Review of Aquaculture & Fish Consumption in Bangladesh

WorldFish Center

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CONTENT

EXECUTIVE SUMMARY

Fish play a crucial role in the Bangladeshi diet, providing more than 60% of animal source food, representing a crucial source of micro-nutrients, and possessing an extremely strong cultural attachment. Fish (including shrimp and prawn) is the second most valuable agricultural crop, and its production contributes to the livelihoods and employment of millions. The culture and consumption of fish therefore has important implications for national food and nutrition security, poverty and growth. This review examines the current state of knowledge on the aquaculture sector and fish consumption in Bangladesh, based on extensive analysis of secondary sources (including unpublished data unavailable elsewhere), consultation with various experts and specially conducted surveys.

Bangladesh has extensive and highly diversified fisheries resources. Official Department of Fisheries (DOF) statistics estimate total fish production of 2.56 million tonnes, of which aquaculture accounts for 39%. However, collection of these statistics is based on a design which has not been able to fully account for recent developments in aquaculture. This review therefore attempts to triangulate official statistics wherever possible using data drawn from numerous sources, including the Household Income and Expenditure Survey 2005. This approach suggests that aquaculture and, in particular, more commercially oriented forms of the activity are likely to play a much more important role in meeting national fish consumption needs and alleviating poverty than previously understood. Estimates derived from these sources suggest that around 399,000 tonnes of fish are produced from homestead ponds; 390,000 from commercial semi-intensive carp culture; 395,000 tonnes from pellet fed intensive systems; and 98,000 tonnes of shrimp and prawn, for a total of 1.35 million tonnes (325,000 t or 27% greater than the 1.06 million tonnes of aquaculture production reported in official statistics).

Inland pond culture represents the mainstay of aquaculture in Bangladesh, accounting for almost 86% of total recorded aquaculture production. DOF figures indicate that pond culture is dominated by production of carps. The next two most important species cultured in ponds are tilapia and pangasius catfish. Our analysis suggests that tilapia and pangasius production is under-represented in official statistics, and comfortably exceeds 335,000 t. We differentiate between three main forms of pond aquaculture; 'homestead pond culture', 'entrepreneurial pond culture', and 'commercial semi-intensive carp culture', and estimate that each type currently accounts for approximately 30% of total aquaculture production. We calculate that 4.27 million households (20% of rural inhabitants) operate a homestead pond, covering a combined area of 265,000 ha. Commercial semi-intensive carp culture covers an area of 110,000 ha, and intensive forms of entrepreneurial pond culture cover just 15,000 ha.

Other inland aquaculture systems are less important than pond farming, although they may play significant roles in the future. Our estimates suggest that fish culture in floodplains, rice fields, cages, and oxbow lakes collectively accounts for around 2% of total aquaculture production. Fish culture in modified water bodies is expanding throughout the country, but often involves the enclosure and effective privatization of resources which may have previously been under common property regimes for some or all of the year, thus having important social implications which are not fully understood. Some studies have also raised questions regarding impacts on biodiversity. Rice-fish culture occurs in numerous locations but (with the exception of the distinctive *gher* systems found in the south) widespread uptake has been rather limited. Adoption of cage culture, while expanding, also remains limited. Although commercial tilapia cage culture has been successfully established in one district, producers there have experienced persistent problems with fish disease and water pollution.

Shrimp and prawn production takes place mainly in south and southwestern Bangladesh in converted rice fields known as *'ghers'*. These cover a total area of 244,000 ha. Estimated combined production of shrimp and prawn for 2010 stood at close to 98,000 t. The contribution of black tiger shrimp *(Penaeus monodon)* and giant freshwater prawn *(Macrobrachium rosenbergii)* to the Bangladesh national economy is significant and shrimp and prawn are the export commodity with the second highest value after readymade garments, generating US$412 million in 2009/2010. Shrimp and prawn culture faces a range of challenges however including disease, compliance with quality standards in importing markets, and inequitable terms of exchange among value chain actors.

Growth of aquaculture has been supported by development of input businesses and suppliers, in particular those related to production of seed and feed. Rapid development of private sector hatcheries and nurseries has followed initial investments in the public sector and has been perhaps the single most decisive factor in the expansion of aquaculture in Bangladesh. At least 98% of seed supplies now derived from private hatcheries. 'Raw' unformulated feeds are widely used in homestead and commercial carp aquaculture. The use of commercially manufactured pelleted feeds predominates in entrepreneurial fish culture. Forty major feed mills produced 0.67 million tonnes of formulated feeds, worth around $220 million in 2010. Whilst seed and feed supply has grown rapidly in recent years, quality remains a major concern for both inputs.

Fish remains by far the most important and frequently consumed animal source food in Bangladesh, but studies on fish consumption show very substantial variation depending on location, income and season. Our analysis of Household Income and Expenditure Survey data shows national fish consumption trending strongly upward during the period 2000–2005. However, the gap in fish consumption between rural and urban areas widened markedly over this period. Per capita fish consumption in urban areas increased by 17.5% to 18.1kg from 2000-2005 against a national average of 15.4kg, while consumption in rural areas climbed 4.8% to 14.5kg. Expenditure on fish among some income quartiles in major city areas is almost twice those in rural areas. Surveys conducted for this report suggest a growing division between rural and urban fish consumption patterns. Low value wild fish and cultured carps remain the most common fish consumed in rural areas, whereas species produced by entrepreneurial aquaculture (i.e., pangasius, tilapia and climbing perch) are increasingly dominant in Dhaka and other urban markets, along with higher value wild fish.

Of the 260 freshwater fish found in Bangladesh more than 140 are classified as small indigenous species (SIS). These fish are a particularly rich source of essential vitamins and minerals, but are increasingly scarce. Excluding shrimp and prawn, Bangladesh is a net importer of fish, receiving 44,000 t of mainly Indian major carps from Myanmar and India in 2010. However, imported fish is destined primarily for the restaurant trade, and net imports account for only 1.1% of total fish consumed.

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LIST OF ABBREVIATIONS

AFP	Adivasi Fisheries Project
BFRI	Bangladesh Fisheries Research Institute
CAARP	Cyclone Affected Aquaculture Rehabilitation Project
CAGES	Cage Aquaculture for Greater Economic Security
CP	Crude protein
CSISA	Cereal Systems Initiative for South Asia project
DFID	Department for International Development (UK)
DOF	Department of Fisheries
DSAP	Development of Sustainable Aquaculture Project
FCR	Food conversion ratio
FPA	Floodplain aquaculture
FRSS	DOF Fisheries Resources Survey System
GNAEP	Greater Noakhali Aquaculture Extension Project
HIES	Household Income and Expenditure Survey
IFAD	International Fund for Agricultural Development
MAEP	Mymensingh Aquaculture Extension Project
SIS	Small indigenous species
Tk	Bangladeshi taka
WAPSA	World's Poultry Science Association
WSD	White spot disease
WSSV	White Spot Syndrome Virus

INTRODUCTION

This review of the current status of aquaculture in Bangladesh is based on information collected during the compilation of a consultancy report by the WorldFish Center on behalf of the International Fund for Agricultural Development (IFAD). A huge volume and range of information on aquaculture in Bangladesh (much of it unpublished or difficult to obtain) was collated for the purposes of the study, but was not included in the final policy-focused report requested by IFAD. Discussions with Government, Universities, NGOs and Private Sector actors were also held as part of this process. Primary research on urban fish consumption, fish marketing, and an analysis of the dataset of the 2005 national Household Income and Expenditure Survey were also conducted as part of this effort. It was decided to publish the present report, which presents data and analysis on production, inputs and consumption, in order to make this information more widely available to researchers and other users. Policy recommendations formulated for IFAD on the basis of this information are not presented here.

Bangladesh has extensive and highly diverse fisheries resources. According to official statistics, the average growth rate of the fishery sector as a whole during the period 1984/85 to 2008/09 has been above 5%. Inland capture fisheries and marine fisheries show growth rates only slightly below and slightly above 4% respectively (DOF, 2010). During this period however, aquaculture enjoyed an impressive growth rate of more than 9% (DOF, 2010). The slower growth of capture fisheries is due to a variety of factors including habitat loss as a result of agricultural intensification, urbanization, environmental degradation, pollution, and overexploitation of resources. Some experts question whether, given the severity of these problems, statistics showing year on year increases in capture fisheries output can be considered reliable. It is beyond the scope of this study to attempt to answer that question. It is clear however, that if demand for fish is to be met in the coming years then aquaculture will play a major role.

The authors of this paper, as well as many professional staff within the Department of Fisheries (DOF) and the Bangladesh Fisheries Research Institute (BFRI), agree that the area and output of aquaculture is almost certainly substantially higher than reported in official statistics. This is in part because the collection of aquaculture statistics is based on an old survey design which has not been able to fully account for recent developments in aquaculture such as the growth of intensive entrepreneurially operated systems. This document therefore attempts to triangulate, or verify, official statistics wherever possible using data drawn from numerous sources, including the government's Household Income and Expenditure Survey 2005 (BBS, 2007) and Agricultural Sample Survey 2005 (BBS, 2006), which we consider reliable due to the large sample size and rigorous data collection methodologies and procedures employed. Our analysis of the datasets for both surveys suggests that total pond area exceeds that officially reported by the DOF Fisheries Resources Survey System (FRSS) by around 28%, and output by around 23%. This approach suggests that aquaculture and, in particular, more commercially oriented forms of the activity are likely to play a much more important role in meeting national fish consumption needs and alleviating poverty than is currently recognized.

The review is comprised of a further three sections. Section 1 describes the main systems of aquaculture production in terms of their technical and social characteristics and outputs. Section 2 addresses issues relating to seed and feed. The final section analyses fish consumption patterns and demand, and attempts to estimate the volumes of fish produced from a range of sources[1].

1. Prices are given throughout this report in Bangladeshi taka. At the time of writing USD1 equaled approximately Tk73.

1. PRODUCTION SYSTEMS

This chapter sets out the key features of the major fish production systems in Bangladesh based on a review of secondary literature and unpublished baseline data from projects implemented by the WorldFish Center and other development institutions.

1.1 POND CULTURE

Pond culture represents the mainstay of aquaculture in Bangladesh, accounting for 85.8% of total recorded production and 57.7% of the area under culture (DOF, 2010). Unlike *gher* culture and seasonal floodplain aquaculture which are limited to a few key districts, pond culture is commonly practiced in nearly every district of the country. For the purposes of this review we differentiate between two main forms of pond aquaculture which we label 'homestead pond culture' and 'entrepreneurial pond culture'. This is an important distinction to make because the two have considerably different profiles in terms of their origins, species produced, size of operations, intensity of production, degree of capital investment, the socio-economic characteristics of producers, and the extent of both primary on-farm employment and secondary employment in associated value chains.

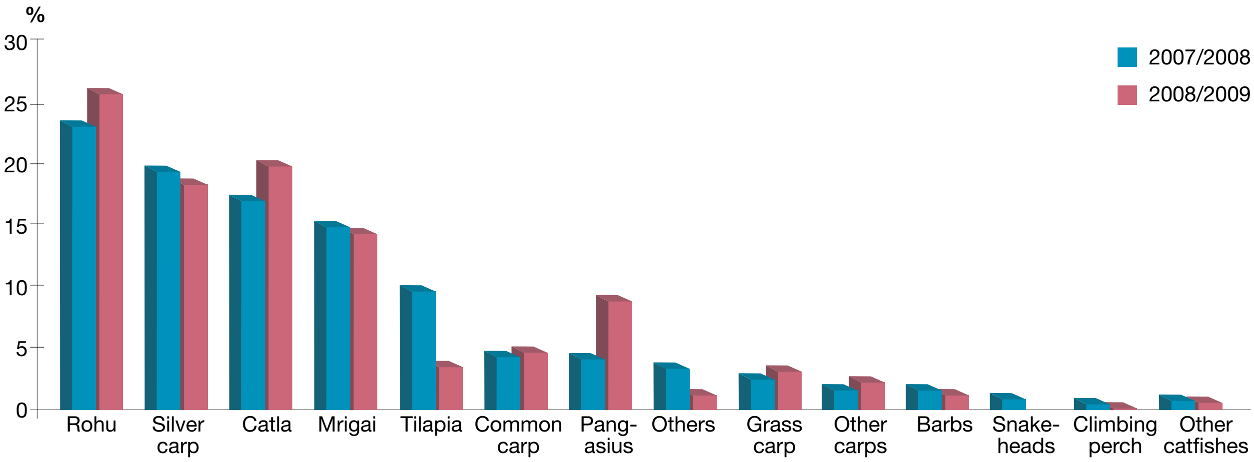

Figure 1.1 Species contribution to total pond production 2007/2008 and 2008/2009. (Source: modified from DOF 2009a, 2010)

DOF figures indicate that pond culture is dominated by production of carps. Fifty-nine percent of the fish produced in ponds are native Indian major carps, and silver carp are the most important non-native species, accounting for a further 19%. When all other non-native carp and Indian minor carp are considered, carps account for 88% of the fish recorded as produced in ponds in Bangladesh (see Figure 1.1 above). The two other major species cultured in ponds are tilapia (close to 7% of the total in 2007/08 but unaccountably reported as only 1.53% for 2008/09) and pangasius (for which almost the inverse pattern is recorded). Significant proportions of the former, and almost all of the latter, originate from ponds operated on an entirely commercial basis by entrepreneurial farmers. Other minor species such as climbing perch and shing (the latter included under 'other catfishes' in the graph above) are also produced primarily in this manner.

1.1.1 HOMESTEAD POND CULTURE

Broadly speaking, homestead pond culture occurs as a small component of the larger household farming system. Homestead ponds are used for multiple purposes including bathing, washing and watering livestock. In addition, many households excavate soil with which to raise the base of their homes in order to avoid flooding. As a result many households in rural Bangladesh possess a small pond close to their homestead (Huda et al., 2010; Kranzlin, 2000). Data generated from a baseline survey conducted for the Development of Sustainable Aquaculture Project (DSAP) in 47 villages in Bogra, Mymensingh, Comilla and Jessore indicates that 20% of rural households own a pond of this type (Jahan et al., 2010). A smaller, intensive survey of a single village in Mymensingh also revealed a very similar level of homestead pond ownership (Belton et al., in press), as did a survey of 20 villages conducted for the Cereal Systems Initiative for South Asia (CSISA) project in the Greater Khulna, Greater Jessore and Greater Barisal regions of southern Bangladesh. This latter survey showed an average household pond ownership rate of 23%, ranging from 17% to 26% across the three regions (CSISA, 2011).

In the past, ponds such as these were often used to capture wild fish which entered during flooding in the monsoon season, and in some cases were stocked with fry harvested from nearby rivers, but received very little, if any, additional intentional management. As the availability of hatchery produced seed has increased, and management and yields have improved following the extension efforts of numerous successive large projects, fish culture has become an increasingly important use of the available pond resources, and the promise of fish culture now serves as an incentive for homestead pond construction or renovation. For instance, a survey by Barman (2001) in northwest Bangladesh reports that more than half the small ponds located close to homestead areas and beside farmers' fields had either been dug or renovated in recent times for the purpose of fish culture. Nevertheless, the multiple use value of ponds continues to be extremely important. This is demonstrated by Hambrey et al. (2008) who report the following uses of ponds also used to culture fish among 100 households in Kishoreganj: washing clothes (94%), bathing (87%), washing dishes (62%), watering livestock (21%), cooking (18%) and drinking water after filtering (1%).

In addition to possessing multiple functions, many homestead ponds also have multiple owners, in large part due to t he division of parental resources between offspring upon inheritance. The extent of multiple-ownership can be seen from Table 1.1, which presents Mymensingh Aquaculture Extension Project (MAEP) baseline survey data for seven sub-districts in Mymensingh and Kishoreganj from 1994. Very similar levels of joint ownership were also reported by a detailed pond survey carried out for the Greater Noakhali Aquaculture Extension Project (GNAEP) in 2000–02. Joint ownership of ponds was formerly considered a major disincentive to investment in aquaculture in Bangladesh (e.g., Panayotou, 1982; Lewis, 1997), and was frequently reported to result in passive types of management or complete abandonment of ponds for culture purposes because of the high transaction costs and potential for conflict relating to the collective organization of stocking, guarding and equitable benefit sharing (Little et al., 2007).

Table 1.1 Pond ownership status in Mymensingh and Kishoreganj. (GoB-DANIDA, 1994)

Sub-district and district	Pond ownership status		
	Single	Joint	Other
Kishoreganj Sadar, Kishoreganj	43.2	55.3	1.5
Pakundia, Kishoreganj	42.3	55.5	2.0
Hossainpur, Kishoreganj	40.8	58.1	1.1
Karimganj, Kishoreganj	32.8	65.7	1.5
Phulpur, Mymensingh	63.4	35.6	1.0
Nandail, Mymensingh	39.5	59.5	1.0
Gaffargon, Mymensingh	48.6	49.9	1.5
Mean	44.3	54.2	1.4

However, anecdotal evidence suggests strongly that as demand for cultured fish has risen along with availability of seed and knowledge of culture practices, the potential value of ponds has increased to the point where these problems have diminished significantly. As a result, ponds are now frequently leased out to others where intractable intra-household disagreements over benefit sharing would have previously prevented their productive use. This trend may encourage leaseholders of such ponds to manage them in a commercially oriented manner commensurate with their need to recoup lease costs (Belton and Little, 2011). Nevertheless, it seems plausible that many of the 7.82% and 1.42% of ponds listed by DOF as 'culturable' and 'derelict' respectively (i.e., those not utilized for fish culture) may remain in this state due to problems related to multiple ownership (DOF, 2010).

Homestead ponds are typically small in size. This is due in part to the limited availability of land and the costs of construction, and in part to the fact that fish culture is often not their primary function. Table 1.2 shows that in most instances mean area is approximately 0.08–0.1 ha. This would imply that the modal average size is actually smaller due to bias produced by small numbers of larger ponds. In certain locations or for particular communities, average pond size may be smaller still. This is suggested by the final entry in Table 1.2 (Hossain et al., 2010), which relates to the pond holdings of disadvantaged Adivasi (indigenous ethnic minority) groups. Baseline survey data from the Cyclone Affected Aquaculture Rehabilitation Project (CAARP), implemented in five coastal districts of southern Bangladesh, also shows average pond size to be just 0.039 ha (WorldFish, 2008).

Table 1.2 Characteristics of homestead aquaculture in Bangladesh. (Note: HH = household)

Mean pond size (ha)	Aquaculture as % HH income	Fish consumed at home (%)	Source
0.1	2.8	41	Thompson et al. (2006)
0.09	3	37	Thompson et al. (2006)
0.08	13.2	n/a	Winrock International (2004)
0.1	10	26	Jahan et al. (2010)
0.1-0.2	15.5	47	Karim (2006)
0.04	10	29	Hossain et al. (2010)

Table 1.2 shows the contribution of homestead pond aquaculture to household income ranging from as little as 2.8% to a maximum of around 15%. This is reflective of a number of factors, including the small size of the ponds themselves, which sets an upper limit on potential production, the technically sub-optimal levels of production achieved by many households, and the relatively high total incomes which pond-owning households often earn. As a result, even where development interventions bring about significant improvements in the productivity of ponds such as these, the increase in pond income as a proportion of total household income is usually incremental.

A final feature common to each of the sources referred to in Table 1.2 is the proportion of fish consumed by the household. This ranges from approximately a quarter to a half of total production. Ahmed and Lorica (2002) report a similar range for home consumption of 33 to 42%. Although Hallman et al. (2003) note that 'fish cultivation [in Bangladesh] has become a business, providing a source of cash when needed... and it is no longer just for consumption' (p. 41), it must also be recognized that providing fish for home consumption remains an important motivation for households to stock and manage homestead ponds, and that virtually all homestead pond owners will consume a portion of the fish they produce. This is confirmed by a study of pond aquaculture in northwest Bangladesh by Barman (2001) which found that all households surveyed used some or all of the fish they produced for household consumption, with a mean quantity consumed of around 120kg per household.

Belton et al. (in press) note that '[in Bangladesh] carp possesses high affective value as a culturally preferred food item. Its production thus contributes to household wellbeing via emotional satisfaction as well as through purely monetary or calorific gains'. Based on a detailed village study in Mymensingh, the same authors also observe that better-off households used sales of surplus fish left over after household consumption strategically, in order to cover expenses related to irrigated winter rice *(boro)* production. In many cases these households deliberately timed sales of fish to coincide with periods when it attracted a high market value, and saved the money in order to reduce the need to take informal credit with high rates of interest for the purchase of inputs and labor during boro rice plantation and/or harvest. In these cases, the homestead pond can be seen as a high interest savings account from which withdrawals can be made in order to smooth seasonal cash shortages.

Numerous projects have promoted simple 'improved' management strategies, such as regular application of fertilizers and feeds, and the stocking of fish species in combinations and densities designed to move the production system from extensive to semi-intensive. When followed consistently, these relatively simple steps have been shown to reliably boost levels of production from less than 1 t/ha to more than 3 t/ha, thereby raising pond yields, household incomes and the availability of fish for home consumption. For instance, ADB (2004) reported that under its Second Aquaculture Development Project, 98% of surveyed project participants from Kishoreganj district practicing carp polyculture in small ponds with organic and inorganic fertilization and supplementary feeding, attained average extrapolated annual yields of 3.1 t/ha. Winrock (2004) also reports an increase in production of over 300% among households adopting similar technologies under MAEP, rising from an average of 1 t/ha in 1989 to 3.3 t/ha in 2001.

