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Potential in Improving Nutritional Security through Aquaculture Development in India: A Regional Level Analysis

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Abstract

A large section of Indian population is dependent on animal source of protein like milk, meat, fish and egg. Except milk and milk products, all the other sources of food are considered as non-vegetarian proteins. Among them, fish is significant as one-quarter of population, numbering around 300 million people, consumes fish in India. It contributes about 44 per cent of non-vegetarian protein. The present paper has analyzed consumption pattern of fish and its contribution to non-vegetarian protein at the regional level. The National Sample Survey data which were available at the state level and were aggregated to the regional level, viz., eastern, north-eastern, western, northern, central and southern regions. The fish and inland fish production in the region vis-a-vis consumption has been analyzed to find out deficit and surplus regions. Based on the resources and aquaculture yield gap at the regional level, the potential for increasing fish production has been analysed. The study has concluded that there is potential to double the fish production at the national level and regional trade would be encouraged due to differential resource endowment across the regions which would contribute to the protein and nutritional security in a significant way.

Key words: Nutritional security, protein, fish, aquaculture, India

JEL Classification: Q18, Q22

Introduction

Indian agriculture has made remarkable strides during past five decades achieving high levels of production and productivity to address food and nutrition security of its 1.3 billion people which is 17.84 per cent of world population (in 2016) (CIA, 2016). The agriculture sector contributes just 15 per cent to India's gross domestic product (GDP), but over 55 per cent of the population still depends on it. More importantly, the nutritional need of all consumers in India is fulfilled through production of nutrient-rich diverse crops, aquaculture and livestock for direct consumption and nutritional security of the country.

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The role of protein is as important as of energy for a healthy human being. Access to adequate quantity of quality protein to maintain normal body composition and function throughout the life-cycle is fundamental for maintaining health. A source of protein supply is an essential component of a healthy diet, allowing both growth and maintenance of the 25,000 proteins encoded within the human genome, as well as other nitrogenous compounds, which together form the body's dynamic system of structural and functional elements that exchange nitrogen with the environment. The amount of protein that has to be consumed, as part of an otherwise nutritionally adequate diet, to achieve the desired structure and function is identified as the protein requirement. The dietary protein requirement consists of metabolic demands that satisfy those needs in the context of efficiency of utilization to meet the need (WHO, 2002).

Cereals, pulses and animal proteins are three main sources of protein. In India, the relative role of plant protein has been on decline while that of animal protein is increasing largly due to rising incomes and urbanization (Mittal, 2006). Similar trends are seen globally which is putting pressure on the agricultural system to produce more such diversified protein-rich foods (FAO, 2011; Thilsted, 2013; Toppe *et al*., 2012).

In India, the animal protein is further divided into milk and non-vegetarian protein owing to preference of a large section of people not eat meat, fish, egg while including milk in their diet. However, among the non-vegetarian sources, fish is considered important among the selected section of people. More of fish food is being demanded over a period of time which has encouraged farmers to produce more aquaculture products to meet these demands (Kumar *et al*., 2005; Dey *et al.*, 2004).

The present paper assesses the consumption of fish and its role in nutritional security and response of the aquaculture sector to meet this fast growing demand for fish in India. The paper is based on the data generated through household survey by National Samples Survey Organization (NSSO) and national level production data by Department of Animal Husbandry Dairy and Fisheries (DAHD&F), Government of India. The paper attempts to identify the areas of improvement in the aquaculture production system to meet the future demand for fish in the country.

Data and Methodology

Two sources of data are available on the consumption of fish in India. One is food balance sheet data produced by Food and Agriculture Organization of United Nations which provides the estimated apparent fish consumption by dividing available food with the population. The other is the data of National Sample Survey Organization (NSSO) who conducts nationwide household consumer expenditure surveys at regular intervals as part of its "rounds", each round normally being of a year's duration. These surveys are conducted through interviews of a representative sample of households selected randomly through a scientific design and cover almost the entire geographical area of the country. Generally, these surveys are conducted at quinquennial intervals roughly at 5-year intervals. The present paper has used quantity and incidence of consumption in 2004-05 (NSS 61st round), 2009-10 (66th round) and 2011-12 (68th round) (NSSO, 1996; 2001; 2007; 2014).

