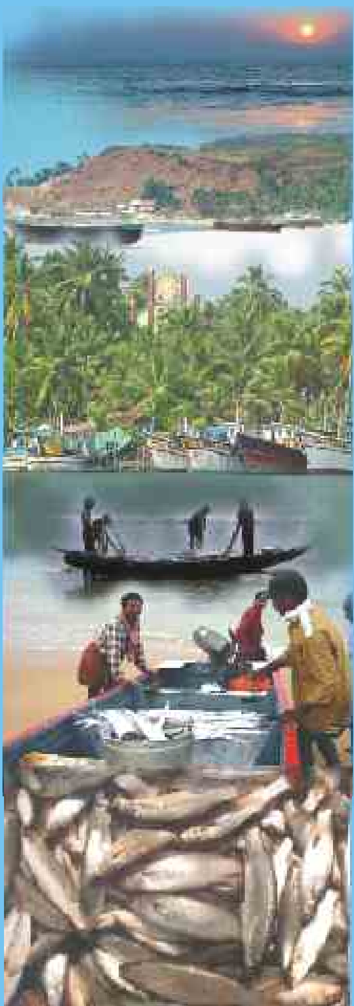
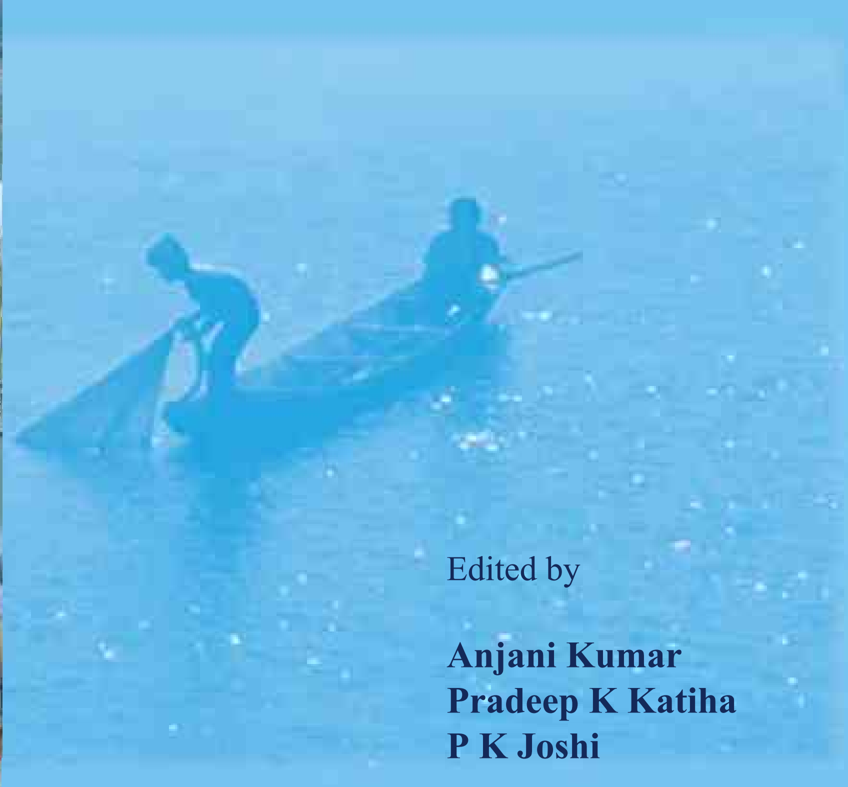
(Workshop Proceedings)

A Profile of People, Technologies and Policies in Fisheries Sector in India





Edited by

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NATIONAL CENTRE FOR AGRICULTURAL ECONOMICS AND POLICY RESEARCH
NEW DELHI, INDIA

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Edited by
Anjani Kumar, Pradeep K Katiha and P K Joshi

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Contents

Foreword

Fisheries is a sunrise sector of our economy. Its role in increasing food supply, generating job opportunities, raising nutritional level and earning foreign exchange has been important. Growing urbanization, globalization, rapidly changing social structures had a major impact on the fisheries structure in the country. Fisheries and aquaculture emerged as the important commercial activity from its traditional role as subsistence supplementary activity.

This publication stems from a workshop held on May 1, 2002 at National Centre for Agricultural Economics and Policy Research, New Delhi. This was the launching workshop of ADB sponsored project on "Strategies and options for increasing and sustaining fisheries and aquaculture production to benefit poor households in Asia" in which India is one of the partners. The workshop brought together selected key researchers, research managers and policy makers from across the country. The publication provides an overview of socioeconomic profile of stakeholders (fishermen/women), fishing and aquaculture technologies, demand and expected supply, policies, institutions and support systems. I hope this volume would be very helpful to policy makers, research managers and others to understand and plan fisheries sector better.

Mruthyunjaya
Director
National Centre for Agricultural
Economics and Policy Research

March
New Delhi

Preface

Fisheries sector in India has witnessed an impressive growth from a subsistence traditional activity to a well developed commercial and diversified enterprise. The fisheries sector has been playing an important role in the Indian economy by its contributions to employment generation, income augmentation, foreign exchange earnings, providing food and nutrition security. Over the last two decades, fisheries issues have emerged from being merely an obscure sectoral concern to an important growth sector with an expanding role in economic development and food security. In recent years, it has emerged as a vibrant sector and is being considered as a strategic sub-sector for promoting agricultural diversification. However, information regarding the development process of this important activity is very sketchy, scattered and not well documented. In this backdrop the National Centre for Agricultural Economics and Policy Research organized a national workshop on ***A Profile of People, Technologies and Policies in Fisheries Sector in India.*** This was sponsored by the ADB under the ICAR-ICLARM project on ***Strategies and Options for Increasing and Sustaining Fisheries and Aquaculture Production to Benefit Poor Households in Asia.*** The present volume tries to document the technological profiles of fisheries and aquaculture, socioeconomic features of different stakeholders, emerging demand and expected supply of fish production, policies, programmes, institutions and support system to promote fisheries and aquaculture production in the country.

Since the contributed papers of this volume were presented and discussed at the above workshop, we were immensely benefited from the comments and views of the participants. We are grateful to Dr. Gopakumar, Dr. Dayanatha Jha, Dr. S Ayyappan, Dr. Mruthyunjaya and Dr. P K Joshi for providing able guidance and invaluable insights. We are also grateful to all the chairpersons, discussants and participants for their significant technical contributions. Authors of the contributed papers deserve special thanks for acceding to our request to contribute papers, revising them and responding to numerous editorial queries.

We have also benefited from suggestions and input provided by Dr. Mahfuzuddin Ahmed and Dr. Madan Mohan Dey from the World Fish

Centre in planning the workshop. Our colleagues at NCAP extended all help in organizing the workshop. Mr. Badruddin and Mr. S. Aravazhi deserve special thanks for assisting us in bringing out this publication. Financial support for organizing the workshop was provided by the above project and the National Centre for Agricultural Economics and Policy Research met the expenditure on publication of this volume. Financial support for both the activities is gratefully acknowledged. We hope that this publication will fill in an important void in fisheries literature in the country.

Editors

Acronyms

AFDC	Assam Fisheries Development Corporation
AgGDP	Agricultural Gross Domestic Product
BFDAs	Brackishwater Fish Farmers Development Agencies
BOBP	Bay of Bengal Programme
CIFA	Central Institute of Freshwater Aquaculture
CIFRI	Central Inland Fisheries Research Institute
CITES	Convention on International Trade in Endangered Species
CMFRI	Central Marine Fisheries Research Institute
CPUE	Catch Per Unit Effort
DANIDA	Danish International Development Agency
DBT	Department of Biotechnology
DOD	Department of Ocean Development
DSFP	Deep Sea Fishing Policy
DST	Department of Science and Technology
EEZ	Exclusive Economic Zone
EIA	Environemental Impact Assessment
EMMP	Environmental Monitoring and Management Programme
FARTC	Freshwater Aquaculture Research and Training Centre
FFDA	Fish Farmers Development Agency
FISHFED	Assam Apex Co-operative Fish Marketing and Processing Federation Limited
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GOI	Government of India
HACCP	Hazard Analysis and Critical Control Point
HYVs	High Yielding Varieties
ICAR	Indian Council of Agricultural Research
IDBI	Industrial Development Bank of India
IFCI	Industrial Finance Corporation of India
IIM	Indian Institute of Management
IIT	Indian Institute of Technology
INP	Indo- Norwegian Project
IPOC	In Process Quality Control
IVLP	Institution Village Linkage Programme
MFRA	Marine Fisheries Regulation Acts
MOC	Mahua Oil Cake

MPEDA	Marine Products Export Development Authority
NABARD	National Bank for Agriculture and Rural Development
NARS	National Agricultural Research System
NCDC	National Co-operative Development Corporation
NGO	Non-government Organization
NORAD	Norwegian Agency for Development and Co-operation
ODA	Overseas Development Assistance
OGL	Open General License
PGE	Pituitary Gland Extract
QRS	Quantitative Restrictions
SAUs	State Agriculture Universities
SCICI	Shipping Credit and Investment Company of India
SFC	State Finance Corporation
TRAFFIC	Trade Record Analysis of Flora and Fauna in Commerce
TRIMS	Trade Related Investment Measures
TRIPS	Trade Related Intellectual Property Rights
UAE	United Arab Emirates
UGC	University Grants Commission
UNDP	United Nations Development Programme
WTO	World Trade Organization

1

Fisheries Sector in India: An Overview of Performance, Policies and Programmes

Anjani Kumar, P K Joshi and Pratap S Birthal

Fishing as an occupation has been in vogue since time immemorial. Till recently it was reckoned to be a supplementary enterprise practised by fishermen community on subsistence level with little external input (Krishnan *et al* 2000). But with the changing consumption pattern, emerging market forces and technological developments, fisheries sector in India is undergoing a transformation.

India's Share in World Fish Production

Fish production in India has touched 5.6 million tonnes in 1999-2000. It was a mere 0.75 million tonne in 1950-51. The world production during the same period has gone up from 23.5 million tonnes to around 120 million tonnes in 1999-2000. The trend of fish production in India as compared to the world production during the last 50 years is given in Table 1. The share of India in

Table 1. Fish production in India and world during last 50 years

Year	World (million tonnes)	India (million tonnes)	India's share (%)
1950-51	23.50	0.75	3.19
1960-61	43.60	1.16	2.66
1970-71	66.20	1.76	2.66
1980-81	72.30	2.44	3.37
1985-86	85.60	2.88	3.36
1990-91	97.97	3.84	3.92
1999-00	120.00	5.66	4.72

Source: Hand Book on Fisheries Statistics (2000), Ministry of Agriculture, Government of India.

global fish production has grown gradually from about 2.6 per cent in 1960s and 1970s to 4.7 per cent in 1999-2000. Thus, compared to growth in global fish production, the growth in India has been at a faster rate, mainly due to increasing contribution from inland fish production.

Growth of Fisheries Sector in India

Fisheries sector plays an important role in the Indian economy. It contributes to the national income, exports, food and nutritional security and in employment generation. This sector is also a principal source of livelihood for a large section of economically underprivileged population of the country, especially in the coastal areas. Share of agriculture and allied activities in the GDP is constantly declining. It has been observed that agriculture sector is gradually diversifying towards high value enterprises including fisheries. It is evident from the contribution of fisheries sector to the GDP, which has gone up from 0.46 per cent in 1950-51 to 1.16 per cent in 1999-00 (at current prices) (Table 2). The share of fisheries in Agricultural GDP (Ag.GDP) has increased more impressively during this period from mere 0.84 per cent to 4.19 per cent. This is largely due to a sustained annual growth rate of well over four per cent in the fisheries GDP during the last five decades. The fisheries sector has recorded faster growth as compared to the agricultural sector in all the decades. The growing production of fish suggests that fisheries sector is booming and contributing to the economic growth of the nation. More than 6 million fishermen and fish farmers are totally dependent on fisheries for their livelihood in India.

Table 2. Contribution and growth of fisheries sector in India

Period	Percent contribution to		Percent annual growth	
	GDP	AgGDP	Fisheris GDP	AgGDP
1950-51	0.46	0.84		
1960-61	0.54	1.18	5.63	2.68
1970-71	0.61	1.37	3.92	1.50
1980-81	0.73	1.98	2.86	1.72
1990-91	0.93	3.00	5.11	2.89
1999-00	1.16	4.19	4.75	3.12

Source: National Accounts Statistics, Central Statistical Organisation, Government of India.

Fish Production: Structure and Trend

The fisheries production in India during 1950s was more pronounced in the marine fisheries and it remained the major contributor till early 1990s (Table 3). Its share in the total fish production was more than 70 per cent in 1960s, but thereafter it started declining and came down to about 62 per cent in 1970s and to 59 per cent in 1980s. In the mid-nineties, the fisheries production witnessed a significant change. The share of inland fish production became almost half of the total fish production in 2000. It seems that marine fisheries production has reached a plateau and at best, it can register only a marginal increase in the near future. On the other hand, inland fish production was on constant rise and its share rose to 38 per cent in 1970s to 41 per cent in 1980s and jumped to over 45 per cent in 1990s. This rise in inland fish production is attributed to the development of aquaculture in our country.

Table 3. Changes in the structure of fish production in India

(in million tonnes)

Year	Marine	Inland	Total
1950-51	0.53 (71.01)	0.22 (28.99)	0.75
1960-61	0.88 (75.86)	0.28 (24.14)	1.16
1970-71	1.09 (61.85)	0.67 (38.15)	1.76
1980-81	1.5 (59.12)	0.89 (40.88)	2.44
1990-91	2.30 (59.96)	1.54 (40.04)	3.84
1995-96	2.71 (54.70)	2.24 (45.30)	4.95
1999-00	2.83 (50.09)	2.82 (49.91)	5.66

Figures in parentheses indicate percentage to total

Source: Hand Book on Fisheries Statistics (2000), Ministry of Agriculture, Government of India.

The growth trends in fisheries production in India during 1980-81 to 1999-00 is given in Table 4. Since 1980-81 fisheries production in India has been increasing at a rate of 5.12 per cent per year. The inland sector has shown a better performance with an annual growth rate of 6.22 per cent. A disaggregated view of the pattern of growth shows that growth in inland fisheries production has accentuated in the 1990s while marine fish production witnessed deceleration. The latter slowed down from 3.73 per cent in the 1980s to 2 per cent in the 1990s. The share of culture fisheries in both freshwater as well as brackish water in the inland sector has increased tremendously in recent years. Its share has risen from 43 per cent in 1984-85 to about 84 per cent in 1994-95. Within the culture fisheries, the major contributor has been the freshwater aquaculture (Krishnan et al 2000). The policy for fisheries development has also been given a tilt towards inland fisheries particularly aquaculture in recent years.

Table 4. Growth trend in fish production in India.

Source of fisheries	Annual Compound Growth rate during different periods (%)		
	1980-81 to 1989-90	1990-91 to 1999-00	1980-81 to 1999-00
Marine	3.73	2.01	4.23
Inland	5.14	6.34	6.22
Total	4.30	4.03	5.12

Source: Hand Book on Fisheries Statistics (2000), Ministry of Agriculture, Government of India.

Exports of Fish and Fish Products

There has been a considerable increase both in the quantum and value of export of fish and fish products since 1960-61. In 1960-61, 0.02 million tonnes worth US $ 10 million were exported (Table 5). It increased to 0.39 million tonnes (about 20 times) worth US $ 1180 million (more than 100 times) in 1999-00. The share of fish and fish products in total exports has increased from 0.74 per cent in 1960-61 to more than 3 per cent in 1999-00.

Table 5. Development of India's exports of fisheries products

Year	Quantity (000 tonnes)	Value (million US $)	% Share in	
			Ag Export	Total export
1960-61	19.9	10	1.68	0.74
1970-71	32.6	40	6.21	1.97
1980-81	69.4	274	10.53	3.23
1990-91	158.9	535	15.19	2.95
1995-96	310.1	1011	16.00	3.18
1999-00	390.6	1180	20.81	3.14

Source: Monthly Statistics of Foreign Trade of India: Volume Exports and Re-exports (various issues), Ministry of commerce.

The share of fish and fish products in total exports was about 2 per cent in 1970-71 and thereafter it has been hovering around 3 per cent. Similarly, the contribution of fish and fish products' exports to agricultural exports also increased from 1.68 per cent in 1960-61 to about 16 per cent in 1990-91 and became about 21 per cent in 1999-00. It seems that the liberalization policies initiated in the 1990s helped the fisheries sector in attaining a higher growth in exports. Four decades ago a humble beginning was made in shrimp export and today the export basket of fisheries includes more than 60 items. Shrimp, however, remains the major item of fisheries' exports in terms of both quantity and value. In 1998-99 the share of shrimp was 26.11 per cent in quantity and 67 per cent in the value of export earnings from fisheries. The share of shrimp has declined and frozen/fresh fish has replaced the shrimp in quantity (Krishnan *et al.* 2000; Kumar *et al.* 2002).

Development Programmes/Policies for Fisheries

Outlays for Fisheries Sector

One of the indicators of development policies and programmes is the allocation of resources for this sector over different periods. The outlay for fisheries sector as per cent of outlay for the agricultural sector over the Five Year Plans has been increasing continuously (Table 6). It increased from 1.74 per cent in the First Five Year Plan to about 6 per cent in the Ninth Five

Table 6. Outlay for fisheries sector during Five Year Plans.

(Rs Crores)

Five Year Plan	Total outlay	Outlay for agricultural sector	Outlay for fisheries sector	Share of fisheries sector (%)	
				Total outlay	Agricultural outlay
First	1960	294	5.13	0.26	1.74
Second	4600	529	12.26	0.27	2.32
Third	7500	1068	28.27	0.38	2.65
Fourth	15902	2728	82.68	0.52	3.03
Fifth	39332	4302	151.24	0.38	3.52
Sixth	97500	6609	371.14	0.38	5.62
Seventh	180000	10524	546.54	0.30	5.19
Eighth	434100	22467	1232.82	0.28	5.49
Ninth	859200	37546	2069.78	0.24	5.51

Source: Hand Book on Fisheries Statistics (2000), Ministry of Agriculture, Government of India.

Year Plan. This shows that greater importance in terms of higher allocation of funds to fisheries sub-sector within agriculture has been accorded. Its share in the total outlay during different plans has been hovering between 0.26 and 0.52 per cent.

Development Programmes

The development plans for India's fisheries sector were aimed at increasing the fish production, improving the welfare of fishermen, promoting export and providing food security. The first step towards developing the fishing as an industry was made in 1898, when the then Madras Presidency was advised to strengthen the fishery so that it could fight famine. It took almost 50 years to concretize this idea. After the independence, the first All India Fisheries Conference, held in 1948 in New Delhi, decided to seek foreign co-operation to create necessary infrastructure for modernizing the fisheries sector. In 1952, a tripartite technical co-operation agreement was signed between India, the USA and the United Nations for fisheries development and a year later, the Indo-Norwegian Project (INP) in Kerala was started. From then onwards the modernization of fisheries was initiated in the coastal states in India. Several programmes have been launched for both marine and inland fishery developments in the country, some of which are briefly described below;

Programmes for Development of Inland Fisheries

In recognition of the increasing role of inland fisheries in overall fish production, the Government of India (GOI) has been implementing two important programmes in the inland freshwater sector since the Fifth/ Sixth Plans. These are the Fish Farmers' Development Agencies (FFDAs) and the National Programme for Fish Seed Development. A network of about 429 FFDAs is functioning today covering all potential districts in the country. The water area brought under the intensive fish culture through the efforts of these FFDAs was 0.46 million hectares (ha) up to 1997-98. The agencies have trained 0.6 million fish farmers in improved practices. Additionally, about 0.07 million ha area has been developed for shrimp culture. Some Brackishwater Fish Farmers Development Agencies (BFFDAs) have also been established in the coastal areas of the country; these provide a compact package of technical, financial and extension support to shrimp farmers. Under the national programme for fish seed production, more than 50 fish seed hatcheries have been commissioned. It has led to a marked improvement in the production of fish seed. Their production has increased from 409 million fry in 1973-74 to about 20000 million in 1999-2000.

Programmes for Development of Marine Fisheries

The programmes for development of marine fisheries as envisaged in different Five Year Plans include: (i) intensive surveys particularly of exclusive economic zone (EEZ), on marine fishery resource assessment, (ii) optimum exploitation of marine resources through a judicious mix of traditional country boats, mechanised boats and deep-sea fishing vessels, (iii) providing adequate landing and berthing facilities to fishing vessels by completing the ongoing construction of major and minor fishing harbours, (iv) intensifying efforts on processing, storage and transportation, (v) improving marketing particularly in the co-operative sector, and (vi) tapping the vast potential for export of marine products. During the Seventh Plan some selected villages were grouped for setting up "Fisheries Industrial Estates". The major developments include construction of 30 minor fishing harbours and 130 fish landing centres apart from five major fishing harbours viz., Cochin, Chennai, Visakhapatnam, Roychowk and Paradip. They provide landing and berthing facilities to fishing crafts. The Government also provides subsidy to poor fishermen for motorizing their traditional craft which increases the fishing area and the frequency of operation with a consequent increase in catch and earnings of fishermen. About 33,000 traditional crafts were sanctioned for motorization up to 1997-98. Improved beach landing crafts are also being supplied to groups of fishermen. A scheme of re-imbursing Central excise duty on HSD oil used in fishing vessels below 20 m length is also in operation to help the small fishermen to reduce their operational cost.

Welfare Programmes for Traditional Fishermen

There are two important programmes for the welfare of traditional fishermen: (i) Group Accident Insurance Scheme for active fishermen, and (ii) Development of Model Fishermen Village. Fishermen are insured for Rs 50,000 in case of death or permanent disability and for Rs 25,000 in case of partial disability. About 1.3 million fishermen were insured during 1998-99 under this scheme. Under the programme of Development of Model Fishermen Villages, basic amenities such as housing, drinking water and community hall are provided to fishermen. About 30,000 houses were constructed up to 1998-99 under this programme.

Programmes with International Aid

Several international organizations, including the World Bank, UNDP, DANIDA, NORAD, ODA (UK and Japan) provide aid to India for the development of fisheries sector. Under the Bay of Bengal Programme (BOBP), started in 1979, assistance is provided for the development of small-scale fisheries and enhancing the socio-economic conditions of the fishing communities. ODA (UK) has provided technical aid for the prevention of post-harvest losses in marine fisheries. Recently, FAO launched a scheme for providing technical assistance to implement Hazard Analysis Critical Control Points (HACCP) in seafood processing industries. A Shrimp and Fish Culture Project was started with the assistance of the World Bank in May 1992 and it continued for a period up to December 1999. The states of Andhra Pradesh, Bihar, Orissa, Uttar Pradesh and West Bengal were covered under this project. Six sites covering a brackish water area of 797 ha have been developed for shrimp culture operations. A total of 101 reservoirs and 22 oxbow lakes have been developed for fish culture.

Policies for Fisheries Development

At present, the fisheries sector does not have a separate policy of its own like the Science Policy, Technology Policy, Industrial Policy, Telecom Policy or the recently announced Agricultural Policy. Only a passing reference has been made in the Agricultural Policy regarding the fisheries development in the country. However, the successive Five Year Plans of India have set up some broad policies with regard to the production in the fisheries sector and investment in it. Policy makers and planners visualize fisheries as an important sector for agricultural diversification, employment generation, export promotion and food security. The main objectives of fishery development policies through different plans have been: (a) enhancing the production of fish and the productivity of fishermen and the fishing industry; (b) generating employment and higher income in fisheries sector; (c) improving the socio-economic conditions of traditional fisherfolk and fish farmers; (d) augmenting the export of marine, brackish and freshwater fin and shell-fishes and other aquatic species; (e) increasing the per capita availability and consumption of fish (present target is 11 kg per annum); (f) adopting an integrated approach to fisheries and aquaculture; and (g) conservation of aquatic resources and genetic diversity (Planning Commission, GOI). A glimpse at the strategies followed in different Five Year Plans reveals that up to third Five Year Plan the focus was mainly on enhancing the fish production with little attention on issues like marketing, storage, transportation etc. However, in subsequent Plans, measures were initiated to create more facilities for ice-clod storage, processing and canning. Moreover, in 1972, Marine Products Export Development Authority (MPEDA) was established in Cochin with branch offices in all the major centres of seafood production and export in India. It has the responsibility for the promotion and regulation of marine products export and it is the nodal agency for joint ventures in deep sea fishing. It also promotes brackish water shrimp farming. However, even after 50 years of planning, post-harvest infrastructure is grossly inadequate in India in both the marine and inland fisheries sector (Dehadrai 1996). The marketing, transportation, storage and processing of fin and shellfish are mostly handled by the private sector. This activity has witnessed a relatively slow growth and has lagged behind production trends. It is also a fact that the marine fisheries industry has given more attention towards export and adequate measures have not been made for the development of the domestic market.

Trade Policy and Prospects of Fisheries Exports

The government policies regarding imports and exports play a significant role in influencing the trade structure of a country. Trade policies are in general categorised into two broad types: (i) export promotion oriented policies, and (ii) import substitution oriented policies. In the early stages of planned development during the 1950s, Indian development strategy was heavily oriented towards import substitution. It was only during the mid-sixties that export promotion explicitly entered the policy frame (Panchmukhi, 1991). However, export orientation for the agricultural sector was not fostered effectively due to various reasons. Firstly, agricultural exports were perceived as a residual and it was generally felt that agricultural production should primarily meet the domestic demand of the Indian population. However, exports of plantation crops, such as tea and coffee, and cash crops, such as tobacco or spices, and later on fish and fish products has been an exception and important source of foreign exchange earnings. For these commodities, the open trade regime has continued from the beginning (Nayyar and Sen 1994). Under the new trade policy initiated in

1991, three major changes have been effected in agricultural trade. Firstly, the canalization of agricultural trade has been almost abandoned and the government does not determine now value or nature of the exports or imports, except for the export of onion and import of cereals, pulses and edible oils. Secondly, quantitative restrictions on agricultural trade flows have been dismantled completely w.e.f April 1, 2001. Thirdly, reductions in tariffs have been announced . The fish and fish products are exported under the open general license (OGL). As stated earlier, MPEDA is looking after the export promotion and regulation of marine products. The Export Inspection Agency was established in 1969 to ensure quality control of products for the export market. Standards for bacteria, virus, heavy metal contamination etc. are evolved in co-operation with MPEDA and the Indian Institute of Packaging.

