INTERNATIONAL JOURNAL OF RESEARCH IN COMMERCE, ECONOMICS AND MANAGEMENT

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FUTURE NUTRITION & FOOD OF INDIA – THE AQUA-CULTURE: AN ENVIRONMENTAL MANAGEMENT & CULINARY PARADIGM PERSPECTIVE STUDY FOR A SUSTAINABLE NATIONAL STRATEGY

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ABSTRACT

Census 2011 of Indian demography is alarming, what can be the census results in 2111 A.D. that is the priority concern of the policy makers and the strategists of the country. Environment management towards a sustainable development along with the food and agricultural products with eco-friendly strategies is the clarion call of the time. Food for the growing population needs to be produced in the ample marine resources of India and technology needs adequate development to sustain the development. Future nutrition and food of India will come from the aquaculture, which will substantially replace the agriculture on the land surface. The current trend of aquaculture food is growing at a rate which is more than hundred percent per decade. High production and organic production with planned culture of aqua-food will provide future sustainability for the world's most populous country. Some prime issues are examined and in the light of the environment management and culinary paradigm perspective.

KEYWORDS
Aquaculture, Fishery, Water Pollution, Organic Production, Eco-friendly, Fish Catch, Fish Culture.

INDIA & WORLD AQUACULTURE – AN OVERVIEW

World aqua-culture production including marine plants and lives has touched 59.4 million to tonnes in 2004 in India, which value USD $ 70.3 billion, comprising nearly 50 percent of the world fish production. As per the estimates of the food and agriculture organization the fish production will reach 100 million tonnes by 2030AD. The trend indicates that aqua-culture is bound to witness expansion, diversity and intensity with modifications in the current system and practices. As per the world fish and aqua-culture production statistics, China leads the world with 41.33 million tones accounting for 69.6 percent of the world production followed by India with 2.47 million tones accounting for 4.2 percent of the world by 2005. (Sakthivel, 2007) Other producers are Philippines 1.7 million tonnes (2.5 percent), Vietnam 1.22 million tonnes (2.1 percent), Thailand 1.17 million tonnes (2.0 percent), South Korea 0.95 million tonnes (1.6 percent) and Bangladesh 0.91 million tonnes (1.5 percent) of the world production. It clearly indicates the Asian coun tries dominance in the global aqua-culture scenario.

India's contribution is mainly in carps (Rohu, Catla, Mirgal and Common Carp) and tiger shrimp. Other major lines of production such as seaweed, bivalves and sea fish with large potential await development. India is a wet country with southwest and north east monsoon rains replenish a few million hectares of water-bodies every year. These water-bodies comprising fresh water, brackish water and sea water are and "gold mines" for aquatic food production. Out of 2.41 million hectares of ponds tanks in fresh water, only 1.5 million hectares have been utilized, with average production of 2 tonnes per hectare a year in India. (Sakthivel, 2007) Only 1.5 Lakh hectares out of 2.41 million hectares of brackish water are used for shrimp production with an average of 800kg/hectare. The potential in sea water is very large.

NON-MARINE AQUACULTURE

Fresh water aqua culture is estimated at 15 million tonnes per year in India. Present national production is not more than 2.5 million tonnes. The expected growth can take place through strategic implementation of increasing productivity of pond culture from the average 2 tonnes to 5 tonnes per hectare through indigenous technology up gradation. Productivity of water reservoirs and Panchyat village tanks can be from the current production of 100 kg to 600 kg per

hectare through adequate stocking of fingerlings. Need of introduction of cage culture in reservoirs and other water-bodies in the places where suitable and consistent depths of water are available for six to eight months in a year. Scientific introduction of diversified species, such as catfish and murrels (air breathing fish) to make use of seasonal water deposits and water bodies for enhancement of fresh water aquaculture in India to provide adequate nutritive food is the prime need of the time.(Sakthivl, 2007) Poly-culture of carps with scampi in ponds and tanks to generate higher income for farmers and Panchayats. A favourable policy to support aquaculture from multiple ownership of common water bodies as well as supply of all essential inputs such as seed, feed, technology and finance will go a long way in utilizing the fresh water bodies rationally for aquaculture and unfold the true potential 15 million tones, worth INR 45,000 crores.

BRACKISH WATER & SEA BASE AQUA-CULTURE TREND

Shrimp and prawn farming dominates this sector with production of about 1.25 lakhs tones per year. Only 15 percent of the total area is utilized at present. China and South East Asia have introduced disease resistance exotic American white shrimp and stepped up production to more than one million tonnes per year. As a result, the world shrimp market is flooded with shrimp and the price has fallen drastically. The production cost of American white shrimp is almost half that of tiger shrimp and the former is amenable for intensive and super intensive system (up to 40 meter / ha in indoor culture in China) it has overtaken tiger shrimp production. There is hesitation to introduce exotic species, shrimp farmers needs support from the government to weather crisis period created by virus and sustain the huge investment (INR 10,000 crore), employment of nearly one million rural population and export earnings of more than INR 45 billion every year. Global consumption of shrimp is anticipated to increase further when the price drops.

