



Faltering fisheries and ascendant aquaculture: Implications for food and nutrition security in Bangladesh



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ABSTRACT

Bangladesh has made considerable progress against human development indicators in recent years, but malnutrition resulting from poor dietary diversity and low micronutrient intakes remains entrenched. Fish is central to the Bangladeshi diet and small fish species are an important micronutrient source. Although fish consumption per capita has increased in recent years as a result of rapid expansion of aquaculture, it is likely that consumption of fish from capture fisheries (including small indigenous species particularly rich in micronutrients), has declined. This paper evaluates data on fish consumption collected in Bangladesh by the International Food Policy Research Institute in 1996/7 and 2006/7 to assess changing patterns of fish consumption and their implications for food and nutrition security. This analysis indicates that growth of aquaculture has been positive, mitigating a sharp reduction in the quantity of fish consumed from capture fisheries and smoothing out seasonal variability in consumption. However, increased availability of fish from aquaculture may not have fully compensated for the loss of fish from capture fisheries in terms of dietary diversity, micronutrient intakes and food and nutrition security, particularly for the poorest consumers. A range of approaches are recommended to sustain and enhance the contributions capture fisheries and aquaculture make to food and nutrition security in Bangladesh

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Introduction

Although one of Asia's poorest countries, Bangladesh has enjoyed more than a decade of sustained 5% GDP growth (World Bank, 2012). The country has achieved near self-sufficiency in rice production (trebled since the 1970s) despite rapid population growth and one of the world's highest population densities (Talukder, 2005). At national level, average rice intakes supply most energy and protein (Talukder, 2005), but dietary diversity remains poor and a substantial proportion of the population continues to experience moderate or severe food insecurity on a seasonal or chronic basis (HKI, 2011). As a result, Bangladesh performs poorly in comparison to other countries at a comparable stage of economic development with regards to a range of indicators of food and nutrition security, including anthropometric indices and prevalence of micronutrient deficiencies - key targets for attaining

some of the Millennium Development Goals (UN, 2012; Ahmed, 2011; Kimmons et al., 2005).

As undernutrition is symptomatic of inadequate micronutrient intakes, rather than just insufficient energy or protein, increasing access to micronutrients, particularly for women and young children, is one of Bangladesh's most pressing policy priorities. This goal features prominently in the government's national Sixth Five Year Plan 2011–2015 (GoB, 2012), Country Investment Plan (GoB, 2010) and Poverty Reduction Strategy Paper (GoB, 2005), as well as initiatives of major international development partners, including the United States Agency for International Development (USAID) and the UK Department for International Development (DFID). The pressing need to address the symptoms and causes of malnutrition is underlined by a recent study which estimated that malnutrition costs Bangladesh \$1 billion per year in terms of economic productivity forgone (Howlader et al., 2012).

Fish is Bangladesh's most important and culturally preferred food, other than rice. It accounts for the largest share of per capita food expenditures after rice (Minten et al., 2010) and is by far the most frequently consumed animal-source food, providing approximately 60% of animal protein in the diet as well as other essential nutrients (Belton et al., 2011; Roos et al., 2007a). This is partly a function of Bangladesh's geographical location at the mouth of the second largest river system in the world, the

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Ganges–Brahmaputra–Meghna (Lewis, 2011). The productivity of Bangladesh's fisheries is driven by the annual monsoonal flood pulse, during which at least 20% of the country's surface area is inundated (de Graaf et al., 2001; Banerjee, 2010), resulting in a diverse and highly productive floodplain fishery from which much of the rural population derive sustenance and livelihoods (Ali, 1997; Craig et al., 2004).

Well-liked, and comprising a large portion capture fisheries output, are small fish, referred to collectively as small indigenous species (SIS). Several of these, e.g. mola (*Amblypharyngodon mola*) and darkina (*Esomus danricus*), are particularly rich sources of micronutrients including iron, zinc, calcium and vitamin A (Table 1). Moreover, animal-source foods, of which fish are by far the most frequently consumed in Bangladesh (Fig. 1), enhance the bioavailability of minerals from all foods in a meal, thus making an additional contribution to nutrient supply above that of their intrinsic value (Thilsted, 2012). However, economic development and rapid population growth over the last three decades have placed increasing pressure on capture fisheries. The intensification of agriculture, water control initiatives, road building, urban encroachment, industrial pollution and increasing fishing effort have combined to place limits to growth on the output of the capture fishery (Ali, 1997; Belton et al., 2011). This resulted in a reported fall in per capita fish consumption of 11% between 1995 and 2000 (Sultana and Thompson, 2007).

Although statistics published by the Department of Fisheries indicate that production from the inland capture fishery grew by around 3% annually from 1985 to 2011 (DOF, various years), it is widely believed that its output is probably now in decline (Belton et al., 2011). This view is supported by circumstantial evidence from a variety of sources. For instance, Ali (1997) has chronicled the catastrophic impacts of numerous flood control schemes on floodplain fisheries, and large declines in freshwater fish biodiversity, including the extinction of many species, have been reported (Sarker et al., 2008; Hossain and Wahab, 2009; IUCN, 2000).

At the same time, aquaculture – the farming of fish and other aquatic organisms – has expanded rapidly. Although aquaculture in Bangladesh originated as a low intensity semi-subsistence activity, rapid commercialization, intensification and specialization have taken place over the last decade, leading to unprecedented expansion in production of farmed fish for the market (Belton and Azad, 2012). This sectoral growth is, in part, an outcome of the income elasticity of fish (Dey et al., 2010), rising real wages, expanding urban markets and a rapidly growing urban middle

class with increasing discretionary spending power (Belton et al., 2011). Part of the areal expansion of aquaculture is taking place on riverine floodplains which have been enclosed to facilitate the intensification of production, resulting in the exclusion of (often poor) households which previously captured naturally occurring fishes from these areas during the monsoon (Toufique and Gregory, 2008; Sultana, 2012).

This pattern of faltering capture fisheries juxtaposed against dramatic growth in output of farmed fish is common throughout much of Asia (Belton and Little, 2011). Substantial increases in average fish consumption per capita during the period 2000 to 2010 indicate that the rise of aquaculture has more than offset declines in capture fishery output, in terms of quantity, at the national level (Belton et al., 2011). However, widely cultured species such as Indian and Chinese major carps, common carp (*Cyprinus carpio*) and tilapia (*Oreochromis spp.*) have poorer micronutrient profiles than commonly eaten SIS which comprise an important part of the diet for many poor households (Table 1). Furthermore, farmed species, which are usually sold whole and weigh several hundred grams or more per individual fish, may be less readily accessible to poor consumers than SIS, which are usually sold in very small portions. The question of whether the loss of dietary diversity and micronutrients provided by the inland capture fishery can be compensated for by growth in aquaculture therefore represents an important issue.

As Allison (2011, p. 9) notes:

'The aggregate data on Asian aquaculture all show increases in the volume and value of trade, increased contribution of production to agricultural GDP, and, in some cases, increased availability of fish in domestic supply as well. That this translates into improved food security... is then often simply assumed, although this is not necessarily the case if... the growing middle classes in Asian cities increase their fish consumption, but nothing changes for the poor and hungry. Deeper analysis is needed before causal linkages can be inferred... and food security benefits for aquaculture can be claimed.'

Furthermore, there have been few specific studies of how increases in farmed fish availability affect access and use by poor consumers (Beveridge et al., 2013). The aim of this paper is therefore to explore how patterns of fish consumption have changed during a period of transition from a capture dominated fishery regime to one in which cultured fish are increasingly pervasive; to analyze the implications of this trend for the status of food and nutrition security in Bangladesh, and to draw appropriate policy recommendations. This is achieved with reference to a dataset on

Table 1

Micronutrient content of selected fish species from capture fisheries and aquaculture (modified from Thilsted, 2012; Tacon and Metian, 2013).

