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A Comprehensive Study on High Value Fish (Tilapia, Pangas and Koi) in Bangladesh

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Submitted by

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Executive Summary

Bangladesh is considered one of the most suitable countries in the world for freshwater aquaculture, because of its favourable resources and agro-climatic conditions. About 371,309 ha of freshwater ponds with 3.08 million farmers are involved in inland aquaculture. The total annual fish production in Bangladesh was estimated at 3.06 million tonnes in the 2010-11 fiscal year, of which 1.46 million tonnes (48%) were obtained from inland aquaculture, 1.05 million tonnes (34%) from inland capture fisheries and 0.55 million tonnes (18%) from marine fisheries. Overall, aquaculture plays an important role in the economy of Bangladesh, contributing to food production, nutritional benefits, incomes, livelihoods and export earnings. Traditionally the culture of Indian major carp and exotic carp has been practiced in Bangladesh. In recent years, an increasing number of farmers are involved in small-scale aquaculture with tilapia, pangas and koi in rural Bangladesh. The culture of these three species has huge contribution to food supply, nutritional benefits, livelihood opportunities and increased income of farmers and associated groups. These three species is therefore commonly referred to as high value fish in Bangladesh. Due to significance of these species for aquaculture in Bangladesh, Katalyst is keen to reassess the current culture practice and status of these three species. The aim of this study is to provide an in-depth analysis of these culture species with a special focus on identifying opportunities and challenges to involve in small-scale aquaculture by small and marginal farmers.

The study was conducted in a number of fish producing districts across the country, including Greater Mymensingh, Barisal, Bogra, Chittagong, Comilla and Sylhet. The study was conducted for a period of 45 days from 01 January to 28 February 2013. A combination of the participatory, qualitative and quantitative methods was used for gathering information. Secondary data were collected from relevant organisations. A total of 344 people, including farmers, hatchery operators, feed producers, traders, intermediaries and key informants such as government fisheries officers, researchers, policymakers and development workers were conducted through interviews and discussions.

Tilapia was introduced to Bangladesh from Thailand in 1954. In spite of long history, tilapia culture has become widespread in Bangladesh in recent years. Tilapia is ranked 6th in terms of pond fish production which contributes 8.1% of total aquaculture production. A total of around 201,000 farmers are involved in tilapia culture. It is projected that the number of tilapia farmers would be around 330,000 in 2016-17. As tilapia culture is possible in a wide range of freshwater and salinity conditions, thus the total tilapia producing area has been increased from 52,694 ha in 2008-09 to 130,057 ha in 2010-11. It is projected that the tilapia culture area will reach at around 330,000 ha in 2016-17 including ponds, *ghers* and floodplains. Tilapia is produced in a wide range of culture systems, including small-scale, low-input, rural ponds, semi-intensive, intensive and commercial operations. Most farmers (70%) produce tilapia under polyculture while the remainder (30%) practice in monoculture. Around 30% of farmers are involved in extensive/improved-extensive farming, while 50% and 20% of farmers practice semi-extensive and intensive farming, respectively. The total annual tilapia production in Bangladesh was estimated at 177,682 tonnes in 2011-12. It is projected that the total production of tilapia will be reached at around 311,000 tonnes in 2016-17.

Pangas aquaculture in Bangladesh has been emerged with an exotic species *Pangasianodon hypophthalmus* which was introduced in 1989 from Thailand, and thus popularly known as Thai pangas. A total of around 54,000 farmers are involved in pangas culture. It is projected that the number of pangas farmers would be around 75,000 in 2016-17. In Bangladesh, total pangas culture area has been increased from 24,922 ha in 2008-09 to 29,390 ha in 2010-11. It is projected that the pangas culture

area will reach at around 43,000 ha in 2016-17. Around 20% of farmers are involved in extensive/improved-extensive farming, while 50% and 30% of farmers practice semi-extensive and intensive farming, respectively. Total pangas production in Bangladesh has increased from 182,098 tonnes in 2008-09 to 254,563 tonnes in 2010-11. It is projected that the total production of pangas will reach at around 421,000 tonnes in 2016-17.

Koi (*Anabas testudineus*) is a prominent indigenous freshwater fish species in Bangladesh. The current culture species of koi was first introduced to Bangladesh from Thailand in 2002. Koi culture has become popular in Bangladesh since the development of induced breeding and mass seed production. Compare to other aquaculture species in Bangladesh, koi is relatively new. A total of around 23,000 farmers are involved in koi production. It is projected that the number of koi farmers would be around 37,000 in 2016-17. Total koi culture area has increased from 7,454 ha in 2008-09 to 14,700 ha in 2010-11. It is projected that the koi culture area will be reached at around 26,400 ha in 2016-17. Most farmers (60%) produce koi under polyculture while the remainder (40%) practice monoculture. About 10% of farmers are involved in extensive/improved-extensive farming, while 60% and 30% practice in semi-extensive and intensive farming, respectively. The total annual koi production in Bangladesh was estimated at 22,989 tonnes in 2010-11. It is projected that the total production of koi will be reached at around 37,400 tonnes in 2016-17.

Contents

1. Introduction

1.1 Background

Aquaculture is the fastest growing food production system in the world as the sector has expanded at an average annual rate of 9% over the last three decades (1980–2010). Global aquaculture production reached 60 million tonnes in 2010 of which Asia accounted for 89% of world aquaculture production. Bangladesh is ranked 5th in global aquaculture production after China, India, Vietnam and Indonesia (FAO, 2012). The total annual fish production in Bangladesh was estimated at 3.06 million tonnes in 2010–11 fiscal year, of which 1.46 million tonnes (48%) were obtained from inland aquaculture, 1.05 million tonnes (34%) from inland capture fisheries and 0.55 million tonnes (18%) from marine fisheries. The total annual fish production has gradually increased from 1.78 million tonnes in 2000-01 to 3.06 million tonnes in 2010-11, an average annual growth rate of 7% during the last decade (FRSS, 2012).

Bangladesh is considered one of the most suitable countries in the world for freshwater aquaculture, because of its favourable resources and agro-climatic conditions. About 371,309 ha of freshwater ponds with 3.08 million farmers are involved in inland aquaculture (DoF, 2012). Overall, aquaculture plays an important role in the economy of Bangladesh, providing food, nutrition, incomes, livelihoods and export earnings (ADB, 2005a; Dey et al., 2010). Fish accounts for 4.43% of gross domestic product and 2.73% of export earnings (DoF, 2012; FRSS, 2012). The aquaculture sector has a significant poverty reduction potential as large number of people are involved in fish farming across the country. Aquaculture contributes to the livelihoods and employment of millions of rural and urban poor in Bangladesh. Fish play an important role in the Bangladeshi diet, contributing 60% of national animal protein consumption, representing a crucial source of micro-nutrients (Bolton et al., 2011). Aquaculture is also considered to have the potential of food security in Bangladesh (Jahan et al., 2010).

Although 260 freshwater native fish species were recorded in Bangladesh (Rahman, 2005), only a few species are cultured (Table 1). Traditionally the culture of Indian major carp such as catla, rohu and mrigal has long been practiced in Bangladesh. The culture of exotic carp, also commonly known as Chinese carp, including bighead carp, common carp, grass carp and silver carp has also been practiced in Bangladesh (ADB, 2005a).Other exotic species, such as tilapia and Pangas has become popular in Bangladesh over the last decade. Another potential species koi has recently been cultured in different parts of Bangladesh. The culture of tilapia, Pangas and koi has been progressing well and those are commonly referred to as high value fish species in Bangladesh.

Table 1: Species composition of freshwater fish production of pond in 2010–11

Species	Production (tonnes)	Production contribution (%)	Rank
Rui	268,563	22.02	1
Catla	209,146	17.15	2
Thai Pangas	156,375	12.82	3
Mrigal	151,821	12.45	4
Silver carp	127,826	10.48	5
Tilapia/ Nilotica	98,758	8.1	6
Common carp	57,509	4.71	7
Thai sarputi	40,421	3.31	8

Kalbasu/ Bata	36,393	2.98	9
Grass carp	21,020	1.72	10
Koi	13,406	1.1	11

Source: FRSS (2012)

An increasing number of farmers are involved in small-scale aquaculture with tilapia, Pangas and koi in rural Bangladesh. In recent years, the culture of these species contributes to livelihood opportunities, food security and nutritional benefits through the availability of fish in markets (Ahmed et al., 2010 and 2012). Moreover, the culture of these species contributes to increase income of farmers and associated groups, and thus, play a significant role in poverty alleviation. It is therefore considered that the culture of these three species has huge potential for food security and economic growth of the country.

Due to significance of tilapia, Pangas and koi for aquaculture in Bangladesh, Katalyst is keen to reassess the current culture practice and status of these three species. Katalyst is implemented under the ministry of Commerce (MOC) of the Government of Bangladesh by Swisscontact and GiZ International Services. It partners with a wide range of private and public sector organisations in order to leverage its resources and maximise impact. The project is jointly funded by the Swiss Agency for Development and Cooperation (SDC), the UK Department for International Development (UKAid), the Canadian International Development Agency (CIDA) and the Embassy of the Kingdom of the Netherlands. Since Katalyst's inception in 2002, the project has achieved significant job and income impact by increasing the competitiveness of micro, small and medium sized enterprises in selected urban and rural sectors. Katalyst follows a pro-poor, market development approach in promoting economic growth.

The Industry and Rural Sectors Group of Katalyst works in selected rural and industrial sectors of which fisheries sector is a prominent one. Katalyst has been working in fisheries sector since 2004. In recent years (since 2010), Katalyst has been involved in working on freshwater aquaculture, particularly focusing on high value fish species, including tilapia, Pangas and koi. Katalyst has been working in this sector by addressing problems that are undermining sustainable growth of the sector.

1.2 Objectives of the Study

The study consists of the culture of high value fish species such as tilapia, Pangas and koi. The aim of this study is to provide an in-depth analysis of the culture of these high value fish species in Bangladesh with a special focus on identifying opportunities and challenges to involve small and marginal farmers for the cultivation of these species. To achieve this aim, the specific objectives are:

1) To understand the current culture practices of tilapia, Pangas and koi in Bangladesh with their production, consumption, distribution and marketing;
2) To assess the future potential of these culture species by small and marginal farmers; and
3) To recommend for sustainable culture practices of these three species in Bangladesh.

It is intended that current commercial/semi-commercial culture practices and the adoption trends of small and marginal farmers, influencing channel players, knowledge and resource among these high value fish species are critical features of the study.

2. Methodology

This section describes the research methodology followed to achieve the objectives of the study and explains the choice for selecting research tools and the methods for data collection. It also describes the selection of the research site and the identification of target groups for data collection. Finally, it describes the process of negotiating to obtain information and gather the necessary data.

2.1 Study Area

The study was conducted in several districts across the country. The study area is divided into 5 zones/clusters, such as: (1) Greater Mymensingh and Netrokona, (2) North Bengal – Bogra, Natore, Dinajpur, (3) Southeast – Chittagong, Comilla and Noakhali districts, (4) Southwest – Khulna and Jessore (5) Northeast – Sylhet and Moulavibazar (Figure 1). These five zones covering different parts of the country those have been identified for promising in aquaculture because of favourable biophysical resources and climatic conditions, including the availability of ponds and low-lying agricultural land, warm climate, fertile soil and abundant labour. These five zones have also been identified for the culture practices of tilapia, Pangas and koi due to the availability of hatchery produced fry, industrially manufactured pellet feed, marketing facilities and potential for future. These five zones representing the country were therefore selected for the study on high value fish species. The study had the intention of covering both progressive areas and newly growing areas of Bangladesh. Selection of the areas represent progressive area for like Mymensingh, Comilla, Bogra and newly growing area like Sylhet, Moulavibazar.

Figure 1: Map of Bangladesh showing the study areas of five zones.

2.2 Data Collection Methods

The study was conducted for a period of 45 days from 01 January 2013 to 28 February 2013 on intermittent basis (Appendix 1). Field visits were carried out in the study areas for a period of 18 days. A combination of the participatory, qualitative and quantitative methods was used for gathering information through rapid appraisal. Rapid Rural Appraisal (RRA) is a group of methods to collect information on participatory basis from rural communities. The advantage of RRA over other methods is that it allows wider participation of the community, therefore the information collected is likely to be more accurate (Chambers, 1992; Chambers, 1994). Rapid appraisal methods are used to obtain accurate information through triangulation (USAID, 2010).

1) Secondary Information

Secondary data were collected from several relevant organisations, including Bangladesh Fisheries Research Institute (BFRI), Department of Fisheries (DoF) and District Fisheries Offices. Fish production, culture areas, number of fish farmers involved and other related information were collected from various organisations. These data were also verified with data from other sources. Literature reviews were also performed with several reports published by BFRI and the WorldFish Centre. Literature reviews were also performed with published articles and unpublished documents. Where information was found contradictory to that of secondary data, further assessment was carried out through field investigations and cross-check interviews with key informants.

2) Mapping Workshop

After completion of the literature review, a Mapping Workshop was conducted in Mymensingh with the stakeholder of these species on January 9, 2013. The objective of the mapping workshop is to identify the major clusters and to draw draft value chains of these three species from the stakeholder in a participatory approach. These stakeholders include Hatchery, Arot, Farmers, Feed retailers and Key expert from Bangladesh Agriculture University (BAU) and Department of Fisheries.

3) Primary Study

a) Questionnaire Interview:

Questionnaire interviews with farmers and associated groups were preceded by preparation and testing of the questionnaire and training of survey operators. The pre-survey activities included reconnaissance for the pilot survey, revision of survey instruments and preparation of sampling frame. For the preparation of the questionnaire, visits to fish farms, hatcheries, feed dealers and markets were conducted. Primary interviews with fish farmers and associated groups including hatchery operators, seed traders, feed producers and traders, and fish market actors were conducted. A total of 329 people were conducted for questionnaire interviews (Table 2). Several visits were made to farming sites and markets for observation of farming and marketing practices. Interviews with farmers, lasting on average one hour, focused on production season, culture period, farming practices, using inputs (seed, feed, fertilizer and labour), productivities and the socioeconomic conditions of farming households.

Table 2: Sample size and target groups for primary data collection

District	Target group										
	Farmers	Hatchery	Input retailers	Traders	Support service providers	Women	Labour	Govt	Company representatives	Key informants	Total
Mymensingh	55	7	22	12	5	14	12	5	2	15	134
Bogra	23	4	10	11	4	3	8	2	2		67
Khulna	5	1	3	3	1	2	2	1	1		19
Comilla	10	1	5	5	2	4	2	1	1		31
Sylhet	5	1	1	3	0	0	2	1	1		14
Chittagong	15	2	5	4	2	0	2	2	1		33
Noakhali	5	1	1	1	0	6	2	0	0		16
Total	118	17	47	39	14	29	30	12	8	15	329

b) Key Informants Interviews

A key informant is someone with special knowledge on aquaculture development. Key informants are expected to be able to answer questions about the knowledge and behaviour of others, and about the operations of the broader systems (Atkinson, 1992; Elmendorf and Luloff, 2006). For this study, key informants' interviews were conducted with government fisheries officers, progressive farmers, hatchery operators, feed traders, market actors, researchers, policymakers, relevant NGOs workers and project staffs (Table 1). A list of questions was used for key informant interviews regarding the existing culture practices of tilapia, Pangas and koi. A total of 15 key informants were interviewed in their offices, houses, and/or working fields (see Appendix 3). Key informants were able to provide information on farming practices, productivities, production trends and future prospects, based on their knowledge, skills and experience. Key informants were also conducted for the validation of collected information and their opinions regarding the future production and consumption trends.

2.3 Data Analysis

Data from secondary sources and questionnaire interviews were analysed using Microsoft Excel software. Descriptive statistics were produced through data analysis. Results from the data analyses, in combination with qualitative information collected through various methods such as field visits and cross-check interviews with key informants, were used to describe tilapia, Pangas and koi farming systems with production, consumption, production costs and returns, market price and profitability. Comparisons among three different species were also performed in terms of culture practices, farmers involved, culture area, stocking and feeding rate, and productivity. Production cost and gross revenue was calculated to determine net returns of tilapia, Pangas and koi farming. The analysis was based on the farm-gate prices of fish and current local market prices of all other items.

2.4 Validation Workshop

A Validation Workshop was held on February 27, 2013 to validate the assumptions and estimation made under this study. In addition to personnel of Innovision and Katalyst, officials from the Department of Fisheries, other projects working with these three species and feed company representative were present in the program. After assessing the findings, all participants critically discussed the outcome to come up with recommendations. Accordingly, these recommendations were incorporated in the final report.

3. Tilapia Farming

With increasing popularity among consumers, tilapia has become the world's second most important cultured fish after carp (ADB, 2005b). There is a long history of tilapia farming in Bangladesh. The Mozambique tilapia (*Oreochromis mossambicus*) was introduced to Bangladesh from Thailand in 1954 (Rahman, 1985). However, this species was not widely accepted for aquaculture because of its early maturation and prolific breeding leading to overcrowded ponds. To overcome this problem the Chitralada strain of Nile tilapia (*O. niloticus*) was introduced to Bangladesh from Thailand by UNICEF (United Nations International Children's Emergency Fund) in 1974 (ADB, 2005a). Nevertheless, Nile tilapia farming was slow to develop as most farmers remained more interested in carp. Gradually, the red tilapia (hybrid of *O. mossambicus* x *O. niloticus*) was imported to Bangladesh from Thailand. The Bangladesh Fisheries Research Institute (BFRI) reintroduced Nile tilapia and Red tilapia from Thailand in 1987 and 1988, respectively (Gupta et al., 1992). Thereafter, Genetically Improved Farmed Tilapia (GIFT) was introduced to Bangladesh by ICLARM (International Centre for Living Aquatic Resources Management, now known as the WorldFish Centre) and BFRI in 1994 (Hussain et al., 2004; Ponzoni et al., 2010). The performance of the GIFT strain was found to be significantly superior to that of other tilapia in many respects (Hussain et al., 2000; Hussain, 2009). Technology was developed to produce sex-reversed male tilapia (i.e. monosex tilapia), to avoid the unwanted reproduction and benefit from the faster growth rate of males compared to females. Since 2000, interest in tilapia farming has grown because of its observed success in other Asian producers and increasing consumer acceptance both within Bangladesh and internationally (Ahmed, 2009b). In recent years, the culture of tilapia has been progressing well because of consumer acceptance as tilapia is often treated as 'aquatic chicken' in Asia. In respect to different tilapia species, the following sections describe tilapia (*Oreochromis sp)* culture with its production, distribution and marketing activities.

3.1 Production Analysis

3.1.1 Division Wise Production

According to the DoF, tilapia (including nilotica) production in pond of Bangladesh was estimated at 98,758 tonnes in 2010-11 which was 8.1% of total pond production (FRSS, 2012). Nevertheless, considerable variation in production data between DoF and Extension Department was found. According to the Extension Department, the total annual production of tilapia in Bangladesh was estimated at 177,682 tonnes in 2010-11 whereas FRSS data estimated 98,750 tonnes production for the same period. After series of discussions with the Key informants and Industry experts it was concluded that in terms of culture area and productivity per hectare, total tilapia production data by Extension Department is reliable. Over the last three years, total tilapia production in Bangladesh has increased more than twice,

from 88,210 tonnes in 2008-09 to 177,682 tonnes in 2010-11 (Table 10). In 2010-11, the highest tilapia production was found in Khunla division (76,686 tonnes), followed by Chittagong (52,163 tonnes) and Dhaka (25,731 tonnes). Over the last three years, tilapia production in Khulna division has increased four times from 18,411 tonnes in 2008-09 to 76,686 tonnes in 2010-11. Nevertheless, the comparative growth rate of tilapia production is slow in other divisions. In 2010-11, the lowest tilapia production was found in Rangpur division (2,182 tonnes), followed by Sylhet (6,211 tonnes), Barisal (7,135 tonnes) and Rajshahi (7,574 tonnes).