There is a prime need for diversification. Potential species are mud crabs, Chanos, mullets, sea bass and pearl spot fishes. The technology for hatchery seed production of mud crabs and sea bass fish has been developed recently by the Central Institute of Brackish Water Aquaculture (CIBA) Chennai, the Marine Products Export Development Authority (MPEDA). The experimental culture with grow-out technology has proved the economic viability. Mudcrabs are wide spread in many parts of Indian estuaries, awaiting a major breakthrough in aquaculture production. Two candidate species (Scylla serrata and Scylla tranquebarica) have been successfully bred in the hatchery of crab seed production in Tamil Nadu recently, and supply of crab seeds to farmers for culture is expected to start shortly. Meanwhile (CIBA) has successfully developed a cost effective pellet feed for crab. Mudcrab culture is identified as one of the best alternatives for shrimp farmers who are suffering heavy financial losses due to viral disease. It is possible to produce one Lakh tones of mud-crabs worth Rupees 2,000 crores annually in India.

SEA BASS AQUACULTURE

CIBA (Central Institute of Brackish Water Aquaculture) has developed technology for hatchery seed production of sea bass for the first time in India. The cost effective pellet feed production is still in the experimental stage. This fish tolerates wide variation in environmental conditions, India holds a great potential in this area. This technology has perfected in South East Asia, so there is no reason for not starting sea bass culture in India. India is endowed with rich resources of bivalves (mussels, oysters, and clams) which remain totally untapped for aquaculture except a small quantity of mussels produced in Calicut, Kerala. These can emerge as the major source of animal protein. The resource survey done by the CMFRI has brought out a broad picture on the distribution of bivalves along the Indian coast. It is not a comprehensive survey; there are many rich unknown grounds in the inshore waters as well as in the inter-tidal zones, which has not yet been explored properly. The estuaries, back waters, costal lagoons and inter-tidal zone along the Indian coast provide enormous natural habitats for the culture of bivalves. Regular monitoring for phytoplankton, biotoxins and amnesic shell poisoning (PSP) is mandatory while planning production for human consumption. Global production of bivalves has reached 12.4 million tones. India can set up its bivalves to a limited extent, and domestic market can be developed.

SEA BASE AQUACULTURE FARMING

Indian aquaculture has to be eventually extended in to the Indian Ocean because of the population pressure and limitations of land and fresh water. Sea farming and aquaculture is popular in many South East Asian countries such as China and Japan. India is yet to make a real beginning. Aquaculture production from mariculture was 30.2 million tonnes in 2005, representing 51 percent of the global production. Marine farming of fishes in floating net cages has grown in to a multibillion-dollar industry. Marine fishes like salmon, tuna, groupers, sea bass, milkfish, sea bream, cobia, snapper, and pompano are culture in cages. Silver pomfret has been included in the list recently. Of these, sea bass, groupers, prom fret and cobia have great potential for farming in sea cages. Seaweeds occupy the second place in global aquaculture, which contributes 24 percent as per the FAO (Food and Agricultural Organisation 2006) report. Seaweeds are wonder plants of the sea and considered as the medical food of the 21st century. These are popularly called “sea vegetables” and are grown in the sallow seas by absorbing the nutrients in the sea water. These are packed with minerals and very high nutrients and food substitutes. India has richness in seaweed resources with more than 800 species. Seaweed farming and seaweed products manufacturing are emerging as a multibillion-dollar industry in the world, employing millions in the coastal areas of many countries. Sizeable natural seaweed collection is mainly in the gulf of Manner. (Sakthivel, 2007) Some manufacturers of the seaweed products attempted cultivation mainly for agarophytes (Gracilaria and Gelidiella) and didn’t succeed for various reasons. The most potential carrageenophyte like Kappaphycus alvarezii was taken up for cultivation recently. The Central Salt and Marine Chemical Research Institute (CSMCRI) under the CSIR (Council of Scientific & Industrial Research) did a lot of research on Kappaphycus alvarezii and developed the technology of cultivation. These technologies were sold to private units on a consultancy basis. Private industries are finding it difficult to get involved in direct cultivation because of heavy lease charges to the Government, they encouraged local self help groups (SHGs) to undertake seaweed cultivation by disseminating the technology through training, assisting them to obtain loan from lead banks like State Bank of India and subsidies from the Government and guaranteeing optional buyback of the produce. Local NGOs (Non Government Organisations) were involved in liaison work. Multinational companies like PEPSI have executed an agreement with SBI for an assured buyback. The department of earth science wants to undertake this scheme for the economic rehabilitation of one Lakh families of the coastal poor in India. Kappaphycus is a major source of carrageenan and bio fertilizer with numerous applications in food, chemical, pharmaceutical and several other industries, the world demand is going up. India can drive maximum benefit through bio fertilizer production to enhance the growth and yield several useful plants including rice, corn, vegetables and sugarcane.

Organic food production is the growing trend for the safest biodiversity and ecological balance of the planet earth. Aquatic food production by following the principles of organic aquaculture is emerging as the most dynamic sector today. Aqua-frames and processors have to gear up themselves to adopt organic principles in farming: Breeding aquatic animals without hormones; selection of aquatic species for culture without genetically modified organism; no use of inorganic fertilizers; criteria of fishmeal, used in feed, to be eco friendly; no synthetic pesticides and herbicides; production of aquatic species with limited stocking density; use of natural medicines; processing of aquaculture produce following organic principles; and monitoring environmental data to detect negative impact. Unpredictable viral and bacterial diseases are potential threats to aquaculture. The success in future will depend on development of biotechnology to combat disease, promote disease resistant brood stock, cost effective nutritious feed and feeding mechanisms, and live feed production to the larvae of fin fishes, pond health management and effluent treatment through “bioreactors”.