Common name	Scientific name	Contents per 100 g raw, cleaned parts				
		Vitamin A (RAE) ^a	Calcium (g)	Calcium (g) ^b	Iron (mg)	Zinc (mg)
<i>Common small fish species from inland capture fisheries in Bangladesh</i>						
Baim	<i>Macrogathus aculeatus</i>	90	0.4	0.2	2.4	1.2
Chanda	<i>Parambassis ranga</i>	1679	1.0	0.9	1.8	2.3
Darkina	<i>Esomus danricus</i>	890	0.9	0.8	12.0	4.0
Dhela	<i>Osteobrama cotio cotio</i>	937	1.3	– ^c	–	–
Mola	<i>Amblypharyngodon mola</i>	2680	0.9	0.8	5.7	3.2
Puti	<i>Puntius sophore</i>	60	1.2	0.8	3.0	3.1
<i>Large fish species farmed widely in Bangladesh</i>						
Common carp	<i>Cyprinus carpio</i>	9	0.4	–	1.2	1.5
Mrigal	<i>Cirrhinus cirrhosis</i>	<30	1.0	0	2.5	–
Silver carp	<i>Hypophthalmichthys molitrix</i>	<30	0.9	0	4.4	–
Tilapia	<i>Oreochromis spp</i>	0	0.1	–	0.6	0.3

^a RAE, retinol activity equivalent.

^b Calcium in raw, edible parts, after correcting for plate waste (mainly bones).

^c Not measured.

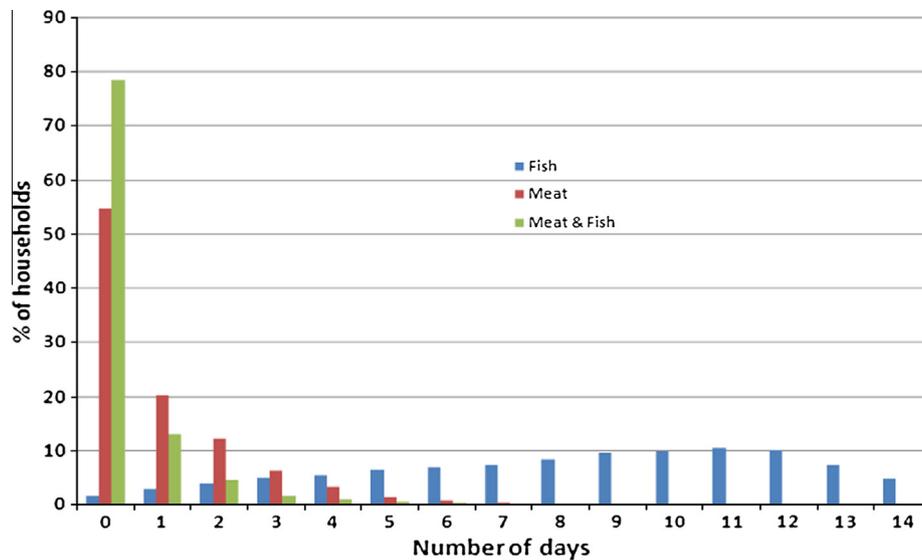


Fig. 1. Frequency of consumption of animal-source foods over a 14 day period. (Source: Belton et al., 2011)

poverty and household livelihood strategies collated by the International Food Policy Research Institute (IFPRI), as part of its Chronic Poverty and Long Term Impact Study between 1996 and 2007. This contains some of the most detailed publicly available data on fish consumption in Bangladesh, but has not been analyzed previously for this purpose. Information from the national five year Household Income and Expenditure Survey (2005 and 2010), conducted by the Bangladesh Bureau of Statistics (BBS, 2007, 2011) is also drawn upon.

The paper is organized as follows: The following two sections outline the characteristics of Bangladesh's capture fisheries and aquaculture sectors, and provide background on fish consumption patterns and the nutrient profiles of a number of frequently consumed captured and cultured species. The subsequent section provides details of the dataset analyzed. Outcomes of the analysis performed are presented in the results section. This is followed by a discussion and conclusion which address the implications of this analysis for policy and investments aimed at improving food and nutrition security in Bangladesh.

Capture fisheries, aquaculture and fish consumption in Bangladesh

Statistics collated by the Department of Fisheries, show that total fisheries output in Bangladesh (capture fisheries and aquaculture combined) grew by 396% over the period 1985 to 2011, reaching a total volume of 3.06 million tonnes in the latter year. Compound annual growth in combined output over the period averaged 5.4%. Aquaculture grew at 10% per annum, while marine and inland capture fisheries averaged 4.2% and 3.2% annual growth, respectively (DOF, 2012). Government statistics indicate that inland capture fisheries contributed 34% of production, aquaculture 48% and marine capture 18%, in 2011 (DOF, 2012). Circumstantial evidence suggests that the rate of growth of inland capture fisheries in the last decade may have been overstated (Belton et al., 2011). Nevertheless, they remain an extremely important source of food fish despite a long-term decline in their relative contribution to total output (Thompson et al., 2002). Capture fisheries provide a great diversity of species, many of which are small in size and possess particular cultural, nutritional and health significance (Deb and Haque, 2010; Thilsted et al.,

1997). In contrast, just ten fish species are farmed widely, of which most attain relatively large maximum sizes. The majority of species commonly produced by aquaculture are exotic (e.g. Chinese carps, tilapia, pangasius catfish), although native Indian major carps account for around 50% of total recorded production (DOF, 2012).

Fig. 1, derived from an analysis of raw data from the Household Income and Expenditure Survey 2005 (which is conducted over the course of a year to control for seasonal variations in consumption), illustrates the centrality of fish in the Bangladeshi diet. The Figure indicates that almost all (98.5%) households consumed fish during the 14 day period over which consumption was recorded, while fewer than half (45%) consumed any meat. Fish was also much more frequently consumed than meat: approximately two-thirds of households ate fish on at least seven occasions during the 14 day survey period, whereas less than 1% of households consumed meat seven or more times. Similar results were found by a large nationally representative survey of 1–4 year old children ($n = 51,177$), conducted by Helen Keller International (HKI) in six rounds, over the course of one year. Fish were consumed more frequently than eggs, lentils or green leafy vegetables – foods which are rich sources of high quality protein and/or micronutrients (HKI, 2002). This underlines again the importance of fish in a diet characterized by low diversity and micronutrient intakes (Arimond et al., 2009; Thorne-Lyman et al., 2010; Roos et al., 2007b).

Despite the importance of fish in the diet, consumption is highly variable; from location to location, throughout the year (due to the seasonality of capture fisheries and, to a lesser extent, aquaculture), and in terms of species composition. This variability is apparent from a meta-analysis of fish consumption studies in Bangladesh from 1962 to 1999 conducted by Thompson et al. (2007) which reported values for daily consumption ranging from as little as 15 g/capita/day to as high as 96 g/capita/day. Unsurprisingly, this analysis also found that the quantity of fish consumed increased from lower to upper income groups.

Expenditure on fish as a proportion of expenditure on food accounts for 6.5% and 16% of total annual food expenditure for the poorest and wealthiest groups, respectively (BBS, 2011). Poorer consumers pay a lower average price per kilogram of fish than better-off consumers (Belton et al., 2011). This indicates that consumption choices are closely linked to the price of fish; poorer consumers buy smaller amounts, cheaper species, and fish of

Table 2
National, rural and urban annual fish intakes per capita, 2000–2010 (derived from BBS, 2007, 2011).