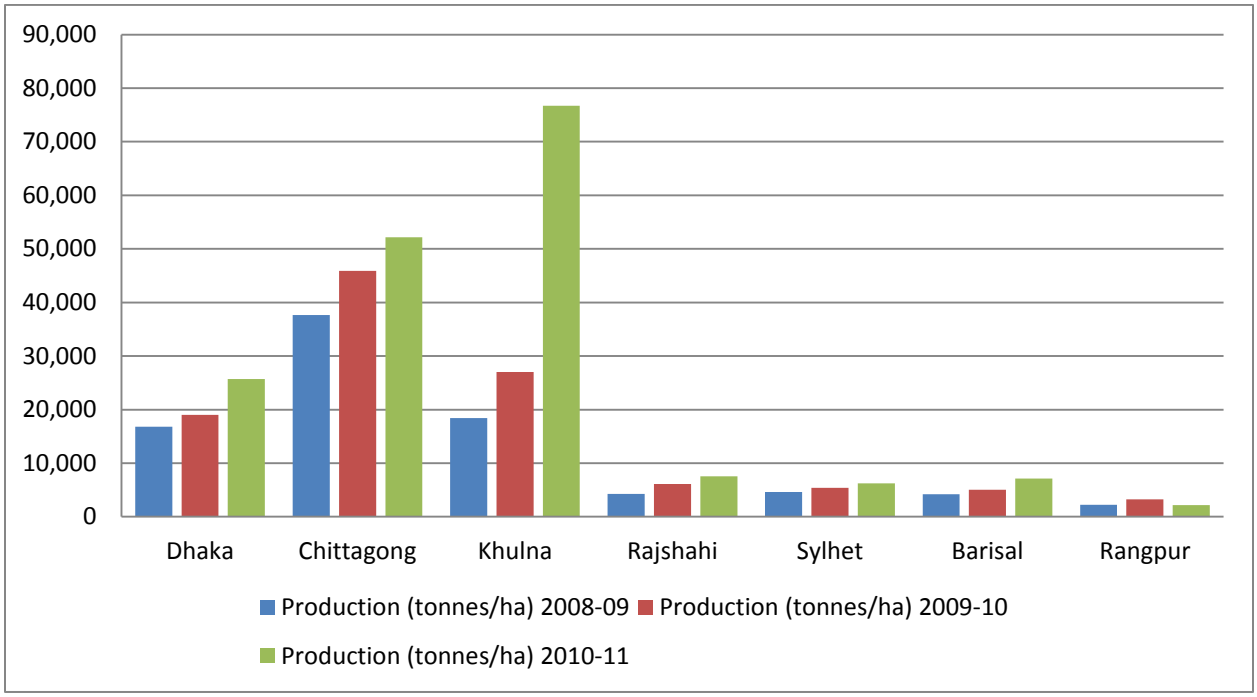

Figure 1: Tilapia Production in Bangladesh (2008-09 to 2010-11)

Source: Extension Data (2012)

3.1.2 Productivity

The productivity of tilapia per hectare farm is low due to extensive culture. It is also found that the productivity of tilapia is low due to polyculture with other fish which is not considered. The average productivity of tilapia in Bangladesh was estimated at 1.37 tonnes/ha in 2010-11 (Table 12). In spite of increased culture area and total production, the average productivity of tilapia slightly increased from 1.67 tonnes/ha in 2008-09 to 1.84 tonnes/ha in 2009-10, and then decreased to 1.37 tonnes/ha in 2010-11. As most tilapias are produced under polyculture in extensive and semi-intensive farming systems, thus the average productivity of tilapia is variable. Nevertheless, the rate of other fish productivity (e.g. carp) seems to be increased considerably. In 2010-11, the highest average tilapia productivity was found in Dhaka division (6.29 tonnes/ha), followed by Sylhet (4.68 tonnes/ha), Rajshahi (4.61 tonnes/ha) and Chittagong (3.64 tonnes/ha). On the other hand, the lowest tilapia productivity in 2010-11 was found in Khulna (0.73 tonnes/ha), followed by Rangpur (1.86 tonnes/ha) and Barisal (3.52 tonnes/ha). In spite of the highest tilapia producing area and total production in Khulna division in 2010-11, the productivity rate was the lowest (0.73 tonne/ha) due to extensive polyculture with prawn, shrimp and other finfish.

It is noted that tilapia culture is possible in a wide range of freshwater, brackishwater and salinity conditions.

Table 3: Productivity of tilapia per hectare farm over the last three years

Division	2008-09			2009-10			2010-11		
	Area (ha)	Yield (t)	Yield rate (t/ha)	Area (ha)	Yield (t)	Yield rate (t/ha)	Area (ha)	Yield (t)	Yield rate (t/ha)
Dhaka	3,376	16,786	4.97	3,655	19,011	5.20	4,093	25,731	6.29
Chittagong	13,790	37,653	2.73	14,350	45,882	3.20	14,314	52,163	3.64
Khulna	31,384	18,411	0.59	38,418	26,998	0.70	105,484	76,686	0.73
Rajshahi	1,051	4,244	4.04	1,368	6,097	4.46	1,643	7,574	4.61
Sylhet	997	4,643	4.66	1,214	5,380	4.43	1,326	6,211	4.68
Barisal	1,248	4,209	3.37	1,397	5,028	3.60	2,026	7,135	3.52
Rangpur	848	2,264	2.67	268	3,250	12.13	1,171	2,182	1.86
Total	52,694	88,210	1.67	60,670	111,646	1.84	130,057	177,682	1.37

Source: Extension Data (2012)

The productivity rate (tonne/ha) per hectare farm of tilapia has been gradually increasing in Dhaka, Chittagong, Khulna and Rajshahi divisions. These divisions belong to major tilapia producing areas such as Mymensingh, Comilla, Khulna and Bogra. As tilapia is becoming popular among farmers, it is expected that production rate per hectare will increase over the next few years.

Table 4: Division wise major Tilapia producing districts

Dhaka Division	Chittagong Division	Khulna Division	Rajshahi Division
Mymensingh	Comillla	Satkhira	Bogra
Gazipur	Chittagong	Khulna	Rajshahi
Narsingdhi	Noakhali		
Gopalganj			

Source: Primary Study (2013)

3.1.3 Production Projection

Most key informants believe that tilapia production in Bangladesh will be increased at a rate of 10-12% per annum although other aquaculture practices have been expanding at a rate of 7% per annum (FRSS, 2012). However, this production growth is likely to decrease in near future as industry experts expect a stagnant growth of 10% from 2014-15. It is therefore projected that the total production of tilapia will be reached at around 311,022 tonnes in 2016-17.

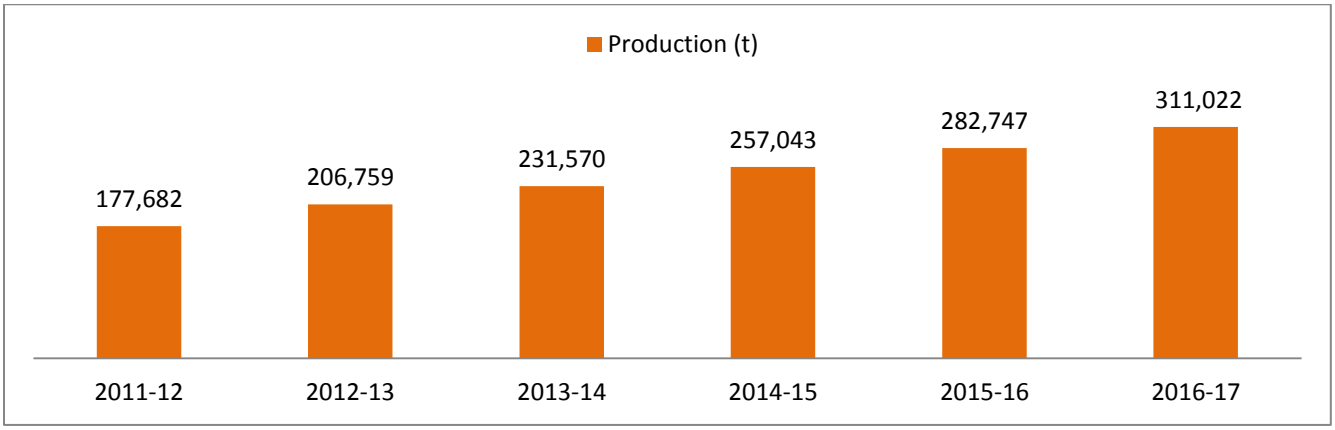

Figure 2: Estimated production of Tilapia in next five years

3.2 Culture Area, Culture Practice and Number of Farmers

3.2.1 Culture Area

Although 371,309 ha of freshwater ponds in Bangladesh are used for inland aquaculture, there is no accurate data about tilapia culture area (DoF, 2012). Nevertheless, Extension Department has gathered tilapia culture area in Bangladesh. According to Extension Department (2012), total tilapia culture area in Bangladesh has increased from 52,694 ha in 2008-09 to 130,057 ha in 2010-11 (Table 3). Over the last three years, tilapia culture area has increased more than twice. In 2010-11, the highest tilapia producing area was found in Khulna division (105,484 ha), followed by Chittagong (14,314 ha), Dhaka (4,093 ha) and Barisal division (2,026 ha). As tilapia culture is possible in a range of freshwater and salinity conditions, thus the total tilapia culture area in Khulna division has been increased three times from 31,384 ha in 2008-09 to 105,484 ha in 2010-11. Nevertheless, the expansion of tilapia culture is comparatively slow in other divisions. In 2010-11, the lowest tilapia producing area was found in Rangpur division (1,171 ha) followed by Sylhet (1,326 ha) and Rajshahi (1,643 ha).

Table 5: Division wise tilapia culture area in Bangladesh over the last three years

Division	Culture area (ha)				
	2008-09	2009-10	Annual expansion rate (%)	2010–11	Annual expansion rate (%)
Dhaka	3,376	3,655	8	4,093	12
Chittagong	13,790	14,350	4	14,314	-0.25
Khulna	31,384	38,418	22	105,484	175
Rajshahi	1,051	1,368	30	1,643	20
Sylhet	997	1,214	22	1,326	9
Barisal	1,248	1,397	12	2,026	45
Rangpur	848	268	-68	1,171	337
Total	52,694	60,670	15	130,057	114

Source: Extension Data (2012)

In addition to pond, the culture of tilapia is practiced in *gher* and floodplain. In 2011–12, the total tilapia culture area in Bangladesh was estimated at 199,693, of which 74,262 ha of pond (37%), 69,223 ha of *gher* (35%) and 56,208 ha of floodplain (28%). Although tilapia culture area has been expanding rapidly in recent years, it may not continue over the next few years. According to key informants, the expansion of tilapia culture area in Bangladesh will be continued at a rate of 10-12% per annum over the next five years although other aquaculture practices have been expanding at a rate of 7% per annum (FRSS, 2012). It is therefore projected that the total tilapia culture area in Bangladesh will be reached at around 330,000 hectare by 2016-15.

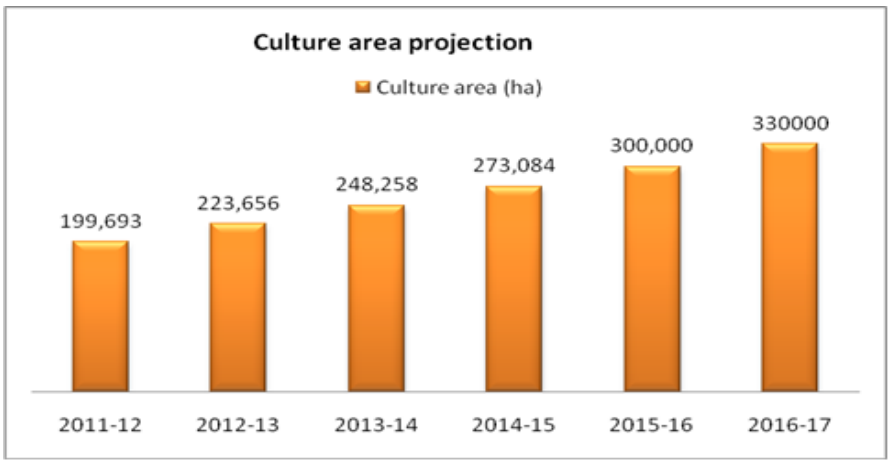

Figure 3: Estimated culture area of Tilapia in next five years

3.2.2 Culture Practices

The main season for tilapia farming is from April to November/December with many farmers beginning the four months production cycle in April/May. Farmers stock their ponds from as early as April/May and harvest tilapia after four months intervals. Due to scarcity of water and cold weather, most farmers usually complete tilapia harvest at the beginning of dry season in November/December. Fish farming in Bangladesh is largely season based where rain water is trapped during monsoon in ponds for aquaculture. Tilapia culture is fully dependent on hatchery produced fry with home-made feed and/or industrially manufactured pellet feed.

Tilapia can be produced in a wide range of culture systems, including small-scale, low-input, rural ponds, semi-intensive, intensive and commercial operations. Tilapia culture is classified as: (1) polyculture and (2) monoculture. Polyculture has long been traditional practiced by fish farmers in rural Bangladesh. Polyculture involves raising two or more species in one pond so that they do not compete for feed and may complement each other's ecological habits. The concept of polyculture is to efficient utilisation of trophic niches of a pond in order to obtain maximum fish production per unit area. On the other hand, monoculture deals only single species aquaculture. According to key informants, a number of entrepreneurs first started tilapia monoculture[1] in the early 2000s. The advantage of monoculture is that it allows high stocking density and thus high production. Although monoculture is a non-diversified

[1]Although monoculture is a culture of single species, other fish species are often naturally found in ponds.

farming system, the productivity of fish is often higher than polyculture due to intensive farming. It seems that there is a recent trend from polyculture to monoculture due to increase tilapia productivity.

Based on the level of inputs[2] tilapia culture can be further classified as: (1) extensive or improved-extensive, (2) semi-intensive and (3) intensive (Table 6). Extensive farming of tilapia typically use slightly modified versions of traditional methods and uses low stocking density (12,000–18,000 fry/ha) and low-inputs of feed, fertiliser and labour. Semi-intensive operations practice intermediate levels of stocking (18,000–25,000 fry/ha) and other inputs. The intensive[3] production system is characterised by relatively high stocking (above 25,000 fry/ha) and high level of inputs. In a true sense, aquaculture practices in Bangladesh are not intensive. Nevertheless, high stocking density and high level of feed application are often considered for intensive farming.

Comparatively, extensive farmers typically use low level of feed application. Semi-intensive farmers use intermediate level of feed, while intensive farmers use high level of feed input. In general, extensive farmers mainly use supplementary diet consisting of a mixture of locally available feed ingredients as rice bran, wheat bran, oil cake and fish meal. In contrast, farm-made aquafeeds[4] and industrially manufactured pellet feeds are used by farmers in semi-intensive and intensive farming. Nevertheless, there is considerable overlap to use feed in different farming systems.

Although tilapia farming has not been associated with negative environmental consequences, in recent years there are some concerns about the long-term environmental sustainability of tilapia culture. The major changes in the environment that have been found include water pollution, poor water quality, excessive use of additives and hormones, and deoxygenate water. Because of narrow dikes, a considerable number of ponds get inundated with floodwater during the monsoon in every year. Preventing fish escape is very difficult during the flood season, especially for small-scale farmers who are reluctant to raise their pond dikes. The risk of environmental degradation in the ponds from high input intensive farming is concerned because of excessive supplementary feed. Excessive use of feed, growth hormones, antibiotics, probiotics and additives has adverse impacts on pond ecosystems and concerns for bio-safety of pond environment. A green water technology could be utilised for sustainable tilapia farming in Bangladesh.

[2] Inputs in aquaculture can be classified as: (1) material inputs such as seed, feed and fertiliser; and (2) management input (labour).

[3] Although high stocking density is a criterion for intensive farming, other aspects of farm management such as water quality, water exchange and environmental issues are not followed by farmers in Bangladesh.

[4] Fish feed and aquafeed are interchangeably used in this report as both meanings are same.

Farming intensity	Description
Extensive[1]	• Small farm size (usually less than 0.3 ha) • Usually practice polyculture • Use low level of inputs (seed, feed, fertiliser and labour) • Irregular feeding of fish or feed application once per day • Mainly use organic fertiliser (cow dung), depends on natural feed • Mostly one production cycle • Low fish productivity • Farmers typically face financial constraints (i.e. resource-poor farmers)
Semi-intensive	• Medium farm size (typically 0.3–0.7 ha) • Farming practice either monoculture or polyculture • Use intermediate level of inputs (seed, feed, fertiliser and labour) • Regular feeding of fish, usually feed application more than once daily • Apply organic (cow dung) and inorganic (urea and TSP) fertilisers • Involve more than one production cycle • Medium level of fish productivity • Farmers are not resource-poor or have access to financial capital
Intensive[2]	• Comparatively large farm size (above 0.7 ha) • Usually practice monoculture • Use high level of inputs (seed, feed, fertiliser and labour) • Regular feeding of fish, usually feed application 2-3 times per day • Mainly use inorganic fertilisers • Involve 2 or 3 production cycles • High level of fish productivity • Better-off farmers, use own financial capital or loan

Table 6: Characteristics of fish culture systems in Bangladesh *(Source: Key Informant Interview)*

[1]Extensive farming is also treated as improved-extensive because of improved culture practices with increasing inputs, but less than semi-intensive farming system.

[2]In a true sense, none of the Bangladeshi farmers are involved in intensive farming. However, a number of farmers are involved in high density fish culture system in Bangladesh which is often known as intensive farming.

3.2.3 Farming area in Culture Practices

According to the field survey and discussion with key informants, most farmers (70%) produce tilapia under polyculture while the remainder (30%) practice monoculture. Farmers practise small-scale tilapia farming with carp and catfish under polyculture. In general, progressive farmers follow specific ratio of different fish species for polyculture, depends on natural productivity of pond, availability of fry, financial ability for inputs and management practices. Nevertheless, most extensive/improved-extensive farmers often do not attempt to stock any specific ratio of different fish species. In recent years, however, an increasing number of farmers and entrepreneurs produce tilapia in monoculture under semi-intensive or intensive systems. In extensive farming system, one annual crop is common whereas two or three crops may be grown in semi-intensive and intensive farming systems. According to the field survey and discussion with key informants, around 30% of the ponds are involved in extensive/improved-extensive farming, while 50% and 20% of the farming area are under semi-extensive and intensive farming, respectively (Table 7). In addition to the pond area, Tilapia is cultured in Ghers and Open water which will fall under the category of the extensive. Therefore the area under the extensive production is around 73% whereas semi-intensive and intensive area is 18% and 8% respectively.

Table 7: Area of tilapia culture in different farming systems

Farming intensity	Area (%)	Farm size (ha)	Stocking density (fry/ha/yr)	Feeding rate (kg/ha/yr)	FCR	Labour involve (man-day/ha/yr)
Extensive farming	73%	0.15–0.30	12000–18000	1500–3000	1.9–2.5	110–150
Semi-intensive farming	18%	0.31–0.70	18000–25000	3000–6000	1.5–1.8	150–210
Intensive farming	8%	0.71–1.50	25000–35000	6000–9000	1.2–1.4	210–240

Source: Key informant estimation (2013)

The size of pond may play an important role as it may reflect the availability of capital, managerial ability, and the potential to operate and use resources efficiently. Farm size appears to have an influence on productivity, an increase in farm size is generally associated with an increase in farming intensity, and hence productivity. In addition, farmers operating larger farms tend to have greater access to capital, managerial support, and the potential to operate and use resources efficiently. According to discussion with key informants, farm size in extensive farming is usually less than 0.3 ha while the range of farm size in semi-intensive farming is 0.31-0.7 ha (Table 7). Nevertheless, the farm size in intensive farming was reported by key informants to be above 0.7 ha. Considerable differences are found between the size of farms and the farming systems.

According to key informants, the range of food conversion ratio (FCR) in extensive farming is 1.9–2.5 while FCR in semi-intensive and intensive farming are 1.5–1.8 and 1.2–1.4, respectively (Table 7). FCR mainly depends on a number of factors, including the quality of feed (protein level), amount of feed, types of feed (sinking or floating), stocking density and water quality issues.

3.2.4 Number of Farmers

So far there is no accurate statistics about the number of tilapia farmers in Bangladesh. Nevertheless, a total of about 3.08 million fish farmers with 371,309 ha of freshwater ponds are involved in aquaculture (DoF, 2012). As the total tilapia culture area (from Table 3) and farm size (Table 7) are known, it is therefore calculated that a total of around 201,000 farmers are involved in tilapia culture in 2011-12 (Table 8). This figure shows that the number of estimated tilapia farmers is around 7% of the total fish farmers in Bangladesh. Although tilapia production contributes 8% of total fish production, it seems that number of tilapia farmers has recently been increased as a number of pangus farmers in many places are switching to tilapia culture. Moreover, tilapia is cultured with carp under polyculture, thus the number of tilapia and carp farmers is often overlap. Nevertheless, most key informants reported that around 8-10% of fish farmers are involved in tilapia culture. It seems that our estimated number of tilapia farmers is acceptable. However, it is suggested that further assessment would be required in order to get realistic data about the number of tilapia farmers.

Table 8: The estimation of tilapia farmers by culture practice in 2011-12

	Pond	**Gher**	**Flood Plain**
Total area (ha)	371309	276892	2810410
Culture area (ha)	74261.8 (20%)	69223 (25%)	56208 (2%)

Pond Culture -74261 ha			
	Extensive	**Semi Intensive**	**Intensive**
Area distribution	30%	50%	20%
Culture area	22279	37131	14852
Average farm size	0.24	0.6	1.2
No. of farmer (pond culture)	92827	61885	12377

Gher Area (ha)	69223
Average farm size (ha)	3
Type	Extensive
No. of farmer	23074

Flood Plain	56208

Average farm size (ha)	5
Type	Extensive
No. of farmer	11242

Total No. of Farmer			
	Extensive	**Semi Intensive**	**Intensive**
Pond	92827	61885	12377
Gher	23074		
Flood Plain	11242		
Total	127143	61885	12377
Grand Total		201405	
%	63.12	30.72	6.14

Sources: Area of Pond, Gher and Open Water from Matshaya Songkolon 2012, Percentage of the area and farm size were taken from Key Informant interview.

Due to the similarity of expansion of tilapia culture area, the number of tilapia farmers would increase 10-12% per annum over the next five years. It is therefore projected that the number of tilapia farmers would be around 333,300 by 2016-17. According to key informants and field assessment, there is a bright future of tilapia culture due to high market demand. It is therefore assumed that the number of farmers will increase in the near future.

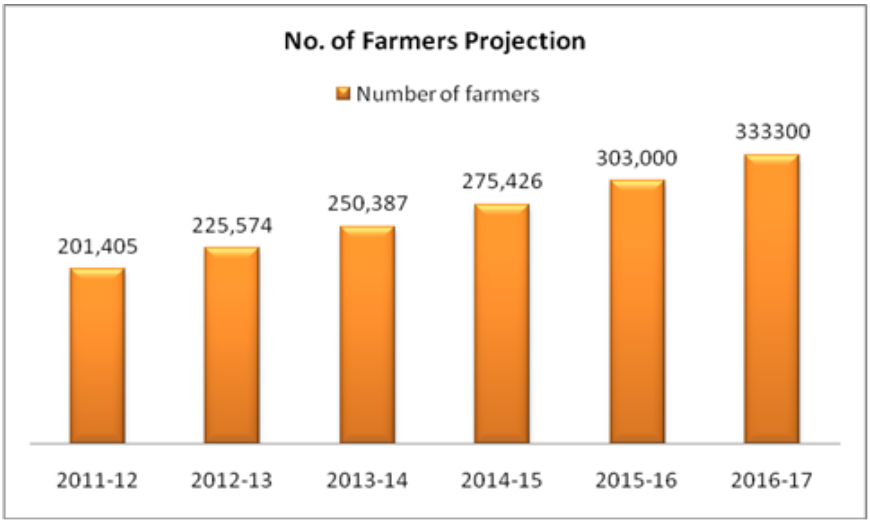

Figure 4. Projection of the number of tilapia farmers over the next five years

3.2.5 Cost-Benefit Structure of Different Culture Practices

The costs of tilapia production relate to the level of inputs, the price of inputs and the culture systems. A comparison of the cost of production and its breakdown to components provides a better understanding of cost structure and relative production efficiency. Production costs are grouped into: (1) variable costs and (2) fixed costs. Variable costs are directly related to the scale of farm operations at any given time. Variable costs in tilapia farming are cost of seed, feed, fertiliser, labour, harvesting and

marketing, and miscellaneous costs (e.g. electricity, vitamin premix, medicine and lime). On the other hand, fixed costs include: (1) depreciation cost of water pump, net and feed machine, (2) interest on operating capital or loan and (3) land use cost or lease money.

