth, morphological deformities and increased incidence of disease has been reported in recent years due to poor brood stock management (Eknath and Doyle 1990; Basavaraju et al. 1997). It was reported in 1997 that some newly established fish hatcheries located in Jessore, Comilla and Mymensingh had no basic idea about brood stock management such as recruitment of new breeders at periodic intervals in the stock, optimum density of the brood stock and their proper feeding. These hatchery procedures lead to unconscious negative selection due to the use of undesirable size of brood fish and generation after generation of mating the related spawners from a small population (Hussain and Mazid 1997). However, since 2005 hatchery management has significantly improved in close cooperation with WorldFish, BFRI and DoF.

Recent research in Bangladesh has proven that 'Milt Bank' can double fish hatchery production in Bangladesh'. The method is simple: milt collected from the best quality wild-origin males of Indian Major Carps that allows the preservation of fresh carp milt for periods of up to 3–4 days at ice-cooled temperature of 4–8°C degrees at the Milt Bank. This milt is used for eggs of the female carps for breeding. Ice-cooled preservation of milt is a simple method, adapted to immediate and easy use by rural hatcheries. The objective of the Milt Bank is to improve the quality of fish seed produced by hatcheries and demonstrate the genetic and economic advantage of using quality milt from centrally established gene banks, similarly as it has been successfully practiced in livestock. The males are electronically tagged for record keeping and ensure traceability of produced hatchling. This method is opening a possibility to keep mainly female breeders in the commercial hatcheries and the milt can be supplied from controlled male stocks of Brood Banks. The main advantage of using milt from best quality males of Milt Bank is the automatic prevention of inbreeding (Rajts and Alam 2013).

Hatcheries of Bangladesh maintain similar numbers of male and female brood fish or outsource males to produce fry. This traditional system affects the level of seed production, lowers business profit, endangers biodiversity and leads to low quality seed. The USAID-funded FTF-AIN project is working toward use of preserved milt for large-scale commercial application in hatcheries. The milt bank system is showing a promise of achieving 100% improved quality fish seed within five years and a reduction in overall operation costs.¹³

¹³ .Channell, 4 June 2013. A private Bangladesh TV 'Channell' announced that the USAID-funded FTF-AIN project is working toward use of preserved milt for large-scale commercial application in hatcheries.

Policies that influence species choice and use of genetically improved strains

In Bangladesh the aquaculture production system has largely been following two basic points that influence species choice of genetically improved strains that are:

- Species that would be easy to culture using low cost and locally available feed
- Culture genetically improved species affordable to low income group people

As a result, it is found that the exotic magur (locally called African magur) has not responded considerably from consumers while pangasius, koi has created a very large market. Recently, genetically improved koi from Vietnam has been introduced at the hatcheries of the southwestern part of the country by a USAID supported project (FTF-AIN 2013). This koi is almost similar to the native one, and has already received popular demand from farmers indicating consumer's choice.

Current policy issues under debate on farmed fish genetics

GIFT has been contributing significantly to the county's fish production, particularly providing micronutrient for low income households; however, likely adverse impact in the long run on aquatic biodiversity of GIFT tilapia is a concern to a group of environment experts in Bangladesh. However, specific reasons for why this is stipulated are not transparent to common people. An initiative should be taken for an open debate on GIFT issues about future consequences on nature.

It is essential to motivate farmers to culture micronutrient-rich small indigenous *mola*, *chapila* or other species that are suitable to local environment. These species contain high nutrition value. The IFAD funded 'Small Fish and Nutrition Project' implemented by WorldFish and DoF.



Inputs and services: Feeds

Structure of fish feed sector

WorldFish/[USAID](#) supported [Feed the Future-Aquaculture](#) for Income and Nutrition assessed the status of the aquaculture feed sector of Bangladesh in 2012. Fish feed value chains, market trends, ingredients and formulation systems, farm feeding practices and ancillary services were investigated. It found that manufactured feeds in aquaculture in Bangladesh have grown rapidly; more than 1 million tonnes of commercially formulated feeds and about 0.4 million tonnes of home-made feeds were produced in 2012. The study identifies a number of entry points for interventions and investments which would improve feed quality and farmer access to better feeds and support the growth of aquaculture (Mamun-Ur-Rashid et al. 2013).

Improved systems of fish culture will require increasing quantities of feed to be made available which must be formulated according to the species and availability of local feeds. With support of research guidelines on feed formulation for different species, feed plants produce and supply feed. Government has developed testing facilities to ensure feeds are compliant with requirements and match specifications stated by feed procedures (DoF 2006).

Value chains have developed in association with the formulated feed industry and widely connect feed suppliers with farmers. However, more remote farmers still lack access to formulated feed. Bangladesh produces about 55% of fish feed ingredients, the rest are imported. These products flow from producers or importers via feed processors to reach farmers through various channels. Some raw materials such as rice bran require processing in mills before incorporation into formulated aquaculture feeds. Various suppliers and traders deliver ingredients to feed formulators, although large and medium feed mills import directly, accounting for about 10–15% of total raw materials used. Machines used for feed processing are directly imported by feed mills with assistance of marketing agents from manufacturing companies. Of them feed dealers distribute 96–98% of feed from feed mills to farmers and typically earn a commission of 6–7% on buying price. The dealers distribute around 5–10% of total feed to remote areas, or to small farmers, through other traders (Mamun-Ur-Rashid et al. 2013).

In the structure of fish feed sector, public and private organizations have been providing services. Public sector organizations: (i) Department of Fisheries (DoF); (ii) Bangladesh Fisheries Research Institute (BFRI); (iii) Custom Department of Bangladesh; and (iv) government laboratories. On the other hand, private sector organizations are: (i) Feed Industries Association of Bangladesh (FIAB); (ii) Animal Health Companies Association of Bangladesh (AHCAB); (iii) Clearing and Forwarding (C&F) agents.

Feeding practices, feed sources and key feed constraints

The amount of feed required by a fish depends firstly on the composition of the feed used. In general, a greater amount will be required of a lower nutrient density feed than a higher nutrient density feed to achieve the same performance level, if two feeds have similar protein and energy balance (Dutta 2011). The main ingredients used for fish feed production are rice bran, maize, soybean meal, mustard oil cake, fish meal, and meat and bone meal. Apart

from that, large volumes of apple snails are collected from coastal water bodies for feeding prawns. Bangladesh imports fish feed ingredients; imported raw materials contribute more than 50% of the total cost of feed production.

Gradually with the intensification and commercialization aquaculture in Bangladesh, commercial pellet feeds are beginning to replace 'home-made' and 'raw' unformulated feeds. Around 100 commercial mills produce feeds in Bangladesh, of them 8–10 are large accounting for about 70% of commercial mill-produced feeds. The number of home-made pellet feed mills is difficult to estimate but the number would be more than 1,000. Due to lack of knowledge operators of home-made mills face difficulties to formulate feeds that provide sufficient nutritive value to fish at various growth stages.

Feed use depends also on the different farming system of fish culture and species. Farmers commonly feed their fish twice daily by broadcast feeding. But feed requirements according to the body weight of fish are rarely measurement through timely sampling. For which floating feed users are better able to measure feed requirements observing of fish behaviour, and feeding satiation. Feed conservation ratios (FCRs) for floating pelleted feed are comparatively lower than for sinking pellet feed: approximately 1.5 vs. 1.85 for tilapia and 1.6 vs. 2.0 for pangasius, though both could be improved by reducing wastage (Mamun-Ur-Rashid et al. 2013).

Feed cost is a major production cost in fish culture yet feeding fish is still mostly guess-work, each fish producer following different guidelines (feed charts) or adopting different practices. Feeding too much leads to feed wastage, a pure economic loss, and greater waste output. Feeding too little results in less growth and this also represents an economic loss. Feeding strategies minimizing feed and total production costs as well as waste output per tonne of fish produced; these are key factors to the economic and environmental sustainability of fish production in Bangladesh (Ahmed 2007).

A group of fisheries experts, mainly working with different donor projects or teaching at universities, interested to introduce feed chart for farmers, citing that many western countries fish producers rely on feed charts provided by feed manufacturers. In the contrast, other experts' opinion is: those feed charts are based on a lot of 'guessing' and little or no real production data. The wide range of fish species, genetic stocks, feed composition, water temperature and growth rates encountered on Bangladesh fish farms makes it impossible for anybody to develop a single feed chart that would be correct for all individual farm situations. Rather more rational should be sited or situation specific approaches to determining feeding level (Dutta 2011).

In Bangladesh, the possibilities exist for integrated fish culture with livestock production. There are about 48 million cattle, buffaloes, sheep, goats and more than 90 million chickens and ducks in the country. Most of the excreta of these animals are used for crop fields; remains are not properly utilized and become wastes which may cause pollution. If these livestock wastes could be applied in fishponds through integrated fish farming, fish production could be increased substantially (in optimal case 4–5t/ha per year) without using any other fertilizer or supplementary feed for fish (FAO 2008). Animal wastes which enter the food web of a pond ecosystem are utilized in several ways: i) as a source of nutrients required for primary production; ii) as nutrients and organic substrates for heterotrophic microorganisms which in turn may be consumed directly by fish or by invertebrate fish food organisms; iii) directly consumed by the fish.

Factors that have been influencing feed production trends.

The demand for quality fish feed products at low price is paradoxical, which compelled producers to reduce feed costs by using cheaper ingredients and lower feed specification (Halteren et al. 2009). Recently with high demand and increased price of feed ingredients some adulteration are noticed. Unfortunately, many of the fish feed brands use poor animal origin material or bi-products or low quality fishmeal. However, good quality fishmeal, meat and bone meal are not available in the country; that's why feed producers have to depend on imports.

However, there are more than 35 low price raw materials found locally in Bangladesh which can be used in the preparation of supplementary feed of fish and shrimp (Ali and Haq 2010). Therefore, the aquaculture industry should plan for the development of locally-produced, low cost, eco-friendly ingredients for fish feed production to provide fish farmers at lower price.

Policies in place that influence production and use

Almost all products imported for use in feeds are duty and VAT free and exempted from pre-shipment inspection' which could have created the scope to importing poor quality feed ingredients. Particularly, fishmeal and meat and bone meal (MBM) need a certificate to confirm they are free from BSE (Bovine Spongiform Encephalopathy) and TSE (Transmissible Spongiform Encephalopathy). Moreover, fishmeal, MBM and all others feed additives also require radioactive and health certificates from the exporting country.

The Feed Act of Bangladesh which ensures licensing by the Department of Fisheries (DoF); and the no-objection certificate must also be issued by DoF before ingredients can be imported and ensuring that the micronutrient content of different categories of feed and raw materials is maintained at optimum levels by all feed producers. But inadequate implementation of these policies has been influencing the production.

Current policy issues under debate regarding fish feed

In principle fish feed are to be prepared in such a way that does not distress the fish health. Thus regulation or standard guidelines are required to ensure the use of quality feed ingredients and suitable technology in feed production. Quality control of raw materials concerning the proper composition and the level of toxic substances must be ensured. Another current policy issue is the feeding strategies, which could minimize the feed and total fish production costs as well as waste output are key to the economic and environmental sustainability of fish production in Bangladesh.

Although government regulations regarding fish feeds and ingredients are sufficient ensuring public health but implementation is not adequate due to lack of skilled technical persons, equipment and other logistical support. Ultimately, in view of this situation, it could hamper the fish growth and could be a serious risk and concern to public health.



Inputs and services: Knowledge systems

This section will focus on how fish farmers' access information for farming technologies and markets, and innovation capacity. It is well known starting a fish farming business requires a lot of knowledge, skill and planning as the investor would have to look into a lot of variables to make the business possible.

Structure of knowledge sector

Bangladesh government has policies on the aquaculture strategies as well as aquaculture extension strategies and related gender dimensions. Virtually Department of Fisheries has the mandate to disseminate fish culture knowledge throughout the country. Apart from this routine activity of DoF, it has been mobilizing aquaculture and capture fisheries activities mainly through donor supported different aquaculture projects that implemented in last three decades in Bangladesh, since mid-1980's. Some of these projects are OLP-I, OLP-II, MAEP, NFEP, CBFM, SCBRMP, FTEP, PBAEP, GNAEP, FFP, AqDP, FTF-AIN etc.; these projects from the beginning involved reputed national NGOs to mobilize and organize fish farmers because of its grassroots level networks which DoF did not have in the early stage of aquaculture drive in 1980's.

Of the national NGO's those which have participated in aquaculture, BRAC¹⁴ played a pioneering role in fisheries activities and developing partnership with government initiatives, which was remarkable. Subsequently Proshika, Caritas, RDRS, TMSS, CODEC, Coast Trust, Padopkhep etc. have played significant roles in advancing particularly aquaculture in partnership with government. With experience and the potential of fisheries sector most of these NGO's have set up their own fisheries wing with qualified human resources on fisheries, apart from technical support micro finance priority has been given to pond operating rural households. Since the 1980's remarkable international organizations like FAO, ICLARM (now WorldFish), CARE etc. have been working closely in partnership with government and national NGOs.

BARD at Comilla district and RDA at Bogura district since their inception have been providing fisheries and livestock training mainly to field workers of government and NGOs and village cooperative members throughout the country in collaboration with DoF.

Trends in investment in aquaculture research

In Bangladesh private sector investment is highly significant while the public sector has been providing appropriate technologies, new research has resulted in increasing fisheries production as well as providing extension services throughout the country in the form of training and motivation. Government had set priority in early 1980's to enhance production from aquaculture for which positive outcomes have been generating. Although overall fisheries production has an increasing trend; out of that aquaculture is the victor.

14. BRAC is now recognized as the largest international NGO.

Bangladesh Fisheries Research Institute (BFRI) through its research findings enriched the aquaculture and fisheries activities of the country. Its central office is at Mymensingh with a number of research stations in different zones of the country disseminating updated technical fisheries knowledge to public, private and NGOs engaged in fisheries sector. BFRI also has been undertaking researches in collaboration with international fisheries research organizations, particularly contribution of FAO and WorldFish are most valuable. Bangladesh Agriculture University (BAU) have the pioneering role in producing fisheries graduates and valuable research works conducted by the teachers and students of its Fisheries Faculty have given an outlook and created enthusiasm among the young graduates to work closely with farmers beyond the formal organizational responsibilities. Now a number of universities have been providing fisheries graduates.

Apart from that, the contribution of University of Stirling (UK) and Asian Institute of Technology (Thailand) have been providing advance training and research support for public and private sector actors of fishers. These two institutes contributed to develop a world-class academic knowledge base among the fisheries specialist of the country who are discharging responsibility for the growth of aquaculture and fisheries of the country. Besides, the SUFER project contributed with field based fisheries researches by the university students.

In the past the Directorate of Fisheries was mainly concerned with the pond culture of carp. They also introduced some exotic varieties of carp, namely Common Carp, Silver Carp, Grass Carp, Mirror Carp and *Nyloika, Tilapia, Thai puti* and, of late, hybrid catfish and Thai *pangas*. The Fisheries Research Institute, using extension personnel of the Directorate of Fisheries and NGOs, did a commendable job in disseminating information and for quick growing and economically profitable fish culture. The institute has also developed technologies for seasonal fish culture in derelict ponds and burrow pits as well as for the culture of fish in irrigated/rainfed paddy fields.

Numbers of extension agents and their coverage

There are four major public organizations/institutions that are directly responsible for the production, research and marketing of fisheries in Bangladesh. However, most of the fish and fisheries products have been marketing through the private sector. Table 12 shows the institutions with approximations of respective human resources available.

Table 12. Human resources of government organizations in the fisheries sector of Bangladesh

Organizations/institutions	Human Resources (nos.)	
	Senior officer*	Junior Staff**
Ministry of Fisheries and Livestock	40	Not available
Department of Fisheries	1010	3041
Bangladesh Fisheries Research Institute	77	169
Bangladesh Fisheries Development Corporation	94	697
Total	1221	3907

Source: DoF (2013).

Note: *Senior officers are Class I and II. **Junior officers are Class III and IV.

Department of fisheries (DoF) has been operating under the leadership of Director General with six directors; including Marine and Training Director. Apart from that, 8 Deputy Directors, 27 Project Directors and 46 Assistant Directors/Deputy Project Directors have been assisting the central office at Dhaka.

Table 13 shows the distribution of human resources seven administrative divisions headed by Deputy Directors and 64 districts headed by District Fisheries officers followed by Senior Upazila Fisheries Officer or Upazila Fisheries Officer, Assistant Fisheries Officer and Field Assistant, Hatchery Managers, Baor Managers and others. The officials of this structure are primarily responsible for inland aquaculture and inland capture fisheries, while districts and upazilas work closely with marine wing and training wing and liaison with all.

Table 13. Structure of senior officials of the Department of Fisheries of Bangladesh

Division	Deputy Director	District Fisheries Officer	Assistant Director	Senior Fisheries Officer	Upazila Fisheries Officer	Hatchery Manager	Baor Manager
Dhaka	1	17	1	43	69	20	
Chitagong	1	11	2	2	48	5	
Rajshahi	1	8	3	19	45	6	
Khulna	1	10	5	29		8	6
Barisal	1	6	2	7	31	5	
Sylhet	1	4	2	12	26	3	
Rangpur	1	8	1	12	46	1	
Marine	2	2					
Training	3	2					
Total	12	20	64	148	295	48	6

Source: DoF (2013).

Presently a total of 13 public universities and one college are awarding fisheries degrees and doing research in various fisheries disciplines. On average, each of these institutions produces 50 to 60 graduates per year; in total almost 700–800 graduates per year, which is sufficient for the sector in terms of technical personnel. Many of these universities also provide fisheries MSc and PhD. However, there is a shortage of field-level technical staff. To redress this shortfall, DoF established the Fisheries Diploma Institute in 2009 at Chandpur (Belton et al. 2011).