The choice of consuming non-vegetarian food which includes fish is a matter of preference depending on social factors like religion, caste, gender, region, etc. Even within non-vegetarian food consuming population, fish consumption depends on factors like season, days of the week, festivities, etc. The data on the actual consumption pattern across these factors are not available, but the National Sample Survey data are available at the state level which could further be aggregated to the regional level like eastern, north-eastern, western, northern, central and southern regions. These regions also share a set of similar physiological and social factors, hence, common factors for fish consumption. The paper presents fish consumption patterns and role of fish in nutritional security at following six regional levels.

Region	States
Central	Chhattisgarh, Jharkhand , Madhya Pradesh
Eastern	Assam, Bihar, Odisha, West Bengal
North-Eastern	Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura
Northern	Delhi, Haryana, Himachal, Pradesh, Jammu and Kashmir, Punjab, Uttar Pradesh, Uttarakhand, Chandigarh
Southern	Andhra Pradesh, Goa, Karnataka, Kerala, Tamil Nadu, Andaman and Nicober islands, Lakshadweep, Puduchery
Western	Gujarat, Maharashtra, Rajasthan, Dadra and Nagar Haveli, Daman & Diu

Results and Discussion

Fish as Source of Protein

A wide range of nutrients are necessary for a person to perform various body functions and also to lead a healthy life. The nutrients include proteins, fat, carbohydrate, vitamins and minerals. Carbohydrates get oxidized in the body to yield energy which the body needs. Although proteins also provide energy, their primary function is to provide amino acids for building body proteins. Fats, particularly the vegetable oils, besides being a concentrated source of energy, provide essential fatty acids which perform a function akin to vitamins in the body. Vitamins and minerals do not

Figure 1. Major sources of protein in Indian food

supply energy, but they play an important role in the regulation of the metabolic activity in the body. Among them, proteins should be available in adequate amounts and some foods contain high amount of proteins and can be classified as protein-rich foods, viz. animal foods like meat, fish and egg; plant foods like pulses, oilseeds and nuts; milk and milk products, as these foods contain over 20 per cent protein. Cereals are a moderate source of protein as they contain about 10 per cent protein. Leafy vegetables, fruits, roots, tubers are generally poor sources of protein as they contain less than 2 per cent protein (NSSO, 2014).

Recently, Bogarda *et al.* (2015) compared nutrient contents of 55 fish species of Bangladesh and found that fishes contain iron ranging from 0.34 to 19 mg/100 g, zinc from 0.6 to 4.7 mg/100 g, calcium from 8.6 to 1900 mg/100 g, vitamin A from 0 to 2503 mg/100 g and vitamin B12 from 0.50 to 14 mg/100 g. Several species were rich in essential fatty acids, particularly docosohexaenoic acid in capture fisheries species (86–310 mg/100 g). This illustrates the diversity in nutrients content of fish species and in particular, the rich nutrient composition of small indigenous species, which has the potential to improve food and nutrition security (Toppes *et al*., 2012; Thilsted, 2013).

The consumption of fish provides energy, protein and a range of other important nutrients, including the long-chain n-3 polyunsaturated fatty acids (LCn3PUFAs). Eating fish is part of the cultural traditions of many peoples. In some population, fish is a major source of food and essential nutrients. Among the general adult population, consumption of fish, particularly fatty fish, lowers the risk of mortality from coronary heart disease (Mozaffarian and Rimm, 2006; FAO/WHO, 2011). Due to its high protein content, fish is considered as a protein-rich food. On an average, fish contains about 14 per cent protein. The chicken, pulse, goat meat and eggs contain higher protein than fish but cereals contain less protein per kg of food (Figure 1).

Fish Consumption Patterns

The consumption of fish is primarily a matter of preference as vegetarian people prefer not to consume fish. Most of the people who consume non-vegetarian food also consume fish along with other foods like chicken, meat and egg. On all-India basis, 24.8 per cent consume fish with a higher preference across rural (26.5%) than urban (21.0%) people (Table 1). The lower fish consumption pattern was found in northern India (6.7%), western India (9.1%) and central India (11.9%), whereas it was as high as 64 per cent in north-eastern India and 62.1 per cent in eastern India. Over a period of time, a decline in the preference of fish consumption was reported through various rounds of NSS surveys. Most of the regions reported a negative growth rate in fish consumption, except in north-eastern India where a positive increase in the preference for fish consumption was reported. A major decline in preference was reported in central and western India. The decline was higher in the urban than rural India (Table 1).