According to the field survey and interviews with key informants, the average annual variable costs of tilapia farming in extensive farming system were estimated at Tk 76,000 per ha, compared with Tk 156,000 per ha in semi-intensive and Tk 290,000 per ha in intensive farming (Table 13). There was a considerable difference of variable costs in different farming categories. Variable costs on average amounted to 83% of total costs in extensive farming, compared with 89% in semi-intensive and 92% in intensive farming.

The average annual fixed costs of tilapia farming varied from Tk 16,000 per ha in extensive farming to Tk 20,000 per ha in semi-intensive and Tk 26,000 per ha in intensive farming. There is a considerable difference of fixed costs in different farming systems. Fixed costs varied from 17% of total costs in extensive farming to 11% in semi-intensive and 8% in intensive farming. Table 13 shows that the average annual total costs of tilapia farming varied from Tk 92,000 per ha in extensive farming to Tk 176,000 per ha in semi-intensive and Tk 316,000 per ha in intensive farming. It was found that the costs of production in all items were higher for intensive farms, compared with semi-intensive and extensive farms. Among production costs, feed dominated all other costs representing about 52% of total costs in extensive farming, compared with 63% in semi-intensive and 66% in intensive farming. According to key informants, production costs has increased notably over recent years due to increasing cost of inputs, especially feed.

Table 9: Production cost and return for tilapia farming by culture intensity in 2012

Cost and return item	Cost and return in farming system (Tk/ha/yr)		
	Extensive	Semi-intensive	Intensive
Variable cost (VC)			
Seed	6,000	10,000	15,000
Feed	48,000	110,000	210,000
Fertiliser	3,000	5,000	7,000
Labour (family and hired)	15,000	25,000	48,000
Harvesting and marketing	2,000	3,000	5,000
Miscellaneous	2,000	3,000	5,000
Sub-total	76,000	156,000	290,000
Fixed cost (FC)			
Depreciation	2,000	3,000	6,000
Interest on operating capital/loan	9,000	12,000	15,000
Land use cost or lease	5,000	5,000	5,000
Sub-total	16,000	20,000	26,000
Total cost (TC = VC + FC)	92,000	176,000	316,000
Average productivity (kg/ha/yr) (P)	1,200	2,500	5,000
Average farm-gate price (Tk/kg) (FP)	100	100	100
Gross revenue (GR = P x FP)	120,000	250,000	500,000
Net return (NR = GR - TC)	28,000	74,000	184,000
Benefit-cost ratio (BCR = GR/TC)	1.30	1.42	1.58

Source: Key informants' interviews and primary study (2013)

The average annual gross revenue from tilapia production varied from Tk 120,000 per ha in extensive farming to Tk 250,000 per ha in semi-intensive and Tk 500,000 per ha in intensive farming (Table 13). There is a considerable variation of gross revenue in different farming systems, because of the different levels of tilapia production. Despite higher production costs, the average annual net return was higher in intensive farming at Tk 184,000 per ha, compared with Tk 74,000 per ha in semi-intensive and Tk 28,000 per ha in extensive farming. Actual net return would higher if other fish production with tilapia under polyculture is considered for cost-return analysis. Almost all interviewed farmers stated that their returns have decreased as costs of tilapia farming have increased significantly while the market price of tilapia (an average farm-gate price Tk 100 kg) has not increased to a similar degree.

The benefit-cost ratio (BCR) is higher in intensive farming at 1.58, compared with 1.42 in semi-intensive and 1.30 in extensive farming. BCR or profitability index of any farming system implies that a ratio of 1 means that the operation is at break-even position. Fish farms with a BCR greater than 1 have greater benefits than costs as well as positive net benefits. The findings indicate that the extensive farms are able to recover Tk 1.30 per Tk 1 of investment while semi-intensive and intensive farms generate a return of Tk 1.42 and Tk 1.58, respectively.

3.3 Market Analysis

3.3.1 Tilapia Consumption

Tilapia has great potential in terms of food security and nutritional benefit. Tilapia is becoming popular among consumers because of taste and less bones making it easier to eat. With increasing popularity among consumers, tilapia has become one of the most important food fish in Bangladesh (Ahmed, 2009b). The consumption of tilapia at household level has been increasing. Tilapia is becoming popular among all groups of people including women, children, young and old due to taste and less bones which easy to eat. Tilapia seems to be accepted by all religious, social and economic groups in Bangladesh. In general, the high income groups (i.e. high officials and rich businessmen) buy large tilapia, and the middle-class is able to afford medium-sized and small tilapia. The large segments of poor people also buy small tilapia (5 to 6 fish/kg) due to equity considerations, i.e. one tilapia per household member. In general, household consumers directly purchase tilapia in retail markets and they usually prefer fresh tilapia without icing. Restaurants, roadside hotels, highway motels, guesthouses, resorts and institutional consumers (university halls, patients of medical hospitals, and participants in training centres) also buy tilapia due to increasing popularity (Ahmed et al., 2012).

According to field visits and discussion with key informants, major tilapia consuming cities are Dhaka, Chittagong, Khulna, Rajshahi, Barisal, Sylhet and Rangpur – all divisional towns. If tilapia can produce widely, the supply of tilapia in Bangladesh would have a favourable impact on food security to meet the growing demand for fish among consumers, including the poor. When eating out, tilapia with rice is the most frequent lunchtime meal for middle class and the poor. Nevertheless, the high income groups prefer to eat tilapia during dinner at home or restaurants. Tilapia is also consumed during festivities and guest entertainments. It is realised that tilapia is becoming an important component of the Bengali diet.

Primary study at wholesale (*arot*) level confirmed that tilapia supply to *arots* has increased considerably over the last few years. However, quantification of increased supply is difficult. Nevertheless, most wholesalers claimed that the supply of tilapia has increased more than double over the last five years.

Dhaka is one of the major consumers of tilapia in Bangladesh as it is the largest fish market in Bangladesh. It is estimated from the interviews of *arotdars* that around 30,000 tonnes of tilapia are sold in Dhaka in 2012. An earlier reference found in PRICE study estimated that Tilapia consumption was around 21,000 tonnes in 2010. However, roughly 25% of the 30,000 tonnes goes to the bulk consumers (military, hostels, restaurants). The rest goes to the retailers of different markets in Dhaka city through traders. In Dhaka, most tilapias come from Mymensingh, Bogra and Comilla districts. Similarly, around 20,000 tonnes of tilapia are sold in Chittagong city which come from different corners of the Chittagong and its adjacent districts such as Comilla, Noakhali and Cox's Bazar. In Barisal, regionally produced tilapia does not go outside the region as its end at the regional markets of Barisal. Similarly, the regional production of tilapia in Sylhet meets only 20% of the total demand and the rest comes from adjacent producing districts, including Mymensingh, Kishoreganj and Netrokona.

3.3.2 Demand-Supply Situation

The demand for fish in Bangladesh has been gradually increasing due to increasing population as well as fish production. Demand-Supply gap estimation is difficult considering the market scenario in Bangladesh. All fish supplied to the market eventually consumed by the consumers. Primary study at Arot level also failed to quantify the demand-supply gap as all Arots claim that they can sell whatever amount they get. Another aspect of calculating demand for fish is the nutrition aspect. According to the Household Income and Expenditure Survey 2010, average fish intake of Bangladesh is 49.5 gram/person/day in 2010 which was 42.2 gram/person/day. Department of Fisheries estimated that nutrition from fish would need to increase to 70 gram/person/day by 2020. This increase in nutrition intake will need 1,200,000 tonnes additional fish production (Source: Validation Workshop). According to this study in 2017, Tilapia will give roughly 100,000 tonnes additional production which would not help much to reduce the gap of the demand. Therefore, a decent growth (10-12%) of Tilapia will not be sufficient to meet the future demand of fish. Primary Study at Arots also suggest that in last few years price different between captured and cultured fish has been increasing and likely to increase more in future. This will have a direct impact on low market price fish like Tilapia.

3.4 Value Chain Analysis

3.4.1 Tilapia Value Chain

The value chain describes the full range of activities which are required to bring a product or service from conception, through the different phases of production, delivery to final consumers. Value chain tends to be extended with a whole range of activities within each link and links between different value chains. Value chain analysis can be a useful analytical tool in understanding the policy environment in terms of efficiency in allocation of resources within the domestic economy while at the same time understanding the manner in which marketing people are participating in the national economy. In tilapia production, distribution and marketing, a number of actors involve in value chain those are playing key roles in different aspects of value addition. Value chain is a structure of physical, economic and social transactions between individuals and organisations engaged in raw material transformation into end products.

Table 10: Key actors and their roles in tilapia production, distribution and marketing

Actors	Functions	Roles
Hatchery operators	Brood collection and management	Commercial brood supplier is absent in Bangladesh. Hatcheries collect broods from abroad through the connection of development projects. In addition, some hatcheries have personal connection with other efficient Tilapia producing countries because of their involvement in ownership of the hatchery. BFRI supplies limited amount of broods to the hatcheries. From the Key informant interview, it was identified that around 2 crore broods are needed every year.
	Hatching	Hatching eggs from brood and keeping it in the tanks to complete initial nursing of newly born fry. Primary Study estimates that total number of hatchery is around 300 in Bangladesh.
Fry traders	Fry trading	Buying fry from hatcheries and small farmers and sell to the farmers; fry traders include traditional patilwala. In addition to selling fry, they also provide embedded information of farming knowledge for their own business incentive. Total number of fry trader is 3000.
Hatchery Agent	Trading Fries	Hatchery Agents are the distribution channel of some brand hatcheries like CP, Mega, Quality, Paragon and Fishtech. Usually, they get a certain commission from the hatcheries for selling fry to the farmers. Primary Study estimates that around 14,000 Hatchery Agents are working in Bangladesh.
Input suppliers	Input retailing	Work as an intermediaries for the feed and other aqua-chemical companies; farmers buy feed and other inputs from the retailers. Considering the average volume of sales, primary study estimates that total number of input supplier is 6000.
Farmers	Production of tilapia	Farmers stock fry in their ponds and produce marketable size (roughly above 125 g) tilapia; later they sell tilapia to the paikers and retailers through arotdars.
Arot (or arotdars)	Wholesale facilitation	Mainly commissioning agents; collecting Tilapia from farmers, and trades to both urban and rural farmers; takes 2-3% commission from the selling price. Total number is around 1200.
Rural Paiker	Trading	Paikers are the buyers in arots and sell it in bulk (usually in maunds) to the retailers; sometimes, rural paikers sell to the urban paikers. Total number is around 1200
Urban paikers	Trading	Buy fish from both arots and rural paikers; trade directly to the urban retailers and wholesale buyers like hostels, Military and Hospitals. Total number is around 500.

Urban retailers	Retailing	Collect Tilapia from different urban paikers and sell to the urban consumers. Total number is around 4000.
Rural Retailers	Retailing	Retailers sell to the consumers; usually, they have specific location in the markets and consumers buy in kg from them. Total number is around 12,000
Rural consumers	Consumption	Consumers located mostly in the rural areas.
Urban consumers	Consumption	Consumers located mostly in the district headquarters and megacities.

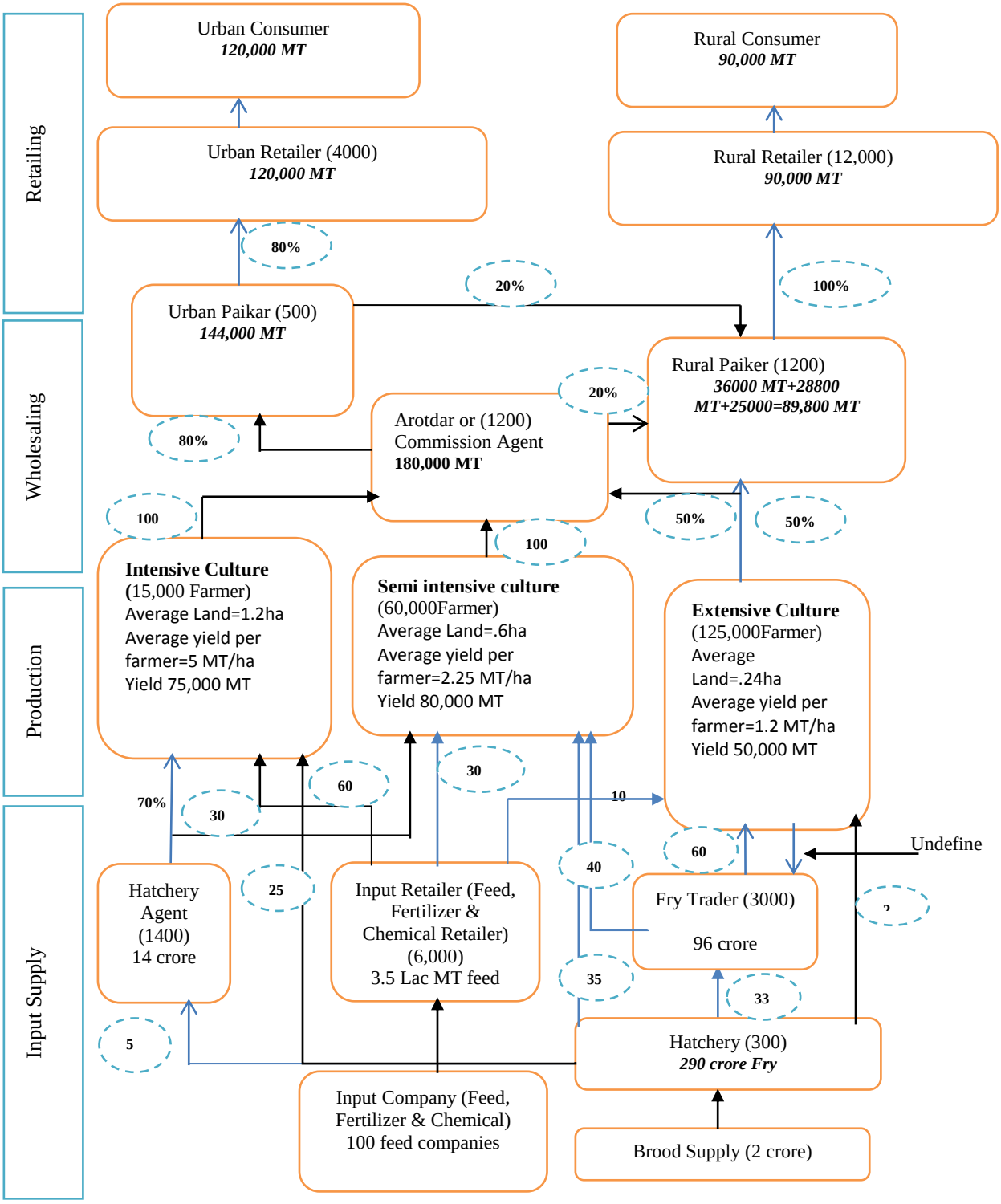

Figure 5: Overall Value Chain Analysis

3.4.2 Hatchery, nursing and fry trading

Aquaculture is primarily dependent upon an adequate supply of fish seed in terms of quality and quantity. Private hatcheries now dominate the seed supply and at present there is an adequate tilapia seed supply from around 300 hatcheries. According to the Primary Study, around 290 crore tilapia fry were produced in 2011-12. However, fry production was 140 crore in 2008-09, then gradually increased 180 crore in 2009-10 and 230 crore in 2010-11 (source: mapping workshop). Growth of hatcheries showed a dramatic increase in last five years due to the strong demand for Tilapia fry. However, some industry experts of DOF argued that number of Tilapia hatchery might be lower than 300. Identifying the right number of hatcheries is difficult for the Tilapia due to the rapid expansion in last few years. Again some Carp, Prawn, Pangas hatchery started Tilapia production which make it more difficult. A previous study of PRICE project suggested that number of Tilapia hatchery was 191 during 2009-2010 and Bolton et. 2011 suggested that in 2007 there were only 30 hatcheries in Bangladesh. Considering this uneven growth within three years it can be said that 300 Tilapia hatcheries in Bangladesh is likely. Hatcheries also increased their production capacity to meet the unmet demand for the fry. Primary study suggested that almost all hatcheries are keen to increase their production capacity to meet the future demand. Some big feed companies like CP, Paragon Feeds, Quality Feeds, and Mega Feeds entered the market of Tilapia fry. These big companies sell high quality fry with highest market price (BDT 1-1.2 per piece) using their own distribution channel of feed. Hatchery Industry Experts believe in future these big names will continue to increase their market share due to their advantage of having distribution channel.

Hatchery is the key value chain actor that contributes to the expansion of tilapia farming in Bangladesh. Tilapia seed prices (Tk 0.3-1.2 per piece) have declined in recent years because of increased availability and quality. The quality of fish seeds depends on many factors including conditions in the hatcheries and selection of broodstock. Quality broods of tilapia are often supplied by the BFRI. Government hatcheries are also sourced quality broods. Majority of the hatcheries maintain their own broodstock. Some development projects like Katalyst and WorldFish Center are trying to develop broodstock of the hatcheries through supporting them to import broods from Thailand, Vietnam and The Philippines.

In order to successful operation, tilapia hatcheries must be maintained brood banks under controlled condition. Tilapia hatcheries do not need induced breeding as tilapia is a prolific breeder. Tilapia breeds naturally in closed water conditions several times in a year. However, excessive breeding in ponds by tilapia creates a number of management problems, including over-stocking, competition for food and space, and low growth rate. Since sex differentiation at early stage and segregation of thousands of same sized tilapia are difficult, thus farmers feel comforts to use monosex tilapia from hatcheries. For monosex treatment, hatchery operators collect fertilised eggs from mother tilapia in ponds and allow the eggs to hatch in hatcheries and treat them with male hormone (17α-methyl testosterone) as feeding. Hormone treatment is reportedly done while first feeding the tilapia fry. First feeding must be done in confined condition, either in concrete tanks or in *hapa* so that tilapia fry get access to natural foods. If the fry takes natural foods their chances of conversion to monosex will be hampered. It is noted that tilapia fry to be kept in a plankton-free pond for nursing before sex-converse is essential. Tilapia fry those who have just opened their mouth are shifted from *hapa* to hatching jar/plate and hormone treated feeds are administered.

The number of fry traders is very low and mostly traditional *patilwala* who sells tilapia fry. According to the hatchery operators, most hatcheries sell directly to the farmers. Again, most of the development projects are now working directly with the hatcheries and farmers to establish nursery under the

umbrella of CBOs. Therefore the role of traditional *patilwala* is becoming lower over years and there is a threat to be abolished them from the value chain.

Conventional hatcheries provide seeds to farmers in the monsoon and are unable to provide seeds before April-May in bulk. This situation has created new economic opportunities in fish nursing. In late monsoon, fish seed price declines dramatically due to less demand and hatcheries are forced to sell spawns/seeds at much lower rates. These low priced spawns/fry are usually procured by non-conventional nursery owners for a prolonged nursing though winter period and popularly termed as over-wintered nursing. Conventional nursing usually goes for couples of weeks whereas over-wintered nursing continues for several months. The use of over-wintered fry help stocking of ponds as early as late January and crops may be harvested by June and second crop with newly available hatchery produced seeds could be used. It is mentioned that conventional nursing initiate as a part of fish farming often practising nursing together with grow-out after selling bulk of nurse seeds and rearing for table fish. In some cases, framers used to stock low-cost seeds in high density and selling apparent excess seeds as nursed to others and retaining required nursed fingerlings or juveniles for table fish production. However, over-wintered nursing has emerged in recent years as new economic activities and many farming households with small water bodies are now practising over-wintering as an extra source of income generation.

3.4.3 Feed Management

Now-a-days a variety of feeds are used for aquaculture in Bangladesh including supplementary feed, farm-made feeds and industrially manufactured pellet feeds. In general, extensive farmers mainly use supplementary feed. The average price of supplementary feed was estimated to be Tk 20 per kg. Mash type homemade feed is usually prepared by rice bran, wheat bran, oil cake and occasionally incorporating soybean meal and fish meal. They apply the feed by making feed balls or as they purchase from the market. In contrast, farm-made feeds and industrially manufactured pellet feeds are used by farmers in semi-intensive and intensive farms. In recent years an increasing number of farmers use industrially manufactured pellet feed for tilapia (Source: Forthcoming report of Ahmed 2012).

The farm-made feed ingredients are mainly rice bran, wheat bran, oilcake, fishmeal, flour, maize, oyster shell, salt, antibiotics, vitamin premix and additives. A significant number of farmers use mixture machines to produce farm-made feed. Normally two types of farmers make their own feeds; firstly those who need huge amount of feeds for their aquaculture operation, secondly farmers who do not rely upon commercial feed due to quality concern and high price. The average price of farm-made feed was calculated at Tk 25 per kg, which is 20-25% lower than industrially manufactured pellet feeds (Source: Forthcoming report of Ahmed 2012). Farmers who use their own feed, believe that the performance of farm-made feed is often better that the commercial feed. The use of farm-made feed for tilapia culture is common in Mymensingh and Noakhali regions.