It was recommended by the Fourth Fisheries Project (FFP, 1999–2006) to develop local extension agents for fisheries (LEAF) at Union or village level. These extension agents should intensify their efforts in reaching farmers and passing useful information to them in order to increase farmers' profitability. This idea has been in implementation combined with a project of the Ministry of Agriculture (NATP funded by World Bank and IFAD). A total of 2714 LEAFs are now working at different villages, of them 110 is female (4%). However, since late 1990s a number of projects had engaged grassroots level fisheries extension workers, of them Patuakhali Barguna Aquaculture Extension Project (PBAEP by Danida) engaged two extension workers at all the 101 unions of the two coastal districts, of them 50% of extension workers were women, i.e. out of two, one was female. Similar approaches were undertaken for providing farmers level extension services by FFP, AqDP, MAEP, GNAEP etc.

Other government institutions also have management responsibilities related to fisheries resources, including the Bangladesh Water Development Board, Local Government and Engineering Department, Department of Land, Commerce ministry, Export Promotion Bureau etc.

Effectiveness and gender issues of knowledge system

Bangladesh has established a continuous process to assess the impact of extension services on fish farming of the country. The principal objective of these initiatives was to disseminate technical knowledge to fish farmers.

For example, one of the components of FFP implemented nation-wide aquaculture training program was for men and women. It shows that women's participation improved greatly in fish farming, in total final participation rate was 24.6%, only fractionally below its target of 25%. Women's post-training level knowledge was worse than those of men, but this was almost entirely due to starting from a lower base. The implication is that training approaches require revision to offset women's initial disadvantage. Poor trainees had lower levels of knowledge than wealthier ones, and less-educated trainees benefited less than those with more education. The two trends are linked because poor people are more likely to have less formal education. As in the case of gender targeting, poverty targeting through aquaculture requires modification of training approaches to offset the initial disadvantage of the target groups. Government and donors decided to effectively engage women and the poor in aquaculture, the duration of training should be increased to offset their initial disadvantage in terms of knowledge. The overall mean conceals a large variation by gender in aquaculture production in FFP. Men's income increased only marginally, by over BDT 3500/ha or about 19%, while that of women trainees increased by over BDT 17,200/ha or almost 39%. It is particularly striking

that the women achieved this gain entirely by improvements in efficiency, rather than by increased expenditure; although there was no significant difference in total production expenditure between trained men and women farmers. For example, in particular, trained women increased their pre-stocking expenditure by almost 60%, whereas trained men did not increase pre-stocking expenditure at all. This agrees with greater adoption of pre-stocking inputs by women and indicates better pre-stocking preparation. Trained women also made modest increase (23%) in post expenditure, but all their increases were offset by an actual decrease in stocking costs; it also observed that women tend to stock the less prestigious but cheaper species (Daplyn et al. 2006).

Fish culture offers opportunities particularly for middle class household women's movements outside the homestead but for poor women it has not been obeyed due to economic imperatives. However, most of the female participation in aquaculture is at homestead ponds, mostly owned by male members of the households.¹⁵ Several studies indicate women's participation in fish culture is predominantly to feeding, fertilizing, manure and feeding the ponds (Barman 2001; ADB 2004). However, these activities are most important and valuable for the growth of fish and have to perform routinely every day, but all their endeavours are considered as household activities (Belton et al. 2011). The IFAD funded Aquaculture Development Project reported that 'pond aquaculture is an appropriate entry point for empowerment of women. A combination of training and credit has enabled women to establish managerial control over pond fish aquaculture, even though the pond remains in the ownership of their husband or rented from leaseholders' (Nathan and Apu2007). Danida funded projects at greater districts of Mymensingh, Barisal and Noakhali contributed significantly for transferring aquaculture knowledge to rural men and women equally, especially Barisal project (covering the districts of Pauakhali, Barguna, Bhola and Barisal) which ensured equal numbers of male and female participants at all the village based 'Fisheries Field School (FFS)' for imparting aquaculture knowledge (PBAEP 2003).

Factors that have been influencing trends in knowledge provision

Indirect participation on agriculture extension programs are found to increase exposure and demand for agricultural advisory services more than is the case with direct participation (Benin et al. 2011). It is not always the case that direct participation promotes access to adoption of a new and improved technologies or practices. In Bangladesh transferring knowledge through informal way by private sector people is really fascinating and encouraging; it is not only at fisheries sector, growth in readymade garments industries, human resource export and widespread micro-credit supported activities are the example of private sector people's sharing knowledge between them even in a competitive market. This could be due to the enigmatic strength of Bangladeshi people. However, direct participation of public sector is known to induce greater average effect on fisheries development in Bangladesh (Golzaret al. 2012).

Private sector initiatives of sharing knowledge are shown by the example of hatcheries in Jessore that share knowledge among each other and with hatcheries in other parts of the country. This has been encouraged by the widespread adoption of mobile phones, including in rural areas. Apart from technical information, market price information is also shared by wholesalers.¹⁶

Attempts have been made by a number of aquaculture projects in Bangladesh to train fry traders, one of the major actors in the fish value chain, to enhance their ability to act as private extension agents for fish culture. This program has been generating positive result but its sustainability is an important issue.

¹⁵. Muslim women possess legal property rights through inheriting is only half the share of land/pond of their brothers, while in Hindu community women has no legal inheriting property rights.

¹⁶.. Recently in Bangladesh mobile phones have become an essential part of working class, beneficial too; one example would give the changed picture, crop harvesters' labour markets, usually they assembled in the early morning at different point of the villages and land owners hired them from there, but now most of the contact has been made over mobile phone in advance (almost every day labour owning a phone); as a result physical presence at the labour market has been diminishing. It is found more at urban working class people such as mason, electrician, plumber, day labour etc. Mobile phone helped them planning when and where they will go for work, on the other hand temporary employers do not have trouble finding labourers at the market or at the shops where they are usually available. Mobile phone contact saves time for both parties.

Policies in place that influence access to aquaculture knowledge and information

National Fisheries Policy (1998) and subsequently the approval of Aquaculture Extension substrategy (2006) indicates the government priority of imparting fish farming knowledge across the country. These policies also aim at improving the technology delivery chain with overall goal of increasing production and productivity of fish. The mandate of the Department of Fisheries according to the National Fisheries Policy is the following key tasks:

The private sector shall be responsible for the commercial production of fish fry. The private sector will be encouraged to establish more hatcheries for fry production.

Arrangements will be made to transfer the improved technologies for aquaculture through regular training in the government fish farms and training centres. Brood banks shall be established in the government farms for distribution of quality brood to the private hatcheries. The government hatcheries/farms will also be used as centres for training farmers and entrepreneurs in fish culture management, fish breeding and fry production technologies.

Based on the policy, the prime role that government has been providing is to coordinate in enhancing the private sector investment and raising farmers' productivity.



Inputs and services: Credit

Structure of credit provision

Credit to the fisheries sector has been classified as agricultural credit. Bangladesh Bank, the central bank of the country, introduced credit norms for the fisheries sector in its agricultural and rural credit policy announced after the country gained its independence. However, initial credit for the culture of fish was restricted to pond culture of carp. Later, the bank took special initiatives to extend bank credit to saltwater shrimp culture in the coastal areas using traditional methods. There are some fishermen's cooperative societies who offered credit for the purchase of boats, nets and other fishing gear. However, their loans were mostly accessed by middlemen who became members of the cooperatives. Borrowers from the bank and the cooperatives have generally avoided repaying their loans using the plea of natural disasters. This default culture has at times discouraged financial institutions from lending to the fisheries sector.

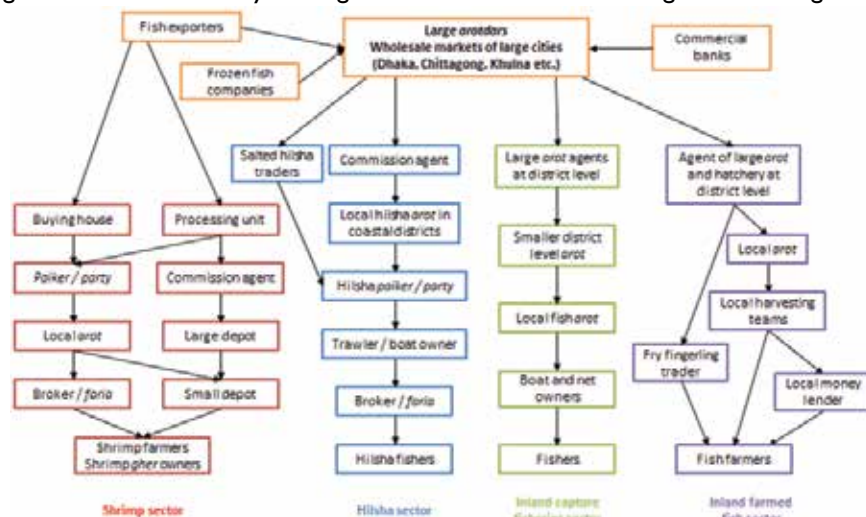
While the owners of boats in inland waters and owners of artisanal boats and trawlers can easily access credit from institutional sources, as they can provide the necessary collateral, the poor and illiterate fishing communities continue to remain impoverished as the capture and marketing systems are controlled by the moneylender-cum-boat-owners and the middlemen who play an exploitative role (Khan 1998).

Banks cannot reach poor fishermen communities, as they need supervised credit together with a package of socioeconomic services. These can only be effectively provided by NGOs. Bangladesh Bank is operating a credit guarantee scheme under which they are lending to fisheries projects without any collateral. Sonali Bank is also implementing a special lending program for fish farming, for up to BDT 50,000 without any collateral. This is an intensively supervised credit program, which involves cost subsidization and cannot be replicated throughout the country.

In Bangladesh, Krishi Bank and Janata Bank disburse loans for fish and shrimp culture and for hatcheries. The interest rates are within the reach of these people, at around 8%. Moreover, Department of Youth trains unemployed youth in fish farming and facilitates bank loans from Bangladesh Krishi Bank and Janata Bank. National NGOs provide credit to fishers and fish farmers under a microcredit program with an interest rate of around 12%.

Historically, the Bangladesh fisheries sector is highly organized through a system of informal moneylenders, from fish exporters to fishers. The fish marketing system is operated by informal capital by different stakeholders. Figure 10 shows the tentative informal money lending networks (*dadon*—advance purchase of the products) that are common in Bangladesh, including inland culture, inland capture (hilsha separately shown) and shrimp farming.

Figure 10. Informal money lending network in the fish marketing chain in Bangladesh.



The government formed the Bangladesh Fisheries Development Corporation but their presence in the market is not significant; it only sells fish from the Kaptai Lake and six DoF operated oxbow lakes in the southwest part of the country. Now some supermarkets are intervening in contract-grower system with fish farmers, but their current position is still at the niche market level.

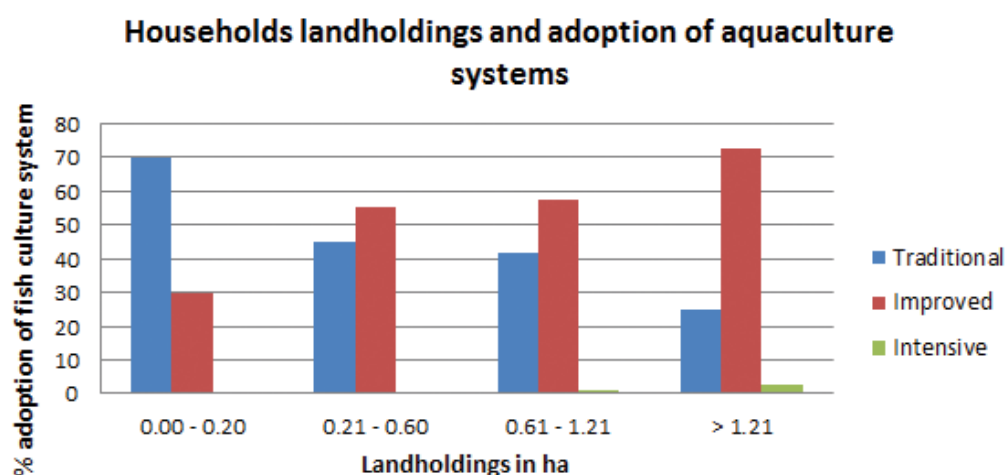
Fish farmers using credit

Hambrey et al. (2008) note that, 'fishpond owners may be generally categorized as relatively better off among rural households in the context of rural Bangladesh but they do not necessarily escape from poverty'. However relatively poor households who own ponds require support for sustainable fish culture. It is not difficult to get credit for the poor in Bangladesh. Networks of microfinance institutions are now spread throughout the country; access to credit for pond-owning households however small it is, is relatively easy to obtain. Microcredit operating NGOs are interested in lending money to these categories of rural households. However, many studies stated that cash payment for stocking fingerling by poor households is difficult and puts them into severe poverty; even relatively well-off households face similar situations (Toufique and Belton forthcoming). The reasons identified for this were as follows:

- Homestead ponds are typically small in size, an average of 0.06 ha (BBS 2005); stocking, fertilizer and feed cost is low, as mainly semi-intensive culture is practised in these ponds
- Lack of technical knowledge and continued appropriate management is important for these households.
- Field workers are occupied more with credit operation than training and technical support.
- All the households' women are borrowers of microcredit from one or more NGOs, for which operating separate financing for aquaculture is not considered meaningful.
- The availability of feed and fertilizer in rural areas is the priority of small pond operators.

Figure 11 shows the fish culture methods by households' landholdings (n=1918). The findings show that over two-thirds of the surveyed households practice traditional management, which require very little investment. If these households used improved culture methods, they would require larger investments. However, it could be safely assumed that most of these low-income households have been borrowing money from NGOs. On the other hand, households with large landholdings are capable of borrowing from commercial banks for intensified fish culture. If financing is not an issue, the important factor is in developing an appropriate credit repayment system that fits with the fish culture system. A number of NGOs are already practicing separate aquaculture loan repayment systems which are measured by the outcome of their participation with the fisheries projects.

Figure 11. Households' landholdings and adoption of different types of aquaculture systems.



Source: Adapted from Jahan et al. (2009); Belton et al. (2011).

Initiatives to improve access to credit

Government and donor supported aquaculture extension projects, for example FFP, AqDP and PBAEP planned to deliver credit or technical information through *paikers* (fish assemblers who often manage harvesting teams and purchase fish from pond owners). Initiatives to do the same through local extension agents for fisheries were developed under the World Bank-supported NATP project. However, no significant attempts have been made to date, of which we are aware of the sustainability or continuation of their service after project implementation period. An in-depth study is required to measure the post-project impact on relevant interventions.

The national aquaculture sector overview emphasized that:

there is a scope for delivering credit and high quality inputs to facilitate quasi-contractual farming arrangements with non-exploitative characteristics. This would require the development of appropriate guidelines and management mechanisms through consultation with stakeholders including DOF to ensure effectiveness. A large NGO, such as BRAC (which has its own hatcheries providing high quality seed, feed manufacturing capacity and experience in training, extension and credit provision), could potentially be a suitable candidate to operate a pilot initiative of this type.. (FAO 2014a)

Other options need to be explored, such as working with Palli Karma-Sahayak Foundation (PKSF), its NGO partners. Hatchery and farmers associations around the country could also be linked to these activities, either as credit and service recipients or providers.

Current policy issues under debate regarding credit service provision

WorldFish Center has proposed the establishment of a dedicated aquaculture credit fund to provide easily accessible loans with reasonable rates of interest and conditions especially tailored to fit the needs of fish producers (e.g. incorporating schedules that allow sufficient time for harvests to take place before repayment). This could offer a means of improving producers' ability to obtain working or start-up capital. This kind of credit could be delivered in a number of ways, to a range of producers and value chain actors to whom it would prove helpful (The WorldFish Center 2011).

One option could be to act as a guarantor for a fund administered by a commercial bank. This fund could facilitate borrowing by non-producers (e.g. *arotdars*, depot owners, market committees, investors who want to establish fish processing facilities). This arrangement would be unsuitable for less powerful producers and other value chain actors. It would propose a complementary bottom-of-the-pyramid-type approach to empower intermediary actors to get access to finance. This investment priority will enhance commercial aquaculture productivity under a public/private partnership and improve public and private advisory services destined for smallholder farmers willing to invest in aquaculture.



Conclusion on inputs and services in the aquaculture sector

With the rapid expansion of aquaculture in Bangladesh, disease-induced mortality is a serious issue for the fish seed industry. We assume about 5–10% fish mortality of stocking fish in aquaculture. Diseases are not the major constraints for improving fish production in Bangladesh, but poor quality of fingerlings due to poor brood selection and in breeding are major issues. Farmers are now more aware of the quality of the source of fingerlings and feed quality.

Intensive farmers are primarily dependent upon commercial fish feed and fertilizer. Feed cost is the main cost factor in aquaculture. Feed industries should use locally-produced, low cost, eco-friendly ingredients for feed production. In Bangladesh, there is a high potential for integrating fish culture with livestock production. FAO is in favour of adding livestock wastes to fishponds through integrated fish farming systems in Bangladesh that could increase production significantly.

The fisheries sector has been working in cooperation with the public and private sectors; this is a unique situation where knowledge and resources are being shared. Transferring knowledge through informal channels between private-sector people is really encouraging. A combination of training, knowledge and credit has enabled both men and women to take up fish culture. It is particularly encouraging to note women's progress in establishing managerial control over pond fish aquaculture.

Historically, the Bangladesh fisheries sector is highly organized by informal moneylenders; from the fish exporters at the top to the fishers at the bottom. The informal money lending in fisheries sector is through the *dadon* system—advance purchase of the products. This network is common in culture and capture fisheries. Formal credit is available through public and private banks; national NGOs also provide credits to fishers and fish farmers.

Government moves for the registration of hatcheries following the Fish Hatchery Registration Act have contributed to better quality fish seed production. Similarly, the Feed Act of Bangladesh, which requires registration for all feed producers, ensures that the macronutrient content of different categories of feed and raw materials is maintained at optimum levels. Continuous follow-up from the relevant government departments and ministries will ensure sustainable growth of the fisheries sector, and will minimize the risk of disease and poor fish health.



Value addition and marketing

This section identifies the post-production value addition in fish and marketing. This process normally involves a combination of physical transformation of fish and use of various inputs and producer services. Actors at every node add value to the fish with the aim of satisfying the final consumer.