	Annual fish consumption per capita 2000 (kg)	Annual fish consumption per capita 2005 (kg)	Annual fish consumption per capita 2010 (kg)	Change in consumption 2000–2005 (kg)	Change in consumption 2000–2005 (%)	Change in consumption 2005–2010 (kg)	Change in consumption 2005–2010 (%)
National	14.05	15.37	18.07	1.32	9.40	2.70	17.57
Rural	13.80	14.49	16.71	0.69	5.00	2.22	15.32
Urban	14.93	18.10	21.86	3.17	21.23	3.76	20.77

smaller sizes or poorer quality. At the national level, consumers in the poorest quartile consume 57% less fish per capita on average than those in the wealthiest quartile. There are also substantial differences in the average quantity of fish eaten by consumers in rural and urban areas. Average per capita expenditure on fish in major cities is nearly twice that in rural areas, largely reflecting geographical differences in income (Belton et al., 2011).

Price elasticities for fish in Bangladesh tend to be greatest for lower income groups (i.e. poorer households tend to respond more to changes in fish price than do richer households). This implies that any reductions in the price of cheaper fish species occurring as a result of increased output will disproportionately benefit the poor. Conversely, this group would be hurt by reduced fish consumption should constricted supply cause prices to rise. Consumption becomes progressively less elastic for households in higher income brackets, so that better-off households tend to treat fish as a daily necessity. This suggests that flexibility in fish demand will absorb potential supply expansion in the market if real per capita incomes in Bangladesh continue to increase (Dey et al., 2010; Belton et al., 2011).

These predictions appear to be borne out by data from the most recent Household Income and Expenditure Survey (Table 2) which indicate that a remarkable 17.6% increase in per capita fish consumption took place between 2005 and 2010, at national level; up an additional 2.7 kg to 18.1 kg/capita/annum. This figure is close to the average global fish consumption per capita of 18.6 kg per annum (FAO, 2012). Urban areas posted an even sharper rise, up 3.8 kg (20.8%) to 21.9 kg/capita/annum. Consumption growth in rural areas, which lagged behind over the period 2000–2005, though slower, had also begun to catch up with that in cities by 2010.

Although very large, these changes are consistent with fish's high income elasticity. The report of the Household Income and Expenditure Survey (HIES) recorded a 38% increase in real (inflation adjusted) household expenditures between 2005 and 2010, and a consequent 8.5% decline in the headcount poverty rate, which fell most rapidly for those below the lower poverty line (BBS, 2011). Real agricultural wage rates in rural areas, where the highest concentrations of poverty are found, also increased by 50% between 2005 and 2010 (Zhang et al., 2013). However, despite the apparent scale of average increases in fish consumption per capita (the vast majority of which has been derived from growth in aquaculture), the food and nutrition security implications of this on-going substitution between wild and cultured fish remain poorly understood.

Methodology and summary of data

This study presents a largely descriptive analysis of fish consumption in Bangladesh, based on data generated by IFPRI, as part of a major study which evaluated the long-term impacts of development interventions implemented during the early 1990s on chronic poverty. Data analyzed in this paper were generated in order to evaluate the effectiveness of agricultural production interventions implemented by development agencies. The complete dataset is publically available through the IFPRI website: (<http://>

www.ifpri.org/dataset/chronic-poverty-and-long-term-impact-study-bangladesh). The survey covered a range of topics relating to poverty, vulnerability, livelihoods, income, food consumption, expenditure, gender and health. Only data on food consumption (including related factors such as per capita monthly expenditures and household size) are analyzed in this paper.

The survey was conducted in 1996/7, in four rounds spread throughout the year (June–September, October–December, February–May, and June–September). A one-off follow up survey was conducted 10 years later, in November–February 2006/07. Longitudinal comparisons between the two datasets presented here use data from the second round of the 1996/7 survey (October–December), which represents the closest temporal fit with the timing of the follow-up survey. All households surveyed in earlier rounds were re-surveyed. Households formed in the interim by division from those originally interviewed were also surveyed. Although the survey included separate responses on food consumption in the preceding 3 and 4–7 day periods, this analysis uses only data for the preceding 3 days on the basis that food consumption recall is most likely to be accurate over short periods (Beegle et al., 2012).

By 1996, aquaculture was fairly well-developed in three districts where the survey took place (Mymensingh, Krishoreganj, and Jessore), but less common in the fourth (Manikganj). Because of high levels of participation in aquaculture interventions (Table 3), levels of pond ownership among the households surveyed were unusually high (40% in 2006, as opposed to the national average of 20% reported by Belton et al., 2011). For the purposes of analysis, households are divided into quartiles based on per capita monthly expenditure¹ in order to identify patterns of consumption related to economic status. The poorest quartile is referred to as Quartile 1, and the wealthiest as Quartile 4.

Results and discussion

This section begins by assessing the contribution of fish to the diet in terms of quantity and frequency of consumption in comparison to other food groups. The frequency and quantity of consumption of different types of fish are then examined. The effects of seasonality and location on the types and quantity of fish consumed are considered. Finally, changes in fish consumption patterns over the 10 year period between the two surveys are explored.

Fig. 2 shows the importance of fish in the diet in terms of frequency of consumption. With the exception of cereals, non-leafy vegetables and edible oil, fish was the food group which households had consumed most frequently in the preceding three days, ahead of all other major food-based sources of micronutrients. Even amongst the two poorest quartiles, approximately 80% of households had consumed fish within the last three days, whereas only 10–20% of households in these quartiles consumed any meat.

¹ We consider expenditure as a proxy for income for methodological reasons set out by Deaton (1997). Therefore, in the analysis which follows, we refer to 'income quartiles'.

Table 3
Summary of the datasets analyzed.

Location	Intervention	No. households in 1996/7	No. households in 2006/7
Manikganj	Homestead vegetable cultivation by women	409	421
Mymensingh	Carp polyculture in homestead ponds	166	179
Krishorganj	Carp polyculture in homestead ponds	214	241
Jessore	Carp polyculture in ponds collectively by women's groups	448	468
Total		1237	1309

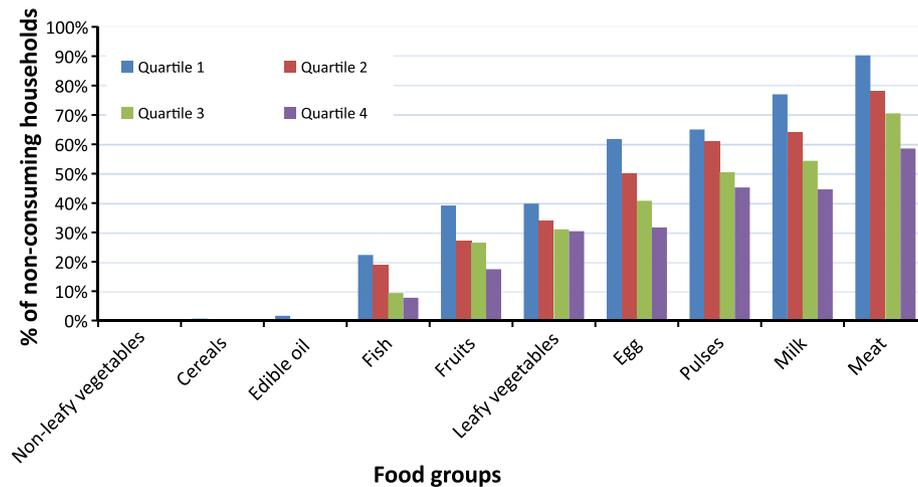


Fig. 2. Non-consumption of food groups in the preceding three days, 2006/7.