The provisions of the World Trade Organization (WTO) include Trade Related Intellectual Property Rights (TRIPS) and the imposition of patent regime, trade related investment measures, reduction in domestic and export subsidies, market access and provision of sanitary and phyto-sanitary measures, and removal of Quantitative Restrictions (QRs) on import. Under TRIPS, the signatories of the General Agreement on Tariffs and Trade (GATT) are obliged to adopt a patent system for microorganisms. However, the patenting of higher animal life forms was left unresolved, with countries having the option to use or not to use patents to protect such intellectual property rights. Under Trade Related Investment Measures (TRIMS), countries would have to treat foreign investors at par with the domestic ones. It allows foreign fishing fleets the same access to domestic waters that local people enjoy. This provision has made a deep impact on the global fishing industry, the conservation of fisheries resources and the communities depending upon them.

As per the WTO agreement, developed countries would reduce subsidies and tariffs. Therefore, better overseas market would become available for Indian fish products. It is worth mentioning that the requirement of subsidies reduction under WTO is not applicable to India. Under the provisions of the SPS agreement, all member countries have the right to take sanitary and phyto-sanitary measures necessary for the protection of animal health or life. To challenge any possible threats under SPS measures, the Indian processing industry has to improve quality parameters by accepting Hazard Analysis Critical Control Points (HACCP), consistent with international standards. These SPS measures would provide protection to Indian industry from the policies of discrimination of developed nations and from disguised restrictions imposed on Indian fisheries exports.

The removal of Quantitative Restrictions (QRs) on the last 714 items by India on April 1, 2001, has developed an atmosphere of anxiety over the entire spectrum of Indian trade, including the fisheries sector. Fish and fish products figured prominently in the list of items on which QR was removed. Fish and fish products figured prominently (60 items) in the list of 714 items on which QR has been removed. This has raised an alarm in the fisheries sector which provides employment to 6 million people directly and indirectly. Perceptions vary among different clientele like fishermen, exporters and consumers. Apprehensions of the fish farmers include crash in prices under large scale import. The exporters are expected to benefit with a regular supply of raw material, which would help processing plants in capacity utilization even during the lean season. The consumers will, by and large be benefited by the import of foreign fish products. At the moment the different stakeholders have conflicting opinions on the removal of QRs. India being a developing country should judiciously use the tariff provision to protect the domestic industry. In the changing global economic scenario it is not possible to prevent imports totally. The only probable solution now is to focus on the changed scenario and gear up to utilize it for full benefit. Moreover, India is quite competitive in fisheries export particularly in shrimp (Kumar et al. 2002) and the WTO compulsions can be converted into opportunities by vigorously pursuing the export of fish and fish products particularly the unexplored brackish water segment. This would be in the interest of the coastal fisherfolk also.

Potential of Fisheries Development

India has abundant resources for fish production. In the case of marine fisheries, India has 0.51 million sq. km of continental shelf area and a 8041 km long coastline (Table 7). Based on the available scientific information, exploratory surveys, experimental fishing and other data available, the potential harvestable yield of the Indian economic exclusive zone (EEZ) has been estimated at 3.9 million tonnes. The highest potential (2.3 million tonnes) is in the waters up to 50 metres depth, whereas the potential in water between 50-200 metres depth is 1.3 million tonnes and beyond that only 0.3 million tonnes. The density of fish is highest about 11 tonnes per

Table 7. Fishery resources of India

Resource	Unit	Quantity
Marine		
Continental shelf	'000' sq. km	506
Landing centres	No.	2333
Coast line	Km	8041
Inland		
Rivers and canals	Million km	0.17
Reservoirs	Million ha	2.05
Tanks and ponds	Million ha	2.86
Beels, oxbow and derelict water	Million ha	0.79
Brackishwater	Million ha	1.42

Source: Hand Book on Fisheries Statistics (2000), Ministry of Agriculture, Government of India

square km in coastal areas (0-50 m). In waters beyond 50 m, it is less than 1 tonne per sq km. At the moment, most of the catches are from waters less than 50 m deep. There does not seem to be any scope for further expansion in these areas, as many of them have already been over exploited. According to fisheries experts emphasis should be laid on deeper waters and on species which have not been exploited so far like tuna and even anchovies for fishmeal production. However, expansion of fisheries activities in deep waters is highly capital intensive and the local investors have neither the will nor resources to take it up.

The inland fisheries resources include a length of 0.17 million kilometres rivers and canals, 2.05 million ha of reservoir area, 2.86 million ha area of ponds and tanks and 0.8 million ha of beels, oxbow and derelict water. The brackish water area for fish production is estimated to be 1.42 million hectare. The inland resources however, have not been tapped fully. Only about 16 per cent of the fresh water area and 10 per cent of the brackish water area are being utilized for fish culture. In the inland sector, the resource potential has been estimated to be 4.5 million tonnes, which takes into account production from both capture and culture fisheries. The productivity however, is low. The average productivity of freshwater aquaculture in 1998-99 was about 2.2 tonnes per ha, while the potential to raise yield was up to 10 tonnes per ha. The realized average productivity of brackish water aquaculture in 1998-99 was 472 kg/ha as against the potential of about 10 tonnes per ha (Krishnan *et al* 2000).

It seems that India's marine fisheries production has reached a plateau and at best, only a marginal increase is predicted in the near future. However, inland fish production has exhibited rapid growth and for all future demand, we have to rely on the inland sector, particularly on aquaculture.

Support Systems for Fisheries Development

R&D in Fisheries sector

India has a huge network of institutions to carry out R&D in fisheries sector. These include: (i) Indian Council of Agricultural Research (ICAR) systems; (ii) Ministry of Agriculture; (iii) Ministry of Commerce; (iv) Ministry of Food Processing Industries; (v) Council of Scientific and Industrial Research (CSIR); and (vi) State Agricultural Universities. Many other organizations/ agencies also support/conduct R&D in fisheries; these include the Department of Ocean Development (DOD); Department of Science and Technology (DST); Department of Biotechnology (DBT); University Grants Commission (UGC); Indian Institutes of Technologiy (IITs); Indian Institutes of Management (IIMs) voluntary agencies/private industries. However, the multiplicity of institutes requires a high degree of co-ordination to avoid duplication and diffusion of efforts and paucity of funds. There are overlapping mandates between institutions even within the same system.

Credit Support System

The fisheries sector particularly the aquaculture is on a steady growth path. The fishermen, in general, are poor and practise traditional farming for want of financial resources. The need for credit support for facing the emerging market forces and harnessing the benefits of technological developments has been realized and some measures have been evolved to enhance the flow of credit to the fisheries sector. The National Bank for Agriculture and Rural Development (NABARD), as a refinance agency for commercial banks, co-operative banks and regional rural banks has been the measure facilitator of credit to the fisheries sector. In view of the brackish water aqua boom in the early 1990s, many financial institutions like Industrial Finance Corporation of India (IFCI), Industrial Development Bank of India (IDBI), Shipping Credit and Investment Company of India (SCICI), State Finance Corporations (SFCs) and National Co-operative Development

Corporation (NCDC) also entered this sector to lend credit. Credit support from financial institutes is available for almost all the activities of fisheries and for creation of infrastructure. The credit disbursements for the fisheries sector witnessed an increasing trend till 1995-96 but thereafter there has been a decline in disbursements as well as in the number of sanctioned schemes. This could be partly due to the interim order of the Supreme Court of India banning shrimp farming in Coastal Regulation Zone, slow progress in mariculture, systematic changes in refinance policies and the environmental/disease problems faced by shrimp farming.

Other Infrastructure

The other infrastructure and support system include more than 376 freezing plants, 13 canning plants, 149 ice plants, 15 fish meal plants, 903 shrimp peeling plants, 451 cold storage units and 3 chitison plants.

Training, extension and transfer of technology

Fisheries development is a state subject in India. However, the centre promotes fisheries development through state level programme planning and implementation units. At the national level, the Fisheries Division of the Ministry of Agriculture is the planning and policy making body for fisheries development. The training programmes in fisheries are mainly dealt with by the Fish Farmers' Development Agency and Brackishwater Fish Farmers' Development Agency. These also provide packages of assistance for popularizing aquaculture technologies. The research institutes and SAUs have also been taking training and extension work as part of their curriculum. The Department of Rural Development promotes fisheries through the Integrated Rural Development Programme. In the states, departments of fisheries have been established at the district level to take care of the fisheries development including training and extension.

The first-line extension system of the ICAR , consisting of demonstration programmes, Lab-to-Land Programme, Operational Research Projects, Krishi Vigyan Kendras and Trainers' Training Centres play an important role in training and extension of fishery development. Technology assessment and refinement through Institution-Village-Linkage programme (IVLP) of the ICAR is a technology integration process fitting the requirements of the farmers suitably in a given farming situation.

Constraints in Fisheries Development

Further enhancement of marine fish production requires diversification of fishing activities not only in the off-shore oceanic regime but also in deep sea fishing which is capital intensive and risk prone. There have already been strong protests in India against foreign equity participation in deep sea fishing and the government had to rescind its Deep Sea Fishing Policy in March 1997. Utilization of marine resources by catch and fishing for unconventional fish species may not be economically viable initially. The conservation of resources and genetic diversity in EEZ would further slow down efforts towards higher production from the marine sector.

The story with the inland sector is similar; aquaculture production could be a base but it is beset with varied uncertainties. The aquaculture, particularly intensive and semi-intensive, which has the potential of gaining quantum but it may face a major fish meal trap. Another important intermediary input for aquaculture is seed of culturable fish species. The country is already facing problems with regard to scarcity of breeder stock in the shrimp sector. For diversified aquaculture, various compatible fish species have to be brought under aquaculture operation.

In the case of coastal aquaculture development in India, some social and political conflicts developed at several places. These conflicts were caused largely by disease outbreaks in shrimp farms, environmental pollution due to overcrowding of farms, salination of drinking water wells, conversion of paddy fields into shrimp farms, causing displacement of labour etc. These episodes have already had their effects.

Land and water resources in the country are not available exclusively for fisheries; there is excessive pressure on the resources from several other sectors. Moreover, programs for fisheries management are split between the national and state governments which differ in their policies and approaches. The national policies in India have largely been export oriented, supporting relatively large scale fisheries for shrimp. But for many states, the primary concern is the welfare of the local small-scale fishermen.

For the development of fishery and aquaculture, such constraints as well as social, legal and political implications have to be taken into account and innovative strategies and policies have to be initiated for a balanced and sustainable growth.

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2

Socio-economic Issues in Fisheries Sector in India

Ramachandra Bhatta

Introduction

Indian fisheries have evolved from the stage of a domestic activity during the 1950s and 60s to a status of an industry by 1990s. During the process of this transformation many changes in the socioeconomic status of fishers have taken place. This paper traces some of such changes that have taken place in the process of fisheries development. The paper addresses the profile of the fish producers in India and the changes over time, the pattern of commercialization across regions, salt and freshwater, capture and culture, between larger and smaller scales of production and between higher and lower value species. The paper also addresses the question of increasing commercialization of the fisheries sector in India and its impact on poor in terms of direct and indirect income gains, employment and the acquisition of skills that contribute to income-earning capacity.

India is endowed with 2.02 million sq. km of EEZ (Exclusive economic Zone) along with a coastline of 8129 km and 0.5 million sq. km continental shelf with a catchable annual fishery potential of 3.93 million tonnes occupying a very important strategic position in the Indian Ocean. The aquaculture resources in the country comprise 2.25 million hectres of ponds and tanks, 1.3 million hectares of bheels and derelict waters, 2.09 million hectares of lakes and reservoirs and also 0.12 million kilometers of irrigation canals. Among the Asian countries India ranks second in the culture and third in capture fish production and one of the top leading exporters of sea foods (Sampath 1998). The marine environment of India consists of unique ecosystems known for their aesthetic beauty and provide habitat for

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numerous biological species. The ecosystem is divided into three basic categories as estuarine, inter-tidal and coral reef. The estuarine ecosystem is a fresh water ecosystem comprising estuaries, mangroves and other wetlands rich in microscopic plant life and abundant in vegetation. They are the rich breeding grounds for larvae of some commercial species, a broad range of algae, fungi and lichens among others. More than 75 per cent of the commercial fish catch in India is dependent on estuaries for part of their life cycle. India ranks 14th in the list of world's major mangrove areas and 5th in the Indo-Pacific regions – the major mangrove areas in India include the northern Bay of Bengal and the Sunder bans (~690 sq. km) (B Sahai 1993).

Marine Fish Production

The marine fish production in India consists of a large number of species using different crafts and gears mostly in the depth range of 0-50 meters. The annual average landings during 1995-99 period was 2.5 million tonnes principally constituted by the Indian mackerel (8.5 per cent), penaeid prawns (7.7 per cent), croakers (6.8 per cent), oil sardine (6.7 per cent), carangids (6.1 per cent), perches (6.1 per cent), non-penaeid prawns (5.2 per cent), ribbon fishes (4.9 per cent), cephalopods (4.1 per cent) and others (CMFRI 1997).

The marine fish production in India is characterized by its annual fluctuations. This phenomenon has led to considerable uncertainties about investment in the production process. Marine fisheries still remains open access and suffer from overcapitalization. The near shore area within 40-80 meter depth range covering an area of 0.45 million sq. km is subjected to heavy fishing pressure (Kurup and Devaraj 2000). About 2,43,000 fishing vessels (1,82,096 artisanal crafts, 26,171 motorized crafts and 34571 mechanized crafts) exploit this area, where the estimated annual potential is 2.2 million tonnes. A conservative estimation made by Kurup and Devaraj (2000) shows that the capital investment in fishing technologies (crafts and gears) at current price is about 33.4 billion, but the return per unit of investment seems to be economically not viable. The estimation of optimum size of fishing fleets which would allow sustainable yields become very important for the better utilization of scarce resources of the society.

Socio-economic Status of Marine Fishers

The coastal communities in India follow multiple fishing and non-fishing activities and most of their income is generated from open access/common property resources. The coastal poor are not confined to any one sector and change occupations as and when necessary. Most coastal people in rural areas also work as seasonal labourers in agriculture or as part-time farmers or occasional wage earners in order to supplement their family incomes. Working as labour in tourism, industries, ports, mining and other industries is a relatively new occupation and it is mostly confined to specific areas from where these industries have come up. As pointed out by many authors, the employment generation potential of many of these industries is often much less than the livelihoods that are adversely affected by them. The issue of some of the social and environmental costs of economic reforms and growth has received considerable attention from the policy makers and researchers. Many studies have shown that during the process of liberalization and structural adjustments the vulnerable groups suffer more than the others. There are ample evidences to believe that the common pool resources of coastal regions, which provide substantial part of the income of the coastal poor communities is declining and degraded. The industrialization on the one hand and developmental projects on the other such as ports, tourism, aquaculture have led to decline of coastal biodiversity and thereby deprived the poor people of the common benefits which they used to get from such resources otherwise. According to Central Water Commission (1996) 16,935 hectares of fertile land was lost and 51,105 people have been displaced in three coastal districts of Karnataka. The CRZ notification relating to coastal protection explicitly states that all estuaries, fish-breeding centres, mangroves etc. are to be declared CRZ-I areas. The coastal zone management plans are yet to be considered as an approved document by the state authorities. The decline of traditional community management institutions and the absence of a strong legal framework are some of the other reasons, which made the poor stakeholders more vulnerable.

Dominance of the informal sector

The marine fishing units are classified into three broad categories depending on their scale of operation namely mechanized, motorized and traditional gears. Each category could be further classified into different classes. The mechanized boats capable of fishing in deeper waters (500 meters depth and above) and for 10-15 days are called multi-day fishing vessels. They generally have all electronic fish finding devices and on-board ice storage facilities. The mechanized boats fishing in near shore waters (50-100 meter depth) normally return in the evening but they are gradually converting themselves into multi-day vessels. The motorized fishing units such as gill nets, harvest valuable fishes and their size is also increasing and currently it ranges between 40-50 feet in overall length, fitted with engines of 25-40 BHP. Theoretically, the main difference between the mechanized and motorized boats is that the motorized boats use the motor power only for reaching the fishing grounds. The motors only help in reducing the risks and time required to reach the fishing grounds. The traditional fishing units normally restrict the fishing to inshore and estuaries and they are competed out by the motorized units.

In India, the crewmen are always paid a share of the value of the catch and not a fixed wage rate. In addition to a share they also get bonus for every fishing trip if the sales revenue is above a specified limit. The on-board food expense is paid by the owner and in some cases this food expense is deducted from the gross income to arrive at share value. The crew share depends on the degree of mechanization. In the case of motorized sector, the sharing pattern is different. The owner receives 50 per cent of the share of the net income (after deducting the operating expenses such as diesel, oil, food and marketing commission) and the rest is shared among the crewmen. The sharing system among traditional fishing category is relatively simple. The entire revenue is divided into three parts and crewmen share one and a half part. Although there is no uniformity in the sharing system, generally with higher mechanization, the percentage share of crewmen decreases, though the absolute amount could be higher than their counter parts in the other sectors. The owners are expected to give advance credit to crewmen to the extent of Rs. 5000-6000 depending on the experience and relationship. The field observations in Andhra Pradesh show that the variability of income among the crewmen is relatively higher than the owners.

In coastal fishing 99 per cent of the workforce in fishing and post harvest activities work in the unorganised sector where they do not get any social security benefits. The main economic activity of men is fishing in estuarine and coastal waters on a cooperative basis using motorized and outboard motorboats. These motorized boats are smaller than rampanies and fitted with 20-25 HP motors and go up to 20-25 km of distance in the sea. On the other hand, the traditional rampanies are operated manually from the shore. They work as crewmen earning a share of the total value of the catch. The quality of fish they land is fresher than fish harvested by large mechanized boats, which reach the market only after three or four days. There is a virtual absence of alternative employment, unemployment insurance and other elements of a social wage. Though most members of the local communities are employed in fisheries-related activities, a large proportion of them earn an extremely low income. Thus, though the unemployment rate is negligible, the level of poverty is high and insecurity of income is a characteristic feature of many post harvest activities. Younger men suffer from higher rates of unemployment as with higher education they tend to move away from fisheries and look for alternative employment, which is not available.

Post harvest activities are very heterogeneous containing both high return activities such as trade in export varieties and employment in shrimp processing plants and low return and low wage work such as fresh fish vending and sun drying of fish. Fresh fish, cured and dried fish for domestic consumption are distributed and marketed in the unorganised sector. The organised sector is concerned with freezing, canning, fish oil and fishmeal production mainly to meet export demand. The utilisation of marine fish varies from state to state depending on catch composition and availability of facilities for preservation, processing and storage. Field studies in Karnataka have shown that some of the important post harvest activities in which the poorest are to be found are shown in Table 1.

As soon as the catch arrives at the landing centre, it is auctioned through the commission agents with whom the fishermen have a financial relationship. The four main types of traders/buyers who market the fish are

- Bulk buyers who buy in large quantities and transport fish to interior parts of Karnataka and other coastal states;
- Wholesale commission agents who buy exportable varieties such as shrimp, cuttlefish, squids, etc. at reduced rates and supply to processors – cum – exporters;
- Cooperative societies;

Table 1. Categories of poor in the fisheries sector

Class of worker	Activities
Fishermen	They work as crewmen during the fishing season and are partners in small-scale fishing activities during the monsoon season.
Head loaders	Men and women are hired by marketing or commission agents to unload fish from the boats to the marketing yard. They get wages paid on the basis of baskets lifted.
Processors	Small-scale processors (both men and women) undertake processing activities such as drying and curing in small scale units and export –oriented peeling sheds and canning companies; they also help in transporting and retailing on behalf of traders. Their livelihood is fast eroding due to the development of the commercial organised sector, which depends on the use of ice, improved transportation and centralisation of landing catches of fish. They are paid at piece rates or per sack of dried fish.
Commission agents and petty traders	Small-scale village level operators (women and men) who trade and lease out their facilities to big merchants.
Workers in fish processing units	Contract workers in peeling sheds, surimi plants, ice plants, fish curing and drying yards.

- Men and women retailers who buy fish regularly in the landing centres and sell to consumers through shops and vendors who either walk (mostly women) or transport fish on cycles / auto rickshaws usually men.

The most important factor that influence the web of relationships that makes up the marketing structure is the mode of sale or more precisely the organisation of transaction between fishermen and buyers. Negotiations are generally conducted through intermediaries who facilitate the sale. Often, middlemen financiers advance loans to fishermen to buy craft and gear and corner the right to sell the fish to buyers of their choice at a 'fair price'. Sales take place in three ways: through bargaining which is the rule when buyers are few; by auction when there are numerous buyers, when supplies fluctuate or when there is a wide variety of fish and at fixed prices, which is the only way exportable fish are sold. The first two ways of selling are most common in disposing the catch on the sea front itself.

Women's Participation in the Marine Fisheries Sector

There has been little research on the role of women in coastal fishing, marketing of fish and their contribution to family income. Their role as 'facilitators' of fish distribution, particularly in states like Kerala is indeed significant. Although women retailers form only a small segment of the total fish trade, they are a vital link between wholesalers and consumers. Women fish traders in Kerala compete with the local traders for fish and if one goes by external appearances – dress, type of fish basket, manner of selling and the like – there seems to be very little difference among women fish traders. Field observations however show that differences exist between them in terms of working capital, sources of fish supply, the mode of transport used and the points of disposal of the harvest of fish.

In the dry fish trade, traditionally in north Kerala, women produce and sell directly to consumers or supply merchants. A few self- help groups have promoted production and marketing. But hundreds of others, wives of fishermen, work for low wages as cheap labour to sort and dry fish for large establishments. Women in Kerala also work for wages as processors and sorters in landing centers in the unorganized sector as well as in the organized sector where they dominate in prawn/shrimp processing and specialize in peeling work. In recent years, highly developed peeling facilities have led to the decrease in the demand for such workers. They are also employed in modern surumi plants established in the 1990s to cater to Southeast Asian markets and in processing factories. These workers are not organized despite the fact that their contract with the contractors violates existing laws.

In Karnataka, small – scale women fish distributors, generally from the traditional fishing community, Mogaveera as well as a few Muslim women, are in the business primarily for subsistence. They buy small quantities of fish, transport it over short distances and serve more or less a regular clientele and make nominal earnings. They usually participate in auctions, purchasing a few baskets depending on their capacity to sell in the retail market to regular customers, their relative bargaining position in the market being backed and also limited by the level of consumer demand. While wholesale merchants buy large quantities to transport over long distances to make high profits, small scale women retailers spent proportionately higher amount on transportation and ice, make low profits, expend more physical labour and work long hours. Although mainly involved in vending fresh and dried fish, they also work for wages as head –loaders, processors and sorters at the landing centres. In the export factories in Karnataka peelers from Kerala -usually young girls and women in their twenties — are preferred as they are considered highly skilled and those migration is encouraged.

Education Among Coastal People

Very little information is available on the educational status of the coastal communities and is scattered in internal documents and reports of NGOs. Tietze (1987 and 1996) publications mention about the poor educational standards of the coastal fishers. Large family size and poor quality of life characterize coastal families since even small children can participate in income generating activities and it is argued that with decline in resource base, the coastal poor feel a need to have large families that can extract enough for survival.

Vivekanandan found that educational standards amongst the fisherfolk caste of Pattapu in southern Andhra Pradesh are abysmally low. He attributed this to the low age of entry (around 12 years) into Catamaran fisheries, in case of males and in case of girls, the need for taking care of younger children in the absence of their mother who goes to work. Salagrama (1990) in a study of a nomadic fishing community found that children were almost as productive as the elders and had no inclination to study. In another paper, Salagrama (2000) suggests that educational standards of the people who migrated out of the fisheries sector are better.

Impact of Fisheries Management Regulations

The ultimate objectives of regulations aim at increasing the productivity of the stock and the net economic yield. The fishery manager would be interested in expanding fishing effort up to the point of maximum rent, which lies before the maximum sustainable yield point. The maximum economic yield (MEY) is preferable to the maximum sustainable yield (MSY) both from the economic and ecological point of view. The regulatory mechanisms usually adopted are:

- Regulations such as gear selectivity and seasonal area closures.
- Regulations that control the fishing effort and catching.

The first fishery regulation was enacted in 1897 to control destructive fishing activities in both marine and inland waters. It explicitly banned the use of explosives and poisons in harvesting fish. However, until 1970s the state governments did not find the need for controlling fishing effort, as the fishing was mostly artisanal in character and mechanized fishing was negligible. With the rising foreign and domestic demand for fishery products private firms apart from traditional fishing communities saw a good opportunity for financial profits in the exploitation of marine resources. Modern mechanized trawlers were subsequently introduced in India with state and central subsidy programmes through cooperatives and commercial banks. During the initial years most of these fishing units operated by domestic firms from within and outside the local communities. Thus, the influx of large number of big trawlers in the early eighties increased the fishing pressure on the marine fishery resources tremendously. This leads to stagnation of catch and decline of average profitability.

