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The contribution of fish intake, aquaculture, and small-scale fisheries to improving food and nutrition security: A literature review

WorldFish CENTER

The contribution of fish intake, aquaculture, and small-scale fisheries to improving food and nutrition security: A literature review

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Contents

List of terminology definition

Aquaculture:

Since the review focuses on aquaculture interventions in developing countries, the term “aquaculture” used in this review means activities related to extensive or semi-intensive aquaculture. Extensive aquaculture is defined as production systems where ‘the aquatic animals must rely solely on available natural food, such as plankton, detritus and seston’ (Coche, 1982). Semi-intensive aquaculture involves “either fertilization to enhance the level of natural food in the systems and/or the use of supplementary feed. Such feeds are often low-protein (generally < 20% DM), usually compounded from locally available plants or agricultural by-products, and complement the intake of natural food which is higher in protein” (Hepher, 1988). Aquaculture activities mentioned in this review include the rearing of fingerlings, culturing large fish and/or prawns, culturing small indigenous species with large fish and/or prawns, agriculture-integrated activities involving aquatic plants and animals, rice-fish, cage culture, netting, fingerling trade, fish trade and marketing, conducted full-time, part-time and with seasonal participation. The resources used for aquaculture include seasonal small fish ponds, year around fish ponds, rice fields, and common-pool resources such as rivers, floodplains and swamps, lakes and reservoirs.

Food and nutrition security:

The term ‘food security’, was defined by FAO (1996) as ‘Food security is a condition when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life’. This definition includes the nutritional aspect which is described as ‘access to nutritious food to meet their dietary needs’, however, this review uses the term ‘food and nutrition security’ to emphasise the access and appropriate utilisation of micronutrient-rich foods, including the process through which they are cooked and absorbed in the body, and then used in physiologic functions at individual level.

Low-Income Food-Deficit Countries (LIFDC):

A low-income food-deficit country is defined by two criteria: per capita income below USD 1,675 in 2005, based on The World Bank’s Atlas method; and food deficient citation by the net food trade position of a country from 2003 to 2005. Trade volumes for a broad basket of basic foodstuff are converted and aggregated by the energy content. Self-exclusion is applied when countries that meet the above two criteria but have a specific request to FAO to be excluded. A total of 77 countries were listed in May 2009 (FAO, 2009 b).

Small fish/large fish:

The terms, ‘small fish’ and ‘large fish’ are distinguished in this review, based on the length. The fish under 25 cm at maximum size are basically categorized as small fish, while the fish over 25 cm at maximum size are defined as large fish, except some fish species which the maximum matured length is over 25 cm but small individuals of these species are most often consumed (Roos, 2001).

Small-scale fisheries:

The term ‘small-scale fisheries’ were adopted from the definition of FAO(2004), ‘small-scale fisheries can be broadly characterized as a dynamic and evolving sector employing labour intensive harvesting, processing and distribution technologies to exploit marine and inland water fisheries resources. The activities of this sub-sector, conducted full-time or part-time or just seasonally, are often targeted on supplying fish and fisheries products to local and domestic markets, and for subsistence consumption. Export-oriented production, however, has increased in many small-scale fisheries during the last one to two decades because of greater market integration and globalization. While typically men are engaged in fishing and women in fish processing and marketing, women are also known to engage in near shore harvesting activities and men are known to engage in fish marketing and distribution. Other ancillary activities such as net-making, boat-building, engine repair and maintenance, etc, can provide additional fishery-related employment and income opportunities in marine and inland fishing communities. Small-scale fisheries operate at widely differing organizational levels ranging from self-employed single operators through informal micro-enterprises to formal sector business. This sub-sector, therefore, is not homogenous within and across countries and regions and attention to this fact is warranted when formulating strategies and policies for enhancing its contribution to food security and poverty alleviation’.

Undernutrition:

This review uses the term ‘undernutrition’, defined as the outcome of insufficient food intake (hunger) and repeated infectious diseases. Undernutrition includes being underweight for one’s age, too short for one’s age (stunted), dangerously thin (wasted), and deficient in vitamins and minerals (micronutrient malnutrition). The term malnutrition refers to both undernutrition and overnutrition (UNICEF, 2006). Although undernutrition includes being deficient in vitamins and minerals, the term ‘micronutrient deficiencies’ are also used to distinguish from underweight.

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1. Introduction

1.1 Addressing the problems of nutrition through fish related interventions

Undernutrition, and high mortality and morbidity, have persisted in many developing countries. While the more obvious physical consequences of undernutrition – mortality, morbidity, stunting and wasting – have received a lot of policy attention, the hidden consequences of inadequate micronutrient intake, which often do not have obvious symptoms, have more recently become a main concern in public health and development organizations. These hidden consequences of micronutrients intake affect immune function, cognitive development, the growth of children, reproductive performance, and work productivity (Underwood, 2000). Reducing undernutrition has become a key focus in the Millennium Development Goals (MDGs) and many countries around the world are working towards achieving the MDGs.

In rural areas, in particular, undernutrition often occurs during the lean season when households run out of their food stocks. This seasonal cycle causes not only transient food shortages and inadequate dietary intake, but also affects future harvests as they may exhaust productive assets, and compromise children's education and health services. The lean season often coincides with the rainy season and leads to high prevalence of certain diseases such as malaria and diarrhoea (Vaitla *et al.*, 2009).

Several interventions related to fish intake, aquaculture and capture fisheries in Asia and Africa have aimed to improve nutritional status through influencing dietary intake directly, and raising productivity and household income. While there are many positive efforts to increase production and income, direct and indirect impacts on nutritional status have not been fully analysed. The pathway through which the increased income and fish production is linked to nutritional status is not clear.

The purpose of this review is to identify the potential impacts and limitations of improving nutritional status through fish intake, aquaculture and small-scale fisheries. The following section summarises the current nutritional situation and its determinants.

1.2 Current nutritional status in developing countries

Although there have been many improvements in nutritional status for a decade through various initiatives such as the development and promotion of the Millennium Development Goals (MDGs), the number of undernourished people increased from 843 million in 2003-5 to 1,020 million in 2009, due to population growth, the food price crises, fuel price increases (affecting costs fertilizers and transport costs) and the world economic recession (Food and Agriculture Organisation (FAO), 2008 a; von Grebmer *et al.*, 2009). Undernutrition still persists in many developing countries, especially among women and children (Table 1).

Table 1: Proportion of population below minimum level of dietary energy consumption (undernourished) in developing regions

	Underweight children under five years of age (%)	Undernourished population (%)
Sub-Saharan Africa	28	29
Latin America/the Caribbean	6	8
South Asia	48	21
South East Asia	25	15
West Asia	14	8
Oceania	-	15

Source: United Nations Inter-Agency and Expert Group on the Millennium Development Goals (2009)

While undernourishment can be improved by increasing energy intake, the problem of micronutrient deficiencies is of a different nature as it results from an inadequate quality of diet. More than two billion people in the world are estimated to be deficient in essential vitamins and minerals (World Health Organisation (WHO), 2001; United Nations Children's Fund (UNICEF), 2009 a), especially iron and vitamin A, with a large proportion in Africa (Table 2). Micronutrient deficiencies increase the general risk of infectious illness (e.g. measles) and non-infectious diseases such as malaria and pneumonia or even diarrhoea (WHO/World Food Program (WFP)/UNICEF), 2006).

Table 2: Prevalence of anaemia (associated with iron deficiency) and vitamin A deficiency

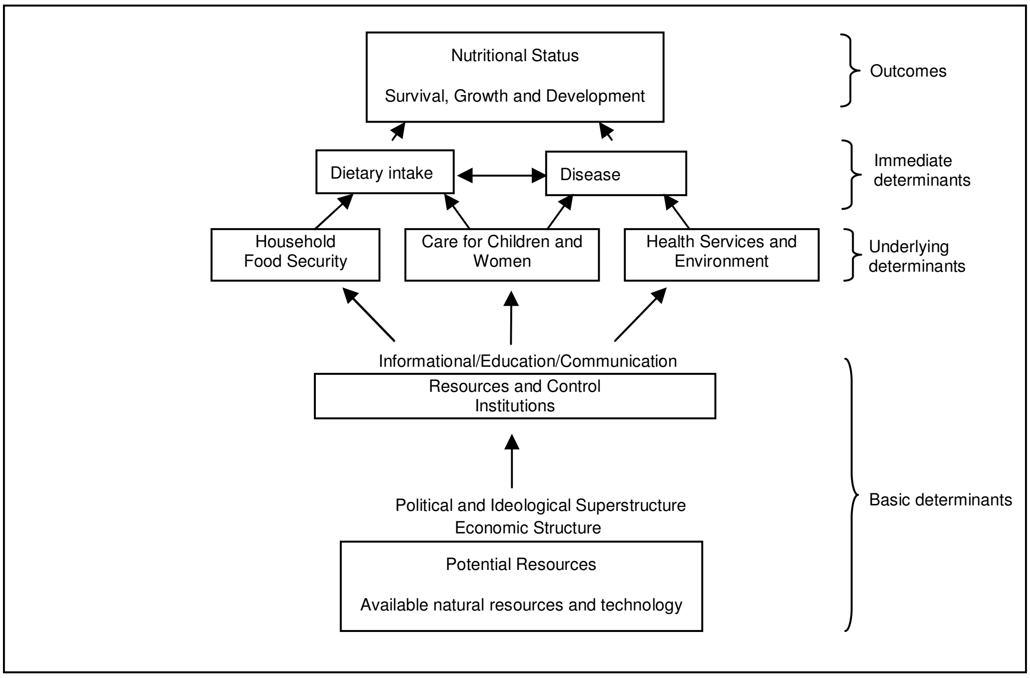
Regions	Prevalence of iron deficiency anaemia (%) [1]		Prevalence of vitamin A deficiency (%) [2]	
	Preschool-aged children	Pregnant women	Preschool-aged children	Pregnant women
Africa	64.6	55.8	41.6	14.3
Asia	47.7	41.6	33.5	18.4
Latin America / Caribbean	39.5	31.1	15.6	2.0
Oceania	28.0	30.4	12.6	1.4
Global	47.4	41.8	33.3	15.3

Source: 1 WHO (2008), 2 WHO (2009)

It has been predicted that the prevalence of micronutrient deficiencies will increase, following impacts of the recent food price crises and economic recessions (United Nations Standing Committees on Nutrition (UNSCN), 2009). The evidence of food and fuel crisis in 2007-2008 showed that urban poor households, as well as the landless and net buyers in rural areas were particularly vulnerable, and it resulted in reducing food expenses, cutting down on non-staple foods consumption, and consequently leading to inadequate intake of essential micronutrients especially of pregnant women and young children (Ruel et al., 2010).

1.3 Conceptual framework for analysing the linkage between fishing and aquaculture activities and nutritional status

UNICEF (1990) proposed a conceptual framework for nutritional status and identified various factors which determine an individual's nutritional status (Figure 1).



Source: UNICEF (1990)

Figure 1: Determinants of nutritional status

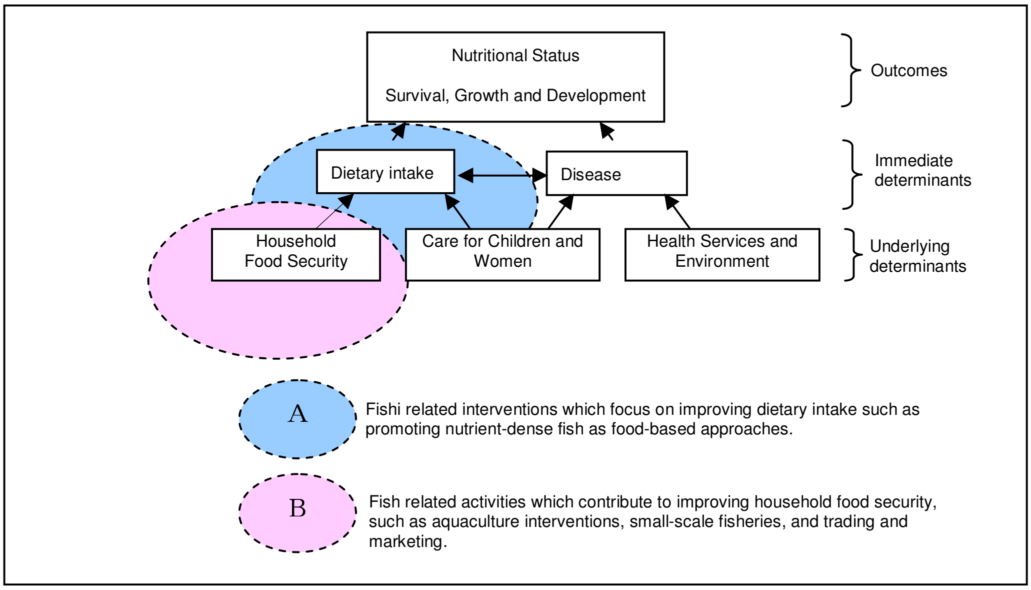
Poor nutritional status results from underlying problems related to social institutions and mechanisms which give rise to poverty and inequality（basic determinants) in a broader context. For example, in South Asia, it is perceived that the low social status of women contributes to a high prevalence of underweight children under five (von Grebmer *et al*., 2009). In addition, in Sub-Saharan Africa, ineffective governments, conflict and political instability are considered fundamental causes of high child mortality and the high proportion of people who cannot meet their daily energy requirements (von Grebmer *et al*., 2009).

Household food security; maternal and child care; and health services and healthy environment, are three pillars of underlying determinants of nutritional status. Diversifying livelihoods to increase household income sources is a way of improving household food security. Although fish-related literature often does not include studies related to other pillars, child care, especially breast-feeding is an important factor to determine children's nutritional status. Access to health services and living environment is also an important factor as it determines the risk of diseases.

Dietary intake is an immediate determinant of nutritional status. The typical diet of the poor is dominated by staple foods with small amounts of other plant-source foods such as vegetables and animal-source foods. Diversifying diet by adding animal-source foods, fruits and vegetables in their diets provides a variety of nutrients, contributing to improving nutritional status. Disease is another determinant of nutritional status, and there is a direct correlation between these two factors. For example, an inadequate diet results in increasing the risk of diseases. Sick people require additional energy intake to fight disease, and at the same time, they have a poor appetite. Meanwhile in affected households, the labour productivity is reduced and extra money and time to care for the sick are needed. Consequently, diseases affect the nutritional status of not only individuals, but also other household members. In contrast, adequate dietary intake maintains the body's immunity and decreases the risk of diseases, contributing to minimising extra costs and time for care and treatment, while optimising labour productivity.

Taking this framework as a basis for analysis, this review discusses how fish intake, aquaculture and small-scale fisheries can contribute to improving nutritional status. It analyses their impacts on immediate and underlying determinants of nutritional status, while basic determinants at national level are not taken into account of the main discussion in this review.