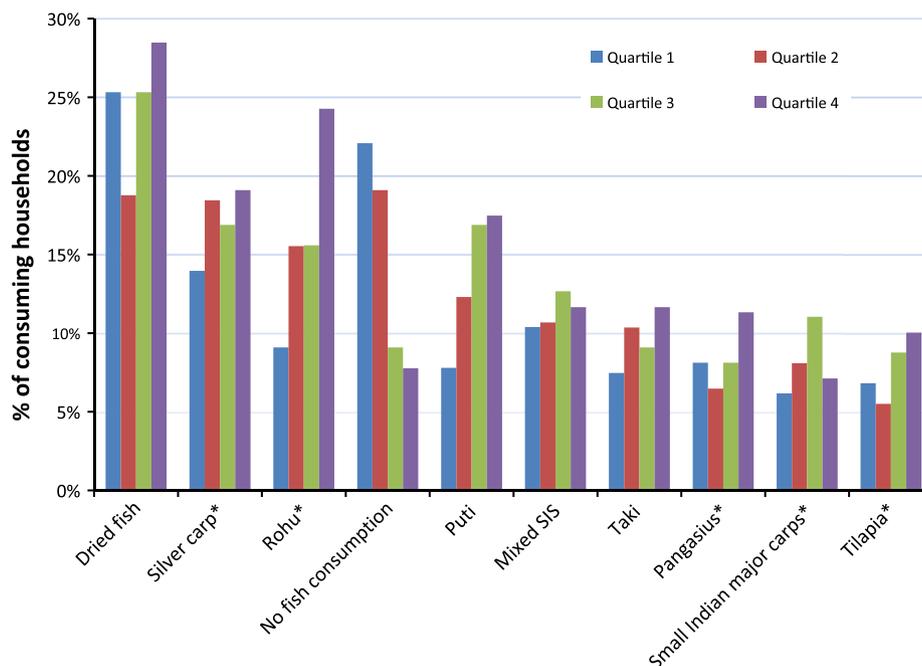


Fig. 3. Frequency of fish consumption in the preceding three days by type, 2006/7. *Note:* Fish originating mainly from aquaculture are marked with an asterisk to aid identification.

This finding is consistent with those of [HKI \(2002\)](#) and [Belton et al. \(2011\)](#), quoted earlier.

On average, fish was the major animal-source food in terms of quantity for households in all income quartiles. It contributed between 58% and 39% of all animal-source foods (including milk) by weight for Quartiles 1 and 4, respectively, in 2006/7. The declining relative contribution of fish to intake of animal-source foods

from Quartile 1 to Quartile 4, despite substantial increases in the absolute quantity consumed, gives a clear indication of its greater relative importance to poorer households.

[Figs. 3 and 4](#) show, respectively, the frequency and quantity of consumption of the top ten most consumed fish species, disaggregated by income quartile. (Frequency refers to the percentage of households consuming any given type of fish within the preceding

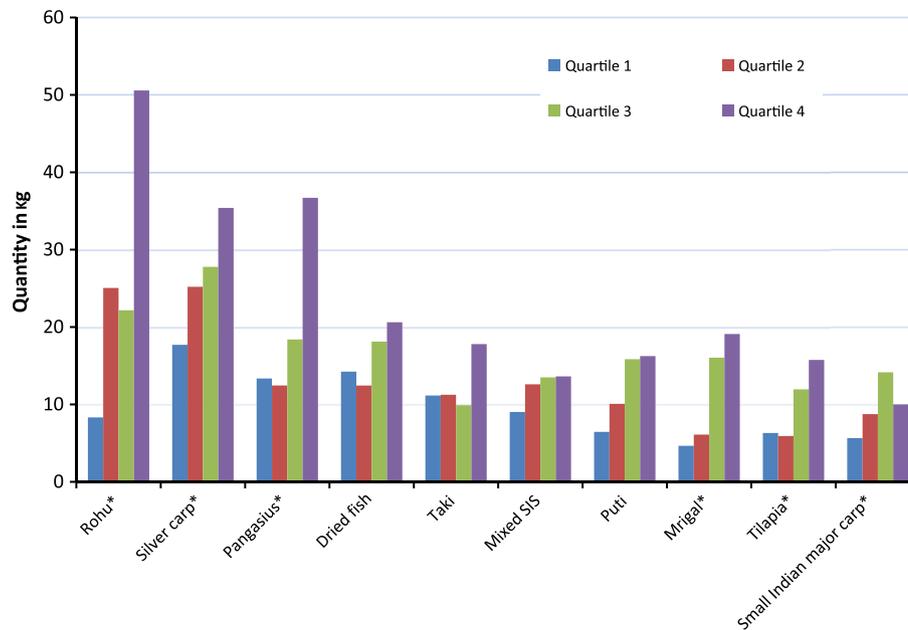


Fig. 4. Quantity of fish consumption in the preceding three days, 2006/7. *Note:* Fish originating mainly from aquaculture are marked with an asterisk to aid identification. Figures for dried fish are calculated as wet weight equivalent (four times the dry weight) based on Hossain et al., (2013).

three days. Quantity refers to the total quantity (kg) of any given type of fish consumed over the preceding three days). The order and composition of species in the two graphs differ because frequency of consumption is not perfectly matched with quantity consumed. The top ten types of fish by quantity accounted for 71% of all fish consumption, out of a total 53 types of fish.

Our analysis highlights a number of patterns. Firstly, dried fish is the most frequently consumed type of fish overall. Dried fish in Bangladesh is made from non-farmed species of either marine or freshwater origin, which are mainly small and of low market value (Hossain et al., 2013). Dried fish is also the fourth most important fish in terms of total quantity consumed, after adjusting for wet weight, and is consumed with a similar degree of frequency by all income quartiles, with the result that its relative contribution to diets is greatest for poorer consumers.

Three other types of small wild fish also feature in the top ten, in terms of both frequency and quantity of consumption. These are; puti (*Puntius spp.*), mixed SIS, referred to in Bengali as *pach mishali*, and taki (*Channa punctata*). The first two types of fish are usually consumed whole, and are thus an important source of bio-available calcium (Hansen et al., 1998). The category, mixed SIS, also includes species particularly rich in other micronutrients such as Vitamin A, iron and zinc (Thilsted, 2012). It is notable that there is no statistically significant difference ($p > 0.05$) between income quartiles in the quantity of mixed SIS and taki consumed. This is in contrast to farmed species in the top 10, for most of which, there is a significant gap ($p < 0.05$) in the quantities consumed by lower upper and income quartiles.

Three of the top four most consumed species by quantity – rohu (*Labeo rohita*), silver carp (*Hypophthalmic molitrix*), and pangasius (*Pangasius hypophthalmus*) – are farmed. Rohu is one of the most culturally preferred freshwater fish species, but is also relatively expensive. This is apparent in the large consumption gap between Quartile 1 and Quartile 4 consumers (a factor of around six). However, although silver carp and pangasius are among the cheapest species available, quantities eaten by consumers in lower and upper income groups also differed significantly ($p < 0.05$). Although wealthier households ate more of almost every fish species in terms of quantity, the difference for pangasius was

particularly great and appears to run against the commonly held view that it is a 'poor person's fish' (Belton et al., 2011).

Pangasius' position as the third most consumed fish in terms of quantity underlines the growing share of commercial aquaculture in farmed fish production, as all pangasius is produced for the market on intensively managed farms, in contrast to carps, which have traditionally been farmed on a semi-subsistence basis, in small low-input homestead ponds (Belton and Azad, 2012). Three other types of farmed fish – mrigal (*Cirrhinus mrigala*), tilapia and small Indian major carps (weighing approximately 250 g or less per individual) – occupy 8th, 9th and 10th place, respectively, in terms of total quantity consumed, and have fairly similar profiles in terms of quantity and frequency of consumption across income quartiles.