INDIA - FISH PRODUCTION & CONSUMPTION TRENDS

Fishes constitute an important and plentiful source of high quality animal protein and rich food meal. About 70 percent of the population would not mind eating fish if good-quality fish is available at a reasonable price. In India the total number of boats, dugouts, catamarans and other crafts engaged in fishing are more than 3.5 lakhs, of which 25 thousands are mechanized crafts. India has a coastline of about 6,100 km long with the inclusion of island shores it is about 7,400 km long, and the total available area for fishing, both inshore and offshore, is nearly 4800 square kms. In addition there are extensive inland water areas comprising the numerous rivers, freshwater and brackish-water lakes, reservoirs, lakes, ponds and swamps. At present the available culturable fresh water area is estimated at 1.62 million hectares. Brackish-water fish farming is nearly 2.02 million hectares. So far 0.61 million hectares of inland waters are utilized for fish farming. Per-capita consumption of fish in India is less than 9 kg per year. (Prasad, 2003) About 5.70 million hectares of water body produced 63.05 Lakh tones of fish in 2005, out of which inland water bodies produced 32.20 Lakh tones and marine water bodies produced 27.85 Lakh tones. In aquaculture, the farm holdings are small and highly dispersed. However, in terms of number, the artisanal fishers and fish farmers dominate the fishing scenario in the country.(Yadava & Mukherjee, 2007) As per the KPMG survey in 2005, there are about 1,400 fishing harbours and fish landing centers (FLC) in the main land to provide landing and berthing

facilities to the fishing fleets. Most of these centers lack the capacity to handle all the boats operating from the vicinity or the volume of the fish landings is insufficient to make them profitable for establishment of commercially viable post-harvest infrastructure. At the national level, there are about 4000 freezing plants with an aggregate freezing capacity of 7283.36 tonnes per day. While this is clearly not sufficient to cater even to the marine fish production, data shows that they are optimally utilized only during the peak season.

Fisheries are playing a key role in the changing profile of Indian economic growth. India produced 6.51 million tonnes of fish in 2006 contributing 1.04 and 5.34 percent of the total GDP and GDP from agriculture respectively. Share of inland fisheries sector to the total fish production, which was 29 percent in 1950 has gone up to 55 percent at present. The aquaculture sector showed an overwhelming growth of 468 percent during the last two decades and is presently contributing 21.6 percent by volume and 49.3 percent by value to the total fisheries products exports. While nearly five Lakh tones of fish worth over INR 7.000 crores are exported annually. The demand for fish is estimated to be around 9 million tonnes by the end of the eleventh plan. Inland fishery resources and potentials: India is blessed with huge inland fishery resources consisting of 2.36 million hectares (ha) of ponds and tanks, 1.3 million ha of bheels, jheels and derelict waters, 0.12 million kilometers of canals, 3.15 million ha of reservoirs, 45000 kilometers of rivers, 2.7 million ha of estuaries and 1.2 million ha of brackish water area that could be put to different fish culture and capture practices.

MARINE FISH ECOLOGY OF EAST & WEST COAST OF INDIA

With an extensive coast-line, fairly wide continental shelf area, rich fishing grounds surround the islands of Andaman, Nicobar and Lakshadweep and with an operational advantage over wide sectors of the Indian Ocean, India occupies a pre-eminent position in marine fish production. The marine fisheries of India comprises of varied species of fish and crustaceans, which are either under-exploited or unexploited. On an average 70 percent of the marine fish catch is landed on the west coast. A characteristic of the Indian fisheries is the dominance of pelagic and multi-pelagic fisheries. Of these two the bulk of fisheries comprise of the clupeoids, a number of species of sardines, and the Indian mackerel. While this is a general picture of the Indian fisheries, there is considerable regional variation in quality and quantity. This difference becomes quite apparent between the east and west coast of India. Although in the area of Arabian Sea is only 1.8 times that of the Bay of Bengal, the yield of fish from the former region is more than twice that of the later. Qualitatively also there are significant differences between the fisheries of the two coasts. Thus, along the west coast there is a dominance of pelagic fisheries, and large shoals of oil-sardines and mackerel are encountered only here. Even though small numbers of these form occasional fisheries on the east coast, there place seems to be taken by the less valuable clupeoids, carangids and leiognathids.

TABLE 1 – FISH CATCH COMPOSITION OF THE WEST & EAST COAST OF INDIA

Groups	Percentages	Percentages
	West Coast	*East Coast*
Clupeoids	20.8	26.6
Perches	3.0	3.3
Crustaceans	19.6	7.7
Mackerel, Seer Fishes & Cutlass Fishes	6.1	23.6
Jacks & Mullets	1.4	3.4
Elasmobranches	4.0	6.3
Flat-fishes	1.2	0.7
Tuna	1.8	1.2
Miscellaneous	42.1	27.2
Others	-	-