Panayotou (1982) identifies broadly two parameters, which the fishery administrators have tried to manipulate: (a) the age or size of fish at first capture and (b) the total amount of fishing effort. The ultimate objective of both the approach is to increase the productivity of the stock and net economic yield. However, the productivity and sustainability of measuring the marine fish production cannot be done in the same way as the productivity of the land or forests. The fishery catch depends on the stock of fish in the fishery grounds as well as on inputs in terms of fishing efforts and quantity of fishing gear used.

The ban on fishing is one of the methods of fish conservation by prohibiting fish harvesting during the breeding season (monsoon). The ban period varies from state to state. Goa observes fishing ban from 1st June to 24th July, every year. In Kerala the ban is from 15th June to 29th July. The ban in Karnataka is from 1st June to 15st August. In Maharashtra, it appears that recently a decision has been taken to ban fishing from 10th June to 7th August each year. Gujarat on the western coast does not have any fishing ban. Recently the Goa High Court gave a judgment (The High Court of

Bombay at Goa, 2002) that the State Government of Goa should strictly implement the above fishing ban against all kinds of mechanized vessels, including country crafts and boats/canoes fitted with inboard or outboard motor and other mechanized boats using nets for the purpose of fishing within the territorial waters of the State Goa, i.e. 22 kms. from the sea coast. It is made clear that the traditional fishing by boats, without any mechanized motors, etc., are permissible and this order will not come in the way of the "ramponkars", earning their day-to-day livelihood by traditional fishing.

However, such a measure may affect the livelihood opportunities of the small-scale fishermen who are dependent on fishing during the monsoon period. Thus, the fisheries management measures need to be implemented cautiously without harming the interests of some of the stakeholders in the resources.

Socio-economic Status of Inland Fishers and Fish Farmers

Fresh water aquaculture resources in the country consists of 2.25 million hectares of ponds and tanks, 1.3 million hectares of bheels and derelict waters, 2.09 million hectares of lakes and reservoirs as also 0.12 million kilometres of irrigation canals and channels.

Indian aquaculture production consists mainly of Indian major carps and common carps. Indian fresh water aquaculture is mainly based on carps such as Indian Major carps (catla, rohu and mrigal), kalbasu, silver carp, grass carp and common carps etc. The factors such as culture practices, breeding and seeds production and socio economic factors play a very important role in productivity enhancement. The socio-demographic characteristics of the freshwater fish producers in the six selected states of India based on a comprehensive survey (Bhatta 2001) are presented in Table 2. The age of carp farmers ranges between 38 years in Andhra Pradesh to 58 years in Haryana with an all India average of 47 years. The number of years of formal school education is the lowest for Haryana and Andhra Pradesh farmers had highest educational attainment with 10 years of schooling. The number of working days indicating the generation of employment was found to be the highest for West Bengal (75 man days) and Karnataka producers spent only 17 man-days on an average.

Table2. Profile of fish farmers

Variable	Overall	States					
		Andhra Pradesh	Haryana	Karna-taka	Orissa	Uttar Pradesh	West Bengal
Total Respondents	417	66	56	64	62	123	46
Household size	8	5	23	5	8	6	7
Age (Years)	47	38	58	47	46	47	51
Education (years)	6	10	2	9	6	6	6
No. of working days available for aqua culture in a year (in %age)	68.66	60.94	47.96	17.48	50.68	44.94	75.07
Average farming duration (number of months in a year)	8	7	9	8	9	8	-
Experience in carp culture	10.21	9.75	3.67	3.14	5.17	7.01	44.3

Source : Bhatta (2001).

The farming durations on the other hand extended up to 8 months in UP with a minimum of 7 months in Andhra Pradesh. The results show that Andhra Pradesh farmers took less farming duration as they have started stocking stunted fingerlings. The size of family varies from 5 in Karnataka to as high as 23 in Haryana. In terms of experience, West Bengal has uniqueness since the back-yard pond system has been in existence for many years.

The share of different sources of income of carp farmers presented in Table 3 shows that 80 per cent of the income is generated from carp farming followed by agricultural crops and others. However, there is wide variation between the states. In Andhra Pradesh the producers are basically fish farmers getting 95 per cent of their income from carp farming, while in Karnataka, Orissa and West Bengal substantial part of the income is generated from agricultural crops. Secondly in Orissa the carp producers received 25 per cent of their income from salaries and wages.

Table 3. Share of income of the carp producers (in percentage)

Variable	Overall	States					
		Andhra Pradesh	Haryana	Karna-taka	Orissa	Uttar Pradesh	West Bengal
Mean households gross income (in Rs.)	410818	1822701	231304	337711	79444	58178	33009
Total Respondents	417	66	56	64	62	123	46
% share of income from:							
Culture	79.66	95.26	54.89	30.1	14.98	58.86	49.26
Fish capture	0.16	-	-	0.61	0.49	1.68	0.02
Hatchery	0.06	-	-	-	0.06	1.32	-
Paddy	9.32	-	22.25	49.7	28.04	4.8	32.89
Other crops	3.76	0.02	22.09	14.19	0.79	4.88	3.01
Live stock	0.03	-	-	-	-	0.8	-
Business	5.18	4.72	0.77	0.75	31.12	15.33	12.05
Salaries & Wages	1.54	-	-	2.91	24.52	10.86	1.9
Others	0.29	-	-	1.74	-	1.47	0.87
Total	100	100	100	100	100	100	100

Source : Bhatta (2001).

Table 4 shows the land use pattern and allocation of land and water spread area of the sample farmers and basic infrastructure facilities available for farmers in selected states. The holding size of carp farms is highest in Andhra Pradesh (8.42 ha) followed by Haryana (7.88 ha) and Karnataka (5.63 ha). The farm size is smallest in West Bengal (0.85 ha) and highest in Andhra Pradesh. In Haryana commercial crops occupied 75 per cent of their land while in Karnataka it was only 25 per cent. The maximum utilization of water-spread area for carp farming was observed in Andhra Pradesh (97 per cent). The minimum water retention level during dry and wet season is one of the major factors, which affects the growth.

West Bengal and Andhra Pradesh farmers maintain maximum level of water, with highest stocking density. Whereas, in Karnataka and Haryana farmers suffer from lack of water during summer season, because many of the ponds are village ponds where the water during the dry season is being utilized for other household and irrigation activities. The farmer in Haryana has to travel 38 kms. to get access to fish seed supply center

Table 4. Profile of fish farms

Variable	Overall	States					
		Andhra Pradesh	Haryana	Karna-taka	Orissa	Uttar Pradesh	West Bengal
Total area (in ha.)	4.24	8.42	7.88	5.63	1.74	2.15	0.85
Percentage of the total area under							
Home stead (%)	1.18	-	1.14	-	11.49	-	7.06
Commercial crops (%)	34.91	2.14	74.75	25.22	66.09	41.86	9.41
Food crops (%)	13.0	-	-	59.15	-	-	38.82
Water spread area including fish pond (%)	50.9	97.86	24.11	15.63	22.41	58.14	44.71
Total owned	3.53	6.68	7.23	5.22	1.77	1.18	0.81
Leased out	0.04	0.15	-	-	0.07	0.02	0.04
State owned	0.11	-	0.43	0.31	-	-	0.06
Minimum water depth (in mts)							
Dry season	2.89	4.38	1.73	1.7	3.84	1.61	5.84
Wet season	4.78	6.18	2.16	2.58	6.79	4.02	8.33
Distance of the farm from (in km)							
District head quarters	66.3	54.18	81.98	64.56	26.04	24.08	231.52
Main road of the district	4.68	2.7	7.58	3.43	4.63	3.42	9.07
Main river of the district	10.3	1	9.17	17.44	8.9	13.01	9.8
Nearest village Market	5.43	-	11.85	10.09	2.77	2.47	2.12
Nearest fish seed supply	17.0	8.28	38.24	19.92	17.71	15.52	2.25
Home	2.52	8.12	1.6	2.11	1.27	1.27	1

Source : Bhatta (2001).

followed by Karnataka (20 kms) and Uttar Pradesh (15.5 kms). In most of the states the farmers are residing within the radius of 1 – 2 kms except in Andhra Pradesh where the farms are located 8 km away from their house.

Table 5 shows the various problems faced by the aquaculture farmers and their ranking. The table indicates that poaching is the most severe problem (4.31) faced by the farmers followed by disease (4.73). It is important to note that the farmers faced a variety of problems in their farming operations.

Table 5. Mean ranking of problems encountered by the producers (1= most severe)

Variable	N	Mean	Std dev	Minimum	Maximum
None	45	6.91	3.03	1	18
Poaching	180	4.31	3.45	1	24
Bad weather	57	7.39	2.45	3	14
Flood	125	4.67	3.77	1	19
Drought	126	5.42	4.30	1	22
Unreliable water supply	93	6.66	4.81	1	24
High cost of water	105	6.41	4.75	1	24
Polluted water	85	7.27	4.77	1	28
Sulphur upwelling	57	8.98	4.91	3	27
Net / pond destruction	55	8.64	4.48	2	26
Poor / slow growth of fry	68	7.72	4.03	2	23
High fingerling mortality	69	7.42	4.19	1	24
Small size of fish at harvest	90	6.21	3.84	1	27
Uncertainty of access to present location	56	7.50	4.86	3	29
Proliferation of carp farms	56	7.16	4.38	1	22
High price of fingerlings	56	6.61	4.26	1	23
Increasing cost of inputs	82	5.55	4.20	1	25
Difficulty in obtaining credit	108	4.81	4.17	1	28
Lack of technical assistance	80	5.71	4.11	1	24
Limited management expertise	57	6.58	4.32	1	21
No skilled workers	70	6.23	4.30	1	20
High capital requirement	70	5.83	4.75	1	22
High marketing cost	61	6.90	6.23	2	28
Disease	103	4.73	3.57	1	26
Cold	55	6.98	5.12	1	29
No buyers at market	91	5.18	4.97	1	28
Others	80	3.56	2.10	1	10

Source : Bhatta (2001).

The intensity of these problems differs between regions, size and intensity of the farming methods.

Fish Consumption Pattern

The studies on fish consumption in India are very few. The study of National Council for Applied Economic Research (NCAER 1980) is a benchmark exhaustive study of fish consumption pattern in some of the metropolitan cities of India. It revealed that 45-88 per cent of households consume fish in big cities like Bangalore, Kolkata and Delhi. The per capita monthly consumption was in the range of 0.56 kg at Bangalore to 1.01 kg at Kolkata. The proportion of expenditure on fish in total expenditure on food ranged between 6.3 to 14.6 per cent in Delhi and Kolkata, respectively. Another study by Sekar *et. al*. (1996) in south India indicated that on an average the urban consumers buy around 4.5 kg of fish per month and spend around 7.5 per cent of their total food expenditure on fish. Birthal and Singh (1997) estimated demand for livestock and fish products in Uttar Pradesh. The results showed that live stock products such as milk, mutton, eggs and fish together accounted for 18 per cent of the total consumption expenditure. The average expenditure share of fish in the total food expenditure increased with increase in income initially but marginally declined with higher income classes. This was explained by socio-cultural factors than economic ones. The study further revealed that at the commodity level, meat, fish, eggs together shared 4.83 per cent of the total expenditure. Average expenditure share of fish across different income groups varied from 0.29 per cent in the lowest class to 0.33 per cent in the highest income class. The income elasticity of demand for fish was found to be 0.37 irrespective of the income class. The National Sample Survey of India also gathered information on fish consumption all over India. The findings of this section are based on the results of a comprehensive survey of urban and rural fish consumers in five Indian states namely, Haryana, Karnataka, Orissa, Uttar Pradesh and West Bengal (Bhatta 2001). Primary data were collected through a food consumption survey of randomly selected 890 (421 rural producer-consumer and the rest from urban areas) sample households from ten districts of six states. Some of the important results of the survey are presented in this section.

Species wise monthly consumption of carps and other species across income classes and regions of urban households are presented in Table 6. The all India monthly average household consumption of fish was 3.17 kg/month, among ‘very poor’ income classes. In the ‘very poor’ category and also in all other income classes West Bengal had the highest monthly consumption. The household monthly fish consumption was found to increase as income increases except for ‘rich’ income class. Rohu and catla constituted higher percentage of consumption among all the income classes and states. In Karnataka the share of common carp varies between 14.78 per cent among very poor class to 11.59 per cent among medium income classes. Even the

Table 6. Species wise household Inland fish consumption in urban area (kg/month)

Income Group	Overall	States				
		Haryana	Karnataka	Orissa	Uttar Pradesh	West Bengal
Very Poor						
Total (kg)	3.17	2.66	3.18	2.62	2.51	4.95
Percentage of						
Rohu	48.58	92.86	15.72	59.16	44.62	41.82
Catla	36.91	4.14	69.50	37.02	28.29	37.58
Mrigal	8.83	1.50	0.00	3.82	13.55	18.79
Common carp	2.84	0.00	14.78	0.00	0.00	0.00
Others	2.84	1.50	0.00	0.00	13.55	1.82
Poor						
Total (kg)	3.17	2.87	2.45	3.28	2.89	4.36
Percentage of						
Rohu	53.00	87.80	35.92	44.51	52.25	46.79
Catla	35.02	3.14	51.02	50.30	24.22	42.43
Mrigal	7.26	9.06	0.00	5.18	10.38	9.40
Common carp	1.89	0.00	13.06	0.00	0.00	0.00
Others	2.84	0.00	0.00	0.00	13.15	1.38
Medium						
Total (kg)	3.60	2.74	2.76	4.80	2.94	4.76
Percentage of						
Rohu	62.78	97.81	43.12	71.25	62.24	46.43
Catla	29.72	2.19	44.57	25.21	28.57	42.02
Mrigal	4.44	0.00	0.72	3.54	4.76	9.45
Common carp	1.67	0.00	11.59	0.00	0.00	0.00
Others	1.39	0.00	0.00	0.00	4.42	2.10
Rich						
Total (kg)	2.91	2.36	0.68	3.73	3.47	4.30
Percentage of						
Rohu	54.64	90.68	35.29	53.62	54.18	39.30
Catla	30.24	8.47	47.06	29.22	31.41	39.30
Mrigal	12.71	0.85	0.00	17.16	7.49	21.40
Common carp	0.69	0.00	17.65	0.00	0.00	0.00
Others	1.72	0.00	0.00	0.00	6.92	0.00

Source : Bhatta (2001).

rich income classes consumed 17.65 per cent of their total monthly household consumption of 0.68 kg.

Species wise monthly household consumption among rural households are presented in Table 7. Since the consumption by rural households represent only producer – consumers, the figures are slightly higher than the average. The average household monthly consumption of 'very poor' class was 7.25 kg and West Bengal had highest consumption of 7.87 kg per month. In the very poor income class Karnataka, Orissa and Uttar Pradesh had least consumption of fish of 2.20, 2.26 and 3.33 kg per month respectively.

Table 7. Species wise household fish consumption in rural areas (kg/month)

Income Group	India	States				
		Haryana	Karnataka	Orissa	Uttar Pradesh	West Bengal
Very Poor						
Total (kg)	4.49	6.81	2.20	2.25	3.33	7.87
Percentage of						
Rohu	44.97	68.87	41.69	55.56	44.74	28.34
Catla	40.97	26.58	58.31	44.44	23.42	24.65
Mrigal	6.48	4.55	0.00	0.00	11.71	20.84
Common carp	0.00	0.00	0.00	0.00	0.00	0.00
Others	7.59	0.00	0.00	0.00	20.12	26.18
Poor						
Total (kg)	7.55	11	3.74	6.55	9.02	7.43
Percentage of						
Rohu	46.36	56.82	24.33	66.26	41.24	30.55
Catla	31.92	34.09	52.67	26.56	30.60	24.36
Mrigal	10.33	0.00	1.60	7.18	18.29	23.28
Common carps	2.12	0.00	21.39	0.00	0.00	0.00
Others	9.27	9.09	0.00	0.00	9.87	21.80
Medium						
Total (kg)	10.55	12.51	4.29	13.55	11.45	11
Percentage of						
Rohu	46.45	43.96	38.69	82.88	30.74	23.64
Catla	25.12	35.97	41.49	12.77	28.47	18.18
Mrigal	12.42	15.03	1.17	4.35	22.97	12.73
Common carp	1.52	0.00	18.65	0.00	0.00	0.00
Others	14.50	5.04	0.00	0.00	17.82	45.45
Rich						
Total (kg)	17.21	12.37	3.94	44.71	11.4	13.66
Percentage of						
Rohu	71.93	60.95	44.92	95.39	40.35	39.02
Catla	18.71	33.87	43.15	3.15	30.44	39.02
Mrigal	5.46	2.59	0.00	1.45	15.18	14.64
Common carps	0.52	0.00	11.93	0.00	0.00	0.00
Others	3.37	2.59	0.00	0.00	14.04	7.32

Source : Bhatta (2001).

Table 8 and 9 shows the annual per capita consumption of fish among different income classes and across states on urban and rural. The household overall annual per capita fish consumption among rural households was 8.52 kg for India, which varies between 4.98 kg in Karnataka and 12.61 kg in West Bengal. Among rural producer–consumer households the overall consumption was double than urban households. Another interesting result has that the rural – producer - consumer consumption level of Haryana was 29.70 kg per annum indicating the impact of increased production and accessibility of fish on consumption pattern. Further, variation in consumption between rural income classes was more than the urban income classes. The overall per capita annual consumption of fish among producer-consumer increased from 7.55 kg by 'very poor' to 31.06 kg by 'rich' income class. In West Bengal there is more uniformity across income classes compared to other states.

Table 8. Annual per capita consumption in urban areas (units in kilograms)

Income group	India	Haryana	Karnataka	Orissa	Uttar Pradesh	West Bengal
Very poor	6.42	7.31	5.33	4.73	5.03	10.59
Poor	8.16	10.15	5.85	7.61	6.25	12.53
Medium	10.33	8.87	7.71	12.32	7.90	15.19
Rich	9.16	8.09	2.06	11.44	10.53	14.00
Over all	8.52	8.33	4.93	7.02	6.91	12.61

Source : Bhatta (2001).

Table 9. Annual per capita consumption in rural areas

Income group	India	Haryana	Karnataka	Orissa	Uttar Pradesh	West Bengal
Very poor	7.55	5.13	10.67	2.70	5.57	14.55
Poor	11.29	8.66	7.90	10.78	16.17	17.16
Medium	18.10	10.00	11.22	27.30	28.31	28.70
Rich	31.06	39.78	13.64	32.75	23.86	49.20
Over all	16.99	29.70	11.32	18.61	13.62	18.40

Source : Bhatta (2001).

Purchasing Power and Price Behavior of Aquaculture Products

Economists suggest several methods to measure changes in degree of economic access to food. One way to measure such changes is to examine the trends in the proportion of per capita income required to buy a unit of food (Tyagi 1988; 1990). Using the fish retail prices, it was observed that the average per capita income required to buy a kg of fish declined by 50 per cent in 1994-95 in the case of rohu and 20 per cent in the case of pomfret which is a marine fish (Table 10).

Table 10. Average per capita income and retail prices of fish

Year	Per capita income at current prices (Rs)	Average retail prices (Rs./Kg)	
		Rohu	Pomfret
1986-87	2303	28 (1.22)	20 (0.87)
1990-91	2837	36 (0.72)	30 (0.60)
1993-94	7060	47 (0.67)	44 (0.62)
1994-95	9983	50 (0.61)	50 (0.61)
1996-97	10771	60 (0.55)	62 (0.57)

Figures in parenthesis indicate percentage to per capita income
Source : Bhatta (2001).

The economic access to fish has increased in these years. If certain section of the population is not able to have access to fish due to very low purchasing power, the solution lies in creating more employment and income opportunities for them rather than solely relying on keeping the product price stable. It may not encourage farmers to adopt new technology and making investment in fisheries and aquaculture.

Fish marketing

The commercialisation of fish harvesting technologies has led to many changes in the total fish landings as well as on composition of the landings. Improved market infrastructure and centralization of landings has no doubt benefited the fisher folk through remunerative prices since such centralized port markets are effectively linked to urban wholesale markets and thus increased marketing efficiency. However, such developments also affected other income generating activities derived from the catches in traditional fishing committees. Thus, many small scale fisher-women processors depending on the landings of smaller ports for their processing activities are finding less fish in the nearer landing centers and also have to face tough competition from the industrial buyers. For the fish varieties, which are frozen and exported (particularly shrimp and cuttlefish) there has been a significant increase in the price received by the fishermen. Considerable competition exists among the processor-exporters to obtain supply for their under-utilized processing plants. Moreover, the high value of such products enables the fishermen to spend on ice and better handling system, which increases their withholding capacity. Many associations of commercial fishermen were organized in order to get a larger share of the export price for their member-fishermen.

The scenario of the domestic marketing is totally different. Although over the years the proportion of the total landings exported is increasing, still 80-85 per cent of the total quantity is traded and consumed in the domestic market. Hence, major part of the income received by the fishermen still depends on the unit value realized from domestic marketing. A case study on marine fish marketing in Tamil Nadu indicated that the average retail price recorded manifold increase between 1974-75 and 1997-98 (Sathiadhas 1998). The price of seer fish increased about 10 times from Rs.9.00/kg in 1973-74 to Rs.100/kg in 1997-98. The price of pomfrets increased from Rs.2.50/kg to Rs.120/kg during the corresponding period. Similarly the price of sharks increased from Rs.2.50/kg in 73-74 to Rs.60/kg in 1997-98. However, fishermen frequently feel that they receive unfair price for their catch, particularly when there are a few buyers or when there are gluts in the landings. The seasonality of catches has also changed significantly. For example in Karnataka due to the development of fishing technology capable of fishing during monsoon season the monsoon landings have increased from a mere 7 per cent of the total during the pre mechanization period (1956-78) to 20 per cent during the post-mechanization period (1985-1993) (Bhatta. R. 1996). This has resulted in round the year availability of fresh fish to the consumers. This led to a decline in the demand for dried fish in the domestic market. Further, the proportion of dried items in the seafood export declined from 41 per cent in 1966 to less than 1 per cent in 1996 (Sathiadhas 1998). These changes in the utilization pattern have many socio-economic implications on the poor income groups living in rural and urban areas.

The cultured fishes such as Indian major carps and freshwater prawns are sold in urban markets and transported to West Bengal and other North-Eastern states. For instance, in Vellore a town in the northern part of Tamil Nadu about 5000 hectares of area is under freshwater fish culture with an estimated fish production of 12,000 tonnes. Most of the cultured fish and fresh water prawns are exported to North-Eastern states and West Bengal. The farmers some times enter into buy back arrangements with the merchants. Under this arrangement the merchants supply inputs such as nets, crafts and feed in advance with an understanding that the entire fish is sold to him by the farmer at the prevailing market price. The total revenue realized by the sale of fish is paid to fishermen after deducting the cost of input advances made.

Role of Fisher Groups and Cooperatives

Some of the fishermen groups attempted to market their own fish by forming community level associations and cooperatives. Pritchard et al. (1997) documented some of the success stories of the fisher-women groups in marketing fresh fish in Tamil Nadu. However, in general only a few of these initiatives were successful. Some of the important reasons for the failure of the group initiatives were the competition by the merchants by offering higher prices temporarily to attract the sales away from the group, lack of quick and right decision-making leadership in the purchase and sale points to get better price and paucity of working capital.

Fishing cooperatives were also expected to play an important role in marine and inland fish marketing. There were about 9500 primary societies with a membership of about one million linked to 108 district cooperative federations, under the National Federation of Fishermen Cooperatives in New Delhi. An examination of the working of these cooperatives showed that these cooperatives were successful when markets had following characteristic features:

- The production of fish was centralized
- Fishing operations were highly mechanized and capital intensive with higher share of inputs imported from outside the region.

The Employment in the Export Oriented Enterprises

The processing units in different parts of the country employ largely women from Kerala mainly on short-term contractual arrangements. The problems of the unorganized sector have become more significant today when liberalization has become center-stage. The work in the processing plants have been divided into two parts; the pre-processing part that involves peeling and cleaning of raw materials and the next stage grading and packing of the product. The companies mainly employ two types of workers casual daily workers drawn from the local areas and the contract workers who are mainly migrant women workers. It is very difficult to estimate the number of actual work force employed in these processing units. The number of permanent workers is relatively insignificant compared to total number of casual workers employed in these units. Further, no systematic data is being maintained by the government organizations such as Marine Products Export Development Authority (MPEDA) and labour commissioners' office.

Socio-economic Impact of Aquatic Biodiversity Conservation

The Ministry of Environments and Forests, Government of India, considering the over harvesting of some of the rare species such as whale sharks included it in the Schedule I of the Wildlife Protection Act. The whale shark is the first species to get protection under the Act. After including the whale shark in the negative list, it is expected that the official exports are likely to come down. However, underground exports are likely to flourish unless the whale fishermen are properly rehabilitated.