Table 1. Preference of fish consumption across regions in India

Region	Consuming population (%) (2011-12)			Growth rates of fish consuming persons per year (%) (1993-2012)		
	Rural	Urban	All-India	Rural	Urban	All-India
Central	12.88	8.98	11.87	-3.58	-3.39	-3.50
Eastern	55.96	62.12	57.16	-0.53	-0.74	-0.64
North-Eastern	63.53	65.02	63.95	3.13	4.85	3.98
Northern	7.78	3.97	6.66	-1.37	-1.31	-1.35
Southern	25.62	27.16	26.26	-0.18	-0.25	-0.21
Western	6.86	12.68	9.12	-2.80	-4.36	-3.73
India	26.50	21.00	24.79	-0.76	-1.46	-1.07

The latest round of consumption survey (2011-12) reported the average fish consumption to be 3.12 kg/cap/year which was higher for rural (3.12 kg) compared to urban (3.02 kg) population. The variation was found to be wide across the regions as it was as high as 7.0 kg for north-east and 6.45 kg for eastern region and as low as 0.58 kg for north, 0.9 kg for west and 1.08 kg for central India. In general, the growth rate in the consumption was found to be positive in most of the regions, except the central and western regions. The annual growth rate was as high as 3 per cent in eastern, 1.82 per cent in north-eastern and 1.78 per cent in northern India. The growth rates for the urban areas was found to be higher (3.2 %) compared to rural (2.7%) areas. Overall, there was an annual increase of 2.8 per cent for the net consumption of fish in India (Table 2).

The estimated fish consumption (in kg/cap/year) taking into consideration only consuming population showed a different picture. The average consumption of fish consuming population was 12.6 kg with as high as 14.4 kg for urban and 12.0 kg for rural areas on all-India basis. The per capita consumption was reported in the range of 8.7 to 21.1 kg. The variability was less conspicuous in these figures. In other words, the fish-consuming populations in most of the area of the country were consuming at least around 9 kg and at best around 21 kg across the regions of the country. The higher consumption rate in the southern region was reported primarily due to predominance of Kerala, islands and maritime states where fish availability and preference was higher. Except these maritime states, most of the fish consumptions were in the range of 9-11 kg/year.

Compared to consumption of fish by Indians, the global consumption of fish was much higher. It was at the level of around 25 kg for most of the developed countries (Figure 2). Globally, the average fish consumption was 20 kg/cap/year. As per the global

Table 2. Consumption of fish across regions in India

Region	Fish consumption in kg/cap/year (all population) (2011-12)			Growth rates per year (1993-2012)			Fish consumption (kg/year/cap) (2011-12)		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Central	1.13	0.94	1.08	-1.11	0.42	-0.69	8.8	10.5	9.1
Eastern	5.84	8.94	6.45	3.15	2.54	3.04	10.4	14.4	11.3
Northeastern	6.52	8.23	6.99	1.61	2.11	1.82	10.3	12.7	10.9
Northern	0.67	0.37	0.58	3.07	4.18	1.78	8.6	9.3	8.7
Southern	5.23	5.96	5.53	0.76	0.49	0.65	20.4	21.9	21.1
Western	0.65	1.34	0.92	-3.29	-0.10	-1.03	9.4	10.6	10.0
India	3.19	3.02	3.12	2.65	3.19	2.82	12.0	14.4	12.6