Source: Indian Council of Agricultural Research, 2006

Several factors contribute to this lower fish production on the east coast and to the differences in the composition of the catch along the two coasts. Although several big rivers open in to the Bay of Bengal, carrying with them large quantities of organic material and creating conditions favourable for good demersal fisheries, much of this material is presumed to be retained on the land itself because of the longer run of these rivers along the plains compared with the rivers emptying in to the Arabian Sea. Also owing to the narrow continental shelf at the mouth of the most of these rivers along the east coast much of the riverine material reaching the sea is lost to great depths. Added to these, there is an absence of large-scale upwelling which leads to the increased production of fish food in surface waters along the east coast; this is presumably the reason of the absence of shoaling fish like the oil-sardine and mackerel, mostly found in the regions coastal upwelling. (Prasad, 2003)

(I) SARDINES

Sardines are the prime constituents of our pelagic fisheries. It forms nearly 15 percent of the total marine fish landings. This group comprises a large number of species, but the oil-sardine (*Sardinella longiceps*) is the most important owing to its comparative abundance, its food value, and industrial use of its body oil. The bulk of oil sardine landings are along the Kerala and Karnataka coasts. Besides the oil sardines, there are number of allied species of commercial importance. The 'lesser sardines' particularly contribute significantly to the fishery along the east coast.

(II) MACKEREL

The Indian mackerel, Rastreliger kanagurta, is widely distributed in the tropical Indo-Pacific and constitutes another important pelagic fishery along the west coast of India. The important fish zone on the west coast extends from Ratnagiri in the north to Cape Camorin in the south. Except a few isolated ones, there is no large scale mackerel fishery on the east coast. Mackerel grows about 26 cm in length, the largest size recorded being 32 cm. in addition to Rastreliger kanagurta at least one more species, viz., Rastreliger brachysome, is known to constitute a good fishery, especially in the neighbourhood of the Anadaman Islands. A third species Rastreliger faughni has been recently reported to occur off the Chennai coast.

(III) BOMBAY DUCK

Harpodon nehereus, commonly known as Bombay duck, is a more or less localized fishery of Gujarat and Maharashtra coasts. It is also found to some extent along the west Bengal, Orissa and Coromandal coasts. The fishery over the last 20 years however has shown a declining trend even though there has been no decrease in the average size of the fish. The fish attains a maximum size of about 33 cm and is highly carnivorous. Very little of this fish is eaten in fresh condition. Almost 80 percent of the catch is sun-dried.

(IV) CRUSTACEANS

Prawns, lobsters and crabs together constitute the crustacean fishery. Of these, the prawns are the most important followed by the lobsters and the crabs. The prawn production in India is about 13.5 percent of the world production. The commercial prawn fishery is classified in to two groups, viz. the penaeids which include several large – sized marine prawns, and non-penaeids comprising mostly small sized species. *Penaeus indicus, Penaeus monodom, Metapenaeus monoceros, Metapenaeus affinis, Metapenaeus dobsoni, M. brevicornis and Parapenaeopsis stylifera* are a few of the commercially important penaeid species supporting the prawn fishery. It is now known that there are 52 species of prawns and shrimps in the Indian waters that are either currently exploited or have commercially potentialities. Within the last three decades there has been a remarkable prawn fishery.

Lobsters, as a commercial fishery, came in to prominence only in the last two decades. The fishery is prevalent at certain regions along the rocky patches of the west and east coasts, the most important being the south-west coast.

Crab fishery is under-exploited in India. About 18,000 tonnes of marine crabs were landed in 1976 mostly in southern Kerala, central Maharashtra and southern Tamil Nadu coasts. The annual catches are subject to market fluctuation. Most of the marine or brackish water crabs belong to the family Portunidae, the swimming crabs. In recent years there have been attempts to explore the deeper waters for these crustaceans. As a result, new resources of prawns and lobsters have been located. Japan and USA are the principal markets for both Indian prawns and lobster tails.

(V) TUNA

An important pelagic fishery which is very much under-exploited by India is that of tunas. The average landing of tuna in India is a little over 13,000 tonnes as against 175,000 tonnes of tunas and billfishes caught from the Indian Ocean by the Japanese. In addition to these tunas, the closely related bill fishes such as the blue marlin, the black marlin, the striped marlin, the sword fish, and the sail fish are also common in the Indian Ocean.

(VI) ELASMOBRANCHS

Elasmobranchs are the cartilaginous fishes comprising sharks, rays, dogfishes and skates. Several species of sharks and dogfishes of the genera constitute appreciable quantities of commercial catches on both the coasts. The fishery is more important along the east coast. The area where the extensive shark fishing are carried out are Kathiawar, Kanara and Kerala coasts, southern and northern sections of the east coast, and West Bengal. The important commercial use of elasmobranchs is the extraction of their liver oil which is extremely rich in vitamin A.

(VII) MOLLUSCS

Molluscs, comprising oysters, clams, mussels, squids, cuttle-fish, octopus etc., form an important resource. Their importance is not fully appreciated. Apart from being an item of food, the members of this group have mainly industrial uses. The edible oysters, mussels, clams, squid, and octopus are utilized as food. Oysters and clams can be extensively cultured; protein yields per unit area from these farms are very high. Pearl-oysters, the sacred chank, Turbo, Trochus, and widow-pane oysters are all commercially important. The pearl fisheries of the Gulf of Mannar, Palk Bay and Gulf of Kutch are well known. There is a well-established fishery of the sacred chank. It is found extensively in Palk Bay, Gulf of Mannar, Gulf of Kutch, Andaman Sea and off the coast of Trivandrum. 'Valampuri' chank, the sinistral shell, is a rarity, and it is priced high due to the belief that it wards of evil. The muscular food of the chank, which is rich in iron and copper, is eaten. There are well-organised fisheries for *Turbo* and *Trochus* in the Andamans, and for window-pane oysters in the Gulf of Kutch, Bombay harbor and its vicinity, and Corangi Bay in Andhra Pradesh. On the east coast it is found in Madras and Sonapur backwaters in Odisha. The cephalopods or the squids, cuttle-fishes octopi are generally caught in nets operated for the fishes. They are caught throughout the year. In the south eastern regions, particularly in Palk Bay and the Gulf of Mannar, there is seasonal fishery for squids.