According to the reports of the TRAFFIC there has been large-scale fishing of whale sharks for their meat, fins, liver, skin and cartilage (Hanfee 2001). The whale sharks are found largely in the west coast. TRAFFIC India's survey revealed that between 1999-2000, 600 whale sharks were caught, smallest catch was two meters long and 0.5 tonne and the largest 14.5 meters and 12 tonnes. While the fresh and frozen meat of whale shark is sold at Rs.40 and Rs.70 per kg in India. It sells for US $ 15.00 (Rs.750) in Taiwan. Export of many biologically sensitive marine species such as crabs, mussels, snail, seaweed (agar) etc. in different product forms is going on. The export of total crabmeat increased from 1844 metric tonnes worth Rs.2283 lakhs in 1994-95 to 2586 metric tonnes worth Rs.3350 lakhs in 1999-2000. The export of shrimp in different product form has increased from 74563 metric tonnes in 1992-93 to 110564 metric tonnes in 1999-2000. The export of fresh water prawn (scampi) has doubled from 102 metric tonnes in 1995-96 to 217 metric tonnes in 1999-2000. With the result freshwater fish biodiversity issues have been completely ignored. Similarly the export of cultured tiger shrimp *P. Monodon* from coastal wetlands has increased significantly. Many local fishes such as mullets and pearl spot have to be eliminated before stocking the shrimp in coastal shrimp farms. These fishes were the staple food of the local communities. The tremendous growth of exports of the cultured shrimp affected biodiversity adversely left less availability of local fishes for the local communities. International trade in many marine species is prohibited under various Acts and notifications. The export of some of the species such as marine turtles, shells, gastropods except the giant clams are banned under the Wild life protection Act 1972 and CITES declaration. The sea cucumber (Beche-de-mer) is another commercially important marine species, which has very high export value. In 1982 Government of India put a ban on the export of Beche-de-mer below the size of 7.5 cm. In Andaman and Nichobar Islands fishing for sea cucumber is totally banned. Corals and associated species like sea fans, sea-sponges are heavily exploited for their known sources of bioactive substances with wide application in the pharmaceutical industry. Especially sea fans (Gorgonids), which constitute only source of prostoglandins and terpenoids (Hanfee 2001). Black corals were listed in CITES Appendix II in 1981 to protect the highly exploited stony corals. However, control of coral trade is difficult since they are often collected in offshore areas not directly controlled by the coastal nations.

Conclusions and Policy Implications

The marine production in India is reaching maximum sustainable yield levels and in the case of some commercially important species the symptoms of over harvesting such as stagnation of total production, decline in the catch per unit of fishing effort are observed. This has negative socio-economic implications in terms of lack of fish availability to local community and nutritional insecurity.

India initiated the aquaculture development programs during 1980s and 1990s. There were restraints to the fish farming initially but the growth in production was accelerated in some regions such as Andhra Pradesh, Punjab, Haryana and Bihar. Hopes have been raised about the increasing domestic consumption, inter state movements and exports with the changing food preferences and urban growth. The composition of species is responding to market changes. It is becoming concentrated in rohu, common carps and fresh water prawns.

However, the current level of fish consumption is very low compared to other countries. The studies on demand projections indicate that there will be very rapid growth in the demand for fish. The socio-economic conditions of fisher folk in terms of education, employment, income, food and nutrition security are not encouraging.

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3

Analysis of Fish Supply and Demand in India

M. B. Dastagiri and Mruthyunjaya

Introduction

Fisheries in the country since the launching of the First Five-Year Plan in 1951, has witnessed an impressive growth from a highly traditional activity to a well developed and diversified enterprise. The fishery sector during the recent past has played an important role in the Indian economy through employment generation, enhanced income, and earning valuable foreign exchange (Government of India 1996). This sector contributes an estimated 1.37 per cent to the country's GDP, and 5.18 per cent to the agricultural output at current prices (1998-99). The value of export of marine products contributed Rs 5116 crores to the country's exchequer in 1998-99.

Slightly more than half (55 per cent) of Indians are non-vegetarians. The annual per capita consumption of fish is 8 kg per person as against the global average of 12 kg (Government of India 1996). So, scope exists to reach the world average of 12 kg/capita/annum. Empirical studies reveal that a structural shift is taking place in human food consumption towards animal products (Huang & Howarth 1996). Typically, economists have explained such changes in food consumption patterns primarily as resulting from increases in disposable income and changes in food prices. The studies by Kumar (1996), Kumar and Mathur (1996), Kumar (1998) and Bhalla and Hazell (1997) have clearly shown that the composition of food demand across commodities is changing because of change in food habits of the people, change of life style, urbanisation etc., besides change in household income and food prices. The major point emphasised in these studies is that on the whole, direct per capita consumption of cereal as food has declined,

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while dairy, meat and fish consumption has increased substantially. Integrating fish, livestock, and crop production is an Indian practice from time immemorial. Moreover, Integrated Fish Farming is attractive to small farmers who are under pressure to produce higher-value commodities, as well as to communities seeking to augment food production and income. Trade liberalization may further add to this pressure. This emerging scenario will have considerable bearing on future demand and supply patterns of fish. The present study was conducted with some of these concerns in view with the following specific objectives.

1. To project the demand and supply of fish for 2020.
2. To estimate the supply - demand gap of fish and discuss policy imperatives.

Methodology

The Data

The demand analysis is based on the data available in National Sample Survey Organization (NSSO) publication on *Consumption of some Important Commodities in India*, NSS 50th round, 1993-94. The data consist of cross-sectional figures on aggregate quantity consumption and values of different food and animal products per person per 30 days for different states by rural and urban categories for the period 1993-94.

The supply analysis is based on time series data on quantity of fish production, fish prices, fish seed (million fry) production, and the status of production technologies of fish for the period 1970 to 1998. The important sources of data are *Basic Animal Husbandry Statistics, Agricultural Prices in India, Handbook on Fisheries Statistics.*

The Models

Supply

The quantity produced of a fish like many other foods is hypothesised to be a function of its own prices, prices of inputs used in the production, the existing state of production technology and government policy variables such as supply of credit. It is, however, observed that there is a lukewarm response to changes in prices. Such response is assumed to be the result of biological and technical factors.

In this study, we consider a polynomial distributed lag model to determine the lagged response of the fish production to changes in the fish prices. This model is reported to be quite suitable. Polynomial distributed lag model was originally suggested by Almon (1965) and then modified by Bischoff (1966), Modigliani & Sutch (1966) and Cooper (1972).

The models employed in the study are :

Linear Regression Model

$$\mathbf{Y = b_0 + b_1x_1 + b_2x_2 + b_3x_3} + m$$

where,
Y = Quantity of fish production (1970-98)
x_1 = Own price of fish
x_2 = Fish seed (in million fry)
x_3 = Time, which is a proxy for technological change.

Almon Polynomial Price Lag Model

$$\mathbf{Y_t = b_0x_t + b_1x_{t-1} + b_2x_{t-2} + b_3f + b_4T} + m_t$$

The transformed model

$$\mathbf{Yt = a_0w_0 + a_1w_1 + a_2w_2 + b_3 f + b_4T} + m_t$$

where,
w_0 Price of current variable
w_1 One lag price
w_2 Two lag price
f is Fish seed
T = Time (proxy for technological change)
The W's are linear combinations of all the x values (current and lagged)
The weights used in the first constructed variable (w_0) are all equal to unity.
The weights of w_1 will be the simple increasing series of integers.

The weights of third constructed variable $w_{2,}$ will be squares of the weights of $w_{1.}$

The estimated response functions incorporate price lags of 1 to 2 years.

It may be noted that fish here means average fish production without reference to marine/inland, species and types. Similarly, the price refers to average price of fish. There are data limitations to be reckoned with.

Demand

The actual model is specified as

$$Y_i = b_0 \cdot P_{x1}^{b1} \cdot P_{x2}^{b2} \cdot P_{x3}^{b3} \cdot P_{x4}^{b4} \cdot P_{x5}^{b5} \cdot P_{x6}^{b6} \cdot P_{x7}^{b7} \cdot P_{x8}^{b8} \cdot I^{b9} \cdot d_iD$$

Where, Y_i = Quantity of fish consumption per capita over 30 days
P_{x1} = Price of milk
P_{x2} = Mutton & goat meat prices
P_{x3} = Beef & buffalo meat prices
P_{x4} = Chicken prices
P_{x5} = Egg prices
P_{x6} = Fish prices
P_{x7} = Other food prices
P_{x8} = Non-Food prices
I = Expenditure (proxy for income)
bi and di are the coefficients for the structural and dummy variables, respectively. Dummy variables for regions (north, east, west, south and hills) were specified in the analysis. Both dependent and independent variables are taken in log form in the functional analysis.

When the above demand model was estimated, the coefficient relating to expenditure came out to be negative (-1.47) for pooled analysis and -1.17 for rural and -0.92 for urban (Appendix I). Since these coefficients are not convincing, we examined the data set again and tried to recast the model. Since the consumer behaviour with respect to fish would be normal and stable in fish eating states, we wanted to go for demand analysis with respect to fish eating states only. Fish eating state was decided on the basis of average fish consumption (kg) per person for 30 days estimated for that state nearer to the national average. Thus, 12 urban and 9 rural states/union territories (UTs) were selected and 21 in pooled analysis

(Appendix II). Since the number of observations have drastically come down by doing this, we decided to specify the demand model only in terms of own price and expenditure unlike demand system estimated earlier. Thus, the final demand model used in the study for rural/urban/pooled sample is specified as:

Recasted Demand Model

$Y_i = b_0 \cdot P_f^{\,b1} \cdot I^{\,b2}$

where

Y_i = Quantity of fish consumption per capita over 30 days.

P_f = Fish prices

I = Income/Expenditure

bi are the coefficients for the structural variables. Both dependent and independent variables are taken in log form in the functional analysis.

Estimation Procedure

Supply

The data for each commodity consists of 29 years observation sets. The estimates of price coefficient generally assume expected positive signs and exhibit a high degree of precision. Linear and Polynomial regression models are used for estimation of regression coefficients. The equations are estimated using the standard OLS method. The lagged model is finite and includes only exogenous lagged variables. The estimated response functions incorporate price lags of 1 to 2 years. Elasticities are estimated by using the formulae, where E_p = supply elasticity, b = co-efficient (regional productions), p = the average production, y = average quantity.

The value of R^2 (adjusted) is fairly satisfactory in the supply response functions of fish. This suggests that the relative prices, fish seed and technological and biological developments (proxies for time trend) have played a significant role in enhancing the production of fish in India.

Demand

The data for estimation of fish demand consists of 21 observation sets representing rural and urban populations across 21 states. We have estimated the demand response function with double log specification using Ordinary Least Square (OLS) procedure. The estimated coefficients provided elasticities. The variables included in the model explained 73 per cent of the variability in rural, 46 per cent in urban and 52 per cent in pooled analysis (Table 4).

Projections through 2020 were made by using simple growth rate model based on estimated expenditure elasticities, population and per capita income growth rates and urbanisation[1] .

Results

In the 1960s, India made headlines with its Green Revolution, using high yielding varieties (HYVs) seeds and improved technology to more than double its output of wheat between 1965 and 1972. Today, India is marching ahead with Blue Revolution, by rapidly increasing fish production in small ponds and water bodies, benefiting small farmers, as well as contributing to nutritional food security and national income.

Changes in structure of fish production in India

The fish production scenario during 1950 to 2000 has been shown in Table 1. Fish production in India has increased steadily from 7.5 lakh tonnes in 1950-51 to 56.6 lakh tonnes in 1999-00. Marine fisheries remained the major contributor till 1990-91. Its contribution to total fish production by 1960-61 was over 75 per cent, but it declined drastically to 61.93 per cent in 1970-71. Since then, it remained almost constant till 1990-91. In the nineties, fish production structure underwent substantial changes. The share of inland fisheries increased drastically reaching to 50 per cent in

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[1] Assumptions:

Population growth at 1.63%, 1.54%, 1.40%, 1.51% per annum in 1993-2000, 2000-2010, 2010-2020 and 1993-2020 respectively.

Per capita Income at 1.46%, 3.62% and 3.49% per annum (rural, urban and pooled) respectively. Urbanisation: It is assumed that the pace of urbanisation will be consistent with the recent historical trend.

$D_t = d_o * N_t (1+ y * e)^t$; Where, D_t is the household demand for a commodity in year t ; d_o is the per capita demand of the commodity in the base year; y is the growth in per capita income; e is the expenditure elasticity of demand for the commodity; and N_t is the projected population in year t.

Table1. Changes in structure of fish production in India

(in lakh tonnes)

Year	Marine	Inland	Total
1950-51	5.3 (70.67)	2.2 (29.33)	7.5 (100)
1960-61	8.8 (75.86)	2.8 (24.14)	11.6 (100)
1970-71	10.9 (61.93)	6.7 (38.07)	17.6 (100)
1980-81	15.5 (63.52)	8.9 (36.48)	24.4 (100)
1990-91	23.0 (59.89)	15.4 (40.10)	38.4 (100)
1999-00	28.3 (50.00)	28.3 (50.00)	56.6 (100)

Figures in parentheses represent percentage to the total.
Source: Economic Survey, 2000-2001.

1999-00. These changes were due to deceleration in growth of marine fish production and a policy shift in favour of inland fisheries, particularly aquaculture.

Trend in Fish Production in India

The trend in fish production during 1950-2000 has been shown in Table 2. Since 1950-51 fish production has been increasing at a rate of 4.12 per cent a year. The inland sector contributed increasingly to the observed growth; inland fish production grew at an annual rate of 5.24 per cent. A desegregated view of pattern of growth shows acceleration in growth of inland fish production during the nineties. On the other hand, growth in marine fish production decelerated to 2.09 per cent during 1990-99 from 4.02 per cent during 1980-90.

Table 2. Growth Trend (%) in fish production in India

Period	Marine	Inland	Total
1950-51 to 1959-60	5.20	2.44	4.45
1960-61 to 1969-70	2.16	9.11	4.26
1970-71 to 1979-80	3.58	2.88	3.32
1980-81 to 1989-90	4.02	5.64	4.64
1990-91 to 1999-00	2.09	6.99	4.4
1950-51 to 1999-00	3.41	5.24	4.12

Source: Economic Survey, 2000-2001.

Fish Supply Response

Estimates of fish supply response through linear and polynomial price lag models (transformed) are presented in Table 3. The supply response equations are shown in Appendix III.

Table 3. Estimates of the fish supply

Equations/Variables	Linear regression	Polynomial regression (transformed model)
Constant	-246.98	574.23
	(-0.719)	(1.117)
Price/ Price W_0	0.1976 *	0.8467 *
	(2.697)	(2.396)
Price W_1	-	-1.1673
		(-1.004)
Price W_2	-	0.4979
		(0.56)
Fish seed	0.2978 *	0.3968 *
	(5.818)	(5.933)
Time	0.133	-0.282
	(0.762)	(-1.085)
$\mathbf{R^2}$	0.972	0.978
$\mathbf{R^{-2}}$	0.968	0.968

Figures in parentheses represent t values
*1 per cent level of significance

Estimates of Linear Regression Model

In conformity with theory, fish price coefficients are positive. Highly significant price coefficients for fish were noticed, implying that higher prices stimulate fish production. Fish seed is used as a variable and it is found to be significant indicating that the availability of fish seed would enhance fish production. Time variable, which represents technological and other structural changes in the fish sector, as expected, is positive.

Estimates of Polynomial Price Lag Model

Fish price coefficients are significant at 1 per cent level, implying that higher prices stimulate the production of fish. It indicates scope of favourable price policy to enable fish farmers to increase investments to improve production of fish. However, time coefficient was negative and non-significant. Fish seed coefficient is positive and significant indicating its availability would increase fish production.

The estimated supply response functions are robust in terms of explaining variability in fish production. The price impact in the first period is positive and significant, indicating the influence of immediate previous lag price on production of these products. It is interesting to note that the dynamic price impact (as depicted by the delayed price coefficients) increases first with lag, then decreases and finally increases indicating cobbweb type situation leading to rise and fall of production with response to price changes.

Fish Demand

The expenditure and price elasticities of recasted model are shown in Table 4. The demand response equations are shown in Appendix IV. These results clearly show that the expenditure elasticity for fish in general, is elastic. It indicates that if consumer's income increases he would spend more on fish

Table 4. Estimates of the fish demand

Elasticity	Rural	Urban	Pooled
Intercept	-5.815	-0.186	-1.273
	(-2.246)	(-0.090)	(-0.918)
Expenditure	2.689 *	0.600	1.046 **
	(2.866)	(0.80)	(2.006)
Own price elasticity	-0.702 ***	-1.040 **	-1.004
	(-1.755)	(-2.587)	(-0.651)
R^2	0.735	0.46	0.525
R^{-2}	0.646	0.34	0.473

Figures in parentheses represent t values.

* 1 per cent level of significance

** 5 per cent level of significance

*** 10 per cent level of significance

particularly in rural areas. Own price elasticity in rural areas is negative, inelastic; elastic in urban and pooled sample. Thus, both income and price changes affect the demand for fish. It is to be noted that our estimates are based on conventional determinants of demand and the structural ones like change of tastes and lifestyle of people, income distribution of consumers, market availability etc. are left out for want of data. Similarly, the price effects of substitute commodities are not examined. Future work in this area should consider these gaps, to estimate the demand system framework to address fast changing structural transformation in society.

Demand - Supply Gap

Projected production (supply) and consumption (demand) figures for fish during 2020 are shown in Table 5. The baseline scenario revealed that the actual production level for fish closely follows its consumption. It may be noted that Kumar's study (1998) under the assumption of 5 per cent GDP growth rate, estimates fish production of 5.7 million tonnes in 2000 and 11.8 million tonnes in 2020 with a growth (1995-2020) rate of 3.75 per cent. However, in 2020, substantial surpluses are expected in fish of about 4.48 million tonnes. The results clearly illustrate the potential of the fish sector and needed strategies to harness it domestically and through exports.

The expected production growth rates of fish, exceeded the corresponding consumption demand rates by more than 1 per cent. Comparison of projected fish production and consumption in 2020 shows a somewhat different story. The surplus production of 4.48 million tonnes of fish needs to be planned for exports or promoting fish eating in non-fish eating states. It is generally felt that post-harvest infrastructure is grossly inadequate in fisheries sector.

Table 5. Projections of fish production and domestic consumption.

Supply/Demand	Year 2000	Year 2020	Growth Rate
Production*	5.66	13.0	4.4
Consumption**	4.45	8.52	3.3
Surplus	1.21	4.48	

* The production growth rate is assumed to grow at 4.4% p.a. as it was during 1990-2000 (Table 2).

** Consumption figures are weighted averages (weighted by rural and urban population divided by total population)

Marketing, transportation, storage, processing and packaging, will be helpful to handle the expected surplus. Also major initiatives are needed for the development of the domestic market (Government of India 1996). It is reported that fish is sold on the roadside and there is no organised effort in marketing of fish. Studies are needed in the areas of price margin, marketable surplus, marketed surplus and price spread. Studies are also needed in the areas of utilisation by catch and diversification in both harvest and post harvest activities including pharmaceuticals, industrial, chemical and medicinal fields. Providing quality fish to markets away from production centres will be a major challenge in the future. Setting up of inland fish marketing units and development of retail markets in non-fish eating states/places should receive priority attention.

India's share in the booming world trade of fish is less than 2 per cent, which is very low considering the huge export potential for exports. The development of transportation facilities such as availability of steamers to different countries in the world and transportation of refrigerated containers have to be vigorously persued to clear the surplus. Since several importing countries are stipulating stringent quality control for marine products, modernisation of the processing facilities to meet international standards assumes significance. Setting standards for intermediary inputs like feed, seed etc. are also critical. Thus, quality control, exports promotion and marketing strategies need to be persued more aggressively, keeping in view the dynamic nature of the export markets.

Conclusions and Policy Implications

India is marching ahead with blue revolution. Fish production in India has increased steadily from 7.5 lakh tonnes in 1950-51 to 56.6 lakh tonnes in 1999-00. Marine fisheries remained the major contributors till 1990-91. The share of inland fisheries increased drastically reaching to 50 per cent in 1999-00. These changes were due to deceleration in growth of marine fish production and a policy shift in favour of inland fisheries, particularly aquaculture.

The lagged price impact in the first period is positive and significant indicating the influence of immediate previous lag price on production. It is interesting to note that the dynamic price impact (as depicted by the delayed price coefficients) increases first with lag, then decreases and finally increases indicating alternative year wise rise and fall of production with response to price changes.

The recasted demand model clearly shows that both income and price changes affect the demand for fish. In conformity with theory, supply price coefficients are positive and highly significant. It clearly shows that production elasticities of fish is highly price elastic. It needs reorientation of price policy to create the environment in which fish farmers will increase investments to further improve production of fish. Since fish seed availability would increase fish production, attention to supply quality fish seed should receive greater attention.

The results relating to supply-demand gap clearly indicated that in 2020, India would be having 4.48 million tonnes surplus in fish produce. The surplus production of this magnitude would need to be either exported or to be domestically consumed mostly by the people in non-fish eating states. This requires substantial investment in post-harvest management, storage, transportation, processing, packaging and marketing. For promoting exports, quality control of both inputs and output, export promotion and marketing strategies need to be persued more aggressively, keeping in view the dynamic nature of the export markets. So there is need to develop domestic market and also to formulate sound export policy for fish.

Finally, future studies in this area should consider the demand system as a whole and estimate the elasticities to gain better insights for effective policy analysis. However such studies require detailed and accurate information and data on fisheries production, consumption, sale (trade) which are at the moment fragmented and rather inadequate.

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Appendix I. Estimates of the Fish Demand Response Model

Elasticity	Rural	Urban	Pooled
Intercept	-0.473	-9.0742	-2.4256
	(-0.0600)	(-0.9724)	(-0.5600)
Expenditure	-1.1661	-0.9227	-1.4702 *
	(-1.2397)	(-0.9363)	(-2.4735)
Own price elasticity			
Fish	-3.4816*	-2.1048**	-3.4203*
	(-4.2787)	(-2.0933)	(-6.4348)
Cross price elasticity			
Milk	6.0601*	6.1637*	5.9048*
	(4.5147)	(2.9403)	(6.1283)
Mutton and goat meat	1.7597*	4.6880*	2.9749*
	(2.1954)	(2.9350)	(3.6757)
Beef and Buffalo meat	1.1268***	0.0075	0.9696*
	(1.4741)	(0.0108)	(2.3726)
Chicken	-0.50008	-0.9742**	-0.8096*
	(-0.4621)	(-2.2502)	(-2.4132)
Egg	-3.0541**	1.0795	-0.9055
	(-2.1573)	(0.6450)	(-0.9066)
Other foods	2.0459	-2.9341	0.4042
	(0.7402)	(-0.8471)	(0.2832)
Non food	-2.3181**	3.78666**	-0.1869
	(-1.7722)	(2.0395)	(-0.2290)
Regional Dummies			
North	-0.8713	-0.8441**	-0.8869*
	(-1.2397)	(-1.7878)	(-2.7520)
South	-1.3564*	-1.5086*	-1.3257*
	(-2.5330)	(-3.3235)	(-4.9548)
East	-0.7251***	-0.7437***	-0.8309*
	(-1.4608)	(-1.3561)	(-2.5233)
West	-0.3088	-0.2603	-0.1144
	(-0.7156)	(-0.6774)	(-0.4353)
R^2	0.92	0.91	0.88
$\bar{R}^2$	0.87	0.84	0.85

Figures in parentheses represent t values.
*1 per cent level of significance,
** 5 per cent level of significance,
*** 10 per cent level of significance.

Appendix II. Fish Per Capita Consumption Per Person Per 30 Days

Sl No.	State	Rural (Kg)	Urban (Kg)
1	Arunachal Pradesh		0.29
2	Assam	0.43	0.43
3	Goa	1.36	1.36
4	Kerala	1.35	1.35
5	Manipur		0.34
6	Meghalaya		0.32
7	Tripura	0.89	0.89
8	West Bengal	0.54	0.54
9	A & N Islands	1.40	1.40
10	Daman & Diu	4.12	4.12
11	Lakshadweep	3.61	3.61
12	Pondicherry	0.69	0.69

Appendix III. Supply Equations of Linear and Polynomial Price Lag Model

Linear Model

$$S_{pf} = -246.98 + 0.1976\,fp + 0.2978\,fs + 0.133\,t \qquad R^{-2}\ 0.968$$
$$(-0.719)\quad(2.697)\quad(5.818)\quad(0.762)$$

Polynomial price lag model

$$S_{pf} = 574.23 + 0.8467\,fw_0 - 1.1673\,fw_1 - 0.4979\,fw_2 - 0.3968\,fs \quad -0.282\,t \qquad R^{-2}\ 0.968$$
$$(1.117)\quad(2.396)\quad(-1.004)\quad(0.56)\quad(5.933)\quad(-1.085)$$

Numbers in parentheses are t^{-} values.

Appendix IV. Recasted Demand Equations of Rural, Urban and Pooled

Rural

$$C_r f = -5.815 \;\; -0.702\, P_f + 2.689\, I \qquad \bar{R}^2 = 0.65$$
$$(2.589) \;\; (0.400) \;\; (0.938)$$

Urban

$$C_r f = -0.186 \;\; -1.004\, P_f + 0.600\, I \qquad \bar{R}^2 = 0.34$$
$$(2.067) \;\; (0.388) \;\; (0.749)$$

Pooled (Rural + Urban)

$$C_r f = -1.273 \;\; -1.040\, P_f + 1.046\, I \qquad \bar{R}^2 = 0.47$$
$$(1.385) \;\; (0.259) \;\; (0.522)$$

Numbers in parentheses are Standard Errors.

4

Profile of Key Inland Freshwater Aquacultural Technologies in India

Pradeep K. Katiha, J.K. Jena and N. K. Barik

Introduction

The inland fisheries in India include both capture and culture fisheries. Capture fisheries have been the major source of inland fish production till mid eighties. But, the fish production from natural waters like rivers, lakes, canals, etc., followed a declining trend, primarily due to proliferation of water control structures, indiscriminate fishing and habitat degradation (Katiha 2000). The depleting resources, energy crisis and resultant high cost of fishing, etc., have led to an increased realisation of the potential and versatility of aquaculture as a viable and cost effective alternative to capture fisheries. During past one and half decade, the inland aquaculture production has increased from 0.51 to 2.38 million tonnes, while for inland capture fisheries the same has declined from over 0.59 to 0.40 million tonne (Anonymous 1996a,b; Anonymous 2000; Gopakumar *et al*. 1999). The percentage share of aquaculture has also increased sharply from 46.36 to 85.65 per cent. It is primarily because of tremendous 4.5 fold increase in freshwater aquaculture. Its share in total inland fish production has also increased from 27.95 per cent to 66.4 per cent (Anonymous 1996a,b; Anonymous 2000). Still, it has greater scope for enhancing fish production.