Processing and marketing

The fish value chain in Bangladesh is not complex; actors are usually divided into two segments: production and marketing. In the overall fish value chain, fish farmers are the main actors; in the production part, hatchery operators are the key actors; while fish wholesalers (*arotdars*) are the key actors in the marketing segment.

Value addition is an activity of the marketing segment. In Bangladesh, value addition in the domestic market is limited to marketing live fish and dry fish (processing and drying in the sun). Live fish marketing is largely the product of aquaculture; dry fish processing is mainly carried out for capture fisheries. Although live fish marketing is growing it is mainly at city fish markets. Dry fish has a large market throughout the country, which is the traditional way of selling fish in Bangladesh. Most local people prefer dry fish both for its taste and low price, and it can be stored at room temperature for many days. Value addition is mandatory for the overseas market; all exported fish is processed at the fish processing industries before being sent to the destination.

Rural markets (usually called *haats*) are the oldest organized marketing and distribution channels in the Indian subcontinent. *Haats* allow farmers and producers, including fish either cultured or harvested in open waters, to liquidate their produce into cash through retail or wholesale trading. *Haats* act as commercial centres and as a place for social gathering that helps in the transfer of production technology (Katalyst 2014).

There are around 17,000 registered markets in the country. Fish are marketed in both rural and urban markets along with other agro-products in Bangladesh. Most of these markets, especially rural markets, tend to be unhygienic and have weak management systems. However, recently local government engineering departments have undertaken upgrading projects for rural markets, and built separate sheds for the fish market (setting aside space for women selling fish) with drainage facilities. Development activities have been completed at approximately 500 markets to date. The development of rural marketing may directly foster growth and entrepreneurship among the rural poor (The WorldFish Center 2011).

Participants in the marketing segments are connected by *dadon*—advance payment of produced fish. Fish farmers harvest and sell at the pond site to fish traders or use professional fisher teams to harvest on cash payment or against 15–20% of the harvest. Customarily, professional harvester teams purchase the harvested fish, unless the pond farmers sell at the local markets or send the fish to local *arots* (possibly a *dadon* arrangement). The remainder of the fish is sent to traders such as *paikers* and wholesalers but some is retained to fulfil local market demand; a certain amount is exported to overseas markets.

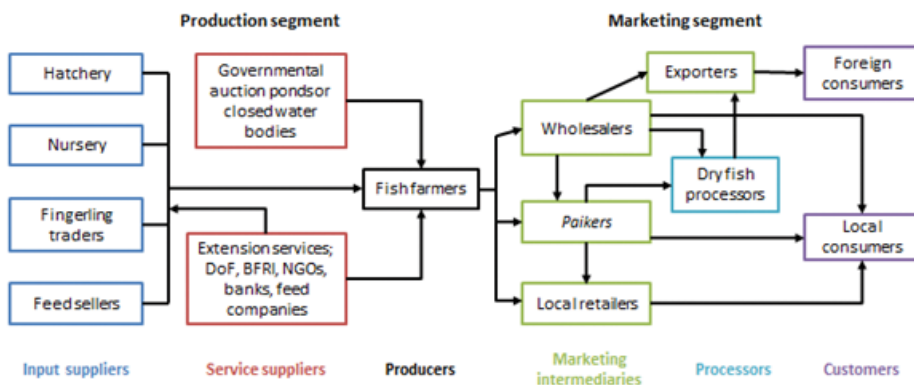
In general fish markets in Bangladesh are situated in both rural and urban areas. Approximately 97% of inland fish production (culture and capture) is marketed internally for domestic consumption, while the remaining 3% is exported (Hasan 2001). A large number of people are involved in the fish marketing chain, which includes: farmers, processors, traders, intermediaries, day labourers and transporters.

Facilities at fish markets are minimal, with poor hygiene and sanitation. There are no standard practices for handling, washing, sorting, grading, cleaning and icing of fish. The main constraints at primary markets are lack of bargaining power and market information. The marketing infrastructure, including cold storage, ice and transport facilities are generally inadequate, unhygienic and in poor condition. Wholesale markets have better facilities, but in general conditions in primary and retail markets are far from satisfactory with regard to: stalls, parking, sanitation, drainage and management (Ahmed 2005).

There are four types of markets are involved in fish distribution: primary markets, secondary markets (assembly markets), higher secondary markets (wholesale markets) and central markets. Locally these steps in the chain are known as: fishermen *nikary* (collectors), *chalani* (transporters), *arotdars* (wholesalers), *paiker* (retailers) and consumers. The market chain defined for freshwater prawn from producer to consumer is the field workers, prawn traders, agents and processing companies. A fish farmer receives 56% of the price paid by the final consumer; in other words 44% of the retail price is taken by the various intermediaries (Alam 2002).

The country’s main exportable product is frozen shrimp; other exported products include hilsha, frozen fish, frozen frog, dry fish, salted fish, turtles, crabs, shark fins and fish maws¹⁷ (DoF 2013). Of the total available fish and fishery products for export, 30.06% is exported to USA, 48.51% to European countries, 9.32% to Japan and the remainder to Thailand and Middle Eastern countries (EPB 2013). Figure 12 shows the main actors in the fish value chain of Bangladesh for aquaculture, which currently contributing over 53% of production, presented in two segments: production chain and marketing chain.

Figure 12. The mainstream actors of the Bangladesh aquaculture market.



Source: Personal communication from fish traders of Jatrabari fish wholesale market (2013).

Among the different stages of this value chain, those who own ponds or have access to ponds are generally engaged in the value chain as farmers (producers), while others are engaged at different stages. Farmers collect inputs from different input suppliers such as seed sellers, fingerlings etc. There are others who provide government (*khas*) ponds or closed water bodies to the farmers by auction.

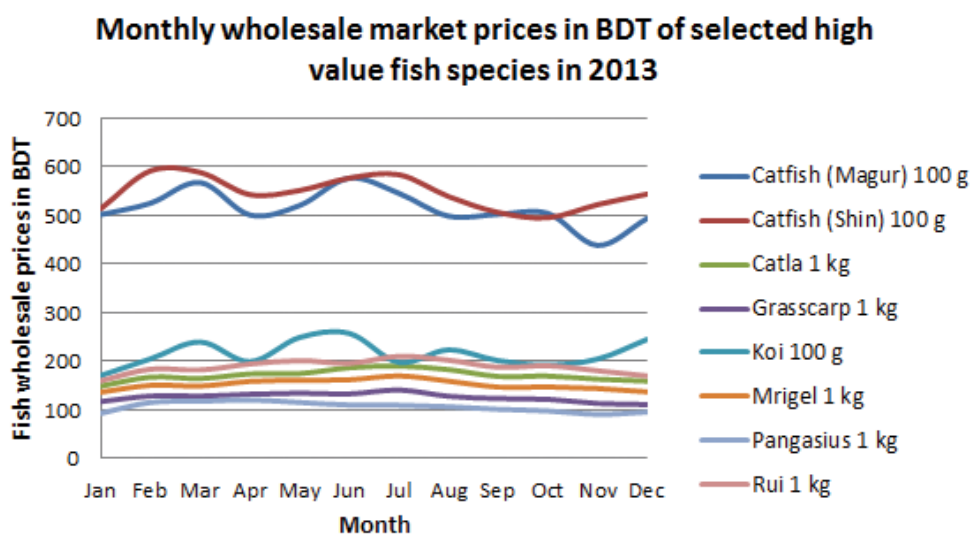
The customers of these products are either local consumers or consumers in national markets. The local consumers get these products from local retailers and *paikers*. National market customers such as customers in Dhaka and other parts of the country get these products from wholesalers or *arotdars* and other marketing intermediaries. Fish farmers mostly sell the fish at the pond site but for better prices they take the product to the local markets and *paikers*, mostly on *haat* day (weekly market). There is also another player in the chain who is the dry fish processor. Dry fish processors buy the raw product (e.g. fish) from wholesalers and *paikers*, process these and deliver them to end customers through market channels.

17 . Maws—dried fish swim bladders.

Volumes, prices and margins, market shares, employment

DoF has keeps nationwide records on volume by major species and by type of water body, but price by species was not found. WorldFish has fish price data covering the administrative divisions of Bangladesh, capturing both wholesale and retail price by species. Figure 13 shows the wholesale price of selective expensive fishes of 2013 (WorldFish 2014); the main buyers are wealthier households. The wholesale price of Magur and Shing of 100 g per pieces is most expensive,¹⁸ rest high value fish price largely remained below BDT 200/kg. However, pangas and grass carp (1 kg size) was around BDT 100/kg.

Figure 13. Wholesale price of high-value fish in BDT, 2013.



Source: WorldFish (2014).

Figure 14 shows the wholesale price of low-value fish; usually low income households have better access to these fish. The cheapest fish is silver carp (around BDT 60/kg), followed by pangas (around BDT 80/kg) although during February–April the price increases to BDT 90–100/kg; while Sar puti (250 g/piece) is most expensive, at between BDT 120–140/kg (WorldFish 2014).

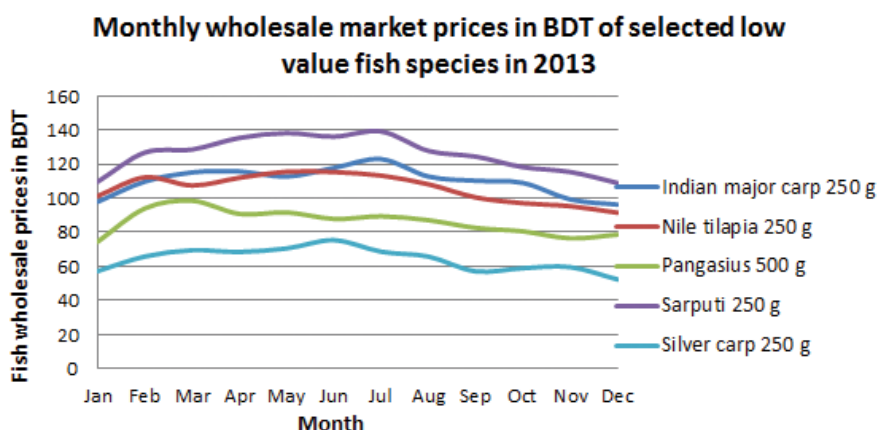
In Bangladesh, most of the fish prices are low during the months of October to January; plenty of fish arrive in the market with the receding of floodplain waters. However, this seasonal price fall does not affect magur, shing and koi because these species can easily be kept in water jars for many days.¹⁹ This seasonal price fall does not discriminate between high- and low-value fish.

Of the expensive (or high-value) fish (see Figure 13 above), there are no price fluctuations because there is a smooth supply to respond to a predictable demand. The price fluctuates at regular intervals in low-value fish, which perhaps is because of difficulty in providing a steady supply for a large number of buyers. Usually fish farmers are not interested in harvesting small-size carps for a better price from one annual harvest from their ponds. Getting greater economic benefit from selling small-size carps (locally called *pona*) is a new concept to most farmers; these small-size carps are the main source of animal protein for low-income households. Fish farmers are gradually adapting a more commercial strategy of fish marketing, and carrying out repeated harvesting and stocking.

¹⁸ . Maximum growth size of shing and magur is between 100-150 g per piece. In this analysis we have only considered the local (deshi) magur, not the African or Thai magur (its cultivation and marketing is banned in Bangladesh).

¹⁹ . In rural areas, households catch shing and magur from dried up floodplains and keep them in earthenware pots with surface water collected from rivers or canals. By changing water on alternate days, these species survive for more than a month and during that time households use the fish for own consumption. According to local people, the survival rate of these catfishes in underground water (mainly tubewell water) is much lower.

Figure 14. Wholesale price of low-value fish in BDT, 2013.

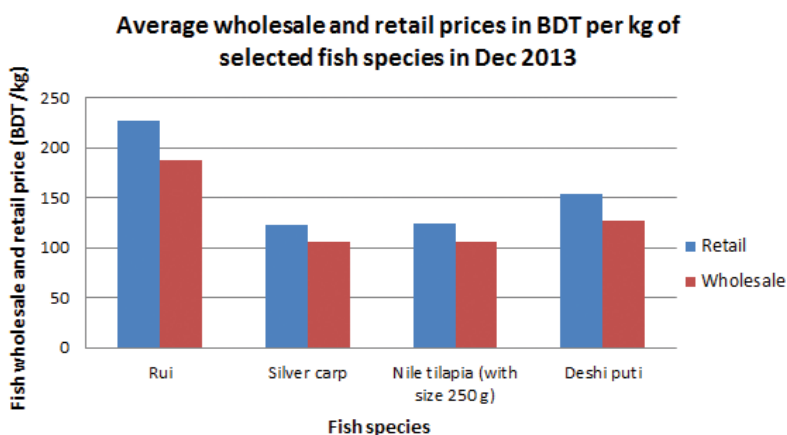


Source: WorldFish (2014).

Historically, fish demand increases for Bengali people for two months in the year; for a month during Falgoun in the Bangla calendar (February–March) when most festivals such as marriages, picnics etc. are held. The other high fish demand month is the month of Ramadan (August in 2013). However, in 2013 during that two-month period, wholesale fish price remained reasonable, which is not usual behaviour of the fish markets from the viewpoint of end consumers.

Figure 15 shows that the price difference between retail and wholesale markets is small; the retail price varies between 14–17% more than the wholesale price (WorldFish 2014); the profit rate is low but their high volume sale means they generate most earnings of the day; and most buyers of these fish are the vast low-income households. This scenario is fairly uniform throughout the country’s fish market chain. We need to understand why fish sellers sell at such minimum profit margins. It may be because historically fish selling is classified as low-grade work in Bengali society: retail fish selling was a job of the low-cast Hindu community, but due to extreme poverty, many people, irrespective of their religion, have now taken up this job (Halder 1968). Poverty could have made them satisfied with minimum profit; moreover retailers are compelled to sell out as soon as possible as they do not have facilities to keep these perishable items overnight and sell them the next market day. Here is the unique difference between fish sellers’ marketing behaviour and poultry or livestock seller’s behaviour. Retailers of poultry and livestock have better options for price bargaining with *paikars* and wholesalers; if the price is not satisfactory, the retailers of poultry and livestock can bring their poultry or livestock back home and sell them on the next market day.

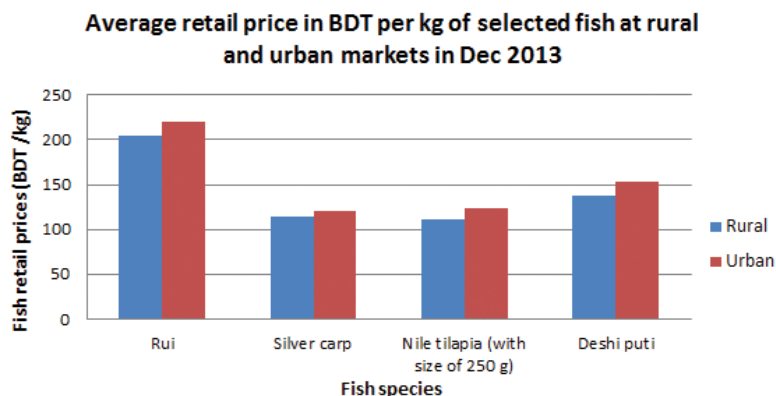
Figure 15. Overall fish price at retail and wholesale markets in BDT/kg, 2013.



Source: WorldFish (2014).

Figure 16 shows the difference in retail price between urban and rural markets; the difference is not significant. Urban markets price is 6–10% higher than rural markets, in case of Rui and Silver carp it is about 8% and 6% respectively; it is over 10% higher for tilapia and puti (WorldFish 2014). With improvement in road communication, most of the harvested fish are transported to higher urban markets; leaving little for rural people, hence the price is high. This scenario of rural markets is similar for other agriculture products.

Figure 16. Overall retail fish price at rural and urban markets in BDT/kg, 2013.



Source: WorldFish (2014).

In the overall fish marketing system throughout the country, women are largely absent. In Bangladesh, LGED has been carrying out rural market development by building separate fish selling sheds with provision for women to sell fish in the corner in an effort to encourage women to work in the fish trade. However, uptake of fish selling by women so far is very low (LGED 2012).

There is a high level of female participation in the value chain associated with the shrimp sector in Bangladesh. This is concentrated mainly on PL collection and shrimp processing factory work (over 80% are women); and on labour: embankment, weeding, and day guarding and in shrimp ponds (Belton et al. 2011).

In dry-fish processing, women participation is very high, although accurate numbers have not been found, but more than 90% of work is carried out by women; men are involved mainly in marketing dry fishes. The wages of dry-fish women workers is very low or they do it as part of their homestead work, which remains unpaid.

Policies that influence the composition of the sector

The common practice of developing a *chatal* (local outlet for selling shrimp from *ghers*) is that influential *gher* owner(s) initially start selling produced shrimp close to their *ghers* either on private land or on government land (*khas* land). *Paikers* also assemble there for purchasing at auction; as a result gradually other *gher* owners bring their products there to get better prices. Most *chatal*s have been developed in the shrimp producing area of southwest Bangladesh. These *chatal*s are an example of a community initiative, like how all other rural markets have been initiated throughout the country. According to current market policy, a market cannot be established on private land. If a local community wants to start a market on private land, it should be legally handed over to the government. *Chatal*s have been following the same policy.



Food safety

Food safety is an area of great importance internationally, as highlighted by recent outbreaks of food borne diseases and food poisoning. Unfortunately, there are several public health concerns in Bangladesh in relation to fish when considering nutrition and food safety. The dangers of fish acting as vectors for human pathogens are still not clear. Public health aspects of fish produced in human wastes might be expected to be more serious than those of animal/fish integration. Use of human waste in fish farming is very limited. A large number of farmers in rural Bangladesh are reluctant to handle and add animal wastes to fishponds. Some farmers are reluctant to eat fishes raised from integrated fish-poultry farming where fish consume fresh poultry manure directly. Most of the ponds in Bangladesh were constructed to serve various social functions such as building foundations for houses, bathing, washing, cooking, and even for drinking. Adoption of integrated fish–livestock farming is not possible in many ponds, particularly in homestead ponds, because of the use of water for domestic purposes.