(VIII) MISCELLANEOUS FISHERIES

Typical of tropical region, the marine fisheries of India also are composed of large numbers of groups each having a very large number of species. In addition to some of the major fisheries described above are found along the coasts of India.

TABLE 2: COMPOSITION OF CATCH OF GROUPS OF MARINE FISH IN INDIA

Groups of Marine Fish		Percentage
1.	Scianeids	6.92
2.	Anchovies and Whitebaits	3.65
3.	Ribbon – Fishes	5.26
4.	Catfishes	3.27
5.	Carangids	1.71
6.	Prom frets	2.98
7.	Leiognathids	3.76

Source : Indian Council of Agricultural Research, 2005

Deep-water trawling conducted along the west coast has revealed the existence of several fishes which could be commercially exploited. Amongst these mention may be made of the kilimeen, the butter-fish, the lizard-fish, and *Cubiceps natelensis*.

(IX) SEAWEEDS

Although the exploitation of seaweeds cannot be termed as fishery in the strict sense, seaweeds constitute an important marine resource and are found along the rocky intertidal and sub-tidal regions of the coast of India. The Sunderbans, the Chilika lake, the deltas of Godavari and Krishna, the rocky shores of Visakhapatanam, Mahabalipuram, Gulf of Mannar, Palk Bay, Gujarat coast; and around Lakshadweep, Andaman and Nicobar islands are areas rich in sea weeds. Sea weeds are used for human consumption, as cattle and poultry feed, as manure and for industrial purposes as the source of phyco-colloids like agar-agar and algin. Although except in some of the coastal districts seaweeds are not used extensively for human consumption purpose in India. Experiments on culture of some of the economically important seaweeds in coastal waters have yielded encouraging results.

INLAND FISHERIES AND AQUACULTURE OF INDIA

India has extensive inland water bodies which sustain fisheries of commercial importance. The term inland fisheries are generally used to include not only freshwater but brackish water fisheries also. The principal types are ponds, tanks, rivers, reservoirs, irrigation canals, estuaries, backwaters, and marshy swamps. These different water areas cover nearly 9.6 million hectares and with a potentiality of 9 million tonnes of fish per year.

TABLE 3: ESTIMATED COMMERCIAL SIGNIFICANCE OF FRESH WATER FISHES

Sl. No.	Group of Fishes	Percentage
1.	Carps	35.2
2.	Catfishes	32.9
3.	Live Fishes	10.0
4.	Prawns	6.5
5.	Feather-Backs	4.8
6.	Mullets	4.4
7.	Eels	0.7
8.	Herrings & Anchovies	0.6
9.	Miscellaneous	4.9

Source : Indian Council of Agricultural Research, 2005

The inland fishes can be divided in to capture fishery and culture fishery, culture fishery is more important. Capture fisheries of inland waters are generally poor and their development is expensive and time consuming. Culture fishery, on the other hand, is highly rewarding. In the recent years considerable headway has been made in this field.

A) INLAND CAPTURE FISHERIES

The significant capture fishes are those of major Carps Catla, Rohu, Calbasu, Mrigal, Barbus supplements, Cat Fishes, air-breathing fishes, Mullets, Prawns, Feather-backs, Hilsa, Bekti, etc. The yield per unit area from rivers, reservoirs of lakes is surprisingly low, being on an average of 4 to 5 kg per hectare. In spite of existence of several large systems of rivers and lakes, the country's total capture fishery resources are exceedingly small.(Prasad, 2003) The more important river systems or rivers, the Gaga river system has the richest fresh water fish and fauna of India. These includes the well-known sport fish Mahseer, the Gangetic carps, Hilsa and several other species of commercial importancs. The Brahamputra river system on the other hand has several species of carps, catfishes, air-fishes and Hilsa. Parts of the Indus river system of India has carps, catfishes and in addition the exotic rainbow and trouts. The trout streams of Kashmir very rich and attract sport-fish enthusiasts. The Mahanadi, the Godavari, the Krishna and the Cauvery rivers also have several species of carps, catfishes and prawns. There ar some Masheer, Murrels and Perches are found in the Narmada and Tapti rivers.

Macrobracium species are important fresh water prawn fishery. The giant fresh water prawn is the most important member of the genus. Giant fresh water prawns have shown decline in the last few years. Pollution in rivers and indiscriminate fishing results in destruction of young prawns. There are possibilities in culturing them and some encouraging results have been achieved in this direction in Mahanadi river system.

Hilsa is marine species which ascends rivers for spawning purposes (Anadromous fish) and fishery is mostly based on this extensive spawning migration. The main fishery is after the monsoon rains. River Padma of the Ganges part in Bangladesh has the record catch of Hilsa and exports too.