In India, aquaculture witnessed an impressive transformation from highly traditional activity to well developed industry. With rich resource base both in terms of water bodies and fish species, the investments in this sector are following an increasing trend. The recent estimates of freshwater aquacultural production around 2.0 million tonnes contributed over one third of total fish production of India. This outcome is primarily propelled by the appropriate technologies, financial investments and entrepreneurial enthusiasm. The success stories of intensive fish culture started from Kolleru lake basin in Andhra Pradesh in mid-eighties and virtually replicated in states like Punjab, Haryana, Uttar Pradesh and so on (Gopakumar *et al*. 1999).

By virtue of its geographical situation in monsoon belt, India is endowed with good rainfall and consequently extensive aquacultural water bodies. The inland aquacultural water resources in the form of ponds and tanks have been distributed over almost all the states of India. Despite immense efforts for horizontal expansion of this industry, only one third of the area could be brought under scientific fish culture. This untapped production potential can be harnessed through effective and intensive adoptions of available technologies, transfer of technical know how and provision for material inputs. Flexibility in areas of operation and scales of investments and compatibility of freshwater aquaculture practices with other farming systems coupled with high potentials of eco-restoration have provided congenial environment to establish it as a fast growing activity. Considering its potential and impressive annual growth rate of over 6 per cent, Government of India is also emphasizing on aquaculture development. The national freshwater aquaculture development plan proposed to increase the area under aquaculture to 1.2 million ha, with average productivity of 2762 kg/ha per year (Gopakumar *et al*. 1999). To achieve this goal, suitable strategies for enhancement of area coverage and productivity are needed considering components of horizontal and vertical expansion in concurrence with the potential and problems of different states.

Key Freshwater Aquacultural Technologies

The researches on aquaculture technologies got momentum only in seventies at Central Inland Fisheries Research Institute (CIFRI), Barrackpore under All India Coordinated Research Projects on Composite Fish Culture, Air-breathing Fish Culture, Riverine Seed Prospecting and Fisheries Management of Freshwater Reservoirs. Later, a new co-ordinated project on brackishwater was framed. Aquaculture research in India received the momentum, when a separate centre called Freshwater Aquaculture Research and Training Centre (FARTC) was established at Dhauli, Bhunbaneswar (Orissa). In 1986, it has got the status of independent ICAR institute and named as Central Institute of Freshwater Aquaculture (CIFA). These two institutions are the pioneers in development of aquacultural and culture based fisheries technologies. A brief profile of aquacultural technologies developed is presented in this chapter.

These technologies may be categorised into technologies for fish seed production and production of table size fish or aquaculture. Both seed production and aquacultural technologies are for different categories of fishes, *i.e.* carps and catfishes including air-breathing fishes, so, described separately. The first part deals with technologies for seed production and fish breeding and second with aquaculture or production of table sized fishes.

Fish Breeding and Seed production

Induced Breeding

The development of indigenous technique of hypophysation has revolutionized the seed production of major carps. The eco or circular hatcheries, based on the technology of induced breeding of carps with pituitary gland extract (PGE) are used for commercial fish seed production of Indian and Chinese carps. Under this technology sexually mature fishes which do not breed in captivity are bred in ponds by PGE to spawn them in captivity. Although, this technology was evolved as early as 1956-57, it took over decade to popularize in India through All India Co-ordinated project on “Seed Production and Composite Fish Culture”. This technique has revolutionized the carp seed production enormously. Nowadays, the synthetic hormone ‘Ovaprim’ is used as a successful substitute of pituitary hormone.

Intensive carp seed rearing

Availability of adequate quantity of carp seeds of desired species at appropriate time is one of the pre-requisite for success of aquaculture operations. The availability of standard stocking materials in time and space still remains a constraint, despite domestication of induced breeding technology and production of carp seed to the tune of over 16,500 million fry in the country. The raising of seeds in the initial stages is associated with high rates of mortality due to several management problems (Anonymous 2000a). Thus, it is essential to follow standardized package of practices for higher growth and survival in intensive seed raising at higher stocking densities, leading to hypoxic conditions and competition for food and space.

The different standardized package of practices for intensive seed production propose measures to control predatory and weed fish, plant derivatives and soap-oil emulsion to control insects, organic and inorganic fertilizers for fertilization of ponds, stocking densities for carp species for mono-culture, supplementary feed, standard or optimum physio-chemical parameters for management of water quality and standard methods for monitoring health-care, etc.

The technology of intensive seed production includes

- Eco or circular hatchery or collection of spawn from natural abode;
- Raising the spawn to fry in nursery ponds; and
- Rearing of fry to fingerlings in ponds

Eco or circular hatchery

The essential features of the eco-hatchery are:

i) Tube well or a dependable source of potable water.
ii) Overhead tank (25000 to 30000 liter capacity) with arrangement of continuous water supply to various hatchery components.
iii) Circular spawning pool (8 m diameter) capable of holding the spawners and male population.
iv) Incubation pool is a circular double walled chamber of 3m diameters. The eggs are released in the outer chamber. The water intake through floor mini pipes prevents eggs to settle down. The hatchlings are kept in the outer chambers for 72 hours.
v) Spawn collection pool is rectangular in shape. The spawn is collected in a rectangular sac like cloth piece called *hapa*.

From the earthen pits to double walled *hapa* hatcheries and associated modifications, carp hatcheries have come a long way in terms of running water glass jar or circular hatcheries (Bhowmick 1978; Dwivedi and Rabindranathan 1982; Dwivedi and Zaidi 1983; Jhingran and Pullin 1985 and Rath and Gupta 1997). These eco-hatcheries have not only provided the scope to produce and handle mass quantities of eggs during hatching but also to greater extent reduced the requirement of water and manpower.

Raising fry from spawn

Generally the size of nursery is 0.04-0.1 ha. The pond preparation includes treatment of the ponds with Mahua oil cake (MOC) atleast 15 days prior to stocking for eradication of unwanted fishes and application of lime. The fertilization includes application of groundnut oil/ mustard oil cake @ 700 kg, cow dung 200 kg and 50 kg single super phosphate per ha, after making a thick paste of the three ingredients. These are applied in three doses i.e. 50 per cent of the paste 3 days before stocking, 25 per cent 5 days after stocking and remaining 25 per cent 10 days after stocking

Stocking density is 3-5 million spawn per ha is usually followed by fish farmers in earthen nurseries, however the intensity can be as high as 10-20 million spawn in cemented nurseries (Jena *et al*. 1998a). Generally mono-culture is done for raising the fry.

The supplementary feed applied is the mixture of rice bran and oil cake at 1:1 ratio. The feeding is done @ 6 kg per day per million spawn for first 5 days followed by 12 kg per day per million spawn for next 10 days, in spilt doses during early morning and evening hours(Jena *et al*. 1998b).

The rearing period is usually for a period of 15 days during which the fry attain a size of 25-30 mm.

In the beginning, during 1950s, the survival rate was 10-20 per cent, but at present it is 50-60 per cent

Rearing of fry to fingerlings

Generally the size of rearing pond is 0.1-0.2 ha. The pond preparation is almost same as that of nursery for raising fry to fingerlings. It includes MOC treatment of the ponds atleast 15 days prior to stocking, eradication of unwanted fishes and application of lime. Fertilization includes application of both organic and inorganic fertilizers at conventional doses (Jena *et al*. 1998b).

The stocking density is 0.1-0.2 million fry per ha. The rearing may be done as poly-culture for raising the fingerlings.

Rice bran and oil cake in ratio of 1:1 are provided as the supplementary feed. The doses of feed over the rearing period are 8-10 per cent of fish biomass per day in first month, 6-8 per cent of fish biomass per day in second month and 3-5 per cent of fish biomass per day in third month.

The rearing period is two to three months till the fingerlings attain a mean size of 100 mm in length and 10 g in weight.

Initially the survival rate was very low, but now it is 60-80 per cent.

Cost and returns of seed production

The process of fish seed production has three stages namely, spawn, fry and fingerlings. Therefore, its economics has been worked out for raising fry from spawn, 3-4 crops may be taken in a year leading to production of 3.6 to 4.8 million fry. The major components of the operating cost were value of seed and lease value. The benefit cost ratio was 1.5 for nursery management. At the other stage of rearing of fry to fingerling the costs incurred on feed, lease value and seed cut the major share in cost. The

Table 1. Economics of seed production

Item Area	Nursery 1 ha	Rearing 1 ha
Lease value (Rs/crop for nursery & Rs/ year for rearing)	5000	15000
Pond preparation		
Predatory and weed fish clearance	7500	7500
Insect control	1000	
Fertilisation	7500	4000
Seed(Spawn 3 million, fry 2 lakh)	15000	12000
Supplementary feed	4500	24000
Labour charges	5000	12000
Miscellaneous	2000	3000
Total cost	47500	79500
Returns (Survival rate 40%)	72000	
Returns (Survival rate 75%)		105000
Profits	24500	25500

average number of fingerlings produced were 0.15 million per ha. The benefit cost ratio was 1.32.

Breeding and Seed Production of Catfishes, Magur and Singhi

The air-breathing catfishes *Clarias batrachus* (magur) and *Heteropneustes fossilis* (singhi) are well adapted to adverse ecological conditions, viz., water bodies with low oxygen and pH, high CO_2, H_2S, CH_4 and heavy silt with decaying vegetation, organic load, etc. These can be stocked @ 20,000-50,000 fingerlings per ha, which attain 100-200 g in 6-8 months (Anonymous 2000a).

Management of Brood Stock

Proper care and maintenance and provision of balanced supplemented feed play a key role in achieving successful spawning. The brood fishes are stocked generally in flow through (21 per min) cement cisterns (3 m X 1 m X 1m) with 10-15 cm thick soil base, an inlet at the top of cistern and outlet at about 20 cm from the bottom.

Induced Breeding Technique

Following standardized induced breeding technique, using different inducing agents like carp or catfish pituitary extract, ovaprim, HCG, LHRHA + Domperidone, etc. the species can be bred from March to September.

The incubation time in singhi is less than magur. Proper flow through system is used for incubating eggs to make seed available over a longer period of a year.

Larval Rearing

The newly hatched larvae reared for a period of 15 days in indoor conditions are stocked at density 2,000-4,000 per sq. m in well aerated water till air-breathing habit commences. They are fed with mixed zooplankters or *Artemia* larvae or *Tubifex* spp. with replenishment of water at least twice a day initially for a few days, followed by compounded supplementary feed. The laboratory reared fry are ready to be reared in earthen nursery ponds or outdoor cement cisterns (4m x 1 m x 0.5m) with soil base, after 10-12 days at 200-300 per sq. m to raise fingerlings of 6-8 cm in a month. Survival levels over 60 per cent may be obtained during raising of fingerlings under optimum rearing conditions.

Grow out Culture for Table size Fish Production

India's aquaculture is basically carp-oriented and the contribution of other species is marginal. The carps both Indian and exotic contributed over 90 per cent of freshwater aquaculture production. The major freshwater culture technologies (Table 2) may be classified into the following types:

1. Polyculture of Indian carps or Indian and exotic carps together (Composite carp culture)
2. Mono- and polyculture of air-breathing fishes
3. Mono- and polyculture of freshwater prawns
4. Integrated fish farming
5. Cage culture
6. Pen culture
7. Pearl culture

The prevalent freshwater aquacultural technologies along with their cultural practices are summarised in Table 2.

a) Low input or fertiliser based system
b) Medium input or fertiliser and feed based system
c) High input or intensive feed and aeration based system
d) Sewage fed water based system
e) Aquatic weed-based system
f) Livestock based or Integrated fish farming

Species mix

The species mix of 3-6 carps has been most prevalent including three indigenous (*Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*) and three

Table 2. Cultural practices under different aquacultural technologies

System	Species	Stocking **(In 000 fingerling ha^{-1})**	**Fertilization / Liming ha^{-1}**	**Feed day^{-1}**	**Management Practices**	Duration of rearing (Month)	Average yield **(t ha^{-1} yr^{-1})**
Low input	3-6 species	3-5	Cow dung 10-15t/ Poultry droppings 3-5t, Urea 2q, SSP 3q,	No feed	Fertiliser use, maintenance of water depth at 1.5-2.5 m	10-12	1-2
Medium input	3-6 species	5-10	Cow dung 10-15t/ Poultry droppings 3-5t, Urea 2q, SSP 3q,	Rice bran and oil cake, @ 2-3% of fish biomass	Maintenance of water depth at 1.5-2 m, Inter-mediate liming at 3 month interval @100kg ha^{-1}	10-12	3-6
High input	3-6 species	15-25	Less use of organic manure, Bio-fertilization with *Azolla*, SSP	Rice bran, oil cake, fish meal, Vitamin and mineral mix, @ 2-3% of fish biomass,	Aeration, water exchange towards later part, intermittent liming at every quarter @100kg ha^{-1}, maintenance of water depth at 2-2.5 m	10-12 Periodical harvest	10-15

SSP –Single super phosphate

Contd…….

……… contd Table 2

System	**Species**	**Stocking (In 000 fingerling ha^{-1})**	**Fertilization / Liming ha^{-1}**	**Feed day^{-1}**	**Management Practices**	**Duration of rearing (Month)**	**Average yield ($t\ ha^{-1}\ yr^{-1}$)**
Sewage fed	3-6 species + *L. bata, C. reba*	30-50 (total in 2-4 intermittent stocking)	Domestic Sewage water	No feed	Multiple stocking and multiple harvesting (Size 100-200gm), Maintenance of water depth at	**8-10**	2-5
				With feed	0.7- 1.5 m		**3-7**
Weed based	50% Grass carp and 50% other species	4-5	SSP 3q for one crop to be applied at 15 days interval Liming @ 100 kg / quarter	Aquatic weed (*Hydrilla, Najas, Ceratophyllum*, Duck weeds like *Spirodella, Lemna, Wolffia*, etc.	Maintenance of water depth at 1.5-2 m	**10-12**	**3-4**
Integrated: Cattle (3 – 4 ha^{-1}) Duck (300 ha^{-1}) Poultry (500 ha^{-1}) Pig (50 ha^{-1})	3-6 species	5-10	No fertiliser use, liming	Rice bran and oil cake, 2-3% of fish biomass	Maintenance of water depth at 1.5-2 m	**8-10**	**3-5**
Paddy- cum-Fish	3-6 species and Medium & Minor carp	5-10	Cow dung 10-15 t	Rice bran and oil cake, 2-3% of fish biomass	Maintenance of water depth at 1.5-2 m in pond	**6**	**0.5-2.0 of fish 3-6 of paddy**

.... contd Table 2

System	Species	Stocking (In 000 fingerling ha^{-1})	Fertilization / Liming ha^{-1}	Feed day^{-1}	Management Practices	Duration of rearing (Month)	Average yield (t ha^{-1} yr^{-1})
Pen	3-6 species	5-10	Liming	Rice bran and oil cake, 2-3% of fish biomass	Maintenance of water depth at 1.5-2 m	**8-10**	**3-5***
Cage	Single species			**Experimental stage**			**10-15***
Running water	Single species			**Experimental stage**			**20-50***
Air-breathing	Mono-culture	20-50	Cow dung 10-15t/ Poultry droppings 3-5t, Urea 2q/ha, SSP 3q	Rice bran, oil cake and Fish meal	Maintenance of water depth at 1-1.5 m	**8-10**	**3-6**
Freshwater Prawn	Mono-culture	20-50	Cow dung 10-15t/ Poultry droppings 3-5t, Urea 2q, SSP 3q	Palletted feed	Maintenance of water depth at 1-1.5 m	**6-8**	**1-1.5**
Polyculture of Carp with Prawn	2-3 species of carp + Prawn	Fish 5 + Prawn 10-15	Cow dung 10-15t/ Poultry droppings 3-5t, Urea 2q/ha, SSP 3q	Rice bran and oil cake, 2-3% of fish biomass	Maintenance of water depth at 1-1.5 m	**10-12**	**Fish 3-4 Prawn 03-0.5**

* kg m^{-2} yr^{-1}

exotic (*Hypophthalmichthys molitrix*, *Ctenopharyngodon idella* and *Cyprinus carpio*) carps. Some of the other fish species and species combination adopted for freshwater aquaculture technologies are *Labeo bata* and *C. reba* in sewage fed, *Ctenopharyngodon idella* (grass carp more than 50 per cent) in weed based, medium and minor carps, viz. *Labeo calbasu*, *L. gonius*, *L. bata*, *Puntius pulchellus*, *P. sarana* and *Cirrhinus cirrhosa* in integrated fish farming with paddy-cum-fish culture.

The low input or fertiliser based, medium input or fertiliser and feed based, sewage fed and weed-based are the carp culture practices having fish yield from 1-3 tonnes per ha, are considered as extensive technologies. The most important carp culture technology is composite fish culture or intensive carp culture therefore, considered for discussion in the present chapter.

Carp Polyculture or Composite Carp Culture

The research and development efforts during last five decades have greatly enhanced average fish yields in the country making carp culture an important economic enterprise. It has grown in geographical coverage, diversification of culture species and methods, besides intensification of farming systems. The three Indian major carps, *viz*., catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) were the principal species cultured by the farmers in ponds since ages and production from these systems remained significantly low (at 600 kg/ha/year) till the introduction of carp polyculture technology. The introduction of exotic species like silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*) into the carp polyculture system during early sixties also added new dimension to the aquaculture development of the country. With the adoption of technology of carp polyculture or composite carp culture production levels of 3-5 tonnes/ha/year could be demonstrated in different regions of the country. Probably it is the technology of carp polyculture that has virtually revolutionized the freshwater aquaculture sector and brought the country from a level of backyard activity to that of a fast growing and well organized industry and placed the country on the threshold of blue revolution. The average national production from still-water ponds has gone up from 600 kg/ha/year to over 2 tonnes/ha/year, with several farmers even demonstrating higher production levels of 8-12 tonnes/ha/year.

The standard recommended carp culture in India involves three species of Indian major carps or combination of three Indian major carps and three exotic carps, though adoption has been with several modifications depending on the market demand and resource availability. Standardized package of practices for carp poly culture include predatory and weed fish control by use of certain chemicals or plant derivatives; stocking of Indian major carps and exotic carps at densities of 4,000-10,000 fingerlings/ha; pond fertilization with application of organic manures like cattle dung or poultry droppings and inorganic fertilizers; provision of supplementary feed and water quality management. The researches over the years (Lakshmanan *et al*. 1971; Sinha *et al*. 1973; Chaudhuri *et al*. 1974, 1975; Chakrabarty *et al*. 1979; Saha *et al*. 1979; Sinha and Saha 1980; Tripathi and Mishra 1986; Rao and Raju 1989; Tripathi *et al*. 2000; Ayyappan and Jena 2001and Jena *et al*. 2002 a,b) have led to the development, refinement and standardization of host of technologies with varied production levels depending on the input use and finally resulted in technology of intensive carp culture.

Intensive Carp Culture Technology

The average production of the country from still water ponds is about 2 tonnes/ha/ year, with the packages of practices developed in the ICAR (Anonymous 2000a). There are possibilities of producing 10 tonnes and 15 tonnes/ha/ year. Standardized package of practices for intensive carp polyculture include:

i) predatory and weed fish control by use of certain chemicals or plant derivatives;
ii) pond fertilization with application of Azolla at 40 tonnes/ha/ year at weekly split doses as bio-fertilizer, substituting traditional organic and inorganic fertilization;
iii) stocking of Indian major carps and exotic carps of 25-50 g size at densities of 15,000-25,000 fingerlings/ha;
iv) provision of balanced formulated supplementary feed, comprising rice-bran, ground nut oil-cake, soybean flour, fish meal and vitamin mineral premix;
v) provision of 4-6 paddle-wheel aspirator/aerators per hectare of water to keep dissolved oxygen within desirable limits especially during night, maintenance of water column of 1.5-2 m;

vi) water replenishment depending on the water quality; and
vii) fish health management through prophylactic and curative measures depending on the necessity.

Though harvesting of the table-size fish is done usually at the end of 10-11 months, partial harvesting of bigger size fishes is done during monthly samplings, after a growth period of 6-7 months, which provides congenial environment for remaining fishes and also reduces amount of supplementary feed provision. Stocking of larger size of seed, preferably 25-50 g, minimizes mortality during initial months and thus leads to higher survival at harvest. Supplementary feed being major input, contributing over 60-70 per cent of input cost, needs judicious application and the quantities are decided based on the fish biomass present at any given point of time. Supplementary feed in the form of dry pellet, provided at 2-3 rations per day, helps in its effective utilization and minimal wastage.

Mono/ Polyculture of Air-breathing Fishes

The air-breathing fishes are distinguished by possession of an accessory respiratory organ, which enables them to survive for hours outside water or indefinitely in water with low oxygen content. These are extremely hardy for environmental stresses and adaptable for the waters unsuitable for conventional cultivable species.

Magur (*Clarias Batrachus*), singhi (*Heteropneustes fossilis*), koi (*Anabas testidineus*) murrels, giant murrel (*Channa marulius*), stripped murrel (*C. striatus*) and spotted murrel (*C. punctatus*) are the most important culturable species in India (Dehardrai *et al*. 1985).

The air-breathing fish culture is particularly oriented to shallow waters (2-3 ft depth). The material inputs needed are only the fingerlings (6-10 gm) and feed. Replenishment of water becomes an essential input in case of very heavy stocking and multiple cropping to obtain high yields. The pond size should be 0.1-0.2 ha, for effective management. Growth of magur and singhi goes very well upto water temperature 32^{o}C. Fishes are stressed around 35^{o}C and mortality starts at 38^{o}C. Collection of their seed from nature continues to be the dependable source for stocking material. The peak season for collection of seed is pre-winter period. Availability of air-breathing fish seed is in plenty in parts of Assam, Andhra Pradesh, Bihar, West Bengal and Karnataka. The fry rearing phase in murrels is complex due to cannibalism. It can be reduced with supplementary feeding.

The mono-culture of magur and singhi permits high stocking density (40-50 thousand), while for poly-culture with carps it varies between 20-30 thousand. For mono-culture of murrels the stocking density ranged between 15-25 thousand, with the lowest for giant and highest for spotted murrels. Feed for singhi and magur includes fish offal, slaughter house waste, dried silkworm pupae mixed with rice bran and oil cake in the ratio of 1:1:1. The mixture of rice bran, oil cake and bio-gas slurry in the ratio of 1:1:1 also proved successful. The feeding schedule varies over the culture period and for different species. Feeding may be done either by broadcasting the feed in small quantity or by lowering feed basket near the banks in addition to broadcasting. The culture period for these fishes may vary between 8-10 months with an average yield of 3-6 tonnes/ha.

Mono/Poly-Culture of Freshwater Prawn

In India, freshwater prawn culture is becoming popular. Mono-culture of *Macrobachium rosenbergii* and *M. malcolmsonii* and their polyculture with carps are common (Reddy *et al*. 1985; Jhingran 1991; Tripathi 1992). They are available in freshwater resources like rivers, streams, canals, beels, swamps, lakes, *etc*. The prawn seeds can be collected from natural resources or produced at government / private prawn hatcheries. Freshwater prawn culture can also be taken up in pens or cages. They feed on algae, insect larvae, molluscs, worms, smaller weed fishes, cereals, slaughter house wastes, oil cakes, etc. Fresh water prawns can tolerate very high range of salinity (upto 28 per cent), but salt concentration upto 5 to 6 per cent is preferred. Rectangular ponds of 0.1-2.0 ha size having unpolluted freshwater, with high concentration of oxygen are considered ideal.

Other culture methodologies are similar to carp farming. Liming and pond fertilization help freshwater prawn in attaining quicker and the healthy growth. Normally stocking density ranges from 20-50 thousand per ha. Male grow bigger than females and attain about 70 gm average weight in 6-8 months.

Periodic sampling to monitor the growth, survival and also to decide the feeding dosages, etc, is essential. The prawn so grown can attain marketable size in 6-8 months. The production ranging from 1-1.5 tonne/

ha can be achieved in scientifically managed system. Fresh water prawn farming is assuming greater importance due to very high demand, good price and high returns.

Integrated Fish Farming

Integrated fish farming is the link of two or more normally separate farming systems, which become sub systems of a whole farming system (Anonymous 2000a). Such farming systems can broadly be categorized into two types:

(i) systems with no direct byproduct utilization from one to other sub system, but optimal utilization of farming space and time e.g. paddy-cum-fish culture and

(ii) systems where, byproduct i.e., waste from one subsystem is being utilized for sustenance of other e.g., fish-pig/poultry/duck farming.

Paddy-cum-fish culture

The practice is undertaken in deep water bodies with fairly strong dykes to prevent escape of cultivated fishes during floods. Presence of channels, small ponds or sump near to the field is essential to give shelter to fish against heat and predators. In India, fish species like catla, rohu, mrigal, common carp, murrel, magur, etc. at 5,000-10,000 per ha are used in paddy-cum-fish culture. The excreta of fish and leftover supplementary feed help in fertilizing soil thereby increasing paddy production. Some fishes eat harmful insects and their larvae, which otherwise can cause problems to paddy. A production level of 0.5-1 tonne fish per ha and 3-6 tonnes paddy per ha can be achieved in a well managed system.

Fish-cum-cattle farming

The pond embankments can be used for cattle shed and their washings drained directly into pond. A better way to utilize dung is in the form of slurry. About 30-60 tonnes slurry per ha could be applied to pond. It has been estimated that dung and urine obtained from 3 to 4 cattle is sufficient to fertilize a pond of 1 hectare. The production levels of 0.5-2 tonnes/ha/year can be achieved from this system without addition of any supplementary feed.