Researchers have made comparative studies of natural fish populations and those grown using cattle manure or effluent. Large numbers of bacteria, including potential pathogens were found in skin, gills and intestines of the fish cultured using manure or effluent; but tissues and blood was sterile in both groups. This suggests that the consumption of fish cultured in waters containing animal manure would not cause a health risk greater than that of fish caught from natural waters (Rola and Hasan 2007).

Various toxic chemicals, such as formalin²⁰ and DDT²¹, are used for fish marketing, which has become a serious concern in Bangladesh. DDT is seriously harmful to human health, even when people eat cooked, dry fish. Each year, millions of citizens suffer from chronic illnesses due to the consumption of unsafe fish. Interestingly, Bangladesh has sufficient laws ensuring safe food for public health, such as the Safe Food Act, 2013, which protects against food adulteration.

WorldFish Bangladesh has been seriously concerned about the implications for public health and poor nutritional impacts of people's diets; it has been providing technical support to a number of projects throughout the country to improve access to fish for poor households. FAO-supported Improving Food Safety in Bangladesh; USAID-supported Feed the Future Aquaculture for Income and Nutrition; IFAD-assisted Production of Micronutrient-rich Small Fish in Floodplains; GIZ-funded Strategy for Conservation and Management of Wetland Biodiversity and other projects, in collaboration with DoF have been assisting the Bangladesh Government to address safety and quality fish food for improving public health. However, public offices responsible for regulation of public health and food safety need a concerted effort to ensure a quality fish supply at the consumers' level.

The people of Bangladesh are becoming increasingly concerned about formalin-contaminated food items such as fish, fruits, and many other food items. DDT has been widely used in open-air fish drying to protect fish against birds, flies and other insects. Both formalin and DDT are seriously harmful to human health; there is no other significant human health risk related to eating rotten fish. The exotic piranha (*Pygocentrus nattereri*) was introduced to Bangladesh

20. Formalin is a solution in water of the gas formaldehyde (CH₂O). It is used as an embalming fluid and for the preservation of animal specimens and tissue samples. In diluted form it is also used as a disinfectant, anti-bacterial wash, and for treating parasite infections in fish in aquariums (<http://www.indigochemicals.in/other-industry.html>).

21 . DDT (dichloro diphenyl trichloroethane) is an organochloride known for its insecticidal properties (<http://en.wikipedia.org/wiki/DDT>).

in the 1990s; it was later noticed it contained poison in the mouth area and the government banned its culture and marketing. However, its culture has been continuing, and it has a good market particularly in expensive restaurants. Interestingly, 'piranha' looks similar to the 'rupchanda', which is an expensive species; cooked 'piranha' is sold in the name of 'rupchanda'. This could have risks for human health in the long-run; a study on the presence of 'piranha' in the market and its impact on human health should be carried out. The attempt to adulterate shrimp by injecting them with gel and fluids was done for export marketing mainly. However, this issue is now under control due to the adopted methodologies of shrimp marketing by buyer countries. The government has taken this issue seriously, in an effort to restore its shrimp export market by all means.

At all fish markets of major cities, formalin is added to all fishes to prevent them from rotting, which largely replaces ice use for fish transportation and marketing. It is easier and cheaper to use formalin than to use ice for storage and transport of fish. Formalin keeps fish fresh looking for 5–6 days after one application. Fish traders use several applications for longer periods of transporting and marketing. In Bangladesh, local fish traders are acquainted with use of formalin in fish because of the imported carps from India and Myanmar. Now it is being used in indigenous fish marketing. It has also been widely used for imported or locally produced fruit marketing. However, other than dry-fish processing, the use of DDT in food has not been noticed (Uddin et al. 2011). The use of this chemical could become a threat to food safety, although the extent of this is presently not well researched.

Structures of the public health sector relevant to fish products

The major actors in public health relevant to fish products marketing are: local government administration, DoF, Ministry of Trade, Ministry of Local Government and Rural Development and BSTI (Bangladesh Standards and Testing Institution). They have the responsibility and authority to influence fish traders to provide safe fish to consumers. These actors have the authority to take action against formalin-contaminated fish marketing.

International organizations, such as FAO and WHO, have shown concern for safe fish marketing in Bangladesh. They have been playing an important role in raising awareness among national authorities in member states responsible for managing food safety emergencies. Recently INFOSAN (International Food Safety Authorities Network, a joint program of FAO and WHO) reported on the public health risks in Bangladesh from fish and fishery products; it also showed concern about exporting shrimp that complies with international standards.

In terms of operation, the Ministry of Trade works together with DoF and concerned organizations, forming 'mobile courts'. A court magistrate and police visit markets and conduct on-the-spot testing of fish for traces of formalin and take necessary action. To date this action has made little impact in the market.

The fish in the supermarkets are usually fresher than market fish and are kept chemical-free. Many supermarkets have arrangements with contract growers and suppliers at production points, that has created positive expectation among fish buyers. However, the confidence that developed in people's mind has recently been damaged by inspection reports of mobile courts for formalin use in fish supermarkets; it found serious irregularities (which was covered by the electronic and print media). In the last year (2013) mobile courts have issued large monetary fines to supermarkets for using formalin in fish, compared to lower fines issued to traditional wholesale fish markets in Dhaka city (personal communication G.M. Shamsul Kabir, Project Director, Control of Formalin Use in Fish Preservation and Mass Awareness Campaign, DoF. January 2014).

Factors that have been influencing control practices

More regulation is required in urban than in rural markets. The use of formalin is more apparent in cases of high-value fish which is either imported or locally produced. In rural areas, buying capacity for high-value fish is limited; this indicates that low-income groups are relatively safe.

Recently, live-fish sales at the city market have increased; this indicates people's anxiety about fish safety. Now both high-value fishes and low-value fishes can be bought live. Gradually, live fish marketing has been expanding, especially at weekends when demand is very high. It indicates awareness against formalin-added fish among low-income groups. Transporting live fish at the market and selling arrangement is a complicated job; the traders get a better price (30–50% higher than other forms of fish) for their labour and risks taken (Apu and Himel 2013).

The government has been operating three laboratories for testing fish, mainly for export: at Dhaka, Chittagong and Khulna. Shrimp processing farms and frozen fish exporting companies have microbiology testing facilities; while sample testing has been undertaken at government laboratories to monitor the quality according to the specification of exporting fish. However, testing of domestic market is limited to testing for formalin levels.

Government laboratories have undertaken microbiology tests on: heavy metals: mercury, cadmium, lead and arsenic; aerobic plate counts; *E. coli*; *Listeria monocytogens*; *Salmonella*; *Vibrio parahaemolyticus*; *Staphylococcus aureus*; *Vibrio cholerae* and filth; and chemical tests on: chloramphenicol; nitrofurans derivatives such as AOZ, AMOZ, AHD, and SEM; dye tests on MG, LMG, CV and LCV; and anthelmintics tests on flubendazole. However, these laboratories have no facilities for microbiology tests for organophosphorus (OP) and organochlorine (OC) pesticides. The Chittagong laboratory is the only one that has facilities for testing heavy metals: mercury, cadmium, lead and arsenic (personal communication from DoF Laboratory in-charge, Dhaka, 2014).²² There is no overall report on testing for the presence of germs in the fishes of Bangladesh. Aerobic plate counts is most common, followed by *Salmonella*, *Vibrio cholerae* and filth. Of the nitrofurans derivatives, the presence of SEM is high.

Recently, in Good Aquaculture Practices (GAQPs) issued by the Department of Fisheries (DoF) and Bangladesh Aquaculture Alliance (BAA), it stated that aquaculture relating business components do not obey most of the regulations of 'Good Aquaculture Practices (GAQPs)' in Bangladesh. It also stated that Noakhali is a district where considerably large volumes of fishes and shrimps are produced, but GAQPs rules are not being practiced according to the food safety requirements due to ignorance of its importance and lack of awareness about this issue (DoF-BAA workshop, Noakhali, 2013).

Policies in place that influence access and use of control practices

Unsafe fish represents a major threat to public health in Bangladesh. The cabinet of Bangladesh has approved the draft Formalin Use Control Act, 2013, to stop the misuse of formalin, with up to 10 years in jail and a fine of BDT 500,000 for violations. Along with administrative action, motivation and awareness programs have been undertaken involving market management committees (MMC)²³ for safe fish marketing. The government distributed formalin testing kits to MMCs in the big city markets, a move which has generated positive results. A number of important markets in Dhaka city have been declared 'formalin free markets'. Government policy against the use of harmful chemicals related to food safety has covered many issues such as

- the use of urea mixing in making puffed rice (a popular food in the country) and bakery produced foods such as biscuits, cakes etc.;

²² . Information on fish testing facilities of the DoF was provided by Md. Manik Mia (Jakir), Fish Inspection and Quality Control Officer, Laboratory In-charge, Dhaka, 25 February 2014.

²³ . In Bangladesh, every market (urban or rural) has a market management committee (MMC), this committee is elected by the traders, shopkeepers and other stakeholders of the concerned market.

- the chemical carbide which is being sprayed on all types of fruits (and vegetables) for artificially keeping them fresh for many days;
- the use of dying colours in dust spices.

Policy on marketing in aquaculture strategy (DoF 2006) mentioned that:

- Fish or shrimp transportation by open van or truck will be banned. Only insulated or refrigerated fish vans will be permitted for fish transportation.
- Fishers will be encouraged to keep fish in cold storage prior to marketing. After harvest, use of sufficient quantity of ice shall be ensured during preservation, transportation and marketing of fish. A cold-chain system will be established in fish marketing. Entrepreneurs will be encouraged to establish marketing of frozen fish.
- Hygienic and modern facilities will be ensured at each fish market. Fish marketing should not be done in open, debris-filled and muddy areas. Fish used for marketing should be free from germs and deterioration. Legal actions will be taken against marketing of fish, which are rotten, have a bad odour and are unsuitable for human consumption.
- Operators of all wholesale and retail markets shall be obliged to abide by the approved government regulations for human health and fish quality control.
- Adequate power will be given to fisheries quality control officers to inspect fish landing centres and wholesale markets and to take punitive measures against the sale of degraded and poor quality fish.

In theory, the policies are useful but in view of the situation in the country, they are not practical as transportation of fish by refrigerated van is not possible. The consumers want hygienic fish but they may often be purchasing formalin-contaminated fish, when ice has been substituted for formalin.

Current policy issues on public health

- The Consumers Association of Bangladesh (CAB) is still very weak; this organization must work jointly with MMCs to protect formalin use in any commodity (i.e. fish, fruit, vegetables) to ensure public food safety.
- There should be promotion of public awareness about safe food. There has been some progress to date—with the expansion of the live fish market. Various actors in the fish value chains must be equipped with appropriate advice on how to improve the quality and safety of fish.



Competitiveness of the fisheries sector

Comparative and competitive advantage in relation to the world market

Table 14 shows the export and import prices of fish compared to that in the local market for the same species and similar size. Interestingly, the export price of hilsha is not higher than the local market price; all exported hilsha are more than 1 kg in size, considering that the export price is relatively low. Only headless shrimp are exported, even then the export price is only little higher than the local market price of similar size shrimp with heads. There must be some other incentive factor for exporting fish. Although carp importers have been importing relatively larger sizes, the price of locally produced similar sized carps are much higher, almost double; because imported carps are perceived to culture in large lagoons in coastal areas of India and Myanmar. Bangladeshi buyers consider imported carp to be of lower quality than locally produced carps. A discussion with a group of importers of carps revealed that informal import amounts are quite high; total import amount exceeds 60,000 t, while formal import is about 45,000 t.

Table 14. Export, import and domestic market prices of fish in Bangladesh

	Price (per kg) (BDT)	Size	Info. source
Hilsha			
Export price	457	over 2 kg in size	DoF 2012
Domestic price	400–600	less than 1 kg in size	Jatrabari fish market
Shrimp			
Export price	789	min. 100 g headless	DoF 2012
Domestic price	500–700	100 g with head	Jatrabari fish market
Carp			
Import price	200–300	2–5 kg	Jatrabari fish market
Domestic price	350–500	2–5 kg	Jatrabari fish market

Current structure of prices and margins across the main value chains

Fish production centres are spread throughout remote areas of Bangladesh. As a result, a well-organized marketing system has been in operation, transporting fish to consumers in every region of the country; this marketing system for fish includes: transportation to and from the market, handling, storing, packaging, sorting, merchandizing etc. It enables the consumer to obtain fresh fish at a reasonable price.

The structure of price and margins across the main fish value chain varies across different marketing channels, including: (i) rural to rural markets; (ii) rural to urban value chain; (iii) urban/per-urban to urban value chain; (iv) urban (wholesalers) to export value chain; and (v) urban fish vendors in the value chain. The total cost structure of marketing fish includes all costs incurred by different types of intermediaries in the chain, from producers to the

end consumers. Marketing margins include costs of marketing and profit or loss incurred by all intermediaries in the marketing channel; the marketing margin is the price intermediaries charge for all of the functions they perform.

To understand the current profit margin of fish marketing in Bangladesh, it would be useful to use past examples. For example, ICLARM conducted a study in 1993 on fish marketing in two thanas (now called upazilas) shows that average purchase and selling price of carps were generally higher than those of the other fishes in the markets. The average seller's margin ranged from 22 to 281%; the margin was lower for the cultured fishes such as carps and exotic fishes than for wild fishes, shrimp/prawn and indigenous small fishes. In another study in 1982, it was observed that the price per maund (37.33 kg) of hilsha paid in Rajshahi in the north was BDT 696, while fishermen were paid a spot price of BDT 387 per maund for their catches in the south. That means, fishermen received 56% of the price consumers paid, while the middlemen involved in the marketing process siphoned off 44% of it as profit and costs for their marketing services (FAO 2001). A recent study shows that farmers receive a relatively higher share (approximately 70%) of the retail value for all species, except for hilsha. In case of hilsha marketing, *mahajon/arotdars* bear all sorts of cost of catching hilsha from deep sea and rivers, for which they absorb a major share of the consumer price (Alam et al. 2012).

However, more in-depth research is needed through systematic sampling to understand the functioning of the fish value chain in terms of: (i) Who among the value chain actors is benefiting more; (ii) Who is mainly marginalized or more vulnerable; (iii) Which share contributes in adding highest value added. This study can be undertaken by a financial analysis (i) from the perspective of individuals operating the business in the fish value chain; and (ii) which draws attention to financial costs and benefits etc.

Conclusions regarding likely growth scenarios

Profits made by fish traders may appear to be high (ranging from 30 to 45% of the consumer price) but they are not excessive when compared to profits from other agricultural commodities such as jute fibre farmers' whose share is 56% (with processing activities); the farmers' share for jute fibre farmers in Aman is 72% and in Boro is 71% (FAO 2001). Fish is a perishable commodity, and transportation is more hazardous for fish than for crop products. Judging from the modest profits of intermediaries and their reasonable marketing margins, fish markets appear to be competitive and efficient. Marketing margins in imperfect markets are likely to be higher because of abnormal profits.

Current growth of aquaculture products is over 6% per year. In a recent study conducted in 2012 on the marketing margin of major carps, pangas and tilapia, the net marketing margin is the highest for catla followed by rohu, tilapia and pangas at all stages of the market intermediaries. The estimated percentages of net marketing margin (Alam et al. 2012) are given below:

Table 15. Average net margin of different value chain actors in the fish value chain

Value chain actor	Average net margin (%)
Arottdar	56.7
Inter-district paiker	40.6
Paiker	52.5
Retailer	77.3
Farmer	95.9

Source: Alam et al. (2012).

The profit of retailers is the highest of all the market intermediaries. The profit of intermediaries varies due to variation in their costs, purchase price and sales price. The highest average marketing cost per maund of fish is over BDT 305 for *paikar* followed by BDT 2884 for the inter-district *paiker*, BDT 186 for the retailer and BDT 41 for the *arottdar*. The average marketing cost for farmers is BDT 137.75/maund for all fishes. Unlike other intermediaries, retailers earn the highest profit from high-value fish such as rohu and the lowest from low-value fish such as pangas (Alam et al. 2012).

The growth potential in the shrimp/prawn sector is significant. The freshwater prawn sector saw an average annual growth of 6.5% between 2000 and 2012 (Ahamed et al. 2014). In 2010 Bangladesh's share of the world prawn market of USD 2.27 billion was 11.3% (FAO 2012) thus there is an opportunity to grow Bangladesh's market share. Bangladesh fetches the second highest prawn price (USD 9.71/kg) in the USA because of its size and organic value but its export contribution to US market is lowest (3.74%) due to low production. Thailand has the highest contribution (37.3%) with a lower price (USD 6.59/kg) because it has high production. On average, Bangladesh produces 200 kg/acre while Thailand produces 1200 kg/acre (NACA 2010). This is due to different production methods rather than any country-specific reasons.

Bangladesh has the potential to penetrate new export markets. Currently 90% of Bangladesh prawn products are exported mainly to the USA and EU (Bangladesh Frozen Food Exporters Association (BFFEA) 2009). Currently prawns are cultivated on 60,000 ha in Bangladesh, which can be expanded to 100,000 ha. Vertical expansion is also a possibility, with the application of more modern farming methods. Profitability could be increased by developing more value added products. For example, processing plants claim to be operating at 20–30% of their full capacity on average (Katalyst 2009).

Government policy is favourable to intervention in the shrimp/prawn sector. The commercial nature of prawn means actors tend to treat the sector as a serious business interest. The existence of some large processors, feed companies and more than 130 hatcheries (DoF 2012) indicates that there are partners who could potentially have a wide impact, including those of small farmers. However, gender disparities permeate the chain, leading to occupational segmentation, wage inequality, and increased job insecurity for women (Gammage et al. 2006).