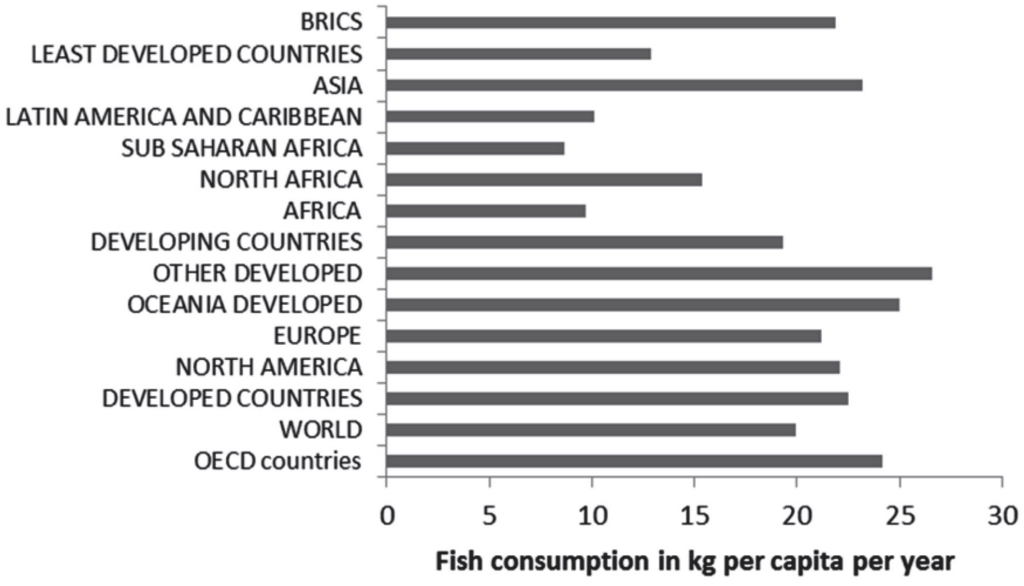

Figure 2. Global scenario of fish consumption: 2014

Table 3. Fish consumers in India: 2011-12

Region	Total population (million)				Consuming population (million)			
	Rural	Urban	Total	Share in all-India (%)	Rural	Urban	Total	Share in all-India (%)
Central	97.18	33.93	131.10	10.83	12.51	3.05	15.56	5.19
Eastern	216.02	52.25	268.27	22.17	120.89	32.46	153.35	51.12
North-Eastern	10.44	3.98	14.42	1.19	6.63	2.59	9.22	3.07
Northern	211.74	88.23	299.97	24.79	16.47	3.50	19.98	6.66
Southern	149.71	104.76	254.47	21.03	38.36	28.45	66.81	22.27
Western	148.00	93.96	241.96	19.99	10.15	11.91	22.06	7.36
All India	833.09	377.11	1210.19	100.00	220.77	79.19	299.96	100.00

standards, the consumption of fish by Indians was lower. Given the condition of accessibility and affordability, the consumption of fish would be higher.

Fish Consumers in India

Despite predominant vegetarianism and low preference for consuming fish, the total number of fish consumers was very high — about 300 million people in India consumed fish in 2011-12. Broadly, eastern, northern, southern and western regions were similar in their share to national population but share of fish consumers distributed skewed manner as the eastern region alone constituted 51 per cent of consumers and together with southern India, 73 per cent of the fish consumers hailed from both of these regions, whereas their share to total population was only about 43 per cent. The total number of consumers in other regions was very low and most of the fish consumers therefore were located in eastern and southern India. Also, the fish eaters were more in the rural areas (74.6 %) vis-à-vis urban consumers.

Share of Fish in Non-vegetarian Proteins

The cereals, pulses and animal proteins were found to be three main sources of proteins for Indian consumers. The animal protein which included milk, meat, fish and egg was increasingly contributing to the total protein supply and nutrition security of the

people. However, the trends in the consumption of milk and other animal proteins were different. The milk was consumed by all sections of people while other non-vegetarian foods were consumed based on the factors like habit, taste, region and preference. Among the non-vegetarian sources, the important food commodities for which data were available were fish, chicken, beef/buffalo meat, goat meat/mutton, eggs, porks and others. Among these, fish was most widely consumed and contributed largest share of non-vegetarian protein (44.3 %) followed by chicken (33 %) and eggs (17 %). Three sources together contributed 94 per cent of non-vegetarian animal protein.

It is significant that contribution of fish to non-vegetarian protein was as high as 66 per cent in eastern India, 46 per cent in north-eastern India and 36 per cent in southern India. In central, western and northern India, the lower share of fish was compensated by chicken and eggs. Overall, the fish was most preferred with largest share in non-vegetarian protein supply (Table 4).

Production Gap and Trade at Regional Levels

During the year of consumption survey (2011-12), the production of total fish and inland fish was reported to be 8.7 million tonnes and 5.3 million tonnes, respectively. The total production included marine and inland sources while inland production included inland capture and culture fisheries. At the regional level, there was a strong correlation between production and consumption of fish. However, in eastern and north-eastern India, the consumption was higher than the production, while in central, southern, northern and western India, there were surpluses (Figure 3). The major surplus in fish production compared to consumption was in the western Indian states like Gujarat where the production was higher due to marine sources but consumption was less. The deficit regions of east and north-east primarily depended on the surplus available in the regions of southern, central, northern and western India. This situation had led to a pan-Indian fish trade where a large portion of fish produced in other parts of the country primarily move to eastern

Table 4. Contributions of various sources of non-vegetarian protein in different regions of India

(in per cent)