Table 1.3 Indicative enterprise budgets for homestead ponds under different management regimes. (Source: Belton et al., in press)

Item	Extensive	Improved extensive	Semi-intensive
Extrapolated yield (kg/ha)	527	1860	2890
Actual yield (kg/household)	42	149	231
Per unit farmgate value ($/kg)	1.44	1.44	1.44
Operating costs ($/household)	58	163	216
Cash equivalent gross income ($/household)	66	215	337
Net cash income ($/household)	0	52	121
Net fish consumption (kg/household)	42	75	116

Note: *Based on unpublished DOF statistics for yields in Phulpur upazila and representative values from field interviews; it is assumed that pond size is 0.08 ha and that 50% of fish produced is utilized for household consumption with the remainder sold, except in 'extensive' for which it is assumed that no fish is sold.*

Table 1.3 above gives an indication of the levels of household consumption and income derived from typical homestead ponds under extensive, improved extensive and semi-intensive management regimes. Despite improved production techniques having been widely disseminated, their uptake remains rather patchy. This is indicated by data presented in Tables 1.4 to 1.6. Table 1.4 (based on unpublished data collected through an intensive pond census conducted as part of a baseline survey for GNAEP in 2000-2002) shows the frequency of pond management practices among 43,256 households in five upazilas (sub-districts) from three districts in the Noakhali division. This indicates that a surprisingly high proportion of ponds in the upazilas surveyed (17%) are not used for fish culture, and that more than one third are cultured in an extensive manner without the application of inputs other than seed. Just 6% of the total ponds are cultured in a technically optimal manner using large fingerlings and regular feeding and fertilization.

Table 1.4 Pond management practices in five upazilas of Noakhali division. (GoB-Danida, 2000-2002)

Upazilla & district		Management status			
		Not cultured	Extensive	Improved extensive	Semi-intensive
Senbag Upazila, Noakhali	(no.)	2435	4589	1323	158
	(%)	28	54	17	2
Sonagazi Upazila, Feni	(no.)	1759	5375	3327	616
	(%)	16	49	30	6
Chatkhil Upazila, Noakhali	(no.)	1177	1735	4421	54
	(%)	16	24	59	1
Raipur Upazila, Lakshmipur	(no.)	955	1033	3997	1006
	(%)	14	15	57	14
Feni sadar Upazila, Feni	(no.)	763	3659	3473	900
	(%)	9	42	39	10
Total	(no.)	7172	16,575	16,742	2767
Mean	(%)	17	38	39	6

Table 1.5, which draws on baseline survey data from 13,603 households in four divisions collected under the DSAP project, shows higher proportions of households practicing improved management techniques than Table 1.4. This may suggest that the development of pond aquaculture in Noakhali division lags behind that in the rest of the country. More importantly however, it also indicates that the uptake of improved management practices is far from universal. This conclusion is also supported by Table 1.6, drawn from a baseline survey of 1,918 households from five districts in southern Bangladesh in 2008 as part of the Cyclone Affected Area Rehabilitation Project (CAARP). Table 1.6 also highlights an interesting mismatch in the perceptions of farmers and project staff regarding the management system practiced, with staff considering over two thirds of surveyed households to practice traditional management and less than a third to practice improved culture, whilst farmers themselves reported almost the inverse of this pattern.

Table 1.5 Pond management practice by size of landholding. (Source: modified from Jahan et al. 2010)

Landholding (ha)	Pond management practice[2] (%)		
	Traditional	Improved	Intensified
≤0.20	70.1	29.9	-
0.21–0.61	44.9	55.1	-
0.61–1.21	41.7	57.3	1.0
>1.21	24.9	72.7	2.4

Table 1.6 Farmer and project staff perceptions of type of pond management practices. (Source: modified from CAARP baseline data)

Source of information	Typology of management system			
	Modern	Improved	Traditional	Not cultured
Interviewer's opinion	1.6%	27.6%	69.2%	1.7%
Farmers' opinion	10.5%	58.8%	30.1%	0.6%

These clear indications of the patchy uptake of improved pond management techniques would appear to imply that average levels of pond productivity are somewhat different to those which can be calculated using officially recorded figures for pond area and production. The most recent official figures suggest that average productivity across all ponds, including those classified as derelict and culturable (i.e., those which are not managed), stands at 2.99 t/ha, while average productivity for cultured ponds alone is 3.14 t/ha (DOF, 2010). However, this level of production cannot be achieved without regular feeding and fertilization (i.e., improved or semi-intensive management). The data presented above therefore seem to suggest that it is unlikely that yields of this order are the norm for homestead pond-owning households. Baseline survey data collected prior to project interventions support this observation, showing that considerably lower yields are typical. For instance, data for 123 control (i.e., non project) farmers under the DSAP project for 2005/2006 showed an average productivity of 1.75 t/ha (Jahan et al., 2010), and baseline surveys for the DANIDA Patuakhali-Barguna Aquaculture Extension Component, and the Greater Noakhali Aquaculture Extension Component recorded an average productivity of 1.55 and 1.36 t/ha respectively (Winrock International, 2003).

Table 1.5 also indicates an important aspect of social differentiation in pond management, whereby only 30% of functionally landless households (the poorest category of pond owner, owning 0.2 ha of land) practice improved techniques, as opposed to 73% of the wealthiest category of pond owner (those with landholdings of more than 1.21 ha). In addition, as Figure 1.2 shows, there is a tendency for wealthier households (classes 1 and 2) to possess larger ponds than those in lower income brackets. This is to be expected given that better-off households are likely both to build larger houses, thus creating larger borrow pits, and to be more likely to possess sufficient homestead land and capital to enable its conversion to ponds.

2. Traditional or extensive aquaculture technologies follow no proper stocking method and require little or no external inputs other than seed. Fish growth depends entirely on naturally available feed. Improved traditional or improved extensive practices use more systematic stocking approaches and use of fertilizers and/or supplementary feeds to promote fish growth. Additional water management and monitoring practices (control of predatory fish species, regular observation of fish behavior, liming, control of aquatic weeds, etc.) are also used. Fish nutrition in intensified systems is derived primarily from supplemental feeds.

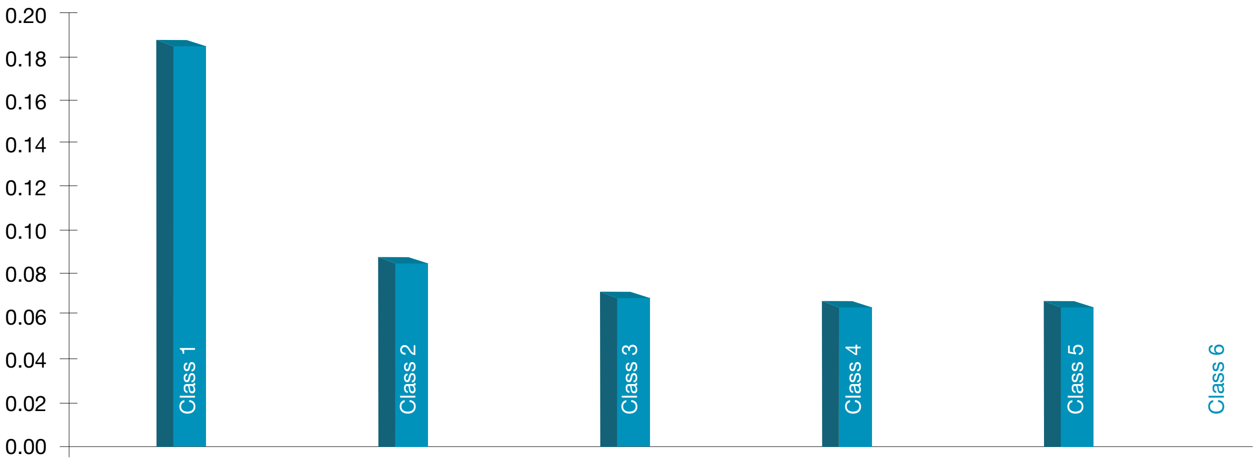

Figure 1.2 Size of homestead pond by social class. (Source: Unpublished survey, Phulpur, Mymensingh: n=52)

This observation is supported by Jahan et al. (2010) who find that 52% of ponds owned by functionally landless households in Bangladesh are below 0.04 ha in size. These factors account for the observation of Barman (2001) that whilst mean annual fish production from ponds in northwest Bangladesh stood at 253kg per household, the amount produced by the poorest households was one-third that produced by the wealthiest households, and that this was mainly related to the differences in pond size.

It is also evident that there is a strong positive association between pond ownership and size of landholding. A survey conducted in two sub-districts of Gazipur in 1993 shows that approximately one-third of the population in both sub-districts owned less than 0.2 ha of land, and that almost no household possessing less than 0.2 ha of land also owned a pond. Conversely, between one-fifth and one-quarter of pond owning households owned more than 3 ha of land, as compared to between just 2 to 4% percent of the population as a whole (Ahmed et al., 1993). Table 1.7 below, which is based on a much larger sample from four divisions which was conducted more than 10 years after the work of Ahmed et al., indicates a similar though, interestingly, less polarized pattern, with 15.5% of pond owning households found to be functionally landless.

Table 1.7 Percent distribution of all households and pond owning households by size of landholding. (Source: modified from Jahan et al. 2010)

Land-holding size (ha)	All households		Pond operating households		Pond operating households as % of landholding group
	N	%	N	%	%
≤0.20	5169	37.9	433	15.5	8.4
0.21–0.60	5033	36.5	889	32.0	17.6
0.61–1.21	2721	20.5	899	32.4	33.0
>1.21	680	5.1	557	20.1	81.9

This change may be reflective of both the declining size of landholdings as a result of population growth and inheritance patterns, and of increasing construction of homestead ponds with the intention of initiating fish culture alongside other household uses. Perhaps the most striking feature of Table 1.7 however is that pond ownership, which is relatively uncommon among those households with small landholdings (only 8.4% of households with less than 0.2 ha, and 17.6% of those with between 0.21 ha and 0.60 ha possess a pond), becomes increasingly ubiquitous amongst those with larger landholdings (33% of households with more than 0.61-1.21 ha of land, and 81.9% of those with more than 1.21 ha being pond owners). A similar pattern is also apparent in 2011 baseline data from the Cereal Systems Initiative for South Asia (CSISA) project indicating that 16.9% of ‘landless or poor’ households, 22% of ‘marginal or small’, and 46.6% of ‘large’ farmers own household ponds.

To summarize, the information presented above indicates that poorer households are less likely to own a pond than their better-off counterparts; that any ponds they do own are likely to be smaller than the average; and that they are likely to be managed at a low intensity, and hence be relatively unproductive, both in terms of total and per unit area output. However, there are some further considerations which should be taken into account when interpreting this information. Hambrey et al. (2008) note that, 'fishpond owners may be generally categorized as relatively better-off among rural households in the context of rural Bangladesh but they do not necessarily escape from poverty'. They go on to state that:

'Among small landowners in Bangladesh with moderate access to land of 0.5-1 ha, including fish ponds, 34 percent live below the poverty line. They do not produce much surplus from farming and are vulnerable to crises. Even some fishpond owners who may be categorized as medium-size landowners with 1-2 ha of land are also vulnerable; 25 percent of them live below the poverty line with the rest precariously above it and they can easily slide into poverty when faced with an unexpected crisis. A large majority of the respondents in the study were exposed to several crises, the most serious being illness of household members, shortage of food, and damage due to floods, erosion, heavy rain and cyclones.' (p. 187)

Although, as Table 1.8 shows, the figures quoted for proportions of households falling below upper and lower poverty lines have declined since the data cited in Hambrey et al. was produced, the observation is still a valuable one. As highlighted above, the total contribution to household income which homestead pond culture makes is fairly small (i.e., usually less than 10%). Whilst it would appear that such increments are unlikely to be sufficiently large to permanently transform the fortunes of households locked in entrenched chronic poverty (particularly as poorer households generally possess small ponds and few resources with which to intensify their management), they may result in other more subtle benefits.

Table 1.8 Percentage of rural households below the upper and lower poverty lines. (Source: adapted from BBS, 2007)

	Size of landholding (ha)					
Proportion of households below poverty line (%)	<0.02	0.02-0.20	0.21-0.6	0.61-1.0	1.01-3.03	>3.04
Upper poverty line	65.7	50.7	37.1	25.6	17.4	3.6
Lower poverty line	47.8	33.3	22.8	12.8	7.7	2

In the first instance, the ability to consume self-produced fish rather than to purchase it can equate to a saving which is not easily captured by monitoring exercises, although it should not be assumed that direct substitution will necessarily occur. More importantly however, the ability to convert stocks of fish into cash may translate into an ability to withstand shocks like ill-health or adverse climatic events which many studies suggest are the major triggers of descent into severe poverty, even among relatively well-off households (e.g., Krishna, 2004; Sen, 2003). This may also prevent or smooth out transient dips below the poverty line, whether one-off or seasonal, particularly by averting the need to borrow money or food at high rates of interest, as the example from Belton et al. (in press) cited earlier, demonstrates. Fish production may therefore play a more important role as a form of insurance which reduces vulnerability and enhances resilience to circumstances likely to precipitate poverty, rather than as a transformative livelihood activity. Finally, since the margins between lower and upper poverty lines are quite narrow, there may be some potential for the incremental increases in income derived from improving pond yields to reduce the severity of poverty, as measured on a headcount basis.

Typical homestead pond, with fruit and vegetable cultivation on pond dykes and trellises. (Photo: Ben Belton)

Harvest of small carps from a homestead pond. (Photo: Biplob Basak)

1.1.2 ENTREPRENEURIAL POND CULTURE

The emergence of 'entrepreneurial' pond culture in Bangladesh is a relatively recent development which has assumed increasing importance and scale since the late 1990s. We use the term entrepreneurial pond culture to indicate a form of aquaculture distinct from homestead pond culture. Whereas the latter is usually a minor section of the overall household farm economy, often making opportunistic use of existing ponds, entrepreneurial pond culture is usually deliberately initiated as a stand-alone enterprise involving significant capital investment.

Entrepreneurially operated ponds are generally constructed for the specific purpose of culturing fish. This is most frequently achieved through the conversion of rice fields, although in some locations *beels* (naturally occurring depressions) and other natural water bodies have been enclosed to allow for the stocking of fish. Land is often leased for the purpose of pond construction. The two species which dominate this form of pond culture in Bangladesh are pangasius and Nile tilapia. Other species including climbing perch *(koi)*, stinging catfish *(shing)* and walking catfish *(magur)* are also produced in this manner. Some production of carps is also practiced in this manner. Management is generally intensive, utilizing pelleted feeds, and yields per hectare are high (typically in the order of 40 t/ha for pangasius, and ≈10 t/ha for tilapia per year). However, the use of pelleted feeds also means that operating costs can be considerable.

Farms of this type frequently employ hired labor, either because they are too large to be managed using household labor alone, or because they are run as businesses by absentee owners. Because of its reliance on large volumes of inputs, production of large volumes of outputs and its relatively labor intensive nature, this form of aquaculture generates considerable employment opportunities in associated value chain activities, particularly where, as is common, clusters of farms are to be found. These features are explored in more detail below, largely with respect to pangasius culture because of a relative dearth of published information on the production of the other species.

Culture of the non-native pangasius catfish in Bangladesh is widely reported to have been initiated by a pioneering farm, Al Falah, in Trishal upazila, Mymensingh in 1993, following importation of the first stocks of the fish from Thailand by BFRI. Production of the fish expanded in Trishal and two other sub-districts of Mymensingh: Baluka and Muktagacha. According to a study by Ali et al. (forthcoming), based on the estimates of several key informants including feed suppliers and DOF staff, there are approximately 2,480 pangasius farms in Muktagacha, 1,720 in Trishal and 1,300 in Baluka.

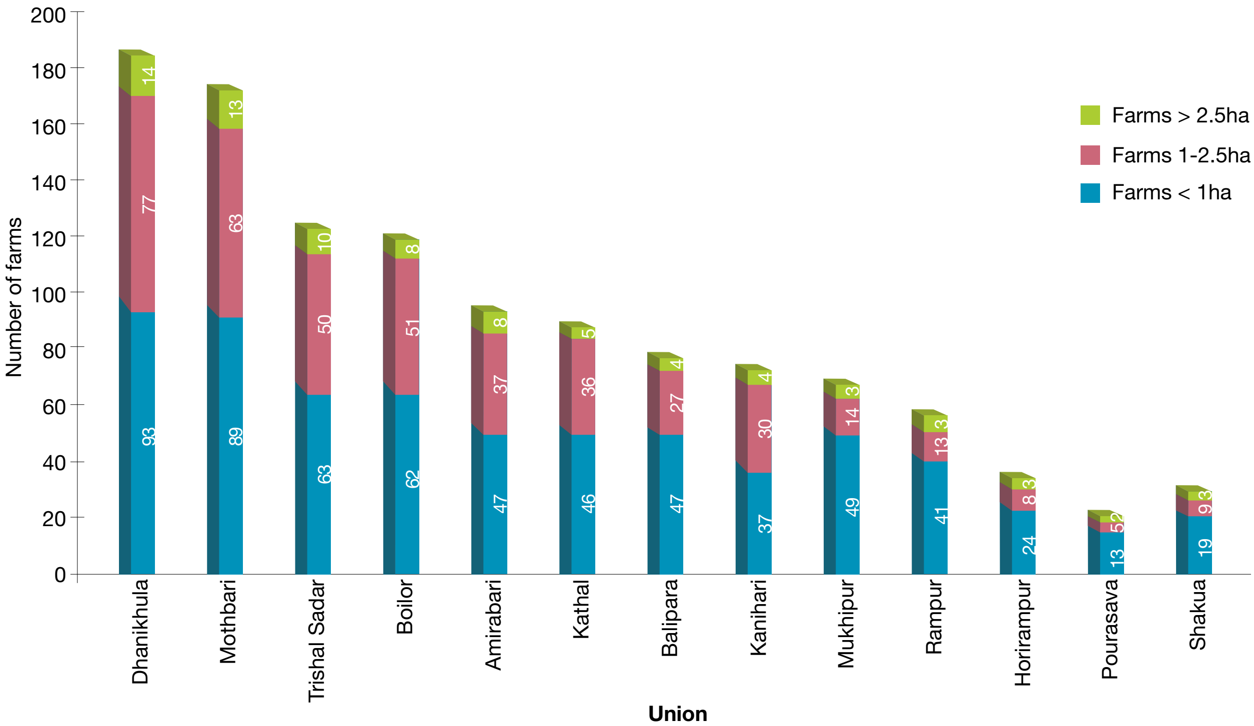

Figure 1.4 Number of pangasius farms in Trishal by farm size and union. (Source: modified from Munir, 2009)

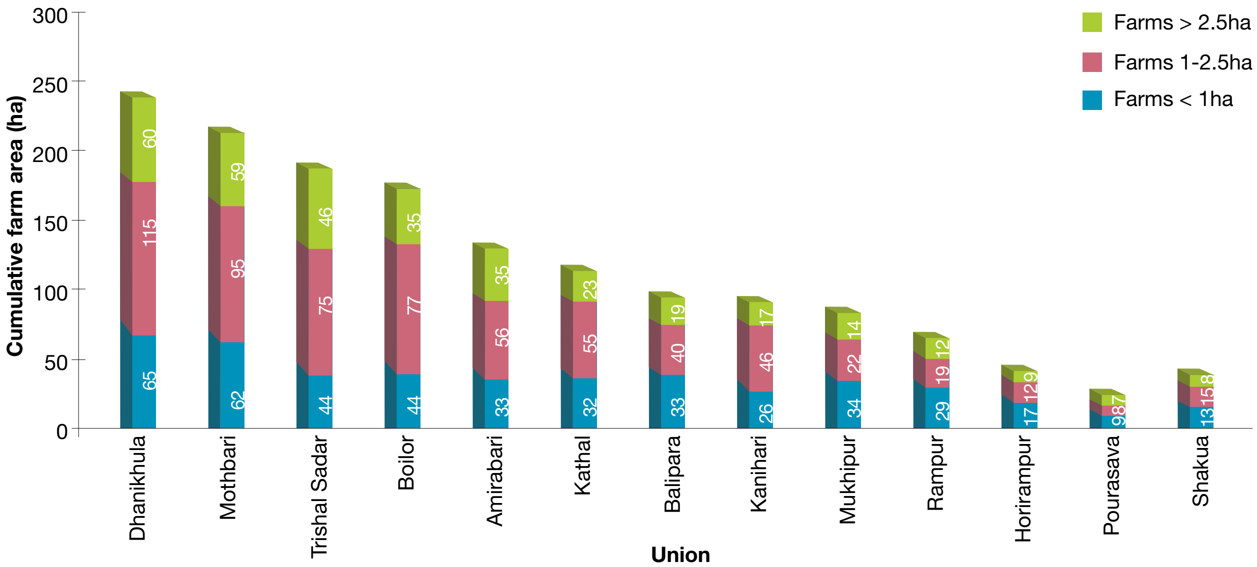

Figure 1.5 Cumulative area of pangasius farms in Trishal by farm size and union. (Source: modified from Munir, 2009)

Munir (2009) arrives at a somewhat lower figure of 1,130 farms in Trishal upazila with an average area of 1.26 ha, based on discussions with local informants (see Figures 1.4 and 1.5) although this is still considerably more than the 697 ha of pangasius farms officially recorded in that upazila by the Upazila Fisheries Office, suggesting considerable underreporting even at the local level. Breakdowns of pangasius farms in Trishal into three size categories (<1 ha, 1-2.5 ha and >2.5 ha), by union (the smallest administrative unit), and by cumulative area and cumulative frequency is given in the figures above. This shows that farms sized under 1 ha are most numerous, but that those sized 1–2 ha account for the largest area, with those <1 ha and >2.5 ha accounting for similar portions of total area and, presumably, production. Belton et al. (in press) also provide a similar mean figure to that given by Munir (2009) for pangasius farm size in these two upazilas. This would seem to suggest a total farm area for Muktagacha and Trishal somewhere in the region of 4,000 ha.

Ali (2010) also reports a cluster of pangasius farms in Narsingdi district (which receives 13% of the fingerlings distributed from Bogra), with approximately 300 farms in Narsingdi Sadar and a similar number in surrounding upazilas. According to Ali (2010) five very large operators each with farm areas totaling above 100 ha produce more than 60% of the pangasius in Narsingdi Sadar upazila, and the number of smaller operations is low. The author of the same study also reports a cluster of pangasius farms in Naogaon district, with approximately 1,500 farms in Raninagar upazila alone, and more than this in surrounding upazilas. The most recent DOF statistics support these observations, suggesting that pangasius culture accounts for 53.7% of fish production in Narsingdi, and 52.2% in Naogaon. It is also recorded as contributing 59.9% in Bogra, 36.7% in Tangail, 33.9% in Sherpur, 26.1% in Mymensingh, 23.1% in Jamalpur, and 13.9% in Netrakona (DOF, 2010). These figures are in line with information presented in Section 2.6.2 showing production of pangasius seed in, and distribution of pangasius seed to, many of these districts.