Pig-cum-fish farming

The excreta from 30-50 pigs have been found adequate to fertilize 1 hectare pond. The pig waste acts as an excellent fertilizer and for some fish species this acts as feed. Production levels as much as 4 tonnes/ha/ year of fish have been achieved along with 16 tonnes pig meat per ha (live weight) from such an integrated farming.

Duck-cum-fish culture

Ducks feed on tadpoles, snails, flies, insects, etc. A total of 200-300 ducks are sufficient to fertilize 1 ha pond. The embankments are used for night shelter. During day when they are in search of food they also aerate pond water, in addition to helping in pond bottom raking effect. The fish yield from duck-cum-fish farming system ranges from 3-5 tonnes/ha/ year, in addition to 4,000-8,000 duck eggs and 2 tonnes duck meat per ha from the unit.

Poultry-cum-fish farming

In this system 500 country birds are adequate to fertilize 1 ha pond. The dosage of application of poultry manure is about one third the rate of cow dung. A production of 3-5 tonnes fish, 28,000 eggs and 5 tonnes meat per ha is expected from this farming system in a year.

Cage Culture

Intensive culture of fishes through non-conventional system like cage culture is gaining importance owing to higher productivity potentials of the systems and possibilities of higher revenue generation from unit water area (Anonymous 2000a). Culture of fish in cages is largely accepted all over the world because of its usefulness in exploitation of large water bodies, which otherwise are under-utilised for fish production, employment and income generation. Various lakes, tanks, and coastal waters can be brought under cage culture technique and can be practiced at various management levels. Cage cultures have many advantages, viz., large extent of larger water bodies can be utilized for aquaculture, which otherwise are not fully exploited for fisheries; high production per unit area can be obtained with high stocking density and intensive feeding; feeding and monitoring of stocks for growth and well being is easy; harvesting is simple and cages can be dismantled and reused in other locations as per requirement.

Cages are circular, cubic or basket like. These may be floating at the surface, just submerged or set at the bottom and enclosed at the bottom as well as sides by bamboo mesh, metal screens or netting (webbing) material.

Seed production and rearing in cages

In nursery phase of cage culture, spawn or early fry are reared to fingerlings within 2-3 months for stocking in grow out cages or other systems, by adopting high density stocking with supplementation of protein rich diet.

The fingerlings of carps can be raised in commercial scale in cages of 5 sq. m, with a depth of 1.5 m. In situations where nursing of fry in ponds is not feasible, cages can be conveniently used.

Grow-out production systems

The fish production levels obtained in grow out cages largely depend on the stocking density, species, provisions of inputs like supplementary feeding and overall management. The number of fishes that can be stocked in a cage depends on the productivity of the water body, rate of circulation, fish species, quality and quantity of feed supplied. The initial size of the fish to be stocked depends primarily on the length of the growing season and the desired size at harvest.

Carp fingerlings for stocking in 16-26 mm mesh cages should be of 10-15 g to expect a final size of over 500 g in a rearing period of 6 months. When natural fish food organisms are limited for high density rearing in cages, supplementary feeding forms the vital component of production. In carps, feeding is provided at 4-5 per cent of fish biomass per day until 100 g size and reduced thereafter to only 2-3 per cent

Pen Culture Technology for Floodplain Wetlands

The floodplain wetlands are commonly known as beels, mauns, chaurs or pats in various states of India. Though there is a great potential of more than 1,000 kg per ha production from floodplain wetlands, an average of 120-300 kg per ha is recorded. Most of these systems are weed choked and are under productive. Efficient use of popular gears is not practical in such water bodies. Till recently, the mainstay of fish production from these waters was through capture fishery. To boost fish production, shift of operation from mere extraction to capture-cum culture fishery has yielded better results.

The pen may be square, rectangular, oval, elongated or horseshoe shaped depending upon nature of banks, land and water depth. For better management pen area should be 0.1 – 0.2 ha. The pen consists of thick bamboo frame, split bamboo or cane screen covered with nylon net lining. Most of the wetlands are infested with unwanted flora and fauna, so, deweeding, eradication of unwanted fauna and liming is essential prior to fixation of the pen(s). The selection of fish species depends upon the productivity and group of flora and fauna. The species combination of indigenous and exotic carps with giant freshwater prawn (*Macrobrachium rosenbergii)* is proved to be successful, although, culture of *M. rosenbergii* alone is more profitable. The stocking density varies according to species combination, *e.g.* monoculture of carps – 4000-5000 per ha, carp + prawn culture 3,000-4,000 carps and 10,000-20,000 prawn per ha and for monoculture of prawn, it may be as high as 30,000-40,000 per ha. Most of the floodplains are rich in natural food. So, supplementary feed is required in special cases like monoculture of prawn. Pen culture can be done round the year, avoiding monsoon months. The culture period may vary between 4-6 months. Therefore, it is possible to take two crops in a year. The range of fish yield for carp culture is 4-5 tonnes/ha/ year, for carp + prawn is 2-2.5 tonnes/ha/ year carp and 0.3-0.5 tonne/ha/ year prawn and for monoculture of prawn 1.3 tonne/ha/ year.

Freshwater Pearl Culture Technology

Freshwater pearl culture is akin to cash crops of land based agriculture system and the technology is a privy to a very few countries in the world, viz, Japan and China. Cultured pearls are produced both in marine and freshwater environments. Freshwater pearl culture is more advantageous in terms of commercial scale availability of natural stocks of pearl mussels in easily accessible habitats, wider area of farming, even in non-maritime regions, operational easiness in management of freshwater culture environment, absence of natural fouling, boring and predatory organisms and overall cost effectiveness of operations. Realizing the potential and scope of inland pearl culture, a package of practices for producing cultured pearls from common freshwater mussels *Lammelidens marginalis, L.corrianus* and *Parreysia corrugata* has been developed (Anonymous 2000a).

The process include

i) Collection and conditioning of native pearl mussels
ii) Surgical implantation of mantle grafts and appropriate nuclei in internal organs of the mussels
iii) Post-operation care of implanted mussels
iv) Pond culture of implanted mussels in specially designed culture units in natural pond environment for 12 months

The pearl products developed at the CIFA includes:

i) Shell attached half-round and designed pearls
ii) Unattached non-nucleated oval to round pearls and nucleated larger round pearls and alternate nuclear material.

In addition to producing regular, free, round cultured pearls, irregular non-nucleated pearls and pearl images (up to 1.0 cm) have also been produced successfully, which are drawing attention of several entrepreneurs.

Cost and returns

The cost structure, returns and benefit cost ratios for different aquacultural technologies are presented in Table 3. Cost structure has primarily the items of lease value of the water body, cost of organic manure and inorganic fertiliser, seed, feed, management and harvesting. The specific costs related to particular technology included expenses on bird/animals in integrated fish culture, cost of paddy cultivation in paddy-cum fish culture, construction of pens in pen culture, etc. The feed is the most important component of cost,

Table 3. Cost and returns for different freshwater aquaculture technologies

(In Rs per ha)

Cost of Cultivation/ Culture	Carp Polyculture			Sewage fed		Weed Based	Integrated				Pen culture	Air-Brea-thing	Prawn culture	Carp-Culture Prawn
	Low input	Medium input	High input	without feed	with feed		Duck	Poultry	Pig	Paddy				
Cost														
Lease value (year^{-1})	10000	10000	10000	10000	10000	10000	10000	10000	10000	5000	2000	10000	10000	10000
Pond preparation	7500	7500	7500	7500	7500	7500	7500	7500	7500	2000	7500	7500	7500	7500
Fertilizers & Lime	10000	7500	7500	2500	2500	2500	2500	2500	2500	2500	7500	7500	7500	7500
Fingerlings (Seed)	3500	7000	20000	7000	7000	3500	3500	3500	3500	3500	7000	20000	30000	15000
Bird/Animal							3600	4000	4500					
Paddy										7500				
Pen											30000			
Feed (Birds/Animals)		60000	200000		30000		10000	50000	7500					
Fish Feed				7500	7500						20000	80000	60000	50000
Sewage cost														
Harvesting)	5000	15000	30000	10000	15000	20000	15000	15000	15000	15000	15000	30000	30000	15000
Miscellaneous	3000	5000	10000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Interest	2925	8400	21375	3713	6338	3638	4283	7313	4163	3038	7050	12000	11250	8250
Total cost	41925	120400	306375	53213	90838	52138	61383	104813	59663	43538	101050	172000	161250	118250
Fish yield (tonnes)	2.5	6	12.5	3	5	3	3	3	3	1	4	4	1.5	3
Gross returns	75000	180000	375000	90000	150000	90000	110000	148000	96400	60000	120000	240000	300000	190000
Profits	33075	59600	68625	36788	59163	37863	48618	43188	36738	16463	18950	68000	138750	71750
B:C ratio	1.79	1.50	1.22	1.69	1.65	1.73	1.79	1.41	1.62	1.38	1.19	1.40	1.86	1.61

Note : The meat obtained from Duck, Poultry and Pig is 2,5 & 16 quintals per ha respectively and eggs obtained are 8000 & 28000 nos. from ducks and poultry respectively. The values of these outputs were included in gross returns wherever applicable.

accounting for more than 50 per cent share in total cost. The lease value varied according to the fertility and property and management regimes of the water body. The cost of inputs varies according to intensity of their use across different technologies in accordance with requirements. The maximum cost was in case of high input carp culture (3.06 lakh) primarily due to feed cost. The lowest cost was for low input carp polyculture (Rs 41,925 per ha), due to absence of feed component. The net profit per ha ranged between Rs 16,462 for paddy cum fish culture to Rs 1.39 lakh in case prawn culture. The benefit cost ratio was maximum for prawn culture (1.86). For rest of the technologies, it is ranged between 1.22 for high input carp culture to 1.79 for low carp polyculture and duck cum fish culture.

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5

Marine Fishing Practices and Coastal Aquaculture Technologies in India

N.G.K. Pillai, Mohan Joseph Modayil and U. Ganga

Marine Capture Fisheries

Introduction

Among the countries bordering the Indian Ocean, India, endowed with 2.02 million sq. km of EEZ along a coastline of 8129 km and 0.5 million sq. km of continental shelf with a catchable annual marine fishery potential of 3.93 million tonnes occupies a unique position. Besides, there are vast brackishwater spread areas along the coastline which offer ideal sites for seafarming and coastal mariculture. Among the Asian countries, India ranks second in culture and third in capture fisheries production and is one of the leading nations in marine products export. The development of Indian marine fisheries from a traditional subsistence-oriented to an industrial fisheries over different Five Year Plans has been phenomenal. However, the present scenario is characterized by declining yields from the inshore waters and increasing conflicts among different stakeholders, whereas the increasing demand for fish in domestic and export markets indicate good prospects for large scale seafarming and coastal mariculture.

Fishery Environment

The total area of EEZ of India is estimated at 2.02 million sq. km against its land area of about 3.2 million sq. km. The continental shelf area between 0 and 50 m depth is estimated at 191.97 thousand sq. km and that between 0 and 200 m depth as 452.06 thousand sq. km. There are general topo-hydrographical differences in the features of the coastline and adjacent seas, distribution and abundance pattern of the species and their fishery characteristics along the west and east coasts. The primary and secondary productivities are higher on the west coast compared to the east coast, mainly due to the strong upwelling process, which therefore supports a more abundant fishery. The northwest coast (15°-23°N latitude) has extensive fishing grounds and the sea bottom is generally muddy while the southwest coast (8°-15°N latitude) has a narrow continental shelf with less extensive fishing grounds. The southeast coast (10°-15° N latitude) is characterized by coral and rocky grounds while the sea bottom of the northeast coast (15°-21°N latitude) is predominantly muddy and suitable for bottom trawling (Figure 1).

The northern Indian Ocean, together with its two major bays, the Arabian Sea and the Bay of Bengal, is landlocked in the north by the Asian continent which separates the northern Indian Ocean from the deep-reaching vertical

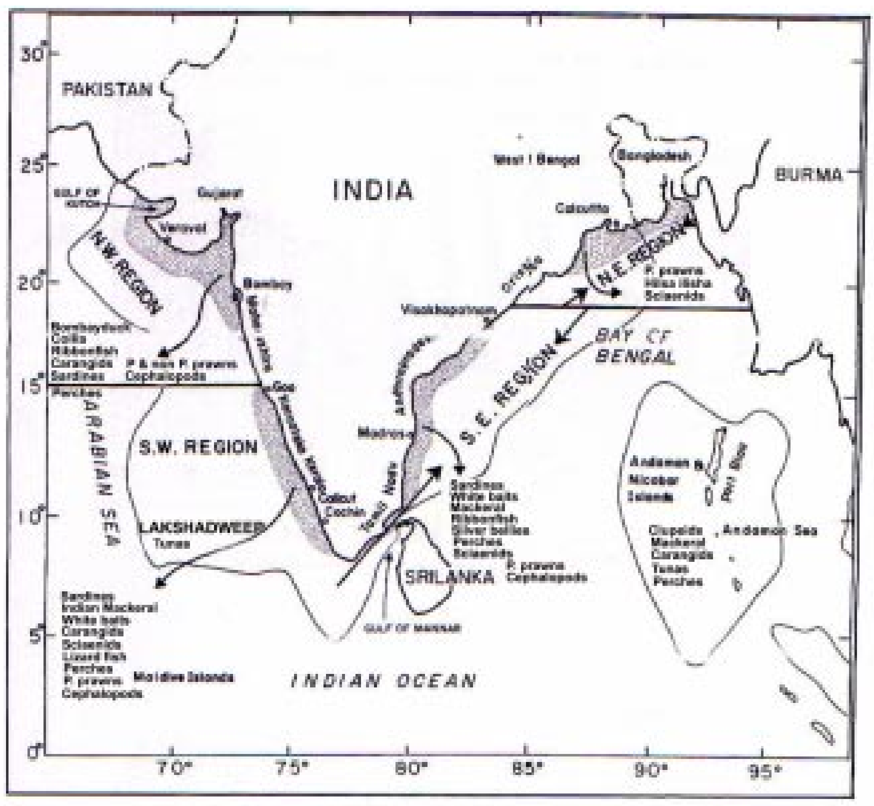

Figure 1. Exclusive economic zone of India

convection areas of the Arctic seas and the cold climate regions of the northern hemisphere. This geographic separation is a major factor, which determines the oceanographic conditions of the northern Indian Ocean. Circulation of waters in the Arabian Sea and Bay of Bengal is influenced by the pattern of winds associated with the summer and winter monsoons and comprise the monsoon current, the equatorial current and the equatorial counter current (Varadachari and Sharma 1967; Pillai *et al*. 1997). The monsoon current which is westerly during the northeast monsoon period (October-December) and easterly during the southwest monsoon season (May-October) has significant impact on the coastal fisheries. Average salinity value ranges between 34 and 37% in Arabian Sea and 30-34% in the Bay of Bengal. Both sea and land breezes are common in this area except during the southwest monsoon (along the west coast) and the northeast monsoon season (along the east coast).

In the Arabian Sea, temperature ranges between 23 and 29°C and in the Bay of Bengal, it is 27 to 29°C. With regards to vertical distribution of temperature in the Bay of Bengal, the thermocline is usually below 50-55 m, occasionally going down to 100-125 m, while in the Arabian sea, it fluctuates a great deal, showing definite seasonal trends (Rao 1973). Coastal upwelling occurs in varying intensities along the west and east coasts of India, corresponding with the southwest monsoon and determines the seasonal productivity patterns. During the months of strongest monsoon winds, coinciding with upwelling, linear banks of greenish, highly organic and mobile mud (*Chakara*) form inshore in many areas between latitudes 8 and 10^{o} N (Bristow 1938) and support a seasonal fishery mainly consisting of sardines, whitebaits, mackerel and prawns.

Profile of Indian Marine Fisheries

The Indian marine fisheries sector is characteristically an open access one with free and common property rights. The multispecies fishery comprise over 200 commercially important finfish and shellfish species. Being a multigear fishery, fishing practices vary between different regions, depending on the nature of the fishing grounds and the distribution of the fisheries resources. Pelagic stocks like mackerel, sardines, whitebaits, ribbonfish, carangids, seerfishes, coastal and oceanic tunas; demersal groups like croakers, threadfin breams, silverbellies, catfish, lizard fish and goatfish; crustaceans like penaeid prawns, crabs, lobsters and stomatopods and cephalopods like squids and cuttlefish are common. The abundance of these stocks varies from region to region with large pelagics like tunas being more abundant around Island Territories and small pelagics like sardines and mackerel supporting a fishery of considerable magnitude along the southwest and southeast coasts. The Bombayduck (*Harpadon nehereus*) and non-penaeid prawns form a good fishery along the northwest coast, while perches (pigface breams, groupers and snappers) are dominant in the southwest and east coasts, especially in the Gulf of Mannar, Palk Bay and Wadge Bank areas.

Among gears, gillnets, drift nets and bag nets of varied mesh sizes are widely employed by traditional fishermen along both the coasts, while ring seines, purse seines and mechanized gillnets are confined to the southwest coast. Bottom trawls up to 13 m OAL are operated along the entire coast, while the second generation large trawlers 13-17m are operated from selected harbours along both the east and west coasts. Currently, 2251 traditional landing centres, 33 minor and six major fishing harbours serve as bases for 2,08,000 traditional non-motorized crafts, 55,000 small scale beach landing, motorized crafts, 51,500 mechanized crafts (mainly bottom trawlers, drift gillnetters and purse seiners) and 180 deep sea fishing vessels of 25 m OAL (Anonymous 2001).

The growth of the fleets shows that the artisanal fleet (including the motorized) increased by about 110 per cent from the 1960s to the 1990s and the mechanized fleet by about 570 per cent during the same period (CMFRI 1997) and has resulted in an overdeployed fleet operating in the inshore waters (Table 1). The pattern of marine fish landings in India during the past fifty years (Figures 2 and 3) clearly reveals that the contribution by the

Table 1. Optimum and existing fleet size, 1996-97 (in number)

Fleet	Existing (Number)	Optimum (Number)	Excess Percent	Contrtibution to total catch (Percent)
Mechanized	46918	20928	55.0	67.0
Motorized	31726	12832	60.0	20.0
Non-mechanized	159481	31059	81.0	13.0

Total catch: 2.41 million tonnes (1996-97)

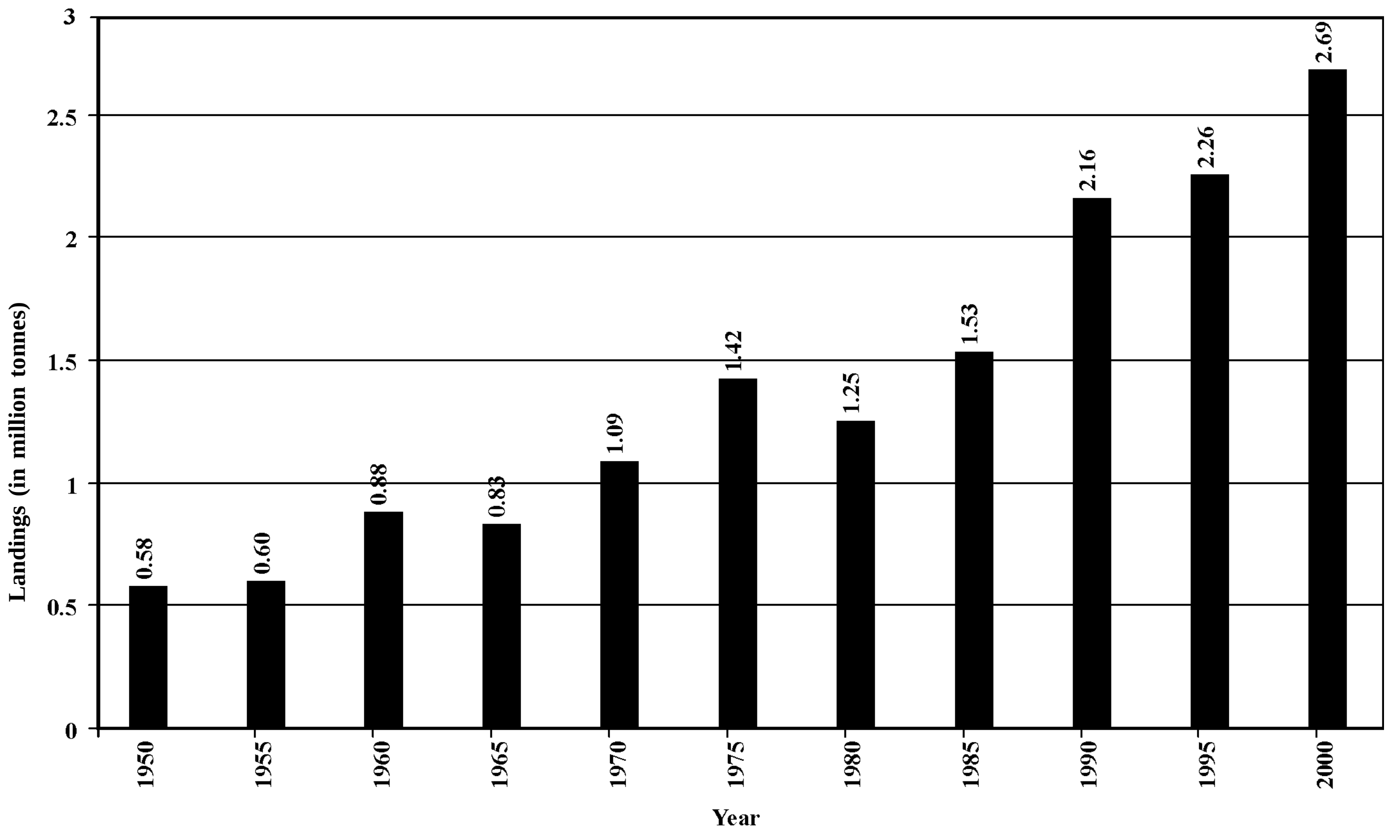

Figure 2 Total Marine fish landings (in million tonnes) in India 1950-2000

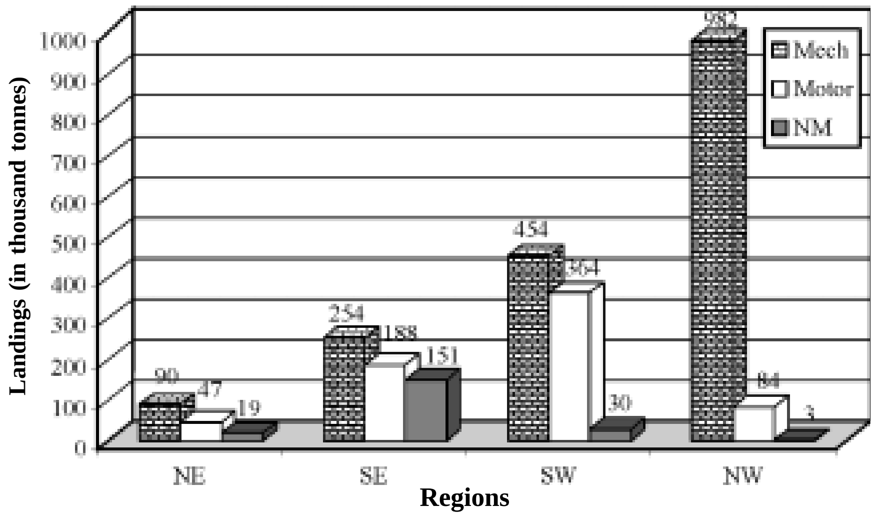

Figure 3 Sector-wise landings in different regions

artisanal sector to the total production was significant up to 1960s while presently, the contribution by the mechanized and motorized sector accounts for 91 per cent of the marine fish catch and the rest by artisanal gear (CMFRI 2000). The development of harbours and landing jetties, motorization of artisanal crafts and the rapid expansion of mechanized fishing have contributed towards a significant increase in fish production, employment generation and revenue earnings. However, as most of this fleet is engaged in coastal fisheries, where signs of decreasing CPUE are being reported, further expansion warrants stringent monitoring and adoption of sustainable fishing practices.

Socio-economic and Demographic Features

Currently, one million active fishermen are engaged in marine fishing in India, of which about 0.2 million are engaged in the mechanized sector, 0.17 million in the motorized sector and the rest in the artisanal sector. Among those engaged in the mechanized sector, 75 per cent work in trawl fisheries and 25 per cent in the fisheries operating gillnets, bag (*dol*) nets, purseseines and deep sea vessels. In the case of the motorized sector, 60 per cent are engaged in the ringseine fishery alone, which is predominant on the southwest coast and the rest in various other forms. In the artisanal sector, of the total 0.63 million active fishermen, 41 per cent are engaged in the operation of catamarans, 31 per cent in plankbuilt boats and the rest in the dugout canoes and others (Devaraj *et al*. 1998). Only 30 per cent of the fisherfolk possesses some sort of ownership of fishing implements, while a large number (70 per cent) of them work as labour force. The annual income of labourers working in a mechanized boat was estimated to be Rs. 34,200, while in motorized boat it has Rs. 15,200 and in artisanal unit Rs. 8,000 during 1995-96 (Table 2). This wide disparity in income between those engaged in the different subsectors results in clashes and conflicts (Sathiadhas 1996).