The commercially manufactured pellet feed got momentum when Pangas was introduced in Bangladesh. There are around 100 feed industries in Bangladesh although there are many unreported feed industries in Bangladesh. The feed industries are located throughout the country. Although the main aim of feed business is profit making, many feed industries provide technical assistance through their technical staff. A typical feed manufacturer produces from 20,000 to 95,000 tonnes per annum, depending on capacity, financial ability, skilled manpower, seasonality and demand of feed. It has been

reported that the production capacity of feed is ranging from 10 to 20 tonnes per hour (Source: Forthcoming report of Ahmed 2012). Two types of feeds are produced by feed industries: (1) floating and (2) sinking. It is roughly estimated that around 70% of produced feeds are sinking and the rest (30%) are floating. However, the demand for floating feed has been increasing significantly in recent years due to tremendous performance in terms of fish productivity and maintaining water quality. Maintaining feed quality remains challenging, and in many cases, poor feed quality results in low production. Each type of feed can be classified as: (1) nursery - mash/powder, crumbled, (2) starter - starter 1, starter 2, starter 3, (3) grower - grower 1, grower 2, and (4) finisher. It is very common that the amount of nutritional value especially the protein content as well as the price is higher for nursery feeds and logically lower in finisher feeds. The price of tilapia feed varied between Tk 25.45 and Tk 50.25 per kg, depending on feed types, quality, culture species, season, supply and demand (Source: Primary Study 2013). In general, floating feeds are expansive than sinking feed, on average 20% higher price.

3.4.4 Fertilisers and Additives

Fish farmers mainly use fertilisers for grow-out operation. Fertilisers stimulate the growth of natural feeds (e.g. phytoplankton, zooplankton, benthos and periphyton), thereby increasing fish yields. Farmers mainly use organic and inorganic fertilisers. The most widely used organic fertiliser is cow dung, which is relatively cheap and readily available in rural Bangladesh. The use of inorganic fertiliser is not widespread, and only better-off farmers can afford them. Semi-intensive farmers often use a mixture of chemical fertilisers including urea and triple super phosphate (TSP), which are usually used in combination with cow dung.

There is a considerable variation between the application of fertilisation rates and different farming systems. In general, intensive farmers using pellet feeds are applied more fertilisers than the extensive and semi-extensive farmers. Extensive farmers using supplementary feed use organic fertiliser for polyculture with carp. The use of cow dung is attributed to a lack of technical expertise in terms of fertiliser application, and an inability to afford most expensive, alternative fertilisers. Farmers employing semi-intensive farming techniques using farm-made feeds rely on both organic and inorganic fertilisers but, due to financial constraints, apply fertilisers at lower rates than the intensive farmers.

In addition to fertilisers, lime is used in ponds for maintaining water quality and natural productivity. Farmers are often induced to use various feed additives, growth hormones, enzymes, antibiotics and probiotics and other aqua products, such as aquaclean, zeofresh, oxylife, aquamix, gastrap, cevit-aqua, panvit-aqua, antivirus, etc. Mainly intensive and semi-intensive farmers are used these additives for higher production, environmental management, maintaining water quality and disease control.

3.4.5 Fish Marketing

Harvesting of tilapia starts as soon as fish reach marketable size. Most small-scale farmers harvest tilapia by themselves although a few large farmers depend on commercial harvesters. Vans and rickshaws are commonly used to transport tilapia from remote villages to the assembling centres near the main roadside. A wide range of poor people are involved in the tilapia marketing chain as traders, intermediaries, transporters and day labourers. The tilapia marketing system is traditional and less competitive but plays a vital role in connecting farmers and consumers, thus creating potential for

adding value. With a few exceptions, farmers seldom communicate with consumers. Instead the marketing channel from farmers to consumers intertwine primary, wholesale and retail markets, involving local agents, suppliers, wholesalers and retailers from whom consumers make most purchases. The demand for tilapia is high in markets but supply is limited, and a strong multifunctional network has developed with intermediaries and traders intervening between farmers and consumers.

In Bangladesh, the tilapia market is small in terms of volume, value and employment. The tilapia marketing system is traditional and less competitive but plays a vital role in connecting the farmers and consumers, thus contributing significantly in the value adding process. Tilapia marketing is almost entirely managed, financed and controlled by a group of intermediaries. The market chain of tilapia from farmers to consumers encompasses mainly primary, secondary and retail markets, involving local agents, suppliers, wholesalers and retailers. Communication between the suppliers and wholesalers is generally good and takes place by mobile phones. Suppliers are a form of intermediary traders who supply tilapia from primary to wholesale markets. In general, suppliers are tied to a limited number of wholesalers. Suppliers commonly use trucks, buses, pickups and taxis to transport tilapia to the wholesale markets. If the transportation time is less than 6 hours from primary market to retail point, tilapia is not iced, or if iced, it is not done properly (Ahmed, 2009b).

As soon as the suppliers land tilapia in the wholesale market, the wholesalers take care of landing, handling and auctioning. Normally, the auction sale is made by heaps. In general, wholesalers follow the incremental price system. It is the most competitive form of auctioning and ensures better prices. Auctioneers appointed by wholesalers, call out the bid loudly in the presence of the buyers. Auctioneers get commission at different rates of the sale proceeds for their services and costs involved. The retailers are also linked to a limited number of wholesalers. The relationship between the retailers and wholesalers is generally good. Two main categories of fish retailers have been encountered: market-based retailers and itinerant retailers (fish vendors, hawkers, etc). Retail sales are made at stalls in fish markets and door-to-door to household customers. Tilapias are traded whole, un-gutted and fresh without processing, apart from sorting and icing.

3.4.6. Margins & Value Additions

A total of BDT 35 value added to Tilapia from farm gate to the retailers. The highest value addition (54%) is done by the Farmers, while second & third place is taken by the Ratailers (27%) and Paikers (15%) respectively. Since Tilapia has the bigger market in the urban areas so, there is more scope for value addition / price increase in the retailing stage. At the same time, Paikers are key actors in delivering the products to a larger perimeter, which gives them the leverage of increasing the price as per their costing. Arots, generally acting as a commissioning agent has the lowest value addition (4.1%), as the bargaining between the Arotdars and Paikers are mostly dominated by the Paikers.

Table 11. Value Addition in different stages of production

	Farmer	Arot	Paikar	Retailer
Price	115	119	130	150
Marketing Cost	3	1	8	5
Value Addition	40	3	11	20
Value Addition %	54.1	4.1	14.9	27.0

Source: Primary Study 2013

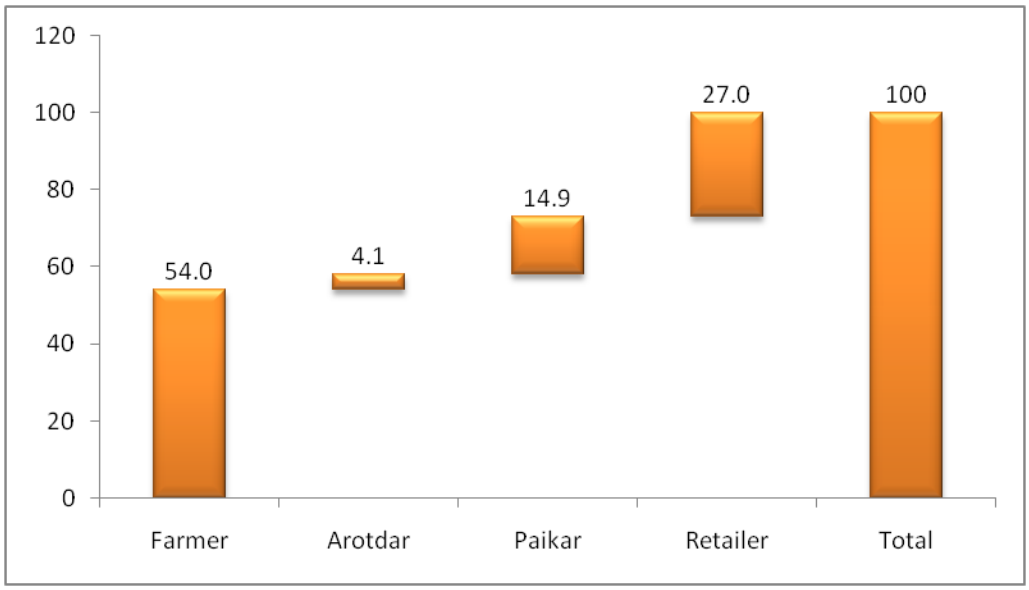

Figure 6: Percentage of Value Addition in different level of Value Chain

4. Pangas

Originally, Pangas (*Pangasianodon hypophthalmus*) is a catfish of the Mekong Delta being recognised as the most important and largest inland fishery in the world. This species developed capture-based fishery to a greater extent in Vietnam and lesser extent in Thailand and Cambodia, because it is a prolific breeder producing relatively large number of fry which is easily harvestable from the flowing river. It became an important aquaculture species in Bangladesh, Cambodia, China, Indonesia, Malaysia and the Lao People's Democratic Republic (Lao PDR). *P. hypophthalmus* has various common English names such as sutchi catfish, iridescent shark-catfish and striped catfish. Ecologically, it is a riverine freshwater species which is limited to the Mekong River, the Chaopraya River and possibly the Mekong basins in Cambodia, Lao PDR, Thailand and Vietnam, together with the Ayeyawady basin of Myanmar (FAO, 2010). It is a highly migratory riverine fish which makes long-distance migrations over several hundred kilometres between upstream refuge and spawning habitats and downstream feeding and nursery habitats. It is omnivorous, feeding on algae, higher plants, zooplankton and insects, while larger specimens also take fruit, crustaceans and fish (FAO, 2010).

The Pangas aquaculture in Bangladesh has been emerged with an exotic species *P. hypophthalmus* (Sauvage, 1878), also known as 'Pangas' or 'Thai Pangas'. This exotic species was brought from Thailand in 1989 and has been established as a cultured species in Bangladesh being recognised by FAO in 1990 (Haque, 2012). It was first introduced by BFRI from Thailand in 1990. In the early 1900s, there were research initiatives of artificial seed production of Pangas in BFRI and Bangladesh Agricultural University (BAU). Following research activities, BFRI developed successful fingerling production techniques through artificial propagations. There is an indigenous riverine Pangas which was not proved to be suitable for seed production artificially however, having introduced exotic Pangas, private entrepreneurs brought into it as a one of the main aquaculture species being cultured in higher stocking density. Due to the success of Pangas aquaculture practices, a large number of private hatcheries have been developed in Bogra and Mymensingh region.

Farming has started commercially by a private enterprise named Al-Falah Fisheries since 1993 in Bailor Union under Trishal Upazila of Mymensingh district. Afterwards, it was steadily expanding from Trishal to the neighbouring villages and other districts. Later, particularly in the last decades, Pangas culture was spreading to an increasing number of districts and has rapidly evolved into an economically significant activity with long backward and forward linkages providing diverse livelihood opportunities for a wide range of value chain actors (Haque, 2009). This rapid growth has occurred due to its popularity to the pond farmers for possessing hardy characteristics, higher survival rates, fast growth, and ability to survive at high stocking densities. The species has also proven popular among consumers due to its low market value, making it one of the most important cultured species, particularly among the poor in urban areas (WorldFish Center, 2011). It is therefore an important issue of addressing Pangas as single species aquaculture being recognised as "*Pangasius* aquaculture" in Bangladesh and here its culture, production, distribution and marketing activities are discussed.

4.1 Production Analysis

4.1.1 Division Wise Production

According to the DoF, Pangas production in pond systems was estimated at 156,375 tonnes in 2010-11 which was about 13% of total pond production (FRSS, 2012). Nevertheless, considerable variation in production data was found between DoF and Extension Department. After a series of discussion with Key informant, back-calculation from the hatchery production, interview of Arots it was concluded that extension data is more realistic consider the present production status of the country. According to the Extension Department, the total annual Pangas production in Bangladesh was estimated at 254,563 tonnes in 2010-11 (Extension Data, 2012). Over the last three years, total Pangas production in Bangladesh has been increased twice, from 182,098 tonnes in 2008-09 to 254,563 tonnes in 2010-11 (Table 22). The highest Pangas production in 2010-11 was recorded in Dhaka division (142,650 tonnes), followed by Chittagong (36,607 tonnes), Khulna (31,233 tonnes) and Rsjshahi (28,422 tonnes). However, the lowest Pangas production in 2010-11 was found in Sylhet division (2,807 tonnes).

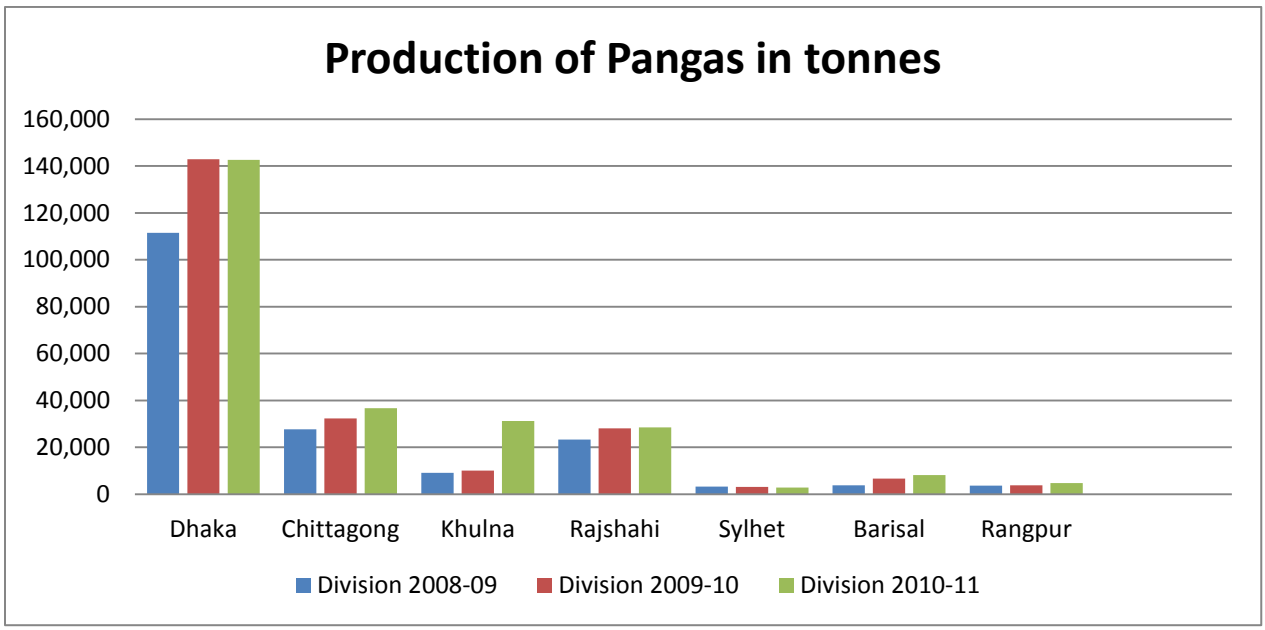

Figure 7: Division wise Pangas production in Bangladesh over the last three years

Source: Extension Data (2012)

4.1.2 Productivity

The productivity of Pangas per hectare farm is high due to high stocking and high feeding culture systems. The average productivity of Pangas in Bangladesh was estimated at 8.7 tonnes/ha in 2010-11 (Table 24). The average productivity of Pangas has gradually increased from 7.3 tonnes/ha in 2008-09 to 8.2 tonnes/ha in 2009-10, and 8.7 tonnes/ha in 2010-11. However, the productivity of Pangas is variable among different divisions across the country. In 2010-11, the highest average Pangas productivity was found in Dhaka division (18.73 tonnes/ha), followed by Khulna (7.8 tonnes/ha) and Rajshahi (7.1

tonnes/ha). On the other hand, almost similar level of productivity was found in Sylhet (4.0 tonnes/ha), Barishal (3.8 tonnes/ha), Chittagong (3.8 tonnes/ha) and Rangpur (3.2 tonnes/ha) divisions.

Table 12: Division wise Pangas production in Bangladesh over the last three years

Division	2008-09			2009-10			2010-11		
	Area (ha)	Yield (t)	Yield rate (t/ha)	Area (ha)	Yield (t)	Yield rate (t/ha)	Area (ha)	Yield (t)	Yield rate (t/ha)
Dhaka	7,933	111,486	14.05	8,873	142,909	16.11	7,615	142,650	18.73
Chittagong	9,086	27,645	3.0	9,473	32,249	3.4	9,536	36,607	3.8
Khulna	897	9,066	10.1	1,512	10,022	6.6	3,983	31,233	7.8
Sylhet	746	3,164	4.2	732	3,060	4.1	702	2,807	4.0
Rajshahi	3,759	23,328	6.2	3,714	28,075	7.5	3,973	28,422	7.1
Rangpur	1,303	3,591	2.7	1,275	3,756	2.9	1,460	4,764	3.2
Barisal	1,198	3,819	3.1	1,816	6,627	3.6	2,121	8,080	3.8
Total	24,922	182,098	7.3	27,394	226,698	8.2	29,390	254,563	8.7

Source: Extension Data (2012)

The productivity rate (tonne/ha) per hectare farm of Pangas has been gradually increasing in Dhaka and Rajshahi divisions. These divisions belong to major Pangas producing districts like Mymensingh and Bogra. According to the primary study, major producing districts are given below:

Table 13: Major Pangas producing districts

Dhaka Division	Chittagong Division	Khulna Division	Rajshahi Division
Mymensingh	Comillla	Kustia	Bogra
Netrokona		Jessore	

Source: Primary Study (2013)

4.1.3 Production estimation and future projection

In 2012, the total number of Hatcheries is 200 (Estimated during the mapping workshop). With an average production rate of 90 lakh fries per Hatchery the total number of fry produced is 180 crore. Out of this 180 crore about 80 crore is smuggled over the border (similar type of estimation was mentioned by Bolton et. 2011). From the rest 100 crore, 50% survive to fingerling stage, among them 90% survive in grow-out, resulting a total number of 45 crore (Key informant estimation). Considering average growth of Pungas 650g/piece the total production volume is 292,500 MT.

It has been reported that Pangas farmers often switch to tilapia and other fish culture due to reduce profitability originated from increasing feed price and decreasing market, thus the annual production rate of Pangas is negative in Dhaka and Sylhet divisions. However, interview with Arots confirmed that production of Pangas is increasing steadily in last five years. In additon the production of Pangas has been gradually increasing in other divisions as fin fish and some Tilapia hatchery started Pangas fry production considering the local famers' demand for Pangas fry (Primary Study 2013). Most key informants reported that total Pangas production in Bangladesh will be increased at a rate of 7% per

annum. It is therefore projected that the total production of Pangas will be reached at around 421,749 tonnes in 2016-17.

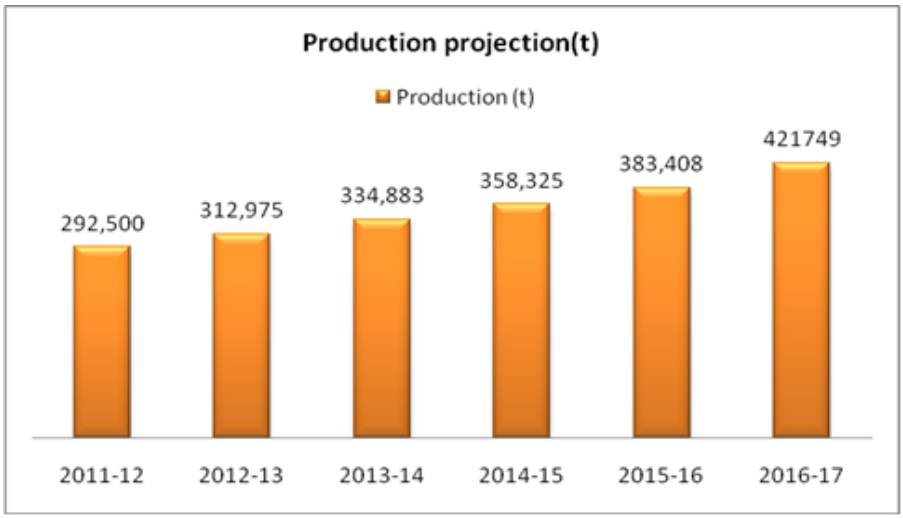

Figure 8: Projection of Pangas production over the next five years

4.2 Culture Area, Culture Practice and Number of Farmers

4.2.1 Culture Area

By species over the years Pangas scored itself 4th rank in the total production of pond aquaculture in Bangladesh (FRSS, 2012). After development of Pangas aquaculture in the early 1990s, till 2007, the contribution of Pangas to national fish production was not addressed by the official statistics. The incompetent official statistical operation and services of the DoF could not update the nationwide aquaculture production data which undermines the contribution of Pangas. However, in the recent years particularly from 2007-2008, the DoF's Fisheries Resource Survey System (FRSS) started surveying the statistics of Pangas production officially. As per FRSS, total estimated country production of Pangas in 2007-2008 was 31,443 tonnes which has been increased by five times into a production figure of 156,375 tonnes in 2010-2011 (FRSS, 2012). This large level of differences between the four years of differences indicates that there is a difference from the reality of Pangas production. According to an USAID funded recent study conducted by Anwar (2011), the total country production was 263,310 tonnes in 2009-2010. A similar level of production was also estimated in difference studies (Haque, 2009; Belton et al., 2011). This large volume of production shaped Pangas aquaculture as an enterprise which in turn contributed to the development of other associated enterprisers in its value-chain.

In Bangladesh, total Pangas culture area has increased from 24,922 ha in 2008-09 to 29,390 ha in 2010-11 (Table 16). During the period from 2008-09 to 2010-11, collectively production area of Pangas was increasing in trend. In 2010-11, the highest Pangas producing area was found in Chittagong (9,536 ha), followed by Dhaka (7,615 ha), Khulna (3,983 ha) and Rajshahi (3,973 ha). In this year, the lowest Pangas farming area was found in Sylhet (702 ha), followed by Rangpur (1,460 ha) and Barisal (2,121 ha).