Fish is more nutritious than staple foods, providing animal protein, essential fatty acids and micronutrients. The interventions of food-based strategies which promote production and consumption of locally available nutritious foods have utilised fish instead of supplement distribution as a sustainable way of tackling micronutrient deficiencies (Gibson *et al*., 2000; Tontisirin *et al.,* 2002; Roos *et al.,* 2007 b). In addition to this direct contribution to dietary intake, fish is sold, contributing to household food security indirectly through increasing household income which can be utilised to purchase other food commodities, including lower cost staple foods (Béné *et al*., 2007; Aiga *et al*., 2009). Also, seasonal availability of fish is often different from crops, reducing seasonal vulnerability of the rural poor by extending availability of income and food to the lean season (Islam, 2007). Aquaculture and small-scale fisheries can also be of direct nutritional importance to the most food-insecure people within a household: women (and children and youth) tend to engage in fishing for household consumption, contributing to meeting nutritional needs of their children and themselves, while trading and processing activities provide cash for women, contributing to empowering them (Overa, 1998). Figure 2 adds the roles of fish-related activities and interventions into the conceptual framework outlined in Figure 1, and Table 3 summarises fishing and aquaculture activities and their relation to nutritional status.



Source: Adapted from UNICEF (1990)

Figure 2: The roles of fish-related activities and interventions in improving nutritional status

Table 3: Summary of the role of fish in improving nutritional status

	Area A in Figure 2 (focusing on immediate determinant of undernutrition)	Area B in Figure 2 (focusing on underlying determinant of undernutrition)
Issues to address	Hidden hunger Micronutrient deficiencies	Chronic and seasonal hunger
Focus	Improving micronutrient intakes through increasing intake of nutrient-dense small fish (food-based approaches)	Increasing household income through small-scale fisheries and aquaculture
Main target fish species	Nutrient-dense fish	Fish produced by aquaculture and supplied from small-scale fisheries for sale, including fish products such as dried and smoked fish
Interventions related to fish intake, aquaculture and small-scale fisheries (Examples)	Utilising fish as complementary food to improve nutritional status of children (Lartey *et al*., 1999; Greco *et al*., 2006) Encouraging children and women to eat nutrient-dense fish through nutrition education at community level (Roos *et al*., 2007 b) Increasing production of nutrition-dense fish species through disseminating polyculture of nutrient-dense fish with large fish(Thilsted *et al*., 1997) Reducing nutritional loss by disseminating better processing and cooking practices(Chittchang *et al*., 1999)	Providing various livelihoods opportunities for poor households including the landless and women through seasonal small-scale fisheries, processing and trading(e.g., Overa, 1998; Rubinoff, 1999; Béné *et al*., 2003, 2009) Disseminating new techniques in fish farming to improve productivity and thereby increasing income(e.g., Jahan *et a*l., 2009) Integrating agriculture and aquaculture (e.g., Dey *et al*., 2006, Karim, 2006) Improving food safety and quality through post-harvest interventions (e.g., Kabahenda and Husken, 2009).
Expected effects at household level	Increase in the production and consumption of nutrient-dense fish Decrease in nutritional loss by processing and cooking Improvement in women's knowledge of nutrition	Increase in household fish consumption Increase in household income and purchasing power Decrease in fish prices and increase in accessibility of fish for many more people Increase in women's status and improvement in children's nutritional status and health care
Indicators	Dietary intake Nutritional status at individual level Reproductive performance	Fish production Household income (to purchase food) Fish consumption at household level Foods consumption and expenditure

Food based approaches have focused on increasing the intake of nutrient-dense fish to address an immediate determinant of undernutrition, while interventions in fishing and aquaculture activities have often focused on improving household food security, however, these two approaches are in fact closely linked. The purpose of this review is to integrate these two areas and find the pathways through which fish can contribute to improving overall food and nutrition security. While this has been partly examined in recent papers on agriculture interventions (Hawkes and Ruel, 2006; World Bank, 2007), animal production (Leroy and Frongillo, 2007), and food-based approaches (Ruel, 2001), this review focuses on recent studies related to fish intake, aquaculture and small-scale fisheries in some areas of Asia, Oceania and Sub-Saharan Africa, as information on other regions were scarce. Although most of the discussion in this review focuses on finfish, other aquatic animals which are commonly consumed by the poor are also considered.

1.4 Structure of the review

Section 2 describes fish consumption patterns in developing countries of the poor and the nutritional importance of fish in fish-dependent communities. Section 3 presents the direct pathway through which fish intake improves the quality of the diet and leads to an improved nutritional status. To understand this pathway, the review clarifies the nutritional value of fish and its contribution to improving nutritional status. Section 4 summarises pathways through which aquaculture can contribute to improving food and nutrition security, using a review of empirical evidence from past interventions and analyses. Section 5 focuses on the roles of small-scale fisheries and presents pathways through which small-scale fisheries can contribute to food and nutrition security. Based on the findings, Section 6 discusses findings and suggests information gaps and research needs to improve our understanding of the potential contribution of fish. Section 7 concludes the discussion by highlighting significance of investing in fish-related activities as a means of improving nutritional status of the poor in developing countries.

1.5 Scope of the review

This review focuses on impacts of fish intake, aquaculture and small-scale fisheries on overall dietary intake and nutritional status of the rural poor households in developing countries in Africa, Asia and Oceania. Food security in a broader context, food safety issues and aquaculture technologies are not explicitly considered in this review.

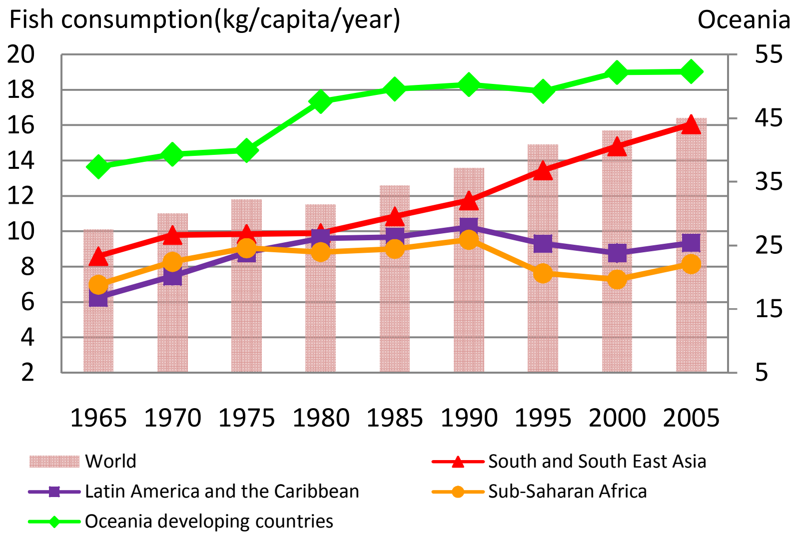
1.6 Methodology

The electronic library databases, ASFA, CABD, and Scopus were used for search, and relevant references cited in these articles were checked. Also the websites of relevant organizations such as FAO and WHO were used. The search terms used were aquaculture, capture fisheries, human nutrition, food-based strategies, food-based approaches, micronutrient deficiencies, malnutrition, fish consumption, food security, food and nutrition security, and HIV/AIDS.

2. Understanding the nutritional importance of fish in developing countries

2.1 Changes in fish consumption at global and regional levels

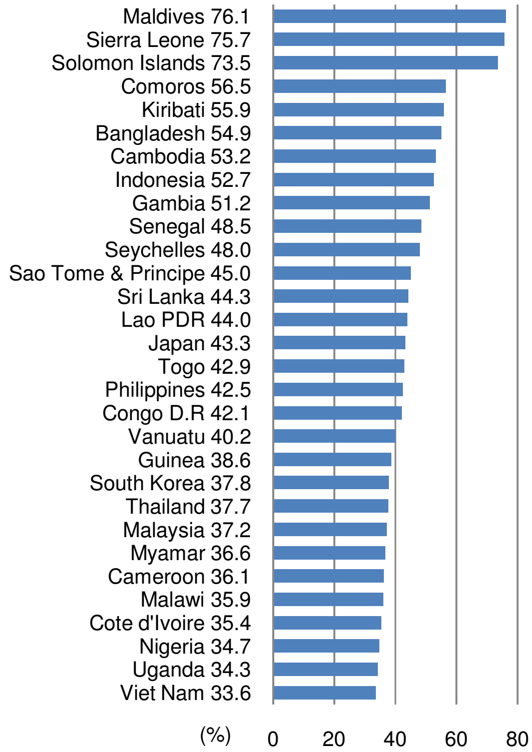
The amount of fish consumption varies with regions. Figure 3 shows changes in per capita fish consumption (estimated by the per capita food fish availability) between 1965 and 2005 for different developing regions of the world. Global fish consumption has increased from an average of 10.1 kg per capita per year in 1965 to 16.4 kg in 2005 reflecting the general increase in fish consumption in most of the world's regions except in Latin America and the Caribbean, and sub-Sahara Africa where fish consumption had stagnated over the last four decades. Fish consumption in sub-Sahara Africa is currently the lowest in the world.

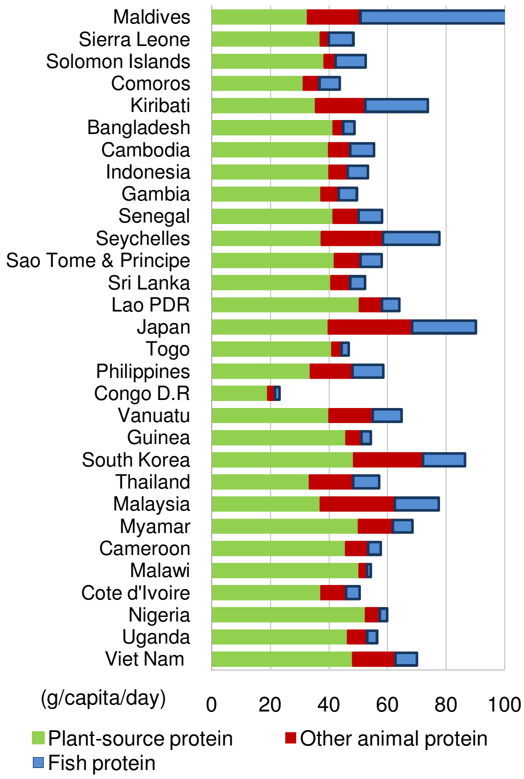


Source: FAO (2009 a)

Figure 3: Changes in per capita fish consumption for different developing regions of the world

Nevertheless, fish is still nutritionally important in many African countries as well as in Asia and Oceania. Figure 4a shows countries where fish contributes more than 1/3 of the total animal protein supply, calculated from the FAO food balance sheets (FAO, 2009 a). There are 30 countries who meet this criterion, including 22 countries which were officially referred to as low-income food-deficit countries (LIFDC) in 2009 (FAO, 2009 b). In other words, a large majority (73%) of the countries where fish is an important source of animal protein are poor and food deficient countries. Figure 4b shows the average protein consumption (g/capita/day) in these countries. In the LIFDC, in particular, the majority of protein in fact comes from plant-source foods and the amount of fish contributed to protein intake is very little, although fish is a major source of animal protein.





Source: Calculated from FAO food balance sheet (2009 b)

Figure 4a: Fish protein/animal protein consumption (%)

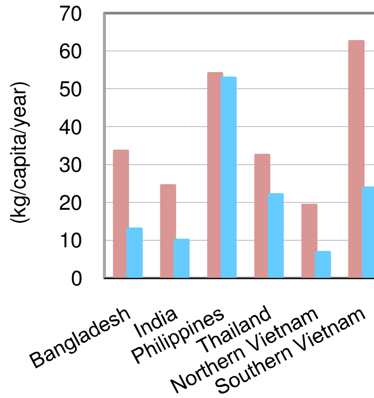
Figure 4b: Total protein consumption (g/capita/day)

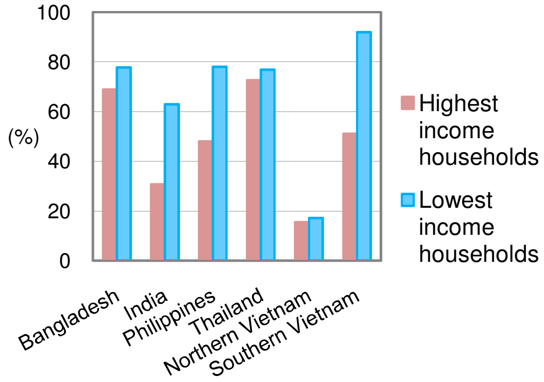
2.2 The nutritional importance of fish at household and individual levels

Fish as a major source of animal protein for the poor

Poor households have generally limited income for food consumption therefore they tend to prioritise certain food items to purchase. The first priority food purchased is usually their staple foods, such as rice and maize. Unless they have enough stock from their own farm, the remaining income is spent on cheaper non-staple foods (von Braun *et al*., 2008; UNSCN, 2009) such as vegetables. Recent studies in Asia suggest that low-income households consume less fish than rich households (Dey *et al.,* 2005; Hossain *et al*., 2005; Bose and Dey, 2007; Islam, 2007), but they still depend on fish as a major source of animal protein (Dey *et al*., 2005; Bose and Dey, 2007; Islam, 2007). One of the above studies in Bangladesh showed that the consumption gap between rich and poor in meat, eggs, milk and milk products is far wider than that of fish (Bose and Dey, 2007). Figure 5a shows the fish consumption gap by household income in five Asian countries. The consumption of fish in the lowest income households is less than half of that in the highest income households in three countries. On the other hand, the lowest income households spend more money on fish than other animal products (Figure 5b). This is because other animal foods are often more expensive than fish and are therefore less affordable for the poor.

These studies indicate that fish is a major animal protein source for the low income households, while high-income households can spend more and therefore have more access to other animal foods.





Source: Adapted from Dey *et al.* (2005)

Figure 5a: Fish consumption gap by household income

Figure 5b: Expenditure on fish as a share of total animal protein expenditure (%)

Fish consumption patterns of the poor

Beyond the average amount of the consumption and expenditure on fish, the consumption patterns by frequency, fish species and seasonality should be taken into account of the analysis to understand the important roles of fish for the poor.

In rural areas in Bangladesh, for example, a variety of small indigenous fish species are commonly consumed with a high frequency during the production season, and these species account for 50-80% of the total amount of fish consumed (Roos, 2003; Hels, 2002; Islam, 2007). In Laos and Cambodia, in addition to fish, other aquatic animals are consumed in the everyday diet among the poor (Meusch *et al.*, 2003; Chamnan *et al.*, 2009).

Availability of staple foods is one of the determinants of fish consumption patterns of the poor. When households lack food, fish produced by aquaculture or supplied by common-pool resources are used for cash, rather than as food for household consumption (Béné *et al.*,2003, Karim, 2006; Islam, 2007). In some areas in Bangladesh, poorer households sold more fish produced by their own ponds than better-off households (Karim, 2006; Islam, 2007). Similarly in a study area in the Lake Chad region where people face chronic food shortages, the poorest households sold a higher proportion of their catches to purchase cheap staple foods (Béné *et al.*,2003), as staple foods are always the first priority among food items. In these situations, fish is still very important for food security since it can be exchanged for staple foods which are cheaper and higher in energy, preventing households from facing serious food insecurity.