Pangasius are typically reared for 7-8 months, up to a maximum of 10 months and harvested at 0.6-1.0kg, with better capitalized farms generally opting to culture longer as larger fish obtain a better market price. The main growing season runs from March to September, with some fish harvested as late as December. Fingerlings are held in ponds for overwintering and stocking at the beginning of the season. Haque (2009) reports that typical yields range from approximately 38 to 47.5 t/ha. Edwards and Hossain (2010) note that smaller farms typically produce in the region of 40 t/ha, while some larger farms obtain yields as high as 60-70 t/ha. This is very similar to information reported by Ali et al. (forthcoming) based on a sample of 90 pangasius farms in Mymensingh. Figure 1.6 shows the frequency distribution of output from these farms as indicated by the study. It should be noted however, that all these figures apply to production in Mymensingh, and that anecdotal evidence suggests yields may be significantly lower in other districts.

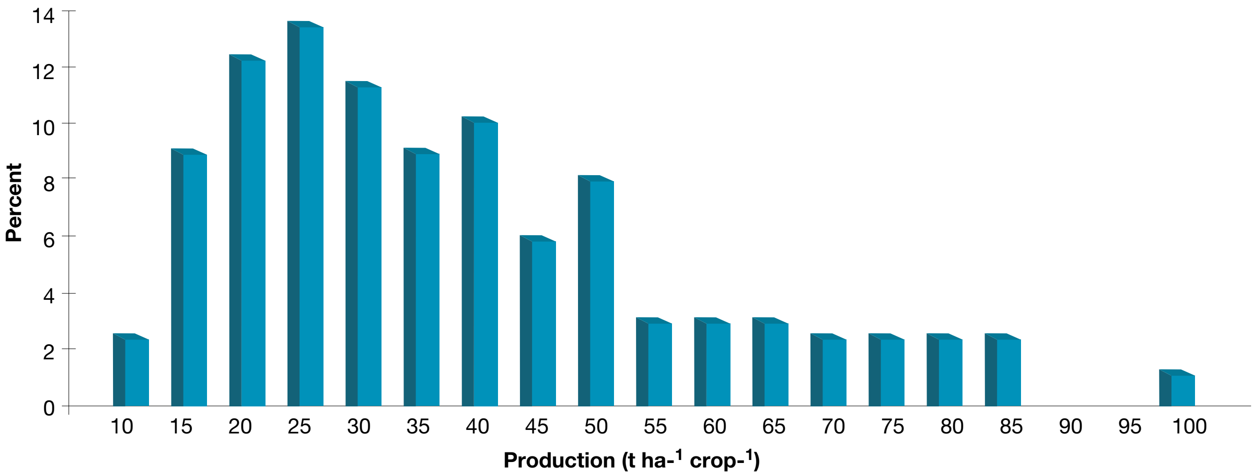

Figure 1.6 Frequency distribution of production in t/ha/crop of pangasius in Mymensingh. (Source: Ali et al., forthcoming)

Pelleted feed, either manufactured in commercial mills or produced locally using basic machinery, is the largest single operating cost in pangasius production. Munir (2009) reported that it accounts for 82% of total production costs, with an average food conversion ratio (FCR) of 2.04. Ali (2009) also reports an FCR of 2. The two authors report somewhat different margins, with Munir giving an average farmgate sales price of Tk46.39/kg which gives a margin of just Tk2.53/kg, but notes that even at this level the high production per unit area equates to a cumulatively large profit. This figure does not include the harvest of carps and tilapia which are stocked to utilize algal blooms which occur in the highly fertile pond water. Production of these fish, which account for around 15% of total harvested weight, is effectively free since no additional feed or management is required to promote their growth, and they are harvested and sold on a regular basis to help cover feeding costs for the main crop of pangasius. Ali (2009) reports a higher profit margin of Tk18.4/kg. This discrepancy is likely to be accounted for by seasonal effects as market value varies considerably according to fish availability throughout the year.

Edwards and Hossain (2010) note that total production of pangasius reached 300,000 t in 2008, a figure also reported by Belton et al. (2011), but that it fell to 200-250,000 t in 2009 as a result of overproduction and depressed farmgate prices, causing producers to withdraw from production temporarily. Belton et al. (2011) also note that this decline in demand coincided with the peak in global food prices in 2008 which, they argue, would have forced lower income consumers to substitute pangasius for rice and other staples. Prices rebounded during early 2010, reflecting constrained supply. Construction of new ponds and the entry of new producers were widely observed in Mymensingh during this time, reflecting the cyclical nature of production of this commodity. Whatever the current levels of pangasius production, these reports would suggest that they are far in excess of the 59,474 t officially reported for 2009 by DOF (2010). It is also noteworthy that Munir (2009) reports that producers with farms over 2.5 ha in size were able to obtain a farmgate price for their product approximately Tk1/kg higher than that of producers with farms of less than 1 ha, although the mechanism by which this advantage was achieved is not clear.

Table 1.9 Education level of pangasius farm owners in Trishal upazila by farm size. (Source: modified from Munir, 2009)

	Education level			
Farm size	Under SSC* (%)	Under HSC** (%)	Undergraduate (%)	Graduate (%)
<1 ha	41	24	35	0
1–2.5 ha	10	16	42	32
>2.5 ha	0	0	67	33

**SSC = Secondary School Certificate; **HSC = Higher Secondary School Certificate*

Munir (2009) presents data on the educational level of operators of pangasius farms of different sizes (Table 1.9). These indicate a high average level of education relative to the general populace, which increases with farm size. This is to be expected given that the level of educational achievement is a strong proxy for income, and indicates that, particularly for the larger two farm categories, farm operators would have been fairly well-off prior to commencing their operations.

The relative wealth of pangasius producers as compared to those not engaged in production is clearly illustrated by Figure 1.7, which displays the results of a wellbeing ranking exercise for one pangasius farming village, shows that of 116 households ranked as poor, not a single one engages directly in pangasius culture as a producer, as opposed to more than 80% of those households in the two wealthiest income brackets. Returns are potentially high, as is investment, with Belton et al. (2011) giving a production cost per hectare of $23,790, and a net return of $8,025/ha. However, Munir (2009) gives rather lower average annual farm incomes of between $780, $2,740, and $4,850 for operators of farms sized <1 ha, 1-2.5 ha, and >2.5 ha respectively.

As Figure 1.8 indicates, pangasius culture plays an important role in livelihood portfolios, being either the primary or secondary occupation of almost all of those who practice it. The graph also indicates that many pangasius farm owners operate businesses or are formally employed, but that agricultural activities make a significant contribution to incomes in only a relatively small number of cases. This seems to suggest that pangasius culture is often entered into as an entrepreneurial venture rather than as an extension of existing farming activities.

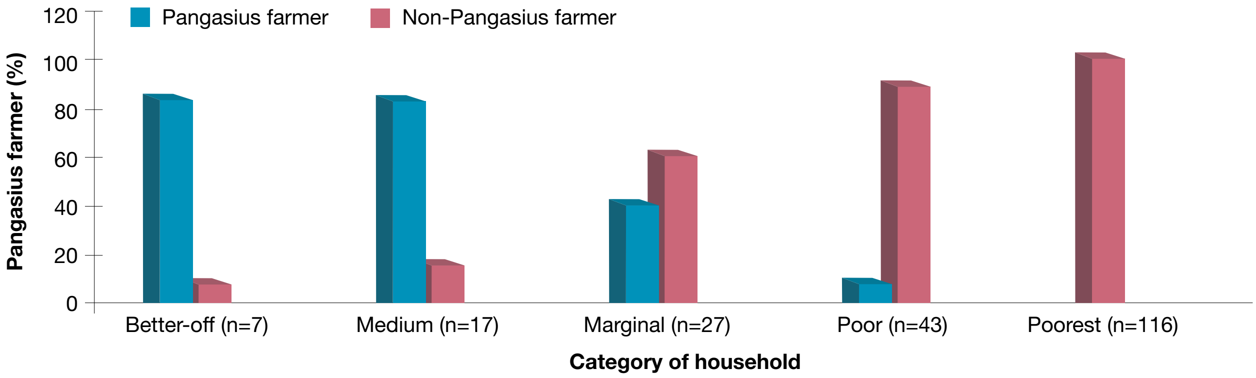

Figure 1.7 Income groups of pangasius farming and non-pangasius farming households in a Trishal village. (Source: Ali, 2009)

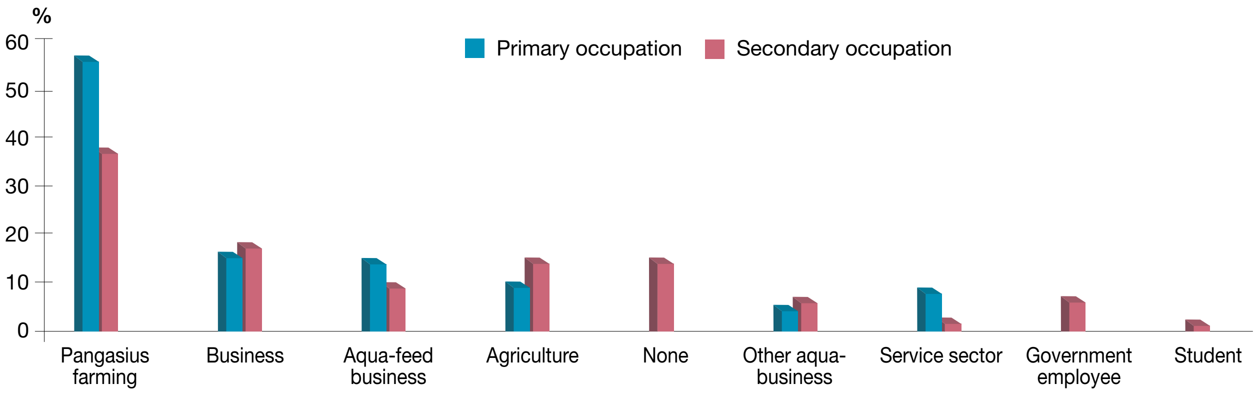

Figure 1.8 Primary and secondary occupations of pangasius farmers in two Mymensingh villages, (n=90). (Source: modified from Haque, 2009)

Interestingly, Munir (2009) notes that out of a sample of 42 farm operators interviewed, none had received any formal training in pangasius culture. He also reports that of the same sample of 25 farms, 59% had expanded their pangasius farming operations within the last five years, with approximately three-quarters of farms more than 1 ha in size, and around one-third of those under 1 ha, having done so.

Finally, although virtually all output is consumed domestically, a small number of powerful pangasius producers are actively exploring export opportunities for overseas markets, as the title of Edwards and Hossain's (2010) article *Bangladesh Seeks Export Markets for Striped Catfish* suggests. Several shrimp processors are documented as having exported pangasius fillets, albeit in small quantities (e.g., Achia Sea Foods Limited of Khulna dispatched 4.6 t to Bulgaria in 2009 (pers. comm. Ali, 2010), and it is possible that this might offer a means of taking up excess capacity in the shrimp processing industry. Members of the Association of Bangladeshi Fish Producers *(Bangladesh Mastshya Chashi Samity)* are reportedly in the process of seeking capital with which to establish a processing plant close to Mymensingh. However, there are questions as to whether the flesh quality of Bangladeshi pangasius is sufficiently high for international markets, and such a move would be likely to increase the vulnerability for producers and might reduce the benefits which the low cost and ready availability of pangasius brings to the national population.

Anwar (2011) provides some information on commercial pond-based tilapia production, noting that the typical market size of 200–300g means that cropping cycles are short at 3–4 months, making two cycles in a year possible. Anwar's study estimates total production of tilapia for 2010 at 67,175 t. This figure is similar to the 66,767 t reported for the year 2007 by Hussain (2009). Anwar identifies a number of districts in which commercial tilapia production takes place. These are listed in Table 1.10, together with typical levels of productivity for each (presumably per annum, rather than per cycle), although the basis of these estimates is unclear.

Table 1.10 Tilapia farming districts by farming intensity. (Source: Anwar, 2011)

	Yield (t/ha)	
15	10-14	8-9
Bogra	Joypurhat	Pabna
Narsingdi	Brahmanbaria	Feni
Jhenaidah	Jessore	Noakhali
Kishoreganj	Dinajpur	Chaudanga
Naogaon	Satkhira	Gaibandha
Kustia	Mymensingh	Habigonj
Netrokona	Sherpur	Shariatpur
Jamalpur	Tangail	Madaripur

Intensive pangasius culture. (Photo: M.M. Haque)

Worker feeding pangasius on a large farm, Mymensingh. (Photo: Ben Belton)

1.2 SEASONAL FLOODPLAIN AQUACULTURE

Seasonal floodplain aquaculture (FPA) involves the enclosure of areas of privately owned floodplain through the construction of an embankment which creates a water body during the monsoon season. During the dry season a crop of irrigated rice is grown. The water body is managed through the stocking of indigenous and exotic fish species, feeding, fertilizing, and then the complete harvesting of the stock. The areas enclosed are typically in the range of 50-100 ha in size. The production from floodplain aquaculture is usually in the range of 1-3 t/ha/year; approximately ten times the natural productivity of most unstocked floodplains (Gregory et al., 2007).

FPA is a fairly recent development in Bangladesh, first being successfully initiated in Daudkhani upazila, Comilla by the NGO SHISUK in 1996. Since this time the concept has spread rapidly to a number of neighboring upazilas, and in 2007, 104 such floodplain aquaculture projects were reported to be in operation. Of these, 68 are in Daukhandi upazila (Apu, 2007). FPA is a profitable enterprise and although the first schemes were organized by an NGO, many of the projects initiated subsequently have been privately organized and managed. The earthworks required to create embankments, which require substantial investment, are funded by the landowners whose land is to be used for fish culture. These individuals receive tradable shares in the project proportionate to the area of land owned. Under the NGO-organized schemes provision has also been made for a portion of the shares to be given to landless households within the project area, but share ownership, and thus access to direct benefits in terms of profits and dividends, remains highly skewed, reflecting patterns of land distribution. In addition, even where these provisions have been made it is reported that elite capture of projects' boards of directors has allowed for accumulation of shares in the hands of powerful individuals in contravention of the projects' rules (Tofique and Gregory, 2008).

The enclosure of areas of floodplain which were previously open access resources whilst submerged during the monsoon season is also reported to have reduced or prevented traditional foraging activities such as subsistence fishing. There are also some concerns as to the implications of the impoundment of water and the stocking of non-native fish species on biodiversity (Gregory et al., 2007). Although there are therefore some reservations relating to the distribution of benefits from FPA, significant localized economic activity has also been created. According to Gregory et al. (2007) a group of enterprises that includes nursery ponds to rear and sell fingerlings to projects, feed and fertilizer shops providing inputs on credit and producing pelleted feed, transport (trucks and vans) to carry fish to local and city markets, and several ice factories have been established in the Daudkhandi area as a result. Locally significant employment has also been created in embankment construction and maintenance, and fish harvesting, and the presence of large embankments has facilitated increased transport and movement of people.

Anecdotal evidence suggests that crime has been reduced as a result of access to these new economic opportunities, and Apu (2007) notes that negative effects for poorer households such as lost access 'are more than offset by the boost to the local economy creating employment opportunities for all sections of the community' (p. 9). The environmental and development outcomes associated with FPA are therefore somewhat ambiguous. In view of this ambiguity and the sustainability which investment by landowners lends FPA schemes, Gregory et al. (2007) suggest that rather than constructing embankments or being directly involved in promoting the approach in new areas, 'funds would be best spent on carrying out a comprehensive zoning exercise to enable more effective, planning, monitoring and regulation of floodplain aquaculture' (p. 4).

Recent anecdotal evidence suggests that schemes involving collective action for the enclosure and stocking of natural water bodies are increasingly common in several areas of Bangladesh. Strategies include the stocking of *baor* (ox-bow lakes) and *beel*, (low lying depressions) with hatchery seed, stocking sections of 'dead' river (Ahmed, 2011), and damning streams to create new water bodies. These activities may originate from within communities, be introduced by NGOs, or may be the private initiative of wealthy individuals. As a result, equity in distribution of any benefits and possible negative outcomes of exclusion may vary considerably from case to case, as may ecological implications.

1.3 RICE-FISH CULTURE

Rice-fish culture has been promoted in Bangladesh by a number of projects. Although not adopted on anything like the scale of pond-based forms of culture, it does occur in numerous locations throughout the country, most notably in parts of the northwest. However, there is a fairly fine line between this type of rice-fish culture and the production of rice and prawns/shrimp/fish in ghers, which is widely practiced in southern districts, particularly given current trends for many farmers in these areas to stock only fish in preference to crustaceans. Countrywide data on rice-fish farming in Bangladesh are not available (Nabi, 2008).

Rice-fish grow-out is practiced in two forms: concurrent and alternate/rotational. In order to integrate fish with rice cultivation farmers strengthen rice plot dikes to raise them above flood level and excavate a sump to act as a refuge for fish when water levels in the field are low. Screens may also be installed on embankments to prevent the escape of fish during heavy rains. The sump typically occupies 1–5% of the rice plot area (Gupta et al., 2002). Under concurrent culture fish may be stocked in aman (rainfed summer rice) season only, when there is most water available, or in both aman and boro (irrigated winter rice) seasons depending on water availability during the latter period. For alternate cultivation, rice will be mono-cropped during boro, and fish is mono-cropped during aman when water levels are high. The concurrent system is generally practiced in plain lands and medium lowlands, while the rotational system is performed in deeply flooded lowlands (Ahmed and Luong, 2009).

The main species stocked in rice fields are common carp, Indian and Chinese major carps, silver barb and tilapia. Ahmed and Luong (2009) report the average annual yield of fish reported by respondents in Mymensingh district to be 259 kg/ha for concurrent farming, and 1,108 kg/ha for rotational farming, the latter corresponding to stocking of larger fingerlings, higher levels of feeding, and a longer culture period. The authors report that in the rotational system 80% of the production was sold to local markets, whereas 40% of fish produced under concurrent culture was consumed by farming households.

A survey by Gupta et al. (2002) showed farmers in Bangladesh who adopted rice-fish farming to have larger than average land holdings and household size and higher than average literacy; all factors indicative of their relatively well-off status. However, Ahmed and Luong's more recent survey (2009), though based on a smaller sample, indicates that farmers practicing concurrent rice-fish had a farm size of 0.33 ha, whilst those practicing rotational farming possessed 0.29 ha. Although the mere fact that they owned land means they are not among the poorest strata of rural society, this data would suggest that they are by no means wealthy either, and this size of landholding is significantly smaller than the average 1.7 ha of agricultural land reported by Gupta et al.

Rice-fish culture possesses a number of well recognized positive environmental attributes. Stocked fish control pests, uproot weeds, fertilize rice plants with their excreta and release nutrients trapped in sediments. Gupta et al. (2002) report that these effects resulted in rice production costs being reduced by around 10% for rice-fish farmers in Bangladesh due to the lower use of fertilizers and pesticides and the lower cost of weeding, with rice yields being raised by a similar margin. However, rice-fish culture is vulnerable to seasonal flooding which may cause fish to escape, causing considerable economic losses for farmers, particularly if feeds have been used, and making it potentially a somewhat risky proposition (Dey et al., 2008).

Rice farmers may also be unwilling to dig a refuge due to the loss of rice-cropped area incurred, and may believe that stocking fish will damage rice plants and that using pesticides on rice will negatively impact fish production (Ahmed and Luong, 2009). Nabi (2008) also suggests that the additional labor effort associated with adding fish to the system may discourage smaller households with no labor surplus from adopting the activity. A combination of these factors may therefore contribute to the relatively limited uptake of rice-fish culture compared to pond based culture, despite apparent benefits, the effects of which may appear too marginal to encourage farmers to adopt the system. The widespread uptake of conservation agriculture practices, such as alternate wet-dry irrigation which are currently being promoted, may also act to discourage rice-fish culture in future.

Rice-fish plot, Nilphamari. (Photo: Ben Belton)

1.4 CAGE CULTURE

Unlike other Asian countries such as Indonesia, Thailand and Vietnam where commercial cage culture for a number of species is a well established practice, cage culture in Bangladesh remains fairly limited at present. A major DFID funded project, Cage Aquaculture for Greater Economic Security (CAGES), operated by the NGO CARE worked with more than 10,000 extreme-and moderate-poor participants, of whom 63% were women, between 1997 and 2001 (Hambrey and Roy, 2002). The project's rationale was that landless participants otherwise excluded from participation in aquaculture by a lack of principle production factors would be able to practice aquaculture using very small ($1m^3$) cages located either in open access or privately owned water bodies, with modest investment costs of between Tk450 and Tk800 per crop, and using readily available inputs. Net incomes derived by participants averaged Tk444 to Tk1,027 per cage (Hambrey and Roy, 2002).

However, despite these apparent advantages and a final project report which suggested a rosy outlook for future sustainability, these small enterprises, though superficially financially viable, have generally faded away. The reasons for this are not entirely clear, but it may well be that the levels of return were inadequate-even for the poorest-to encourage the required level of commitment and husbandry. Furthermore, it seems that few poor farmers were able to retain tenure or secure access to a water body (Hambrey et al., 2008). Similar problems have been reported with attempts to establish smallscale poverty focused cage culture elsewhere in Asia (Pollock, 2005), although it has been reported that in one instance a wealthy local entrepreneur adopted the system promoted by CARE, establishing around 80 cages on a commercial basis.