Fish Marketing System

The estimated first sale value of marine fish landings in the year 2000 was Rs. 102 thousand million with seafood exports earning Rs. 63 thousand million during 2000-01. The post-harvest fisheries including processing, product development, transport and marketing generate more employment than the harvesting sector, which, due to increasing demand and price of fish in both domestic and export markets, keeps growing. While the infrastructure for fish marketing is still principally oriented towards the export market, vast improvements in handling technologies and quick transportation facilities have led to increased market penetration of fresh iced fish to interior markets also. Currently, 50 per cent of fish is consumed fresh in and around producing centres, 43 per cent in centres up to 200 km interior to the coast and 5 per cent beyond 200 km limit (Sathiadhas *et al*. 1994). It is estimated that 44 per cent of fresh fish is auctioned off by fishermen themselves and the rest by involving intermediaries like wholesalers and retailers. Fisherman's share can be as high as 95 per cent in case of direct sale to the consumers (Devaraj 1987) and 30-68 per cent otherwise, with the wholesalers receiving 5-32 per cent and retailers 14-47 per cent of the consumer's rupee for different species of marine fish (Devaraj *et al*. 1998). Earlier, hardly 5 per cent of fish in the internal marketing system was marketed through co-operatives but the recent significant development of fisheries co-operatives has helped in reducing the high costs of marketing through integration of marketing and credit, establishing links with consumer co-operatives and introducing modern machinery and labour saving gadgets in all stages of marketing (Singh 2000). Fisheries associations are also coming up which will take up not only fishing but also direct selling of the catches to the consumers, thereby eliminating middlemen traders. At present, about 30 per cent of the total landings are processed after they become unsuitable for fresh consumption (Devaraj *et al*. 1998) and hygienically processed and

Table 2 . Sectorwise per capita investment, production, earnings and wages in Indian marine fisheries

Sectors (Rs. million)	Capital investment engaged	No. of fishermen per fishing (million)	Per capita investment production labour (Rs.)	Annual per capita of fishing of fishing labour (kg)	Per capita production per kg labour per working day (kg)	Av. value realised by fishing of fish (Rs.)	Income generated fishing labour/trip (Rs.)	Per capita earnings of of fishing labourer per trip (Rs.)	Annual wages* labourer (Rs.)
Mechanized	17,710	0.2	88,550	7,550	38	45	1,710	171	34,200
Motorized	3,380	0.17	19,888	2,588	13	35	455	76	15,200
Artisanal	8,810	0.65	13,440	437	2.4	25	60	40	8,000

(*Assuming 200 fishing days per annum)
Source: Sathiadhas *et al*. 1999

packed dried fish for domestic consumption in interior towns and canned fish in cities and defence establishments offer a good scope.

Fishing Regulations

Until 1970s, the emphasis of fisheries management in India was on increasing the fish production through improved fishing technology, infrastructure (harbours, roads, processing and market facilities) development and incentives and subsidies to the fishermen. These paved the way for increasing the marine fish production from 0.5 million tonne in 1950 to 2.7 million tonnes in 2000 (Figure 3). However, during the 1980s and 1990s, serious concerns were expressed that the unrestricted growth of the fishing industry might become counterproductive (Devaraj and Vivekanandan 1999) and therefore, the management strategy started aiming at sustaining the fisheries. Marine Fisheries Regulation Acts (MFRA) were promulgated in the 1980s with the focus on controlling the fishing area fishing gears, enforcing mesh size regulations and closed seasons.

Deep Sea Fishing Policy

To increase fisheries production from the outer continental shelf, the Govt. of India introduced the Deep Sea Fishing Policy (DSFP) in 1991, which allowed for chartered and leased vessels and joint ventures with foreign fishing vessels to operate in the Indian EEZ. But, due to protests from the fishery sector, this policy was scrapped and has adversely affected the exploitation of offshore resources. The lack of harvesting infrastructure and expertise on onboard processing of offshore resources is a serious bottleneck in developing the deep sea fishing sector.

Economic Evaluation

The total investment cost of fishing (Rs. 41.17 thousand million) by the marine fisheries sector (Table 3) and the estimated total value of the marine landings at about Rs. 102 thousand million indicate a fairly good profit ratio for the fishing industry as a whole (CMFRI 1997a). The economic feasibility of each fishing unit in the fishing industry, which is operating under nearly perfect competitive conditions depends on several factors like input and output prices, level of production and its functions (type and size of the vessel, age of the vessel, crew size and its skill, fishing time, fishing effort

Table 3. Capital investments, fixed cost and annual operating costs (Rs. in million) of the Indian marine fishing fleet during 1995

Fishing Fleet	Invest-ment	Fixed cost	Operating cost				Total cost	Fishing cost (Rupees/ kg)
			Fuel cost	Labour	Others	Total		
1. Mechanized Sector								
(i) Medium trawlers (14-17m OAL)	8500	2550	2220	2330	1070	5620	8170	22.56
(ii) Small trawlers (10-13 m OAL)	20250	4500	6250	4100	2450	12800	17300	22.56
(iii) Dolnetters	300	90	60	120	40	220	310	2.95
(iv) Purseseiners	900	270	140	170	110	420	690	4.42
(v) Pablo & plank built boats	4340	1090	1050	2420	500	3970	5060	32.65
(vi)Others	200	60	30	60	20	110	170	3.40
Total	34490	8560	9750	9200	4190	23140	31700	19.87
2. Motorized Sector								
(i) Canoes	3750	750	470	1870	780	3120	3870	12.29
(ii) Catamarans	310	90	40	21	90	340	430	10.75
Total	4060	840	510	2080	870	3460	4300	12.11
3. Artisanal sector								
(i) Canoes, Catamarans & Plankbuilt boats	2620	660	-	11710	730	2440	3100	10.93
Total	2620	660	-	11710	730	2440	3100	10.93
Grand Total	41170	16000	10260	22990	5790	29040	39100	14.30

Source : CMFRI 1997a

and other inputs like fuel, food, insurance etc.) and above all, the marketing avenues and prospects (Sathiadas *et al*. 1995).

The rates of return for the deep sea vessels are less as compared to those of the fishing units (both mechanized and artisanal) operating in the inshore waters; because of the huge investment required for these vessels (Table 4). The tuna longliner fetches better rates of return as compared to the other deep sea vessels which concentrate mainly on prawns. Hence,

Table 4. Annual economic performance of different types of offshore vessels operating in the marine sector (1989-92)

Sl. No.	Economic parameters	Deep sea trawler (25 m OAL)	Deep sea multipurpose (26 m OAL)	Tuna long line (30 m OAL)
1.	Initial Investment (Rs. in million)	16.00	15.00	16.40
2.	Annual catch rate (tonnes)	46.00	76.00 (P-36, F-40)	91.00
3.	Value (Rs. in million)	7.82	6.83	10.10
4.	Operating cost (Rs. in million)	3.30	2.60	4.10
5.	Fixed cost (Rs. in million)	2.80	3.00	4.00
6.	Total cost (Rs. in million)	6.10	5.60	8.10
7.	Net operating income (Rs. in million)	4.52	4.23	6.00
8.	Net income (Rs. in million)	1.72	1.23	2.00
9.	Rate of return (%)	26	24	27
10.	Payback period (years)	7.6	7.6	4.7
11.	Value realised per kg of fish (Rs./kg)	170.00	90.00	11.00
12.	Average total cost per kg of fish (Rs./kg)	133.00	74.00	9.00
13.	Average operating cost per kg of fish (Rs./kg)	72.00	40.00	4.50

P – Prawns: F - Fishes
Source: Sathiadhas *et al*. 1995

the sustained development of deep sea fishing requires formulation and implementation of resource management policies that would ensure reduction in the fishing pressure on the penaeid shrimp and diversify fishing efforts to other resources.

Status of Exploitation

The coastal fisheries exploit a large number of species (Tables 5 and 6) using different crafts and gears, mostly in the depth range of 0 to 50 m. Although in recent years, this has been extended up to about 120 m in some regions. The annual average landing during the period 1995-99 was 2.5 million tonnes principally constituted by the Indian mackerel (8.5 per cent), penaeid prawns (7.7 per cent), croakers (6.8 per cent), oil sardine (6.7 per cent), carangids (6.1 per cent), perches (6.1 per cent), non-penaeid prawns (5.2 per cent), ribbonfishes (4.9 per cent), cephalopods (4.1 per cent), and others (10.7 per cent) (Table 5). Catch trend during the year 2000 indicates

Table 5. Catch trends and potential yield estimates of different species

Group	Average catch (t) 1985-89	Average catch (t) 1995-99	Group contribution (%)	Potential yield (t)
Elasmobranchs	54027	68861	2.8	71408
Oil sardine	141831	167123	6.7	294869
Other sardines	76541	116458	4.7	101490
Anchovies	68630	138080	5.5	141817
Other clupeids	132626	51868	2.1	78932
Bombay duck	93185	99714	4.0	116227
Ribbonfishes	78384	122805	4.9	193670
Carangids	111040	151601	6.1	238148
Indian mackerel	123832	212633	8.5	295040
Seerfishes	35171	45059	1.8	61719
Coastal tunas	34185	42786	1.7	65472
Barracudas	-	15717	0.6	20849
Catfishes	50630	43762	1.8	51255
Eels	6317	8317	0.3	9081
Croakers	102934	169643	6.8	273027
Perches	90083	152477	6.1	226793
Flatfishes	29612	44975	1.8	47304
Silverbellies	60766	60641	2.4	67247
Pomfrets	37356	41891	1.7	46088
Penaeid prawns	143073	192571	7.7	194192
Non-penaeid prawns	48057	130781	5.2	13874
Stomatopods	-	70758	2.8	120351
Lobster	-	2409	0.1	3874
Cuttlefish	-	52698	2.1	49989
Squids	39799	53185	2.1	49821
Others	40034	267135	10.7	
Total	1598113	2497342	100.0	3934417

Table 6. Status of exploitation of different species-stocks along the Indian coast in the 0-50 m depth zone

Species	State of exploitation		
	Full	Over	Under
Sardinella longiceps	All along	-	-
S. gibbosa	SW coast	-	West coast
Hilsa ilisha	NE coast	-	-
Encrassicolina devisi	-	-	All along
Stolephorus waitei	-	-	-
Rastrelliger kanagurta	All along	-	-
Scomberomorus commerson	-	SE&SW coast	-
Euthynnus affinis	All along	-	-
Thunnus tonggol	All along	-	-
Auxis rochei	-	-	All along
Katsuwonus pelamis	-	-	All along
Megalaspis cordyla	-	-	SW coast
Decapterus russelli	-	-	All along
Selaroides lepiolepis	SE coast	-	-
Atropus atropus	NW coast	-	-
Alepes kalla	SW coast	-	-
Atule mate	-	-	SW coast
Caranx carangus	SE coast	-	-
Parastromateus argenteus	-	West coast	-
Formio niger	-	SW coast	-
Trichiurus lepturus	-	East coast	West coast
Harpodon nehereus	NW coat	-	-
Nemipterus japonicus	All along	-	-
Nemipterus mesoprion	All along	-	-
Leiognathus bindus	East coast	-	-
L. dussumieri	Tamil Nadu	-	-
L. jonesi	Tamil Nadu	-	-
Secutor insidiator	East coast	-	-
Tachysurus tenuispinis	-	West coast	-
T. thalassinus	-	W&NE coast	-
Otolithus cuvieri	NW coast	-	-
Johnius macrorhynus	NW coast	-	-
J. vogleri	NW coast	-	-
J. sina	SW coast	-	-
J. carutta	SE coast	-	-
Penaeus monodon	East coast	-	-
P. indicus	-	East coast	-
P. semisulcatus	-	SE coast	-
Metapenaeus monoceros	All along	-	-
M. dobsoni	All along	-	-
Acetes indicus	NW coast	-	-
Panilurus polyphagus	-	NW coast	-
Loligo duvauceli	All along	-	-
Sepia aculeata	East coast	-	West coast
S. pharaonis	East coast	-	West coast

Source: Murty and Rao 1996

that the northwest coast contributed 40 per cent to the total marine fish production, followed by the southwest coast (32.0 per cent), southeast coast (22.0 per cent) and northeast coast (6.0 per cent) (Figure 4) (CMFRI 2000).

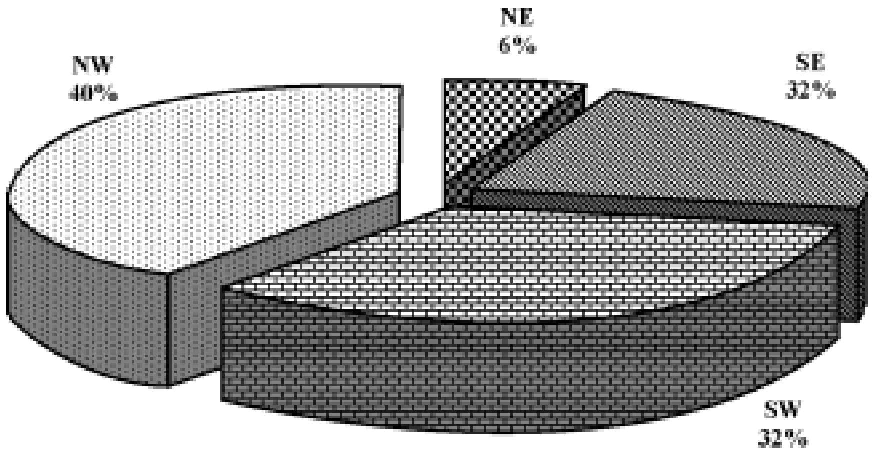

Figure 4. Region-wise contribution to all India production during 2000

Oceanic resources consist of tunas (*Thunnus albacares*, *T. obesus*, *Katsuwonus pelamis*), billfishes, myctophids (*Benthosema* spp., *Myctophum* spp. and *Diaphus* spp.) and oceanic squids (*Symplectoteuthis oualaniensis*, *Onychoteuthis banskii*, *Thysanoteuthis rhombus*). But there is no directed fishery for these species, except the marginal exploitation by chartered vessels, which operated under the deep sea fishing schemes during 1990s and which have since been suspended. Longline surveys conducted by Fishery Survey of India (FSI) has also revealed abundant resources of yellowfin tunas and pelagic sharks (Somavanshi 2001).

Ornamental Fish and Fisheries

Marine aquarium fish trade is gaining increasing popularity worldover with an estimated value of US $ 4.5 billion (Srivastava 1994). The Gulf of Mannar, Palk Bay, Gulf of Kutch, southwest coast and the Lakshadweep and Andaman group of islands are known to be rich in ornamental fishes (Murty 1969; Murty *et al*.1989). The wrasses, damselfish, surgeons, butterflyfish, moorish idol, squirrelfish, triggerfish, rabbitfish, parrotfish, angels, goatfish and pufferfish are the major aquarium fishes represented by nearly 180 species. Most of these fishes are abundant and offer scope for live fish export and development of home aquariculture in the country. The results of the survey and assessment of marine ornamental fishes of Lakshadweep (nine islands) implemented by the Central Marine Fisheries Research Institute (CMFRI) indicate an annual potential yield of 25 million fish consisting mainly of wrasses (38.0 per cent), damsel fishes (32.7 per cent), goat fish (8.4 per cent), parrot fish (7.4 per cent), squirrel fish (4.9 per cent), surgeon fish (4.8 per cent), butterfly fish (2.1 per cent), trigger fish (0.8 per cent) and others (1.7 per cent).

The seahorses or pipefishes are suitable for aquaria and are in great demand in Singapore and China for making soup and for medicinal purposes. In recent years, they are also being intensively exploited, particularly by divers from the southeast coast of India. A majority of these fishes are associated with coral reefs and those in great demand are not very abundant, their exploitation may disturb the habitats and result in depletion of stocks warranting restricted exploitation and monitoring and development of culture and hatchery technologies for the major species.

Issues

Declining CPUE and Idling Fleets

The annual growth rate of marine fisheries production increased from 4.3 per cent during 1970s to 4.8 per cent during 1980s and declined to 4.0 per cent during 1990s (CMFRI 1997a) and lowering down in growth rate is reflected in the annual catch attaining the optimum levels in the inshore fishing grounds up to a depth of 50 m of about 0.18×10^6 sq km area. The substantial increase in fishing effort since the 1970s has resulted in the decrease in per capita area per active fishermen and per boat in the inshore fishing grounds and also in the CPUE, which, in turn, has given rise to conflicts among different categories of fishermen, especially artisanal and mechanized sectors (Sathiadhas 1996). Technological improvements in capital intensive fishing implements have also rendered existing older units less economical or non-operational, leading to substantial idling of fleets and underemployment (Sathiadhas *et al*. 1999) .

Impact of Bottom Trawling on Sea Bottom and Its Benthic Biota

At present about 42,000 bottom trawlers operate (mainly targeting shrimps) in the entire coastal stretch, against the optimum number of 20,000. This kind of excessive bottom trawling is feared to have far reaching consequences, such as degradation of the sea-bed ecosystem and its biodiversity, as a large number of non-target groups comprising juveniles and sub-adults of economically important finfishes and shellfishes and also benthic organisms, most of them with little edible value but occupying key positions in the marine food web, are also destroyed (CMFRI 2000).

Discards

The discards in the Indian Ocean region account for 2.27 million tonnes, forming nearly 8.4 per cent of the total global discards (Alverson *et al*. 1994). Though there are no precise estimates of discards along the Indian coast, preliminary studies indicate that about 0.3 million tonnes is discarded by shrimp trawlers annually. The quantity of discards from trawlers may further increase in view of the rapid expansion of the multiday / distant water fishing. Therefore, there is an urgent need to devise suitable methods for onboard collection/preservation of discards and their value addition to prevent economic wastes.

Credit Facilities

With most of the traditional fishermen belonging to socio-economically weaker sections and adoption of advanced fishing methods becoming a necessity, availability of credit becomes crucial. Currently, only about 25 per cent of the active fishermen have ownership over fishing equipments and indebtedness is a serious issue in rural areas, where money lender and middlemen provide loans at exorbitant interest rates to purchase crafts and gear and almost confiscate the catches in return (BOBP 1983).

Coastal Aquaculture

Introduction

India is the second largest global aquaculture producer with a production of 2.03 million tonnes (1998), contributing 6.2 per cent to the global output.

Table 7. Open water fishery resources of India and their modes of fishery management

Resource	Unit	Size	Management Mode
Brackishwater	km	29000	Aquaculture
Rivers	ha	356000	Capture fisheries
Mangrove	ha	300000	Subsistence fisheries
Estuaries	ha	39600	Capture fisheries/Aquaculture
Estuarine wet lands	ha	190500	Aquaculture
Backwaters/lagoons	ha	1485557	Ranching
Reservoirs (small)	ha	202213	Culture- based fisheries
Flood plain wetlands	ha	2 million	Culture- based fisheries

Source : Pandian 2001

Coastal aquaculture is a significant contributor to this production, constituting mainly the shrimps like *Penaeus monodon* and *P. indicus*. However, vast water bodies highly suitable for aquaculture (Tables 7 and 8) and the varied biodiversity that has the potential to capture new markets with a wide range of seafood products, have prompted consideration of other candidate species like oysters, mussels, crabs, lobsters, scampi, seabass, groupers, seacucumber, ornamental fishes and seaweeds in the new aquaculture scenario in the country. Hatchery and rearing techniques have also been standardized for many of these organisms (Table 9).

Shrimp Farming

Shrimps being a highly valued export commodity, shrimp farming is considered a lucrative industry. Depending on the area of the pond; inputs like seed, feed; and management measures like predator control, water exchange through tidal effects or pumping, etc., farming systems have been classified into four groups: extensive, modified extensive, semi-intensive and intensive. According to Marine Products Export Development Authority (MPEDA), which is the main agency promoting shrimp farming through its various schemes and subsidies, during 2000-01, about 1,45,900 ha was under shrimp culture, with an average production of 0.7 tonne/ha/annum. Currently, 80 per cent of the shrimp production comes from small and marginal holdings, with farms of less than 2 ha constituting 49.2 per cent of the total area under culture, between 2-5 ha (15.8 per cent), 5-10 ha (13 per cent) and the

Table 8. Mariculture potential in India

Sl No.	Area	T.A. (million ha)	PCA (million ha)	CCA (million ha)	CAP (tonne)
1.	Coastal landbased	2.5	1.2	0.14	85,000 (mainly shrimps)
2.	Hinterland saline soil aquifer-based	8.5		100	200 (milkfish, mullets, pearlspot, shrimps, scampi)
Seafarming					
	(a) Open sea (EEZ)	202	1.8 (inshore 0-50 m depth)	20	1,500 (mussel)
	(b) Bays, coves and gulf	-	10,700	-	-
	(c) Estuaries and backwaters	-	2,050	5	800 (oysters)
	(d) Island lagoons/ lakes	-	35,000	-	-
Stock Enhancement Programme					
	(a) Searanching	18 (0-50 m depth)	18	Nominal	Nominal (shrimp, pearl oyster, clams, seacucumber)
	(b) Artificial fish habitat	-		50 reefs	10
	(c) Bottom artificial reefs/FAD	-		150 FAD	

TA = Total area; PCA = Potential cultivable area; CCA = Current cultivated area;
CAP = Current Annual Production.
Source : Devaraj *et al*. 1999

rest >10 ha. Presently, there are about 200 operational shrimp hatcheries with a total annual production capacity of 10.8 billion seeds (PL 20), most of them located on the east coast, with state-of-the-art facilities. There are also 33 feed mills with a total installed capacity of 1,50,000 tonnes to cater to shrimp industry.

Table 9. Marine organisms of aquaculture importance in India

Species	Hatchery Techniques	Rearing Techniques
Fishes		
Mugil cephalus, *Liza parsia*, *L. macrolepis*, *Valamugil seheli*, *Chanos chanos*, *Etroplus suratensis*, *Epinephelus tauvina*, *E. dussumieri*, *Lethrinus* spp., *Sillago sihama*, *Anguilla bicolor* and *Siganus* spp.	X	X
Anemone fish, *Chromis* sp. and *Lates calcarifer*	XX	XX
Crustaceans		
Penaeus monodon, *P. indicus* and *P. semisulcatus*	XXX	XXX
Scylla serrata	X	XXX
Portunus pelagicus	XX	XX
Panulirus homarus, *P. ornatus* *P. polyphagus* and *Thenus orientalis*	X	X
Molluscs		
Perna viridis, *P. indica*, *Pinctada fucata*, *Crassostrea madrasensis*, *Anadara granosa*, *Meretrix meretrix*, *M. casta* and *Paphia malabarica*	XXX	XXX
Trochus radiatus, *Xancus pyrum*, *Sepia pharaonis* and *Loligo duvaucelli*	X	X
Seaweeds		
Gracilaria edulis, *Gelidiella acerosa*, *Porphyra* sp., *Sargassum* spp., *Ulva* spp. and *Euchaemia* sp.	XX	XX
Seacucumber		
Holothuria scabra	X X	X X

x = Techniques under development
xx = Techniques developed
xxx = Techniques developed and commercialized

Fluctuating marine fish production combined with increased demand for shrimp in global market, successful demonstration of semi-intensive shrimp culture and establishment of commercial hatcheries along the east coast of India have led to rapid development of intensive/semi-intensive shrimp farms with a production of 5-10 tonnes/ha/crop in 4-5 months. Farmed shrimp production increased from 40,000 tonnes in 1991-92 to 82,850 tonnes in

1995-96 but subsequently, slumped to about 70,000 tonnes between 1995-97 (Table 10) as the fast pace of development failed to look at sustainability which resulted in disease outbreak, crop failures, environmental degradation and social tensions (Varghese 2001). Presently, most of the large farms run by corporate bodies have closed down due to disease problems, public litigations and protests by environmental groups over issues like salination of land and fresh water aquifers adjacent to shrimp farms, through seepage. The farming community has now become more responsive to the concepts of environment-friendliness and sustainable aquaculture. Disease problems are being overcome through adoption of closed system of farming (recirculation system, zero water exchange) in grow outs, application of probiotics, secondary aquaculture of selected fishes like mullets, milkfish, molluscs and seaweeds in reservoirs and drain canals, adoption of indigenous, good quality seed and feed and reduction in stocking density to 5-6 nos./sq. m in the farms. Preliminary trials of culture of *P. monodon* in freshwater

Table 10. Trend of shrimp exports and contribution by aquaculture

Year	Shrimp exports		Cultured shrimp			Per cent contribution	
	Quantity (mt)	Value (Indian Rupees. million)	Production (mt)	Export (mt)	Value (Indian Rupees million)	Shrimp export	Export value
1985	50349	3298.2					
1986	49203	3779.3					
1987	55736	4257.8					
1988	56835	4703.3	28000	18300	2293.0	33.00	48.78
1989	57819	4633.1	30000	19500	2597.0	33.72	58.57
1990	62395	6633.2	35500	23075	3764.0	36.98	56.77
1991	76107	9661.6	40000	26000	5447.6	34.16	55.81
1992	74393	11802.6	47000	30550	7662.5	41.06	64.93
1993	86541	17707.3	62000	40300	12889.3	47.14	72.79
1994	101751	25102.7	82850	53853	18662.3	52.92	74.35
1995	95724	23560.0	70573	47992	15316.9	50.96	64.09
1996	105426	27017.8	70686	45945	16425.6	43.58	60.80
1997	101318	31405.6	66868	43454	20860.0	42.90	66.42
1998	102484	33449.0	82634	53712	25110.0	52.41	75.07
1999	110275	36452.2	86000	54000	27820.0	48.96	76.32
2000	111874	44815.1	113700	65894	38700.0	58.90	86.35

Source: Ganapati and Viswakumar 2001

have shown fast growth and high production and have been adopted in many farms along the Andhra Pradesh and Kerala coasts. Advanced molecular techniques like Polymerase Chain Reaction (PCR) for early and rapid detection of viral pathogens, which cause disease outbreaks, are also being used to prevent disease problems in the growout system.