Value chain governance

Historically *haat-bazaar* (market) administration and management is a part of land management of the Indian subcontinent. In 1978, the government decided to transfer all *haats*, *bazaars*, ferries, and ponds/tanks to the local bodies to make local government institutions financially viable. Although every market has a market management committee involving local representatives and representatives of different actors of the market intermediaries, the shop-owners²⁴ in the market areas and wholesalers are the main actors who take the day-to-day decisions (Apu and Hannan 2011).

Fish wholesaler or *arotdars* supply fish to markets and decide on the type and make an estimate of the volume of fish to be sold on a daily basis; this is communicated through *paikers* to other actors in that particular market. The price estimate depends on consumer demand and price status at production farms. The government's role is minimal in the overall marketing system.²⁵ It fixes a toll collection rate for all items from *paikars* and retailers which is collected by the market leaseholder, who wins the leases based on an annual auction; however, the toll is not usually paid.

Synthesis of structure in main value chains

Hatchery operators; input providers; fish farmers; and various market intermediaries such as fingerling traders, *faria* (brokers) and *paiker* (wholesalers) at fish markets; transport agencies; are the main actors in fisheries activities throughout the country –producing fish in one part of the country and ensuring that it is available for consumers in another parts. These actors are interrelated and cooperate with each other.

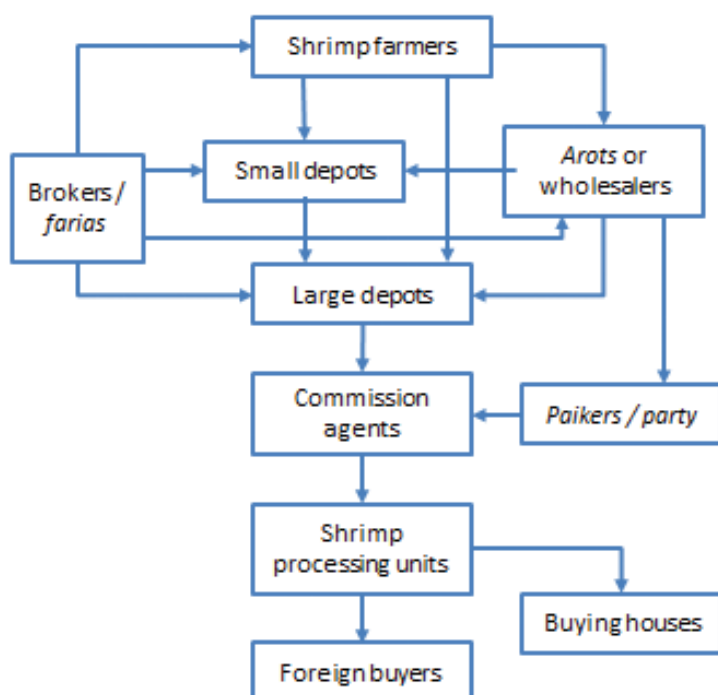
The life-force of the cooperation is the flow of informal money through money lending (*dadon*); showing the transactions between different nodes. Who provides credit to who and the contract between them operates on the principle of 'advance purchase or sale' of the product. Other issues such as rate of the product, seasonal price variation, or interest rate of money lending etc. depends on the relationship between the parties, their level of trust and how long the different actors have worked together.

The shrimp sector is a good example of the degree of coordination between different actors and the types of transactions between nodes. Figure 17 shows the shrimp supply chain from one actor to the next market intermediaries and illustrates the overall coordination of the shrimp value chain.

24 . Most of the shop-owners either have business partnerships with wholesalers for different commodities or operate an independent wholesale trade too, which is common in rural markets.

25 . Apart from fixing toll rate, government policy is to transfer 25% of the concerned auction money to the market for development works. Recently government has undertaken infrastructure development of remote rural markets by connecting road facilities to higher markets.

Figure 17. Value chain map of shrimp in Bangladesh.



Source: Modified from Shetty and Islam (2013).

The degree of supply of shrimp products between different actors in the shrimp value chain of Bangladesh is given below (Shetty and Islam 2013):

Shrimp farms/*ghers* supply shrimp products through *farias*/brokers (33%), small depots (28%), arots/wholesaler (22%) and big depots (17%).

Of the volume collected by *farias*/brokers, 53% are supplied to big depots, 29% to small depots and 18% to *arots*. Similarly, 44% of procured volume of *arots* are supplied to *paikers*/party (44%), 38% are supplied to big depots and 18% are supplied to small depots.

The procured volume of shrimp from big depots and *paikers* is supplied by commission agents to processing units. After processing, the finished shrimp products are marketed through foreign buyers and shrimp buying houses.

Indicators of concentration, competition within the sector and main value chains

The fish market in Bangladesh is large in terms of volume, value and employment. The marketing system has a vital role in connecting fish producers and consumers in the value adding process in fisheries sector. Fish and fishery product consumption is increasing sharply. The fish marketing systems are traditional, complex and competitive. However, competition is minimal at wholesale level; there is an informal restriction on new entrants to the wholesale market due to the presence of a strong wholesale traders' association. On the other hand, at retailers level, competition is high and open, both in fingerling and fish selling; anybody can join the retail market and contact wholesalers or their agents directly; either using cash purchases or credit contracts (*dadon* system) with wholesalers. Usually credit-retailers initially get low-value fish from wholesalers for marketing, with trust being built up over time; they are then allowed to sell high-value fish. Inequality in terms of the gap between average low income and average high income has widened; inequality has increased. There is need for a reduction of power of wholesalers and commission agents (personal communication from focus group discussion with fish traders, Jatrabari fish market, Dhaka, 2013).

Overview of existing policies that influence governance and openness to upgrading

The practice of improving value addition of fish products in the value chains is rare in Bangladesh. As a result, there is no particular policy for upgrading fish products. There are no active organizations for fish farmers, retail traders and other small actors, which has resulted in exploitation by the well-organized, influential actors (fish wholesalers, fish seed producers and feed companies). Although the fisheries sector has experienced significant growth, the livelihoods of small actors have not improved much, while the lion's share of the profits has been accumulated by the principal actors of the fish value chain. Inequality in terms of the gap between average low income and average high income has increased. There is a need for a pro-poor producer and distributor friendly policy to elevate their positions along the fish value chain.



Externalities

Fish farmers and other stakeholders need sustainable production to respond to demand. This means that to enjoy positive outcome in fisheries sector, there must be a steady supply and use of quality inputs and environmental issues must be included. Broadly, two categories of externalities should be considered, those generated by

- activities that create unsuitable conditions for others;
- competition in access to a limited resource, which lead to economic inefficiency and less benefits (Nathan and Apu 2007).

The general perception in Bangladesh is that the influence of externalities in aquaculture practices is less in ponds/dighis than in seasonal floodplains, baors, coastal areas and other water bodies. Various forms of pollution such as: salinity from shrimp farms; antibiotics in feeds; discharge of nutrients; and escape of non-native species are the main issues, but they have not yet become serious constraints for Bangladesh aquaculture. In floodplain aquaculture the loss of access of small farmers to floodplains is crucial; local influence combined with external capital virtually pushes small landholders off floodplains and into auxiliary activities such as guarding, selling their labour for different fish farming activities; e.g. Dautkandi floodplain aquaculture (Apu 2007).

In coastal areas, the participation of small landholders was seriously restricted at the initial stages of shrimp culture in *ghers*,²⁶ now forming *gono-ghers*²⁷ with small landholders has reduced the monopoly of external capital and social tensions. In shrimp development in southwest Bangladesh, very few *ghers* are over 20 years old, and over 60% are 10 years old or less. At the beginning of commercial shrimp farming, the stereotype of farming as a large capitalist enterprise with major external actors is becoming outdated. For example, in Polder 23, over 46% of *ghers* are formed from shareholders' own land, and a further 34% lease land from five owners or fewer. The remaining 20% of *ghers* show the typical pattern of large *ghers*, controlling over 70% of the total *gher* area of Polder 23 (Daplyn et al. 2005).

Environmental impacts

Aquaculture in Bangladesh, like all terrestrial farming systems, faces a number of challenges, including increasing competition for limited resources, such as water, land and feed inputs; and environmental degradation of the resources utilized. In Bangladesh, the National Environment Policy is clear on issues concerning sustainable social and economic development and maintaining environmental quality in the long-run.

Interventions in Bangladesh aquaculture cover a wide range of different aquatic farming practices in terms of species and production systems. It offers enhanced fish production and income generation for rural and suburban areas.

An increase of fish production in Bangladesh, using intensive culture methods on a larger scale could change the balance of required animal food in the country but could have a negative environmental impact. These are general

26 .Artificial pond or lagoon for cultivation of shrimp.

27 .Group of small landholders who jointly operate a shrimp gher (gono means common people).

perceptions and it is not possible to give a clear idea of what measures should be used in Bangladesh. General preventive measures to restoring biodiversity in enhanced fish production are underway in Bangladesh. Bangladesh has a more limited intensive system of fish culture than other big producing countries, so its potential impact on the environment would be smaller.

Waste management

The lack of adequate labour and technology in hatcheries; the practice of fish processing in the city markets; and inadequate waste management at wholesale markets; are largely responsible for the waste problem in the aquaculture sector. Fish processing wastes have been used on a daily basis as feed for hybrid magur and other animals. However, these need to be well managed according to the Environmental Protection Act. Market management committees also have a role in waste management according to their terms of references.

Waste management in aquaculture is not a major issue but the industrial wastewater that contaminates inland surface waters used for fisheries and aquaculture is a major concern. The issue of discharge of wastewater is included in the application for an environmental clearance certificate; existing industrial units must include the location of an effluent treatment plant and its design. The Protection and Conservation of Fish Act empowers the government to make rules that prohibit the destruction of fish by poisoning of the water or the depletion of fisheries by pollution, effluents or otherwise.

Feed competition and impacts on ecosystem health

Here we discuss the impacts that the production of feeds has on the environment—e.g. how does use of fish meal in feeds affect ecosystems? More precisely, a larger impact would be created in the future with the increasing use of feeds in Bangladesh aquaculture. It is important to note here that freshwater ecosystems are a subset of earth's aquatic ecosystems. They include lakes and ponds, rivers, streams and springs, and wetlands. They can be contrasted with marine ecosystems, which have a larger salt content. Fish meal can be made from almost any type of seafood but is generally from wild-caught, small, marine fish that contain a high percentage of bones and oil, and is usually deemed not suitable for direct human consumption. Other sources of fish meal are from by-catch of other fisheries and by-products of value additions made during processing (fish waste).

A comprehensive analysis released by WorldFish and Conservation International (CI) has investigated the environmental impact of the world's major aquaculture production systems and species. It concludes that the demand for aquaculture products will continue to grow over the next two decades as a key source of animal protein for growing urban populations, and that the industry needs to meet this demand with improved efficiencies and reduced environmental impacts. This global review is an analysis of global aquaculture production across all major species and farm production systems (Hall et al. 2011).

In Bangladesh, aquaculture's reliance on wild caught seed is very low while brood stock is of increasing concern. Since fish meal is used for wild fish stock to feed farmed fish, this places pressure on fisheries resources. Indirect effects are also apparent, such as diminishing wild fisheries, habitat modification and food-web interactions. There is also the possibility of trace contaminants getting into the feed, which will cause diseases and fish mortality. Fish meal and its source of raw materials and costs are hotly debated by scientists and conservationists. The positive aspect of current aquaculture practices in Bangladesh is that most of the fish farmed are low-trophic level species so the impacts will not be that great on the ecosystem. Low-trophic species constitute a high proportion of the biomass in the ecosystem, achieving 80% of the conventional maximum sustainable yield (Smith et al.2011).

Impacts on climate change: Greenhouse gas (GHG) emissions

In spite of all the debates and controversies, a global consensus has been reached that climate change is a reality and that it will impact on food production systems, global biodiversity and overall human well-being. Aquaculture is no exception. The emission of greenhouse gas (GHG) in the fisheries industries is not well understood in Bangladesh.

Blue Frontiers: Managing the environmental effects of aquaculture has released a policy recommendations paper *Sustainable Fisheries for Food Security towards 2020* that aims to inform policymakers about the impacts of aquaculture on the environment and to stimulate debate on the optimal animal food production systems for the near future. In understanding and quantifying the environmental impacts of aquaculture, policymakers can establish evidence-based and fair environmental regulations. Fish farmers can understand and comply with environmental regulations while implementing good management practices. Development and environmental organizations need it to guide their strategies and actions, while retailers and consumers need it to make informed choices and drive appropriate policy and farming practices (Hall et al. 2011).

Public health concerns: Nutritional impacts and food safety

Aquaculture can provide essential nutritional support for humans. More production and consumption of fish by the poor could improve their diets and reduce rates of malnutrition. Given the low economic capacity of poor households, most of them do not have access to ponds or options to improve their diets. On the other hand, floodplains, which are mostly open access, are a free source of fish; recently a large area of floodplain has been brought under commercial cultured fisheries, which narrows down the opportunities of nutritional aspects for poor households. However, low-cost species such as tilapia and pangas (both are of small size) are a major option for the poor. Aquaculture might compensate for a reduction in the consumption of nutritious small indigenous species (SIS) from capture fisheries, although it might not adequately offset the most vulnerable households. To bring a balance in the long-term, several initiatives have been underway to increase the production of SIS in small homestead ponds, ditches and floodplains (Akhter 2013).



Aquaculture development strategies and activities

In 1991, World Bank carried out a review. The report analysed the conditions to accelerate the development of the fisheries sector in Bangladesh. It also outlined the main elements of a fisheries development strategy for Bangladesh. It outlined, based on the available evidence, the serious environmental problems that hinder fisheries development. These include: (i) flood control and drainage (FCD) projects that reduce fish habitat and the potential for floodplains fish production; (ii) the use of pesticides that can kill fish and fries; and (iii) industrial pollution of inland and marine waters, which harms fish habitats. The report stated: 'If these problems are addressed, in the next twenty years Bangladesh could see fish production doubling' (World Bank 1991).

The fisheries sector in Bangladesh has shown a higher performance than what was predicted two decades before; to-date, production has grown threefold. This was made possible with the introduction of commercial fish farming. The emergence of 'entrepreneurial' pond culture in Bangladesh is a relatively recent development that has gained increasing importance and scale since the late 1990s (Belton et al. 2011).

Alignment of aquaculture sector development with national economic development and poverty reduction strategies

The rapid growth of the fisheries sector was made possible by a systematic national approach to modernize the Department of Fisheries in the early 1980s by a group of young fisheries graduates at upazila level whose main task was to enhance aquaculture production, especially pond fisheries. Recommendations of the World Bank fisheries sector review in 1991 highlighted the following issues for the national fisheries development strategy:

- Accelerate aquaculture technology.
- Coastal aquaculture should be given the highest priority.
- Strengthen public-sector fisheries institutions.
- Encourage the private sector in commercial aquaculture such as hatcheries and others.
- Inland fisheries, including floodplains should get priority.
- Special attention should be given to fishers.
- Encourage NGOs to organize small fishers.

Although significant growth was made in fisheries it was not expanded throughout the country. Information on potential areas for expansion of fisheries activities was limited. In the late 1990s, a concerted effort was undertaken to target a poverty reduction strategy through aquaculture including women's participation; that reflected in different national development strategies of Bangladesh government; of them major documents are:

- Bangladesh Country Investment Plan (CIP).
- Bangladesh: Poverty Reduction Strategy Paper (PRSP).

Bangladesh Country Investment Plan (CIP)

In 2011, the Government of Bangladesh produced the Bangladesh Country Investment Plan (CIP) and its plan of action is from 2008 to 2015. This report represents the updated version of the Bangladesh CIP. It is a country-led planning, mobilization and alignment tool. It supports increased, effective public investment to increase and diversify food availability in a sustainable manner and improve access to food and nutrition security. Its interventions also aim to mobilize investment by smallholders and other private sector food security actors. It is a five-year comprehensive plan that aims to ensure sustainable food security.

The expected aggregate output from the CIP is a sustainable increase in fisheries production through improved technology and natural resources management.

Priorities from the consultation process:

The development of fisheries and aquaculture provides an opportunity to strengthen the production of nutritious, protein-rich food in Bangladesh. The call for development of this sector came from government agencies, civil society organizations, the private sector and farmers, due to its important role in employment generation, poverty reduction, and food and nutrition security. Current challenges of the sector include constraints related: to leasing and management of public water bodies; species degradation; diseases; low quality of brood, fingerlings and feeds; inadequate laboratory facilities of DOF at field level for diseases diagnosis; and lack of storage and processing facilities of fisheries.

Proposed focus and priority interventions:

- *Develop small-scale aquaculture through access to quality inputs, advice and skills:* Proposed prioritized interventions are: promotion of small-scale aquaculture practices with quality feeds, fingerlings and drugs and the enhancement of disease diagnosis facilities in the field offices of DoF. Backyard ponds for small-scale aquaculture should be developed by addressing the constraints faced by smallholders.
- *Improve management of fisheries resources:* Priority interventions are: community-based management of open-water fisheries through training and access to credit; excavation of water bodies for fish breeding; and the establishment of local hatcheries to ensure the supply of quality brood stock/fingerlings.
- *Develop public private partnerships in infrastructure and services development:* Development of partnerships is proposed to promote the establishment of hatcheries, feed and fish processing industries with backward and forward linkages; the establishment of cold storage and cold chains; and the production of quality fingerling, feed and drugs.
- *Promote production in the south through sustainable shrimp and prawn development and community-based co-management of wetlands:* Proposed interventions are: marine and brackish water fisheries resources management and capacity development; zoning of land for shrimp production; development of fish breeding grounds in the brackish water system; diversification of coastal aquaculture (crab, mussels, seaweeds, shrimp, tilapia etc.) and promotion of technology for integrated use of embankment areas for fish production.
- *Additional Considerations/ Implementation:* Collaboration between the Ministry of Fisheries and Livestock and Ministry of Water Resources is essential. DoF, Bangladesh Fisheries Development Corporation, Bangladesh Fisheries Research Institute, universities and the private sector should also participate in the proposed interventions. It will be important to involve community-based organizations of farmers and fishers as well as the private sector. An enabling policy environment will be needed for promotion of public–private partnerships and enhanced participation of private sector entrepreneurs. In particular, the sustainability of lease arrangements must be improved to enable effective community-based management of open-water fisheries.