Other technical reasons for the limited sustainability of the CAGES intervention, suggested by a key informant, included the project's focus on grow-out rather than nursing (which involves quicker turnover and lower levels of risk), inappropriate species selection, a dependence on external inputs of feed (as opposed to natural feed) and the poor availability of cage making materials at the time of the project which meant that they had to be imported. The technical constraints have been avoided in subsequent projects such as the EU funded Adivasi Fisheries Project (AFP), implemented by the WorldFish Center and Caritas, in which cage based nursing of silver carp and tilapia was one of the interventions used to boost incomes among Adivasi (indigenous ethnic minority) communities in north and northwest Bangladesh.

Under AFP, the cost of net materials (which are now readily available), bamboo frame and labor for making a one cubic meter cage was around Tk300-400. This cage could be used for at least 2-3 seasons for fingerling production with minimum repair. One cycle of fingerling production cost Tk350-450. The income produced from fingerlings varied from Tk1,300 to Tk4,000 for a single cage. Twenty six percent of households involved in the project produced 20kg or more of fingerlings, 37% produced 10-19kg, and 37% produced less than 10kg. Fingerlings produced in cages were largely sold for cash income directly to grow-out farmers from the same or nearby communities, or to fingerling traders. A significant proportion of the larger fingerlings was used directly for regular household consumption (Naser and Barman, 2010).

Larger scale commercial tilapia cage culture has been successfully established on the Dakita River in Chandpur district. This form of cage culture was introduced from Thailand in 2001 by a businessman who had observed cage farms whilst visiting the country. The system was adopted by other inhabitants of the locality from 2004 onwards with assistance from a local Department of Fisheries official. Cages are approximately 30 m^3 in size and constructed using metal pipe, polyethylene netting and oil drums. They are stocked at a density of approximately 25-30 per cubic meter, and each cage yields 400kg of fish per 7-8 month cropping cycle. Only commercial floating feeds are used. Fish are harvested live at a size of around 500g and sold at Tk100/kg to traders who dispose of them in local markets (Amin Sarker, 2010). Operating costs per cage for a single cycle are around Tk28,800 and farmers make a margin of approximately 27% (Table 1.11).

Amin Sarker (2010) reported that there are now a total of 1,500 cages at two locations on the Dakita River, although Baqui and Bhujel (2011) put this figure at 3,510, with an additional 475 cages in nearby Laxmipur district. According to Amin Sarker (2010), 43% of tilapia cages are owned by individuals and 57% are operated by consortia. There are 52 consortia consisting of a total of 250 members. Around 300 full time laborers are employed in cage management. Most cage owners are middle class, working in a range of professions including business, commercial agriculture, teaching and NGOs. The three most important problems affecting tilapia cage culture in Chandpur are reported to be the high cost and low quality of feeds, security problems and theft, severe disease problems and high mortality (Amin Sarker, 2010).

Table 1.11 Cost/kg of tilapia production in cages, Dakita River, Chandpur. (Source: modified from Amin Sarker, 2010)

Item	Cost (Tk/kg fish produced)	Remarks
Seed	8.22	15% mortality
Feed	51.0	FCR 1.7; feed @ Tk30/kg
Electricity	1.20	
Labor	3.44	
Land lease	0.00	No lease required
Bank interest	3.40	If bank loan taken
Cage depreciation	3.44	
Others	2.00	
Total cost	72.7	
Sales value	100	
Net benefit	27.3	

1.5 GHER CULTURE

Shrimp and prawn production in Bangladesh takes place mainly in converted rice fields known as ghers. Shrimp has undergone more rapid expansion in volume and value terms than any other agro-export commodity in Bangladesh. The contribution of black tiger shrimp *(Penaeus monodon)* to the Bangladesh national economy is significant and shrimp exports are now the second highest foreign income earner in the country (DOF, 2010). The shrimp sector of Bangladesh grew rapidly from the 1970s until the mid 1990s. In 2008–2009, Bangladesh produced 97,746 t of tiger shrimp and giant freshwater prawn *(Macrobrachium rosenbergii)*, of which the prawn's share was around a quarter, with a total export value of approximately $380million (DOF, 2010).

Freshwater prawn farming in Bangladesh first started in the southwest region during the early 1970s (Mazid, 1994). A few well-off local farmers in the Fakirhat area of Bagerhat district began to experiment with stocking prawn post-larvae in carp ponds during 1978. These innovators experimented with construction design, feeding, stocking and other technical aspects (Kendrick, 1994). Later on, sometime between the late 1970s and the mid 1980s, a few innovative farmers developed the prawn cultivation system in rice fields in low lying agricultural land. In the late 1980s, this farming practice began to be adopted widely in the original location in the Fakirhat area, where prawns were grown along with carps and rice in ghers (Kamp and Brand, 1994; Kendrick, 1994).

Most shrimp culture activities are carried out in ghers located on land protected from the sea by polders (very large dikes). The diked brackish water region is normally suitable for one crop of transplanted aman paddy during August–December, when the water and soil salinities are low. Freshwater for irrigation is not available in coastal areas since both surface water and ground water are saline during the dry months. Agricultural crop production during January–July is difficult, and the soil is acidic in many places. When exposed to the sun, the soil acidity increases further, reducing soil productivity. Instead of keeping the land fallow during the high salinity period, many farmers find it profitable to utilize the low-lying and adequately submerged lands for shrimp and fish farming. Thus, many tidal flood plains are used for agriculture during the wet months and aquaculture during the dry months. Table 1.12 presents data on the number and area of shrimp and prawn ghers in each of the major districts where gher culture takes place.

Shrimp ghers are usually connected with estuaries and canals by sluice gates which allow farmers to manage the flow of brackish or tidal water. In the months of February to April, tidal waters carry shrimp post larvae (PL) into ghers at high tide. These are trapped inside the gher by bamboo barriers placed at the gates. Trapping wild seed, as practiced in the initial stages of shrimp culture in Bangladesh, has been largely replaced by artificial stocking of PL, either collected from the wild or produced in hatcheries. Similarly, prawn PL are collected from both natural sources and hatcheries. Shrimp are usually grown from March to June, whereas prawn fry generally take eight months to reach marketable size. Farmers generally harvest shrimp more frequently than prawn.

Table 1.12 Number and area of shrimp and prawn gher by district, May 2010. (Source: unpublished DOF data, 2010)

	Tiger shrimp			Freshwater prawn			All	
District	No. ghers	Area (ha)	Average size	No. ghers	Area (ha)	Average size	No. ghers	Area (ha)
Khulna	20,616	35,850	1.74	29,515	13,006	0.44	50,131	48,856
Satkhira	33,285	58,680	1.76	7,753	7,203	0.93	41,038	65,882
Bagerhat	30,047	46,923	1.56	37,855	18,023	0.48	67,902	64,946
Jessore	954	825	0.86	14,070	14,479	1.03	15,024	15,304
Narail	0	0	0	5,158	2,198	0.43	5,158	2,198
Gopalgonj	0	0	0	3,494	1,340	0.36	3,494	1,340
Cox's Bazar	4,546	45,768	13.7	0	0	0	4,546	45,768
Total	89,448	188,046	2.10	97,845	56,248	0.57	187,293	244,294

Brackish water aquaculture is widespread throughout Satkhira, Khulna, Bagerhat and Cox's Bazar districts. Black tiger shrimp (known as *bagda*) and giant freshwater prawn (known as *golda*) are the two major species cultivated in these areas. Golda is largely produced in the southwest of the country. The total land under shrimp and prawn production is 244,294 ha of which approximately 75% is under shrimp cultivation. However, the smaller average size of prawn ghers (0.57 ha) compared to shrimp ghers (2.10 ha) means that prawn farms are more numerous. The largest concentration of shrimp and prawn farms is found in the greater Khulna region-Khulna, Satkhira and Bagerhat districts (Table 1.12).

Although gher farming is often conceived of as two distinct types (brackish water shrimp farming, and freshwater prawn farming), in practice farmers often stock shrimp, prawn and white fish in the same system (Ahmed et al., 2002; Barman et al., 2004). These mixed farming systems undergo seasonal changes in salinity regimes. A high saline period occurs from January to July. During this time brackish water shrimp and euryhaline fish species are cultured and harvested. A period of lower salinity occurs from August to December, during which freshwater fish and prawn may be grown together with brackish water fish species and/or shrimp. Slightly salt-tolerant transplanted aman paddy may also be cultivated in the elevated parts of the fields.

Shrimp farming can also be grouped into three categories based on the level of intensity:

a. Extensive culture: shrimp depend entirely on naturally produced organisms in the ponds for their growth;
b. Improved extensive or semi-intensive culture: depends on both natural food and the application of fertilizer to the pond water, and sometimes supplementary feeds are also given to enhance the growth rate;
c. Intensive culture: depends entirely on artificial feeds and utilizes intensive management practices, i.e., aeration, draining of water between cycles, adjustments to water quality.

The majority of shrimp farms in the coastal region of Bangladesh however, follow extensive culture practices, relying mainly on natural productivity, with little or no management in respect of drying the gher bottom, plowing, liming, fertilization and feeding. The PL stocking density ranges from 0.2-1.5 PL/m^2 and annual yields of shrimp are in the order of 160-230 kg/ha. The improved extensive method is a slight modification of the traditional system, whereby farmers stock at a density of 1-2.5 PL/m^2 and an annual yield of 350-500kg is obtained. The semi-intensive method requires practices which include heavy feeding, removal of waste, installation of an aeration system and high stocking densities (5-10 PL/m^2). Annual yields in this system range from 500-5,000kg/ha, with an average of 2,000kg/ha, but it is investment intensive and remains very rare in Bangladesh.

Table 1.13 Types of gher farming systems based on species combination and integration with agriculture.

System type	Species combination
Monoculture	Only shrimp cultured
Shrimp and paddy (gher) culture	Shrimp—February to August
	Paddy—August to January
	Paddy and shrimp sometimes cultured together (February to June)
Shrimp and salt culture	Salt—January to March
	Shrimp—March to November
Shrimp and prawn gher culture with paddy and fish	Shrimp—in dry season (Feb to Aug)
	Prawn (golda)—July to January
	Carp and paddy culture integrated with shrimp and prawn

The following section summarizes the findings of the baseline survey of *Greater Harvest and Economic Returns from Shrimp* project, funded by USAID as part of its PRICE program. This was carried out with 369 gher farming households from June to July 2010 in three districts (Bagerhat, Khulna and Satkhira) of Khulna division. Surveyed households were categorized into seven different groups based on the cropping patterns of the farming systems adopted by the households.

The mean size of the ghers was 1.0 ha, ranging from 0.51 ha to 1.2 ha. The mean size of relatively more integrated ghers was somewhat smaller than that of ghers integrated with fewer agricultural components (Table 1.14). The overall average production of bagda, golda, white fish and *harina* shrimp *(Metapenaeus monoceros)* from a 1 ha gher was 202kg, 69kg, 264kg and 66kg respectively (Table 1.15). In addition, farmers gained a per hectare yield of 3.2 t of rice and 1.06 t of vegetable from the same system.

Table 1.14 Gher size by cropping patterns followed by shrimp farmers. (Figures in parentheses are standard deviations)

Cropping patterns	Farm size	Area leased in	Area leased out
Bagda (n=10)	0.93 (0.49)	0.15 (0.25)	0.00 (0.00)
Bagda+Golda (n=15)	1.10 (0.80)	0.12 (0.25)	0.02 (0.07)
Bagda+White fish (n=91)	1.14 (1.33)	0.46 (0.68)	0.32 (0.76)
Bagda+Golda+White fish (n=153)	1.07 (1.18)	0.44 (0.79)	0.19 (0.68)
Bagda+White fish+Rice (n=8)	1.64 (1.28)	0.49 (0.93)	0.00 (0.00)
Bagda+White fish+Vegetables (n=9)	1.47 (2.88)	0.04 (0.08)	0.31 (0.68)
Bagda+Golda+White fish+Rice (n=35)	1.27 (1.03)	0.59 (1.02)	0.01 (0.03)
Bagda+Golda+White fish+Vegetables (n=30)	0.80 (0.68)	0.12 (0.23)	0.08 (0.15)
Bagda+White fish+Golda+Rice+Vegetables (n=16)	0.67 (0.41)	0.26 (0.31)	0.04 (0.10)
Total (n=367)	1.09 (1.19)	0.40 (0.72)	0.18 (0.60)

Table 1.15 Per hectare production of shrimp, fish, rice and dike crops (kg/ha/year).

Cropping patterns	Bagda	Golda	Fish	Harina	Rice	Vegetables
Bagda (n=10)	437			5		
Bagda+Golda (n=15)	137	69		28		
Bagda+White fish (n=91)	235		247	62		
Bagda+Golda+White fish (n=153)	211	67	285	83		
Bagda+White fish+Rice (n=8)	124		151	36	3939	
Bagda+White fish+Vegetables (n=9)	226		163			604
Bagda+Golda+White fish+Rice (n=35)	156	54	265	46	2720	
Bagda+Golda+White fish+Vegetables (n=30)	130	86	278	80		981
Bagda+White fish+Golda+Rice+Vegetables (n=16)	108	91	257	52	4066	1448
Total (n=367)	202	69	264	66	3250	1055

Table 1.16 Cost, return and gross margin of shrimp farming (US$/ha/year).

Cropping patterns	Seed cost	Operating cost	Labor cost	Total variable cost	Total return	Gross margin
Bagda (n=10)	384	753	181	1370	2648	1278
Bagda+Golda (n=15)	343	408	238	1028	1411	382
Bagda+White fish (n=91)	583	152	417	1197	1784	587
Bagda+Golda+White fish (n=153)	747	403	418	1630	2073	443
Bagda+White fish+Rice (n=8)	420	157	192	800	1399	600
Bagda+White fish+Vegetables (n=9)	492	147	269	945	1616	672
Bagda+Golda+White fish+Rice (n=35)	684	368	286	1392	1955	563
Bagda+Golda+White fish+Vegetables (n=30)	734	711	458	1980	2013	33
Bagda+White fish+Golda+Rice+Vegetables (n=16)	633	819	563	2096	2229	134
Total (n=367)	655	379	392	1482	1955	472

Yields of white fish and unstocked harina shrimp were similar across most systems. Production of bagda and golda varied among the groups, however. Highest production of bagda was obtained by households who focused on this species, followed by households producing golda with bagda. Bagda production was similar amongst all other categories of gher, and in all cases production of bagda was higher than production of golda.

The mean production cost, gross return and gross margin per hectare across all categories of farm were $1,482, $1,955 and $472 respectively (Table 1.16). The highest economic gain in terms of gross return and gross margin was obtained by households growing only bagda. Households raising golda, golda plus vegetables, and golda plus rice and bagda gained a similar level of income, followed by the remaining groups.

The shrimp sector in Bangladesh is expanding and provides significant economic opportunities for those actors controlling each node of the value chain, in addition to numerous lower value livelihood opportunities for the rural poor who represent the overwhelming majority of value chain participants. Shrimp and prawn are farmed using both wild and hatchery-produced PL. A large variety and number of intermediaries are involved in the production and supply of PL to farms. Upon harvest, shrimp and prawn are sold on through a range of other intermediaries who distribute them to processors and exporters. The sector is thought to support the livelihoods of more than 600,000 people including farmers and service providers such as traders and processors (USAID, 2006).

However, the value chain is a buyer-driven one in which producers, particularly small producers, have little ability to influence the price at which they sell their product. They are frequently locked into contracts that limit the price they receive when compared with prices that they could freely obtain in spot markets or with buyers elsewhere. In Bangladesh, suppliers such as PL catchers and small farmers tend to be dependent on larger, dominant buyers, or are locked into contracts where they must sell to particular buyers. Intermediaries such as PL *faria* (collectors) and *aratdar* (auctioneers) and shrimp faria and aratdar inject informal credit into the system and engage with suppliers and farmers setting the terms of exchange. Furthermore, barriers to entry, poor infrastructure, inadequate communications, and significant transaction and transport costs limit the markets where producers and traders sell. The types of exchange observed along the shrimp value chain are indicative of unequal bargaining power at a number of key points: fry catching and sale, small-farmer shrimp production and sale, and even consolidation in the depots (USAID, 2006; Islam, 2008a).

Several other issues are also of concern. Shrimp are often affected by White Spot Disease (WSD) caused by the white spot virus, now commonly referred to as White Spot Syndrome Virus (WSSV). This has been responsible for major losses in the sub-sector since 1993, and is regarded as the major constraint to the sustainability and further expansion of the shrimp sub-sector in the country (Karim et al., 2011). There is potential for water logging and increased salinity levels to alter drainage patterns and soil quality. The use of fine seine nets to sieve for shrimp larvae from the wild for cultivation has been associated with the decline of wild fish populations (Deb, 1998).

Mud snails are also harvested in large quantities to be used as feed for prawn production, with direct, but poorly understood impacts on the ecology of the areas from which they are harvested. Social and human rights concerns have been documented where land has been annexed for shrimp farming and where communities and activists organizing against shrimp production have been the targets of repression, although these problems may have been more acute during the early stages of the shrimp boom than at present. There are also concerns about terms and conditions of employment in processing factories, depots and on boats (Ito, 2002, 2004; Islam, 2008b, 2009).

The European Union (EU) has a number of extremely strict criteria governing permissible levels for a large range of substances, and Bangladeshi shrimp exports suffered a major setback in 2009 following the repeated detection of nitrofuran compounds in several consignments. The export of shrimp resumed on 12 June 2010 after a self-imposed ban of over seven months. In May 2009 Bangladesh also halted the export of freshwater prawn to the EU after 54 consignments were rejected between late 2008 and early 2009 due to an EU 'rapid alert' notice. Hatcheries, feeds and feed ingredients (including local sun-dried fish) and organic fertilizers (cow dung and poultry manure) have all been identified as possible sources of nitrofuran contamination. Bangladesh resumed exports to the EU following the self-imposed eight month ban. Central lab facilities for detection of nitrofurans and other contaminants have since been established.

Increasingly strict international standards for aquaculture products, including certification schemes being adopted by the major global buyers, suggest that Bangladesh will have to address issues pertaining to product quality as well as to social and environmental conditions of production sooner rather than later if it is to make the best out of the development potential associated with the sector. This represents a major challenge however, given the very large number of small farmers and other up and downstream value chain actors involved in the sector, and its weak governance conditions.

Harvesting a prawn gher in Bagerhat. (Photo: Ben Belton)

Shrimp ghers, Satkhira. (Photo: Ben Belton)

1.6 GENDER AND PRODUCTION

This section explores the extent and implications of women's participation in aquaculture and explores the outcomes of attempts by some projects to secure women's involvement in the activity. In Bangladesh, movement of women outside the homestead is circumscribed by the ideal of *purdah*, which limits their appearance in the public sphere, although this is becoming less rigidly adhered to over time and is frequently contravened by very poor women due to economic imperatives. Although Muslim women possess legal property rights (though inheriting only half the share of land of their male siblings) this is not actively exercised in many cases. Independent movement beyond the homestead and control over productive assets is therefore heavily curtailed for much of the female population (White, 1992).

Some commentators have observed that fish culture offers opportunities for women, in part because ponds are often constructed adjacent to the homestead where fish culture can be pursued as an addition to activities such as kitchen gardening and livestock rearing in which women routinely engage (Shelly and D'Costa, 2001). However, several studies indicate that under normal circumstances there is a marked gender division of labor with respect to the activities carried out by men and women, with women's sphere of participation in fish culture is predominantly restricted to feeding and fertilizing ponds (Barman et al., 2002a; Barman, 2001; ADB, 2004). Women's use of manure and feed is in part related to their involvement in livestock rearing and their management of rice bran or kitchen waste as part of their post-harvest or household activities (Barman, 2001). The type and extent of female participation in homestead pond culture is indicated in Tables 1.17 and 1.18.

Table 1.17 Participation of household members in fish culture activities. (Source: Barman, 2001)

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	4	71	-	25

Table 1.18 Gender roles in fish farming activities in Kishoreganj (n=100). (Source: ADB, 2004)

Activity	Only male (%)	Only female (%)	Shared (%)	No response (%)
Pond preparation	90	0	1	9
Fingerling procurement	100	0	0	0
Feed procurement	88	0	12	0
Fertilizer procurement	90	0	10	0
Applying fertilizer	85	0	15	0
Feeding fish	61	2	37	0
Harvesting fish	99	0	1	0
Grading fish	93	0	3	4
Marketing fish	100	0	0	0

Partly in response to the apparent potential for women to participate in the activity, numerous projects designed to promote aquaculture have sought to include women as participants. This includes government implemented projects, for which there is a target of 20–30% of all beneficiaries to be women. The success of such efforts has been variable. ADB (2004) reports that its Command Area Development Project, which established 175 groups of 10-15 poor women and trained them, secured leases on private ponds and provided microcredit for operational costs, to have been successful in generating good average yields of 3.7 t/ha and annual returns of at least Tk8,000 per groupmember. It is not known however, whether these groups proved self-sustaining once project support ended. The IFAD funded Aquaculture Development Project which operated along similar lines reported that 'pond aquaculture is an appropriate entry point for empowerment of women. A combination of training and credit has enabled women to establish managerial control over pond fish aquaculture, even though the pond remains in the ownership of their husbands' (IFAD, 2006, p. vi).

However, a component of another IFAD project, the Oxbow Lakes Project, which attempted the rather more ambitious intervention of establishing user rights to new purposely constructed ponds on behalf of women's groups, faced difficulties. More powerful groups of men (local elites and organized fishers) contested these women's legitimate claims over the ponds and attempted to seize control for themselves. In a number of cases it proved possible to successfully establish women's legal rights to the ponds with support from various project organizations, resulting in an 'improvement in women's status consequent to their higher income-earning capacity' as they earned US$55 to 70 each per year from the ponds. However, even in instances where rights were initially recognized the women's groups often proved unable to resist the moves of the more powerful groups of males, which were often bound up with the dynamics of local party politics (Nathan and Apu, 2002). However, such events are by no means unique to women's groups. CARE (2004) reports on several examples of mixed gender groups whose project-facilitated access to *khas* ponds was ultimately lost.