Market value of fish is also an important determinant of fish consumption patterns of the poor, as low income households have limited purchasing power. A study in Cambodia showed that poor people can afford only comparatively cheap-price small fish species, whereas, the rich can afford for medium-size fish species and consume fish which are tasty, less bony and are their favorite (Chamnan *et al.*, 2009). In some areas in Bangladesh, during a peak season of capture fisheries, people consume more small indigenous fish species than cultured large fish, as they are available in common-pool resources and rice fields. Households engaging in aquaculture also capture small indigenous fish species for household consumption while they sell large fish produced by aquaculture, as a strategy to meet their daily needs (Thompson *et al.*, 2006; Karim, 2006). On the other hand, during the dry season when fish supply from common-pool resources is limited and stocks in fish ponds are insufficient, fermented and dried fish become more frequently consumed (Karim, 2006).

Also, in Sub-Saharan Africa, fish consumption patterns of low-income households depend on the market value. In East Africa, the small dried fish, dagaa/omena/mukene (*Rastrineobola Argentea),* is one relatively cheap fish and it is commonly consumed among poor people in the lake shore communities around Lake Victoria (FAO, 2008 b: Geheb *et al.,* 2008). Although most people prefer fresh fish in East Africa (FAO, 2008 b; Kabahenda and Hüsken, 2009), fresh large fish, such as tilapia and Nile perch (*Lates niloticus*), are not always affordable even for the middle class population due to their high market value (Jansen, 1997). In Mukono district in Uganda, rejects and waste of Nile perch for export, were widely consumed among the low-income households, although the food quality and safety are poor due to inadequate processing methods (Kabahenda and Hüsken, 2009). Similar trends were found in Zambia. Fish products such as small dried fish, Kapenta (*Limnothrissa miodon),* and rejects and waste of Nile perch for export were reported as the most available fish to the most vulnerable households (Banda-Nyirenda *et al.*, 2009).

The intra-household distribution of fish

Fish consumption patterns at individual level differ among household members. There are few studies on the distribution of fish within a household. A study in Nigeria found that male heads of households consumed 59% more fish by weight than the wife and children. The consumption gap calculated by per unit body weight shows that the average fish consumption is 0.27 kg/kg body weight/year for the male head of households and 0.17 kg/kg body weight/year for the wife and children. When a single fish was shared within the household, there was a tendency to distribute the body of fish to the man, the tail to his wife, and the head to the children on 7-8 out of 10 occasions (Gomna and Rana, 2007).

Although small fish are more likely to be distributed evenly among household members than large fish or other animal-source foods (Thilsted *et al.,* 1997), a study in Bangladesh showed that preschool boys received a larger share of animal-source foods including fish than their sisters, equivalent to almost the same amount to that consumed by adult women in the same households (Bouis, 2000).

In summary, the limited field data at household level from Asia and Africa show that fish consumption patterns of the poor depend more on affordability than other factors such as preference. Affordability of fish is determined by availability of staple foods, seasonality, and the market value of fish. Fish and other aquatic animals, supplied by common-pool resources and rice fields in particular seasons, play very important roles in the diet of the poor. These fish species are processed, extending the period of consumption for the poor to the lean season. However, data on fish consumption patterns of the poor are scarce and are not necessarily reflected in national statistics. Understanding typical diet in populations with a high prevalence of undernutrition will help to develop strategies and appropriate interventions to improve the nutritional status. Therefore, further data on commonly consumed fish species, preference, seasonality and intra-household distribution are needed as well as consumption patterns of other food items.

3. The contribution of fish intake to improving nutritional status

The contribution of fish to human nutrition and its impact on health have been examined from different aspects in both developed and developing countries. In developed countries, researchers and consumers have been interested in the health benefits of poly-unsaturated fatty acids (PUFAs), which lower blood pressure, reduce the risk of heart disease(Wang *et al.*, 2006), and possibly benefit of infant growth and cognitive development(Koletzko *et al.*, 2007). On the other hand, in developing countries, undernutrition, micronutrient deficiencies, and HIV/AIDS are the main public health problems related to nutrition. The role of fish in contributing to nutritional needs has been highlighted in public health and fisheries literature, although the data are negligible compared to studies from developed countries. This review focuses on the situation in developing countries, and examines the potential role of fish in improving nutrition and combating health problems.

3.1 Nutrients in fish

Nutrient content varies with fish species. There are limited data on the nutritional composition of fish species which are commonly consumed by the poor in developing countries in Asia and sub-Saharan Africa. In Bangladesh, the micronutrient content of more than 20 small indigenous fish species has been examined and several nutrient-dense fish have been found (Thilsted, *et al.*, 1997; Roos, 2001). The potential of aquaculture in the production of these species has been examined (Roos *et al.*, 1999; Alim *et al.*, 2004; Kadir *et al.*, 2006). There are also some data on 29 small indigenous species from Cambodia, collected by the same authors (Roos *et al.*, 2007 c, 2007 d). In Malawi, four small indigenous species were examined for protein and some minerals to examine changes in nutrient content by processing (Mumba and Jose, 2005), but the specific content of vitamin A was not established. In northeast Thailand, fatty acid composition in five fish species and a prawn that inhabit rice fields were examined (Karapanagiotidis et al). Table 4 shows the nutritional composition of fish in three different categories of differing nutritional significance. In addition, the data on other food items are provided for comparison. The source of the data is the United States Department of Agriculture (USDA, 2005), except some data on small indigenous species which are from studies. The following discussion does not include the nutrient content variation induced by factors such as sea temperature, season, wild or cultured, the feeding of cultured fish, analytical methods, and number of samples analysed.

Table 4: The nutrient content of fish and other foods (per 100g)

	Scientific name/Common name (local name/common name)	Protein	Fat					Calcium	Iron	Zinc	Vitamin A	Notes	Source
			total lipid (fat)	total saturated	total polyunsaturated	EPA	DHA						
	Units	g	g	g	g	g	g	mg	mg	mg	RAE[a]	per 100g	
large freshwater fish and prawn	Carp	17.83	5.60	1.08	1.431	0.238	0.114	41	1.24	1.48	9	raw, edible	1
	Catfish farmed	15.60	7.59	1.77	1.568	0.067	0.207	9	0.50	0.74	15	farmed, raw, edible	1
	Channa striatus(Snakehead)		0.99	0.34	0.475	<0.001	0.133					raw, whole, Thailand	2
	Tilapia	20.80	1.70	0.77	0.476	0.007	0.113	10	0.56	0.33	0	raw, edible	1
	Macrobrachium nipponense (Prawn)		1.13	0.37	0.020	0.008	0.061					raw, whole, Thailand	2
small freshwater fish	*Amblypharyngodon mola* (Mola)							776	5.70	3.20	>2680	raw, edible. Bangladesh	3
	Esomus danricus (Darkina)							775	12.00	4.00	500-1500	raw, edible. Bangladesh	3
	Esomus longimanus(Chanwa phlieng)							350	45.10	20.30	100-500	raw, edible. Cambodia	4, 5
	Helostoma temmincki (Kanthtrawb)							432*	5.3*	6.5*	100-500	raw, edible. Cambodia	4, 5
	Puntius ticto (Puti)							992	3.00	3.10	500-1500	raw, edible. Bangladesh	3
	Rasbora tornieri (Changwa mool)							700*	0.70*	2.7*	>1500	raw, edible. Cambodia	4, 5
	Anabas testudineus(Climbing perch)		0.99	0.34	0.384	<0.001	0.088					raw, whole, Thailand	2
	Puntius brevis (Swamp barb)		0.90	0.31	0.314	0.000	0.047					raw, whole, Thailand	2
	Rasbora borapensis(Blackline rasbora)		0.86	0.33	0.319	0.002	0.083					raw, whole, Thailand	2
marine fish	Anchovy	20.35	4.84	1.28	1.637	0.538	0.911	147	3.25	1.72	15	raw, edible, Europian	1
	Herring	16.39	9.04	2.04	2.423	0.969	0.689	83	1.12	0.99	32	raw, eddible, Pacific	1
	Mackerel	18.60	13.89	3.26	3.350	0.898	1.401	12	1.63	0.63	50	raw, edibel	1
	Milkfish	20.53	6.73	1.67	1.840			51	0.32	0.82	30	raw, eddible, Philippinnes	1
	Sardine	24.60	11.45	1.53	5.148	0.470	0.509	382	2.92	1.31	33	canned in oil, drained solids with bone	1
	Skipjack	22.00	1.01	0.33	0.315	0.071	0.185	29	1.25	0.82	16	raw, eddible, Pacific	1
	Yellowfin	23.40	0.95	0.24	0.284	0.037	0.181	16	0.73	0.52	18	raw, eddible	1
other animal-source foods	Beef ground	14.30	30.00	11.29	0.696			24	1.64	3.57	0	raw, ground, 70 %lean meat 30 % fat	1
	Chicken breast	14.70	15.75	3.26	3.340			19	1.11	0.78	0	breast tenders, uncooked	1
	Chicken egg	35.60	9.94	3.10	7.555	0.004	0.037	171	3.23	1.11	140	raw, whole	1
	Chicken liver	16.90	4.83	1.56	1.306			8	8.99	2.67	3292	all classes, raw	1
	Cow milk	3.28	3.66	2.28	0.136			119	0.05	0.37	33	3.7% milk fat	1
plant-source foods	Cassava	1.40	0.28	0.28	0.048			16	0.27	0.34	1	raw	1
	Rice	2.69	0.28	0.28	0.323			10	1.20	0.49	0	white, long-grain, regular, cooked	1
	Kidney beans	8.67	0.09	0.09	0.278			35	2.22	0.86	0	mature, cooked	1
	Carrot	0.93	0.17	0.04	0.117			33	0.30	0.24	835	raw	1
	Kale	3.30	0.70	0.70	0.338			135	1.70	0.44	769	raw	1
	Spinach	2.86	0.39	0.39	0.165			99	2.71	0.53	469	Raw	1
	High light: high content	>15.00			>2.000	>0.400	>0.400	>100	>3.00	>3.50	>500		

* raw, cleaned parts. The palte-waste was not examined (Roos *et al.*, 2007 d).

a. RAE=Retinol Activity Equivalent

Blank: no available data

Source: 1.USDA (2005), 2. Karapanagiotidis et al. (2010), 3. Roos (2001), 4. Roos et al.(2007 c), 5. Roos et al.(2007 d)

Fish as a source of animal protein

The daily requirement of protein for women is 30-56 g, depending on body weight and age. During pregnancy and lactation, an additional 6 g/day and 17.5 g/day of protein are required respectively, and children's requirement is about 1.5-2.5 times higher by body weight than that of adults, as protein is essential for growth (WHO, 2007). The previous section (Figure 5) highlighted that the major source of protein in LIFDC is derived from plant-source foods. Nearly 80% of protein, in average 44 g/capita/day in South Asia, and 48 g/capita/day in Africa are supplied from plant-source foods (FAO, 2009 c). However, all fresh fish, as well as other animal-source foods, contain higher proportions of protein, around 14-20 g /100 g raw, edible parts, than plant-source foods, for example 2.7 g /100 g cooked rice and 8.7 g/100 g cooked bean. In other words, fish is a more efficient source of protein than plant-source foods.

Furthermore, the digestibility and the concentrations of essential amino acids in food proteins are important determinants of the efficacy of protein absorption into the body. In this respect, protein from animal-source foods is superior to that of plant-source foods. The digestibility of fish is approximately 5-15% higher than plant-source foods (WHO, 1985). In terms of the concentrations of amino acids, the total amount of protein absorbed into the body is determined by the lowest concentration of essential amino acid. For example, the plant-source foods, especially staple foods such as rice and maize, contain only a small amount of lysine, one of essential amino acids, limiting the total absorption level of protein. In contrast, animal-source foods such as fish have well-balanced concentrations of all essential amino acids, and the concentration of lysine is particularly high. Therefore, adding fish to a plant-based diet increases the total protein intake as well as enhances protein absorption due to the lysine content in the fish.

To improve nutritional status of moderately undernourished children, it is estimated that approximately one-third of protein should be provided by animal-source foods in the diet, so that lysine from animal-source foods can be fully utilised to compensate the shortage of lysine in staple foods thereby having a significant impact on their growth (Michaelsen *et al*., 2009). In this respect, fish is more affordable and accessible animal-source foods, and therefore fish, frequently consumed by the poor is very important, especially for women in the reproductive age and children.

Fish as a source of poly-unsaturated fatty acids

Fat composition of fish is unique, having PUFAs, in the form of arachidonic acid (C20:4n-6), eicosapentaenoic acid (C20:5n-3), and docosahexaenoic acid (C22:6n-3), in contrast to other animal-source foods in particular, beef, which have predominantly unsaturated fatty acids (see Table 3). On the other hand, the amount of PUFAs in fish is in fact very little, and vegetable oils are major source of essential fatty acids, in the form of linoleic acid (C18:2n-6) and α-linoelenic acid (C18:3n-3). Marine fish species such as tuna have high levels of PUFAs, however, these species are less likely to be consumed by the poor. Small pelagic forage fish such as anchovy and sardine are also rich in PUFAs, and they are cheaper and preferably consumed by low-income households (Tacon and Metian, 2009). In contrast, the amounts of PUFAs in large freshwater fish such as carps and tilapia are little, while that of small indigenous species is unknown.

Fish as a source of micronutrients

While the importance of fish as a source of animal protein and essential fatty acids is well known, little attention has been given to the role of fish as a source of micronutrients. Small fish species are rich in micronutrients, in particular, vitamin A, calcium, iron and zinc, as they are consumed whole with bones, heads and viscera where most micronutrients are concentrated. These species are commonly consumed by the poor, and thus have a high potential to address micronutrient deficiencies.

Vitamin A

Dark-green, orange and yellow vegetables which contain provitamin A carotenoids have been considered as a major source of vitamin A and utilised in food-based approaches aimed for increasing vitamin A intake. However, the vitamin A content of some small fish is twice as high as the content of carrot or spinach (Table 4). Most of the vitamin A in fish is concentrated in the eyes and viscera (Roos, 2001), therefore fish species which are eaten as whole are an important source of vitamin A. In Bangladesh, two species, mola (A*mblypharyngodon mola*) and chanda (*Parambassis baculis*) were identified as having a very high content of vitamin A, >2500 μg RE[1]/100 g raw edible parts, and >1500 μg RE/100 g raw, edible parts, respectively (Roos, 2001). In Cambodia, chanteas phluk (*Parachela sianensis*) and changwa mool (Rasbora *tornieri*) contained more than 1500 μg RAE/100 g raw, edible parts (Roos *et al.*, 2007 c) (Table 5). Furthermore, in Bangladesh and Cambodia, small fish are consumed even more frequently than vegetable among rural poor households (Roos, 2001; Chamnan *et al.*, 2009), and therefore vitamin-A rich small fish have a potential to improve vitamin A intake of those vulnerable populations.

[1] RE = retinol equivalent. 1 RE = 1 µg all-*trans* retinol = 1 REA (retinol activity equivalent) (Institute of Medicine (IOM), 2000).