Bangladesh: Poverty reduction strategy paper—Unlocking the potential

Poverty Reduction Strategy Papers (PRSPs) are prepared by member countries in broad consultation with stakeholders and development partners, including the staff of the World Bank and the IMF. Updated every three years with annual progress reports, they describe the country's macroeconomic, structural, and social policies in support of growth and poverty reduction, as well as associated external financing needs and major sources of financing. This country document for Bangladesh, dated 16 October 2005,²⁸ prepared by General Economics Division, Planning Commission, Government of People's Republic of Bangladesh, is being made available on the IMF website by agreement with the member country as a service to users of the IMF website. Key recommendations those related to poverty reduction and food security are given below:

- The country has experienced significant growth in the fisheries subsector. The main spurt came from the rapid growth in aquaculture: pond fishery and shrimp culture. More recently, floodplain fisheries have emerged as a highly potential area with particular significance for poverty reduction goals. As fish is income elastic, the aggregate demand will continue to rise with a rise in income.
- Inland open-water capture fisheries have declined substantially and adversely affected the poor who used to earn a livelihood from subsistence fishing in the floodplain. Traditional livelihood opportunities of the poor in the shrimp sector have been adversely affected. The issue of employment and livelihood opportunities in backward and forward linkage activities—fingerling production, fish catching, processing, marketing etc.—has also gained prominence.
- Home-based pond aquaculture involves women and children. The recent innovation of poly-culture in rice fields has opened up further opportunities for small and marginal farmers to exploit whatever little land they have in growing fish in rice plots concurrently and alternately.
- Fisheries sector suffers from shortage of quality fish seeds for which brood fish stock, hatchery and nursery management has to be addressed seriously.
- The capacity of the Department of Fishery (DoF) will be redefined and strengthened so that it can consolidate support inland aquaculture through intensification of culture fisheries with improved knowledge of fish culture, brood fish stock, quality fingerlings and feeds. The underlying strategy will be to promote a dynamic rural aquaculture, involving the key actors among NGOs, private sector entrepreneurs and community-based fishing groups, i.e. fish farmers, hatchery and nursery operators, fingerlings vendors, feed manufacturers and fish processors.
- DoF will preserve, patronize and make more productive use of inland capture fishery through community based participation of fishermen and fishery related stakeholders. The National Fisheries Policy will ensure access of the poor and community groups to water bodies. Three points merit priority consideration: firstly, appropriate long-term leases, secondly, viable production plans against which *jalmahal* lease rights are to be granted, and thirdly, ensuring adequate opportunities for poor fishermen and community groups to be participant in the process.
- Fisheries research will be upgraded to continue flow of technology generation. The plan of action will address development of inland and coastal fishery management, education, research and extension services, organizational as well as commercial policies (i.e. marketing, processing, quality control, export and transportation). Especially quality assurance in fish harvesting and processing will be emphasized.
- Various policies of other ministries impinge upon the fishery sector development because these policies regulate the availability of, access to and use pattern of the open water bodies. These will be coordinated and a necessary legal framework will be formulated. Development of water bodies should be planned by BWDB and LGED in coordination with DOF and DLS.
- Human resource development will be given priority by the Department of Fisheries, which will support in respect of fish production, processing and marketing through public sector agencies, NGOs and private sector.
- In the past various programs, they usually chose to ignore including small ponds, which surround most houses of poor households. Inclusion of smallholder fish farming has shown to contribute to rapid changes in existing

28. Update of the PRSR will be done by 2015.

resources through improved cultivation. There is no doubt that above mentioned policy issues have made a great influence in having the drive in fisheries sector to address both the objectives of production increase as well as poverty reduction.

Synthesis from review of aquaculture development activities

There are numerous local, national, regional and international initiatives promoting sustainable development of aquaculture in Bangladesh. Responsibilities for sustainable aquaculture development must be shared among government authorities, aqua-farmers, manufacturers and suppliers of aquaculture inputs, processors and traders of aquaculture products, financing institutions, researchers, special interest groups, professional associations, non-governmental organizations (NGOs), and others (FAO 2014a).

Aquaculture growth has not been uniform throughout the country, but the government has been concentrated resources with support from development partners in the areas of: Mymensingh, Barisal, Patuakhali and Banrguna (Danida-supported); Faridpur, Kustia, Jessore, Meherpur, Jhenaidha, Choadanga (IFAD-supported) and countrywide coverage of Fourth Fisheries Project (World Bank/DFID-supported). The government program of establishing over 100 fish hatcheries throughout the country in the early 1980s (World Bank-funded) had made a remarkable contribution to the emergence of private sector hatcheries in Jessore area. However, growth has been faster in areas where the environment and climate is more suited to aquaculture, not constrained by sandy soils or cool winter (DoF 2006). Department of Fisheries has been implementing numerous aquaculture projects with the support of development partners and using revenue funds; most of these NGOs are involved as implementation partners. Table 16 presents a list of some aquaculture projects that have contributed significantly to development in Bangladesh.

Table 16. List of aquaculture projects in Bangladesh

Name of project	Funded by	Period
First Aquaculture Project	ADB	
Oxbow Lakes Project (OLP-I)	World Bank	1982–88
Second Aquaculture Project	ADB	
Oxbow Lakes Small Scale Fishermen Project (OLP-II)	IFAD	1989–97
Community-Based Fisheries Management Project (CBFM-I and II)	DFID	
Mymensingh Aquaculture Extension Project (MAEP)	Danida	1986–2006
Fisheries Training and Extension Project (FTEP)	DFID	
Northeast Fisheries Extension Project (NFEP)	DFID	
Patuakhali Barguna Aquaculture Extension Project (PBAEP)	Danida	1998–2005
Greater Noakhali Aquaculture Extension Project (GNAEP)	Danida	1998–2005
Third Fisheries Project (TFP)	World Bank	
Fourth Fisheries Project (FFP)	World Bank	1999–2006
Aquaculture Development Project (AqDP)	IFAD	1999–2005
Sunamgonj Community Based Resource Management Project (SCBRMP)	IFAD	2002–2013
Regional Fisheries and Livestock Development (Barisal Component)	Danida	2006–1013
Regional Fisheries and Livestock Development (Noakhali Component)	Danida	2006–2013
Brood Bank Establishment Project	GoB	2007–2013
Bagda Shrimp Culture Technology Extension Project	GoB	2007–2012
Greater Pabna Fisheries Development Project		2009–2013
Expansion of Aquaculture Technology Services up to Union Level	GoB	2009–2014
Project on Aquaculture and Fisheries Management in Bhabodha Area	GoB	2009–2014
Greater Faridpur Fisheries Development Project	GoB	2009–2014
Poverty Reduction and Livelihoods Security for the people of Economically Depressed Area		2010–2013
Development and Management of Identified Degraded Water Bodies and Conservation of Small Indigenous Fishes	GoB	2009–2014
National Agriculture Technology Project (NATP), DoF component	IDA	2007–2012
Aquaculture and Fisheries Management Program in Haor area	DoF	2010–2014
Fish production, Conservation and Strengthening Management Project in Kaptai Lake (DoF part)	GoB	2011–2013
Re-excavation of connecting river, development of irrigation facilities and fish culture project of Gazner Beel area (Fisheries Component) under Pabna district		2010–2013
Hura Sagar Aquaculture and Fisheries Management Project		2011–2014
Control of formalin use in fish preservation and mass awareness campaign		2011–2014

One of the largest aquaculture projects in Bangladesh, Feed the Future Aquaculture for Income and Nutrition (FTF AIN), is a five-year transformative USAID investment in aquaculture, working in 20 southern districts in Barisal, Khulna and Dhaka divisions of the country. It aims to improve fish and shrimp seed quality, household income and nutritional status and provide rural employment opportunities in the southwest –one of the poorest and most disaster-prone areas of the country. A total of 1.33 million households will benefit by producing fish, shrimp and vegetables (using the pond-dike and homestead system). Through this project, government brood centres and private hatchery operators are being helped to source quality brood stock to develop seed quality, and to distribute improved quality of fish, shrimp and prawn to farmers. The project will train 181,500 poor and vulnerable households in WorldFish aquaculture technologies and horticulture to generate improved nutrition and income; the number of meals containing fish per month is expected to double; the production of small indigenous fish species is also being promoted. The project provides technical support to around 60,000 shrimp and prawn farmers, 20,000 carp farmers and 500 cage fish farmers for adopting high-value commercial fish and shrimp culture. FTF AIN project will support the government in implementing existing policy and regulatory measures in the Hatchery and Feed Act, and other recommendations. Finally, the project will provide assistance in implementing the Aquaculture and Fisheries MoU signed between Bangladesh and India on cooperation in fish seed improvement and germplasm conservation and management.

A review on Bangladesh aquaculture carried out by WorldFish on request of IFAD, highlighted numerous projects that have promoted simple technologies and management techniques such as regular application of fertilizers and feeds; and the stocking of fish species in combination and in densities designed to move the culture system from extensive to semi-intensive production regimens. The review also indicates that better-off households are likely to own larger ponds than poorer households do and manage them more intensively (The WorldFish Center 2011).

WorldFish conducted a fish market survey which showed a division between rural and urban consumption patterns, suggesting that high-cost wild fish and commercially cultured species (pangas, tilapia and climbing perch) are exported from rural areas to Dhaka, while the majority of cultured carps remain in rural areas. Better transport and communications means that fish may be transferred quickly and directly from fishers and farmers in one district to wholesalers in other distant parts of the country. Marketing margins obtained by intermediaries are generally quite low, which is suggestive of a competitive marketing system (The WorldFish Center 2011).

The governing regulations of Bangladesh fisheries sector

From the earliest times in the Indian subcontinent, conceptually all land (including water areas) has belonged to the state. All persons who cultivate or hold intermediate interests in land are bound to pay a share of the produce of the soil to the state.

In 1793, the Permanent Settlement Law put forward by British rulers as an incentive to *zamindars*, that 'for fair revenue collection, the hereditary tenure of possession is to be the only necessary security'.²⁹The *zamindars* and independent *talukdars* were declared to be the proprietors of the soil (Farooque 1994).

The Bengal Tenancy Act 1885, defined land which is cultivated, uncultivated, fallow or covered land with water any time of the year, either open or closed where fish culture undertaken or not (Hussain 1995).

The first legislation that is relevant to aquaculture is the Tanks Improvement Act (1939), which provides for the improvement of tanks for irrigation and aquaculture purposes.

The basic act regulating inland fisheries is the Protection and Conservation of Fish Act (1950), as amended by the Protection and Conservation (Amendment) Ordinance (1982) and implemented by the Protection and Conservation of Fish Rules (1985).

29. Source: Letter from the directors of the East Indian Company to Lord Cornwallis, the Governor General of India.

The Marine Fisheries Ordinance (1983), as implemented by the Marine Fisheries Rules (1983), is the basic act regulating marine fisheries.

The Protection and Conservation of Fish Rules, for instance, deals with the protection of certain carp species, prohibits certain activities to facilitate their augmentation and production and stipulates that licenses for their catch shall only be issued for the purposes of aquaculture. In Bangladesh, seeding is traditionally by wild post larval and juvenile shrimps, or fish fry, which are trapped in ponds during tidal exchanges or gathered from estuaries in the vicinity and used to stock the ponds. As fry collection from nature may result in long-term ecological destruction, in 2000 the government prohibited the collection of fry or post larvae of fish, shrimp and prawns of any kind, in any form and in any way in estuary and coastal waters.

The Shrimp Culture Users Tax Ordinance (1992) stipulates that shrimp cultivation areas developed by the government by construction of embankments, excavation of canals or other water management structures shall be liable to payment of tax. In addition to these laws, aquaculture, and the conditions of its development, is affected by a variety of other laws, such as land laws, water laws and environmental regulations.

The Ministry of Fisheries and Livestock (MoFL), through its Department of Fisheries (DoF), has overall responsibility for fisheries and aquaculture development, management and conservation. Its functions, which are both regulatory and development-oriented, are defined in Schedule I of the Rules of Business (1975) and include, inter alia, the preparation of schemes and the coordination of national policy in respect of fisheries, the prevention of fish disease, the conservation, management and development of fisheries resources, the management of fish farms and training and the collection of information. The activities of DoF are supported by the Bangladesh Fisheries Research Institute (BFRI), which is responsible for fisheries research and its coordination. In addition, the Bangladesh Fisheries Development Corporation (BFDC), established under the Bangladesh Fisheries Development Corporation Act (1973), supports DoF in developing the fishing industry. The functions of BFDC include the establishment of units for fishing, preservation, processing, distribution and marketing of fish and fishery products.

In 1998, a National Fisheries Policy was adopted to develop and increase fish production through optimum utilization of resources, to meet the demand for animal protein, to promote economic growth and earn foreign currency through export of fish and fishery products, to alleviate poverty by creating opportunities for self-employment and by improving socioeconomic conditions of fisher folk, and to preserve environmental balance, biodiversity and improve public health. The policy extends to all government organizations involved in fisheries and to all water bodies used for fisheries. It includes separate policies for inland closed water fish culture and for coastal shrimp and fish culture. The policy touches on many contentious issues. For instance, it addresses conflicts over shrimp cultivation and underscores the need for formulation of suitable guidelines. To help conservation efforts, it prescribes a moratorium on further cutting of mangroves for shrimp cultivation. It also supports an integrated culture of fish, shrimp and paddy in paddy fields. In addition, the policy deals with many other relevant issues such as quality control, industrial pollution and the use of land.

The National Fisheries Strategy 2006 is a government document related to key concerns set out in the PRSP. To implement the strategy, eight substrategies and action plans were created. These are: i) Inland capture fisheries substrategy; ii) Marine capture fisheries substrategy; iii) Shrimp substrategy; iv) Aquaculture substrategy; v) Aquaculture extension substrategy; vi) Quality control substrategy; vii) Monitoring and evaluation substrategy; viii) Human resource development substrategy.

A new Fish and Animal Feed Law has recently been introduced to improve the quality and safety of shrimp and fish products for export and domestic markets. The law will mandate the licensing of all feed factories and feed sellers by DoF and will set standards for inclusion of feed ingredients and require all feed packaging to include a list of ingredients. The law will also ban the import, export and sale of contaminated feed and prohibit the use of growth hormones and banned antibiotics.

A new Fish Hatchery Law has been approved in order to ensure quality seed production. This requires registration of all hatcheries; prevents the import of fry, larvae, or post larva without government permission; and disallows inbreeding or hybridization by stipulating that hatchery operators must follow detailed hatchery management rules.

The eventual aim of the department is to institute good aquaculture practices (GAP) for both exports and domestic products to raise productivity and ensure that all aquaculture products are safe for human consumption. Ensuring supplies of good quality feed and seed is seen as the first step in this process.

Bangladesh Jalmohal (inland open water bodies) Policy, 2009 was adopted to ensure long-term lease (6 years at a time) to genuine local fisher's associations through auction for enhancing production and implementation conservation policies.

With the rapid expansion of aquaculture and inland capture fisheries activities, the organizational framework of DoF deserves more qualified extension human resources, particularly at the grass-root level offices; upazila fisheries office need to be equipped to support the private sector and NGOs but the government response in this regard is not sufficient. For example, only 55% of approved 634 second-class officers (mostly posted at upazila officers, who are key extension persons) of DoF have been appointed to date. Apart from human resources, other logistic support is also needed at the field offices.



Research and Development (R&D) partnership landscape

The policy of the Government of Bangladesh is generally favourable towards aquaculture, and the DoF³⁰ has several activities covering the following areas: extension; training, regulatory activities, fisheries management, quality control, marine fisheries, surveys, and support to policy making. Extension, training, enforcement and other field activities are carried out by field-level officers and staff (mainly UFOs and farm managers) throughout the country. Bangladesh Fisheries Research Institute (BFRI) conducts research and pilots the results, thereafter up-scaling those findings throughout the country through DoF's aquaculture and extension wings.

The following institutional bodies are involved in aquaculture and fisheries development in Bangladesh:

- Department of Fisheries (DoF) under the Ministry of Fisheries and Livestock (MoFL) is the sole authority with administrative control over aquaculture in Bangladesh. The DoF is managed by a Director General and has two main sub-departments: inland and marine. The main responsibilities held by the DoF are: planning, development, extension and training. DoF has six divisional offices, 64 district offices and 497 upazilla (subdistricts) offices; it has 118 hatcheries and four training centres.
- Bangladesh Fisheries Research Institute (BFRI) conducts and coordinates research and to some extent, training.
- Bangladesh Rural Development Board is responsible for the fisheries component of integrated rural development.
- Ministry of Land (MoL) is responsible for the leasing of public water bodies.
- Local Government and Engineering Department is responsible for leasing rural roadside canals (recently carried out fisheries development in haor areas of the country).
- Export Promotion Bureau is responsible for export of fisheries products, along with the Bangladesh Frozen Foods Exporters Association, which is involved in the export of frozen shrimp, fish and fish products.
- The country's universities are responsible for third-level fisheries education.
- External Resource Division under the Ministry of Finance is responsible for external aid for aquaculture development.
- Bangladesh Krishi (Agriculture) Bank, Bangladesh Samabay (Co-operative) Bank and other commercial banks are responsible for issuing credit to the aquaculture sector.
- Many national and international NGOs provide credits to fish farmers and implement projects in aquaculture extension and development.
- International organizations (ADB, Danida, DFID, IFAD, IMF, JICA, NORAD, World Bank) provide grants and credits for aquaculture development.

30. The Department of Fisheries has a total manpower of 4831, of which about 950 are Class I fisheries officers (Upazila Fisheries Officer level or above).

- Youth Development Training Centers, under the Ministry of Youth, deals with extension and the training of unemployed young people and fish farmers.

National aquaculture research actors for applied research, education and training

The Bangladesh Agricultural Research Council (BARC) is the national body for coordinating, monitoring and evaluating all aquaculture research. Experts from the DoF, BFRI, universities and NGOs develop research ideas and agree priorities through detailed discussion in workshops; the selected research topics are then sent to the MoFL for approval and execution. The main task of conducting applied and adaptive research is the responsibility of BFRI, although universities are also involved.