Non-consumption of fish was the 4th most common type of consumption in terms of frequency, with around 20% of households in Quartiles 1 and 2 consuming no fish within the preceding three days, as opposed to fewer than 10% of households in Quartile 3 and 4. Taken as a whole, better-off households consumed not only a greater quantity, but a greater diversity of fish than poorer ones. Within the three day recall period of the 2006/7 survey, households in Quartile 1 consumed a maximum of five types of fish, whilst those in Quartile 4 ate a maximum of seven. Considering the proportion of households eating at least one type of fish over the last three days, the largest proportion of Quartile 1 households (42%) consumed only one type of fish, whilst the largest portion of Quartile 4 households (27%) consumed three, reflecting increasing diversity of consumption with income.

Consumption also varied considerably by season and location. Overall average fish consumption was highest in the October–December round of the 1996/7 survey. This corresponds with the end of the rainy season when fish are most easily captured as natural water bodies dry up. During this period, 58% of all households reported consuming two or more types of fish within the preceding 3 days, as compared to 42% and 38% in February–May and June–September, respectively. The quantity of fish consumed per capita was also more than 50% greater in October–December compared to the other two survey rounds.

Types of fish consumed varied considerably with season. By quantity, consumption of the farmed fishes commonly grown in

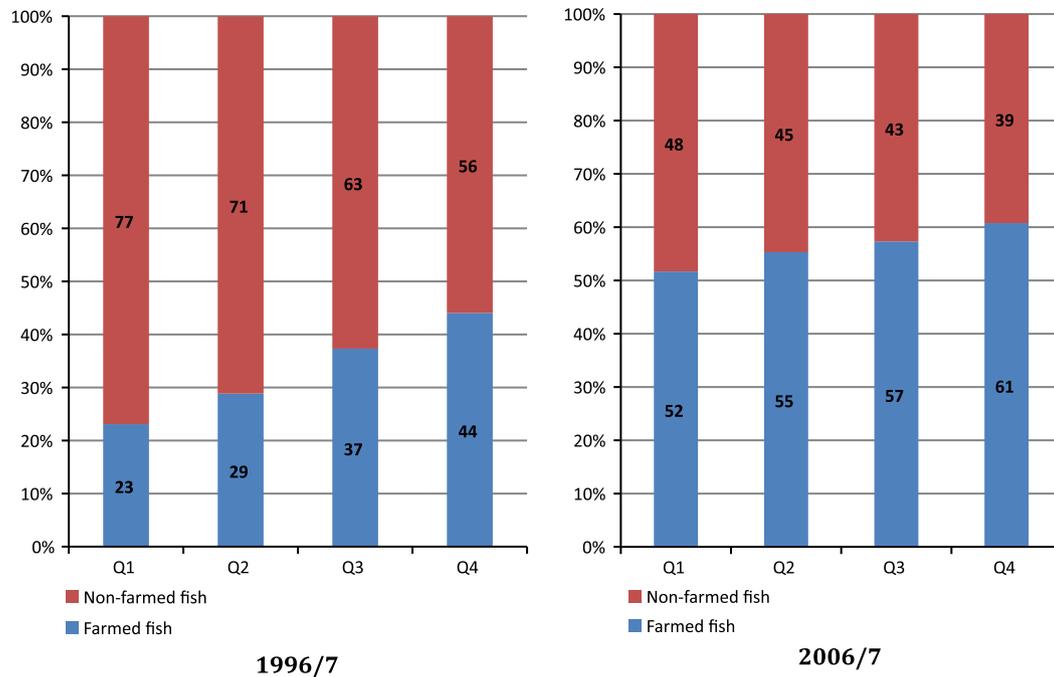


Fig. 5. Consumption of non-farmed fish and farmed fish by income quartile and year. Note: Q1 = Quartile 1, etc.; Figures for non-farmed fish factor in the wet weight equivalent of dried fish.

homestead ponds (rohu, mrigal and silver carp) was highest during the February–May round of the survey. This corresponds with a tendency to harvest homestead ponds during the dry season, as water levels fall. In contrast, most non-farmed fish were consumed in the greatest quantities in October–December, making this the period of highest per capita fish consumption, and reflecting their peak availability at this time.

Most dried fish consumption occurred during October–December, suggesting that this was comprised of predominantly small, non-farmed freshwater species, harvested during or just after the monsoon, and preserved by rudimentary processing. A peak in consumption of mixed SIS during June–September may reflect the increased availability of small species such as darkina and puti which spawn in rice fields during this period of the monsoon. The somewhat staggered peaks in availability of farmed and non-farmed fish are complementary, with farmed fish easing seasonal variability in consumption.

Major spatial variability in fish consumption was also identified. Extremely high frequency of dried fish consumption was recorded in Mymensingh and Kishoreganj (two adjoining districts), whereas very low frequency was recorded in Manikganj and Jessore. This was probably related to the abundance of SIS in the numerous natural water bodies found in the former two districts, as well as to localized cultural food preferences. This temporal and spatial variability in consumption is obscured if data are presented as aggregate annual averages.

Consumption of pangasius was low in Mymensingh, despite this being the most important district for its production in Bangladesh (Ali et al., 2012), and highest in Manikganj. This reflects the high availability of other preferred farmed species and non-farmed fish in Mymensingh, and the limited availability of both these types of fish in Manikganj. It also appears to suggest that pangasius is not a favoured consumption choice where other options are available, but that it fulfills an important role in meeting fish demand in areas with low production from capture fisheries and/or aquaculture. This conclusion is in line with observations made elsewhere (Belton and Azad, 2012).

Households with pond access consumed fish in greater quantities than those without (307 g per household per day, versus 194 g), and with greater frequency (73% of households with pond access consumed fish every day, as opposed to 47% of households without). However, on average, households with pond access purchased more than half (55%) of the fish they consumed. This may be because small homestead ponds are unable to meet all household consumption needs, particularly when they do not hold water year round. It may also suggest that households opt to sell high market value pond-raised fish such as rohu, and purchase cheaper species in the market, as noted by Little et al. (2007). Moreover, it is likely that consumption of a variety of fish, including non-farmed species, is preferred to consumption of a relatively limited number of farmed species.

Only a small amount of fish consumed was captured from open water fisheries by households themselves; 5% and 6% by households with and without pond access, respectively. This implies that most capture fishery fish consumed was purchased from the market. Other studies support this observation, showing that even close to water bodies supporting productive capture fisheries only a quarter to a third of fish eaten was self-caught (Thompson et al., 2007). Non-pond owning households received 10% of the fish they consumed as gifts given by others (presumably mainly pond owners), whereas households with pond access obtained just 2% of the fish they ate in this way. This implies a moderate degree of redistribution of fish from households with ponds to those without.

Fig. 5 shows the increasing prominence of farmed fish in the diet. This grew from 34% to 57% of total fish consumed over the period 1996/7 to 2006/7. Poorer households tended to consume proportionately more non-farmed fish than better-off households. In 1996/7, non-farmed fish accounted for 77% of consumption for Quartile 1 households, and 56% for households in Quartile 4. By 2006/7, 48% of fish consumed by Quartile 1 households, and 39% consumed by households in Quartile 4, remained non-farmed. This change reflects large increases in aquaculture output that occurred over this period coupled with declines in the availability and/or accessibility of wild fish.