Table 5: The micronutrient contents of fish species in Bangladesh and Cambodia (per 100 g, raw, edible parts)

		Scientific name	Common name/ local name	Calcium[b]	Iron: Total iron	Iron: Haem iron	Iron: Hm-Fe/T-Fe	Zinc	Vitamin A	Source
			Units	mg	mg	mg	%	mg	RAE[c]	
Bangladesh	Small fish	*Amblypharyngodon mola*	Mola	776	5.7			3.2	>2680	2
		Chanda beculis	Chanda	379	0.8			1.8	>1500	2
		Chanda nama	Chanda	863	2.1			2.0	100 - 500	2
		Chanda ranga	Chanda	1061	2.1			2.6	100 - 500	2
		Chanda ssp.	Chanda	879	1.8			2.3		2
		Channa punctuatus	Taki	199	1.8			1.5		2
		Corica soborna	Kaski	443	2.8			3.1	<100	2
		Esomus danricus	Darkina	775	12.0			4.0	500 - 1500	2
		Gudusia Chapra	Chapila	786	7.6			2.1	<100	2
		Mastocembelus aculeatus	Chikra	201	2.5			1.2	<100	2
		Mastocembelus armatus	Chikra	198	1.9			1.1		2
		Mastocembelus pancolus	Chikra	216	2.7			1.3	<100	2
		Mystus vittatus	Tengra	481	4.0			3.1		2
		Puntius chola	Puti	750	4.1			3.1	<100	2
		Puntius ticto	Puti	992	3.4			3.8	500 - 1500	2
		Putius ssp.	Puti	785	3.0			3.1	<100	2
		Putius sophore	Puti	698	2.2			2.9	<100	2
		Ssp	Chikra	203	2.4			1.2	<100	2
	large fish	*Chirrhinus mrigala*	Mrigal	0	2.5			1.5	<100	2
		Hilsa ilisha	Hilsa	0					69	1
		Hypophthalmichthys molitrix	Silver Carp	4	4.4			1.4	<100	2
		Labeo rohita	Rui	317					27	1
	Juvenile	*Colisha lalius*	Tilapia						19	1
		Hypophthalmichthys molitrix	Silver Carp						13	1
Cambodia	Indigenous species common in commercial catches	*Anguilla bicolor*	Chlok						<100	3
		Channa marulius	Ros/Ptuok/Raws	604*	6.2*	1.3*	77	6.1*	100 - 500**	3.4
		Channa micropeltes	Diep/Chhaur	453*	5.2*	4.0*	76	6.0*	<100	3.4
		Cyclocheilichthys apogon	Srawka kdam	483*	2.9*	2.2*	71	8.7*	<100	3.4
		Cyclocheilichthys armatus	Pka kor						<100	3
		Dangia lineata	Khnawng veng						<100	3
		Dangia spilopleura	Arch kok	325*	7.6*	5.4*	70	7.1*	<100	3.4
		Henicorhynchus siamensis	Kantrawb						100 - 500**	3
		Notopterus notopterus	Slat						<100	3
		Osteochilus hasselti	Kros	414*	4.2*	2.2*	54	6.8*	<100	3.4
		Parambassis wollfi	Kantrang preng	466*	5.7*	4.6*	78	6.7*	100 - 500	3.4
		Puntioplites proctozystron	Chra keng	267*	3.4*	2.3*	66	5.2*	500 - 1500	3.4
		Thynnichthys thynnoides	Linh						500 - 1500	3
	Small fish species with low market value	*Dermogenys pusilla*	Phtong	416*	3.6*	2.1*	56	11.0*	<100	3.4
		Helostoma temmincki	Kanthtrawb	432*	5.3*	3.7*	71	6.5*	100 - 500**	3.4
		Parachela siamensis	Chunteas phluk	243*	5.0*	3.4*	67	9.1*	100 - 500	3.4
		Parachela siamensis(juvinile)	Chunteas phluk						<100	3
		Trichogaster microlepis	Kamphleanh phluk	373*	5.0*	3.3*	67	6.5*	100 - 500**	3.4
		Trichogaster trichopterus	Kawmphleanh samrei						100 - 500**	3
	Other small non-commercial species common in rice fields	*Clupeoides borneensis*	Bawndol ampeou						100 - 500	3
		Corica laciniata	Bawndol ampeou						100 - 500**	3
		Esomus longimanus	Chanwa phlieng	350	45.1	36.0	78	20.3	100 - 500	3.4
		Euryglossa panoides	Andat chhke veng	439*	5.2*	3.9*	72	7.1*	100 - 500**	3.4
		Luciosoma setigerum	Changwa ronaung						100 - 500**	3
		Rasbora tornieri	Changwe mool	304*	2.7*	2.0*	72	11.4*	100 - 500	3.4
		Trichopsis pumila	Kroem tun sai						100 - 500**	3
	Potential interest in aquaculture	*Barbodes altus*	Kahe	216*	3.4*	2.7*	76	4.1*	<100	3.4
		Barbodes gonionotus	Chhpin	204*	3.4*	2.6*	76	4.4*	100 - 500	3.4
		Osteochilus melanopleusu	Krum						100 - 500**	3
			Highlight: high content	>700	>5.0			>4.0	>500	

Blank: data not available

[a.] Edible parts was obtained by employing local women to clean the fish accordimg to traditional practices

[b]. Calcim content in edible parts was calculated from plate-waste in Bangladesh (Roos, 2001, p.53). The calcium content in Cambodian fish is raw, cleaned parts, except *Esomus longimanus* which was faund that all fish bones were consumed and therefore the calcium intake from fish was proportional to the measured calcium content(Roos *et al.*, 2007 d, p.1231).

[c.] RE-Retinol Equivalent. RAE-Retinol Activity Equivalent. 1 RE = 1µg all-*trans* retinol=1 RAE. All-*trans* 3,4-dehydroretinol and all-*cis* 3,4-dehydroretinol found in examined fish was calculated as having 40% activity in relation to all-*trans* retinol, and β-carotene as having 16% activity(Roos, 2001, p.30; Roos, *et al.* 2007 d, p.1106).

* Raw, cleaned parts

** Raw, whole fish

Source: 1 Thilsted and Roos (1999), 2 Roos (2001), 3 Roos et al.(2007 c), 4 Roos et al.(2007 d)

Vitamin A is a fat-soluble vitamin, therefore about 3-5 g fat/meal are required to enhance absorption of vitamin A (Castenmiller and West, 1998). Fish which are rich in vitamin A, cooked with some vegetables with some vegetable oil give an ideal combination to maximise vitamin A intake.

Unlike other minerals and water-soluble vitamins such as vitamin C, vitamin A can be stored in the liver for 3-4 months (Olson, 1996). Therefore, vitamin A rich fish only consumed in a particular season are still effective to meet the nutritional needs for a longer period.

Calcium

Fish bones are very rich in calcium. However, as fish bones are not necessarily eaten, the amount of bones discarded as plate-waste must be adjusted for to obtain the calcium content of the edible parts. Consequently, fish which are not eaten with bones do not contribute to calcium intake. However, all small fish species have high calcium content such as puti (*Puntius ticto*) and chanda (*Chanda ranga*), having >800 mg/100 g raw, edible parts, calculated from plate-waste (Roos, 2001). The calcium content of these fish is around eight times higher than that of milk, and calcium in fish bones has the same bioavailability[2] as milk (Hansen *et al.,* 1998; Larsen *et al*., 2000). Therefore, small fish consumed with bones are important as a source of calcium, especially in populations with low intakes of milk and milk products.

Iron

Some fish are rich in iron and it concentrated in the head and viscera, therefore, iron content is determined by cleaning methods such as leaving the head or cutting off it. In a study in Cambodia, chanwa phlieng (*Esomus longimanus*) was found to have a high content of iron in its edible parts, after using traditional cleaning methods by village women. A serving of the traditional sour soup made with chanwa phlieng (*Esomus longimanus*), eaten with boiled rice, the most common meal in the study area, supplied 45% of the daily requirement of iron in women of childbearing age, and 42% of that of children (Roos *et al*. 2007 c). Furthermore, the composition of iron in fish is different from that in plant-source foods, containing large amounts of haem iron and a high molecular sub-pool of complex-bound non-haem iron, with a higher bioavailability than non-haem iron.

Zinc

Animal source foods, such as fish, meat and dairy products are usually rich in zinc, while cereals and legumes contain inhibitors of zinc absorption, such as phytic acid (International zinc nutrition consultative group; 2004). Because the habitual diets of the poor dominated by staple foods reduce bioavailability of zinc, little zinc intake is expected from such diets. Yet, the daily zinc requirement in women in the third semester pregnancy and lactating with low bioavailability diet is as high as 20 mg/day (WHO/FAO, 2004). Children with low zinc bioavailability diet are required 8.3-11.2 mg/day depend on the body weight.

[2] The term 'bioavailability' was defined as 'the fraction of an ingested nutrient available for use in normal physiologic functions and storage (Jackson, 1997).

Small fish eaten as whole are very rich in zinc compare with other animal source foods and large fish species (Table 4 and 5). In Cambodia, low-market value small fish commonly consumed by poor people in particular, were found as very rich in zinc. The local species chanwa philieng (*Esomus longimanus*), for example, has 20.3 mg / 100g, raw edible parts (Roos *et al*., 2007 d). As requirement is very high, it is difficult to meet unless a significant amount of animal-source foods are taken every day (unlike vitamin A, zinc cannot be stored in human body (WHO/FAO, 2004) and is therefore needed from everyday diet). In this respect, adding small fish, even a small amount to a plant-based diet can greatly increase zinc intake and compensate for the low bioavailability induced by the phytic acid of the staple foods.

Overall, small fish are rich in micronutrients and consumed frequently in the everyday diets, contribute to the intake of multiple micronutrients from a meal. Therefore, utilising locally available small fish has the potential as a food-based strategy to enhance micronutrient intakes. According to a study in Kishoreganj, Bangladesh, it was estimated that daily consumption of small fish contributed 40% of the total daily requirement of vitamin A, and 31% of calcium at household level (Roos *et al*, 2007 a). Gibson *et al*. (2000) also noted that adding small dried fish to plant-based diets can enhance the content and bioavailability of iron, zinc and calcium. In Malawi, according to the data calculated from the food composition, serving 24 g of the small dried fish, usipa (*Engraulicypris sardella*), consumed whole with bones, in a meal, twice a day, can lead to significant increases in iron, zinc, and calcium intakes to meet the needs of children (Gibson and Hotz, 2001). Small fish also have many advantages because they can be available for a long period by processing in peak seasons and storing them for year-round consumption, are more affordable for the poor as they are purchased in small portions, and can also be more evenly divided between household members (Thilsted *et al*, 1997).

3.2 The effect of processing and cooking on nutritional value of fish

Fish processing and its effects on nutritional value of products

Some vitamins are sensitive to heat, sunlight and water, while other nutrients such as protein, fat, iron and calcium are stable, even after processing and cooking. According to a study in Thailand, boiled and sun-drying methods of processing destroyed 90% of vitamin A in small fish while an alternative steamed and oven-dried method resulted in only 50% loss (Chittchang *et al*., 1999) (Table 6). This was supported by another study in Bangladesh which found that nearly all vitamin A in small fish was destroyed after sun-drying (Roos *et al*., 2002).

Table 6: Post-harvest loss of vitamin A in fish processing

	Loss of amount in vitamin A	The share of daily requirement	Source
Boiled and sun-dried	90%	4-6%	Chittchang *et al.*, (1999)
Steamed and oven dried	50%	20-30%	Chittchang *et al.*, (1999)
Sun-dried	>99%		Roos (2001,p.49)

Blank: Data not measured

Although vitamin A is lost by processing, vitamin A intake from fish cooked from fresh fish during the productive season can be stored in the body for 3-4 months (Olson, 1996). Therefore, processing can contribute greatly to extend the period of fish intake availability for the poor, as a source of animal protein and micronutrients, with the exception of vitamin A.

Cleaning of fish, cooking methods and combination of foods in a meal

As micronutrients in fish are concentrated in particular parts such as heads, bones and viscera, the amount of nutrients in a fish that are actually consumed by people is determined by the cleaning and cooking methods and plate-waste. Also, the combination of foods eaten together with fish in a meal is an important factor to determine bioavailability and total dietary intake. In Bangladesh, small fish are cooked with some oil, chilli, lemon, tamarind and vegetables (Roos, 2001), contributing to vitamin C and additional vitamin A from the other foods eaten in the cooked with the fish and eaten in a meal with small fish. Also vitamin C from vegetables and spices enhance bioavailability of iron. The oil used to cook fish enhances absorption of vitamin A from fish and provitamin A carotenoids from vegetables (Kongsbak, 2007).

Currently, fish consumption data are limited to the amount of fish consumed at household level, which is not sufficient to evaluate micronutrient intakes from fish at individual level. Understanding local cooking methods, the combination of foods in a meal, and plate-waste are essential to evaluate the nutritional value of fish and develop appropriate food-based strategies to maximise micronutrient intakes through the everyday diet.

3.3 The effects of fish intake on improving nutritional status

Dietary diversification strategies are recommended to improve micronutrient intakes by promoting production and consumption of locally available nutritious foods (Ruel, 2001). While nutrient supplementation often has particular targets such as children under five years olds, dietary diversification strategies have many advantages as they are often more economically feasible, sustainable, and also reach all vulnerable household members. This section analyses interventions related to dietary diversification strategies and examines to what extent fish can contribute to improving nutritional status.

Fish as a complementary food for undernourished children

Locally available fish have often been utilised as an ingredient in complementary feeding trials for infants in some developing countries where undernutrition is a public health concern and fish are consumed in the everyday diet. Positive impacts on both dietary intakes and infant growth were observed and summarised in a review paper (Caulfield *et al*., 1999).

While fish were not the main interest in the above interventions, a study in Ghana focused on the nutritional role of local fish in complementary food (Lartey *et al*., 1999). Fish powder from smoked anchovies mixed with local fermented maize porridge supported growth of infants to the same extent as a cereal-legume blend with a vitamin- and mineral-fortified supplement, indicating the potential role of local fish to improve infant growth. Another study in Uganda utilised local dried fish, mukene (*Rastrineobola argentea*) mixed with maize porridge to feed undernourished children. It showed better outcomes than the diet of imported skimmed milk that are usually used for undernourished children in hospitals (Greco *et al*., 2006).

Small indigenous fish to improve vitamin A status of children

In Bangladesh, since mola (*Amblypharyngodon mola*) was found to be rich in vitamin A (Thilsted, 1997), a study examined the efficacy of mola intake in a daily diet (9 weeks, 6 days/week) in improving vitamin A status. Children, aged 3-7 years, with marginal serum retinol concentration were selected and the outcomes were measured by biochemical indicators (serum retinol concentrations) (Kongsbak, 2007). This was the first trial on the effect of vitamin A rich small fish on vitamin A status in humans. However, a positive impact was not found in serum retinol concentrations in the group fed mola curry, indicating that vitamin A from mola, of which 80% is 3,4-dehydroretinol, was not converted to retinol or was converted in an insufficient amount, thereby the effect was not reflected in serum retinol concentration. Nevertheless, the author hypothesized that 3,4-dehydroretinol in mola may effect changes in physiological functions such as improving vision, growth and reproduction in humans, as studies in rats have shown this. Further studies on the effect of 3,4-dehydroretinol in humans are needed, as well as developing other indicators and approaches to asses vitamin A status.