Formal fisheries education and research first began at the faculty of fisheries, Bangladesh Agricultural University in Mymensingh in 1967, when the faculty offers BSc fisheries (eight semesters), MSc (three semesters) and PhD degrees in various specialized areas of fisheries and aquaculture. Later, the Institute of Marine Science was established at Chittagong University in 1973, followed by the fisheries and marine science discipline in Khulna University in 1991, the Department of Aquaculture and Fisheries at Dhaka University in 1998 and the Department of Aquaculture at Rajshahi University in 2000 for fisheries education and research. The zoology departments at the above and other universities also offer subjects related to aquaculture and fisheries.

The Bangladesh Agricultural University offers training to government and NGO fisheries officers through its Graduate Training Institute; other institutes which offer fisheries education and training are the Marine Fisheries Academy, Chittagong which offers 1–2 year diploma courses; the Fisheries Training Academy at Savar, Dhaka; the Fisheries Training Institute, Chandpur, which offers 1–3 months training. The Fish Hatchery and Training Center, Raipur, the Fisheries Training Center, Faridpur and Vocational Youth Training Centers provide diploma certificates.

To encourage employment opportunities among the youth, DoF established a new institution in 2009, the Fisheries Diploma Institute, in Chandpur. The first-year intake was 25 students. The course runs for four years.

Bangladesh Fisheries Research Forum (BFRF) is involved in aquaculture research in fisheries and social sciences.

Regional/international aquaculture research actors active in Bangladesh

International organizations such as CIDA, CIRDAP, Danida, DFID, FAO, IDRC, World Bank, and WorldFish Center are involved in action-oriented research programs related to aquaculture in Bangladesh. FAO Aquaculture and Fisheries Department has been contributing significantly to producing valuable research and studies on the Bangladesh aquaculture sector.

A network of Aquaculture Centers in Asia-Pacific (NACA) is involved in action-oriented research and training in fisheries for government and the private sector in Bangladesh. Asian Fisheries Society, Asian Fisheries and Aquaculture Forum (AFAF), World Fisheries Society (WFS) and other international forums on fisheries have been supplementing and sharing the most recent developments on fisheries and aquaculture.

Development partners in the fisheries sector of Bangladesh

In the fisheries sector there are a large number of partners/donors involved in development initiatives in Bangladesh. These are: World Bank, International Fund for Agricultural Development (IFAD), International Development Agency

(IDA), Food and Agriculture Organization of the United Nations (FAO), United Nations Development Programme (UNDP), United Nations World Food Programme (WFP), United States Agency for International Development (USAID), Danish International Development Agency (Danida), Department for International Development of the UK (DFID), and Ford Foundation.

The activities of the partnership are: funding, study, research, institutional development and piloting the activities in production. Danida, DFID, IFAD, WB, WFP and WorldFish Center are the major leading bilateral partners in the fisheries sector. Some of them (i.e. DFID) took part in the sector review process. The fisheries sector review and future development study was conducted by DFID. A number of activities were promoted directly through government initiatives by many of the agencies.

The longer funded projects: Mymensingh Aquaculture Extension Project, supported by Danida, Fisheries Training and Extension Project and New Fisheries Extension Project, both supported by DFID have contributed significantly in developing and using knowledge, particularly among the poorer rural communities. The Third and Forth Fisheries Projects built capacity primarily in aquaculture.

SUFER (Support for University Fisheries Education and Research) project of DFID under University Grants Commission (UGC) initiated 1999–2004 with partnership of universities in the country such as Bangladesh Agriculture University (BAU), Dhaka, Khulna and Chittagong university beyond the traditional form of activities the support was initiated to updating and development of the fisheries curricula, moderation of syllabus, research capacity development of the researchers and demand lead aquaculture technology generation in partnership with the communities.

WorldFish Center formerly ICLARM (International Center for Living Aquatic Resources Management) has implemented pro-poor fisheries projects directly with beneficiaries since 1996 under a MoU signed with BARC, in partnership with DoF and NGOs. Until recently (2005–2010), WFC with BARC and DoF implemented a participatory project entitled Community-Based Fisheries Management (CBFM) in Floodplains and Irrigation Systems. The CBFM approach is considered the best way of managing floodplain fisheries nationally and globally. The approach was first initiated by WFC through DoF (1995–1999). Based on the experiences of first phase CBFM 2 (2001–2006) was implemented.

The concept was further used in the projects—Third Fisheries Project (1991–1996), Fourth Fisheries Project (1999–2006) and Management of Aquatic Resources through Community Husbandry (1998–2007). Among others, WFC is implementing an action research project called Adivasi Fisheries Project with the ethnic people in the north and northwest of the country. The performance of all these projects has improved homestead pond management and sustainable floodplains management, resulted in greater employment, increased nutritional and income status, ensured a social safety net and improved food security.

The Government of Bangladesh and Denmark have been implementing the Agriculture Sector Support (ASPS) Project, covering a range of agricultural activities since 2000. The first phase (ASPS I) concluded in 2006 and the second phase (ASPS II) commenced immediately afterwards and was ended by 2012. The components of the ASPS II include: crops, seeds, horticulture, fisheries and livestock. The activities of fisheries and livestock are being implementing under the Regional Fisheries and Livestock Development Component (RFLDC) covering the greater Noakhali and Barisal region in Bangladesh.³¹

31. Chapter 18 is derived from website of Bangladesh Agricultural Research Council (BARC), <http://www.barc.gov.bd/home.php>. Accessed on 15 April 2014.



Opportunities for pro-poor fish value chain development

Although it is one of the world's poorest and most densely populated countries, Bangladesh has made major strides to meet the food needs of its growing population, through increased domestic production, augmented by imports. The country's main endowments include its vast human resource base, rich agricultural land, relatively abundant water, and substantial reserves of natural gas. The land is devoted mainly to rice and jute cultivation; the country is largely self-sufficient in rice production. Bangladesh is one of the world's leading inland fisheries producers; aquaculture accounted for about 53% of total fish production during 2013, with inland open-water fisheries contributed over 29% (DoF 2013). Fish represents an essential source of micronutrients for the people of Bangladesh. It provides about 60% of animal protein in daily food consumption. Its production contributes to the livelihoods, income-generation and employment of millions. The culture and consumption of fish has important implications for national food and nutrition security, poverty and growth. Bangladesh people, especially rural communities, have an extremely strong cultural attachment to fish.

During the twentieth century, Bangladesh adopted one-sided production-oriented policies in the agricultural sector to feed its rapidly growing population. This strategy included increasing fish production, which was in decline mainly because of environmental degradation brought about by the expansion of agriculture. The solution was aquaculture development and later the promotion of culture-based fisheries and large-scale stocking in the floodplains and beels (lakes) that previously sustained the capture fisheries. Although fish production in many cases may have increased as a result of this type of intervention, benefits are not socially and environmentally sustainable. Fisheries policy in Bangladesh is still trying to come to terms with the major dilemmas of maximizing benefits from natural resources while, at the same time, ensuring an acceptable degree of equity in distribution of benefits and protecting the ecosystems that support the resources (Valbo-Jørgensen and Thompson 2007).

This section will present a review of the present status of the fisheries sector based on a SWOT analysis, which is a strategic planning method used to evaluate its strengths, weaknesses, opportunities and threats.

Strengths of Bangladesh fisheries:

- vast fisheries resource in Bangladesh
- largest sweet water fish producer in the world, with potential for exporting
- contributes 4.39% of GDP
- gives 22.76% of agriculture GDP
- contributes 2.46% of national exports

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- source of livelihoods of 11% of the total population, of them over 10% are women
 - about four fold increase in fish production (1.66 t 1999 to 3.26 t in 2012)
 - source of food and nutritional security
 - tool for poverty alleviation and women's empowerment
 - requires relatively low capital investment
 - skilled work force
 - government provides monetary assistance
 - low management costs, particularly in small-scale fish farming
 - the domestic market is large.

Weaknesses of Bangladesh fisheries:

- enormous inbreeding problem
- lack of quality fingerlings
- high production costs (feeding)
- poor water quality of inland capture fisheries
- small profit margin in fish trading
- low value addition in fish processing, no policy for processed fish product
- lack of disease diagnostic facilities
- dominance of poor pond management practices resulting in low productivity
- on-farm poaching in aquaculture is significant
- poor coverage of financial services; commercialized production may limit options for resource-poor producers
- inadequate feeding practice due to lack of technical knowledge of fish farming
- low value addition and fish processing. There are no organized and coherent efforts in the country to formulate and implement policies for the processed fish/fishery products for domestic markets.
- fish stocks in Bangladesh territorial deep-sea waters remain untapped because of lack of suitable fishing vessels.
- post-harvest losses (marine and inland) re significant; estimated at about 15% of the total Bangladesh marine and inland industry.

Opportunities of Bangladesh fisheries:

- income level is constantly increasing
- growing sector of the country's economy
- venture capital
- new products and services
- improve food safety

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- enhanced value addition; due to value addition, fish farmers and fishers across the country will receive remunerative prices for their produce.
 - in the case of aquaculture, scope exists to bring more fish species with a focus on food fish, ornamental species and those with potential for sport and tourism
 - growing demand for domestic freshwater fish
 - fish production can be enhanced in rain-fed water bodies by two to four fold
 - positive impact on the poor in terms of food supply and livelihoods

Threats to the Bangladesh fisheries:

- poor quality of fish seed
- brood stock production activity is not well organized
- rising cost of feed and other raw materials
- use of formalin in fish for transportation and marketing
- limited financial capital
- increasing interest rate of credit of informal moneylenders (*dadon* system)
- natural disasters (flood, drought)
- high competition in retail fish markets
- inadequate implementation of government rules and regulations
- stagnation of marine fish catch due to uncontrolled fishing and over-exploitation of coastal resources
- decrease in marine fish catches because of climate change and other factors
- climate change impacting on aquaculture and inland capture fisheries
- import of processed fish products such as canned tuna, salmon etc. by stores (i.e. increased international competition)
- unsustainable capture inland fishery activities in the past which led to habitat degradation; multiple uses of inland water bodies with low priority for fisheries wealth.



Annotated database of Bangladesh data sets

Aquaculture, poverty and employment survey

This integrated qualitative–quantitative survey was conducted by WorldFish in 2012 in seven villages, each with a high concentration of aquaculture operations. A structured household survey based on a stratified random sample and a qualitative survey based on in-depth semi-structured interviews was conducted simultaneously. A representative cross section of all the inhabitants of the seven villages was obtained in order to account for the impacts of aquaculture on employment, food security and well-being at community level. Data was entered in MS Access and cleaned, and analysis is nearly complete. The data will be made available on an open access basis.

Aquaculture production economic survey

This household survey was conducted by WorldFish in 2012. Data was collected on the yield, profitability input use in 15 aquaculture systems in 10 districts, representing nearly all of the major culture systems practiced in Bangladesh. The data was entered in MS Access format and is fully cleaned, and analysis is ongoing. The data will be made publically available on an open access basis once the analysis is completed

Bangladesh economic review

The Bangladesh Economic Review is published annually by the Ministry of Finance and is available online. It includes a summary of data on the country's macroeconomic status and progress, as well as sectoral information, including the GDP contribution of fisheries www.mof.gov.bd/en/index.php?option=com_content&view=article&id=72&Itemid=1

Census of agriculture

The BBS Census of Agriculture is conducted approximately every 10 years. National and district reports are published. The key information contained in these reports relates to landholding size and land ownership patterns. The census contains some information on aquaculture, but this is limited in scope. The entire data set is not publically available due to its size (the census covers all farm holdings nationally), but a representative portion of the data is available for purchase. WorldFish does not currently own this.

Chronic poverty and long-term impact study in Bangladesh

This data set, supervised by IFPRI, provides information on the impact of commercial vegetable and polyculture fish production on income, household resource allocation and nutrition in Bangladesh. The questionnaire was administered to 5541 individuals in 955 rural households in 47 villages in four rounds from June 1996 to September 1997. The data was collected as part of an impact evaluation of new agricultural technologies being disseminated through NGOs.

Topics in the household survey included: income; household value of consumed goods; social capital; shock history; credit given and obtained; inheritance/assets at wedding/divorce; family background; health care and birth control use; household sanitation behaviour; reproductive history and mortality; nutrition knowledge; food preferences; women's autonomy and decision-making. Topics in the community survey include temperature and rainfall. Data is fully cleaned and available in SPSS and Stata formats. www.ifpri.org/dataset/bangladesh-1

Feed the future Bangladesh integrated household survey

The Bangladesh Integrated Household Survey data set is an assessment of the current standard of food security in Bangladesh taken from 2011–2012 under the USAID-led Feed the Future initiative. The BIHS sample is statistically representative at the following levels: (i) nationally representative of rural Bangladesh; (ii) representative of rural areas of each of the seven administrative divisions of the country: Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Rangpur, and Sylhet; and, (iii) representative of the Feed the Future (FTF) zone of influence. The sampling of the FTF locations (districts and upazilas) was done separately for its statistical analysis. The survey has detailed data on (i) plot-level agricultural production and practices, (ii) dietary intake of individual household members, and (iii) anthropometric measurements (height and weight) of all household members. The survey was designed and supervised by the International Food Policy Research Institute (IFPRI). The survey was administered by Data Analysis and Technical Assistance, Dhaka, Bangladesh. The data set is available for download in Stata format. However, the data is not completely clean, and thus requires considerable work to make it usable. Nevertheless, it is an extremely rich source of information, containing unique data on intra-household distribution of food and data on aquaculture productivity. http://www.usaid.gov/opengov/developer/data_sets/bangladesh-integrated-household-survey-data_set.zip

Fisheries Statistical Year Book of Bangladesh

The Fisheries Statistical Year book of Bangladesh is published annually by the Fisheries Resource Survey System of the Department of Fisheries (DoF). Although there are concerns about the quality of the data (there has been a tendency to overestimate production from inland capture fisheries and underestimate production from aquaculture), there have been signs of improvement in recent years, and the year book is the only historical source of fisheries statistics. Information is presented at the aggregate national level, and on a district-by-district basis, for a variety of species. Statistics for capture fisheries and aquaculture are presented separately. Data sets from 2001/2 onwards are available from the DoF website at www.fisheries.gov.bd/stats?order=field_statistic_title_value&sort=asc

Household income and expenditure survey

The Bangladesh Bureau of Statistics (BBS) Household Income and Expenditure Survey (HIES) is a five-yearly nationally representative survey implemented by the Government of Bangladesh, and is similar in design to the World Bank Living Standards Measurement Survey. It is used to generate statistics on poverty and other development indicators, and is generally considered to be the 'gold standard' for data on consumption. BBS publishes a summary report upon completion of each survey, which is publically available and can be purchased for a small fee. The raw HIES data sets can be purchased from BBS for several hundred USD. WorldFish already owns copies of the data set for 2010, 2005, 2000 and 1995. Earlier versions of the data set are in Foxpro format, which is difficult to handle, so technical assistance may be required if information is to be extracted. The two most important sets of information provided by

HIES are national, rural and urban poverty lines, and food consumption data (quantity and frequency) disaggregated by income. Food consumption data is collected every two days over a 14-day period, and staggered over the course of a year to correct for seasonality. A shortcoming of the data on fish consumption in surveys conducted after 1990 is that fish is aggregated into 15 groups, some of which do not appear to have a logical basis. HIES (both published reports and raw data) is a valuable resource and key point of reference.

References

- ADB(Asian Development Bank). 2004. *An evaluation of small-scale freshwater rural aquaculture development for poverty reduction*. Manila, the Philippines: Asian Development Bank.
- Ahamed, F., Fulanda, B., Siddik, M.A.B., Hossain, M.Y., Rahman, M.M., Mondol, Z.F.A. and Ohtomi, J. 2014. An overview of freshwater prawn fishery in Bangladesh: Present status and future prospect. *Journal of Coastal Life Medicine* 2(7):580–588.
- Ahmed, N. 2007. Economics of aquaculture feeding practices: Bangladesh. In: Hasan, M.R.(ed), *Economics of aquaculture feeding practices in selected Asian countries*. FAO Fisheries Technical Paper. No. 505. Rome, Italy: FAO. pp. 33–64.
- Ahmed, N., Young, A.A., Dey, M.M. and Muir, J.F. 2012. From production to consumption: A case study of tilapia marketing systems in Bangladesh. *Aquaculture International* 20:51–70.
- Akhter, S., Barman, B.K. and Thilsted, S.H. 2013. Production of micronutrient-rich small fish in the floodplain. Dhaka, Bangladesh: WorldFish and Department of Fisheries, Bangladesh.
- Alam, M.J. 2002. Socioeconomic conditions of Haor fishermen. PhD thesis. Chittagong University, Bangladesh.
- Alam, M.S. and Faruk, A.M.O. 2013. *Fisheries sector: Climate change impacts and development potential*. Dhaka, Bangladesh: Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh.
- Alam, M.F., Palash, M.S., Mian, M.I.A. and Dey, M.M. 2012. Marketing of major fish species in Bangladesh: A value chain analysis. A report submitted to Food and Agriculture Organization for the project 'A Value-chain Analysis of International Fish Trade and Food Security with an Impact Assessment of the Small-scale Sector'.
- Ali, M.Z. and Haq, M.E. 2010. *Improved fish feed management in aquaculture*. Extension Manual No. 38. Mymensingh, Bangladesh: Bangladesh Fisheries Research Institute.
- Apu, N.A. 2007. Rice-fish culture in the floodplains of eastern Bangladesh. Draft Report prepared for IFAD.
- Apu, N.A. and Hannan, M.A. 2011. *Functioning of market institution: Historical perspective and experiences of market infrastructure development project in coastal regions (MIDPCR)*. Rome, Italy: LGED IFAD.
- Apu, N.A. and Himel, F.B. 2013. *Initial performance assessment of fish hatcheries in southern Bangladesh under USAID-AIN project*. Dhaka, Bangladesh: WorldFish.
- Azad, S.A. 2013. *Fisheries sector of Bangladesh: Achievements and potentials*. Dhaka, Bangladesh: Department of Fisheries.
- Barman, B.K. 2001. Women in small-scale aquaculture in North-West Bangladesh. *Gender, Technology and Development* 5(2):267–287.
- Basavaraju, Y., Mair, G.C. and Penman, D.K. 1997. A genetic improvement programme on Catla in Karnataka state, India—Primary findings. Paper presented at workshop on Genetic improvement of carps in Asia, Kausalyaganga, India, 26–29, July 1997.
- BBS(Bangladesh Bureau of Statistics). 1981. *Bangladesh population and housing census 1981*. Dhaka, Bangladesh: Bangladesh Bureau of Statistics.
- BBS (Bangladesh Bureau of Statistics). 1991. *Bangladesh population and housing census 1991*. Dhaka, Bangladesh: Bangladesh Bureau of Statistics.
- BBS(Bangladesh Bureau of Statistics). 2005. *Agriculture sample survey of Bangladesh*. Dhaka, Bangladesh: Bangladesh Bureau of Statistics.
- BBS(Bangladesh Bureau of Statistics). 2010. *Report of the households income and expenditure survey (HIES)*. Dhaka, Bangladesh: Bangladesh Bureau of Statistics.