Table 14: Division wise Pangas culture area in Bangladesh over the last three years

Division	Culture area (ha)				
	2008-09	2009-10	Annual growth rate (%)	2010–11	Annual growth rate (%)
Dhaka	7,933	8,873	12	7,615	-14
Chittagong	9,086	9,473	4	9,536	1
Khulna	897	1,512	68	3,983	163
Rajshahi	3,759	3,714	-1	3,973	7
Sylhet	746	732	-2	702	-4
Barisal	1,198	1,816	52	2,121	17
Rangpur	1,303	1,275	-2	1,460	14
Total	24,922	27,395	10	29,390	7

Source: Extension Data (2012)

The average annual growth rate of Pangas culture area was found at 7% in 2010-11 (Table 14). Among seven divisions, the growth rate in terms of Pangas farming area was jumped in Khulna and Barishal over the last three years. However, negative growth rate in terms of culture area was found in many divisions over the last three years. It has been reported that a number of Pangas farmers in highly developed aquaculture areas (e.g. Mymensingh, Bogra) often switch to tilapia culture due to reduce profitability from Pangas production. Nevertheless, the expansion of Pangas culture is happening in other districts at slow pace. According to key informants, the expansion of Pangas culture area in Bangladesh will be continued at a rate of 7% per annum over the next five years which is similar growth rate of current Pangas farming (Table 14), and aquaculture practices in Bangladesh (FRSS, 2012). It is therefore projected that the total Pangas culture area in Bangladesh will be reached at 43,870 ha in 2016-17.

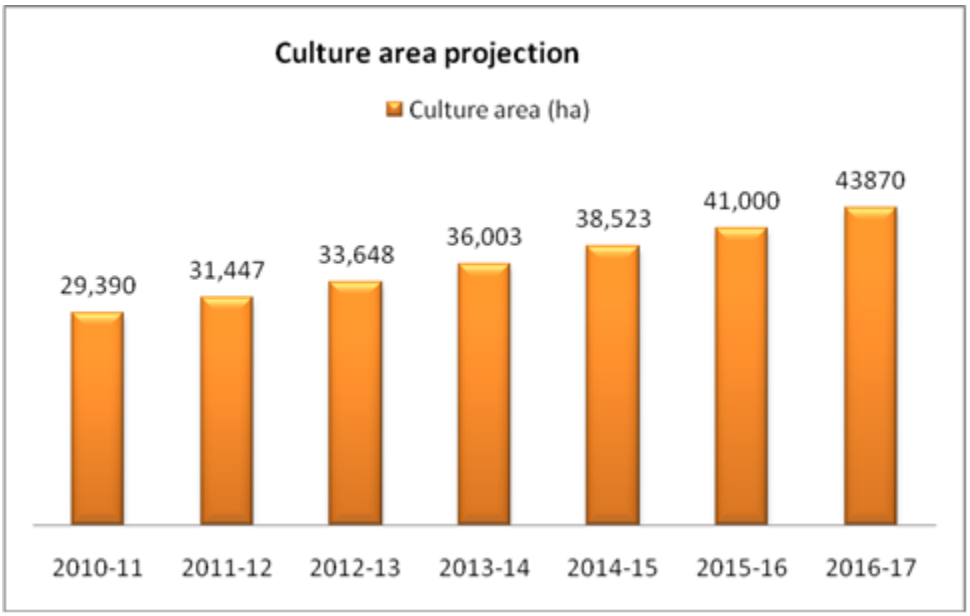

Figure 9: Projection of Pangas culture area over the next five years

4.2.2 Area under different Culture Practices

According to key informants and discussion with farmers, 50% of Pangas farming area is under the practice of semi-intensive farming while 20% and 30% of farmer areas are under extensive and intensive farming, respectively. The higher proportion of semi-intensive culture is due the growth of Pangas as with tilapia is not occurred in the fertilized ponds depending on the natural food production. Moreover, the high price of feed cost cannot be afforded by the small-scale farmers. According to field survey and discussion with key informants, most farmers produce Pangas under polyculture systems with carps. In extensive farming level farmers stock Pangas with carps and the proportion of carps of the total stock are 13%. In the semi-intensive farming practice, farmers stock about 5% carps with 95% of Pangas. In intensive farming, however, farmers stocked very minimum percentage (1%) of carps with 99% of Pangas. Hence, it could be argued that farmers practice monoculture in intensive farming of Pangas. It is therefore summarised that most farmers (70%) produce Pangas under polyculture with carp while the remainder (30%) practice monoculture.

Table 15: Different Culture Practice and Area under the Culture Practice

Culture intensity	Definition/ criteria	% of area	Farm size (ha)	Stocking (No/ha)	Feeding practice	Feed consumption (kg/ha/yr)	Average labor (man day/ha/yr) 1 man day = 8 hrs	Yield (t/ha)
Extensive	Extensive farming is characterised by small farm size, low stoking density, dependency on feed supplementation and operated by household labour	20%	Less than 0.25 ha	20,000 - 30,000	Industrial feed and supplementary feed (e.g. boiled rice, rice bran etc.) Feeding: once/day	15,000 - 25,000 FCR= >2.00	200 (mainly of household labour)	5-15
Semi-Intensive	Characterized by intermediate level of stocking density, pelleted feeding, higher pond depth and operated by small number of salaried labour	50%	0.26 – 0.80 ha	30,000 – 45,000	Home-made feed and/or industrial feed Feeding: twice/day	25,000-50,000 FCR= 1.8-2.0	450	15-30
Intensive	Characterized by higher stocking density, larger farm area, deeper pond; quality feeding, operated by large number of salaried labour	30%	0.81-2 ha	45,000 - 65,000	Home-made feed and/or industrial feed Feeding: 2-3 times/day	50,000-80,000 FCR= 1.6-1.8	600	30-50

Source: Field survey and key informants' interviews (2013)

According to discussion with key informants, farm size in extensive Pangas farming is usually less than 0.25 ha while the range of farm size in semi-intensive farming between 0.26 and 0.80 ha (Table 19). Nevertheless, the farm size in intensive farming was reported by key informants to be above 0.8 ha, typically ranging from 1 to 2 ha. Considerable differences are found between the size of farms and the farming systems.

Relatively, extensive farmers typically use low inputs of seed and feed operated by household labour. Semi-intensive farmers use intermediate levels of inputs, while intensive farmers use high level of inputs. The range of FCR in extensive, semi-intensive and intensive farming reported by key informants were >0.2, 1.8-2.0 and 1.6-1.8, respectively (Table 14). The level of FCR depends on the quality of feed, feed ingredients (e.g. protein level), types of feed and other factors including water quality and stocking density. In general, extensive farmers mainly use commercially produced feed at a limited level being purchased in credit from the local dealers. They also provide supplementary feed of rice bran and boiled rice. This is because they cannot invest for farm site pellet machine installation and purchasing large amount of feed ingredients. Moreover, farm site pellet machine produced feed production needs a large cemented yard to dry feed that needs large amount of investment which is unaffordable for the extensive farmers. On the other hand, the semi-intensive and intensive farmers invested large amount of money for installation of a pellet machine and feed drying yard for own feed preparation. Feed production by own pellet machine can save Tk 2-3 per kg of feed production. This level of price reduction of a kilogram feed collectively became a huge monetary savings for intensive and semi-intensive farmers.

4.2.2 Number of Farmers

So far there is no statistics about the number of farmers involved in Pangas farming in Bangladesh. Nevertheless, a total of about 3.08 million fish farmers with 371,309 ha of freshwater ponds are functioning in aquaculture which indicates that an average farm size is 0.12 ha or 30 decimals (DoF, 2012). From this statistics it is very difficult to make the accurate figure of total number of Pangas farmers in Bangladesh. However, it is roughly estimated that around 54,000 farmers are involved in Pangas farming. It should be mentioned here that the number of Pangas farmers is smaller (almost one-fourth of Tilapia farmer) than number of Tilapia farmers whereas production of Pangas is almost 1.5 times higher compared to the production of Tilapia. But this number is logical as national productivity of Pangas is almost 6 times higher than the national productivity of Tilapia which is 8.7 mt/ha and 1.37 mt/ha respectively (mentioned in the productivity section of this document). However, it is suggested that further assessment would be required in order to get accurate data about the number of Pangas farmers.

Table 16: Estimated Number of Pangas Farmers

Information	Extensive	Semi-intensive	Intensive
Total culture area in Bangladesh (ha)[1]	31,447		
Culture area by farming system (%)	20	50	30
Culture area by farming system (ha)	6288	15724	9434
Average farm size by a farmer (ha)	0.25	0.68	1.57
Number of farmers[2]	25000	23077	6000
Total number of farmers	54,077≈ 54,000		

[1]Source: Extension Department (2012)
[2]The number of farmers = culture area by farming system (ha)/ average culture area by a farmer (ha)

Due to the similarity of expansion of Pangas culture area, the number of Pangas farmers would increase 7% per annum over the next five years. It is therefore projected that the number of Pangas farmers would be 75,846 in 2016-17 (Figure 9). According to key informants and field assessment, there is still positive culture attitude towards Pangas production especially in new areas where other fin fish and Tilapia hatchery started Pangas fry production. It is therefore assumed that the number of Pangas farmers will increase steadily in the future to meet growing demand for low market price fish. An estimated number of Pangas farmers has been given below:

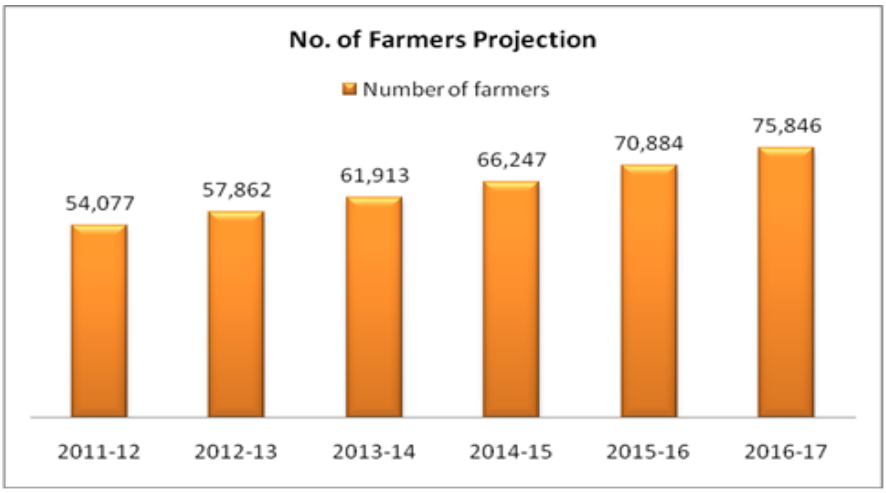

Figure 10: Estimated number of farmers in next five years

4.2.3 Cost-Benefit Structure of Different Culture Practices

According to the field survey and interviews with key informants, the average annual variable costs of Pangas farming in extensive system were estimated at Tk 334,000 per ha, compared with Tk 596,000 per ha in semi-intensive and Tk 977,000 per ha in intensive farming. There was a considerable difference of variable costs in different farming categories. The major variable costs occurred in case of feed because Pangas production is feed intensive and totally depends on supplied feed without any dependency on natural food production. The semi-intensive and intensive farms can reduce their feed price to a greater extent installing own feed machine/mill and drying yard which is not possible for the extensive farmers due the requirement of large investment. For this reason, semi-intensive and intensive farmers can reduce about 20% of feed cost compared to commercial feed producing feed in their own farms. This factor positively affect the intensive famers to provide regular feed at an optimum level in their farms for longer period of time which in turn make their fish larger in size that ensures the higher market price. This all indicate that Pangas farming tends to be consolidated into larger intensive farming system which has export potential in the coming days.

The average annual fixed costs of Pangas farming varied from Tk 16,000 per ha in extensive farming to Tk 20,000 per ha in semi-intensive and Tk 26,000 per ha in intensive farming. There is a considerable difference of fixed costs in different farming systems. Table 25 shows that the average annual total costs of Pangas farming varied from Tk 350,000 per ha in extensive farming to Tk 616,000 per ha in semi-

intensive and Tk 1003,000 per ha in intensive farming.

Table 17: Average production cost and return for Pangas farming by different culture intensity

Cost and return item	Cost and return in farming system (Tk/ha/yr)		
	Extensive	Semi-intensive	Intensive
Variable cost (VC)			
Seed	72,000	110,000	192,000
Feed	240,000	450,000	720,000
Fertiliser	3,000	5,000	7,000
Labor (family[1] and hired)	15,000	25,000	48,000
Harvesting and marketing	2,000	3,000	5,000
Miscellaneous	2,000	3,000	5,000
Sub-total	334,000	596,000	977,000
Fixed cost (FC)			
Depreciation[2]	2,000	3,000	6,000
Interest on operating capital/loan	9,000	12,000	15,000
Land use cost or lease	5,000	5,000	5,000
Sub-total	16,000	20,000	26,000
Total cost (TC = VC + FC)	350,000	616,000	1003,000
Average productivity (kg/ha/yr) (P)[3]	5,000	9,000	15,000
Average farm-gate price (Tk/kg) (FP)	80	80	80
Gross revenue (GR = P x FP)	400,000	720,000	1200,000
Net return (NR = GR - TC)	50,000	104,000	197,000
Benefit-cost ratio (BCR = GR/TC)	1.14	1.17	1.20

Source: Key informants interviews and discussion with farmers (2013)

[1]To determine the cost of unpaid family labour the opportunity cost principle was adopted. The opportunity cost of human labour is its value in its best alternative use.

Depreciation costs of water pump, net, feed machine, etc are calculated as: [(purchase price – salvage value)/economic life].

[3] The productivity of Pangas in extensive and semi-intensive farming is associated with carp under polyculture, thus the actual productivity is higher than these figures. Nevertheless, intensive farmers are usually involved in monoculture.

The average annual gross revenue from Pangas production varied from Tk 400,000 per ha in extensive farming to Tk 720,000 per ha in semi-intensive and Tk 1200,000 per ha in intensive farming (Table 25). There is a considerable variation of gross revenue in different farming systems, because of the different levels of production. Despite higher production costs, the average annual net return was higher in intensive farming at Tk 197,000 per ha, compared with Tk 104,000 per ha in semi-intensive and Tk 50,000 per ha in extensive farming. The BCR is higher in intensive farming at 1.20, compared with 1.17 in semi-intensive and 1.14 in extensive farming. This indicates that Pangas farming is still having a productivity as well as economic potential. Possibly for this reasons, the Vietnamese farmers explored this potential and they already reached to highest productivity in the world which is 10 times higher than that of Bangladeshi intensive farms.

4.3 Market Analysis

4.3.1 Pangas Consumption

In term of protein rich food supply, Pangas aquaculture impacted positively on both farmers and non-farmers living in and around the producing communities (Haque, 2012). To the non-farmers who are poor, Pangas was found cheaper protein source than other fish, meat and *dal* (lentil soup). This indicates the easy access of poor people to protein rich food being produced within their community. Pangas aquaculture tends to make the fish available to the community people for longer period of time in the year due its higher survival, higher yield, regular/partial harvesting and sale. Thus poor people can afford the fish with their low level of income that is not possible for carps and meat. Pangas is hardy fish which is normally sold and transported to the market in live condition. People can buy this fish in live, thus its freshness was ranked with higher score compared to other perishable food items. According to the interviews of Arots, 95% of the Pangas are sold in live condition whereas only leftover 5% are sold in dead condition. The non-farmer group of people perceived the taste of Pangas higher than the farmers group. Moreover, both of groups have given almost equal scores to the Pangas in terms of its preference to the children. Children prefer this fish because of its less intramuscular bones and higher taste (Anwar 2011).

Meeting the local demand, the bulk of the Pangas are marketed to the urban areas via a long intermediary chain. According to a recent study conducted by WorldFish Center (2011), cultured fish accounted for 31% of total consumption in 2010. When cultured fish were broken down into their composite species, it was evident that Indian major carp, Pangas and tilapia account for three quarters of total consumption, each with an almost equal share. According to another recent study (Anwar, 2011), the consistent demand of fish is met by the supply of Pangas for a range of organized consumers living in the urban areas who need huge amount of fish in restaurants, student dormitories, hospitals, jails, army cantonment, police lines etc. The preference of *Pangasius* is possibly due to its cheaper price and easy way of pre-cooking processing to cook. Again, it can be estimated from the interviews of Arots that Pangas are equally consumed in urban and rural areas. However, undersized Pangas goes to the rural markets whereas relatively bigger size Pangas goes to urban market.

4.3.2 Demand-Supply Situation

As mentioned earlier, it is difficult in Bangladesh to estimate demand for any specific fish species. All fish supplied to the markets eventually consumed which makes it difficult to measure the demand for fish. However, in-depth interviews of Arots confirmed that the demand for Pangas has been increasing steadily in last five years and likely to increase more in future both in rural and urban areas. During the study, it was also observed that price of Pangas was much higher than any other time of last five years. Arotdars reported that this unusual price hike was originated from the disrupted supply of Pangas. In late 2012, supply of Pangas fell significantly due to the excessive cold that resulted death of Pangas fish in the ponds. This increase in price shows the strong demand of Pangas. During the study, some hatcheries reported that they went for producing Pangas fry considering the growing demand for Pangas fish in their locality. To feed the future demand for fish, Pangas may play an important role due to the high productivity, low market price and opportunity for more intensification. Though Pangas

production may increase by around 130,000 MT by 2017, it will not be adequate to meet the future demand.

4.4 Value Chain Analysis

4.4.1 Pangas Value Chain

For Pangas value chain analysis, variables like production, distribution and marketing are considered. In marketing and distribution of inputs, marketing costs and margins, number of middlemen in the marketing channel, distance between primary and retail markets, and consumers' behaviours on price are considered. A large number of people are involved in the process of Pangas production, distribution and marketing from the producers to consumers. In Pangas production, distribution and marketing, a number of actors involve in value chain those are playing key roles in different aspects of value addition.

Table 18: Key actors and their roles in Pangas production, distribution and marketing

Actors	Functions	Roles
Brood supplier	Brood rear and supply	Rear brood in ponds and sell to the hatcheries. Total number is undefined. Fails to maintain steady quality of broods all through the year.
Hatchery operators	Brood collection and Hatching	Some hatcheries collect brood from abroad; hatching eggs from broods and selling fry to nurseries and fry traders. Total number of hatchery is 200.
Input supplier	Feed and aqua-chemical selling	Selling ready or local feed, also selling aqua-chemicals: Zeolite, Lime etc. Total number of input supplier is around 3,000 supplying a total of 4.5 lac MT of feed.
Fry trader/ nurseries	Fry rearing and selling	Buy fry from the hatcheries and nurture them to fingerlings; sell fingerlings to the farmers. Total number is around 14,000 and about 90% of the fries produced is traded through them.
Farmers	Grow-out	Buys Pangas fingerlings and stocking up to marketable size of Pangas; sell to arotdars and forias.
Foria	Trading	Buys Pangas from farmers (mostly extensive) and sells to arots. Total number is 349 and doesn't play any significant role is value addition. They buy products mostly from the extensive farmers. The channel through forias is quite informal.
Arotdars	Trading	Mainly commissioning agents; collecting Pangas from farmers and forias, and trades to both urban and rural farmers; takes 2-3% commission from the selling price. Total number is around 156.

Rural paikers	Trading	Buy fish from arots and trade mostly to the rural retail markets; a small portion of fish is also sold to the bigger urban paikers. Total number is around 494.
Urban paikers	Trading	Buy fish from both arots and rural paikers; trade directly to the urban retailers. Total number is around 311.
Rural retailers	Retailing	Collect Pangas from different rural paikers and sell to the rural consumers. Total number is around 4053.
Urban retailers	Retailing	Collect Pangas from different urban paikers and sell to the urban consumers. Total number is around 1944.
Rural consumers	Consumption	Consumers located mostly in the rural areas.
Urban consumers	Consumption	Consumers located mostly in the district headquarters and megacities.

Pangas value chain is a structure of physical, economic and social transactions between individuals and organizations engaged in raw material transformation into end products. Flows of Pangas products and money are exchanged through value adding transactions driven by profit and allocation. Figure 3 shows overall value chain of Pangas in terms of input supply, production, distribution and marketing with value addition process in different stages.