Maternal fish intake and the content of PUFAs in breastmilk

Fish intake in lactating women influences AA and DHA levels in their breast-milk. In China, the concentration of DHA in breastmilk of women living in coastal regions is higher than in other regions (Ruan *et al*., 1995). Women in Tanzania with high intakes of freshwater fish had AA and DHA in their breastmilk that are above present recommendations for infant formulae, indicating the importance of freshwater fish as a source of PUFAs (Muskiet *et al*., 2006). However, it is not clear how PUFAs in breastmilk contribute to foetal and infant development, especially in developing countries, and further investigations are required on the quantities and nutritional significance of these fatty acids in fish species commonly consumed by the poor (Roos *et al*., 2007 b; Dewailly *et al*., 2008).

Fish intake and people living with HIV/AIDS

The importance of nutrition for people living with HIV/AIDS has been well established (WHO, 2003; FANTA, 2007, for example). In Zambia, a local small freshwater pelagic fish, kapenta (*Limnothrissa miodon*) has been included in the diets of people living with HIV/AIDS, and positive impacts on reducing opportunistic infections and chronic wound healing have been found (Kaunda *et al.,* 2008). Currently, clinical trials on food supplements with fish powder are being undertaken by Kenneth Kaunda Children of Africa Foundation (KKCAF), in collaboration with the University of Zambia to examine the impact on the response to anti-retroviral therapy (ART) (Banda-Nyirenda *et al.,* 2009).

3.4 Challenges

Indicators to measure nutritional outcomes

Fish intake may improve the micronutrient content of the diet, yet it does not necessarily improve the nutritional status of the person. There are three ways to evaluate the effects of fish consumption on nutritional status, which are commonly used in public health and nutrition science to understand nutritional outcomes: anthropometric indicators; morbidity and mortality; and biochemical indicators. With regard to measuring the effect of micronutrient deficiencies, biochemical indicators are used while anthropometric indicators are considered more appropriate to measure energy and macronutrient deficiencies. Studies in Ghana and Bangladesh examined the effect of fish intake on micronutrient status by using biochemical indicators such as ferritin score for iron and retinol score for vitamin A. However significant effects were not found (Lartey *et al.*, 1999; Kongsbak *et al.*, 2008). Developing appropriate indicators to measure the effects of fish intake on improved nutritional status is needed. Also, other factors which affect the biochemical indicators such as malaria and diarrhoea should be considered and addressed.

Sustainable supply of nutrient-dense fish

The limited data from Bangladesh and Cambodia showed the potential of small indigenous species to improve micronutrient intakes, therefore, consumption of these species should be encouraged. However, the availability and accessibility of small indigenous species are decreasing due to various reasons, such as population growth, irrigation and increased pesticide use. As these species are self-recruiting, they can increase in fish ponds and rice fields, without breeding technology and additional investment, although the productivity is low compare to aquaculture of large fish species. It is estimated that a production of only 10 kg/pond/year of the vitamin A-rich small fish, mola (A*mblypharyngodon mola)* in the estimated in1.3 million small, seasonal ponds in Bangladesh can meet the annual recommended intake of two million children (Roos *et al.*, 2003). To make mola and other nutrient-dense species available to vulnerable populations, efforts should be also made to promote the production as well as consumption.

3.5 Summary

This section examined the nutrient contents by species, the effects of processing and cooking methods on the nutritional value, and bioavailability and the efficacy of fish in improving nutritional status (Table 7). The nutritional importance of fish was not so much in its contribution to protein and PUFAs, but in its contribution to micronutrient needs in the diets of the poor.

Although aquaculture tend to favour the production of larger fish with higher value markets, their nutritional value was in fact lower than small fish. There is a strong need to ensure that the fishing activities of small fish that take place in common-pool resources (ponds, floodplains, rivers) remain sustainable. Conservation of wild stocks and dissemination of aquaculture of these species are needed in order to make full use of the potential role of these species in food-based approaches to prevent and control micronutrient deficiencies.

The data on nutrient contents of fish commonly consumed by the poor were scarce, and the review heavily relied on studies conducted in Bangladesh and Cambodia. It is essential to examine the nutritional contents, cleaning methods of fish, plate-waste and the combination of foods in a meal in other countries, in order to understand the nutritional contribution of fish to the poor, so that appropriate strategies on conservation and increasing production and consumption through food-based approaches can be developed.

Table 7: Summary of nutritional role by fish groups

	Main nutrients	*Species (examples)*	*Identified contribution to improving nutritional status*	*The nutrition loss by processing method*	*Need for further research*
Fresh-water small fish	protein vitamin A calcium iron zinc (PUFAs)	<u>Very high in vitamin A</u> *Parachela siamensis* (Cambodia) *Rasbora tornieri* (Cambodia) *Amblypharyngodon mola* (Bangladesh) <u>Very high in calcium</u> *Puntius ticto* (Bangladesh) *Chanda ranga* (Bangladesh) <u>Very high in iron</u> *Esomus longimanus* (Cambodia) *Esomus danricus* (Bangladesh) <u>Very high in zinc</u> *Esomus longimanus* (Cambodia) *Rasbora tornieri* (Cambodia)	Consumed frequently in poor household, contributes to a large part to daily nutritional needs of micronutrients Enhance the content and bioavailability of iron, zinc and calcium of plant-based diets Increases bioavailability of protein from staple food Increase bioefficacy of vitamin A Complementary food for malnourished children / people living with HIV AIDS	Sun-dry kills nearly all vitamin A No effect on protein and minerals	Document food habits, culture and other factors affecting consumption and dietary intake at individual and household levels Develop more appropriate indicators to measure the effects of fish intake on improved nutritional status Develop and test new indicators to assess vitamin A status Quantify contribution of fish-based diet in increasing response of people living with HIV AIDS to ART Document the role of fish PUFAs in foetal and infant development
Fresh-water large fish	protein PUFAs	Carps Catfish Tilapia	Contribute to daily nutritional needs of PUFAs	Mostly traded as fresh fish	
marine fish	protein PUFAs (iron) (calcium)	Anchovy Herring Mackerel Sardine	Complementary food for malnourished children		

4. Contributions of aquaculture to improving food and nutrition security

In theory, aquaculture interventions can contribute to improving nutritional status of households through people consuming fish produced from their own ponds, selling fish for household income to enhance their purchasing power, and by expanding wider accessibility to fish by lowering market prices (Ahmed and Lorica, 2002; Dey *et al.,* 2006; Aiga *et al*, 2009; Jahan *et al*., 2009). It is not clear, however, to what extent increased fish consumption can contribute exactly to overall dietary intake.

This section examines recent studies on the impact of aquaculture on dietary intake. Aquaculture interventions were initially practised through extensive and semi-intensive methods and catfish, carps, and tilapia have often been targeted as they can be cultured by using sustainable local resources. Aquaculture has also been practised from a human nutrition perspective in order to improve dietary intake directly. In this context, in Bangladesh, selected nutrient-dense small indigenous species have been cultured for the purpose of household consumption to combat micronutrient deficiencies by mixing them with large fish species and prawns, which are grown to generate household income from their sale (Thilsted *et al.,* 1997, Roos *et al*., 1999; Alim *et al.,* 2004; Kadir *et al*., 2006; Roos *et al,* 2007 a, for example). This review includes all types of interventions and also examines agriculture-aquaculture integrated interventions, such as rice-fish culture, and growing vegetables on the dikes of fish ponds. The following section will be analysed through the pathways demonstrated in Figure 6.

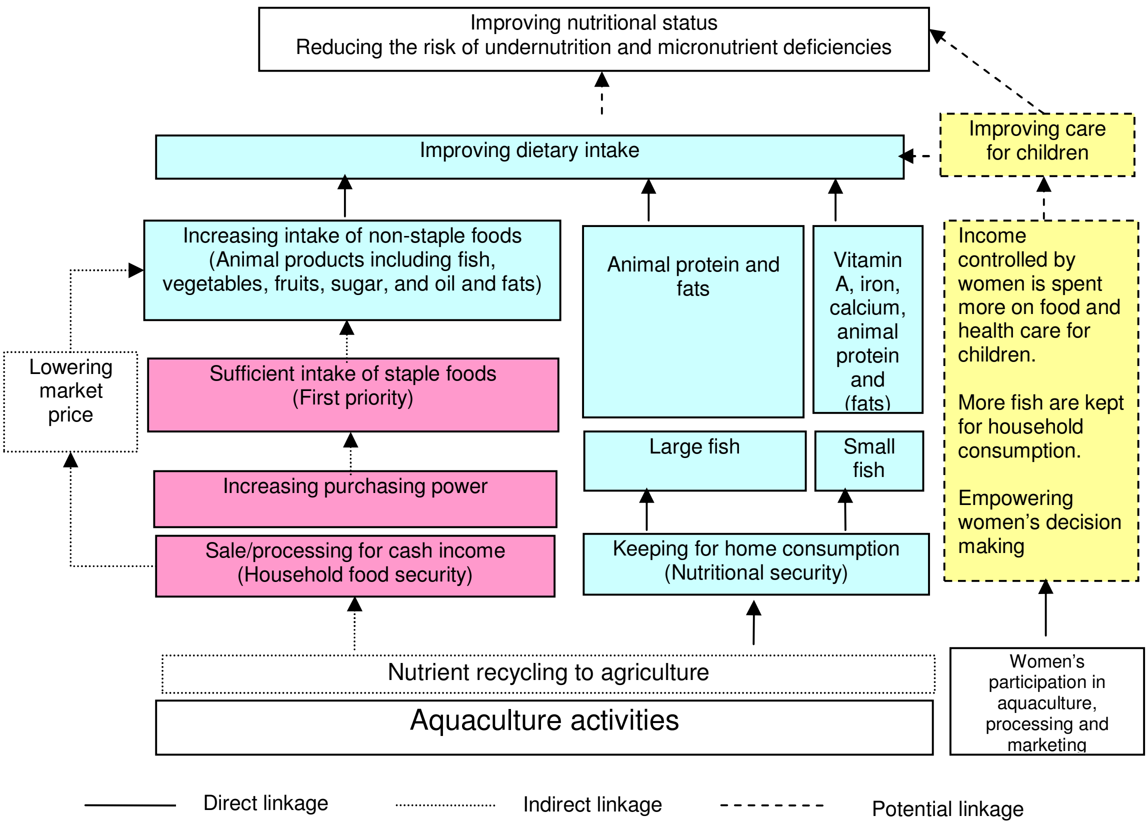


Figure 6: The pathways through which aquaculture can contribute to improving nutritional status

Fish produced by aquaculture are either kept for household consumption or sold for cash income. Fish for household consumption contribute to dietary intake, but the nutritional role varies with species as discussed in Section 3. Currently, large freshwater fish are predominant in aquaculture and therefore the figure below shows the greater share of aquaculture production as large fish. Fish sold for cash income contribute to purchasing sufficient staple foods, and can also be used for consumption or purchase of non-staple foods which directly improve dietary intake beyond energy intake.

This review examined 10 recent case studies on the impact of aquaculture on dietary intake and/or nutritional status. The key information of these studies is summarized in table 8.

Table 8: Summary of intervention of recent studies which identified the impact of aquaculture on dietary intake/nutritional status (published between 2000 and 2009)

Country Reference	Activities	Design	Evaluation	Findings
Bangladesh [Kishoreganji] Roos (2001)	Fish pond Large fish Small fish	Ex-post with control	Fish consumption Expenditure on fish Nutrient intakes	There was no significant difference in fish consumption between fish producing and non—producing households 57% of harvested small fish and 47% of mola were consumed in the households 32% of the households never consumed fish produced in own fish ponds 326 taka/person/7 months with pond households and 387 taka/person/7 months without pond hhouseholds Mola harvested and consumed contributed average 21% of the recommended safe level intake of households.
Bangladesh [Kapasia] Thompson *et al.* (2002)	Fish pond Large fish	Ex-post with control	Fish consumption Household income	There was no significant difference in fish consumption by pond size but large farmer eat 15 % more fish Pond owners are still dependent on capture fisheries for consumption rather than own cultured carps Landless and non-pond households were more dependent cheaper cultured fish sold in the markets Income increased 2.8 times in participated households (1.9 times in non-participated households)
Malawi Dey *et al.* (2006)	Fish pond Large fish Agriculture	Ex-post with control	Fish consumption Food consumption Household income Agriculture impact	The frequency of fresh fish and dried fish consumption is higher in households with fish ponds The frequency in other animal-source foods is higher In households with fish ponds Income of households with fish pond is 1.5 times higher than that of households without fish pond Nutrients generated by the pond as were used as fertiliser and resulted in increase in production of vegetables and other crops
India Kumar and Dey (2006)	Secondary data analysis		Energy intake Nutritional status	Energy intake 10.9% (285 kcal/capita/day) higher in households engaging farming with aquaculture than that of farming with waged earner. Undernourished population is 12% lower in farming with aquaculture than farming with wages earner
Bangladesh [Mymensingh] Karim (2006)	Fish pond Large fish Agriculture	Ex-post with control	Fish consumption Seasonality Household income Agriculture impact	Non-pond households consume less. The poor consume less and sale for cash to purchase cheaper fish in the markets Peri urban area got higher income from fish products (27% of the total income) than rural (11%) due to market access Fish supplies from own ponds are particularly important for the poor during the lowest income months Pond owners growing vegetables on their pond dikes consumed more vegetables than non-pond households
Malawi WorldFish/ World vision (2007)	Fish pond Large fish Agriculture	Pre-post	Fish consumption Household income Agriculture impact Other impact	150% increase in fish consumption 50% increase in farm incomes Resilience in drought, nutrient generated by the pond resulted in reducing off-farm inputs HIV affected households benefited from the intervention
Bangladesh [Dinajpur] Islam (2007)	Fish pond Large fish Small fish Rice-fish	Ex-post with control	Fish consumption Household income Seasonality Other impact	Poorer households sold both carp and mall fish. Better-off households usually consumed rather than sold them Small fish compensated for shortage of income and fish consumption when large fish are less available Small fish remains as an important food item for the poor in low-income vegetable scarce months Non-pond owners also benefited from cultured small fish species through free access to rice-field
Bangadesh [Mymensing, Comilla, Magura, Bogra] Jahan *et al.* (2009)	Fish pond Large fish	Pre-post with control	Fish consumption Household income Employment Women's role	Fish consumption increased from 1.5 kg/capita/month to 1.79 kg/capita/month The gross household income grew 8.1% year by farm and fish income increases The return on family labour grew 15.6% year, control group was 8.3% year Women-operated ponds received 12 % higher production (+324 kg/ha/year) than male-operated Fish consumption was 50 g/capita/month higher in households of women-produced
Bangladesh [Sherpur] WorldFish (2009)	Fish pond Large fish Fingerlings Rice-fish	Pre-post with control	Household Income Other impact Food security	The average income of participated households increased from USD647/y in 2007 to USD 763 in2008 In rice-fish farming, the profits generated from the plot nearly doubled on average The landless benefited from cage culture and trading of fingerlings, and forming netting teams to catch fish Reducing their food deficit period from 1.7 months in 2007 to 1.4 months in 2008
Malawi Aiga *et al.* (2009)	Fish pond Large fish	Ex-post with control	Nutritional status Fish consumption Household income Dietary intake	The prevalence of malnutrition was lower in fish pond owned households There was no association in fish consumption with malnutrition Income from fish pond might protect against being underweight Increased purchasing power through fish ponds might influence oil and fats intake thereby prevent underweight

4.1 Contributing to dietary intake through consuming fish produced by aquaculture

Consuming fish produced by their own ponds is a way for households to directly improve nutritional status through aquaculture. Many but not all studies found increases in household consumption by households taking up pond-based aquaculture (see Table 8). On the other hand, a food consumption survey in Bangladesh showed that fish produced by own-pond aquaculture only contributed 1-11% of the total amount of fish consumed at household level, and fish from sold in the markets is the single most important source of fish (57-69%, depends on season) for both households with fish ponds and without fish ponds (Roos, 2001), and expenditure on purchasing fish did not show significant difference between households with fish ponds (326 taka/person/7months) and without fish ponds (387 taka/person/7months).