Table 1.19 Proportion of female employment in different key nodes of shrimp aquaculture. (Source: modified from Islam, 2008b)

Value chain node	Women's involvement (% of total)
Collection of wild PL	70
Labor in shrimp ponds (e.g., embankment, weeding)	40
Management in processing centers	1
Casual jobs in processing factories (e.g., de-heading, counting, peeling)	80
Food processing, snail collection, snail breaking for freshwater prawn	80
Shrimp pond owners/farmers	1–2
Shrimp business (e.g., trading, contractors, middlemen)	3–4

There is a high degree of female participation in the value chains associated with the shrimp sector of Bangladesh. This is concentrated mainly in PL collection and processing factories (Table 1.19). In addition to being flexible (part-time, temporary, casual), much of this employment is also informal, without an employment contract or its associated rights (Islam, 2008b), though this in part reflects the highly seasonal nature of shrimp production and irregularity of supply to processors. Halim (2004) notes that women receive a lower wage compared to their male counterparts for all activities related to shrimp production, though this is normal in all sectors of the economy in Bangladesh. Halim also notes that poor women engaged in harvesting PL and working as labor on shrimp farms are vulnerable to exploitation and sexual harassment, and 'see employment in shrimp as the only resort in a no-choice situation where opportunities for productive engagements are scarce' (p. 99). Conversely however, Hamid and Alauddin (1998) state that the ability of women in southern Bangladesh to access such work has 'saved many rural landless poor families from starvation and hunger' (p. 330).

The total numbers employed are quite large. It is estimated that more than 20,000 women work in shrimp processing factories at present (Islam, 2008b); 55,000 women were employed in the PL fishery in 1995. Given this rather ambiguous picture it is unclear whether the greater employment opportunities for rural women associated with shrimp aquaculture have empowered them, have exposed them to new forms of exploitation, or both.

Female workers in a shrimp processing factory, Khulna. (Photo: Ben Belton)

2. INPUTS

This chapter addresses the production and use of two key inputs for fish culture: seed and feed.

2.1 SEED

2.1.1 CARP SEED

Rapid development of private sector hatcheries and nurseries has followed initial investments in the public sector and has been perhaps the single most decisive factor in the expansion of aquaculture in Bangladesh. Hatcheries and nurseries initially developed in four major clusters in Jessore, Bogra, Mymensingh and Comilla, close to government fisheries stations or where nursing of wild riverine seed was a traditional activity. They have subsequently become established throughout the country as technicians from these centers have been employed to set up new operations or have established their own.

This geographical expansion within the sector along with rapidly improving transport and communications has broken down the monopolistic relationships between wholesalers and small traders described by Lewis et al. (1996) in their classic *Trading the Silver Seed*. The advent of mobile phone communication has also made it possible for itinerant fry traders to communicate directly with customers in advance, substantially reducing the element of risk involved, and as rural incomes have increased these traders increasingly move seed by bicycle or even by motor vehicle, rather than on foot as in the past.

ADB (2004) notes that seed traders build and maintain strong networks of relationships with client farmers and owners of hatcheries and nurseries, providing a critical link between seed producers and fish farmers. They often operate with very limited working capital, taking short-term renewable loans of several days from hatchery owners, rather than paying cash in advance each time they obtain seed. For many, seed trading is a secondary rather than primary occupation, and is seasonal, with the peak trading season running from March-July but extending up to September and October, reflecting water availability and temperature regimes. ADB (2004) reports that individual traders typically sell between 1,000 and 2,000 fingerlings per day (averaging 1,360) with net incomes of Tk136-275, and those surveyed reported seed trading to have improved their socioeconomic conditions.

This summary is largely consistent with our observations in the field, with small traders typically selling seed to several customers each day within a radius of roughly ten kilometers. Barman et al. (2002b) note that almost 70% of farmers purchase fingerlings from fry traders at the pond side, and we assume that the majority of seed used for stocking homestead ponds continues to be distributed via traders in this manner, although where nurseries are conveniently located homestead pond owners may buy seed directly. Because large quantities of seed are required for entrepreneurial operations these are purchased directly from producers or via commission agents rather than through small traders.

Currently 98% of fish seed is produced by private hatcheries (WorldFish, 2010). Unpublished DOF statistics list 802 fish hatcheries in Bangladesh (it is now a legal requirement that hatcheries are registered with the Department), with the capacity to produce 818 t of hatchlings per year and an actual output of 487 t of hatchlings in 2009 (59% of capacity) (DOF, 2009b). No figures for numbers of nurseries exist but they may be assumed to number well in excess of 10,000. According to Barman et al. (2002b) nursery operators normally nurse eight or nine fish species. The vast majority of hatcheries produce carps but may also produce additional species such as catfishes and climbing perch. A smaller number specialize exclusively in the production of monosex tilapia (see Section 2.1.3). Non-availability of hatchery produced fish seed is no longer considered a major problem, although at certain times of the year (e.g., the end of the cool season, or following the recession of flood waters) the demand may sometimes exceed local supply, particularly for large sized seed.

Although the quantity of seed supply is now generally adequate there is much concern relating to the quality of seed produced, particularly that of carps. Rajts et al. (2002, p. 101) state for instance that improper hatchery management has resulted in declines in genetic quality of endemic and exotic fish populations for the following reasons:

(i) proper selection of breeders has not been maintained;
(ii) closely related and small stocks have been repeatedly used generation after generation resulting in inbreeding, genetic drift and reduced resistance to diseases;
(iii) negative selection was made for smaller size at sexual maturation;
(iv) failure to follow selection criteria for improved varieties of Mirror carp and GIFT tilapia resulted in loss of improved performance; and
(v) hazardous hybridizations were made resulting in genetic introgression of several species.

Dey et al. (2010) also note that hatcheries in Bangladesh face problems related to the poor selection of broodstock, indiscriminate hybridization and inbreeding, though Little (2006) contends that the extent of inbreeding commonly reported has not been substantiated by analyses of broodfish management practices. Furthermore, it is not always clear whether poor performance of fish seed is due to the genetic quality itself or results from inadequate management by grow-out farmers or poor handling by traders (Barman et al., 2002b).

Figure 2.1 A mirror carp, a mirror carp X catla hybrid, and a catla, photographed in a Mymensingh fish market. (Photo: Ben Belton)

Interspecific hybridization, whether deliberate or unintentional, is commonplace however, as Figure 2.1 showing a mirror carp (top), catla (bottom) and hybrid of the two (middle) attests. Mia et al. (2005) reported that nearly 8.3% of silver carp broodfish obtained from a sample of hatcheries in Bangladesh were hybridized with bighead carp to some degree. Rajts et al. (2002) note that hybrids of these two species possess an intermediate number of gill rakers and an intermediate length of digestive tube, meaning that they cannot feed on smaller phytoplankton as a pure silver carp would, and consume more zooplankton, thus resulting in stronger competition with catla in comparison to pure silver carp. They conclude that the potential productivity forgone probably equates to a substantial economic loss, given the importance of both silver carp and catla to aquaculture in Bangladesh. The same authors also note that the mass release of hatchery produced endemic species into natural water bodies for fisheries enhancement may have detrimental effects on the gene pool of wild stocks, particularly if the domesticated stocks are genetically degraded.

To date there have been only limited attempts to actively improve the quality of carp seed in Bangladesh[3]. Hussain et al. (2002) report on efforts to develop an improved strain of silver barb at BFRI, which showed increases in growth and weight gain over non-selected control fish, but the current status of this program is unclear. An improved strain of rohu called *'jayanti'* has been developed by the Indian government, but to date attempts to import stocks of the fish through official channels have been unsuccessful.

The recent decision of DOF to register all hatcheries may eventually pave the way for implementation of a licensing system based on certification of their adherence to best practices and may thus help to improve the genetic quality of seed produced. WorldFish (2010) reports that hatcheries with a reputation for producing better quality seed experience very high customer demand and are able to obtain a premium for the spawn they produce, suggesting that economic incentives for good hatchery management do exist.

2.1.2 PANGASIUS SEED

According to DOF statistics, 174 hatcheries in 14 districts (out of the 802 registered in Bangladesh) produce pangasius seed. Anwar (2011) reports slightly higher figures: 217 hatcheries in 17 districts. The majority of pangasius seed production takes place in Bogra (particularly in Adamdighi union, where the first private pangasius hatchery was established in 1995) (Table 2.1). Bogra is generally held to produce the highest quality pangasius seed in the country, and many pangasius nurseries and farms located in Mymensingh use seed originating from Adamdighi. Ali et al. (forthcoming) report annual production of pangasius hatchlings in Bogra totals approximately 60,000kg. Anwar (2011) reports a lower figure for production from hatcheries in Bogra (24,130kg) and, largely as a result, somewhat lower total production of pangasius hatchlings (66,628kg as opposed to 89,879kg).

Table 2.2 indicates the distribution of pangasius fingerlings originating from Bogra to other districts of Bangladesh (note that these figures do not include hatchlings, many of which are distributed to Mymensingh and other districts for nursing). Ali et al. (2010) report that 80% of pangasius fingerlings produced in Adamdighi are exported to India through Hilli and Jessore. The remaining 20% is distributed throughout Bangladesh through five or six agents; 30% to Mymensingh, and 70% to other regions of Bangladesh.

A comparison of Table 2.2 and Table 2.1 reveals that many of the districts where there is some production of pangasius seed are also importers of pangasius fingerlings from Bogra, suggesting local demand from grow-out farmers. This seems to imply either that the local availability of pangasius seed stimulates uptake of the fish's culture among grow-out farmers, or that demand for seed from established pangasius farms has encouraged hatcheries nearby to take up production in response or, perhaps, that both scenarios occur.

3. A major USAID funded investment beginning in late 2011 should go some way towards remedying this situation.

Table 2.1 Number of pangasius hatchery locations and output by district. (Source: Ali et al., forthcoming)

District	No. hatcheries producing pangasius	Quantity of hatchlings produced (kg)
Mymensingh	50	16,800
Jamalpur	1	150
Kishoreganj	4	350
Narsingdi	1	200
Comilla	49	4,941
Brahmanbaria	6	220
Chandpur	2	10
Feni	2	95
Jessore	15	3,293
Naogaon	15	3,334
Dinajpur	1	130
Barisal	1	6
Bhola	2	350
Bogra	87	60,000
Total	**174**	**89,879**

Table 2.2 Distribution of pangasius fingerlings originating from Bogra to other districts. (Source: Ali, 2010)

District	% fingerlings distributed to each district
Mymensingh	23
Kishoreganj	3
Narsingdi	13
Comilla	4
Brahmanbaria	4
Naogaon	12
Sylhet	4
Maulvi bazar	4
Pabna	4
Chittagong	4
Netrokona	3
Others	20

2.1.3 TILAPIA SEED

Mixed-sex tilapia seed is not widely available from hatcheries and nurseries on a commercial basis, but tilapia are present in many rural areas where self sustaining populations reproduce in homestead ponds and ditches. Several projects in northwest Bangladesh (most recently the DFID funded Enhancing the Impacts of Decentralised Fish Seed Project) have promoted the use of rice fields as nurseries for tilapia seed in order to enhance the availability of tilapia seed in remote areas and provide additional incomes to adopting families (Haque et al., 2010).

Edwards and Karim, writing in 2007, report that sex-reversed tilapia fingerlings are produced by about 30 hatcheries in Bangladesh. However, numbers have increased dramatically since this time. Most hatcheries are fairly small and probably produce seed of inconsistent quality (i.e., less than 98% male fish), although a number of joint ventures and direct investments by foreign operators have been initiated, including one from Thailand's CP group. Whilst under normal circumstances it might be assumed that such competition would eventually drive up standards throughout the industry, the typical marketable size of tilapia produced in Bangladesh of around 200g means that in many cases commercially produced fish are harvested before precocious breeding significantly slows growth rates and performance. This may mean that the differences in the performance between tilapia from hatcheries obtaining differing rates of sex reversal may not become fully apparent within the production cycle.

Table 2.3 Monthly output of fry from tilapia hatcheries in Bangladesh. (Source: modified from Bhujel, 2008)

Hatchery name	Location	Year established	Production (million fry/month)
Niribili Hatchery	Cox's Bazar	2003	1.6
United Aqua	Cox's Bazar	1999	3.8
Allah Walla Hatchery	Cox's Bazar	2003	0.8-0.9
Cox's Bazar Hatchery	Cox's Bazar	-	0.6-0.8
Chittagong Fisheries	Chittagong	2004	0.8
Jubin Agro Based Industry	Noakhali	2007	0.37
Chitralada Aquapark	Pabna	2007	1
Pioneer Tilapia Hatchery	Chandpur	2006	0.7-0.8
Rahman Agro Fisheries	Sathia	2006	0.8
Bangla Fishgen	Gazipur	2005	0.25
Midway Scientific Fisheries Ltd	Cox's Bazar	2003	0.8
Testy Super Hybrid Monosex Tilapia	Jamalpur	2005	2.5
Nobarun Hatchery	Tangail	2004	1.6
Reliance Aquafarm	Mymensingh	2004	4
Agro-3 Fisheries	Mymensingh	2005	1

Bhujel (2008) gives figures for the monthly production of monosex tilapia fry from 15 hatcheries in Bangladesh (Table 2.3). However, as Table 2.4 indicates, there are now a great many more monosex hatcheries established, with some observers suggesting that the figure exceeds even the 191 indentified by Anwar (2011). Assuming a post-stocking survival rate of 50% for the 1,430.4 million fry recorded as annual production in Table 2.4, and an average individual weight of 200g at harvest, this would imply total production of tilapia of approximately 143,040 t. However, this figure should be treated with caution as it appears excessively high when triangulation with data from other sources is attempted (e.g., Section 2.2).

The improved GIFT strain of tilapia was introduced to Bangladesh in 1994. On-farm pond trials conducted by BFRI in 1995–1996 indicated that GIFT were on average 58% superior to locally available Nile tilapia in terms of growth (ADB, 2005). However, the extent of impacts on performance at the farmer level is unclear, and BFRI's subsequent role in maintaining, improving and distributing GIFT broodfish appears to have been limited. In any case, the private sector may have negated the need for the public sector to perform the function to some extent, with a number of monosex tilapia hatcheries importing high quality GIFT broodstock from Thailand and elsewhere.

Table 2.4 Location and output of tilapia hatcheries in Bangladesh. (Anwar, 2011)

District	No. of Hatcheries	Seed Production (million)
Brahmanbaria	2	12
Chandpur	7	52
Chittagong	8	63
Comilla	32	171.8
Cox's Bazar	13	318
Feni	1	20
Lakshmipur	2	7.1
Noakhali	12	70
Rangamati	1	3
Barishal	2	12
Patuakhali	3	11
Rajshahi	3	12
Bogra	2	11
Natore	2	10
Pabna	3	35
Gaibanda	1	4
Rangpur	2	24
Tangail	3	23
Sherpur	1	2.7
Dhaka	8	44
Faridpur	2	7
Gazipur	4	24
Jamalpur	6	43.2
Keshorgonj	2	9
Manikgonj	1	3
Mymensingh	39	268
Netrokona	3	12.5
Jessore	11	50.2
Magura	2	24.8
Narail	1	0.1
Satkhira	8	67
Bagerhat	2	7
Sylhet	2	9
Total	**191**	**1,430.4**

Fish seed trader, northwest Bangladesh. (Photo: Ben Belton)

2.2 FEED

'Raw' unformulated feeds-most importantly rice bran and, to a lesser degree, mustard oil cake-are widely used throughout Bangladesh in homestead aquaculture. In some cases these feeds may be derived from on-farm sources, but are more frequently purchased in local markets and are usually of domestic (rather than imported) origin. Barman and Karim (2007) calculate that around 80,000 tonnes of raw feeds are used annually in homestead pond grow-out in Bangladesh on the basis of the assumption that 100kg is required to produce one tonne of carps in improved-extensive systems (the remainder of fish nutrition being derived from natural feeds produced in situ through pond fertilization). The authors estimate that another 20,000 t of unprocessed supplementary feed is utilized for nursing seed, amounting to a total 100,000 t. However, as discussed in section 1.1, use of supplementary feeds, organic fertilizers such as cow dung and compost and manufactured inorganic fertilizers in homestead pond culture remains rather patchy. This is indicated by the high proportion of operating costs accounted for by seed in homestead ponds, as opposed to semi-intensive and intensive systems for which feed represents the major portion of variable costs.

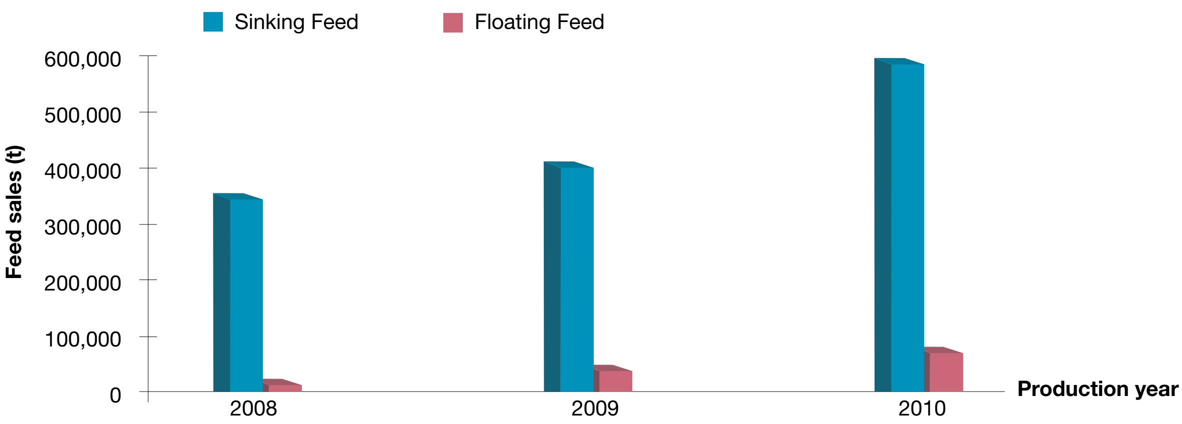

Figure 2.2 Sales of formulated fish feeds in Bangladesh by leading manufacturers. (Source: Amin Sarker, 2011)

The remainder of this section focuses primarily on the use of pelleted feeds in entrepreneurial pond culture. Production of formulated fish feeds in Bangladesh began following the establishment of the poultry sector as feed producing companies sought to diversify their markets. The poultry sector remains the dominant user of compound feed in Bangladesh absorbing an estimated 3 million tonnes in 2009 compared to 0.45 million tonnes of fish and shrimp feed (pers. comm. Amin Sarker).

Table 2.5 Production of sinking and floating fish feeds (t) in Bangladesh 2008-2010. (Amin Sarker, 2011)

Company Name	2008		2009		2010	
	Sinking	Floating	Sinking	Floating	Floating	Sinking
ACI-Godrej Agrovet Pvt. Ltd. (S)	25,000	0	30,000	0	40,000	6,000
Aftab Feed (Sinking)	35,000	0	25,000	5,200	45,000	8,000
Agro Industrial Trust	25,000	0	12,175	0	17,500	0
Aleya Feeds Ltd	7,500	0	8,000	0	16,000	0
Aman Feed Ltd	8,000	0	12,000	0	15,000	0
Aqua Feeds	0	3,000	0	5,000	0	6,000
Bengal Feeds	0	0	3,000	0	3,000	0
Bishwas Sinking Feeds	10,000	0	15,000	0	20,000	2,500
BNS Feeds Ltd	1,200	0	1,500	0	6,500	0
BRAC Feeds Marketing	8,000	0	7,000	0	6,000	0
Classic Fish Feeds	3,000	0	2,500	0	300	0
CP Bangladesh Co. Ltd/ CP Feeds Thailand	17,000	0	24,000	7,000	32,000	14,000
Fresh Feeds Ltd	5,500	0	7,000	0	18,000	0
Gausia Fish Feeds Ltd	1,000	0	1,200	0	1,500	0
Jamuna Fish Feed	6,000	0	5,500	0	7,000	0
Lion Feeds Limited	3,000	0	4,000	0	6,000	0
Lucky Feeds Ltd	1,000	0	1,200	0	4,000	0
M M Agha Ltd	1,400	0	1,000	0	2,500	0
Mega-Spectra Sinking Feed/Mega Feeds	0	10,000	0	15,000	10,000	25,000
Mondal Agro	2,500	0	3,000	0	4,000	0
Mono Feeds Mills Ltd	6,000	0	6,500	0	10,000	0
National Feeds Ltd	12,000	0	13,000	0	17,000	0
New Hope Feed Mills	10,000	0	15,000	0	19,000	0
Niribilli Fish Feed	5,000	0	4,000	0	4,500	0
Nourish Fish Feed	8,000	0	5,000	0	9,000	0
Paragon Group (Sinking)	15,000	0	15,000	0	22,000	0
Paragon Feeds	0	0	0	2,000	0	15,000
Premier Fish Feed	5,000	0	4,000	0	5,000	0
Provita Feed Ltd	2,500	0	4,000	0	6,000	0
Quality Feeds Ltd	55,000	0	67,158	0	100,000	0
Rupshi Feeds	0	3,800	0	4,000	0	3,500
Saudi-Bangla Fish Feeds Ltd	25,000	0	28,000	0	33,500	0
Shah Sultan Fish Feeds Ltd	3,000	0	3,500	0	4,000	0
SGS Feeds	0	0	3,000	0	5,000	0
Shushama Feeds Ltd	7,000	0	16,460	0	19,000	0
SMS Feed	5,000	0	4,000	0	10,000	0
Star Feeds Ltd	2,000	0	3,000	0	5,000	0
Sunny Feeds Ltd	6,000	0	9,000	0	5,000	0
Tamim Agro Ltd	5,500	0	14,000	0	30,000	0
Teer Feeds-City Group	8,000	0	24,000	0	30,000	0
Total Feed Production	**340,100**	**16,800**	**401,693**	**38,200**	**588,300**	**80,080**

A report from the World's Poultry Science Association (WAPSA) put fish and shrimp feed production at 0.6 million tonnes in 2008 (Khaleduzzaman and Khandaker, 2009). This is considerably higher than the 0.36 million tonnes reported as produced in 2008 in Figure 2.2 and Table 2.5. However, these lower figures only take into account production from the 40 leading feed mills, and do not include output from around 40-60 smaller mills which were factored into the WAPSA calculation. Combined output from these leading feed mills for 2010 rose to 668,380 t (with an estimated value of around $220 million) reflecting the rapidity with which commercial aquaculture expansion took place over this period.