Estuaries are part of the river systems. These are extremely interesting areas in the environmental conditions are in a state of flux and the fauna is the combination of fresh water and salt water species which can tolerate considerable variations in salinity. Amongst the various groups constituting estuarine fisheries mention may be made of the clupeoids, mullets, catfishes, sciaenids, polynemids, perches, prawns, leiognathids, soles, oysters, and mussels. Estuaries also offer scopes for culture fisheries and are highly productive. Experiments in the Lake Chilika in Odisha have yielded high production of culture tiger prawns and other species.

B) CULTURE FISHES OF INLAND WATERS

India has several reservoirs and lakes but on an average the production from these does not exceed 5 to 8 kg per hectare per year. The reservoirs and lakes offer ample scope for both capture and culture fisheries. The culture of major carps, especially in West Bengal, Odisha and Bihar, has been in vogue for centuries. The average fish production from pond culture in India has been about 600 kg per hectare per year against yields exceeding 5,000 kg per hectare per year reported by fish culturist in some of the South East Asian countries. Air breathing fishes or 'live fishes', which the carp culturist would like to eradicate from the fish farms because of their predatory habits, are extremely popular in certain states and culture of these offers considerable scope. People of Bihar, Karnataka, Andhra Pradesh and Assam prefer these live fishes to carps. There are extensive marshy or swampy areas in the country which are not suitable for culture of carps but exceedingly well for culture but exceedingly well suited for culture of these air-breathing fishes. Attempts are being made to evolve technologies for the culture of fresh water prawns. Results so far achieved have indicated the possibility of large scale culture of these prawns. Success has also been achieved in breeding them under controlled conditions. For further intensification of research in freshwater fish culture systems a Freshwater Aquaculture Research and Training Center (FARTC) was established at Dhauli, Odisha.

C) FISH-SEED PRODUCTION IN INDIA

The prime important and perhaps the most limiting factor in fish culture operations is the non-availability of pure fish seed. It is estimated that for the adequate stocking of the various water sheds the fish seed requirements will be over 9,500 million. The present production is only 4,500 million. It would not be possible to this wide gap by intensifying the collection of fish seed from natural sources alone; further, the major carps do not breed in confined waters. Fish seed for stocking purposes are generally collected from river systems where the fishes naturally breed during the monsoon months. To bridge the gap between the demand and supply of quality fish seed the Government of India has proposed to establish 5 fish hatcheries one each in Uttar Pradesh, Bihar, West Bengal, Odisha and Madhya Pradesh. Induced spawning has been extended to exotic varieties such as silver carps and grass carps, and this is being done on a limited scale in a few states.

D) FISH CULTURE IN INDIAN PADDY FIELDS

Growing fish in tropical waters is rapid. By selecting the right species, adjusting their size and density at stocking, maintaining an optimum level of nutrients, and providing other satisfactory environmental conditions like adequate water, it is possible to raise a fish crop of marketable size from the paddy fields by the time the paddy is harvested. Organized paddy cum fish culture is non-existent in India, although these have been tried in several places. The reasons for these are the increasing use of inorganic fertilizers and insecticides in paddy fields because of low water levels.

E) FROG CULTURE IN INDIA

Recently there has been an increasing demand from European countries for frog legs. Recognizing these demands from foreign markets, Indian entrepreneurs started exporting frog legs. To protect the natural resources and at the same time provide adequate raw material for a continued and steady export trade in frog legs, efforts are being made to culture different commercially important species of frogs. This effort is quite rewarding and, in addition frog cum fish culture is being attempted. Rana Tigrina and Rana Hexadactyla are the two most common species commercially exploited.

F) FIELD PROBLEMS IN INDIAN FISH CULTURE

A very serious menace, which has been the bane of fish farmers, is the aquatic weeds. Weeds, whether submerged, emergent or floating, are detrimental to fish production in fishery waters because the natural fertility will be used by the unwanted vegetation and to that extent fish yields will be reduced. Further, fishing is difficult in weed-choked waters. To obtain maximum yield it is necessary to clear the area of all weeds. Chemicals such as copper sulphate, ammonia and 2-4D compounds are found to be quite effective in controlling weeds. Mechanical devices like de-weeding machines have been found quite effective. In the design and construction of composite fish farms including hatcheries, nurseries, stocking ponds, etc. there are several engineering problems which require closer study as many of these are location specific.

WATER POLLUTION IMPACT ON AQUACULTURE

Water pollution as affects fish is of greater consequences these days, particularly in fresh waters. Verities of insecticides, and industrial effluents, in addition to domestic sewage, find their way in to many of the rivers and pose a major threat for fisheries. The magnitude of pollution varies with the size of the rivers, flow of water, etc. which determine their capacity for receiving these pollutants and dispersing them. To cite some examples, the paper mills located on the banks of the Ibb River in Odisha consume nearly 270 million liters of water per day. This drawl of water together with the discharge of high toxic effluents causes considerable harm to the fisheries for a stretch of 24 km downstream. The industrial discharge let in to the Kulu River from a large number of different industries located in Kalyan-Bombay sector pollute the water to such an extent that the river which was once well known for the ascent of Hilsa is now completely devoid of this fishery. Detailed investigations in respect of effluents of paper-pulp, textiles, tannery, sugar, distillery, coal washery, cycle rim and Vanaspati factories have shown that these effluents have adverse effects on fisheries. Similarly, effects of sewage have shown that in certain places a large part of the area of discharge has become a septic zone uninhabitated by fish. While sewage can cause extensive damage to fisheries, treated sewage can be used for fish culture as it functions as a fertilizer for fish farms. Although not prevalent at present, a potential source of pollution is the atomic reactor wastes. Marine pollution is assuming greater importance. Instances of large scale occurrences of tar balls along the west and east coast, oil spills, etc. are on the increase. Research on the various aspects of marine pollution is being carried out by more than one agency but these are limited to isolated and local problems. Different agencies are also carrying out periodical monitoring studies at selected centers. The seriousness of the awareness of the problem of pollution has led to introduction of bills for the prevention of water pollution for setting up of Central and State Prevention of Water Pollution Boards. To protected the environment as a whole and to maintain a healthy environment a separate department of Environment has been created in the Government of India. Environmental damage through accidents, such as an oil spill, may cause the closing of a fishery. As opposed to sudden natural disasters, other hazards build up over time. Outbreaks of disease and other threats to farmed fish in particular cause production losses. (Yadava & Ayyappan, 2011)