Region		Fish	Chicken	Beef/buffalo meat	Goat meat/ mutton	Eggs	Other birds/ crab, etc.	Pork
Central	Rural	19.52	69.02	0.07	1.92	9.30	0.01	0.16
	Urban	8.22	63.02	0.49	8.70	19.55	0.00	0.02
	Total	15.88	67.08	0.20	4.11	12.60	0.01	0.11
Eastern	Rural	68.07	14.00	1.94	0.53	14.96	0.04	0.44
	Urban	61.80	18.00	1.30	1.04	17.84	0.00	0.01
	Total	66.16	15.22	1.75	0.69	15.84	0.03	0.31
North-Eastern	Rural	45.95	7.76	16.89	0.77	6.00	3.04	19.60
	Urban	45.29	11.19	6.04	0.32	10.08	2.92	24.16
	Total	45.74	8.85	13.44	0.63	7.30	3.00	21.05
Northern	Rural	13.46	34.96	13.83	14.82	22.91	0.00	0.01
	Urban	1.50	40.13	16.61	8.58	33.16	0.00	0.02
	Total	7.55	37.52	15.20	11.74	27.97	0.00	0.02
Southern	Rural	35.52	45.54	0.82	2.08	16.02	0.01	0.02
	Urban	38.36	39.08	0.85	2.76	18.94	0.00	0.01
	Total	36.73	42.79	0.83	2.37	17.26	0.00	0.01
Western	Rural	7.97	65.37	1.00	10.17	15.47	0.01	0.00
	Urban	11.69	52.08	2.33	9.37	24.53	0.00	0.00
	Total	10.25	57.22	1.82	9.68	21.02	0.01	0.00
India	Rural	47.05	32.18	2.33	2.15	15.21	0.14	0.95
	Urban	39.94	34.20	2.09	3.30	19.70	0.08	0.68
	Total	44.27	32.97	2.24	2.60	16.96	0.12	0.84

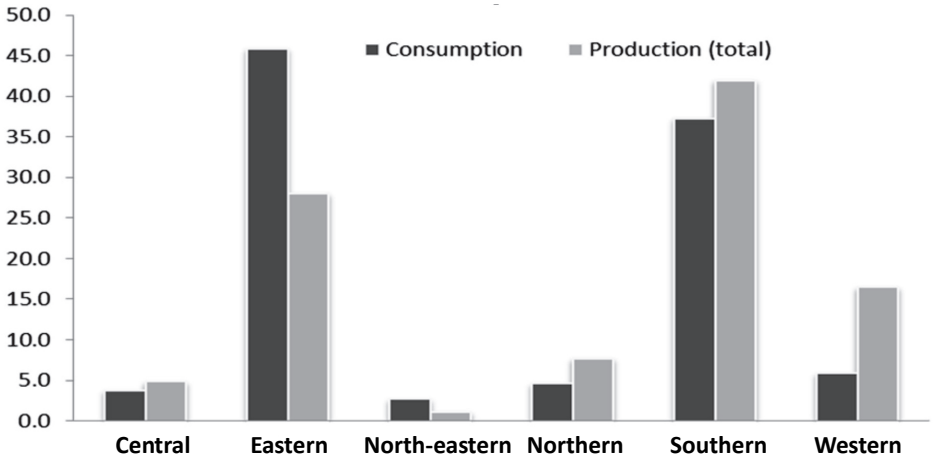

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Figure 3. The regional share of consumption and total fish production in India: 2011-12

India where scale of fish consumption was higher. There were also considerable levels of fish trade within the regional level which could be analyzed in the state level analysis but it was beyond scope of the paper.

There was a strong positive relationship between fish consumption and inland fish production. The inland fish production included aquaculture from small ponds and tanks as well as inland capture fisheries from rivers, reservoirs and wetlands. The areas with higher production were also shared equivalent share in the inland fish production was an indication of increased effort to improve fish production in the higher consumption regions.

Productivity and Yield Gap in Aquaculture

Traditionally, inland capture fisheries was the predominant source of fish for the non-coastal regions, but over a period of time, aquaculture has improved considerably. Unfortunately, there were no information available on separate state-wise data for aquaculture and inland capture fisheries in India. Moreover, the major technological transformations were occurring in aquaculture, therefore, increase in the inland fisheries production was primarily due to growth in aquaculture. The ponds and tanks were the major resources available for increasing fish production in future.