A key informant estimated that, of this quantity an estimated 60% is pangasius feed, 30% tilapia and 7% shrimp, with 2% used for carp culture and 1% for production of climbing perch. However, it should also be noted that on-farm production of feeds using basic locally manufactured machinery is commonplace on pangasius farms in Mymensingh district, and it is reported by Ali et al. (forthcoming) that 37% of farms in Mymensingh use these farm-made feeds.

Taking the figure of 0.67 million tonnes of fish feed sold in 2010 and assuming an average feed conversion ratio (FCR) of 2, this would seem to indicate approximately 335,000 t of pellet-fed fish produced per annum. This figure excludes fish produced using farm-made pellets, feed from smaller mills, and the additional 10-20% crop of carps produced in pangasius and mono-sex tilapia dominated ponds. This would seem to suggest that perhaps 30% of aquaculture production in Bangladesh now originates from entrepreneurially operated pellet-fed systems. The figure is in line with our calculations in Section 3.2, and suggests that much of the recent gains in aquaculture production have come from the rapid but, thus far under-recognized expansion of intensified pellet-fed aquaculture.

Table 2.6 lists, in order of importance, the districts in Bangladesh where formulated fish feed is used, according to the key informant on whose information this section is based. Information on the species cultured using pelleted feeds and the nature of the culture system is also included in the table. This indicates the growing prevalence of commercial pellet-fed aquaculture in a number of areas of Bangladesh. These observations also coincide with reports on clusters of commercial pangasius and tilapia farms in a number of districts other than Mymensingh, as noted in Section 1.1.2.

Table 2.6 Districts where significant sales of pelleted fish feeds occur, and characteristics of pellet-fed aquaculture in each. (Source: Key informant interview)

Rank	District	Species	Remarks
1	Mymensingh	Pangasius, Tilapia	10-20% carps and tilapia stocked in pangasius dominated ponds to improve water quality and provide extra income; Some tilapia dominated pond culture with 10-20% carps also stocked
2	Comilla	Tilapia	High pellet-fed tilapia production in ponds; Floodplain aquaculture projects also present but use of feed is more limited
3	Chittagong	Tilapia	Tilapia polyculture in ponds and water bodies created by damming streams
4	Chandpur	Tilapia, pangasius	Tilapia culture mainly in ponds and some cage culture. Some pangasius produced here and sent to Dhaka
5	Bogra	Pangasius, Tilapia	Mainly pangasius culture, some tilapia also stocked
6	Jessore	Carps, pangasius, Tilapia	Pond culture
7	Khulna	Shrimp, carps, pangasius, tilapia	Shrimp and prawn cultured in ghers, carps also stocked; Carps, pangasius, and tilapia also produced in ponds
8	Naogaon, Natore, Rashjahi	Pangasius, carps	Pangasius and carps cultured together at lower densities than in Mymensingh
9	Cox's Bazar	Tilapia, shrimp	Tilapia culture pond; Shrimp culture (substantial by-catch of mullet, sea bass, and crabs from shrimp ponds)
10	Rangpur	Carps, tilapia	Some pellet-fed aquaculture emerging

Fish feed is generally sold through dealerships, with several dealers affiliated to each major manufacturer, operating in upazilas where there is significant demand. The largest companies employ around 450-500 dealers in total, medium sized companies employ 200-300, and mills with only regional coverage typically employ from 20-100. Credit is often extended from dealers to their customers but rarely from manufacturers to either dealers or farmers. Dealers typically offer a list price for feed paid for upfront and negotiate a higher price if credit is extended to the farmer, with the size of the premium charged depending on the amount of feed, the length of time for which it is offered in credit, and the relationship between the two parties. Typically farmers try to avoid taking feed on credit for as long as possible due to the additional costs involved, using the facility toward the end of the grow-out cycle when funds are exhausted and feed costs are highest. The prevalence of taking credit from dealerships for feed varies from region to region but is the commonest in Mymensingh. Farmers unable to repay credit extended by feed dealerships may also have to forfeit their fish in part payment. Four feed companies currently supply mono-sex tilapia fingerlings to their customers along with feed, and a fifth has recently established a hatchery with the intention of doing so, although to date there is little, if any, contract fish farming in the strict sense of the term.

Eighty-eight percent of formulated fish feeds produced by major feed manufacturers are sinking, and the remainder floating (Figure 2.2). Almost all sinking feed is produced locally. At present eight companies sell floating feeds in Bangladesh. Of these, six companies produce the floating feed locally with the other two importing feeds from India and Thailand. However, demand exceeds supply, and a further six companies are in the process of importing extruding equipment with which to begin production of floating feed. Most floating feed (which is considerably more expensive than sinking feed) is used for tilapia culture due to the fish's higher market value relative to that of pangasius (Table 2.7). Although tilapia have lower biological requirements for protein from animal sources than pangasius, feeds for tilapia in Bangladesh have a higher protein content and cost more than those for pangasius.

With the exception of feeds produced by a small number of reputable companies, most brands have a lower crude protein (CP) content than stated on the bag. Table 2.7 gives an indication of the magnitude of the difference for typical finisher and grower feeds. FCRs from sinking feed are variable but tend to be rather high, perhaps reflecting the variable quality of the ingredients used.

Table 2.7 Typical stated and actual crude protein content of floating and sinking tilapia and pangasius feeds in Bangladesh. (Source: Key informant interview)

Item	Pangasius		Tilapia	
	Floating	Sinking	Floating	Sinking
Cost/kg (Tk)	32-34	23	36-47	26
Stated CP (%)	24-26		26-30	
Actual CP (%)	18-20		20-22	
FCR	2.0-2.5		1.6-2.0	

Fish feed production generally takes place from March to November. Cooler water temperatures over the winter period severely curtail demand. The quality of local fishmeal is generally low as it is unsterilized and may contain sand, salt or crab meal. Contamination with large quantities of sand damages milling machinery during processing, and CP is low, ranging from less than 30% to a maximum of 43%. Some manufactures use this low quality local fishmeal for the aroma it imparts to the feed, but more reputable companies avoid its inclusion. There is a domestic source of better quality fish meal with a CP of 44-52% made from *chewa* (mudskipper) produced on Hatia Island, in Noakhali district, but demand exceeds supply and only ten companies are able to utilize fish meal from this source. As a result much of the fish meal used is imported, mainly from China, Malaysia and India. Indian meal tends to be fairly low quality, with a CP content of 43-45%. The quality of meal from other sources is variable. Good quality fishmeal (CP 55-60%) is sometimes available, but adulteration with melamine is thought to be common, and feeding melamine contaminated feeds reportedly led to skin discoloration in some farmed pangasius and tilapia in Bangladesh during 2009. Unadulterated meal is more expensive however, at Tk60-78/kg as opposed to Tk40-45/kg for that containing melamine.

The other major feed ingredients utilized in Bangladesh for compound feeds are meat and bone meal, rice bran, wheat bran, maize, rapeseed meal, mustard oil cake and soy. Meat and bone meal is utilized as a source of cheap protein (52% CP for Tk19-25/kg), and is imported, particularly from the EU. Rice bran is mainly locally produced. Maize originates from both local and imported sources, and rapeseed meal is imported from India, as is much mustard oil cake, which is not generally commercially available in sufficiently large quantities for industrial use. Soy is mainly imported, although around 120,000 t is grown in Bangladesh. It is typically included in sinking fish feeds at around 12%, and in higher proportions in floating feeds. There are currently two solvent extraction mills for soy and a third is planned. Table 2.8 provides further details of the origin and inclusion rates of ingredients commonly used in the manufacture of formulated feeds in Bangladesh.

Table 2.8 Fish feed ingredients used in Bangladesh, typical inclusion rates and country of origin. (Source: modified from Amin Sarker, 2011)

Feed ingredient	Inclusion level (%)	Country of origin
Antibiotics	Irregular	India, China, Singapore, Germany, Netherlands
Antioxidant	0.03-0.2	India, China, UK, Finland
Blood meal	2-5	India, China, New Zealand
Calcium phosphate, dibasic	0.1-0.2	China, Tunisia, Belgium
Calcium phosphate, monobasic	0.1-0.2	China, UK, Tunisia, Belgium
DDGS	1-5	USA
Deoiled rice bran	Up to 25	Bangladesh, India
Fish meal (imported)	Up to 10	China, Malaysia, India, Australia
Fish meal (local) - *chewa*/shrimp/crab/*chanda*	Up to 20	Bangladesh
Fish oil	0.1-0.2	India, Vietnam, Australia
Fish oil (crude)	0.1-0.4	Bangladesh, Vietnam, Australia
Full fat soy	Up to 10	Bangladesh
Growth promoting antibiotics	Irregular	India, China, Singapore, Netherlands
Lysine	0.02-0.1	Thailand, Korea, China, Singapore
Maize	Up to 10	Bangladesh, India
Meat and Bone Meal	Up to 30	EU countries, Croatia, Norway
Methionine	0.02-0.1	Thailand, Korea, China, Singapore, Germany
Mineral and mineral premixes	0.05-0.2	China, India, Singapore, Indonesia, Thailand, Bangladesh
Molasses	Up to 2	Bangladesh
Mold inhibitor	0.02-0.1	India, China, UK, Finland, USA
Mustard oil cake	Up to 15	Bangladesh
Pellet binder	0.05-0.4	China, India, Thailand, UK
Protein concentrate	Irregular	USA, China, KSA, UK
Rapeseed meal (India)	Up to 30	India, Bangladesh
Rice (broken)	Up to 30	Bangladesh
Rice polish	Up to 50	Bangladesh
Salt	0.05-1	Bangladesh
Shrimp shell meal	Irregular	Bangladesh
Soy bean meal	Up to 30	Bangladesh, India, South America, US
Soy oil	0.1-0.3	Bangladesh
Vitamin and vitamin premixes	0.1–0.2	India, China, Singapore, Germany, Netherlands, Thailand
Wheat, bran	Up to 20	Bangladesh, India
Wheat, flour	Up to 15	Bangladesh
Wheat, whole	Up to 20	India, Bangladesh, Ukraine

Trishaw pullers moving feed to a pangasius farm, Mymensingh. (Photo: Ben Belton)

3. ESTIMATED FISH CONSUMPTION AND PRODUCTION

3.1 ESTIMATED FISH CONSUMPTION

Fish is the most important animal source food in Bangladesh, accounting for approximately 66% of total intake (BBS, 2007). Figure 3.1 provides a striking illustration of this. The graph, which is based on raw data extracted from the Household Income and Expenditure Survey 2005, represents the daily frequency of fish and meat consumption over a two week period among all households surveyed. This indicates that approximately 55% of the households surveyed consumed no meat at all during the survey period, and over 85% ate meat on fewer than three occasions during this period. In contrast, 98.5% of households consumed fish on at least one occasion, and 60% ate fish at least every second day. These figures underline the critical and continuing importance of fish to the Bengali diet. However, consumption can vary very substantially depending on income, season and location. This is clearly demonstrated in Table 3.1, taken from Thompson et al. (2002), which provides the most comprehensive review of studies on fish consumption in Bangladesh. This shows reported values for daily per capita consumption ranging from as little as 15g to as high as 96g.

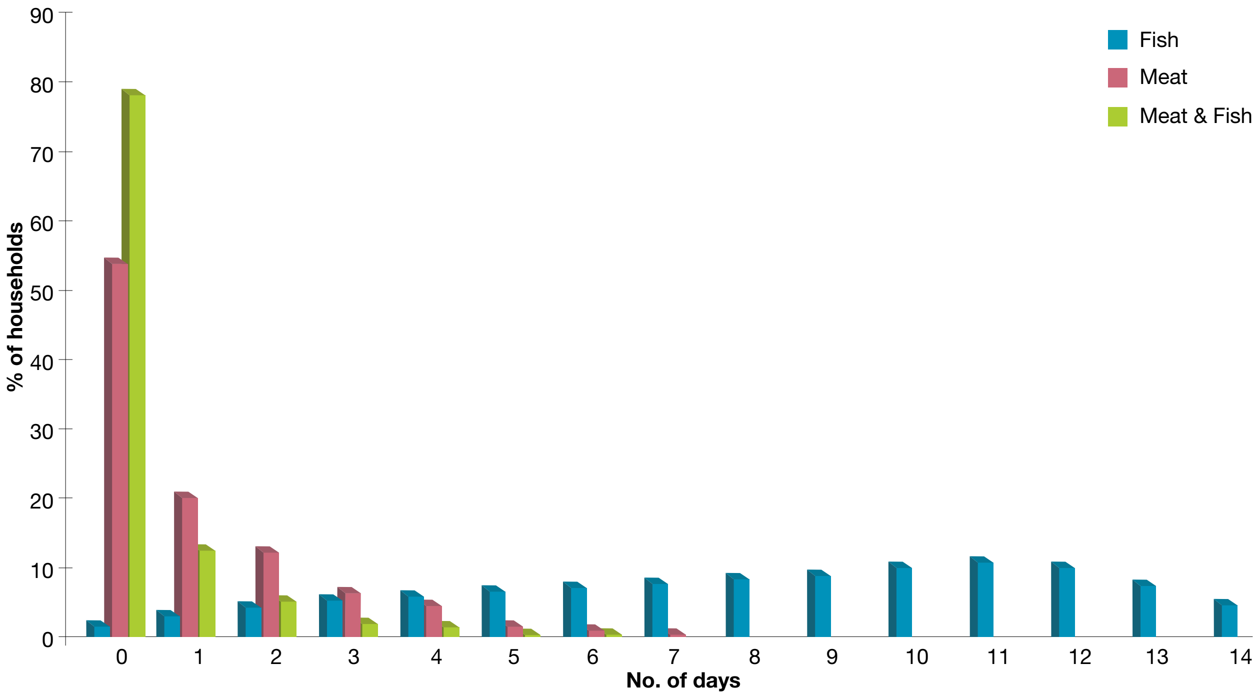

Figure 3.1 Frequency of consumption of food of animal origin (number of days in a two week period). (Source: based on data from BBS, 2007)

Table 3.1 Fish intake in Bangladesh from selected studies. (Thompson et al., 2002)

Location	Year/Season		Small fish Mean, g/capita/day ± SD (median)	Large fish Mean, g/capita/day ± SD (median)	Total fish Mean, g/capita/day ± SD (median)	Method	Reference
Rural Bangladesh	1962-64				28	700 hh, 14 locations, 24 h food weighing	US Department of Health, Education and Welfare, 1966
Rural Bangladesh	1975-76				23	750 hh, 12 locations, 24 hfood weighing	Institute of Nutrition and Food Science,1997
Rural Bangladesh	1981-82				23	600 hh, 12 locations, 24 h food weighing	Ahmad and Hassan, 1983
Tangail	1992				12	520 hh, interview	Minkin et al., 1997
Surma – Kushiya Floodplains	1992				18		
Singra	1992				22		
Matlab	1992				34		
Manikganj	1991-92	Dec-Jan	13±19 (5)	5±14 (0)	18±22 (12)	119 hh, 24 h food weighing	Hels, 1995
Manikganj	1995	Oct-Nov	28±45 (8)	29±51 (0)	57±62 (42)	152 hh, 769 individuals, 24 h food weighing	Tetens et al. (unpublished)
	1996	Jan-Mar	25±47 (0)	12±36 (0)	37±56 (19)	145 hh, 717 individuals, 24 h food weighing	
Kishoreganj	1997	Jul	28±26 (21)	10±17 (5)	37±33 (27)	84 hh, 5 d recall interview	Roos, 2001
	1997	Oct	65±55 (45)	18±25 (7)	82±65 (64)		
	1998	Feb	38±40 (25)	16±18 (12)	55±48 (42)		
Kapasia							
Small farm	1998-99	Aug-Jul			83	20 hh, 84 days 24 h fish weighing	Thompson et al., 2000
Medium farm	1998-99	Aug-Jul			85	36 hh, 84 days 24 h fish weighing	
Large farm	1998-99	Aug-Jul			96	12 hh, 84 days 24 h fish weighing	
Mymensingh	1995	Oct-Nov	14±33 (0)	24±38 (6)	38±47 (25)	152 hh, 765 individuals, 24 h food weighing	Tetens et al. (unpublished)
	1996	Jan-Mar	12±22 (0)	20±34 (0)	32±37 (24)	146 hh, 729 individuals, 24 h food weighing	
Mymensingh							
Low income	1996	Jun-Sep	17±21 (8)	9±18 (0)	26±26 (21)	104 hh, 24 h recall	Bouis et al., 1998
Medium income			22±26 (13)	14±22 (2)	35±31 (30)	104 hh, 24 h recall	
High income			25±34 (11)	17±27 (3)	42±40 (31)	105 hh, 24 h recall	
Low income	1996	Oct-Dec	26±41 (18)	6±12 (0)	32±42 (25)	104 hh, 24 h recall	
Medium income			23±2 (19)	19±49 (2)	42±54 (34)	104 hh, 24 h recall	
High income			25±24 (19)	18±25 (4)	43±32 (38)	105 hh, 24 h recall	
Low income	1997	Feb-May	12±17 (4)	8±13 (2)	20±21 (14)	104 hh, 24 h recall	
Medium income			13±19 (4)	12±18 (3)	25±25 (19)	104 hh, 24 h recall	
High income			14±19 (6)	15±21 (3)	29±26 (24)	105 hh, 24 h recall	
Low income	1997	Jun-Sep	21±24 (13)	9±16 (0)	30±27 (23)	104 hh, 24 h recall	
Medium income			30±38 (18)	11±17 (3)	41±38 (30)	104 hh, 24 h recall	
High income			28±31 (21)	13±25 (0)	41±37 (32)	105 hh, 24 h recall	
Tangail	1999	Feb-May	9±7 (6)	6±6 (5)	15±9 (12)	90 hh, 24 h food weighing, 7 days per month	ICLARM (unpublished)
(Hamil Beel)		Jun-Sep	11±9 (9)	6±6 (5)	17±12 (14)		
		Oct-Dec	15±12 (13)	7±8 (6)	23±14 (20)		
Dinajpur	1999	Feb-May	8±7 (6)	5±8 (3)	13±11 (11)	90 hh, 24 h food weighing, 7 days per month	
(Ashurar Beel)		Jun-Sep	24±19 (20)	2±4 (0)	26±19 (23)		
		Oct-Dec	29±17 (25)	5±7 (3)	34±19 (31)		
Kishorganj	1999	Jan-May	18±9 (16)	8±7 (6)	26±14 (23)	90 hh, 24 h food weighing, 7 days per month	
(Kali Nadi)		Jun-Sep	20±10 (19)	9±8 (7)	28±13 (26)		
		Oct-Dec	28±15 (25)	12±12 (8)	40±21 (36)		

Per capita fish consumption increases from lower to upper income groups, in both quantity and value terms and as a proportion of expenditure on food. There is a range in spending on fish from just over 9% of total food expenditure in low income groups to 14–15% for the wealthiest categories, with wealthier consumers eating larger quantities of both freshwater and marine fish (Figures 3.2 and 3.3). Dey et al. (2010) report that an average consumer in the poorest quartile consumes just 39% of the fish consumed by an average consumer in the richest quartile, and Table 3.2 shows that poorer consumers pay a lower average price per kilogram for fish than better-off consumers. This indicates that consumption choices are closely linked to the price of fish; poorer consumers buying cheaper species, and fish of smaller sizes or of poorer quality. Consumption of dried fish (mainly small, low value marine and freshwater capture fishery species) is fairly even across all income groups in terms of quantity, meaning that it makes a more important relative contribution to the diets of poorer consumers. Figures 3.4 and 3.5 show that there are substantial differences in the value and quantity of fish consumed between rural and urban areas, as well as across income groups within these areas, with the result that average per capita expenditure on fish in major cities is nearly twice that in rural areas. This largely reflects geographical income differentials.

Table 3.2 Fish price by household income group. (Source: Anon, undated)

Household income (Tk/month)	Fish expenditure (Tk/kg)
< 750	46
750 – 999	55
1,000 – 1,249	89
1,250 – 1,499	93
1,500 – 1,999	69
2,000 – 2,499	68
2,500 – 2,999	58
3,000 – 3,999	65
4,000 – 4,999	63
5,000 – 5,999	49
6,000 – 6,999	68
7,000 – 7,999	77
8,000 – 8,999	64
9,000 – 9,999	73
10,000 – 12,499	76
12,500 – 14,999	87
15,000 – 17,499	112
17,500 – 19,999	124
20,000+	109

There is an important seasonal element to the supply of fish in Bangladesh which results in temporal variation in fish consumption and prices throughout the year. Figure 3.6 illustrates an inverse relationship between per capita fish consumption and the average price of fish which is attributable to variations in supply. Dey et al. (2008) explain the factors driving this relationship thus:

‘During the first quarter of the year (January-March), open waters like rivers, canals and beels dry up, and the fish catch from open water increases, as does fish availability in markets. During the third quarter (July-September), cultured fish attain marketable size and the market supply increases. The assorted small fish, which are mostly from freshwater capture fisheries, seem to be the major driving factor for this seasonality pattern, followed by cultured Indian carps and exotic carps’ (p. 47).

Thompson et al. (2007) report a similar temporal pattern of fish consumption for communities close to three wetlands, but with a slightly different timing, with the highest quantity of fish consumed in October to December when fish catch and availability are at their highest, and the least in March-April, the driest months of the year when water levels are at their lowest. Fish consumption increases rapidly from June-July onwards through the monsoon, peaking post-monsoon when the major fishing in the beels takes place.