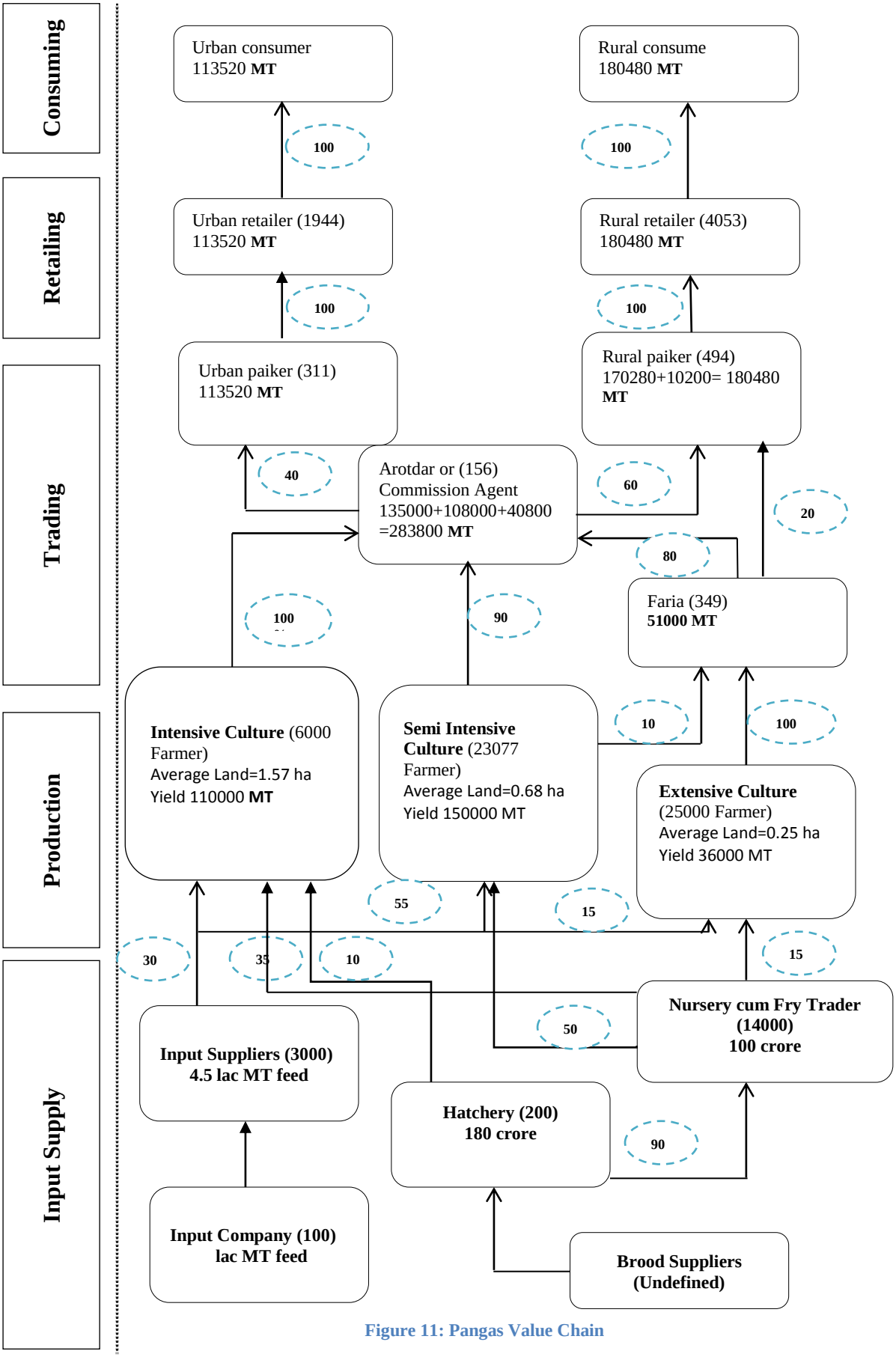

Figure 11: Pangas Value Chain

4.4.2 Brood Supply, Hatchery Operation and Nursery

Private hatcheries now dominate the seed supply and at present there is an adequate Pangas seed supply from around 200 hatcheries. However, in 2009 a total of 174 Pangas hatcheries were in Bangladesh (Ali et al., 2011). Total spawn production is about 200,000 kg per annum with about 30-40% of survival rate. According to field survey, around 180 crore Pangas fry were produced in 2011-12. A previous study found that Pangas seed production mainly occurred in Bogra (67%), Mymensingh (19%), Comilla (6%), Jessore (4%) and Naogaon (4%) districts (Ali et al., 2011). Usually 60-70% of Pangas fry are used by domestic farmers while the rest is exported (illegally) to India. The number of Pangas hatcheries as well as fry production has increased over the past few years. According to the discussion with the key informants, Pangas fry production was 140 crore in 2008-09, then gradually increased 160 crore in 2009-10 and 180 crore in 2010-11 (Source: Mapping workshop).

Most hatchery has own broodstock rearing pond and every year owners recruit new broodstock from their own farms or from different grow-out farms. Most farmers purchased hatchling directly from hatchery and then nursed in their own nursery pond before transfer to grow-out ponds. In Mymensingh region, farmers purchase a large volume of Pangas fry at the end of seed production season (September-October) in hatchery and keep them in their nursery ponds at higher density for 6 months to produce fingerling which is called overwintered fingerlings. Farmers stock overwintered fingerlings in their grow-out ponds very early in the following year and they experienced faster growth and marketable size compared to newly hatched fry (Haque, 2012).

Although a large number of Pangas fry are produced, quality is often variable. The quality of broodstock is also concerned and thus inbreeding is common. According to hatchery operators, a few hatcheries imported broodstock from abroad around 10 years ago. Since then broodstock have been using year after year. This has resulted in lower quality of fry. These fry have lower survival rate and poor growth rate. Low quality fry and poor quality feed has together resulted in higher production costs for Pangas farmers.

Nursery is an important value chain actor for Pangas farming. Conventional and Over-wintering nurseries are present in Bangladesh. However, rate of mortality is high for the Pangas nursery. Primary Study found that mortality of Pangas fry in nursery is as high as 50%. However, nurseries still make a lucrative profit due to the strong demand for the fingerling of Pangas.

4.4.3 Feed Management

Feed is one of the most important inputs to increase Pangas production. A major controlling factor of growth for Pangas is feed intake. Feed costs generally constitute the highest single operating cost in Pangas aquaculture. Thus, there is a high degree of variability among farmers in terms of their use of supplemental feeds to minimise the production costs. A variety of feeds is used for Pangas farming including supplementary diets, farm-made feeds and industrially produced pellet feeds.

With the intensification of Pangas farming, commercially produced pellet feed have been made available to augment production. In recent years, several small to medium sized feed industries have been established. There are about 100 feed mills producing aquaculture and poultry feeds. All aquaculture feed industries produce Pangas feed and others. However, maintaining feed quality remains problematic, and

in many instances, poor feed quality results in low production. Furthermore, feed ingredient prices have risen dramatically in recent years. While the main causes influencing these rapid price increases are not well understood, it has been suggested that the limited supplies combined with a high demand within the country is driving higher prices.

Farm-made feed producers mainly use hauler machines. The peak season of farm-made feed production is from April to September during the peak season of Pangas farming. All produced farm-made feed are used for local Pangas culture, not for commercial marketing. A variety of ingredients are used in the production of farm-made feeds. In general, farmers use a mixture of rice bran, rice polish, mustard oilcake, sesame oilcake, soybean meal, fishmeal, maize, oyster shell, lime, salt and vitamins. However, nutritional values of these feed ingredients vary considerably.

In addition to feed, farmers also depend on natural productivity of ponds for feeding of carp with Pangas through the application of fertilisers, such as cow dung, urea, murate of potash and TSP. It has further been reported that farmers are often induced to use various feed supplements, such as hormones, enzymes, growth promoters, antibiotics and other substances which are not certified by the relevant authorities, and that their use does not fall within defined quality standards. To prevent the adulteration of the feed products, and to ensure the quality of feed, the Government of Bangladesh has introduced the Fish and Animal Food Act, 2011. To date, it is not apparent how far this act is being implemented. It is therefore a critical need to assess the implementation of the new legislation, and the extent to which feed additives are used in aquaculture, and to determine their efficacy in terms of improving production. There is also a need to build capacity to enable famers to assess the quality of their feeds and feed additives.

4.4.4 Marketing Systems

The marketing channel of Pangas from farmers to consumers intertwine primary, wholesale, and retail markets, involving local agents, suppliers, wholesalers, and retailers from whom consumers mostly purchases. From the intensive farming system, 100% Pangas is directly goes to the *arots.* In case of semi-intensive farmers, 90% is sold directly to the *arotdars* and 10% by *foria.* However, in case of extensive system, all Pangas are sold via *foria* to *arotdars.* Overall the intensive and semi-intensive to a greater extent sold their produces directly to the *arotdars.* This possibly makes relative differences between the profit margin of intensive and extensive farmers. In all the cases, Pangas is marketed in live condition from farm to market transporting in water filled plastic drums to get the original live weight in the market place for ensuring higher profit margin. This contributes to food safety for the consumers because live fish has very little food hazards in terms of microbial contamination (Haque, 2012).

The *arotdar* is the main focal point that unites all the supply from various channels of Pangas originated from the farmers. The traded volume and number of actors involved in the forward market is higher in rural market compared to urban market. A significant number of retailers are involved in the rural and urban markets for Pangas as well as other fish trading. This indicates that Pangas is not only contributing to the food security, also providing livelihood opportunities.

4.4.5 Margin & Value Addition:

A total of BDT 35 value added to Pungas from farm gate to the retailers. The highest value addition (34%) is done by the Paikers, while second place is taken by the farmers (30%) and retailers (30%). Since Pungas has the bigger market in the rural areas so, there is lesser scope for value addition / price increase in the retailing stage. At the same time, Paikers are key actors in delivering the products to a larger perimeter, which gives them the leverage of increasing the price as per their costing. Arots, generally acting as a commissioning agent has the lowest value addition (6%), as the bargaining between the Arotdars and Paikers are mostly dominated by the Paikers.

	Farmer	Arot	Paikar	Retailer
Price	80	83	100	115
Marketing Cost	3	1	8	5
Value Addition	15	3	17	15
Value Addition %	30.0	6.0	34.0	30.0

Source: Primary Study (2013)

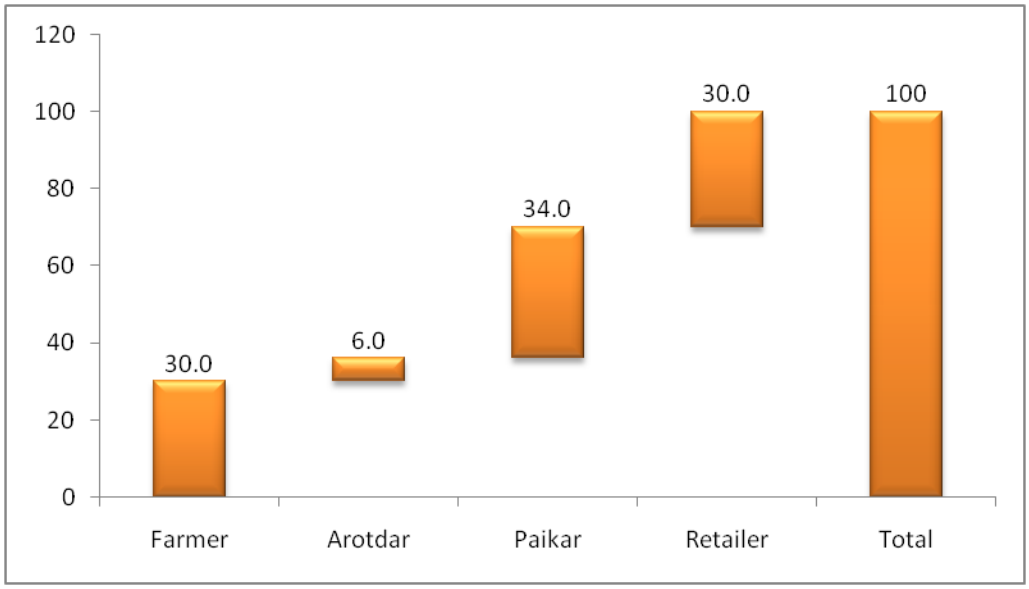

Figure 12: Value Addition in Different Stages of Production and Distribution

5. Koi Farming

Koi (*Anabas testudineus*) is a prominent indigenous freshwater fish species in Bangladesh which is also known as 'Climbing Perch'. Koi was once abundantly found in the canals, rice fields, small rivers, wetlands and floodplains in Bangladesh. Because of decrease the availability of wild koi, commercial koi culture in pond has become popular in Bangladesh. Different strains of this species are widely distributed in Bangladesh, India, Myanmar, Nepal, Sri Lanka and Thailand (Talwar and Jhingran, 1991). A number of fish species has become a popular culture species in the Asian countries due to trans-boundary movement and similar environmental conditions (Rahman, 2005). The current culture species of koi was first introduced to Bangladesh from Thailand in 2002 (BFRI, 2006) and henceforth referred to as Thai koi which is recognised as a strain of *A. Testudineus*. Thai koi has a number of positive culture attributes due to its faster growth rate, bigger size, resist poor environmental condition, high market demand, taste, nutritional value and high market price (Hasan et al., 2007). Compare to other aquaculture species in Bangladesh, koi is relatively new. Koi culture has become popular in Bangladesh since the development of induced breeding and mass seed production.

5.1 Production Analysis

5.1.1 Division Wise Production

According to the DoF, koi production in pond of Bangladesh was estimated at 13,406 tonnes in 2010-11 which was 1.1% of total pond production (FRSS, 2012). Nevertheless, considerable variation in production data between DoFs and Extension Department was found. According to the Extension Department (2012), the total annual koi production in Bangladesh was estimated at 22,989 tonnes in 2010-11. According to discussion with key informants and back calculation, data from Extension Department can be accepted. Over the last three years, total koi production in Bangladesh has been increased from 15,449 tonnes in 2008-09 to 22,989 tonnes in 2010-11 (Table 34). In 2010-11, the highest koi production was found in Dhaka division (15,593 tonnes), followed by Chittagong (5,055 tonnes). The lowest koi production in 2010-11 was found in Rangpur (188 tonnes) in 201-11, followed by Sylhet (467 tonnes), Rajshahi (476 tonnes), Khulna (569 tonnes) and Barisal division (641 tonnes).

Table 19: Division wise koi production in Bangladesh over the last three years

Division	Production (tonnes/ha)				
	2008-09	2009-10	Annual growth rate (%)	2010-11	Annual growth rate (%)
Dhaka	10,820	15,904	47	15,593	-2
Chittagong	3,129	4,570	46	5,055	11
Khulna	162	156	-4	569	266
Rajshahi	311	353	13	476	35
Sylhet	488	342	-30	467	37
Barisal	399	503	26	641	27
Rangpur	140	161	15	188	17
Total	15,449	21,989	42	22,989	5

Source: Extension Data (2012)

Table 18 shows that the average annual growth rate of koi production in Bangladesh was 5% in 2010-11. The highest growth rate in 2010-11 was found in Khulna division (266%) while negative growth rate was estimated in Dhaka division (-2%) due to reduced culture area as a result of switching from koi to other fish culture. Nevertheless, most key informants reported that koi production in Bangladesh will be continued at a rate of 10% per annum over the next five years if Vietnamese koi gets success. Over the last few years, farmers were facing the problem of in-breeding of Koi which resulted under-sized production. Eventually farmers started to make loss from production of Thai Koi. In 2010, Vietnamese Koi was imported with the assistance of Katalyst and Innovision. This Koi has the potential to grow over 300 gram within four months of culture. Farmers are now eagerly waiting for the fry of Vietnamese koi which are now available in market. According to the DoF officials, the demand for this fry is now over 10 crore which two-third of total demand for Koi fry in Bangladesh. Considering all above mentioned issue, Koi production is estimated as stagnant for the 2011-12 which is likely to increase steadily over next five years depending on the potential success of Vietnamese Koi. However, some Key informants are still suspicious about the immense success of this Koi as consumer may not like it. However, with the overwhelming assumption and impact on production, it can be projected that the total production of koi will be reached at around 37,400 tonnes in 2016-17.

Table 20: Estimated production of Koi over the next five years

Year	Production (t)	% of growth
2011-12	22,989	5 (from Table 5)
2012-13	25,288	10
2013-14	27,817	10
2014-15	30,599	10
2015-16	34,000	10
2016-17	37,400	10

Source: Primary Study and Key informant interview 2013

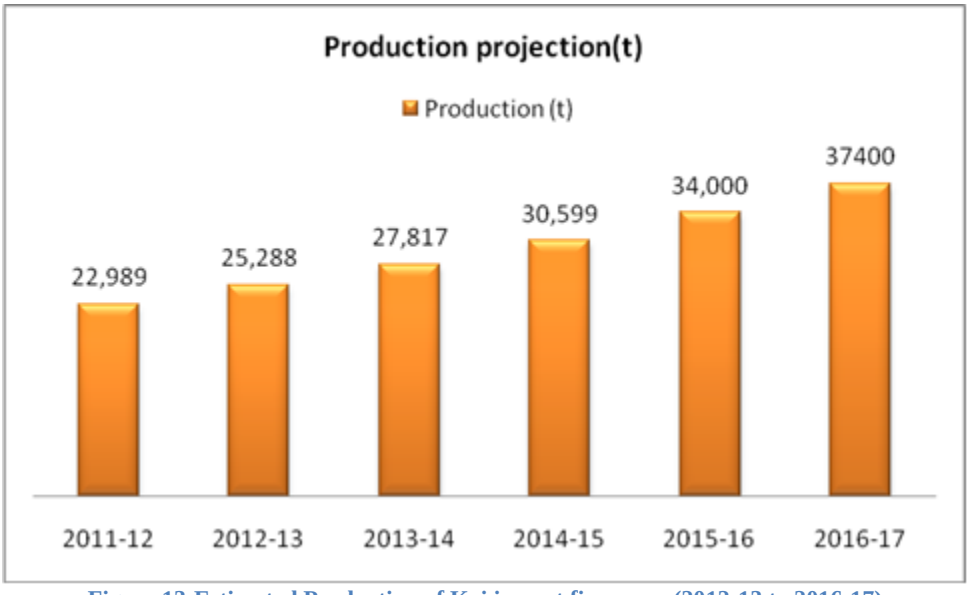

Figure 13:Estimated Production of Koi in next five years (2012-13 to 2016-17)

5.1.2 Productivity

The average productivity of koi per hectare farm in Bangladesh is low due to polyculture with other fish which is not considered. The average productivity of koi in Bangladesh was estimated at 1.56 tonnes/ha in 2010-11 (Table 36). In spite of increased culture area and total production of koi, the average productivity of koi slightly increased from 2.07 tonnes/ha in 2008-09 to 2.59 tonnes/ha in 2009-10, and then decreased to 1.56 tonnes/ha in 2010-11. As most koi are produced under polyculture in extensive and semi-intensive farming systems, thus the average productivity of koi is variable. Nevertheless, the rate of other fish productivity with koi under polyculture seems to be increased considerably. In 2010-11, the highest average koi productivity was found in Dhaka division (7.46 tonnes/ha), followed by Sylhet (3.34 tonnes/ha), Chittagong (1.89 tonnes/ha) and Rajshahi division (1.49 tonnes/ha). The lowest koi productivity in 2010-11 was found in Khulna (0.08 tonnes/ha), followed by Rangpur (0.25 tonnes/ha) and Barisal division (0.40 tonnes/ha). In spite of the highest koi producing area in Khulana division, the productivity rate was the lowest in 2010-11 due to extensive polyculture with other fish species.

Table 21: Productivity of koi per hectare farm over the last three years

Division	2008-09			2009-10			2010-11		
	Area (ha)	Yield (t)	Yield rate (t/ha)	Area (ha)	Yield (t)	Yield rate (t/ha)	Area (ha)	Yield (t)	Yield rate (t/ha)
Dhaka	1,557	10,820	6.95	2,306	15,904	6.90	2,089	15,593	7.46
Chittagong	2,400	3,129	1.30	2,637	4,570	1.73	2,674	5,055	1.89
Khulna	945	162	0.17	950	156	0.16	7,115	569	0.08
Rajshahi	179	311	1.74	202	353	1.75	319	476	1.49
Sylhet	141	488	3.47	119	342	2.88	140	467	3.34
Barisal	1,510	399	0.26	1,551	503	0.32	1,602	641	0.40
Rangpur	722	140	0.19	734	161	0.22	761	188	0.25
Total	7,454	15,449	2.07	8,499	21,989	2.59	14,700	22,989	1.56

Source: Extension Data (2012)

The productivity rate per hectare farm of koi is considerably variable among different divisions in Bangladesh. Most key informants reported that the productivity rate of koi varies due to culture intensity and other species composition under polyculture. Nevertheless, koi is becoming popular among farmers and consumers. It is therefore expected that the production rate per hectare will increase over the next few years. According to the Primary Study, following districts are found as the major producers of Koi in Bangladesh:

Table 22: Major Producers of Koi in Bangladesh

Dhaka Division	Chittagong Division	Khulna Division	Rajshahi Division
Mymensingh	Comillla	Jessore	Bogra
Netrokona			
Narsingdhi			

Source: Primary Study (2013)

5.2 Culture Area and Farming Practices

5.2.1 Culture Area

The culture of koi has been practiced in recent years in Bangladesh. Total koi culture area in the country has been increased from 7,454 ha in 2008-09 to 14,700 ha in 2010-11 (Table 29). Over the last three years, the culture area of koi has been increased twice. In 2010-11, the highest koi producing area was found in Khulna division (7,115 ha), followed by Chittagong (2,674 ha), Dhaka (2,089 ha) and Barisal division (1,602 ha). In Khulna division, the culture area of koi has been significantly increased from 950 ha in 2009-10 to 7,115 ha in 2010-11. In 2010-11, the lowest tilapia producing area was found in Sylhet division (140 ha), followed by Rajshahi (319 ha) and Rangpur division (761 ha).

Table 23: Division wise koi culture area in Bangladesh over the last three years

Division	Culture area (ha)				
	2008-09	2009-10	Annual expansion rate (%)	2010-11	Annual expansion rate (%)
Dhaka	1,557	2,306	48	2,089	- 9
Chittagong	2,400	2,637	10	2,674	1
Khulna	945	950	0.48	7,115	649
Rajshahi	179	202	13	319	58
Sylhet	141	119	-15	140	18
Barisal	1,510	1,551	3	1,602	3
Rangpur	722	734	2	761	4
Total	7,454	8,499	14	14,700	73

Source: Extension Data (2012)

Koi has been producing in a number of districts across the country, including Mymensingh, Comilla, Bogra and Chittagong. The average annual expansion rate of koi culture area in Bangladesh was estimated at 73% in 2010-11. However, it may not continue over the next few years. According to key informants, the expansion of koi culture area in Bangladesh will be continued at a rate of 10% per annum over the next five years, if Vietnamese koi will be successfully introduced in Bangladesh. It is therefore projected that the total koi culture area in Bangladesh will be reached at around 26,400 ha in 2016-17.