- [BBS] Bangladesh Bureau of Statistics. 2011. *Bangladesh population and housing census 2011*. Dhaka, Bangladesh: Bangladesh Bureau of Statistics.
- Begum, A. and Alam, S.M.N. 2002. Social and economic impacts of shrimp disease among small-scale, coastal farmers and communities in Bangladesh. In: Arthur, J.R., Phillips, M.J., Subasinghe, R.P., Reantaso, M.B. and MacRae, I.H.(eds), *Primary aquatic animal health care in rural, small-scale, aquaculture development*. FAO Fisheries Technical Paper No. 406. pp. 191–200. Rome, Italy: FAO.
- Belton, B., Karim, M., Thilsted, S., Murshed-E-Jahan, K., Collis, W. and Phillips, M. 2011. *Review of aquaculture and fish consumption in Bangladesh*. Studies and Reviews 2011–53. Penang, Bangladesh: The WorldFish Center.
- BFFEA (Bangladesh Frozen Food Exporters Association). 2009. Quarterly Newsletter, March–May 2009. Khulna, Bangladesh. <http://www.bffea.net/>.
- Bolwig, S., Ponte, S., du Toit, A. and Halberg, N. 2010. Integrating poverty and environmental concerns into value-chain analysis: A conceptual framework. *Development Policy Review* 28(2):173–194.
- Daplyn, M., Apu, N.A. and Islam, M.R. 2005. *Baseline study of shrimp ghers and gher landowners in Polder 23, Shatkhira, Khulna, Bangladesh*. Fourth Fisheries Project implemented by the Department of Fisheries Bangladesh, supported by World Bank and DFID.
- Daplyn, M., Apu, N.A. and Islam, M.R. 2006. Sample impact study of trainee farmers in fisheries villages of the aquaculture extension and training component of Fourth Fisheries Project, Bangladesh.
- DoF (Department of Fisheries). 1992. *National fish fortnight*. In Bangla. Dhaka, Bangladesh: Department of Fisheries, Ministry of Fisheries and Livestock.
- [DoF] Department of Fisheries. 2005. *Annual report of Fisheries Resource Survey System wing 2005*. Dhaka, Bangladesh: Department of Fisheries, Ministry of Fisheries and Livestock.
- [DoF] Department of Fisheries. 2006. *Background History of Fisheries Activities in Bangladesh*. Dhaka, Bangladesh: Department of Fisheries, Ministry of Fisheries and Livestock.
- [DoF] Department of Fisheries. 2012. *Annual report of Fisheries Resource Survey System wing 2012*. Dhaka, Bangladesh: Department of Fisheries, Ministry of Fisheries and Livestock.
- [DoF] Department of Fisheries. 2013. *National Fish Week 2013 Compendium*. In Bangla. Dhaka, Bangladesh: Department of Fisheries, Ministry of Fisheries and Livestock.
- Dutta UB. 2011. *Code of conduct for selected segments of the aquaculture industry in Bangladesh*. Dhaka, Bangladesh: Department of Fisheries, Ministry of Fisheries and Livestock.
- Edwards, P. and Hossain, M.S. 2010. Bangladesh seeks export markets for striped catfish. *Global Aquaculture Advocate* May/June 2010:59–60.
- Eknath, A.E. and Doyle, R.W. 1990. Effective population size and rate of inbreeding in aquaculture of Indian major carps. *Aquaculture* 85:293–305.
- EPB (Export Promotion Bureau). 2011. *Annual Report 2011*. Dhaka, Bangladesh: Export Promotion Bureau.
- EPB (Export Promotion Bureau). 2013. *Annual Report 2013*. Dhaka, Bangladesh: Export Promotion Bureau.
- FAO (Food and Agriculture Organization of the United Nations). 2001. *Production, accessibility, marketing and consumption patterns of freshwater aquaculture products in Asia: A cross-country comparison*. FAO Inland Water Resources and Aquaculture Service (FIRI) and Fish Utilization and Marketing Service (FIU), in collaboration with the International Centre for Living Marine Resources Management (ICLARM). Rome, Italy: FAO.
- FAO (Food and Agriculture Organization of the United Nations). 2002. *Bangladesh shrimp sector review*. Fisheries and Aquaculture Department. Rome, Italy: FAO.
- FAO (Food and Agriculture Organization of the United Nations). 2003. *Bangladesh livestock review*. Fisheries and Aquaculture Department. Rome, Italy: FAO.
- FAO (Food and Agriculture Organization of the United Nations). 2006. *National aquaculture sector overview: Bangladesh*. Fisheries and Aquaculture Department. Rome, Italy: FAO.
- FAO (Food and Agriculture Organization of the United Nations). 2008. *Integrated fish farming system in Bangladesh: Concept paper and potential of integrated fish farming*. Fisheries and Aquaculture Department. Rome, Italy: FAO.
- FAO (Food and Agriculture Organization of the United Nations). 2012. *Fishery Statistical Collections: Global Aquaculture Production*. Rome, Italy: FAO. <http://www.fao.org/fishery/statistics/global-aquaculture-production/query/en>

- FAO (Food and Agriculture Organization of the United Nations). 2014a. *National Aquaculture Sector Overview Bangladesh*. National Aquaculture Sector Overview Fact Sheets. Rome, Italy. FAO. http://www.fao.org/fishery/countrysector/naso_bangladesh/en
- FAO (Food and Agriculture Organization of the United Nations). 2014b. Fisheries and Aquaculture topics. Composition of fish. Topics Fact Sheets. Rome, Italy: FAO. <http://www.fao.org/fishery/topic/14869/en>.
- Farooque, M. 1994. *Regulatory Regime on Inland Fisheries in Bangladesh: Some Remedies*. Dhaka, Bangladesh.
- Faruk RAM. 2011. Disease outbreaks in fish hatcheries and nurseries: prevention and control measures. MSc thesis. Mymensingh, Bangladesh: Aquaculture Department, Bangladesh Agriculture University.
- FTF-AIN (Feed the Future Aquaculture for Income and Nutrition). 2013. *Review paper*. Dhaka, Bangladesh: WorldFish.
- Gammage, S., Swanberg, K., Khondkar, M., Hassan, M.Z., Zobair, M. and Muzareba, A.M. 2006. *A pro-poor analysis of the shrimp sector in Bangladesh*. Dhaka, Bangladesh: USAID.
- Gatlin, D.M. 2010. *Principal of Fish Nutrition*. SRAC Publication No. 5003. Southern Regional Aquaculture Centre.
- GED (General Economics Division). 2013. *The Millennium Development Goals: Bangladesh Progress Report 2012*. Dhaka, Bangladesh: General Economics Division, Bangladesh Planning Commission, Government of the People's Republic of Bangladesh.
- Golzar, M.H., Haque, K.M. and Bhuayain, A.K.M.A. 2012. *Bangladesh fisheries extension: Its indispensable role and challenges*. Dhaka, Bangladesh: Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh.
- Gupta, M.V. and Acosta, B.O. 2004. Tilapia farming: A global review. *NACA News*. <http://www.enaca.org/modules/news/article.php?storyid=453>
- Halder, G. 1968. *Bangalir Shangskritc Rupantor* (Cultural Evolution of Bengalis). Calcutta, India.
- Hall, S.J., Delaporte, A., Phillips, M., Beveridge, M. and O'Keefe, M. 2011. *Blue frontiers: Managing the environmental costs of aquaculture*. Penang, Bangladesh: The WorldFish Center. http://www.worldfishcenter.org/global_aquaculture/.
- Halteren, A.P., Lam, N.V., Nguyen, H.D. and Couttean, P. 2009. Optimising the application of noval feed additive to improve feed utilization and fillet yield in pangasius catfish farming. *Aquaculture Asia Pacific Magazine*.
- Hambrey, J., Edwards, P. and Belton, B. 2008. An ecosystem approach (EAA) to freshwater aquaculture: a global review. In: Soto, D., Aguilar-Manjarrez, J. and Hishamunda, N. (eds), *Building an ecosystem approach to aquaculture*. FAO Fisheries Proceedings No. 14. Rome, Italy: FAO. pp. 117–173.
- Hoggarth, D.D., Cowan, V.J., Halls, A.S., Aeron-Thomas, M., McGregor, J.A., Garaway, C.A., Payne, A.I. and Welcomme, R.L. 1996. *Management Guidelines for Asian Floodplain River Fisheries. Part 1: A spatial, hierarchical and integrated strategy for adaptive co-management*. FAO Fisheries Technical Paper 384/1. Rome, Italy: FAO.
- Hossain, M.K., Islam, K.T., Hossain, M.D. and Rahman, M.H. 2011. Environmental impact assessment of fish diseases on fish production. *Journal of Science Foundation* (1&2):125–131.
- Hussain, T. 1995. *Land rights in Bangladesh: Problem of management*. Dhaka, Bangladesh: University Press Limited.
- Hussain, M.G. 2010. *Genetic studies and stock improvement of commercially important carp, pangas and tilapia species*. Bangladesh: BFRI. http://180.211.164.225/rmis/pdf_detail_info.php?linkid=6069
- Hussain, M.G. and Mazid, M.A. 1997. Carp genetic resources in Bangladesh. In: Gupta, M.V., Dey, M.M., Dunham, R. and Bimbao, G. (eds), *Proceeding of the collaborative research and training on genetic improvement of carp species in Asia, 26–29 July 1997*. Bhubaneswar, India: Central Institute of Freshwater Aquaculture.
- Hussain, M.G. and Mazid, M.A. 2001. Aquaculture genetics research in Bangladesh. In: Gupta, M.V. and Acosta, B.O. (eds), *Fish genetics research in member countries and institutions of the International Network on Genetics in Aquaculture*. ICLARM Conference Proceedings 64:7–14.
- Islam, M. 2013. Increased consumption of small fishes effective for mother and child health. Paper presented at a seminar. WorldFish and CSISA-BD. 19 December 2013. Rangpur, Bangladesh: WorldFish.
- Kabir, G.M.S. and Monir, S.M.I. 2013. *Role of Department of Fisheries to control abuse of formalin in fish*. Dhaka, Bangladesh: Department of Fisheries.
- Katalyst. 2014. *Rural market development (Haats)*. http://www.katalyst.com.bd/bee_rmd.php

- Khan, M.A.A.B.M. 1995. Financing of aquaculture, capture, processing and marketing of fish, shrimp and other aquatic resources in Bangladesh. In: Khan, B.A., Ahmed, L., Ali, L., Nishat, A. and Karim, M. (eds), *Report of the National Workshop on Fisheries Resources Development and Management in Bangladesh 29 Oct–1 Nov 1995, Dhaka*. Chennai, Bangladesh: Bay of Bengal Programme. pp. 179–200.
- LGED (Local Government Engineering Department). 2012. *Annual Report of Market Infrastructure Development Project in Char Area (MIDPCR)*. Funded by IFAD, Dhaka, Bangladesh.
- Mahmud, S., Alam, R.M. and Alam, J.M. 2013. *Suitable technique to reduce off-flavour in pangasius and tilapia*. Department of Fisheries, Bangladesh.
- Mamun-Ur-Rashid, M., Belton, B., Phillips, M. and Rosentrater, K.A. 2013. *Improving aquaculture feed Bangladesh: from feed ingredients to farmer profit to safe consumption*. WorldFish working paper 2013-34. Dhaka, Bangladesh: WorldFish.
- Mazid, M.A. 1994. *Evaluation of prawn farming socioeconomic aspects*. Mymensingh, Bangladesh: Fisheries Research Institute.
- Mostafa, A.R., Hossain, M., Nahiduzzaman, M., Sayed, M.A., Saha, D. and Azim, M.E. 2004. *Fish consumption amongst poor people in Bangladesh: Effects of gender, location and wealth class*. Bangladesh: Faculty of Fisheries, Bangladesh Agriculture University.
- NACA (Network of Aquaculture Centres in the Asia-Pacific). 2010. Shrimp price study, Phase II: Case studies in Vietnam, Indonesia and Bangladesh. http://www.enaca.org/modules/library/publication.php?publication_id=1002.
- Nathan, D. and Apu, N.A. 1998. Women's independent access to productive resources: Fish ponds in the oxbow lakes project, Bangladesh. *Gender, Technology and Development* 2(3):397.
- Nathan, D. and Apu, N.A. 2002. *Securing women's property rights: Problems of good governance and establishing norms of economic functioning*. IFAD Report. Rome, Italy: IFAD.
- Nathan, D. and Apu, N.A. 2007. *Access to common property resources and poverty reduction: Inland open-water fisheries in Bangladesh*. IFAD Report. Rome, Italy: IFAD.
- PBAEP (Patuakhali Barguna Aquaculture Extension Project). 2003. *Performance report of the 'Fisheries Field School'*. Bangladesh Department of Fisheries Bangladesh and Danida.
- Ponzoni, R.W., Khaw, H.L. and Yee, H.Y. 2010. *GIFT: The story since leaving ICLARM (now known as The WorldFish Center). Socio-economic, access and benefit sharing and dissemination aspects*. FNI Report 14 2010. Lysaker, Norway: Fridtjof Nansen Institute (FNI).
- Rahman, M. 2012. Fish exporters fear adverse impact on local industry. New Age online edition, 15 October 2012. http://www.newagebd.com/detail.php?date=2012-10-15&nid=27097#.U70km_k0W-0
- Rahman, A.A., Quddus, A.H.G., Pokrant, B. and Ali, M.L. 2006. *Sustainability, trade and livelihoods*. Bangladesh Centre for Advanced Studies (BCAS) and University Press Limited (UPL).
- Rajts, F. and Alam, M.B. 2013. Milt Bank Establishment. Leaflet of the USAID funded Feed the Future Aquaculture for Income and Nutrition project. Dhaka, Bangladesh: WorldFish.
- RIU (Research Into Use). 2010. *Natural Resource Knowledge: Improving fishers' livelihoods: better fisheries management and aquaculture*. Oxon, UK: DFID.
- Rola, W.R. and Hasan, M.R. 2007. Economics of aquaculture feeding practices: A synthesis of case studies undertaken in six Asian countries. In: Hasan, M.R. (ed), *Economics of aquaculture feeding practices in selected Asian countries*. FAO Fisheries Technical Paper. No. 505. Rome, Italy: FAO. pp. 1–31.
- Roy, N.C. and Habib, A.B.M.J. 2012. *Hilsha fishery development: Present situation, problems and recommendations*. Dhaka, Bangladesh: Department of Fisheries.
- Shetty, T.S. and Islam, R.M. 2013. *Shrimp supply chain: Challenges and a framework for improvement*. in Bangla. Dhaka, Bangladesh: BEST project, Department of Fisheries.
- Smith, A.D., Brown, C.J., Bulman, C.M., Fulton, E.A., Johnson, P., Kaplan, I.C., Lozano-Montes, H., Mackinson, S., Marzloff, M., Shannon, L.J., Shin, Y.-J. and Tam, J. 2011. Impacts of fishing low-trophic level species on marine ecosystems. *Science* 333(6046):1147–1150.
- Sumon, M.A.H., Azher, S.A. and Rahaman, M.T. 2013. *Strategy for conservation and management of wetland biodiversity*. Dhaka, Bangladesh: Department of Fisheries.

-
- Terry, G. 2013. Literature review on gender issues in aquaculture value chains and in fish consumption in Southern Bangladesh. Dhaka, Bangladesh: WorldFish (unpublished).
- Toufique, K.A. and Belton, B. (Forthcoming.) Is aquaculture pro-poor? Empirical evidence of impacts on fish consumption from Bangladesh. *World Development*.
- The Daily Jugantar. 2013. Roadside morning fish markets of Dhaka city getting popularity (in Bangla). The Daily Jugantar, 18 December 2013.
- The WorldFish Center. 2011. Bangladesh Fisheries Review: Input towards IFAD's Bangladesh COSOP. Dhaka: WorldFish Center.
- Uddin, R., Wahid, M., Jasmeen, T., Huda, N. and Sutradhar, K. 2011. Detection of Formalin in Fish Samples Collected from Dhaka City, Bangladesh. *Stamford Journal of Pharmaceutical Sciences* 4.
- UNDP. 2013. *Human Development Report 2013. The Rise of the South: Human Progress in a Diverse World*. New York, USA: United Nations Development Program.
- Valbo-Jørgensen, J. and Thompson, P.M. 2007. *Culture-based fisheries in Bangladesh: a socio-economic perspective*. FAO Fisheries Technical Paper No. 499. Rome, Italy: FAO.
- World Bank. 1991. *Bangladesh Fisheries Sector Review*. Report No. 8830-BD. Agriculture Operations Division, Asia Country Department, World Bank.
- World Bank. 2014. *WorldBank data by indicator*. <http://data.worldbank.org/>
- WorldFish. 2014. Fish market price database. Cereal Systems in South Asia project, Dhaka, Bangladesh: WorldFish.

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