Table 4 demonstrates the extent to which farmed fish replaced non-farmed in the diet over the period in question. Consumption of non-farmed fish, upon which poorer households are more dependent, declined sharply. The rate of decline was fastest for lower income quartiles (35% for Quartile 1), and slightly slower for the better-off (26% for Quartile 4). Conversely, consumption of farmed fish grew fastest among poorer households (131% for Quartile 1), and slowest for the better-off (45% for Quartile 4). However, poorer households started from a much lower average base of farmed fish consumption, and the absolute increase in the quantity of farmed fish consumed by Quartile 4 households (6.2 kg/capita/year) was actually double the consumption increase among households in Quartile 1 (3.1 kg/capita/year). Annual per capita consumption of fish increased for all income quartiles between 1996/7 and 2006, though to a lesser degree for Quartile 1 households (0.3 kg; 3.2%) and Quartile 2 households (0.3 kg; 2.3%), than for the upper quartiles (e.g. Quartile 4, 1.6 kg; 5%). However, although indicative of an overall trend towards increasing fish consumption, particularly among the better-off, these changes were not statistically significant ($p < 0.05$).

Thus, although it appears that, in terms of quantity, aquaculture has offset declining accessibility of wild fish, differences in micro-nutrient profiles between some SIS and larger farmed species mean that the question of whether it has been able to compensate in terms of dietary quality requires further investigation (Thilsted, 2012). The possibility that it did not do so has particularly important implications for households in the poorest two quartiles, for which, the increase in consumption of farmed fish only just matched the decline in intake of capture fish.

Table 5 shows changes in the rankings of the ten most frequently consumed types of fish between 1996/7 and 2006/7. In 1996/7, six of the most frequently consumed types of fish were non-farmed, and only three farmed. By 2006/7, two non-farmed species – tengra (*Mystus tengra*), and small prawns – were no longer among the ten most frequently consumed fish. Additionally, three other types of non-farmed fish, including puti (formerly the most frequently consumed fish of all) fell several positions. The only type of fish of non-farmed origin which increased in rank was dried fish, which moved up a single place to replace puti as the most frequently consumed type of fish.

Two farmed species, rohu and silver carp, moved up from 6th to 3rd position, and 3rd to 2nd position respectively, while tilapia remained in its original position. Two types of farmed fish, pangasius and small Indian major carps, appeared as new entrants in 8th and 9th positions, respectively. In 1996/7, consumption of pangasius was reported by only a single household, and small Indian major carps were not recorded as a separate category. The appearance of pangasius is significant because it indicates the emergence of intensive commercial aquaculture as an important contributor to national fish supplies; a trend which has since become more pronounced (Belton and Azad, 2012). The appearance of small Indian major carps is also indicative of the growth of aquaculture and, perhaps, of an emerging tendency to substitute consumption of increasingly scarce non-farmed fish with small, low market value farmed ones.

Despite an overall increase in the total quantity of fish consumed by all income quartiles, frequency of non-consumption of fish appears to have increased slightly from 1996/7 to 2006. It is therefore possible that the frequency with which fish was consumed declined somewhat, despite absolute quantities of fish consumed remaining stable or increasing slightly. This could have been linked to declining availability of SIS, and would imply that the weight for weight substitution of non-farmed fish by farmed fish did not necessarily translate to maintenance of dietary diversity at 1996/7 levels. Moreover, the greater relative dependency of the poorest households on non-farmed fish suggests that they

Table 4
Change in annual consumption per capita of non-farmed fish and farmed fish, 1996/7 to 2006/7. Note: Figures for non-farmed fish factor in the wet weight equivalent of dried fish.

	Quartile 1			Quartile 2			Quartile 3			Quartile 4			All		
	Year		Change	Year		Change									
	1996/7	2006/7	kg %	1996/7	2006/7	kg %									
Non-farmed fish	7.8	5.1	-2.8 -35.1	10.6	6.8	-3.8 -35.8	12.6	9.4	-3.2 -25.5	17.7	13.0	-4.7 -26.3	12.5	8.4	-4.0 -32.5
Farmed fish	2.4	5.4	3.1 131	4.3	8.4	4.2 97.0	7.5	12.6	5.1 68.0	13.9	20.2	6.2 44.8	6.3	11.3	5.0 79.9
All fish	10.2	10.5	0.3 3.2	14.9	15.2	0.3 2.3	20.2	22.1	1.9 9.4	31.6	33.2	1.6 5.0	18.8	19.7	1.0 5.3

Table 5
Changes in rank of the ten most frequently consumed fish types, 1996/7–2006/7.

Rank 2006/7	1996/7 (October–December)	2006/7 (November–February)	Change in rank 1996/7–2006/7 ^a
1	Puti	Dried fish	↑ (2)
2	Dried fish	Silver carp	↑ (3)
3	Silver carp	Rohu	↑ (6)
4	Taki	No consumption	↑ (7)
5	Mixed SIS	Puti	↓ (1)
6	Rohu	Mixed SIS	↓ (5)
7	No consumption	Taki	↓ (4)
8	Small prawn	Pangasius	↑ new
9	Tengra	Small carps	↑ new
10	Tilapia	Tilapia	–

^a Note: The figure in brackets is the rank in 1996/97. Species in bold font are farmed.

are likely to be most severely affected by adverse nutritional outcomes resulting from the loss of these from diets.

Conclusions

This paper has described changing fish consumption patterns in Bangladesh through an analysis of household consumption data collected by two IFPRI surveys, in 1996/7 and 2006/7, and explored their implications for food and nutrition security. Although caution must be employed in extrapolating from datasets which are not nationally representative, a number of patterns are discerned which appear indicative of broader trends taking place within the fisheries sector. The implications for food and nutrition security, as well as for policy are summarized below.

In Bangladesh, consumers in all income brackets are becoming more reliant on farmed fish. This reflects, on the one hand, declining availability and accessibility of fish from capture fisheries and, on the other, increasing production of farmed fish. This shift is most marked for the poorest consumers. Overall, aquaculture has had a strong positive effect in mitigating the declining availability of capture fish: access to fish would have become far more constrained were it not for the rapid growth of farmed production. Whilst part of the increase in farmed fish originated from home-stead ponds, a sharp rise in consumption of pangasius also indicates the importance of intensive commercial aquaculture in contributing to meeting national demand for fish. However, contrary to popular belief that pangasius is a 'poor person's fish' because of its low market value, it was consumed more frequently and in much larger quantities by better-off households, indicating that fish size, as well as price, determine its accessibility to consumers.

Fish consumption as a whole did not increase to a statistically significant degree. The nominal trend across all income groups was slightly upwards however, though to a lesser degree for the lower income quartiles than for the upper. The data presented also suggest, though not conclusively, that fish consumption frequency, and hence dietary diversity, may have declined between 1996/7 and 2006/7 (again, particularly for the poorest consumers), despite increases in farmed fish consumption equaling or exceeding losses of non-farmed fish on a weight for weight basis.

Aquaculture is complementary to capture fisheries in terms of seasonality of production, serving to increase the availability of fish during the dry season when capture fish are scarcest. There is a clear positive relationship between pond ownership or access and frequency and quantity of fish consumption, although this may in part reflect pond owners' better than average financial status and ability to purchase fish from the market (Belton and Azad, 2012). The results presented also highlight the importance of location in determining fish consumption patterns. This is most apparent in the case of dried fish, which was one of the most

frequently consumed categories of fish and one of the most important in terms of quantity (wet weight equivalent) on average, but which was only consumed in significant quantities in two out of the four districts surveyed, and mainly during the post-monsoon period (October–December). This location and temporal specificity suggests that surveys in other parts of the country (for instance, in coastal districts) might have yielded markedly different results.

It is difficult to determine conclusively on the basis of the evidence presented here whether, among the households surveyed, expanded access to farmed fish compensated for the loss of non-farmed fish in terms of dietary quality and diversity. However, given the inferior micronutrient profiles of farmed species to many commonly consumed SIS, it may be surmised that for consumers in the lowest two income quartiles - for whom total annual per capita fish consumption did not increase by a statistically significant amount over the 10 year period between surveys - it did not.