NUTRITIVE VALUE OF AQUACULTURE FOOD

Chemical compositions of the marine animals come fairly close to land animals, and principal constituents are water (66 to 84 percent), protein (15 to 24 percent), lipids (0.1 to 22 percent), and minerals (0.8 to 2 percent). Fish in the strict sense contains only minute quantities of sugar, and the amount of glycogen in the flesh of bony fishes is much lower than that of meat except in the case of certain mollusks which contain appreciable quantity of glycogen. (ICAR, 2011) The amount of protein in fish is influenced by the fat and the water contents, and there is an inverse relationship between the fat and the protein contents of the edible part of the same fish. The fish proteins from different species seem to vary insignificantly and this applies to such major groups as bony fishes, cartilaginous fishes, and marine and fresh water fishes.(Prasad, 2003) Fish also contains a large number of minerals, only few of these have been studied in detail.

TABLE 4: COMPOSITIONS OF SEA FOOD EDIBLE PARTS

Sl. No.	Category Sea Food	Water (%)	Protein (%)	Lipid (%)	Ash (%)
1	Fat Fish	68.6	20	10	1.4
2	Semi-Fat Fish	77.2	19	2.5	1.3
3	Lean Fish	81.8	16.4	0.5	1.3
4	Crustaceans	76.0	17.8	2.1	2.1
5	Molluscs	81.0	13	1.5	1.6

Source: Indian Council of Agricultural Research (2006).

TABLE 5: MINERALS IN FISH FLESH (MG PER 100 GRAMS OF FLESH)

Sl. No.	Elements in Fish Flesh	Range	Average
1	Sulphur	100-300	200
2	Chlorine	60-250	100
3	Sodium	30-150	60
4	Potassium	250-500	400
5	Phosphorus	100-400	220
6	Calcium	5-200	30
7	Magnesium	10-60	30
8	Iron	0-475	1
9	Copper	0.04-0.6	0.25
10	Iodine	0.01-0.5	0.17
11	Fluorine	0.5-1.0	-
12	Manganese	0.01-0.05	0.025
13	Zinc	0.7-3.0	-
14	Lead	0.005-0.02	-

Source: Indian Council of Agricultural Research (2010)

Aqua-food is one of the best sources of animal protein, and is adequate as principal sources of dietary protein. Inadequate intake of proteins which fail to provide the essential amino-acids is a significant factor in human malnutrition. The recognition that fish has excellent nutritional properties makes it an important category of food. (Prasad, 2003), (Ayyappan & Krishnan, 2007)

MAL-EFFECTS OF HI-TECH FISH CULTURE

High tech aquaculture and animal food culture are made by antibiotic shots, being used at will to make shrimps bigger will be regulated soon. For the first time the National Policy for Containment of Antimicrobial Resistance has put a cap on how much antibiotics can be pumped in to sea food products, including shrimps and prawns or fish and fishery products. The policy has named common antibiotics like tetracycline, oxytetracycline, trimethroprim and oxolinic acid and clearly defined that it shall not exceed the prescribed tolerance limit. The use of over 20 antibiotics or pharmacologically active substances has been prohibited in sea food and poultry products. The measure is initiated to prevent such fish and meat to enter the food chain and lead to the emergence of antibiotic resistance in human who eat it.

HOUSEHOLD FISH CONSUMPTION PATTERN IN INDIA – A GROWING TREND

India's population in the last four censuses 1981, 1991, 2001.2011 are alarming with the rapid growth which is beyond control. In the next census we are likely to cross the China and will be recorded as the world's most populous country. Enormous problems are gripping our national growth, in which malnutrition and sustainable food strategies are going to be the prime concerns of the policy makers. Hi-tech productions in staple food and other nutritive animal proteins have raised the issues of infertility in future that we have experienced in the fatality of the 'Green Revolution' in north India. Organic means are the eco friendly solutions of the mankind without any doubts. Protein sources are likely to be the major food of the population in the near future. Shelter and settlements are diminishing the productive agriculture land in the country by converting in to the concrete jungles. Strategically, India has a large and sizeable sea and ocean resource to use in future for the food production ground of its huge population. No wonder we will be harvesting the stale food in the sea bed in near future through technology revolution.