Fish supplied by common-pool resources have declined in many areas and consequently, decreased fish consumption, particularly among the rural poor, has been reported in some countries such as Bangladesh (Kent, 1997; Thompson *et al.*, 2002; Roos *et al.,* 2007 a), Laos (Meusch *et al.,* 2003) and Malawi (Dey *et al.,* 2006). On the other hand aquaculture has been expanded, however fish produced by aquaculture differ from fish supplied by common-pool recourses in their species or variety, and in the markets they serve. It is not clear to what extent increased fish consumption through aquaculture can contribute to improving daily nutrient requirements in many case studies. The results from polyculture in Bangladesh of small indigenous species with large fish showed that mola *(Amblypharyngodon mola)* harvested and consumed in households contributed average 21% of the recommended minimum safe intake level of vitamin A (Roos,2001). According to experiments on aquaculture of large fish with small indigenous species in Bangladesh (Kadir *et al.,* 2006), it was estimated that 250 g of mola *(Amblypharyngodon mola)* and punti *(Puntius sophore)* could be harvested weekly from a small homestead pond of 5 decimals (5x40 m^2) (Wahab, MA, 2010. pers, comm.) and it can provide sufficient levels of vitamin A, calcium and iron to meet daily requirements of five to six family members. Also, this could be a great contribution as vegetables (another source of micronutrients) are seasonal and the small indigenous species played a particularly important role to meet micronutrient needs during the lean season when vegetables were not available or affordable (Islam, 2007).

This review particularly focused on the nutritional benefit of fish to producers in rural areas alone. However such benefits can be observed among consumers in urban areas, although large fish are still not affordable for the urban poor (as discussed in Section 2) and nutritional value of large freshwater fish is not as high as small fish in terms of micronutrient content (see Section 3).

4.2 Contributing to dietary intake through increasing household income

Another pathway through which aquaculture can contribute to improving nutritional status is by the sale of fish produced by aquaculture. Much aquaculture development is orientated towards producing fish for higher value markets – fish and other aquatic animals in these systems are best thought of as a 'cash crop', rather than a food crop for household consumption.

Earlier studies on agriculture interventions including aquaculture identified that increasing household income is a particularly important factor to improve dietary intake as the consumption of non-staple foods is positively related to increases in income (Hawkes and Ruel, 2006; World Bank, 2007; Leroy and Frongillo, 2007). Recent studies support the positive effects of household income, by demonstrating increasing consumption of staple foods (Jahan *et al*, 2009), and of other animal-source foods including fish (Dey *et al.,* 2006). Secondary data in India also showed that daily energy intake is higher in households engaging in farming with aquaculture than that in farming with waged earning (Kumar and Dey, 2006).

Increased household income were found not only from aquaculture but also from agriculture, which benefited from fish pond activities by using waste nutrients derived from fish ponds (Dey *et al*., 2006; WorldFish Center, 2007). Fish ponds in homesteads also play an important role in maintaining an on-farm source of water for crops, and for resisting droughts in a broader context (see Dey *et al*., 2007, 2010; van der Zipp *et al*., 2007; Miller, 2009), contributing indirectly to agriculture production. After the intervention in Bangladesh, households cultivating vegetables such as pumpkin and bitter gourd on the pond dikes increased from 4% to 66%, contributed to the additional income, as well as household consumption.

These types of effect were also found in the landless, women and poorest population who do not have a pond, but who are able to grow fish in cages in public water bodies, or in the ponds of neighbours. An intervention in Sherpur, Bangladesh provided cages for the landless to culture fingerlings in neighbours' ponds, and also formed a netting team to harvest fish cultured in neighbours' ponds. These activities contributed to increasing household income, especially in the hunger period in October and November, when their major livelihood, daily agricultural wage labour, is not available (WorldFish, 2009). These types of interventions have potential to provide livelihood opportunities for the landless and women in particular in areas where common-pool resources and seasonal fish ponds are abundant.

4.3 Contributing to improving nutrition through women's participation

Women's access to and control of resources is understood as a key determinant of household food security and nutritional outcomes and the pathway to improving child nutrition through empowering women agriculturists were identified in a past review (WorldBank, 2007). In aquaculture activities, women can participate in the whole processes of activities more equally to men than small-scale fisheries which are usually physically demanding. Since fish farming is not as labour intensive as small-scale fisheries, it is physically adoptable for women and also for people living with HIV and AIDS (WorldFish Center, 2007). Furthermore it is culturally acceptable in countries like Bangladesh where women are only allowed to work within the homestead (WorldFish Center, 2006).

From a gender perspective, it is evident that women's access to water resources, cash income, and participation in resource management at community levels can raise their status at household and community levels, thereby improving the nutritional status of household members, especially children.

Many interventions succeeded in involving women in aquaculture activities, for example in Bangladesh (Shelly and Costa, 2002; WorldFish Center, 2006), Nepal (Bhujel *et al*., 2008), and Malawi (WorldFish Center, 2007). However the data on the impacts of women's participation on the nutritional status of household members is limited. A study in Bangladesh (Jahan *et al*., 2009) found that women-operated fish farming produced 12% more products than male-operated ones, and fish consumption in women-operated households was 50 g/capita/month higher. However, further studies are required to understand the direct effects of women's participation in aquaculture on dietary intakes and nutritional outcomes. Also, the impacts of increased work and changes in time allocated to other household work, including caring for children, should be further investigated.

4.4 The nutritional outcomes of aquaculture activities

Although the pathways through which aquaculture can contribute to improving dietary intake were identified, there is little evidence of positive changes in nutritional status among households taking up aquaculture. Kumar and Dey (2006) showed that households who engaging in farming and having additional income from aquaculture were generally less undernourished than households engaging in farming with seasonal, part-time wage labourers in India, yet this might be influenced by primary determinants such as land size and education levels.

A recent study in Malawi (Aiga *et al.,* 2009) found that the prevalence of malnutrition among children (6 – 59 months) was lower in fish farming households compared to non-fish farming households. One factor associated with malnutrition was lack of fat and oils, not inadequate fish consumption. The authors concluded that fish farming indirectly contributed to a lower prevalence of underweight among children through increasing purchasing power which resulted in more frequent intake of oil and fats, indicating the importance of cash income. Fats and oils cannot be produced in subsistence farming, and also they were not given in food aid programmes in the study area. Meanwhile the authors proposed that the primary causes might be breast-feeding practices, which showed a strong association with malnutrition, or other factors which were not tested, such as effects of diseases, for example, malaria and respiratory infections. This study in Malawi indicates that there is a certain limitation in the role of aquaculture as a means of improving nutritional status since there are many other significant determinants (see also section 1, figure 1), hence aquaculture can only partly address the improvement of nutritional and health status.

4.5 Summary

This section examined the pathways through which aquaculture can contribute to dietary intake of the households engaging in aquaculture activities. Household income from aquaculture was important as it can enhance purchasing power thereby increasing both quantity and quality of the diet. Aquaculture can bring synergy with agriculture productivity and profitability and contribute to improving dietary intake. In this respect, rice-fish farming and vegetable cultivation on the dikes of ponds have potential to improve dietary intake.

Fish produced by aquaculture was kept for household consumption to some extent. The direct effect of increased fish consumption on dietary intake was not clear but in the cases of the polyculture of nutrient-dense small indigenous fish species with carps and prawns, significant increase in micronutrient intake was projected from trial interventions. Therefore, disseminating polyculture in already existing fish ponds with large fish has the potential to reduce micronutrient deficiencies and their adverse health consequences.

Women's participation in aquaculture may have certain effects on improving nutritional status but the pathways are not clear and this needs specific strategies in interventions to ensure participation of women and researches need to find clear design to demonstrate pathways. Aquaculture interventions could have positive impacts on the people living with HIV and AIDS as it can help to attain their increasing nutritional needs and sustain livelihoods with lower intensive work.

Many aquaculture interventions did not examine the nutritional outcomes by using indicators such as anthropometric indicators, biochemical tests, and morbidity and mortality. It seems to be difficult to show nutritional outcomes in short term interventions focusing on aquaculture alone without addressing other factors which determine nutritional status. Nevertheless, as a case study in Malawi demonstrated (Aiga *et al.*, 2009), aquaculture can be one factor among others which contribute to improved nutritional status, and this kind of study may be useful for linking the role of aquaculture to nutrition.

5. Contributions of small-scale fisheries to improving food and nutrition security

While aquaculture can contribute to improving dietary intake as discussed in Section 4, this might also be true in small-scale fisheries. However, the nature of small-scale fisheries is different from that of expanding aquaculture interventions in the amount of production, species variety, and beneficial population coverage. While impacts of aquaculture interventions on nutritional status were analysed through surveys of pre-post or with-without interventions, many studies on small-scale fisheries rely on household surveys and comparisons within fishing communities. By analysing available data in Asia, Africa and the Pacific, this section attempts to identify pathways through which small-scale fisheries contribute to nutritional status. The presented pathway is basically the same as that in aquaculture, but the share of small fish is drawn larger than that in large fish, based on the analysis of consumption patterns of the poor in section 2.2(Figure 7).

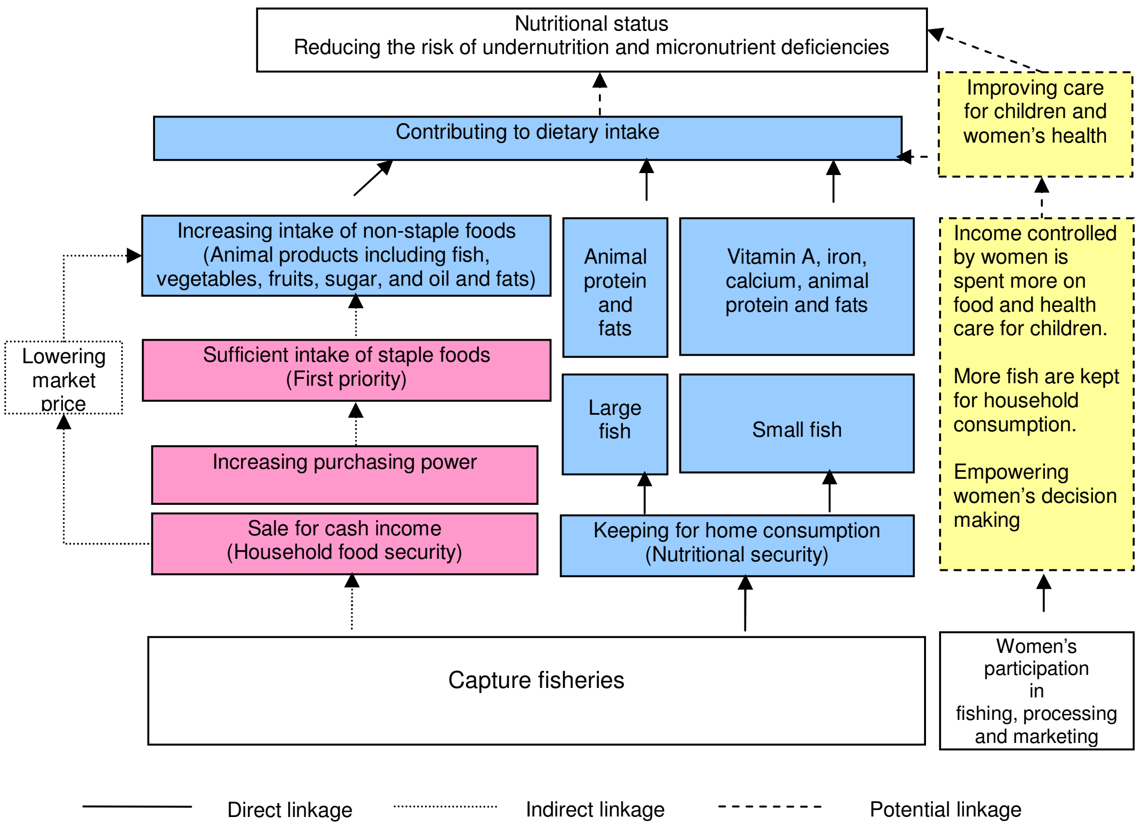


Figure 7: The pathways through which small-scale fisheries can contribute to nutritional status

This review examined 13 recent case studies on the role of small-scale fisheries on dietary intake. The key information of these studies was demonstrated as a summary in table 9.