The aquaculture productivity data were taken from the Department of Animal Husbandry Dairy and Fisheries, Government of India. The data report productivity in the Fish Farmers Development Agency (FFDA) adopted pond. For the present analysis, these data were adjusted to reduce FFDA effect to make it comparable and representing average level of productivity. The figures available for 2013-14 by DAHD&F were used along with available pond and tank resources to determine potential of production from aquaculture. The average yield from the aquaculture ponds in India was estimated to be 2.67 t/ha

Table 5. Fish production and sufficiency at regional level: 2011-12

Region	Total fish production		Inland fish production		Surplus	
	Quantity (Mt)	Share (%)	Quantity (Mt)	Share (%)	Quantity (Mt)	Per cent of production
Central	0.4	4.8	0.4	7.9	0.11	26.31
Eastern	2.4	28.0	2.1	40.2	-1.23	-50.85
North-Eastern	0.1	1.1	0.1	1.8	-0.13	-135.67
Northern	0.7	7.7	0.7	12.6	0.29	42.92
Southern	3.6	41.9	1.7	32.2	0.05	1.39
Western	1.4	16.5	0.3	5.4	0.91	64.08
All India	8.7	100.0	5.3	100.0		

Table 6. Aquaculture resources, productivity and potential: 2013-14

Region	Yield (t/ha)	Pond and tank (M ha)	Share of ponds & tank area (%)	Yield gap (t/ha)	Additional production (M t)	Additional production (share, %)
Central	1.84	0.15	6.25	4.16	0.63	7.79
Eastern	3.28	0.52	21.25	2.72	1.41	17.36
North-Eastern	1.25	0.35	14.31	4.75	1.65	20.41
Northern	3.13	0.20	8.08	2.87	0.56	6.97
Southern	2.62	0.90	36.83	3.38	3.03	37.39
Western	1.28	0.32	13.28	4.72	1.52	18.81
All India	2.67	2.43	100.00	3.33	8.11	100.00

which was above average in case of eastern and northern India — the regions led by West Bengal and Punjab, respectively. The southern India was at the average level though Andhra Pradesh was much above than other states of the region. The north-east reported lowest productivity (1.25 t/ha), followed by west (1.28 t/ha) and central India (1.84 t/ha) (Table 6).

Potential in Fish Production

The natural capture fisheries in inland waters are multiple purpose large water bodies where the fisheries productivity is dependent on environmental management and productivity can be increased through management options like stock enhancement, species enhancements, etc. At present, the wetlands produce fish in the range of 200-500 kg/ha and reservoirs 20-50 kg/ha (Sugunan and Sinha, 2001). However, there is huge potential of increasing fish production from small water bodies like ponds and tanks through scientific management of aquaculture. In specific cases, the productivity of 40-50 t/ha is also reported (Gopal Rao, 2010). In 2013-14, the average productivity was reported to be 6.1 t/ha in Punjab and 4.4 t/ha in West Bengal and Haryana. It is not unusual to report as high as 8-10 t/ha by some enterprising farmers. Therefore, the average productivity of 6 t/ha for all aquaculture ponds is attainable across the country in near future.

On taking 6 t/ha as the potential production of aquaculture ponds, the yield gap across the regions is wide, it is as high as 4.8 t/ha for north-eastern region and minimum of 2.7 t/ha in eastern region. At the national level 3.3 t/ha is the additional productivity which is attainable in the future. It is also found that the southern and eastern India with considerably higher level of aquaculture development has also attained a higher level of productivity; hence, yield gap is lower. But, in most of the other regions, the production can be increased many-fold by adoption of scientific aquaculture management practices.

It is estimated that an additional production of around 8.1 Mt of fish can be achieved in aquaculture (Figure 4). It would be more than double of the present level of productions of aquaculture and almost double of total fish production for India. The past four decades have witnessed a steady expansion of aquaculture and more so in the eastern and southern parts of the country. In future, the other regions would contribute significantly to the fish production through use of the available small water resources and scientific management practices. Therefore, there is considerable potential for increasing fish production in the country.

Implications for Nutrition Security

The continued growth of aquaculture sector in the context of stagnating marine and inland capture fisheries sector provides a greater scope to provide additional demand of fishes in India. In future, it is expected to expand aquaculture to the extent of doubling total fish available for nutrition. The doubling fish production would also double the average consumption at the regional, state and local levels. The consumption of locally available fish is preferred and hence, increase in the production will also increase local consumption. But, as the increase in aquaculture production is expected more from the areas with lower level of consumption preference, the additional fish