Figure 3.2 Distribution of consumption expenditure on fish by monthly household per capita income group. (Source: BBS, 2007)

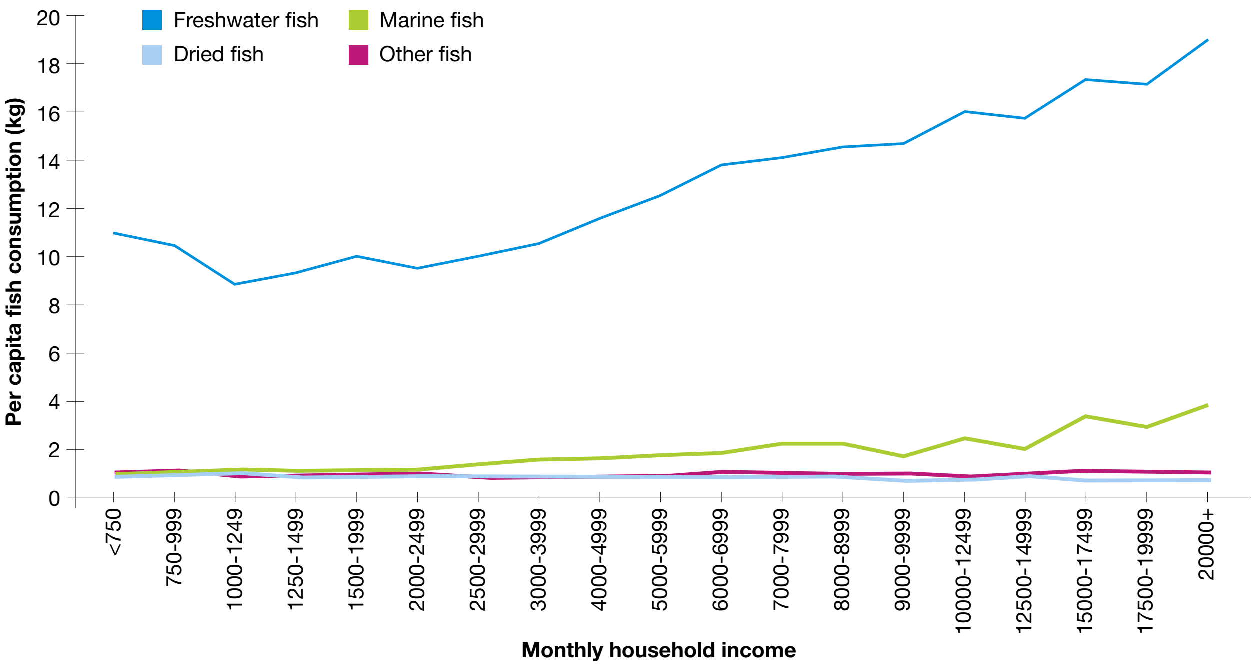

Figure 3.3 Annual per capita consumption of fish by monthly household per capita income group. (Source: BBS, 2007)

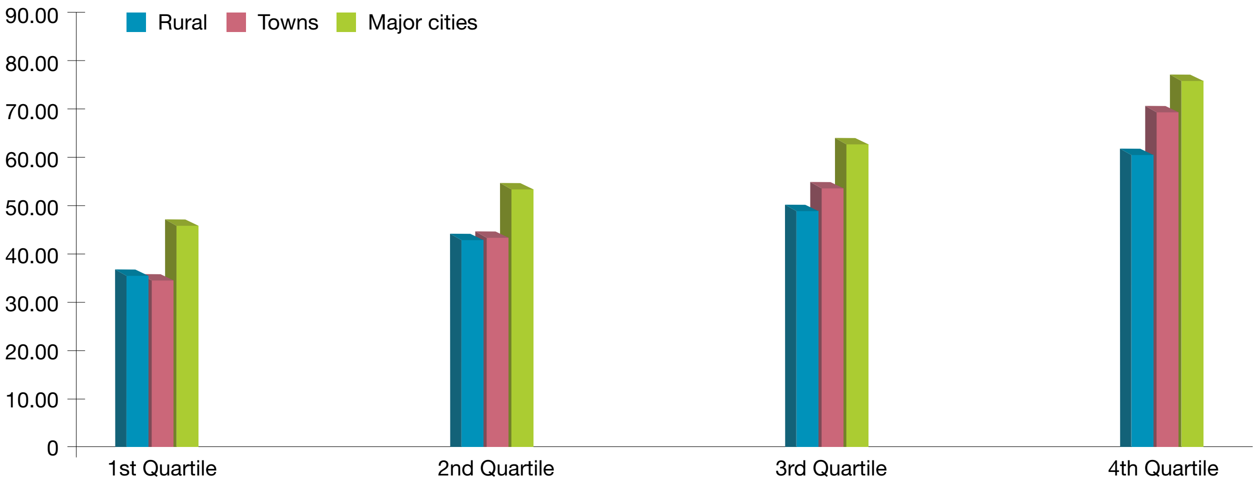

Figure 3.4 Daily per capita consumption of fish (g) by location and income quartile. (Source: BBS, 2007)

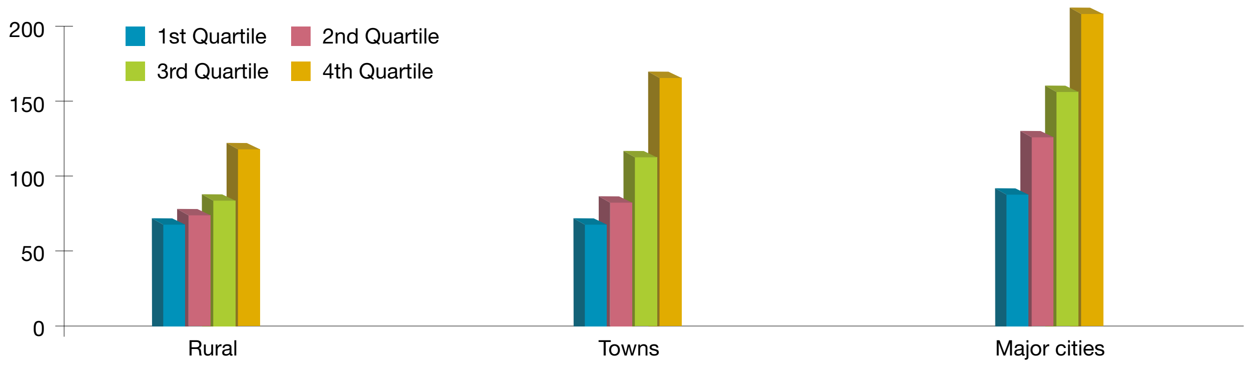

Figure 3.5 Monthly per capita expenditure (Tk) on fish by location and income quartile. (Source: BBS, 2007)

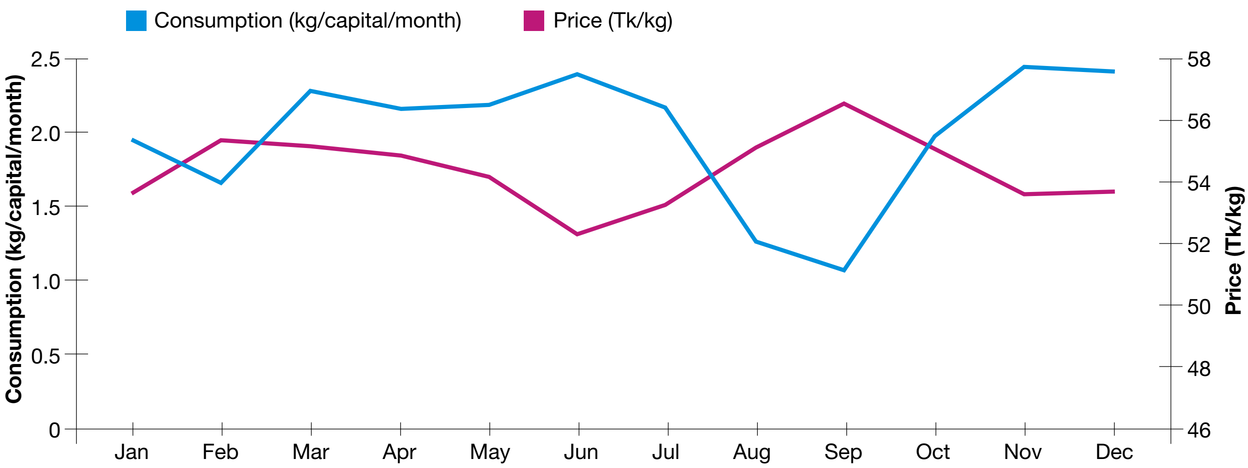

Figure 3.6 Seasonality of fish consumption and price in Bangladesh. (Dey et al., 2008)

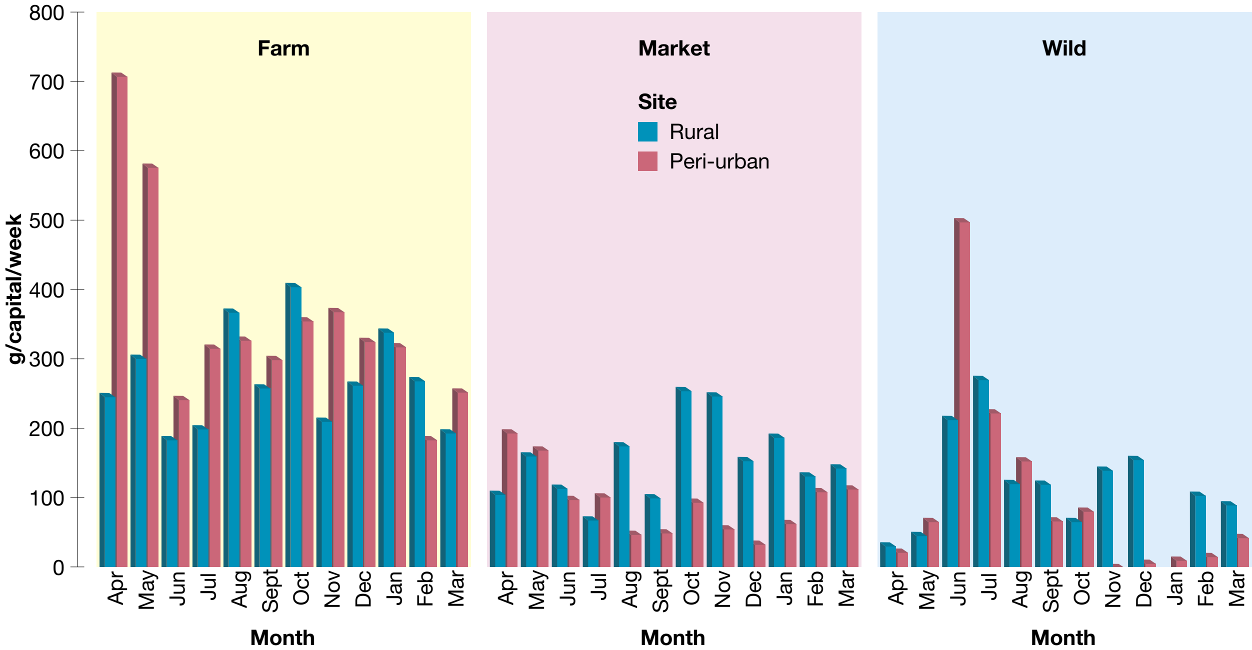

Figure: 3.7 Monthly consumption of freshwater fish by source (farm, market or wild) for households in rural and peri-urban communities in Mymensingh. (Little et al., 2007)

Even among pond owners there is considerable seasonal variation in consumption of cultured fish, with catches from household ponds low during periods when fish availability from unmanaged stocks is high (Little et al., 2007). Figure 3.7 demonstrates that ponds are rarely the only source of fish for those who access them; wild fish may be used strategically to avoid self-consumption of cultured fish which can be sold for cash, and are preferred for the dietary variation that they provide. However, it has been reported that substitution of low cost wild fish by small pond reared silver carp and tilapia is becoming increasingly common as the former decline in availability and increase in price (Little et al., 2007).

Comparable consumption patterns are also noted by Thompson et al. (2007) for households living adjacent to wetlands, with fishing households deriving the majority of fish consumed from the market even when they caught considerable quantities. This behavior suggests the disposal of higher value species in the market and the purchase of lower value ones, including those derived from aquaculture. This is nicely illustrated in Table 3.3, which shows the increasing prominence of low value cultured species in the diets of households adjacent to a natural water body over a six year period, despite very substantial increases in floodplain catches as a result of a successful project intervention. Two other wetlands studies showed similar, though less strongly pronounced, patterns (Thompson et al., 2007).

Table 3.3 Top 20 species in terms of frequency of consumption in Turag-Bangshi wetland. (Thompson et al., 2007)

Impact 1	Impact 2	Impact 3	Impact 4	Impact 5	Impact 6	Impact 6
Gura mach	Jat puti	Gura mach	Gura mach	Gura mach	Gura mach	**Pangasius**
Jat puti	Gura mach	Gura echa	**Pangasius**	Jat puti	**Pangasius**	Gura mach
Gura echa	Gura echa	Jat puti	Jat puti	**Pangasius**	Jat puti	Jat puti
Rui	Rui	**Pangasius**	Rui	Rui	Rui	Rui
Tengra	Lamba chanda	Rui	Gura echa	Gura echa	Gura echa	**Silver carp**
Taki	Taki	Taki	**Silver carp**	Mrigal	Chapila	Gura echa
Lamba chanda	Chapila	**Silver carp**	Mrigal	Chapila	**Silver carp**	Mrigal
Boro baim	Tengra	Dry fish	Taki	Dry fish	Dry fish	Chapila
Chapila	Mrigal	Hilsha	Dry fish	**Silver carp**	Mrigal	Taki
Silver barb	Dry fish	Mrigal	**Silver barb**	Taki	**Common carp**	Dry fish
Dry fish	Hilsha	Tengra	Chapila	Hilsha	**Silver barb**	Hilsha
Mrigal	Boro baim	**Silver barb**	Tengra	**Silver barb**	Taki	**Common carp**
Silver carp	**Silver carp**	Chapila	**Common carp**	**Common carp**	Catla	Catla
Common carp	**Pangasius**	**Common carp**	Hilsha	Tengra	Tengra	**Silver barb**
Bele	**Common carp**	Lamba chanda	**Tilapia**	**Tilapia**	Hilsha	Tengra
Hilsha	**Silver barb**	Boro baim	Boro baim	Boro baim	Boro baim	Bighead carp
Shing	Mola	**Tilapia**	Lamba chanda	**Tilapia**	**Tilapia**	Boro baim
Mola	Bele	Bele	Catla	Lamba chanda	Lamba chanda	**Tilapia**
Catla	Catla	**Tilapia**	Guchi baim	Shol	Guchi baim	Guchi baim
Ayer	Shing	Guchi baim	Shol	Guchi baim	**Bighead carp**	Sharputi

3.1.1 THE IMPORTANCE OF SMALL INDIGENOUS FISH SPECIES

Of the 260 freshwater fishes found in Bangladesh more than 140 attain a maximum length of 25cm and are classified as small indigenous species (SIS). Some studies have shown that in rural Bangladesh small fish make up from 50% to 80% of all fish eaten during periods of peak production, and much of the small fish consumed by the rural poor are caught by household members and bought in local markets, and therefore do not appear in national statistics (Roos et al., 2007a). Small fish, as well as the little oil, vegetables and spices which are used for cooking improve diet diversity. Small fish are a rich source of animal protein, fatty acids and essential vitamins and minerals. As many small fish are eaten whole, with head, organs and bones, they are a particularly good source of calcium, and some are also rich in vitamin A, iron and zinc.

Vitamin A is present as dehydroretinol and retinol, found mainly in the eyes and viscera, and the proportions of these two preformed vitamin A compounds vary with species. Sun drying has been shown to destroy the vitamin A content (Roos et al., 2002).

Analyses of SIS from Bangladesh showed that one of the most common, darkina *(Esomus danricus)*, has an especially high iron content. Iron is present in the forms of haem iron, a high molecular sub-pool of complex-bound non haem iron, and inorganic iron, the proportions of which vary with species. The bioavailability of the first two iron fractions is estimated as high at 25%, and 10% for the third fraction. Darkina also has a high zinc content (Roos et al., 2007b). Studies have shown that fish has an enhancing effect on non-haem iron and zinc absorption from the diet in humans (Aung-Than-Batu et al., 1976). All small fish which are eaten with bones are an extremely rich calcium source. In addition, studies in humans have shown that the bioavailability of calcium from small fish is as high as that from milk (Hansen et al., 1998). In contrast, large fish-of which the edible parts are mainly the muscles, and the bones are plate waste-do not contribute to micronutrient intake (Roos et al., 2003).

A study of poor rural households in 1997 showed that small fish provided 40% of the vitamin A and 32% of the calcium recommended for an average household during the peak fish production season (Roos et al., 2003). However, freshwater capture fisheries have declined and household members fish less frequently, leading to decreased total fish intake and a significant decrease in the proportion of small fish intake (Thompson et al., 2002). Pond polyculture has grown tremendously in the past 25 years however, and in some areas this has greatly increased the availability and accessibility of cultured species such as silver carp, making it cheaper than many small fish and increasing total fish intake. However, intake of SIS continues to decline. Thus, enhancing the production of small fish species may have a large untapped potential to prevent and combat micronutrient deficiencies in rural populations (Roos et al., 2007c). These authors calculate that production of 10 kg/pond/year of the vitamin A rich small fish, mola (Amblypharyngodon mola) could meet the annual recommended intake of two million children based on an estimate of 1.3 million ponds in Bangladesh. However, figures given in Section 3.2 indicate that the number of ponds is considerably higher than this, suggesting even greater potential impact.

Small indigenous fish for home consumption, harvested from a rice field in northwest Bangladesh during the monsoon season. (Photo: Ben Belton)

3.1.2 FISH CONSUMPTION IN URBAN AREAS

A survey of 150 consumers in Dhaka conducted by the WorldFish Center in November 2010 reveals a number of interesting patterns with respect to urban fish consumption. Table 3.4 shows that, as expected, frequency of fish consumption increases with income. This is also the case for quantity consumed. When consumption is disaggregated further by origin and species some interesting patterns emerge. Medium sized freshwater capture species and *hilsha* (including immature *jatka*) are the first and second most important categories of fish, being eaten in large quantities by consumers in all income groups[4] (Figure 3.8). Cultured fish accounted for 31% of total consumption at the time of the survey (Figure 3.9)[5]. When cultured fish are broken down into their composite species (Figure 3.10) it is evident that Indian major carp, pangasius and tilapia account for three quarters of total consumption, each with an almost equal share. Exotic carps, including Silver carp, account for only 8% of the total, behind climbing perch, which accounts for 12%. This points to an emerging division between rural and urban consumption patterns, suggesting a tendency for high value wild fish and commercially cultured species (pangasius, tilapia and climbing perch) to be exported from rural areas to Dhaka, while cultured carps are mainly consumed rural areas. This conclusion also appears to be supported by a survey of markets conducted during the research that informs this report, which indicated that smaller farmed fish (rohu, silver carp, etc.) and small capture fish (*puti*, *bain*, etc.) are the most commonly available species in rural markets, while larger farmed and wild fish are more abundant in urban markets.

Table 3.4 Frequency of daily fish consumption by consumers in Dhaka. (Source: WorldFish Center survey data)

No. of days fish was consumed in the last week	Income category									
	Very Poor		Poor		Medium		Middle Class		All	
	No.	%	No.	%	No.	%	No.	%	No.	%
0	4	8.5	0	0.0	0	0.0	0	0.0	4	2.7
1	11	23.4	4	7.7	0	0.0	0	0.0	15	10.0
2	11	23.4	9	17.3	1	4	0	0.0	21	14.0
3	11	23.4	12	23.1	4	16	0	0.0	27	18.0
4	5	10.6	11	21.2	8	32	2	7.7	26	17.3
5	1	2.1	7	13.5	6	24	11	42.3	25	16.7
6	4	8.5	7	13.5	3	12	9	34.6	23	15
7	0	0.0	2	3.8	3	12	4	15.4	9	6
Total	**47**	**100**	**52**	**100**	**25**	**100**	**26**	**100**	**150**	**100**

4. Mature *hilsha*, which are very costly, are eaten mainly by better off-consumers. Consumption of immature (illegally harvested) *hilsha*, known as *jatka*, is common for lower income groups (Figure 3.8).
5. The survey took place during the peak season for both the *hilsha* and inland capture fisheries. It should be stressed that a survey conducted at a different time of year might therefore have yielded quite different results with regards to the composition of fish consumption by source.