Table 9: Summary of recent studies which identified the impact of capture fisheries on dietary intake/nutritional status (published between 2000 and 2009)

Country Reference	Design	Evaluation	Findings
Nigeria Neiland *et al.* (2000)	Household survey in fishing communities (n=1316)	Fish consumption Household income Livelihoods Agriculture Seasonality Fish catch decline	19 -33% of fish caught by household members was used for household consumption 67-81% of fish caught by household members was sold for cash income to purchase other foods and to invest in farming activities Fishing provided the second most important source of income after farming Fishing households tended to be more productive in farming than non-fishing households Fishing is a seasonal activity for the majority of households, contributing to diversify livelihoods Fish catches declined over 30 years
Bangladesh Roos (2001)	Household fish consumption surveys	Fish consumption Nutrient intake	16% (low season) - 37% (high season) of fish consumed at households were captured by household members Small fish (either captured or purchased) contributed to 84% of fish intake Total fish intake contributed to reach to average 40% of vitamin A and 32% of calcium of the daily requirement
Lao PDR Meusch *et al.* (2003)	Participatory household survey in three villages	Fish consumption Household income Fishing catch decline Fishing gear	Aquatic resources contribute more to local diets than livestock or animals hunted in the forest Households that routinely suffer from insufficient rice often depend on aquatic resources to compensate for shortage of rice Aquatic animals were sold or barter to compensate for shortage of rice Fish catch declined significantly and people consume more aquatic animals than fish Due to the decline in fish catch, more investment is required in household fishing gear
Lao PDR Garaway (2005)	Household survey by socioeconomic status (n=103)	Fish consumption Household income Livelihoods Seasonality	> 74.5% of fish caught by household members were used for household consumption 18.9% (12.5 kg/y) of fish caught by household members was sold Fishing provide livelihood opportunities not for the poorer groups alone but for the richer groups Richer (wealth rank) households caught fish more (82.2 kg/y) than middle (53 kg/y) and poorer (74.4 kg/y) October/November is the highest season(>2kg/m) and April/May is the lowest (<0.5 kg/m)
Cambodia Hori *et al.* (2006)	Household survey by fishing grounds (n=209)	Household income Livelihoods Seasonality Fishing gear	31.6% - 90% of fish caught by household members were sold for household income Almost all households in the area were engaged in fishing for cash income to purchase rice Fishing in rice fields was seasonal while fishing in a lake was available longer term therefore the group fishing in the lake earned more Villagers who can initially invest in large gear would generate much income from fishing
Zambia [Kafue Flats] Merten and Haller (2008)	Household survey in the 13 villages Kafue Flats (n=390)	Access to fishing Nutritional status Livelihoods	Women who customary used to go to fishing to cope with food scarcity had currently no access to fishing Prevalence of malnutrition (stunting) is higher in households engaging fishing as a main livelihood thatn agro-pastoralosm (25.3%) and agriculture (22%) Batwa minority communities exclusively rely on fishing as a single source of livelihood despite declining access rights due to migrant fishing groups
Solomon Island Molea and Vuki (2008)	Household survey (n=24)	Fish consumption Household income	Only a small proportion of the fish caught by household members were used for household consumption Fish were consumed on average, 225 g/capita/day and seven days a week, twice of three times per day Fishing is a main source of household income The bulk of the fish caught were exchanged for root crops and vegetables or sold at the markets
Kiribati Awira *et al.* (2008)	Household survey (n=98)	Fish consumption Household income Livelihoods The role of women	Fresh fish were consumed 5.6 times/week and invertebrates were consumed 0.7 times/week 60-79% (differ with community) of fish caught by household members were sold for household income 34% and 24% of households depended on fisheries for income as a 1st and 2nd source, 58% depended on agriculture as 1st income source Women focused primarily on invertebrate harvesting and finfish fishing was dominated by men
Papua New Guinea Friedman *et al.* (2008 a)	Household survey (n=120)	Fish consumption Household income Livelihoods The role of women	Fresh fish were consumed 3.34 times/week and invertebrates were consumed 1.49 times/week The fresh fish and invertebrates consumed were caught by household members and hardly ever bought 80-89% (differ with community) of fin-fish caught by household members were sold for household income 53.3% and 32.5% of households depended on fisheries as 1st and 2nd source of income The total contribution of women's catch was one-quarter, most of them were used for household consumption

Country References	Design	Evaluation	Findings
Solomon Islands Pinca *et al.* (2008)	Household survey (n=182)	Fish consumption Household income Livelihoods The role of women	97.6% of fresh fish and 71.4% of invertebrates consumed was caught by household members Fresh fish were consumed 3.57 times/week and invertebrates were consumed 1.2 times/week 24-54 % (differ with community) of fin-fish caught by household members were sold for household income 30 % and 32 % of households depended on fisheries as 1st and 2nd source of income, agriculture was equally important Women exclusively catch invertebrates for household consumption
Tuvalu Sauni *et al.* (2008)	Household survey (n=113)	Fish consumption Household income Livelihoods The role of women	Fresh fish were consumed 6.1 times/week and invertebrates were consumed 0.4 times/week 34-54% (differ with community) of fin-fish caught by household members were sold for household income 24 % and 25 % of households depended on fisheries as 1st and 2nd source of income, agriculture was equally important Women tend to focus more on invertebrates collection for home consumption but they do fishing as well
Vanuatu Friedman *et al.* (2008)	Household survey (n=124)	Fish consumption Household income Livelihoods The role of women	Fresh fish were consumed 1.9 times/week and invertebrates were consumed 1.15 times/week 70-83 % (differ with community) of fin-fish caught by household members were sold for household income 22% and 39% of households depended on fisheries as 1st and 2nd source of income, agriculture was equally important Women focused primarily on harvesting invertebrates
Cambodia Chamnan *et al.* (2009)	Food consumption surveys	Fish consumption The role of women	Fish played the third rank after rice and vegetable in terms of quantity in the diet Fish was the second rank in terms of frequency after rice in the diet and 54% of household consume fish everyday Poor households depends on fish from common-pool resources, which were caught by household members or bought by the local markets Women were overwhelmingly dominated (87%) in fish selling

5.1 Contributing to dietary intake through consuming fish supplied from small-scale fisheries

All 13 studies in Table 8 show that fish is a major animal protein source and own catches are kept for household consumption although the proportion of catches consumed at household varies from around 10% to 70% of total catches. In the areas where fish are abundant year-round or seasonally, people consume fish caught by household members, and hardly buy them in the markets (Neiland *et al*., 2000; Meusch *et al*., 2003; Gareway, 2005; Friedman *et al*., 2008 a; Pinca *et al*., 2008). The species consumed at household level are low market-value fish and other aquatic animals. Invertebrate and other aquatic animals are more likely to be kept for household consumption while high market-value finfish are exclusively sold at market. Also fish supplied by common-pool resources is still very important even for those households with ponds and who engage in aquaculture (Roos, 2001; Thompson *et al*., 2006; Karim, 2006).

Furthermore, fish supplied from common-pool resources are widely traded in the local markets and therefore fish sold in the local markets can nutritionally contribute to not only households that engage in fishing for household consumption, but also large populations including those who do not engage in small-scale fisheries but purchase fish from local markets. For example, food consumption surveys in Cambodia (Chamnam *et al*., 2009) showed that fish was the second ranked food group after rice in terms of frequency in the diet, and 54% of households consume fish every day. The majority of fish consumed in households were purchased in the local markets and were originally supplied by small-scale fisheries. Fish and other aquatic animals contribute to average 37% of total protein intake, 51% of calcium, 39% of zinc, and 33% of iron intake of the women, indicating the importance of fish in diet as a major source of protein and micronutrients. On the other hand, contribution of fish to vitamin A intake of women was only 14% and the total vitamin A intake of the women was very low, meeting less than 10% of dairy requirement. Since fish species which are rich in vitamin A in Cambodia have been identified in nutritional composition studies (see Section 3, Table 6), increasing production and consumption of these species will contribute to improving micronutrient deficiencies and its adverse health consequences.

5.2 Contributing to dietary intake through increasing household income

Fish supplied by common-pool resources are also an important source of household income for the poor. The pathway is very similar to that of aquaculture, where cash from fish is primarily used to purchase staple foods in some studies (Meusch *et al*., 2003; Hori *et al*., 2006; Molea and Vuki, 2008). The proportions of fish catches sold varied from 30% to 90% among different countries. Many case studies showed the important role of small-scale fisheries as a seasonal part-time income source, contributing to diversifying livelihoods, especially during lean seasons when incomes from farming or labour wages are low(Neiland *et al*., 2000; Garaway, 2005; Hori *et al*., 2006; Friedman *et al*., 2008 a; Pinca *et al*., 2008). Furthermore, unlike fish produced by aquaculture which are mostly traded as fresh fish, fish supplied by small-scale fisheries are often seasonal and therefore many fish are processed during high production season. Hence, processing is also an important income source in seasonal small-scale fisheries, in particular, the areas where marketing network for locally processed fish (smoked and dried) to urban markets are well developed (Neiland *et al*., 2000).

A study in Kompong Thom Province, Cambodia (Hori *et al*., 2006) highlights the importance of small-scale fisheries as a source of income beyond household consumption. During dry seasons, some villagers fish in Tonle Sap Lake, located 30km away from the study villages, and sell most of the catches for cash, while others only fish in rice fields, ponds, and some streams and rivers around the villages. The high income from fishing in the lake contributed to their annual household income, which is approximately double that of the latter group. Since all villages are similarly suffering from the shortage of rice stock, cash from fish is generally utilised for purchasing rice. However, it is pointed out that fishers who engage in fishing in the lake generally use large equipment, indicating that households who can invest in fishing gear may benefit more from the lake resources, resulting in their higher household income and higher rice consumption. Another study in Cambodia (Chamnan *et al*., 2009) observed that the average amount of land owned by the households was less than 0.1 ha and only 3.7% of households had fish ponds. In such situations, rural poor households engage in small-scale fishing in common-pool resources as a second major activity (31.2%) after daily wage labour (32.5%), providing income opportunities in particular in the lean season after harvest of the rice, when daily labour work was not available, whereas farming was the primary activity for supplying food for household consumption.

A study in North East Nigeria showed the pathway to improving dietary intake through utilising household income from fish for agriculture inputs. There was a strong correlation between agriculture production and in fishing and farming in three communities (Neiland *et al*., 2000). Income from fishing activities was utilised as input for farming (seed purchase and hiring labour). The result showed that the average agricultural output was higher in fishing households (average 625 and 1558 kg/adult/year in two villages, respectively) than non-fishing households (average 353 and 1348 kg/adult/year). The authors emphasised the important role of fishing activities as a household income source.

5.3 Contributing to improving nutrition through women's participation

Since small-scale fisheries are usually physically demanding as compared to aquaculture, the actual fishing is often dominated by men. On the other hand, in many developing countries, particularly in Sub-Saharan Africa, women are involved in the processing and trading sectors of both capture fisheries and aquaculture. Overa's study in Ghana (1998) showed women's involvement in processing and trading as a real economic empowerment tool. Heck and Béné (2007) also highlighted the fact that in Africa, women's involvement in processing and marketing contributed to securing their children's nutritional needs, and women would not be able to do it if they had to rely on men's income. In the Kafue floodplain, Zambia, the women used to play an important role of fishing as a customary practice to compensate for food scarcity during the lean season, however currently it became difficult since fishing is commercialised and little space was given for local women to continue the practice (Merten and Haller, 2008).

In Oceania, on the other hand, women often go fishing for their household consumption using less labour intensive methods and techniques, in contrast to the men, who engage in fishing for cash by using larger fishing equipment (See Table 8). A similar trend was observed in a study in the Salonga area in the Congo, where women usually catch small fish by the traditional basket trap methods. These fish are mostly for household consumption, while the fish caught by men are sold to the market in a larger proportion (Béné *et al.*, 2009). In Cambodia, rural fish markets surveys found that the fish sellers were predominated women (82-92%, variation between markets) and they were mostly grown up in the same commune and married (79-92%, variation between markets), and not highly educated (34.5% had not completed primary education, 41.1% had completed only primary) indicating that the significant contribution of the small-scale fisheries as a livelihood opportunity for the women from rural poor households in the community.

Although the above case studies are not enough to generalise about the way in which women's roles in the fishing sector can improve the nutritional status of household members, it is clear that their involvement helps to meet the nutritional needs of their children to some extent.

5.4 The nutritional outcomes of small-scale fisheries

Many case studies of small-scale fisheries production and livelihoods do not primarily focus on the nutritional status of people engaged in these activities, and therefore analysing nutritional outcome of small-scale fisheries is difficult. Two studies showed consequences of fishing pressures such as declining fish catch and restricted access rights on nutritional outcomes in the areas where households depend heavily on fishing activities.

A study in Laos (Meusch *et al*, 2003) showed that decreased fish catch resulted in the consumption of other aquatic animals more frequently than fish. In addition, households that could not afford expensive fishing gear, had less access to common-pool resources. The authors pointed out the high prevalence of malnutrition in the study areas and suggested building capacity of sustainable aquatic resource management as one of the strategies to improve the current nutritional status of the poor.

Another study in the Kafue flats, Zambia (Merten and Haller, 2008) found links between reduced access rights to fishing for the local population, and household food insecurity and child growth. Fishing activities were an important customary practice for the local women to cope with food insecurity, especially during a food scarcity period. Commercialisation of fish and increased migrants made it difficult for the locals to engage in fishing, resulting in increasing vulnerability to food insecurity. This was supported by the findings of higher prevalence of malnutrition in fishing communities (39.8%) than agricultural (22%) or agro-pastoral (25.3%) communities during the southern African food crisis in 2002 to 2003. The authors suggested additional factors affecting malnutrition, such as the marginalised environment of fishing communities and unavailability of alternative livelihoods.

However, small-scale fisheries and undernutrition cannot be simply connected as a causal relationship because the nutritional status is determined by many factors (Figure 1). Fishing activities are only a small part which can influence some of the key factors which directly and indirectly relate to nutritional status. As the authors pointed out in above studies, the high prevalence of undernutrition in fishing communities should be carefully analysed by identifying their basic and underlying determinants.

Nevertheless, small-scale fisheries contribute to additional income in rural poor households who do not have enough land assets to sustain themselves from agriculture. Cash income from fish is used for compensating for the shortage of staple foods, preventing serious food insecurity, although the income may not be enough to diversify diet and therefore the contribution is invisible to their nutritional status.

5.5 Summary

This section examined the pathways through which small-scale fisheries contribute to nutritional status. The pathways appeared to be basically the same as aquaculture, and fish captured in common-pool resources were not only used for household consumption, but also widely traded in the local markets, providing various livelihood opportunities such as processing, trading and selling. Seasonal small-scale fisheries help compensate for the shortage of foods, and in the cases of better-off households, income from fish can be used for purchasing non-staple foods and investing future harvests in agriculture. Women's role in small-scale fisheries was found in various sectors. Fish caught by women were mostly for household consumption, and trading, processing and selling observed in Asia, Africa and Oceania, contribute to empowering women through cash income from fish.

Although the data was limited, fish supplied in common-pool resources include various fish species and other aquatic animals and some of them are rich in micronutrients. For rural poor households, fish is a major source of animal protein and some micronutrients, and therefore conservation and increasing production of these species are important so that fish can contribute as a mean of reducing micronutrient deficiencies.

The nutritional outcomes were not clearly demonstrated in this review. In some cases, cash income from fish was used for compensating for the shortage of staple foods, preventing households from serious food insecurity, yet cash income from fish may not enough to move forward to increasing non-staple foods, thereby nutritional status may still remained without improvement. Other many factors including basic determinants were not considered in the discussion but they are also critical elements and interventions and researches need to take them into account.

6. Discussion

6.1. The pathways through which fish can contribute to improving food and nutritional security

This review has identified various pathways through which fish contribute to improving nutritional status of the poor in developing countries. Figure 8 summarises these pathways by combining findings from Section, 3, 4 and 5 and adapting them into the initial framework by UNICEF (1990).