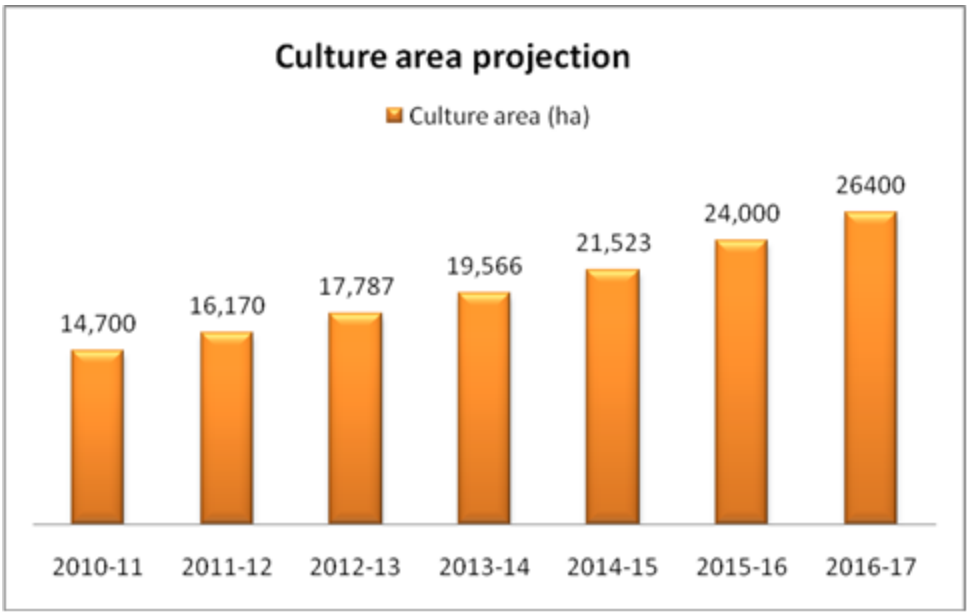

Figure 14: Projection of koi culture area over the next five years

5.2.2 Culture Practices

The main culture season for koi is from April to November. Farmers stock their ponds from as early as April/May and harvest koi after four months intervals. Due to scarcity of water and unavailability of fry, most farmers do not culture fish during the dry season from December to February, unless ponds are perennial. Koi culture is fully dependent on hatchery produced fry with commercial pellet feed. Koi culture is classified as: (1) polyculture and (2) monoculture. The productivity of koi in monoculture is often higher than polyculture due to intensive farming.

Based on the level of inputs koi culture can be further classified as: (1) extensive or improved-extensive, (2) semi-intensive and (3) intensive. Extensive farming of koi typically use slightly modified versions of traditional methods and uses low stocking density and low-inputs of feed, fertiliser and labour. Semi-intensive operations practice intermediate levels of stocking and other inputs. The intensive production system is characterised by relatively high stocking and high level of inputs.

5.2.3 Area under different Culture Practices

According to field survey and discussion with key informants, most farmers (60%) produce koi under polyculture while the remainder (40%) practice monoculture. Farmers practise koi farming with stinging catfish (*shing*), walking catfish (*magur*), tilapia and carp under polyculture. In general, progressive farmers follow specific ratio of different fish species for polyculture, depends on natural productivity of pond, availability of fry, financial ability for inputs and management practices. In recent years, however, an increasing number of better-off farmers and entrepreneurs produce koi as a monoculture under semi-intensive or intensive systems. In extensive farming systems one annual crop is common whereas two or three crops may be grown in semi-intensive and intensive farming systems. According to field survey and discussion with key informants, 10% of farmers are involved in extensive/improved-extensive farming, while 60% and 30% practice semi-extensive and intensive farming, respectively.

Table 24: Involvement of farmers for tilapia culture in different farming systems

Farming intensity	Farmer involve (%)	Farm size (ha)	Stocking density (fry/ha/yr)	Feeding rate (kg/ha/yr)	FCR[1]	Labour involve[2] (man-day/ha/yr)
Extensive farming	10	0.2–0.40	15000–20000	2000–3500	1.9–2.4	120–160
Semi-intensive farming	50	0.41–0.80	20000–26000	3500–6500	1.5–1.8	160–220
Intensive farming	30	0.81–1.50	26000–35000	6500–9500	1.2–1.4	220–280

Source: Field survey (2013)

[1] FCR is the net amount (kg) of feed used to produce one kg of fish.

The source of human labour are: (1) family labour for which no payment is made, and (2) hired labour for which farmers have to pay in cash. A man-day is considered to be 8 hours of work.

According to discussion with key informants, farm size in extensive farming is usually less than 0.4 ha while the range of farm size in semi-intensive farming is 0.41-0.8 ha (Table 31). Nevertheless, the farm size in intensive farming was reported by key informants to be above 0.8 ha. Considerable variations are found between the size of farms and the farming systems. There is a positive relationship between farm size and labour productivity, and therefore income. Although aquaculture in Bangladesh is usually characterised by small farms, comparatively koi farmers are larger than tilapia farmers. Nevertheless, average farm size indicates that most koi farmers are small-scale.

Comparatively, extensive farmers typically use low inputs of seed, feed, fertiliser and labour. Semi-intensive farmers use intermediate levels of inputs, while intensive farmers use high level of inputs. In general, extensive farmers mainly use supplementary diet consisting of a mixture of locally available feed ingredients and/or farm by-products such as rice bran, wheat bran, oil cake and fish meal. In contrast, farm-made feeds and industrially manufactured pellet feeds are used by farmers in semi-intensive and intensive farming. According to key informants, the range of FCR in extensive farming is 1.9-2.4 while FCR in semi-intensive and intensive farming are 1.5-1.8 and 1.2-1.4, respectively. FCR mainly depends on a number of factors, including the quality and quantity of feed, protein level, types of feed whether sinking or floating, stocking density, water quality and other aspects of farm management.

5.2.4 Number of Farmers

The accurate number of koi farmers in Bangladesh has not yet been estimated. Nevertheless, as the total koi culture area and range of koi farm size in Bangladesh are known, it is therefore calculated that around 23,000 farmers are involved in koi production. This figure shows that the number of estimated koi farmers is around 1% of the total fish farmers in Bangladesh. It is noted that a total of 3.08 million fish farmers are involved in freshwater aquaculture (DoF, 2012). The percent of koi farmers (1% of total farmers) is similar to the contribution of koi production against total fish production in Bangladesh (1% of total production). According to key informants and discussion with relevant stakeholders, around 1-2% of fish farmers are involved in koi culture. It seems that our estimated number of koi farmers is

acceptable. However, it is suggested that further assessment would be carried out in order to get accurate data about the number of koi farmers in Bangladesh.

Table 25: The estimation of koi farmers by culture practice in 2011-12

Particular	Extensive	Semi-intensive	Intensive
Total culture area in Bangladesh (ha)[1]	14,700		
Culture area by farming system (%)	10%	60%	30%
Culture area by farming system (ha)	1470	7,350	4410
Average culture area by a farmer (ha)	0.30	0.55	0.90
Number of farmers by culture system[2]	4900	13,364	4900
Total farmers	23164 ≈ 23,000		

1Source: Extension Department (2012)

[2]The number of farmers = culture area by farming system (ha)/ average culture area by a farmer (ha)

Due to the similarity of expansion rate of culture area, the number of koi farmers would increase 10% per annum over the next five years. According to key informants, the number of farmers will increase 10% per annum over the next five years, if Vietnamese koi is introduced in Bangladesh. It is therefore projected that the number of koi farmers would be around 37,400 in 2016-17 (Table 33). Recent field assessment also suggests that there is a bright future of koi culture due to high market demand.

Table 26: Projection of the number of Koi farmers over the next five years

Year	Number of farmers	% of increase
2011-12	23,164	-
2012-13	25,880	10
2013-14	28,028	10
2014-15	30,830	10
2015-16	34,000	10
2016-17	37,400	10

Source: Primary Study 2013 and Key Informant Interview

5.2.5 Cost-Benefit Structure of Different Culture Practices

According to the field survey and interviews with key informants, the average annual variable costs of koi farming in extensive system were estimated at Tk 95,000 per ha, compared with Tk 199,000 per ha in semi-intensive and Tk 295,000 per ha in intensive farming (Table 37). There was a considerable difference of variable costs in different farming categories. Variable costs on average accounted to 83% of total costs in extensive farming, compared with 90% in semi-intensive and 92% in intensive farming. The average annual fixed costs of koi farming varied from Tk 19,000 per ha in extensive farming to Tk 23,000 per ha in semi-intensive and Tk 27,000 per ha in intensive farming. Fixed costs varied from 17% of total costs in extensive farming to 10% in semi-intensive and 8% in intensive farming.

Table 37 shows that the average annual total costs of koi farming varied from Tk 114,000 per ha in extensive farming to Tk 222,000 per ha in semi-intensive and Tk 322,000 per ha in intensive farming. It was found that the costs of production in all items were higher for intensive farms, compared with semi-

intensive and extensive farms. Among production costs, feed dominated all other costs representing about 48% of total costs in extensive farming, compared with 56% in semi-intensive and 57% in intensive farming. According to key informants, production costs has increased notably over recent years due to increasing cost of inputs, especially feed.

Table 27: Production cost and return for koi farming by culture intensity in 2012

Cost and return item	Cost and return in farming system (Tk/ha/yr)		
	Extensive	Semi-intensive	Intensive
Variable cost (VC)			
Seed	8,000	15,000	22,000
Feed	55,000	125,000	185,000
Fertiliser	4,000	8,000	12,000
Labour (family[1] and hired)	22,000	40,000	60,000
Harvesting and marketing	3,000	6,000	10,000
Miscellaneous	3,000	5,000	6,000
Sub-total	95,000	199,000	295,000
Fixed cost (FC)			
Depreciation[2]	4,000	5,000	6,000
Interest on operating capital/loan	10,000	13,000	16,000
Land use cost or lease	5,000	5,000	5,000
Sub-total	19,000	23,000	27,00
Total cost (TC = VC + FC)	114,000	222,000	322,000
Average productivity (kg/ha/yr) (P)[3]	1,600	3,700	6,000
Average farm-gate price (Tk/kg) (FP)	105	105	105
Gross revenue (GR = P x FP)	168,000	388,500	630,000
Net return (NR = GR - TC)	54,000	166,500	308,000
Benefit-cost ratio (BCR = GR/TC)	1.47	1.75	1.96

Source: Key informants interviews and discussion with farmers (2013)

[1]To determine the cost of unpaid family labour the opportunity cost principle was adopted. The opportunity cost of human labour is its value in its best alternative use.

Depreciation costs of water pump, net, feed machine, etc are calculated as: [(purchase price – salvage value)/economic life].

[3] The productivity of koi in extensive and semi-intensive farming is also associated with other fish under polyculture, thus the actual productivity is higher than these figures. Nevertheless, intensive farmers are usually involved in monoculture.

The average annual gross revenue from koi production varied from Tk 168,000 per ha in extensive farming to Tk 388,500 per ha in semi-intensive and Tk 630,000 per ha in intensive farming (Table 37). There is a considerable variation of gross revenue in different farming systems, because of the different levels of production. Despite higher production costs, the average annual net return was higher in intensive farming at Tk 308,000 per ha, compared with Tk 166,500 per ha in semi-intensive and Tk 54,000 per ha in extensive farming. Almost all interviewed farmers stated that their returns have decreased as costs of koi farming have increased significantly while the market price of koi has decreased.

The benefit-cost ratio (BCR) is higher in intensive farming at 1.96, compared with 1.75 in semi-intensive and 1.47 in extensive farming (Table 37). The findings indicate that the extensive farms are able to recover Tk 1.47 per Tk 1 of investment while semi-intensive and intensive farms generate a return of Tk 1.75 and Tk 1.96, respectively.

5.3 Value Chain Analysis

5.3.1 Koi Value Chain

The koi value chain has some significant division in the forward market level. The chain has substantial volume of trade and consumption in different two branches: (1) urban and (2) rural. The rest of the backward chain is pretty similar generic fish value chains. One significant structure of the koi value chain is the absence of any fry trader/*foria* in the chain. There is usually negligible or no significant presence is noticed of these two actors. The popular practice is that farmers collect fry directly from the hatchery and trades directly to the arots.

In koi production, distribution and marketing, a number of actors involve in value chain those are playing key roles in different aspects of value addition. Value chain tends to be extended with a whole range of activities within each link and links between different value chains. The value chain of koi describes the full range of activities which are required to bring a product or service from conception, through the different phases of production, delivery to final consumers.

Table 28: Different actors with their functions and role of koi production and marketing

Actors	Functions	Roles
Brood suppliers	Brood rear and supply	Rear brood in ponds and sell to the hatcheries. Total number is undefined.
Hatchery operators	Brood collection and hatching	Some hatcheries collect brood from abroad; hatching eggs from broods and selling fry to nurseries and fry traders. Total number of hatchery is 300.
Input suppliers	Feed and aqua-chemical selling	Selling ready or local feed, also selling aqua-chemicals: Zeolite, Lime etc. Total number of input supplier is around 6000 supplying a total of 50,000 MT of feed.
Farmers	Grow-out	Buy koi fry and stocking up to marketable size, sell to arots.
Arotdars	Trading	Mainly commissioning agents; collecting koi from the farmers and trades to both urban and rural paikers; take 2-3% commission from the selling price. Total number is around 261.

Rural paikers	Trading	Buy fish from arots and trade to the rural retail markets. Total number is around 130.
Urban paikers	Trading	Buy fish from both; trade directly to the urban retailers. Total number is around 685.
Rural retailer	Retailing	Collect Pangas from different rural paikers and sell to the rural consumers. Total number is around 2000.
Urban retailer	Retailing	Collect Pangas from different urban paikers and sell to the urban consumers. Total number is around 3400.
Rural consumer	Consumption	Consumers located mostly in the rural areas.
Urban consumer	Consumption	Consumers located mostly in the district headquarters and megacities.

Degree of vertical and horizontal integration is mostly present within the input supply and production level of the value chain. A moderate number of input retailers vertically integrate with koi farming. Another vertical integration is performed by the hatcheries that either rear their own brood or acquire brood from abroad.

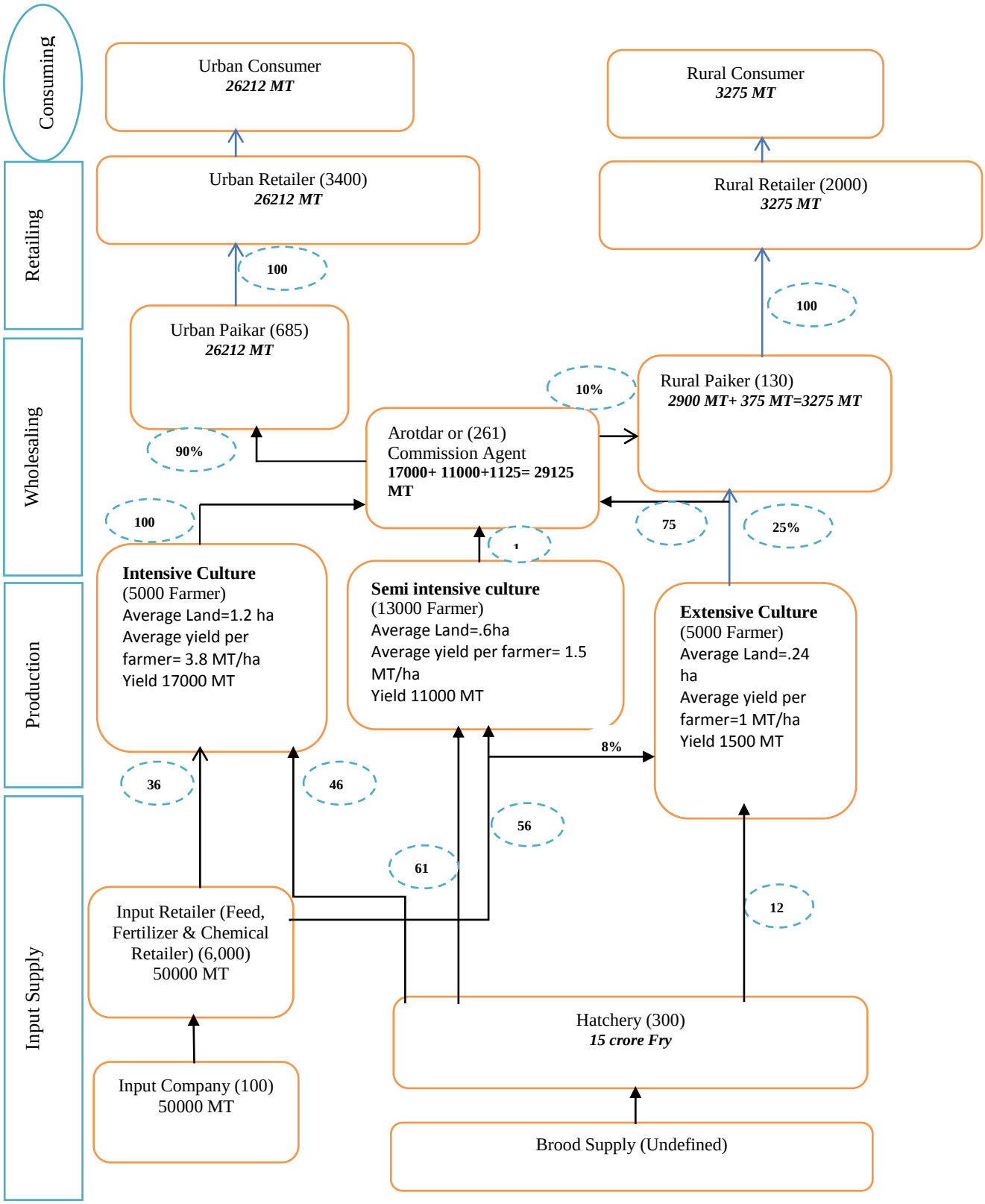

Figure 15: Koi Value Chain

5.3.3 Hatchery Operation

Private hatcheries now dominate the seed supply and at present there is an adequate koi seed supply from around 300 hatcheries. According to field survey, around 15 crore koi fry were produced in 2011-12. In hatcheries, the quality of brood has declined year after year because of inbreeding. Farmers reported that other than self-initiative, the last imported brood from abroad was in almost 5-6 years ago. From then, broods are reared indiscriminately and caused inbreeding complex. This has resulted lower quality of fry. These fry have lower growth rate and higher mortality rate. Low quality fry and poor quality feed has together resulted higher production cost for the farmers. Farmers became demotivated to culture Koi. Price of Koi varies significantly with size. Larger size has higher market price. Farmers are incurring loss due to the small size of Thai Koi. However, this Katalyst and Innovision helped some hatcheries to introduce Vietnamese Koi. This Koi has potential to grow 300 gram above. Success of this Koi may change the history of Koi culture in Bangladesh.

5.3.4 Feed Management

Feed is one of the most important inputs to increase koi production. A major controlling factor of growth for koi is feed intake. A variety of feeds is used for koi farming including supplementary diets, farm-made feeds and industrially produced pellet feeds. Supplementary feeds are a mixture of rice bran, wheat bran, oil cake and fish meal. However, a variety of ingredients are used in the production of farm-made feeds. In general, farmers use a mixture of rice bran, rice polish, mustard oilcake, sesame oilcake, soybean meal, fishmeal, maize, oyster shell, lime, salt and vitamins. However, nutritional values of these feed ingredients vary considerably. Farm-made feed producers mainly use hauler machines. With the intensification of koi farming, commercially produced pellet feed have been made available to augment production. In recent years, several small to medium sized feed industries have been established. There are about 100 feed mills producing aquaculture and poultry feeds. However, primary study estimated that only 50,000 MT of feed are produced for the Koi for farming which is around 5% of the total production of feed in Bangladesh (Source: Key informant of Feed Industry). Market price of per KG feed has a wide range of BDT 25-50 depending on the brands (Source: Primary Study).

5.4 Market Analysis

5.4.1 Koi Consumption

Koi is becoming popular among consumers because of taste. With increasing popularity among consumers, koi has become one of the most important food fish in Bangladesh. Koi is becoming popular among all groups of people. The consumption of koi at household level has been increasing. According to field visits and discussion with key informants, major koi consuming cities are Dhaka, Chittagong, Khulna, Rajshahi, Barisal, Sylhet and Rangpur – all divisional towns. Koi has great potential in terms of food supply and nutritional benefit. If koi can produce widely, the supply of koi in Bangladesh would have a favourable impact on food security to meet the growing demand for fish among consumers.

According to field survey, the demand for koi in city or town markets is evidently higher than rural and urban markets. The consumers of city and urban markets have higher purchasing power and there is an

increasing trend in fish consumption. On the other hand, the demand for koi and consumption level in rural and urban areas is lower due to low purchasing power and slow growth of income.

5.4.2 Demand-Supply:

As this study heavily dependent on the outcome of the introduction of Vietnamese Koi in Bangladesh, future demand supply of Koi is related to the acceptance of this Koi by the consumer. Most of the Key informants believe that this Koi will be widely accepted by consumer as it looks more similar to the indigenous Koi. It may be more demanded Koi in near future. However, some other Key informants believe that unusual size of Vietnamese Koi may fail to draw the attention of the consumers like African *Magur.* It can be said that the acceptance of the consumer will play a key role in determining the future demand-supply scenario of the Koi.

Another important factor is the price of Koi which reduced dramatically due to the culture of Koi in last five years. During the primary study Farmers reported that they got a high price (BDT 500) for the Koi which is now BDT 100 at farm gate. Koi was a niche market due to the high price earlier eventually became a common fish for all income group people for low price. As a low market price fish, Koi will play an important role in future demand supply of fish.

5.4.3 Marketing Systems

In Bangladesh, the koi market is small in terms of volume, value and employment. The koi marketing plays a vital role in connecting the farmers and consumers, thus contributing significantly in the value adding process. Koi marketing is almost entirely managed, financed and controlled by a group of intermediaries. The market chain of koi from farmers to consumers encompasses mainly primary, secondary and retail markets, involving local agents, suppliers, wholesalers and retailers. Communication between the suppliers and wholesalers is generally good and takes place by mobile phones. Suppliers are a form of intermediary traders who supply tilapia from primary markets to wholesale markets. In general, suppliers are tied to a limited number of wholesalers. Suppliers commonly use trucks, buses, pickups and taxis to transport tilapia to the wholesale markets. In general, koi is traded fresh and often live. Transport services are arranged most of the times by the buyers/paikers that bear the cost. Both the services were reported to be available.