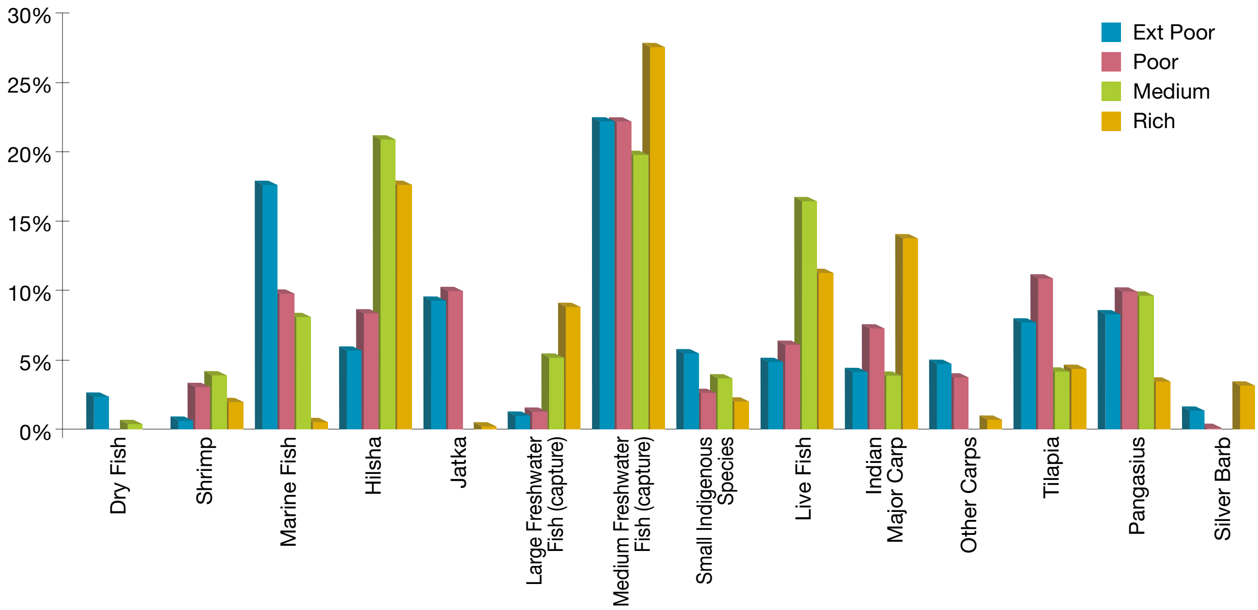

Figure 3.8 Fish consumption by species among extreme poor, poor, medium and rich consumers in Dhaka.[6]

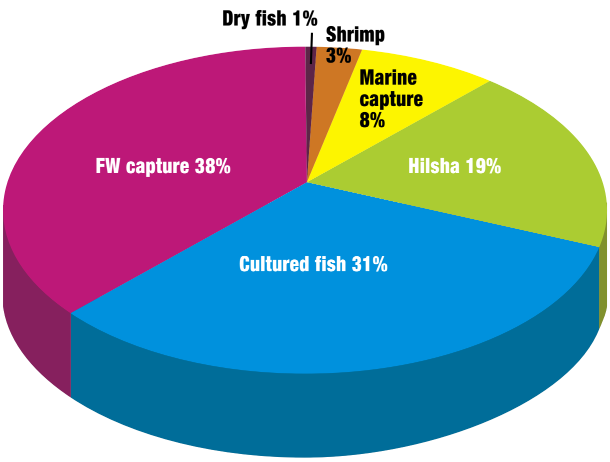

Figure 3.9 Fish consumption in Dhaka by source. (Source: WorldFish Center survey data)

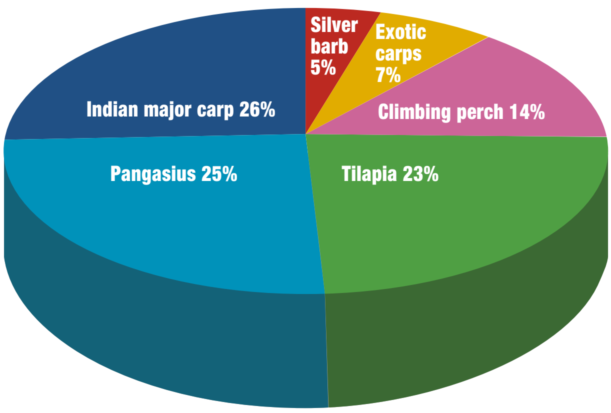

Figure 3.10 Consumption of cultured fish in Dhaka. (Source: WorldFish Center survey data)

6. We divide the species *hilsha (Tenualosa ilisha)* into hilsha (high-value adult fish) and jatka, (immature hilsha with a much lower market value than adult *hilsha*).

Price elasticities for all categories of fish in Bangladesh tend to be highest for lower income groups (that is to say, that poorer households tend to respond more to changes in fish price than do richer households). In addition, 'price elasticity moves from elastic to inelastic with increased household income' (Dey et al., 2010, p. 27). Income elasticities also shift from elastic to inelastic as households occupy higher income brackets, suggesting that fish consumption in poorer households is more responsive to income changes than in richer ones. This implies that poorer households treat fish as something of a luxury good, whereas richer households treat it more as a staple necessity. Dey et al. (2010) thus suggest that if population growth and per capita incomes in Bangladesh increase as anticipated and increases in fish production fail to keep pace, poorer sections of the population will be disproportionately negatively affected by rising prices. However, conversely, and more positively, this relationship also means that 'flexibility in fish demand by the Bangladeshi poor absorbs potential supply expansion in the market' (p. 27), indicating that very significant further opportunities for the expansion of fish production exist, and that this would benefit poorer sections of the population.

3.2 ESTIMATED FISH PRODUCTION

National per capita fish consumption trended sharply up from 2000 to 2005. This increase reflects rapidly expanding production from freshwater aquaculture over this period. Dey et al. (2010) note that estimated regression coefficients confirm that this positive relationship is significant. However, the gap in consumption between rural and urban areas widened over this period (Table 3.5), and the fact that consumption is higher in urban areas than rural ones despite the majority of production occurring in the latter is indicative of the crucial importance that income plays in securing access to food.

Table 3.5 Annual fish intake per capita by region. (Source: modified from BBS, 2007)

	Annual fish consumption per capita 2000 (kg)	Annual fish consumption per capita 2005 (kg)	Change in consumption 2000-2005 (kg)	Change in consumption 2000-2005 (%)
National	14.05	15.37	+1.31	+8.55
Rural	13.80	14.49	+0.69	+4.79
Urban	14.93	18.10	+3.18	+17.54

Dey et al. (2010) note that actual per capita fish consumption in Bangladesh is generally assumed to be higher than reported in official statistics, and cite several household consumption surveys which found per capita fish consumption to exceed officially reported figures for both consumption and production, sometimes by very large margins. However, the context specific variability in consumption revealed by Table 3.1, suggests that drawing conclusions about national levels of fish consumption based on isolated surveys with small sample sizes may be problematic.

The data collection procedures of the national five year Household Income and Expenditure Survey (HIES), which includes data on fish consumption, are generally considered rigorous however, and this dataset is probably the most reliable of those available with respect to providing a clear overview of fish consumption in Bangladesh. A study conducted by Winrock International (2004) used the 2000 Household Income and Expenditure Survey fish consumption figures in an attempt to infer the extent of possible official underreporting of fish production. Table 3.6 shows the result of this attempt, which reveals a gap between reported and inferred production of around 25% for the year 2000.

Table 3.6 Comparison of fish consumption and production data 1991-2000 ('000 t). (Source: Winrock, 2004)

Category	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
HIES Freshwater	1231	1344	1457	1570	1683	1666	1650	1633	1617	1601
HIES Sea	561	578	594	611	628	622	616	610	603	597
HIES Total	1792	1922	2051	2181	2311	2288	2266	2243	2220	2198
DOF Freshwater	654	707	770	838	908	988	1086	1191	1243	1321
DOF Sea	242	246	251	253	256	270	275	273	310	334
DOF Total	896	953	1021	1091	1164	1258	1361	1464	1553	1655

We have also adopted this approach to investigate possible differences between reported and actual fish production. It must be noted however that while the underlying principle-that consumption data is likely to be more accurate than production data-is convincing, these calculations rest on a number of critical assumptions and should therefore be treated as very broadly indicative only. Dried fish consumption is significant for this exercise because, when considered in terms of wet weight, it implies higher levels of fish production than those indicated by consumption figures alone. The ratio of wet weight to dry weight for most freshwater and marine species is 5:1, indicating that production of 20g of dried fish requires 100g of fresh fish (CRESP, 2006; Mmopelwa, 1992).

The results, presented in Table 3.7, suggest a gap between actual consumption and officially reported production in both 2005 and 2009: amounting to 394,953 t (12.75%) in 2009. This would appear to confirm that underreporting of actual production does occur, although to a lesser extent than in the past in comparison to Winrock's figures. This data is disaggregated further by fisheries sub-sector in Table 3.8. This table suggests that marine fisheries production may be slightly underreported, and that output from freshwater culture may be underreported by almost 325,000 t (approximately 23%). However, it should be emphasized that this outcome rests heavily on a number of critical assumptions and must therefore be treated with caution. In addition, Bangladesh is a net importer of fish when shrimp and prawn are excluded (shrimp and prawn are produced almost exclusively for export and therefore should not significantly affect national consumption data). Comparing import and export figures for carp and hilsha from India and Myanmar (Table 3.9), Bangladesh had net fish imports of around 33,000 t, as well as imports of 6,498 t of dried fish in 2009/2010 (calculated from unpublished DOF data). This would imply that the difference between inferred production and reported production is likely to be somewhat smaller than indicated in Table 3.8, though still substantial.

Table 3.7 Comparison of national fish production and consumption data 2005 and 2009[7].

	Production (DOF data)		Consumption (adjusted HIES data)	
Year	Tonnes	kg/capita	Tonnes	kg/capita
2005	2,215,957	15.96	2,480,036	17.87
2009	2,701,370	16.65	3,096,323	19.09
Increase '05-'09	485,413	0.69	616,287	1.22

Table 3.8 Official and adjusted fish production for 2009 by sub-sector[8].

Source	DOF (t)	Adjusted (t)	Difference (t)
Freshwater capture	1,123,925	1,123,925	0
Marine capture	514,644	584,620	69,976
Aquaculture	1,062,801	1,387,777	324,976
Total	2,701,370	3,096,323	394,953

Table 3.9 Selected fish imports and exports for 2009/2010. (Calculated from unpublished DOF data)

	Imports (India)	Imports (Myanmar)	Total Imports	Total Exports	Net imports
Carp (t)	34,653	9,630	44,284	4,779	39,505
Hilsha (t)	0	4,352	4,352	3,107	1,245
All fish			59,242	26,044	33,198

7. This table is based on the following assumptions: Production data is from DOF (2006) and DOF (2010). Consumption data is from the 2005 HIES (BBS, 2007). The HIES category 'dry fish' is adjusted upwards on the assumption that dry fish weighs 20% of wet weight equivalent (i.e. 20g of dry fish possesses a wet weight of 100g). This is consistent with figures published in CRESP (2006) and Mmopelwa (1992). There is no HIES data for 2009. This is calculated on the basis of a linear increase in consumption of 1.71% per annum over four years. This assumption is derived from figures reported in HIES 2005 showing an annual increase in fish consumption of 1.71% between 2000 and 2005. For the purposes of this table we assume fish imports and exports do not significantly impact national fish consumption. Population for 2009 is taken to be 162,220,762 based on the World Bank's World Development Indicators.

8. Assumptions are as follows: Official production data is from DOF (2010). Adjusted total production is derived from Table 3.7. Eighty percent of the fish in HIES category 'dry fish' is assumed to originate from marine sources, and 20% from freshwater, based on observations from a market survey conducted for this study. The HIES category 'other fish' is assumed to originate entirely from freshwater sources. The DOF (2010) figure for freshwater capture production is held to be correct on the basis assumption that it is unlikely to be any higher than reported and no alternative estimate is available, and is used because a figure is needed in order to obtain an estimate for the output from freshwater culture (i.e. total adjusted production less freshwater capture and adjusted marine).

Table 3.10 Estimated fish production and consumption in Bangladesh for 2010.

	Area (ha)	Productivity (t/ha)	Production (t)	% of production	% of aquaculture	References and assumptions
Capture fishery						
Inland capture	4,047,316		1,123,925	37.13	n/a	DOF (2010)
Marine capture			584,620	19.31	n/a	Adjusted HIES 2005 data (Table 3.8)
Total capture fishery			1,708,545	56.44	n/a	
Aquaculture						
Cage culture	45,000 (m^3)	13.3 (kg/m^3)	600	0.02	0.04	Amin Sarker (2010); 1,500 cages @ $30m^3$
Baors (oxbow lakes)	5488	918	5038	0.17	0.37	DOF (2010)
Rice-fish	32,070	0.2	6414	0.21	0.47	Assume 0.5% of rural households operate 0.3 ha under rice-fish culture
Seasonal floodpain aquaculture	7500	1.5	11,250	0.37	0.83	5,000 ha in Comilla (Gregory et al., 2007), plus reports of projects in other districts (assumed to total a further 2,500 ha)
Ghers (Of which)	244,294	0.60	145,585	4.82	11.08	DOF (2010), Unpublished DOF data (Table 1.12)
Shrimp & prawn	244,294	0.40	97,746	3.23	7.23	DOF (2010)
Fish	244,294	0.20	47,839	1.85	3.54	DOF (2010)
Homestead ponds	265,275	1.5	397,912	13.14	29.44	2005 Agricultural sample survey (BBS, 2006) plus assumed 2% growth in pond area per annum to 2010
Commercial ponds (Of which)	126,436		785,027	25.93	58.07	2005 Agricultural sample survey (BBS, 2006) plus assumed 2% growth in pond area per annum to 2010
Semi-intensive	111,436	3.5	390,027	12.88	28.85	BBS (2006) data for area under commercial culture, minus area under intensive culture
Intensified	5000	10	50,000	1.65	3.70	Estimate based on key informant interviews
Intensive	5000	20	115,000	3.80	8.51	Estimate based on key informant interviews and Ali (2010)
Very intensive	5000	40	230,000	7.60	17.01	Estimate based on Ali (2010), Edwards and Hossain (2010), Munir (2009)
Total aquaculture			1,351,826	44.66	100	
Net fish imports*	n/a		33,198	1.10		Net fish imports-DOF data (Table 3.9)
Total consumption	n/a		2,995,823			Total output, plus net fish imports, less shrimp and prawn
Total production	n/a		3,027,173			Total output, less net fish imports

** Excluding shrimp and prawn*

Table 3.10 presents our estimate of quantity of aquatic foods produced and consumed in Bangladesh according to their mode of production, based on a combination of our analyses in preceding sections. This provides figures for total production of 3,027,173 t, of which 44.7% is derived from aquaculture. Total consumption is 2,995,823 t, of which a slightly lower portion (42%) is derived from aquaculture. The difference between these two figures is accounted for by culture of shrimp and prawn (for which we assume none is consumed locally), less net imports of fish. These figures are around 100,000 t lower than the level of production we infer for 2009 based on HIES 2005 data, but this amounts to a fairly small difference, and is still significantly higher than the officially reported total, and we estimate aquaculture to account for around 5% more of total production than is officially reported.

The breakdown of the origins of this production reveals a number of interesting conclusions. Cage, oxbow lake *(baor)*, rice-fish, and seasonal floodplain aquaculture appear to account collectively for just under 2% of aquaculture production. Production of shrimp and prawn amounts to 7% of the total (97,746 t), while the ‘bycatch’ of stocked and unstocked fish species from prawn and shrimp ghers amounts to 3.5% of national production. Figures taken from the 2005 Agricultural Sample Survey, which we consider to be a more reliable measure than DOF figures, show homestead ponds covered an area of 241,159 ha, and commercially operated ponds covered an area of 114,942 ha. We consider it likely that pond numbers for 2010 are higher than this, given the continued expansion of commercial production noted by our key informants and in our market survey, and due to the practice of constructing borrow pits when new households are formed. We assume a rate of 2% expansion per year in the area of both types of pond, which is conservative given that Thompson et al. (2002) reported an annual 5% rate of pond expansion in Gazipur in the north and 8% in Patuakhali in the south. This implies a total present pond area of 391,711 ha, which is 86,686 ha (28%) more than that reported by DOF (2010).

Based on these revised figures, homestead ponds cover 265,275 ha and account for 29% of total farm output, based on an assumed level of production of 1.5 t/ha which is typical of the values recorded in most project baseline surveys. Analysis of the HIES 2005 dataset shows that 20% of households practice what the survey refers to as ‘pond/sink fishing’. This is in line with the findings of Jahan et al. (2010) and others with respect to levels of homestead pond ownership, and we therefore interpret the HIES heading ‘pond/sink fishing’ to imply homestead pond production. On this basis we calculate that approximately 4.27 million households own a homestead pond which, working backwards, equates to mean homestead pond size of 0.06 ha, which is consistent with the range of figures reported in Section 1.1.1. HIES 2005 data records average household production from ‘pond/sink fishing’ as 93.4kg, of which 50.3kg is consumed, and 38.9kg sold. Multiplying this level of production by our imputed number of homestead pond owning households puts total production from homestead ponds at 399,293 t, which is closely in line with the figure of 397,912 t (Table 3.10) that we arrive at through our analysis of Agricultural Sample Survey data, thus appearing to confirm the validity of these assumptions.

Table 3.11 Comparison of pond numbers and areas reported in selected upazilas in the greater Mymensingh region by official statistics (FRSS) and unofficial pond census (MAEP). (Source: modified from unpublished MAEP survey data)

		F R S S (1986)			**MAEP Survey (1993-96)**			**Difference %**	
			Pond Area (ha)			Pond Area (ha)			
District	**Thana**	Pond No.	Total	Mean	Pond No.	Total	Mean	No.	Area (ha)
Mymensingh	Sadar	5,076	341	0.11	3,040	472	0.09	67	38
	Fulbaria	8,205	443	0.11	3,947	657	0.08	108	48
	Ishwargonj	5,993	256	0.11	2,280	517	0.09	163	102
	Muktaghacha	8,108	275	0.11	2,448	710	0.09	231	158
	Trishal	9,684	228	0.11	2,026	680	0.07	378	199
	Gouripur	4,161	228	0.11	2,026	347	0.08	105	53
	Fulpur	13,765	552	0.11	4,918	835	0.06	180	51
	Nandail	10,161	296	0.11	2,638	631	0.06	285	113
	Goffargaon	10,556	357	0.11	3,187	593	0.06	231	66
Sub Total		*75,709*	*2,975*	*0.11*	*26,510*	*5,442*	*0.07*	*186*	*83*
Kishoregonj	Sadar	6,718	164	0.11	1,456	503	0.07	361	208
	Pakundia	3,923	164	0.11	1,456	228	0.06	169	39
	Hossainpur	4,845	109	0.11	971	324	0.07	399	198
	Karimgonj	3,142	175	0.11	1,562	255	0.08	101	45
Sub Total		*18,628*	*611*	*0.11*	*5,445*	*1,310*	*0.07*	*242*	*114*
Netrokona	Sadar	5,232	284	0.11	2,533	446	0.09	107	57
	Purbadhala	7,426	311	0.11	2,765	451	0.06	169	45
	Atpara	2,583	178	0.11	1,583	269	0.1	63	51
	Kendua	7,457	298	0.11	2,660	658	0.09	180	121
Sub Total		*22,698*	*1,071*	*0.11*	*9,541*	*1,825*	*0.08*	*138*	*70*
Sherpur	S. Sadar	5,467	153	0.14	1,086	284	0.05	403	86
&	Nakla	2,525	74	0.14	527	154	0.06	379	107
Jamalpur	J. Sadar	11,360	208	0.14	1,472	671	0.06	672	223
Sub Total		*19,352*	*435*	*0.14*	*3,085*	*1,110*	*0.06*	*527*	*155*
Tangail	Ghatail	5,590	184	0.14	1,307	447	0.08	328	143
	Madhupur	7,432	206	0.14	1,464	494	0.07	408	139
	Mirzapur	2,482	158	0.14	1,118	276	0.11	122	75
Sub Total		*15,504*	*549*	*0.14*	*3,889*	*1,217*	*0.08*	*299*	*122*
Gazipur	Sadar	4,646	462	0.13	3,651	531	0.11	27	15
	Kaliakoir	2,019	286	0.13	2,258	318	0.16	-11	11
	Kapasia	2,200	324	0.13	2,559	212	0.1	-14	-35
Sub Total		*8,865*	*1,072*	*0.13*	*8,468*	*1,061*	*0.12*	*5*	*-1*
Grand Total		**160,756**	**6,713**	**0.12**	**56,938**	**11,964**	**0.07**	**182**	**78**

Table 3.11 provides support for our contention that numbers of homestead pond are considerably greater than officially reported. It compares data from a pond census carried out in selected upazilas in districts within the greater Mymensingh region over the period 1993–1996 with official data collected by the Fisheries Resources Survey System (part of DOF) by a satellite survey in 1986. This reveals total pond numbers for these upazilas to be 178% greater than that officially recorded, and total pond area to be 78% larger, while mean pond area is 0.07 ha, as opposed to the 0.12 ha reported by FRSS. Much of this difference can be attributed to the failure of the FRSS survey to record ponds below a certain size.

Our adjusted figure for commercially operated ponds of 126,436 ha (Table 3.10) can be broken down into two categories; semi-intensive and pellet-fed, and we disaggregate pellet-fed systems into a further three categories based on intensity. Based on data reported in Section 1.1.2, we estimate that pangasius ponds in Mymensingh cover 5,000 ha, with an average productivity of 40 t/ha. We label this category of production ‘very intensive’. Also, from figures reported in the same Section, we estimate a further 5,000 ha of ponds under pangasius culture around the country, particularly in Bogra, Naogaon, and Narsingdi districts. We assume productivity from these ponds to be 20 t/ha, given the observation of key informants that production was less intensive than that practiced in Mymensingh, and the apparent dominance of pangasius produced in Mymensingh in our market survey. We label this category of production ‘intensive’, and assume that intensive and very intensive production produces a 15% additional ‘bycatch’ of carps and tilapias.

Finally, we estimate a further 5,000 ha of ponds to be under ‘intensified’ culture with an average productivity of 10 t/ha, mainly for production of tilapia, but also including climbing perch and very small amounts of shing and other catfishes. By subtracting this combined area from the total area of commercially operated ponds we arrive at a figure of 111,436 ha for commercially operated semi-intensively managed ponds under carp polyculture, for which we assume an average productivity of 3.5 t/ha. On this basis we conclude that 29% of cultured fish consumed in Bangladesh (390,027 t) is derived from commercial semi-intensive systems, and that a similar quantity (395,000 t) originates from pellet-fed systems, of which 350,000 t is comprised of the primary crop and 45,000 t is ‘bycatch’ of carps and tilapias. These last figures are consistent with our data for the output of feed mills (Section 2.2), which put production of pelleted feed at 670,000 t. Allowing for feed use in shrimp culture and assuming an FCR of 2 this would equate to production of around 334,000 t of pellet-fed fish, but excludes the production of fish raised on farm-made pellets, which Ali et al. (forthcoming) reports are used by 37% of farms in Mymensingh. These figures also coincide with reported annual production of 300,000 t of pangasius and, to some extent, with the likely levels of intensified tilapia production implied by the output of mono-sex tilapia fry reported in Section 2.1.3.

Pangasius is popular amongst poorer consumers. (Photo: Ben Belton)

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