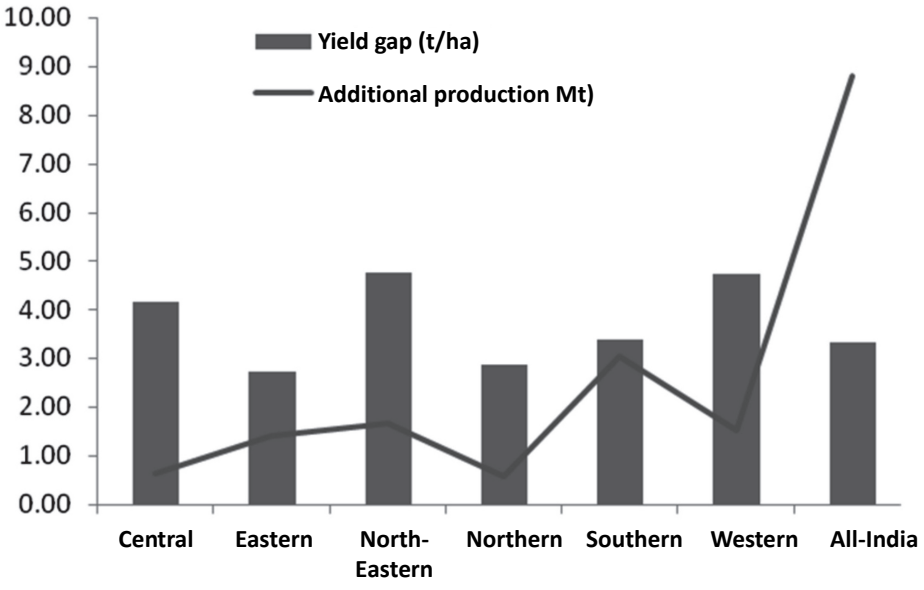

Figure 4. Yield gap and potential of additional fish production from aquaculture in India

produced is expected to be traded across the regions to make fish available in the high consumption regions. The increase in fish consumption would have significant implications on the net protein availability to the people.

In addition to protein, fish also provides a wide range of essential fatty acids, micro-nutrients and minerals. The studies have proved beyond doubt the health implications of fish consumption especially for the early stage of life (WHO/FAO, 2002). The increased consumption of fish will also improve the quality and quantity of the protein intake and hence, nutrition security of India.

Conclusions

India primarily being a vegetarian country both plant and animal proteins are important for the food and nutrition security. Milk, meat, fish and egg are four important sources of animal proteins; however, within these, the milk is considered as vegetarian food and hence is consumed by all sections of people, whereas other animal proteins are consumed by the selected sections of people categorized as non-vegetarian population. Diverse species of fishes provide a wide range of nutrients to the fish consuming people and benefits of consumptions are far greater than the risk associated with it. For analysis of nutrition security, fish is primarily regarded as a source of proteins.

The net consumption of fish for the consuming population is 12.6 kg/cap/year, which is far less as per global standards. Many developing and developed countries consume fish in much higher quantity than India. There are regional variations in the consumption of fish as states like Kerala and islands states consume a much higher quantity than other states. The consumption of fish in southern India has been found to be more than double of central India. Even though one-fourth of people are fish consumers, the total fish consumers in India are 300 million with more than 73 per cent located in eastern and southern India.

Among the non-vegetarians sources, fish is most important protein supplier contributing about 44 per cent of the non-vegetarian proteins, but it was only 8 per cent for north India, whereas in eastern India, the dependence on fish is to the extent of 66 per cent. In eastern and north-eastern India, the consumption of fish was higher than its production while in central, southern, northern and western India, there were surpluses. The major surplus in the production compared to consumption was in the western India in states like Gujarat where the production was higher due to marine sources but consumption was less. The deficit regions of eastern and north-eastern were primarily dependent on the surplus available in the regions of southern, central, northern and western India to meet the consumption demand.

It is estimated that the additional production of around 8.1 million tonnes of fish can be achieved from aquaculture. It would be more than double of the present level of productions of aquaculture and almost double of total fish production for India. Therefore, there is considerable potential for increasing fish production in the country. The appropriate policy and institutional framework is essential to realize such huge potential in the country which would contribute to the national nutritional security significantly.

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References

Bogarda Jessica, R., Shakuntala H. Thilsted., Geoffrey C. Marks, Md. Abdul Wahab, Mostafa A.R. Hossain, JetteJakobsen and Stangoulis, James (2015) Nutrient composition of important fish species in Bangladesh and potential contribution to recommended nutrient intakes. *Journal of Food Composition and Analysis,* **42**: 120-133.

CIA (Central Intelligence Agency of United States) (2016) *The World Factbook-India*. Available at: *https://www.cia.gov/library/publications/resources/the-world-factbook/geos/in.html.*

DAHD&F (Department of Animal Husbandry, Dairy and Fisheries) (2014) *Handbook of Fisheries Statistics-2014*. Ministry of Agriculture, Government of India, New Delhi.