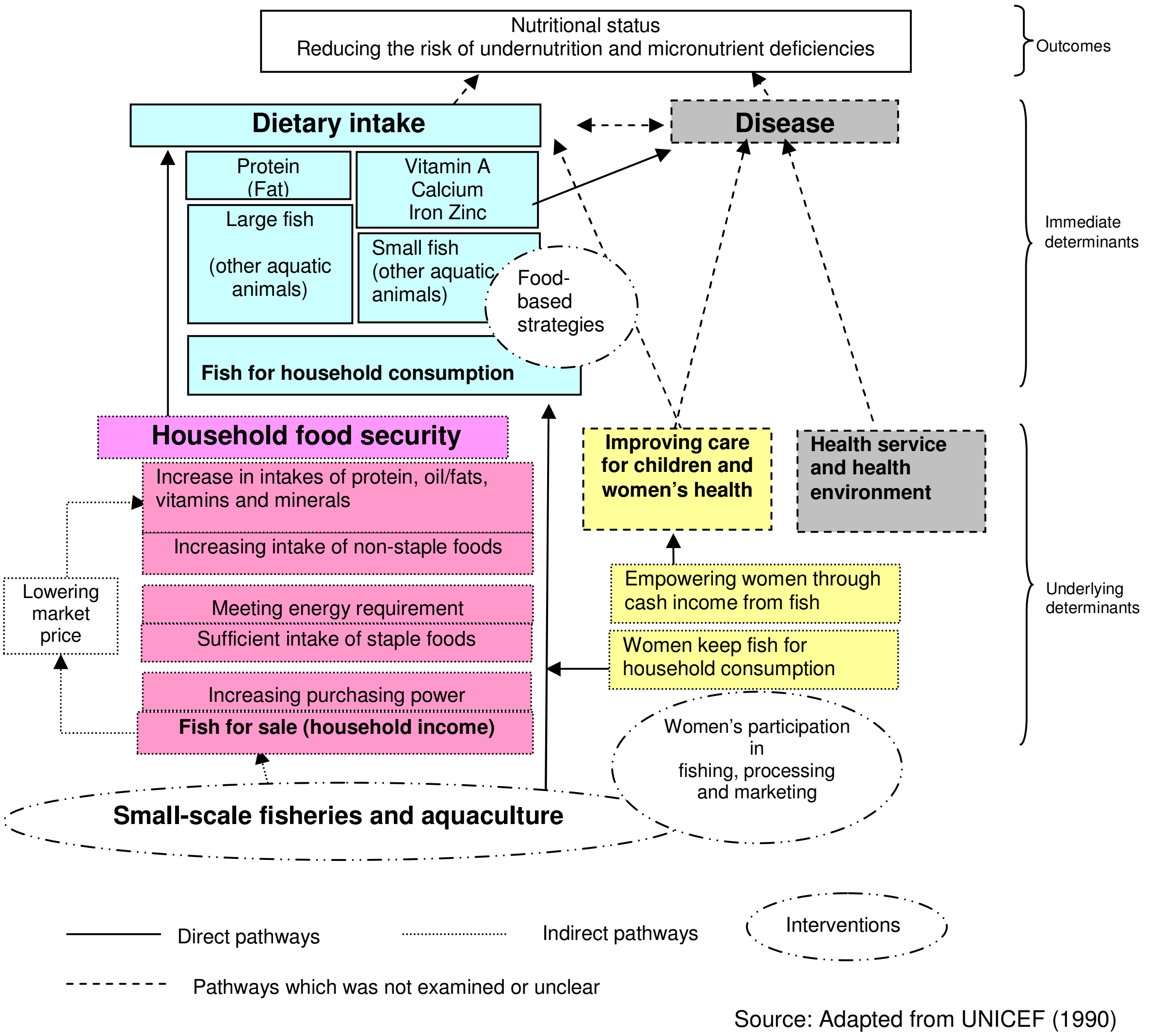


Figure 8: Identified pathways through which fish contribute to improving nutritional status

Improving dietary intake through diversifying the diet is one way to improve nutritional status. Adding small fish into the starch-based diet, as characteristic of the poor, increases micronutrient intakes effectively, with a high bioavailability, and fish carry other vegetables and some oil through a cooking process, contributing also to enhancing the bioavailability of the micronutrients in these foods. In this direct pathway, small-scale fisheries and aquaculture of nutrient-dense fish played an important role, while the nutritional effect of adding large fish into the diet was not fully analysed although it provided animal protein and PUFAs to some extent. Most nutrient-dense fish come from small-scale fisheries, and therefore conservation of these species and integrating them into already existing aquaculture systems is recommended. Food-based strategies which include the promotion and nutritional education of nutrient-dense fish have potential to strengthen this direct pathway.

Increasing purchasing power through the sale of fish for cash income which can be used to ensure household food security is an indirect pathway to improve overall dietary intake. Cash income from fish enabled households to add various food items into the diet, besides fish. Some studies reported that household income was used for purchasing animal-source foods or other food items. However there is a challenge that households with insufficient staple foods exchange fish for staple foods, but did not make enough cash from their fish sales to purchase other food items. In this case, households remain with starch-based diets, thereby their quality of diet is not improved.

Another pathway linking small-scale fishery and aquaculture activities with household nutritional outcomes was through women's involvement in production, processing or sale of fish. Women often engage in fishing activities for household consumption, contributing to strengthen the direct pathway, while trading and processing contribute to empowering women which indirectly improves care for and diet of children.

This review analysed the role of aquaculture and small-scale fisheries separately. The pathways appeared however, to be basically the same. Aquaculture contributed to increasing household income with its high profitability and productivity. However owning a fish pond is an essential condition to initiate aquaculture, except in some cases where common-pool resources and seasonal fish ponds are abundant. On the other hand, fish supplied by small-scale fisheries were not only caught and consumed by household members, but also widely traded in the local markets, providing various livelihood opportunities for the poor, landless and women. Supporting small-scale fisheries through increasing capacity of sustainable resource management is required to keep fish supply from common-pool resources for the poor, as current aquaculture technologies and production systems cannot exactly replace the role played by small-scale fisheries. Nevertheless, aquaculture using common-pool resources such as river channels and floodplains, near shore, marine and lake waters, and seasonal water bodies, has potential for the sustainable supply of fish and household income for the poor, especially the landless and women.

Other linkages, such as health service and health environment of communities, and diseases were not examined as the data were scarce. To fully understand the determinants of nutritional status, integrated research and interventions are required.

6.2 The areas where follow up research is required

Research on fish commonly consumed by the poor

While research and interventions for increasing productivities of catfish, carps and tilapia have greatly contributed to increasing household income and the total production and consumption of fish, indigenous fish and other aquatic animals which are commonly consumed by the poor have not been taken into account in research, monitoring and policies for food security and poverty alleviation. As this review has shown, indigenous fish supplied by common-pool resources and rice fields are still very important as a food and livelihood source in highly populated countries with high rates of poverty and nutritional insecurity, such as Bangladesh, Malawi, Laos and Cambodia. Sustainable supply of these smaller, lower-value species should be prioritised and the production and consumption of nutrient-dense fish should be promoted as it strengthens the direct pathways between fish production and improved nutrition. Since there are little data on these species, further data are required in the areas such as the nutrient composition of these species, impact of declining fish catches on the fish consumption patterns of the poor, seasonal availability, and factors which affect bioavailability and micronutrient intakes at individual level such as cleaning and cooking methods, plate-waste and combination of foods in a meal. Also, the feasibility of aquaculture of these species, together with large fish for cash income, should be tested in many countries where aquaculture has been promoted and disseminated.

Developing research methods to identify nutritional outcomes

Fish consumption and household income were often used as indicators to measure impacts of interventions. However these indicators are not enough to show the impacts on nutritional status. There were few studies which examined nutritional outcomes. Biochemical indicators can examine the effects of micronutrient intakes from fish but serum retinol concentration was not appropriate to examine the efficacy of vitamin A from freshwater fish (Kongsbak, 2007). Anthropometric indicators are appropriate to measure for undernutrition, but not micronutrient deficiencies. Only few studies examined the consumption surveys at individual level. Long term surveys help understand the changes in dietary intake at individual levels, the seasonal diversity of diet, and the traditional ways of cooking and processing which affect bioavailability. The appropriate indicators and research methods should be further developed in order to link from aquaculture and small-scale fisheries to nutritional outcomes.

Also, measuring the indirect pathways through which cash income from fish contributes to nutritional status has not been well established. Aiga *et al.* (2009) was a unique case study which statistically demonstrated the indirect link between fish farming and nutritional status. Expanding this type of study will help to improve our understanding of the mechanisms through which poor households can move forward in improving their dietary intake and nutritional status. Yet, as those authors pointed out, primary causes of undernutrition might be more complicated than just dietary intake, with other factors such as child care practice or diseases being potentially important. These factors should therefore be integrated into studies of nutritional status of households and the actual and potential roles of fisheries and aquaculture in them.

In research on small-scale fisheries, the statistical demonstration may be more difficult as fish-related activities are diverse and the situation surrounding water resources and fishing activities are changing due to increasing fishing pressures. However the question remains why rural communities engaging in fishing often have a high prevalence of undernutrition despite fish-related activities provide extra opportunities for livelihoods and fish as food that is relatively easy to access. The explanation for this apparent paradox may be that rural communities engaged in fishing are often located in marginalised areas where health systems are limited, and have specific vulnerability to waterborne diseases and HIV and AIDS in some areas, which undermine the health benefits they may gain from direct consumption of fish. Also, where markets are inefficient (e.g. poor infrastructure, lack of access to inputs and credit) and where fish resources are in decline, the incomes from fishing may be insufficient to purchase more than the basic starch-based staples, leaving fishing communities no better off nutritionally than farming communities. There is a need for research to develop methods which integrate other determinants of undernutrition such as market and income constraints, disease incidence and effects, health service provision and health environment including hygiene norms, and child care (See Figure 1). Also integrated interventions such as improving health care systems in marginalised fishing communities, and activities related to primary health care, malaria and HIV and AIDS may contribute to strengthening pathways and improving nutritional status.

The limitation of this review is that examined pathways were only for the rural poor households who produce fish by aquaculture or engage in small-scale fisheries (although some comparison with rural households in the same areas which did not engage in fishery and aquaculture activities were available for some studies reviewed). The impact of aquaculture and small-scale fisheries on other rural and particularly on urban consumers were not analysed. It will be critical to understand as to how aquaculture and small-scale fisheries can contribute to the wider rural and urban poor population through the trading and marketing system.

7. Conclusion

The significance of investing in aquaculture and small-scale fisheries as a means of improving nutritional status

The percentage of protein from fish to total animal protein intake can be used as an indicator to demonstrate the direct contribution of fish to human nutrition at national level. However the data on animal protein intake at national level masks the importance of fish for the poor and does not show the pathways through which fish contribute to nutritional status, which are largely through provision of key micronutrients, rather than protein. This review analysed various pathways and found clear linkages in direct contribution through fish intake which increase micronutrient intakes, and indirect contributions through increasing household income thereby improving overall dietary intake. Although the data on the linkage from improved dietary intake to nutritional status were scarce, expanding aquaculture and supporting small-scale fisheries have potentials as a sustainable way of improving nutritional status and household food security through demonstrated direct and indirect pathways.

The challenge is that many poor households do not have enough food stocks even for their staple foods (energy deficits). For this population, fish are less likely to be utilised to diversify diet and invest in the future harvests, rather it results in compensating for staple foods to meet their daily energy needs. At national level, many countries which relay on fish as their main animal protein source (and they would rely on fish-related activities as essential livelihoods), are officially referred to low-income food-deficient countries (FAO; 2009 c) (See Appendix1). In this respect, further researches and various interventions are needed in order to make full use of fish resources and find ways which optimise the benefits from fish for the poor.

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Appendix 1: A list of countries where fish contributes more than 30% of the total animal protein supply

Country	Fish protein / Animal protein (%)	Fish consumption (kg/capita/year)	Total food consumption (kcal/capita/day)	Total protein consumption quantity (g/capita/day)	Fat consumption (g/capita/day)	Low-income Food-Deficit Countries	Children Underweight (moderate) for age (% under 5)	Proportion of undernourished in total population (%)
Source	(A)	(A)	(A)	(A)	(A)	(B)	(C)	(D)
Maldives	76.1	67.6	2666	107.8	180.1	□	30	
Sierra Leone	75.7	25.3	1933	48.2	51.3	✓	30	45
Solomon Islands	73.5	31.8	2437	52.5	44.6	✓	21	
Comoros	56.5	20.5	1821	43.6	45.0	✓	25	
Kiribati	55.9	75.0	2859	73.7	96.9	✓	13	
Bangladesh	54.9	14.0	2261	48.7	27.6	✓	46	36
Cambodia	53.2	25.7	2200	55.5	35.4	✓	36	38
Indonesia	52.7	20.5	2434	53.3	45.7	✓	28	19
Gambia	51.2	20.3	2136	49.5	72.0	✓	20	20
Senegal	48.5	26.8	2199	58.2	58.2	✓	17	28
Seychelles	48.0	62.0	2403	77.7	73.7	□		
Sao Tome & Principe	45.0	23.6	2620	58.0	71.3	✓	9	
Sri Lanka	44.3	14.4	2350	52.3	42.7	✓	29	27
Lao PDR	44.0	19.9	2341	64.1	31.6	✓	37	27
Japan	43.3	60.5	2743	90.2	85.2	□		<5
Togo	42.9	8.1	2035	46.8	44.9	✓	21	45
Philippines	42.5	32.6	2503	58.5	47.5	✓	28	21
Congo D.R	42.1	5.3	1486	23.1	21.2	✓	31	29
Vanuatu	40.2	32.1	2755	64.8	91.1	✓		
Guinea	38.6	11.1	2560	54.4	60.9	✓	26	19
South Korea	37.8	52.8	3053	86.3	84.0	□		
Thailand	37.7	31.6	2510	57.1	56.2	□	9	
Malaysia	37.2	51.8	2863	77.5	87.1	□	8	<5
Myanmar	36.6	26.1	2439	68.6	58.8	□	32	44
Cameroon	36.1	14.7	2240	57.7	46.3	✓	19	34
Malawi	35.9	4.6	2143	54.8	27.3	✓	21	45
Cote d'Ivoire	35.4	15.0	2542	50.4	53.4	✓	20	15
Nigeria	34.7	9.0	2655	59.8	65.4	✓	27	15
Uganda	34.3	11.5	2371	56.4	48.4	✓	20	19
Viet Nam	33.6	26.4	2698	70.0	54.4	□	20	28
Benin	31.8	10.3	2315	54.0	59.8	✓	23	28
Fiji	31.7	36.3	3003	78.1	96.1	□		
Congo	31.7	19.7	2353	50.0	60.0	✓	14	40

Source: (A) FAO (2009 a), (B) FAO (2009 b), (C) UNICEF(2009), (D) FAO(2009 c)
Blank: Data not available
Highlight: Non- low-income food-deficit countries

Much of fish consumed by the poor are caught by household members and traded in local markets. These fish are rarely or poorly included in national statistics, and it is therefore difficult to estimate precisely the real contribution of fish to the rural poor households. This report is the first global overview of the role played by fish in improving nutrition. Fish consumption patterns of the poor, the nutritional value of fish, and small-scale fisheries and aquaculture activities are considered. It also highlights the gap in knowledge where more research is needed.

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