The analysis presented above suggests a number of nutrition-related policy implications. First, it underlines the continued centrality of fish in the Bengali diet and its importance as an essential source of much-needed micronutrients, implying the need to include fish as a core component of policies which aim to promote food and nutrition security. More specifically, aquaculture has proven highly successful at responding to demand spurred by faltering capture fisheries and a growing, more affluent, population, but seems to have been relatively more beneficial for better-off consumers than for poorer.

On the basis of this evidence, it appears that interventions which aim to improve nutrition by increasing fish production can be expected to leverage greater impacts in terms of improved nutritional equity by targeting capture fisheries rather than aquaculture. Bangladesh has numerous examples of both donor driven and government owned projects which have successfully supported the management of fisheries and water by community based organisations (CBOs) (Thompson, 2012). This has been achieved through the collective enforcement of rules regarding the observance of closed seasons, gear restrictions, the establishment and protection of fish sanctuaries and, sometimes, stocking of closed water bodies (Sultana and Thompson, 2007).

A complementary approach may be to enhance fisheries productivity by better management of flood control, drainage and irrigation schemes to improve the access of migratory species to floodplain habitats and maintain higher dry season water levels to provide habitat for resident floodplain species (Halls et al., 2008; Shankar et al., 2004). Such initiatives are not panaceas however. In rural Bangladesh, powerful interests are often able to wrest control of natural resources from the communities which manage them (Toufique, 1997), and neither state nor civil society possesses the capacity to establish and maintain such management arrangements everywhere that they are required.

Given this context, and the complementary role which aquaculture has played in averting substantial declines in fish consumption among all classes of consumers, there is also a need to promote forms of aquaculture with pro-poor consumption outcomes. One such option, which is already being pursued by WorldFish in Bangladesh, is the development of technologies for farming nutrient-rich SIS. Widespread production of species such as mola and darkina has the potential to reverse downward trends in consumption by increasing availability and access. Although already proven technically feasible on a small scale using seed harvested from open sources, larger scale commercial production is likely to require closure of the lifecycle of key SIS to enable the mass production of seed in hatcheries. Efforts to do so should receive priority investments.

A further important area for policy intervention involves the nexus of aquaculture and fisheries. As noted in the introduction, growth of aquaculture is increasingly taking place through the enclosure and stocking of floodplains and natural water bodies which formerly served as common access fisheries during the monsoon season. This has increased production of fish per unit area land, but mainly for the large and/or high market value species least accessible to poor consumers, and has excluded poor resource users, limiting their ability to harvest the SIS on which they are most dependent (Toufique and Gregory, 2008; Sultana, 2012). Enclosure of floodplains and natural water bodies is one of the fastest growing frontiers for the expansion of aquaculture in Bangladesh. Effective regulation of aquaculture in wetland areas is therefore desirable from the standpoint of nutritional and social equity. Although, under some circumstances, benefits associated with such forms of aquaculture development (e.g. employment generation) may offset exclusionary outcomes, measures are required to ensure that large-scale displacement of poor fishers and adverse impacts on productive capture fisheries do not occur. By following the range of approaches suggested above, it should be possible to sustain and enhance the contributions which capture fisheries and aquaculture make to food and nutrition security in Bangladesh.

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References

- Ahmed, A., 2011. Food and Nutrition Security in Bangladesh: Achievements, Challenges, and Opportunities. Presentation given at Workshop on Food and Nutrition Security in Bangladesh. ICDDR,B, Dhaka, Bangladesh 25 October 2011.
- Ali, M.Y., 1997. *Fish, Water and People: Reflections on Inland Openwater Fisheries Resources of Bangladesh*. The University Press Limited, Dhaka.
- Ali, M.H., Haque, M.M., Belton, B., 2012. Striped catfish (*Pangasianodon hypophthalmus*, Sauvage, 1878) aquaculture in Bangladesh: an overview. *Aquaculture Research*. <http://dx.doi.org/10.1111/j.1365-2109.2012.03101.x>.
- Allison, E., 2011. Aquaculture, Fisheries, Poverty and Food Security. Working Paper 2011-65. The WorldFish Center, Penang, p. 62.
- Arimond, M., Torheim, L.E., Wiesmann, D., Joseph, M., Carriquiry, A., 2009. Dietary Diversity as a Measure of the Micronutrient Adequacy of Women's Diets: Results from Rural Bangladesh Site. Food and Nutrition Technical Assistance II Project, Academy for Educational Development, Washington, DC.
- Banerjee, L., 2010. Effects of flood on agricultural productivity in Bangladesh. *Oxford Development Studies* 38 (3), 339–356.
- BBS, 2007. Household Income and Expenditure Survey 2005. Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.
- BBS, 2011. Household Income and Expenditure Survey 2010. Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.
- Beegle, K., De Weerd, J., Friedman, J., Gibson, J., 2012. Methods of household consumption measurement through surveys: experimental results from Tanzania. *Journal of Development Economics* 98, 3–18.
- Belton, B., Azad, A., 2012. The Characteristics and Status of Pond Aquaculture in Bangladesh. *Aquaculture* 358–359, 196–204.
- Belton, B., Little, D.C., 2011. Immanent and interventionist inland Asian aquaculture development and its outcomes. *Development Policy Review* 29 (4), 459–484.
- Belton, B., Karim, M., Thilsted, S., Jahan, K.M., Collis, W., Phillips, M., 2011. Review of Aquaculture and Fish Consumption in Bangladesh. Studies and Reviews 2011-53. The WorldFish Center, Penang, p. 76.
- Beveridge, M.C., Thilsted, S.H., Phillips, M.J., Metian, M., Troell, M., Hall, S.J., 2013. Meeting the food and nutrition needs of the poor: the role of fish and the opportunities and challenges emerging from the rise of aquaculture. *Journal of Fisheries Biology*. <http://dx.doi.org/10.1111/jfb.12187>.
- Craig, J.F., Halls, A.S., Barr, J.J.F., Bean, C.W., 2004. The Bangladesh floodplain fisheries. *Fisheries Research* 66 (2–3), 271–286.
- de Graaf, G., Born, B., Uddin, A.M.K., Martin, F., 2001. *Floods, fish and fishermen*. The University Press Limited, Dhaka.
- Deaton, A., 1997. *The Analysis of Household Surveys: A Microeconomic Approach to Development Policy*. The Johns Hopkins University Press, Baltimore.
- Deb, A.K., Haque, C.E., 2010. 'Every mother is a mini-doctor': Ethnomedicinal uses of fish, shellfish and some other aquatic animals in Bangladesh. *Journal of Ethnopharmacology* 134 (2), 259–267.
- Dey, M.M., Bose, M.L., Alam, M.F., 2010. Demand for aquaculture development: perspectives from Bangladesh for improved planning. *Reviews in Aquaculture* 2, 16–32.
- DOF, 2012. Fisheries Statistical Year Book of Bangladesh 2010–2011, vol. 26, no. 1. Fisheries Resource Survey System, Department of Fisheries, Ministry of Fisheries and Livestock.
- FAO, 2012. The State of World Fisheries and Aquaculture 2012. FAO Fisheries and Aquaculture Department. Food and Agriculture Organization of the United Nations, Rome.
- GoB, 2005. Bangladesh: Poverty Reduction Strategy Paper. General Economics Division Planning Commission. Government of People's Republic of Bangladesh, Dhaka, 370pp.
- GoB, 2010. Bangladesh Country Investment Plan: A Road Map Towards Investment in Agriculture, Food Security and Nutrition. Food Division, Ministry of Food and Disaster Management. Government of People's Republic of Bangladesh, Dhaka, 29pp.
- GoB, 2012. Sixth Five Year Plan 2011–2015. Planning Commission, Ministry of Planning, Dhaka: Government of the People's Republic of Bangladesh, 265pp.
- Halls, A.S., Payne, A.I., Alam, S.S., Barman, S.K., 2008. Impacts of flood control schemes on inland fisheries in Bangladesh: guidelines for mitigation. *Hydrobiologia* 609 (1), 45–58.
- Hansen, M., Thilsted, S.H., Sandstrom, B., Kongsbak, K., Larsen, T., Jensen, M., Sorensen, S.S., 1998. Calcium absorption from small soft-boned fish. *Journal of Trace Elements in Medicine and Biology* 12, 148–154.
- HKI, 2011. State of Food Security and Nutrition in Bangladesh: 2010. Helen Keller International and James P Grant School of Public Health, Dhaka, BD.
- HKI, 2002. Eggs are rarely eaten in rural Bangladesh: why and how to improve their availability. *Nutritional Surveillance Project Bulletin* No. 11. Helen Keller International, Dhaka, Bangladesh.
- Hossain, M.A.R., Wahab, M.A., 2009. The diversity of cypriniforms throughout Bangladesh: present status and conservation challenges. In: Tepper, G.H. (Ed.), *Species Diversity and Extinction*. Nova Science Publishers Inc., New York.
- Hossain, M.A.R., Belton, B., Thilsted, S.H., 2013. Preliminary Rapid Appraisal of Dried Fish Value Chains in Bangladesh. WorldFish, Dhaka, Bangladesh.
- Howlader, S.R., Kavita, S., Ferdousi, B., Dipika, P., Sommerfelt, E.A., Tara, K., 2012. Investing in Nutrition Now: A Smart Start for Our Children, Our Future. Estimates of Benefits and Costs of a Comprehensive Program for Nutrition in Bangladesh, 2011–2021. PROFILES and Nutrition Costing Technical Report. Food and Nutrition Technical Assistance III Project (FANTA), FHI 360, Washington, DC.
- IUCN, 2000. *Red List of Threatened Animals of Bangladesh*. IUCN – The World Conservation Union, IUCN Bangladesh.
- Kimmons, J.E., Dewey, K.G., Haque, E., Chakraborty, J., Osendarp, S.J.M., Brown, K.H., 2005. Low nutrient intakes among infants in rural Bangladesh are attributable to low intake and micronutrient density of complementary foods. *The Journal of Nutrition* 135 (3), 444–451.
- Lewis, D., 2011. *Bangladesh: Politics, Economy and Civil Society*. Cambridge University Press, Cambridge.
- Little, D., Karim, M., Turongruang, D., Morales, E., Murray, F., Barman, B., Haque, M., Kundu, N., Belton, B., Faruque, G., Azim, E., Islam, F., Pollock, L., Verdegem, M., Leschen, W., Wahab, A., 2007. Livelihood impacts of ponds in Asia—opportunities and constraints. In: van der Zijpp, A., Verreth, J., Tri, L.Q., van Mensvoort, R. (Eds.), *Fishponds in Farming Systems*. Wageningen Academic Publishers, pp. 177–202.
- Minten, B., Alam, A.Z.M.S., Deb, U.K., Kabir, A.Z.K., Laborde, D., Hassanullah, M., Murshid, K.A.S., 2010. *Agricultural Marketing, Price Stabilization, Value Chains, and Global/Regional Trade*. Bangladesh Food Security Investment Forum, Dhaka.
- Roos, N., Wahab, M.A., Hossain, M.A.R., Thilsted, S.H., 2007a. Linking human nutrition and fisheries: incorporating micronutrient dense, small indigenous fish species in carp polyculture production in Bangladesh. *Food and Nutrition Bulletin* 28 (2), S280–S293 (Suppl.).