However the fish consumption in India is asymmetrical. As per the 61st round of NSS (National Sample Survey) data on food consumption, at the national level only 28 percent households consume fish. This is high in eastern (65 percent) and southern (47 percent) regions, but low in western (20 percent) and northern (4 percent) India. The existing fish markets in the country command a value of INR 27,104 lakhs per month as per 2004-05 prices (annually about 813 million US$). About 600 Lakh families consume fish in India on a regular basis. At the national level monthly per capita consumption of fish is estimated at 204 grams. Among the major states, Kerala has the highest monthly per capita fish consumption 1.913 kg), followed by West Bengal (0.768 kg) and Assam (0.631 kg). In terms of value at the all India level the monthly per capita value of fish consumption is INR 8. 50. Among the states, Kerala again has the highest value (INR 47.78), followed by Assam (INR 41.88) and West Bengal (INR 39.12). (Yadava, 2007)

The aquaculture sector has showed an overwhelming growth of 468 percent during the last two decades and is presently contributing 21.6 percent by volume and 49.3 percent by value to the total fisheries products exports. Inland fisheries consistently recorded a growth of over 5 percent per annum over the period of 1991 – 2005. (Ayyappan & Krishnan, 2007)

According to NSSO estimates, a 'silent revolution' is under way and consumption of meat, eggs and fish has increased 100 percent. The size of Indian urban food market is estimated INR 350, 000 crores, the changing demographic profile of the country with a third of its population under 14 years of age, the rise in the number of working women and change in their lifestyle, besides the growing number of consumers with an outlook on value-for-money spending is expected to propel growth of the organized retail houses. The consumption pattern of the population exposed to a variety of fish and fish products is expected to change and lead to increased consumption levels in India too and thus impact the growth of inland fisheries, as happening in other parts of the world.

FUTURE SCOPE & PROSPECTS

The declaration by the Government of India of an Exclusive Economic Zone of 320 km in 1976 has added nearly 2 million square kms of water area for exploitation, management and conservation of the living and nonliving resources . The information of the location of the trawling grounds off the east coast is rather patchy. Good fishing grounds have been located off the coast of West Bengal, the mouth of River Mahanadi, Paradip, Puri, Visakhapatanam, the mouth of River Godavari, Pulicat, Ennore, Chennai, Sadras, Pondicherry, Cuddalore, Tranquebar, Nagapattinam, Point Calimere, Adirampattinam, Rameswaram, Pamban and Tuticorin. The continental shelf along the west coast is relatively broad and offers good grounds for trawling. On the other hand the slelf along the east coast is somewhat narrow except in certain regions where, especially near the openings of the major rivers, the shelf is not as suitable for trawling as that of west coast. Not only an adequate and strong infrastructure development but also an integrated and coordinated approach by the various national fisheries and allied research, training and developmental agencies in order to ensure the best use of the finances, man-power and other facilities to obtain the maximum sustainable yield. India undoubtedly will bank on to its marine resources and aquaculture for the future food and nutrition of the country. Scientific sustainable management of the environment aquaculture will sustain India's growth.

TABLE 6: STATE-WISE FISH PRODUCTION IN INDIA (2008-09) (P)

States & Union Territories	Marine Fish	Inland Fish	In 000' Tonnes (Total)
Andhra Pradesh	291159	961618	1252777
Arunachal Pradesh	0	2880	2880
Assam	0	206150	206150
Bihar	0	300650	300650
Goa	82950	2284	85234
Gujarat	623055	142847	765902
Jammu & Kashmir	0	19270	19270
Karnataka	218137	143005	361142
Kerala	583579	82574	666153
Madhya Pradesh	0	68466	68466
Maharashtra	395963	127138	523101
Manipur	0	18800	18800
Meghalaya	0	3959	3959
Mizoram	0	3760	3760
Nagaland	0	6175	6175
Odisha	135486	235973	371459
Punjab	0	104770	104770
Rajasthan	0	25700	25700
Sikkim	0	168	168
Tamil Nadu	365280	168885	534165
Tripura	0	36000	36000
Uttar Pradesh	0	349274	349274
West Bengal	186789	1323123	1509912
Andaman & N. Islands	32785	167	32952
Chandigarh	0	244	244
Dadra N. Haveli	0	48	48
Daman & Diu	14060	81	14141
Delhi	0	511	511
Lakshadweep	11586	0	11586
Pondicherry	36550	3306	39856
Chattisgarh	0	158699	158699
Uttrakhand	0	3163	3163
Jharkhand	0	75816	75816
Haryana	0	76285	76285
Himachal Pradesh	0	7793	7793
Total	**2977379**	**4659582**	**7636961**
P. = Provisional			

Source: Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, GOI, (2011).

TABLE 7: FISH PRODUCTION IN INDIA

Year	Marine	Inland	Total (Lakh Tonnes)
1950-51	5.34	2.18	7.52
1960-61	8.80	2.80	11.60
1970-71	10.86	6.70	17.46
1980-81	15.55	8.87	24.42
1990-91	23.00	15.36	38.36
2000-01	28.11	28.45	56.56
2001-02	28.30	31.26	59.56
2002-03	29.90	32.10	62.00
2003-04	29.41	34.58	63.99
2004-05	27.79	35.25	63.05
2005-06	28.16	37.56	65.72
2006-07	30.24	38.45	68.69
2007-08	29.19	42.07	71.26
2008-09 (P)	29.77	46.60	76.37
(P) Provisional			

Source: Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture, Government of India, (2011).

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