As soon as the suppliers land koi in the wholesale market, the wholesalers take care of landing, handling and auctioning. Normally, the auction sale is made by heaps. In general, wholesalers follow the incremental price system. It is the most competitive form of auctioning and ensures better prices. Auctioneers appointed by wholesalers, call out the bid loudly in the presence of the buyers. Auctioneers get commission at different rates of the sale proceeds for their services and costs involved. The retailers are also linked to a limited number of wholesalers. The relationship between the retailers and wholesalers is generally good. Two main categories of fish retailers have been encountered: market-based retailers and itinerant retailers (fish vendors, hawkers, etc). Retail sales are made at stalls in fish markets and door-to-door to household customers. Koi are traded whole, un-gutted and fresh without processing.

Koi has particular demand in household consumption. Largest koi consumer is the major divisional cities. Also, due to the availability of koi it is also becoming popular among the rural consumers. Although

market demand for koi is generally strong and driven by population growth, there is a growing gap between available supplies and market demands. Koi production as well as supply is not enough in order to fulfil the market demands. So there is scope for more horizontal expansion. Koi has higher market price than tilapia and Pangas. The retail price trend of koi is decreasing over the last few years. However, recent introduction of Vietnamese koi, which is much larger in size, is expected to bring price boom in the retail market.

5.4.6 Margin and Value Addition:

A total of BDT 70 value added to Koi from farm gate to the retailers. The highest value addition (44%) is done by the Farmers, while second & third place is taken by the Ratailers (28%) and Paikers (25%) respectively. Since Koi has the bigger market in the urban areas so, there is more scope for value addition / price increase in the retailing stage. At the same time, Paikers are key actors in delivering the products to a larger perimeter, which gives them the leverage of increasing the price as per their costing. Arots, generally acting as a commissioning agent has the lowest value addition (2.5%), as the bargaining between the Arotdars and Paikers are mostly dominated by the Paikers.

	Farmer	Arot	Paikar	Retailer
Price	105	108	140	175
Marketing Cost	3	1	15	10
Value Addition	56.4	3	32	35
Value Addition %	44.6	2.4	25.3	27.7

Source: Primary Study (2013)

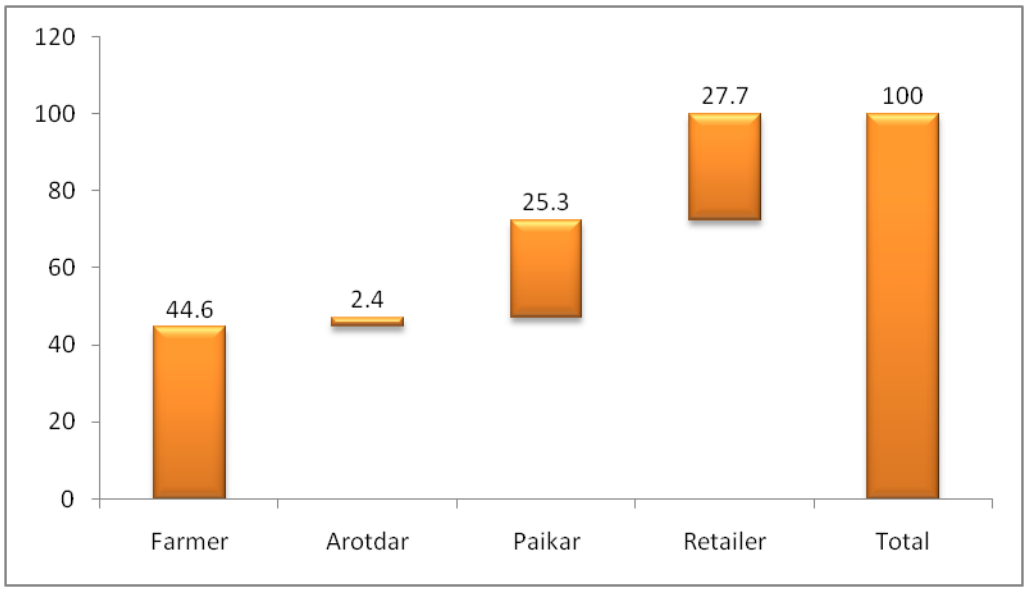

Figure 16: Margin & Value addition in different stages of production and trading

6. Gender

Women in Bangladesh showed numerous examples of being competent in adopting aquaculture technologies, despite the fact that their contribution and skills in fish culture were not adequately recognized and remained poorly addressed. The partaking of women in different aspects of household activities as well as aquaculture practices is strongly affected by social, cultural and religious norms such as seclusion, isolation and the veiling of women in public. These restrictions and the gender division of labor created the custom of a segregated and restricted role for women, and forced women's mobility and participation in the activities related to aquaculture. The present study revealed the similar situation, where female involvement in the culture practices of Tilapia, Pangus and Koi was limited.

However, the traditional scenario of rural women in small-scale aquaculture development is gaining a rapid change in Bangladesh as a large number of women are now getting involved in various aspects of aquaculture activities, including stocking of ponds, feeding of fish, pond management, fertilisation, liming, fish harvesting and marketing (Table 29). Though women are not effectively engaged in production, they play a key role in applying feed to fish. It is usually the responsibility of the women as the male family members are engaged in different types of economic activities outside the house. Interestingly, a few women in the study were observed engaging themselves in the operation of Tilapia hatcheries. Their roles ranged from brood rearing and feeding to hormone treatment and hatching of fries.

In the field survey, it was found that around one fourth of the farmers engage their female family members in cultivation. However, most of the women who are engaged in fish farming are not paid for their work since it is regarded as a household work.

Table 29: Women involvement in various aquaculture activities in Bangladesh

Activity	Household members (% participation)			
	Women	Men	Girls	Boys
Pond excavation	4	80	-	16
Pond preparation	6	78	-	16
Applying manure	25	53	9	13
Fish selection	15	83	-	13
Stocking	17	71	1	11
Feeding	31	39	12	18
Harvesting	8	59	8	25
Sale/ marketing	4	71	-	25

Source: Belton et al. (2011)

According to key informants, fish farming activities of women at village level have enhanced their position in families and societies. Their fish-related cash income has given them some economic independence. Income from fish production offers to engage women in poultry farming, livestock rearing and homestead gardening to supplement their income. They now tend to play a stronger role in economic decisions for the management of their households, including those concerning education of children, attending social functions, inviting guests, accepting family planning methods, attending

religious functions, and advising sons and daughters on selection of spouses. The role of women in small-scale aquaculture related activities is potentially very important for their empowerment (Shirajee et al., 2010). The participation of women in aquaculture has increased rural women's mobility and access to markets. They can also get access to better health services, recreational opportunities and financial services. Women's growing participation in aquaculture has been a significant indicator of increased empowerment at the household level as well as society.

Primary study also observed that there is a strong social issue which affect women involvement in aquaculture. In Greater Chittagong women has little opportunity to be involved in aquaculture activities due to the social barrier to work in ponds. At the same time, south-west region has more involvement of women mainly in the areas where religious view plays an important role. In some areas of Jessore, Narail, Khulna and Bagerhat women work in the *ghers* and ponds who are mainly Hindu by religion.

7. Labour

Aquaculture offers diverse livelihood opportunities for the poor in Bangladesh. A range of associated groups, such as fish farmers, hatchery operators, fry traders, feed producers, fish harvesters and traders have been benefited from the involvement of labourers in aquaculture. Labourers are also required in different stages in culture and marketing of Tilapia, Pangus and Koi such as fry trading, feed and aqua-chemical supply, transport, processing and trading.

Manual labourers are mainly involved in fish culture with a wide range of activities like pond preparation or excavation, feeding, liming and fertilization, cleaning of water and banks, harvesting, marketing and supervisory role in managing other labourers. In hatcheries, labourers carry out brood rearing, hormone treatment, water treatment, feed formulation and hatching from egg under the technical supervision. They also contribute to sorting, acclimatization, oxygenation, packaging and transport of fish seeds accordingly.

The production, supply and transport of fish feed as well as aqua-chemical generated a number of employment opportunities for the manual laborers. A growing labor pool was also observed for fish distribution and marketing systems, employed by local agents, suppliers, transporters, wholesalers and retailers. Numerous laborers work in fish markets to perform post-landing tasks that include cleaning, sorting, grading and icing of fish. They also work to carry ice from the ice factories, break it up, mix ice with fish and upload the fish produces into the vehicles.

Most of the surveyed laborers were found having no formal education or at best, secondary school education only. Their skills and performances were found limited due to lack of adequate formal training or orientation in aquaculture practices. Most of them became proficient by repeated practice under the guidance of employer or superior technical resources within the current working area.

A good number of laborers work monthly basis while the others get paid daily. The monthly services usually refer to permanent jobs, whether, the temporary jobs are commonly offered by a daily-basis payment. A laborer involved in fish culture, processing or marketing gets a monthly salary ranging from BDT 3500 to BDT 6000. A major portion of this labor pool also gets the benefit of temporary accommodation and/ or daily meal beyond the monthly payment. Neither the medical facility nor the

overtime payment is offered for these laborers. On the other hand, each of the daily laborers gets usually BDT 200-300 in exchange of day-long efforts in production, marketing or transport for both the aquaculture inputs and fish produces.

8. Access to Finance

Although aquaculture in Bangladesh has grown significantly as an industry over the years, its full potential is yet to be recognized with proper attention. Access to institutional finance remains a major challenge for many of the fish farmers, especially the small-scale farmers. Lack of convenient loan schemes and limited availability of information about those are hindering a smooth development of culture fisheries in the country. Besides, financial institutions and banks are often unaware of the sector specific needs of the rural aquaculture value chain actors and relevant SMEs to offer their best.

The current study observed that credit sources available for aquaculture production, processing and marketing are both formal (commercial banks, finance companies, and government initiated institutions and schemes) and informal (money lenders, traders, relatives and others). As the access to finance is very limited for the majority of fish farmers, most farming operations rely on the farmers' own capital. Small-scale farmers reported difficulties in gaining access to formal credit. The apparent risks of aquaculture investments and inadequate collateral are the two main reasons for this difficulty, especially for small loan seekers.

Poor fish farmers therefore remain dependent on informal credit, which is more convenient to obtain but subject to heavy interest rates. It was found that intermediaries providing production credit to farmers link the loan with marketing, whereby the fish farmers receiving credit are obliged to sell their produce to the credit supplier at prices below the prevailing market price. No insurance schemes exist to cover the loss of fish production.

Input retailers (Aqua feed and chemical) and the hatchery owners also complained on their limited access to required credit for their investments. However, some of them started to have good access to bank borrowings in recent years.

Fish traders (wholesaler/ aratder/ commission agent) were found deploying a good amount of currency almost every day. Unlike the producers, they face relatively less pressure in sourcing fund as they make their payments after the sales of the fish produces. Even though, they urged for easy and lenient processes in getting necessary loan facilities.

9. Access to Information

There are two major channels by which information/knowledge reaches to the farmers. Comparatively stronger channel for information/knowledge exists between farmers & input suppliers, which are hatcheries and feed-aquachemical retailers. Farmers get information on nursing, feeding etc. from the hatcheries. Input retailers share information with the farmers on applying feed-aquachemicals properly. This embedded service from the service providers was found throughout all the study regions.

Another information sharing channel was reported between farmers and input companies/NGOs. This channel is rather formal but only operational when the actors have running events in the region within the selected sectors. Input companies organize workshops/seminars as a part of their promotional activities particularly when they introduce new products in the market. On the other hand NGOs working in related sectors organize meetings, trainings and similar activities which stand within their project mandate. Reach of these activities generally is limited within working regions and smaller number of peoples where the beneficiary groups are mostly dominant.

A very informal and weak channel of market information is subsistent between the farmers and forward market players, mostly limited to arots. Farmers get price related market information from them and sometimes from the Forias also. The information is transferred mostly by cellular conversations, where they notify the farmers about current market price. This channel is relatively weak because sometimes the information supplied, varies from the market and information is not always available. This unavailability is mainly because the source of information starts from retailers and easily interrupted in the pathway.

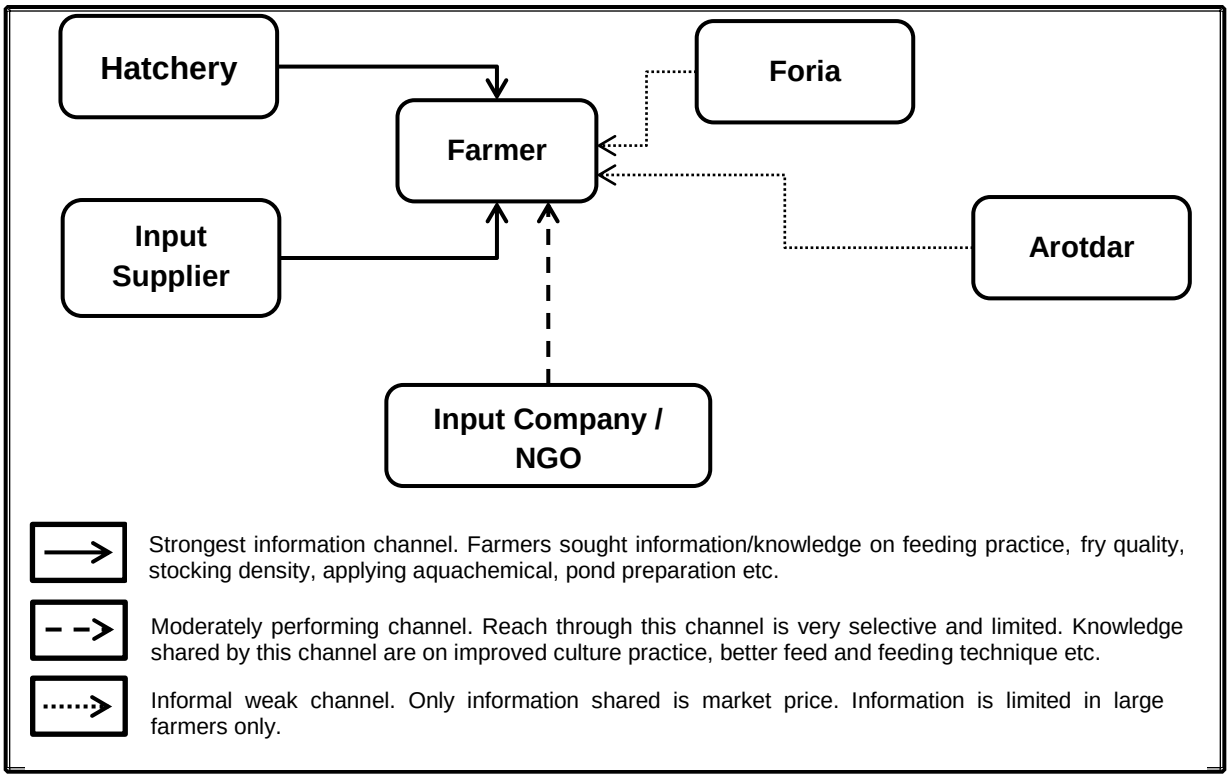

Figure 17: Information Channel

Barriers on Access to Information

Two main reasons identified which acts as the barrier on accessing the proper information source and dispersing the knowledge are –

1) Weak linkage with the DoF on information exchange
2) Traditional mind-set and culture practice of the farmers.

The linkage between the farmers and Govt. offices were found weak throughout the study regions. Farmers usually don't visit DoF in case of any queries or help needed and the presence of fisheries officers were reported scarce. Only the large farmers with strong personal linkages with Govt. officials were found to avail their services. This situation acts as a barrier to the farmers on better access to information, as Govt. information sources are still considered the most reliable.

Another underlying reason for information not dispersing properly or not showing expected result is the traditional mind-set of the farmers. This problem is mostly seen between the extensive farmers. They are quite used to with their traditional culture practices and often not ready to accept the changes introduced to them. So, unless project/programs reach them directly, they show little or no initiative from their side to improve themselves. They also found preferring copying techniques from other farmers rather than taking formal trainings, which in-fact fails to give them better outcome.

10. Influencing Matrix

	Input Supply			
	Brood Supplier	Input Supplier	Hatchery	Fry Traders
Price				
Seasonality			√	
Credit Facility		√	√	
Access to Forward Market				
Superior Quality			√	
Price Knowledge				

- Hatchery is the most influential actor in the Input Supply level of the value chain. Hatchery controls the fry supply chain, as the supply in influenced by seasonality and quality of the fries. Also, they keep the product flow steady by providing credit facility to the farmers.
- Input suppliers also influence the regular product flow in the chain by providing credit facility.
- Fry traders & Brood suppliers have no significant influences. Hatcheries also rear brood when brood suppliers fail to supply better broods.

	Production		
	Extensive Farmer	Semi-Intensive	Intensive
Price			
Seasonality	√	√	√
Credit Facility			
Access to Forward Market			
Superior Quality	√	√	√
Price Knowledge			

- Farmers influence the production chain with the seasonal variation of production and by ensuring better product quality. Farm gate price if influenced by these two factors.

	Trading			
	Foria	Arotdar	Rural Paiker	Urban Paiker
Price			√	√
Seasonality				
Credit Facility		√		
Access to Forward Market		√		
Superior Quality		√		
Price Knowledge			√	√

- In the trading stage, Arotdars influence the market by providing credit facilities and maintaining the quality of the products. They also have better access to the forward market than the actors he's trading with in his backward linkage.
- Paikers, both rural and urban has influence over the trading function as they have better grip over the bargaining and better knowledge on the market price.

	Retailing		Consuming	
	Rural Retailer	Urban Retailer	Rural Consumer	Urban Consumer
Price				
Seasonality				
Credit Facility				
Access to Forward Market				
Superior Quality	√	√	√	√
Price Knowledge				

- Both retailer and consumers have the influence over the chain by maintaining the demand for better quality fish. This demand for better quality fish has top down effect over the price of whole value chain.

11. Policy

The Ministry of Fisheries and Livestock (MoFL), through its DoF, has overall responsibility for fisheries and aquaculture development. The activities of DoF are supported by the 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.

In 1998, a National Fisheries Policy was adopted to develop and increase fish production through optimum utilisation of resources. The policy extends to all government organisations 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. It also supports an integrated culture of fish, shrimp and paddy in rice fields. In addition, the policy deals with many other relevant issues such as quality control, industrial pollution and the use of land. Under this policy, fish culture will be encouraged in all ponds and other water bodies. It is also suggested that proper studies will be made for exotic fish, before introduction, and encourage them as cultivable item in the closed water bodies. Introduced fish species could have negative environmental impacts on indigenous species and on ecology as well.

In 1992, the Government of Bangladesh adopted a National Environment Policy for the protection, conservation and development of the environment and to ensure maintenance of environmental quality in all development activities. The Environmental Protection Act (1995) aims to protect the environment and to control and mitigate environmental pollution including water pollution. The act has been implemented by the Environment Conservation Rules (1997), according to which all new industries and projects must apply for an Environmental Clearance Certificate.

The overall responsibility for fish inspection and quality control is vested in DoF, which maintains several testing laboratories to certify the quality of exportable fish and fishery products. The Ordinance is further implemented by the Fish and Fish Product (Inspection and Quality Control) Rules (1997)**,** which include Hazard Analysis Critical Control Point (HACCP) requirements for shrimp processing plants. In recent years, the DoF has been implementing the registration and certification of shrimp farms.

In 2010, the Government of Bangladesh has approved the Fish Hatchery Acts, 2010 and Hatchery Rules-I to register fish hatcheries and also maintain quality of fry. Similarly the Government of Bangladesh has approved the Fish and Animal Feed Act (Act 2 of 2010) and regulations (2011), provide an appropriate regulatory framework to control the production and use of fish feeds and aqua-chemicals in the country. However, these newly introduced policies are not implemented strongly. Both Ministry of Fisheries and Livestock and DoF lack the man-power to implement these policies strictly.

12. Other Projects

Name of The Project	Financed by	Location	Contact Person	
FtF Aquaculture (WorldFish)	USAID	20 district (South Part of Bangladesh)	Dr Manjurul Karim, Cell 01714131209	Genetic development of Tilapia and other Carps through training, demonstration, exchange visit, along with workshop, seminar etc.
CSISA (WorldFish)	USAID	Jessore, Khulna, Barishal, Faridpur, Rangpur and Mymensingh region	Mokarrom Hossain, Cell 01713077026	Wider dissemination of aquaculture technology through training, demonstration, exchange visit, along with workshop, seminar etc.
Nobojibon (WorldFish)	USAID	Greater Barishal	Mokarrom Hossain, Cell 01713077026	WorldFish build capacity of input providers (Nurserer, Fry Hawkers, Feed seller) , develop Lead Farmers , conduct exchange visit, Exposure visit, experience learning sharing session, linkage meeting etc activities for expansion of aquaculture
PRICE	USAID	All Bangladesh	Nurul Islam, Cell 01730056313	Dissemination of aquaculture technology through training, exchange visit, workshop, seminar etc. with all value chain actors.

REGIONAL FISHERIES & LIVESTOCK DEVELOPMENT COMPONENT (Barishal)	DANIDA	Greater Barishal	Mr Ziaul Huq, Cell 01711431668	To improve livelihood of rural people through fisheries and livestock extension services. Technical trainings, inputs supports and grants are being given to the producer groups for improved agricultural production and marketing. Project builds capacity of input providers (Nurserer, Fry Hawkers, Feed seller, inputs seller) , develop local extension agents, conduct exchange visit, Exposure visit, experience learning sharing session, linkage meeting etc activities for the expansion of fisheries and livestock businesses.
REGIONAL FISHERIES & LIVESTOCK DEVELOPMENT COMPONENT (Noakhali)	DANIDA	Greater Noakhali	Dr Abdus Sobhas, Cell 01711434809	To improve livelihood of rural people through fisheries and livestock extension services. Technical trainings, inputs supports and grants are being given to the producer groups for improved agricultural production and marketing. Project builds capacity of input providers (Nurserer, Fry Hawkers, Feed seller, inputs seller) , develop local extension agents, conduct exchange visit, Exposure visit, experience learning sharing session, linkage

				meeting etc activities for the expansion of fisheries and livestock businesses.
National Agricultural Technology Project	GOB	All Bangladesh	Md.Goljar Hossain, Cell 01712127634	Dissemination of aquaculture technology through training, demonstration, exchange visit, workshop, seminar etc.

Source: Primary Study (2013)