Dey, Madan M., U-Primo Rodriguez, Roehlano M. Briones, Chen Oai Li, Muhammad Sirajul Haque, Luping Li, Kumar, Praduman, Sonny Koeshendrajana, Tai Shzee Yew, Athula Senaratne, Ayut Nissapa, Nguyen Tri Khiem and Ahmed, Mahfuz (2004) *Disaggregated Projections on Supply, Demand, and Trade for Developing Asia: Preliminary Results from The Asiafish Model.* IIFET 2004 Japan Proceedings.

FAO (Food and Agriculture Organization of United Nations) (2011) *Biodiversity for Food and Agriculture Contributing to Food Security and Sustainability in a Changing World*. Outcomes of an Expert Workshop held by FAO and the Platform on Agrobiodiversity Research in Rome, Italy. 14-16 April, 2010.

FAO/WHO (Food and Agriculture Organization of the United Nations, Geneva; World Health Organization) (2011) *Report of the Joint FAO/WHO Expert Consultation on the Risks and Benefits of Fish Consumption*. Rome. 50 p.

Gopal Rao, K. (2010) *Present Status of Pangasius, Pangasianodon hypophthalmus (Sauvage) Farming in Andhra Pradesh, India*. A comprehensive study report, submitted to the National Fisheries Development Board (NFDB), Hyderabad. 41 p.

Gopalan, C., Rama Sastri, B.V. and Balasubramanian, S.C. (2004) *Nutritive Value of Indian Foods*. National Institute of Nutrition, ICMR, Hyderabad.

Kumar, Praduman, Dey, Madan M. and Paraguas, Ferdinand J. (2005) Demand for fish by species in India: Three stage budgeting framework. *Agricultural Economics Research Review*, **18**: 167-186.

Mittal, Surabhi (2006) *Structural Shift in Demand for Food: Projections for 2020*. Working Paper No. 184. Indian Council for Research on International Economic Relations, New Delhi.

Mozaffarian, D. and Rimm, E.B. (2006) Fish intake, contaminants, and human health—Evaluating the risks and the benefits. *Journal of the American Medical Association*, **296**(15): 1885-1899.

NSSO (National Sample Survey Organization) (1996) *Nutritional Intake in India*. NSS 50th Round. July 1993 - June 1994. Report No. 405. Fifth quinquennial survey on consumer expenditure. Department of Statistics and Programme Implementation. Government of India, New Delhi.

NSSO (National Sample Survey Organization) (2001) *Nutritional Intake in India*. NSS 55th Round. July 1999-June 2000. Ministry of Statistics and Programme Implementation. Government of India, New Delhi.

NSSO (National Sample Survey Organization) (2007) *Nutritional Intake in India*. NSS 61st Round. July 2004-June 2005. Report No. 513. Ministry of Statistics & Programme Implementation. Government of India, New Delhi.

NSSO (National Sample Survey Organization) (2014) *Nutritional Intake in India, 2011-12*. NSS 68th Round. July 2011–June 2012. Report No. 560. Ministry of Statistics and Programme Implementation, Government of India, New Delhi.

Sugunan, V.V. and Sinha, M. (2001) Sustainable capture and culture based fisheries in fresh waters of India. In: *Sustainable Indian Fisheries*, edited by T. J. Pandian. National Academy of Agricultural Sciences, New Delhi. pp. 43-70.

Thilsted, S.H. (2013) Fish diversity and fish consumption in Bangladesh- Case 4. In: *Diversifying Food and Diets Using Agricultural Biodiversity to Improve Nutrition and Health- Issues in Agricultural Biodiversity*, edited by Jessica Fanzo, Danny Hunter, Teresa Borelli and Federico Mattei. Biodiversity International and Routledge.

Toppe, J., Bondad-Reantaso, M.G., Hasan, M.R., Josupeit, H., Subasinghe, R.P., Halwart, M. and James, D. (2012) Aquatic biodiversity for sustainable diets: The role of aquatic foods in food and nutrition security. In: *Sustainable Diets and Biodiversity*, edited by B. Burlingame and S. Dernini. FAO and Bioversity International, Rome. pp. 94-101.

WHO (World Health Organization) (2002) *Protein and Amino Acid Requirements in Human Nutrition*. Report of a joint FAO/WHO/UNU expert consultation on Protein and Amino Acid Requirements in Human Nutrition. WHO technical report series- 935. Geneva, Switzerland.