- Roos, N., Wahab, M.A., Chamnan, C., Thilsted, S.H., 2007b. The role of fish in foodbased strategies to combat vitamin A and mineral deficiencies in developing countries. *Journal of Nutrition* 37, 1106–1109.
- Sarker, M.Y., Ayub, F., Mian, S., Lucky, N.S., Hossain, M.A.R., 2008. Biodiversity status of freshwater catfishes in some selected waterbodies of Bangladesh. *Journal of Taxonomy and Biodiversity Research* 2 (1), 17–26.
- Shankar, B., Halls, A., Barr, J., 2004. Rice versus fish revisited: on the integrated management of floodplain resources in Bangladesh. *Natural Resources Forum* 28 (2), 91–101.
- Sultana, P., 2012. Implications of floodplain aquaculture enclosure. *Journal of Environmental Planning and Management*. <http://dx.doi.org/10.1080/09640568.2011.637104>.
- Sultana, P., Thompson, P., 2007. Community based fisheries management and fisher livelihoods: Bangladesh case studies. *Human Ecology* 35 (5), 527–546.
- Tacon, A.G.J., Metian, M., 2013. Fish matters: importance of aquatic foods in human nutrition and global food supply. *Reviews in Fisheries Science* 21 (1), 22–38.
- Talukder, R.K., 2005. Food security, self-sufficiency and nutrition gap in Bangladesh. *The Bangladesh Development Studies* 31 (3&4), 35–62.
- Thilsted, S.H., 2012. The potential of nutrient-rich small fish species in aquaculture to improve human nutrition and health. In: Subasinghe, R.P., Arthur, J.R., Bartley, D.M., De Silva, S.S., Halwart, M., Hishamunda, N., Mohan, C.V., Sorgeloos, P. (Eds.), *Farming the Waters for People and Food*. Proceedings of the Global Conference on Aquaculture 2010, Phuket, Thailand. 22–25 September 2010. FAO, Rome and NACA, Bangkok, 896pp.
- Thilsted, S.H., Roos, N., Hassan, N., 1997. The role of small indigenous fish species in food and nutrition security in Bangladesh. *Naga, The ICLARM Quarterly* 20 (3&4), 82–84 (Supp I.).
- Thompson, P., 2012. Sustainability of community-based organizations in Bangladesh. *Society & Natural Resources* 26 (7), 778–794.
- Thompson, P., Roos, N., Sultana, P., Thilsted, S.H., 2002. Changing significance of inland fisheries for livelihoods and nutrition in Bangladesh. *Journal of Crop Production* 6, 231–249.
- Thompson, P., Halder, S., Rozario, R.R., 2007. Trends in Fish Consumption in Community Restored Wetlands. MACH Technical Paper 8. Winrock, International, 35pp.
- Thorne-Lyman, A.L., Kraemer, K., Valpiani, N., Akhter, A., Bloem, M.W., 2010. Household dietary diversity and food expenditures are closely linked in rural Bangladesh, increasing the risk of malnutrition due to the financial crisis. *The Journal of Nutrition* 140 (1), 182S–188S.
- Toufique, K.A., 1997. Some observations on power and property rights in the inland fisheries of Bangladesh. *World Development* 25 (3), 457–467.
- Toufique, K.A., Gregory, R., 2008. Common waters and private lands: distributional impacts of floodplain aquaculture in Bangladesh. *Food Policy* 33 (6), 587–594.
- UN, 2012. *The Millennium Development Goals Report 2012*. United Nations, New York.
- World Bank, 2012. *World Development Indicators 2012*. World Bank, Washington, DC.
- Zhang, X., Rashid, S., Ahmad, K., Mueller, V., Lee, H.L., Lemma, S., Belal, S., Ahmed, A., 2013. *Rising Wages in Bangladesh*. IFPRI Discussion Paper 01249. International Food Policy Research Institute, Washington, DC.