Socio-economic development through integrated farming systems and group farming experiments

In the coastal low lands (*Pokkali* fields in Kerala, *Khar* lands in Goa, *Khazans* in Karnataka State and *Bheri* in West Bengal) along the west coast of India, there is a traditional practice of shrimp farming in rice fields, which is done as a rotational crop after rice harvest giving production up to 0.5 tonne/ha/year. Fragmented holdings and poor socio-economic conditions of these small farmers, for whom the aquaculture is a livelihood activity, prevent the adoption of advanced technologies. Group farming approach, which relies on synchronized farming operations and collective management by the farmers of a locality is found to help increase production by improving the farmers' access to required inputs and reducing the cost of cultivation. As part of its action, research project on empowerment of rural communities through extension, the Central Marine Fisheries Research Institute (CMFRI) initiated group farming approach using shrimp (*P. indicus*) – rice rotation culture through its Institute-Village-Linkage Programmes (IVLP), designed to transfer technologies efficiently from lab to field and improve rural economy. Besides achieving social and economic gains for the farmers, it was especially useful in empowering women farmers, where women for the first time directly participated in an area entirely dominated by men and production of scientifically developed shrimp feed was taken up by women on a commercial basis (Krishna Srinath *et al*. 2000).

Unemployment is a serious issue, especially in rural areas of India. Consequent upon the establishment of shrimp farms , employment is reported to have increased by 2-15 per cent and the average income of farm labourers has increased by 6-22 per cent (CIBA 1997). The average labour requirement for paddy cultivation was found to be 180 labour days/crop/ha compared to shrimp farming where 2 crops were taken and labour requirement was 600 labour days/crop/ha (Rao and Ravichandran 2001). Ancillary industries like hatcheries, feed mills, processing and ice plants have also generated employment opportunities and boosted the rural economy (Patil and Krishnan 1998).

It has also helped in the development of indigenous technologies, especially with regard to feed and seed production. Imported shrimp feed is expensive and beyond the reach of small farmers and special low pollution diets which cost half the imported feeds and yet with an FCR of 1.5:1 has been developed indigenously and widely adopted by small farmers in improved extensive farming ventures. In addition, production of this scientifically formulated ecofriendly feed, *Mahima*, on a commercial basis, has been taken up by women in certain villages, which has also aided in empowering them.

In shrimp hatcheries, a regular supply of healthy broodstock is necessary. However, the supply of spawners from the wild is limited. Until recently, eyestalk ablation was the widely adopted method to induce rapid maturation and spawning. Presently, the technology has been developed to induce maturation and repetitive spawning using environmental and nutritional manipulation strategies in shrimps like *P. indicus* and *P. semisulcatus* (Pillai and Maheswarudu 2000).

Issues in shrimp farming

While extensive farming methods are sustainable and produce little waste, intensive operations discharge effluents carrying nitrogenous excretory waste, uneaten food, residues of chemicals and drugs that cause damage to the ecosystem. The quality of effluent water from different systems of shrimp farming in India (Table 11) is generally believed to be low without any serious impact on biodiversity (Kutty 2001). The Ministry of Agriculture (GOI) has prescribed standards for shrimp farm waste water (Table 12) which is in the interest of the aquaculturist to adhere and ensure sustainable production system. The MPEDA is also extending assistance for setting up effluent treatment units in shrimp farms of 5 ha or more water area, either singly or in a group.

Conversion of mangroves and agricultural lands are also serious reasons for conflicts arising out of competitive utilisation of limited natural resources, although such practices have been minimal (Rao and Ravichandran 2001) and mainly fallow and unproductive agricultural lands have been converted.

Table 11. Quality of water from different systems of shrimp farming in India (Mg/l)

Parameter	Extensive	Semi-intensive	Intensive
Phosphate P	0.05	0.12	0.11
Nitrate – N	0.15	0.04	0.22
NH_3 – N	0.007	0.02	0.013
Hydrogen sulphide	0.02	BDL*	BDL*

* Below detection level

Table 12. Standards for shrimp farm waste water

Sl. No.	Parameter	Guidelines issued by MoA**		Standards for discharge of pollutants* in marine coastal areas
		Coastal marine waters	Creeks	
1.	pH	6.0 – 8.5	6.0 –8.5	5.5 – 9.0
2.	Suspended solids (mg/L)	100	100	100
3.	Dissolved oxygen (mg/L)	not less than 3	not less than 3	-
4.	Free ammonia (as NH_3 -N) (mg/L)	1.0	0.5	5
5.	Biochemical Oxygen Demand - BOD (5 days @ 20°C) (mg/L)	50	20	100
6.	Chemical Oxygen Demand -COD (mg/L)	100	75	250
7.	Dissolved phosphate (as P) (mg/L max)	0.4	0.2	-
8.	Total nitrogen (as N) (mg/L)	2.0	2.0	-

* Gazette Notification G.S.R. No. 422 (E) dated May19, 1993, General Standards for discharge of environmental pollutants Part-A: Effluents

** Ministry of Agriculture

There are also reports of salinization of ground water and agricultural land through seepage from aquaculture ponds (Patil and Krishnan 1998). Wild seed capture rampant before establishment of hatcheries and the blocking of access to sea by large farms were also causes for conflict with the capture fisheries sector, which has been resolved to a large extent now.

In view of the numerous conflicts that arose and litigations by environmental groups, the Coastal Regulation Zone (CRZ) notification, 1991 under the Environment (Protection) Act, 1986, restricts construction of shrimp farms a landward boundary up to 500 m from high tide line (HTL) and has put an end to the construction of coastal farms. While aquaculture development is controlled by local state governments, its overall supervision is done by the Central Ministry of Agriculture, which in 1995, issued guidelines for sustainable development and management of brackishwater aquaculture. It seeks to discourage conversion of agriculture lands, mangroves and other ecologically sensitive wetlands for aquaculture. Also, Environmental Monitoring and Management Programme (EMMP) and Environment Impact Assessment (EIA) have been made mandatory for shrimp farms of 10-40 ha and >40 ha, respectively, which require a 'No Objection Certificate' from the State Pollution Control Boards for all the qualifying aquaculture units.

A National Aquaculture Authority has also come into force, which consists of representatives of Pollution Control Boards, Revenue Authorities, Fisheries Departments, Developmental bodies and Research Institutions, who have been assigned the role of regulating shrimp culture in a sustainable manner in the country. The code of practices for shrimp hatcheries and farms are also being issued by MPEDA.

Shrimp farming being more economical and rewarding than any other agricultural farming (Table 13), suitable areas may be marked out for shrimp farming by an identified Integrated Coastal Area Management Authority and coastal aquaculture may be suitably integrated in an eco-friendly manner with other activities in the coastal region to reap maximum benefits. In general, there is a greater awareness of the need to adopt sustainable aquaculture methods like low stocking density, minimum usage of chemicals and feeds and prevention of conflicts at most of the major shrimp farming centres. The apex shrimp farming associations and other stakeholders are coming together to discuss the common problems related to shrimp farming and evolve remedial measures for sustainable aquaculture practices.

Financing and supporting agencies

The National Bank for Agriculture and Rural Development (NABARD) extends help in fisheries development activities by assisting in pilot scale

Table 13. Economics of shrimp aquaculture/ hatchery units

Enterprise	Shrimp farm	Shrimp hatchery	Broodstock/ nauplii Facility
Area & production capacity	1 ha 1.0 – 2.0 t/ha/crop	0.3 ha 40 million PL20/year	0.1 ha 200 million nauplii/year
Species	*P. monodon, P. indicus, P. semisulcatus*	*P. monodon, P. indicus, P. semisulcatus*	*P. monodon,*
Farming method	Modified extensive	Broodstock develop-ment, induced maturation, larval and post-larval rearing	Indoor tanks
Duration	4-4$^{1}/_{2}$ months	30 days/run	15 days
Economics (in Rs.)			
Initial investment	18,000	7,60,000	38,500
Recurring cost	9,000	90,000	13,750
Total cost	27,000	3,80,000	52,250
Production	3.12 t (2 crops)	40 million PL 20/yr	200 million nauplii/yr
Revenue	97,500	2,62,500	50,000
Net profit	22,250	65,500	18,000

Source: ICAR 2000

demonstration of mariculture technologies under its Research and Development Grant Scheme and also encourages commercial scale projects through its refinance mechanism. Besides, the Brackishwater Fish Farmers' Development Agency and MPEDA also extend financial support/subsidies to farmers.

Lobster Farming/Fattening

There is great demand for live and whole cooked lobsters in the international market but in the absence of a viable hatchery technology and limited availability of juveniles and subadults from the wild, lobster farming has not yet picked up in the country. However, lobster fattening, which is carried out on a small scale, using the undersized lobster caught along with the commercial size lobsters from capture fisheries, is profitable. The spiny lobster, *Panulirus polyphagus*, is farmed in intertidal pits, provided with numerous shelters at a stocking density of 5 numbers/sq.m. Molluscan meat, trash fish and pelleted feed are used to grow the lobsters until they attain the weight of 125-150 g.

Crab Farming/Fattening

In view of the widespread disease problems in shrimp farming during 1990s, farmers started looking for alternate, more disease-resistant and economically important commercial fish species. Live mud crabs (*Scylla serrata*, *S. tranquebarica)* being a much sought export commodity, mud crab fattening was considered the best alternative. Seed stock consist of freshly moulted crabs (water crabs) of 550 g which are stocked in small brackishwater ponds at a stocking density of 1/sq. m or in individual cages for a period of 3-4 weeks while being fed thrice daily with trashfish @ 5-10 per cent of their biomass. Selective harvesting is done according to size, growth and demand and the venture is profitable (Table 14) because of low operating costs and fast turnover. Monoculture (with single size and multiple size stocking) and polyculture with milkfish and mullets are being carried out on a small scale, as the seed supply is still mainly from the wild. Experiments on breeding and seed production of *S. tranquebarica* have given 20 per cent survival rate from egg to first instar stage and attempts are on to improve the survival rate for an economically viable hatchery technology.

Table 14. Economics of three systems of mud crab farming

Culture Method	Monoculture	Polyculture	Fattening
Species	*Scylla tranquebarica* *S. serrata*	*S. tranquebarica* *S. serrata*	*S. tranquebarica* *S. serrata*
Culture period, days	120	138	30
Expenditure, Rs. (seed, feed, pond, preparation, labour)	43,860	48,400	56,200
Production, t crabs	0.78	1.14 and 0.7 tonne milkfish	0.56
Income, Rs.	1,57,200	2,61,200	1,22,850
Net profit/crop, Rs.	1,13,340	2,12,800	66,650

Source: ICAR 2000

Hatchery technology for breeding and seed production of the blue swimming crab, *Portunus pelagicus*, has also been developed and four generations of crabs have been produced by domestication. The hatchery seed is being mainly utilized for stock enhancement programmes along the east coast.

Molluscan Culture

Edible Oyster Farming

The first attempt to develop oyster culture in India dates back to 1910 by James Hornell. Since 1970s, the CMFRI has taken up R&D programmes on all aspects of oyster (*Crassostrea madrasensis*) culture and has produced a complete package of technology, which is presently being widely adopted by small scale farmers in shallow estuaries, bays and backwaters all along the coast.

In the adopted rack and ren method, a series of vertical poles are driven into the bottom in rows, on top of which horizontal bars are placed. Spat collection is done either from the wild or produced in hatcheries, on suitable cultch materials. Spat collectors consist of clean oyster shells (5-6 Nos.) suspended on a 3 mm nylon rope at spaced intervals of 15-20 cm and suspended from racks, close to natural oyster beds. Spat collection and further rearing is carried out at the same farm site and harvestable size of 80 mm is reached in 8-10 months. Harvesting is done manually with a production rate of 8-10 tonnes/ha. Oyster shells are also in demand by local cement and lime industry and culture production has increased to 800 tonnes in the year 2000.

Mussel (*Perna viridis, Perna indica*) Farming

Raft method (in bays, inshore waters), rack method (in brackishwater, estuaries) or longline method (open sea) are commonly adopted for mussel farming. Mussel seeds of 15-25 mm size collected from intertidal and subtidal beds are attached to coir/nylon ropes of 1-6 m length and enveloped by mosquito or cotton netting. Seeds get attached to rope within a few days while the netting disintegrates. The seeded ropes are hung from rafts, racks or longlines. A harvestable size of 70-80 mm is reached in 5-7 months and production of 12-14 kg mussel (shell on) per metre of rope can be obtained. Attempts to demonstrate the economic feasibility of mussel culture has led to the development of group farming activities in the coastal communities (especially rural women groups) with active support from local administration and developmental agencies like Brackishwater Fish Farmers Development Agency (BFFDA) and State Fisheries Department. Cultured mussel production has increased from 20 tonnes (1996) to 800 tonnes (2000) mainly through the rack system in estuarine area. Molluscan culture technologies and their economics are given in Table 15.

Pearl Oyster Farming and Pearl Production

In India, the marine pearls are obtained from the pearl oyster, *Pinctada fucata*. Success in the production of cultured pearls was achieved for the

Table 15. Molluscan culture technologies and economics

Technology	Edible oyster farming	Mussel farming	Pearl oyster culture
Species	*Crassostrea madrasensis*	*Perna viridis, P. indica*	*Pinctada fucata*
Farming method	Rack and Ren (30 x 10 m)	Raft (8 x 8 m)	Cages suspended from rafts/ racks
Culture period	8 months	5-7 months	12-15 months
Unit area	300 sq m	64 sq m	Open sea; 6 rafts and 600 box cages
Economics (US $)			
Initial investment	371	203	10,000
Recurring cost	139	357	4,419
Total cost	510	560	
Production	5.83 tonnes shell- on (0.48 tonne meat)	0.8 t shell on	
Revenue	736	934	Depends on percentage pearl production and market value of pearls
Profit	226	303	30% (at 25% pearl production)

Source: ICAR 2000

first time in 1973 by CMFRI. Raft culture and rack culture in nearshore areas are the two methods commonly adopted for rearing pearl oysters and recently attempts have been made to develop onshore culture methods.

Shell bead nucleus (3-8 mm) implantation is done in the gonads of the oyster through surgical incision while graft tissues are prepared from donor oysters of the same size and age group. Implanted oysters are kept under observation for 3-4 days in the labs, under flow through system and then shifted to the farm in suitable cages for rearing. Periodic monitoring is done and harvest is carried out after 3-12 months. Pearls are categorized into A, B and C types depending on colour, lustre and iridescence. 25 per cent pearl production has been successfully demonstrated in a series of farm trials at various locations along the Indian coast. Research is also directed towards development of a technology for *in vitro* pearl production using mantle tissue culture of pearl oyster.

The technology for mass production of pearl oyster seed and pearl production has paved the way for its emergence as a profitable coastal aquaculture activity at certain selected centres along the coast. Village level pearl oyster farming and pearl production, through direct involvement of small scale fishermen have been carried out successfully as part of technology transfer programme along the Valinokkam Bay on the east coast (Table 16). Pearl

Table 16. Economics of pearl culture programme at Valinokkam Bay – A group farming success

Number of oysters implanted	9414
Total expenditure incurred, US $	1571
Rate of Return, %	56.7
Total pearls harvested	1849
Revenue earned from sale of pearls, US $	2178
Pearls distributed to fishermen	250
Revenue earned from sale of pearls	US $ 2178

Expenditure incurred (as percentage of total)

Raft	Cages	Pearl oyster (for implantation)	Pearl oyster (for graft tissue)	Shellbead nuclei	Labour	Miscella-neous
24	18	24	2	17	6	9

Source: APAARI 2000

oyster farming has already generated income worth US $ 26,000 and several young women who are trained in pearl surgery in pearl farms are finding ready employment in this developing industry. The CMFRI also imparts training on pearl culture to trainees in neighbouring Asian countries, and various Memorandum of Understanding (MoU) have been signed with entrepreneurs, desirous of pearl culture since 1996.

Clam Culture

Package of clam culture practices has been developed for the blood clam *Anadara granosa* and *Paphia malabarica*, where production of 40 tonnes/ha/6 months and 15-25 tonnes/ha/4-5 months have been achieved in field trials. Induced spawning and larval rearing to setting of spat has been perfected for clams like *P. malabarica*, *Meretrix meretrix* and *Marcia opima*.

Sea Cucumber Culture

More than 200 species of sea cucumbers are found in Indian waters mainly in the Gulf of Mannar, Palk Bay and Andaman and Nicobar Islands. The most important commercial species is *Holothuria scabra*, whose continuous exploitation has led to depletion of natural population (James 1999). Seed of *H. scabra* was produced in the hatchery for the first time in India in 1988 through induced spawning using thermal stimulation (James 1989) and has been used widely since then to produce seed for stock enhancement programmes. Water quality is the most important parameter in hatcheries with ideal conditions being temperature, 27-29^{o}C; salinity 26.2 – 32.7 ppt, dissolved oxygen 5-6 ml/l; pH, 6-9; and ammonia content, 70-430 mg/cubic metre (James 1999). Larvae require different diets at different developmental stages and algae like *Isochrysis galbana*, *Chaetoceros calcitrans*, *Tetraselmis chuii* and *Sargassum* are used. Seed produced in hatcheries are grown in velon screen cages (2 sq.m area), netlon cages (1.65 sq.m area, 5 mm mesh net), concrete rings (70 cm dia x 30 cm height) and also at the bottom of prawn farms. Artificial diets prepared with soyabean powder, rice bran and prawn head waste is used for feeding juveniles and results are encouraging. Juveniles have been stocked @ 30,000/ha and grown along with shrimps (*P. monodon*) in farms (James 1999). Sea cucumbers being detritus feeders, feed on waste shrimp feed and organic matter on the pond bottom, reducing the organic pollution load in the farm. Being an eco-friendly practice, which also provides an additional income to the farmer, it is expected to become popular among farmers who have been facing problems of shrimp disease outbreaks in the recent past.

Marine Finfish Culture

In the area of marine fish culture, the country is still in the experimental phase only. Attempts are being made to develop suitable hatchery and farming technology for mullets (*Mugil cephalus*, *Liza macrolepis*, *V. seheli*), groupers (*Epinephelus tauvina*), seabass (*Lates calcarifer*), milkfish (*Chanos chanos*) and pearlspot (*Etroplus suratensis*). The Central Institute of Brackishwater Aquaculture (CIBA) has developed an indigenous hatchery technology for seabass using captive broodstock which were stocked in large RCC tanks (12 x 6 x 2 m) with 70-80 per cent water exchange daily. Maturation process was accelerated using LHRH hormone injection and larvae were maintained with rotifers and *Artemia* nauplii. Cooked and minced fish meat is used for nursery rearing and survival rates up to 14 per cent in larval rearing phase and 84 per cent in the nursery phase have been recorded.

Ornamental Fish Culture

There are a wide variety of ornamental fishes in the vast water bodies and coral reef ecosystems along the Indian coast, which if judiciously used, can earn a sizeable foreign exchange. Hatchery technology for clownfish (*Amphiprion chrysogaster*), damsel fishes (*Pomacentrus caeruleus*, *Neopomacentrus nemurus* and *N. filamentosus*) and the sea horse (*Hippocampus kuda*) has been developed, which can be scaled up for mass production of these species.

Seaweed Culture

Around 60 species of commercially important seaweeds with a standing crop of one lakh tonne occur along the Indian coast (Table 17), from which, nearly 880 tonnes dry agarophytes and 3,600 tonnes dry alginophytes are exploited annually from the wild (Kaladharan and Kaliaperumal 1999).

Table 17. Commercially important Indian seaweeds and their standing crop

Sl No.	Group	Species	Standing crop (t)
1.	Agarophytes	*Gracilaria edulis, G. corticata, G. crassa, G. folifera, G. verrucosa, Gelidiella acerosa, Gelidium* spp., *Pterocladia* spp.	*6,000*
2.	Alginophytes	*Sargassum* spp., *Turbinaria* spp., *Laminaria* spp., *Undaria* spp., *Dictyota* spp., *Hormophysa* spp.	16,000
3.	Carageenophytes	*Hypnea* spp., *Chondrus* spp., *Eucheuma* spp.	8,000
4.	Edible	*Ulva* spp., *Enteromorpha, Caulerpa* spp., *Codium* spp., *Laurencia* spp., *Acanthophora* spp.	70,000

Seaweed products like agar, algin, carragenan and liquid fertiliser are in demand in global markets and some economically viable seaweed cultivation technologies have been developed in India by CMFRI and Central Salt and Marine Chemical Research Institute (CSMCRI). CMFRI has developed technology to culture seaweeds by either vegetative propagation using fragments of seaweeds collected from natural beds or spores (tetraspores/carpospores). It has the potential to develop in large productive coastal belts and also in onshore culture tanks, ponds and raceways. Carrageenan yielding seaweed, *Kappaphycus striatus*, was introduced from the Philippines by CSMCRI (Mairh *et al*. 1995) and presently this species is acclimatized and cultivated extensively along the Mandapam coast. To make the seaweed industry more economically viable, research aimed at improvement of strains of commercially important species by isolating viable protoplasts and somatic hybridization techniques, is being carried out. The rate of production of *Gelidiella acerosa* from culture amounts to 5 tonnes dry weight per hectare, while *Gracilaria edulis* and *Hypnea* production is about 15 tonnes dry weight per hectare (Gomkale *et al*. 2000).

Fish Processing Sector – Profile and Issues

The preservation and processing infrastructure include 372 freezing plants with capacity of 52.5 tonnes per day, 148 ice making plants with about 1,800 tonnes capacity per day, 450 cold storage having capacity of over 80,000 tonnes and 15 fish meal plants with about 330 tonnes capacity per day. There are also 900 registered prawn peeling sheds with a capacity of 2,684 tonnes, which form the pre-processing centres. The capacity utilization of the processing plants at present is hardly 25 per cent, mainly because of the shortage of raw materials. Most of the processing factories are old and only a few meet the criteria of the European Union Certification for imports to Europe.

The stringent import policies of many importing countries have also influenced the type and quality of products being exported. Out of the total marine fish landings, only about 15 per cent, including cephalopods and crustaceans, is exported. Finfishes constitute the single largest commodity in the seafood export market with major varieties as ribbonfish, pomfrets, seerfishes, mackerel, reef cod, snappers and tunas. The *surimi* based products, pasteurized crab meat and live fish (crabs, groupers, lobsters) also offer an immense scope for development (Table 18). Fresh and frozen farmed mussels and oysters have good demand in domestic market while mussels are also exported to countries like UAE, Germany and Republic of South Africa. Export to European countries requires certification of the water bodies used for mariculture and the appropriate authority issuing such certificate has to be decided. Production of value added fishery products is

Table 18. Item-wise exports of marine products from India

Item	1997-98		1999	
	Quantity, t	Value, million Indian Rupees	Quantity, t	Value, million Indian Rupees
Fr. Shrimp	100720	31341.5	103070	33623.8
Fr. Fish	188029	7267.3	126474	5257.8
Fr. Squid	35095	2708.9	34451	2878.1
Fr. Cuttle Fish	37258	3234.1	33771	2852.5
Fr. Lobsters	1289	477.9	1364	661.5
Chilled Items	3183	443.1	2793	360.1
Live Items	1700	293.4	1733	389.8
Dried Items	5669	334.5	5661	343.0
Others	12875	874.1	17887	207.3
Total	385818	46974.8	327205	47573.9

Source: MPEDA 2001 (Marine Products Export Development Authority) also being done although it is highly capital intensive and advanced processing and packaging technologies are currently insufficient in India.

Quality assurance in fishery products has been introduced since 1965 with pre-shipment inspection scheme (Export Quality Control and Inspection Act) and the In Process Quality Control (IPQC) was implemented in early 1978, prescribing the minimum requirements for raw materials, manufacturing processes, end product testing, preservation and packaging of final products. The Hazard Analysis Critical Control Point (HACCP) with stress on safety was introduced in 1995 and it is the responsibility of the processors to ensure proper hygienic conditions and observe the prescribed standards for seafood exports.

The steps taken by the Govt. of India to relax the policy on trade and convertibility of Indian rupee into foreign currencies have resulted in an increase of export of fish/fishery products. The MPEDA is also conducting numerous promotional efforts which have benefited exporters of fish and fishery products. In view of the rigorous quality requirements of the European countries, the quality vigilance and compliance to attain the required international standards are being stepped up. Irradiation process (Radurization) for the extension of shelf-life of fresh fishery products and improvement in microbial safety have been standardized in many countries, including India and would pave the way for the reduced post-harvest losses (Shamsundar 2001).

Conclusions

Indian fisheries sector is not only a source of valuable food and employment generation, but also contributes significantly to the national income also. In recent years, mariculture has gained importance and much research input has gone into the selection of candidate species, hatchery production of seed, farming/fattening, growout systems, genetics, nutrition, physiology and pathology of candidate species but lacuna still exist with regards to breeding and seed production techniques of certain edible finfishes and lobsters and seafarming technology requirements in diverse hydro-climatic conditions and the mariculture yield remains at less than 3 per cent of the total marine fish production. To develop fisheries sector further, a concerted effort by the stakeholders and policy makers is essential for formulating responsible and sustainable fishing practices and increase the productivity/production through artificial reefs, sea ranching programmes, aquaculture, reduced post-harvest losses along with a higher investment and allotment of funds for infrastructure and manpower training and technology development.

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6

Socio-economic Profile of Fisherfolk in Gujarat

R. L. Shiyani

Introduction

Gujarat is one of the leading maritime states of India. The state is situated on the west coat of India which lies between 20.1^0 and 24.7^0 North latitude and 68.4^0 and 74.4^0 East longitude. It has the longest coastline of 1600 Km. which extends along 10 districts from Kutch in the north and Valsad in the south. Over the last four decades, fisheries sector of Gujarat has undergone radical changes. While marine resources of Gujarat are spread mainly in the Arabian sea, the inland waters in the form of rivers, canals, estuarines, ponds, reservoirs, brackish water impoundments, waterlogged areas etc. constitute a bed rock of inland fisheries in the state. An incredible achievement of the state has been made in the foreign exchange earnings through export of fish and fish products. The current emphasis on the development of fisheries sector in the state is on conducting research for providing valuable information which can contribute to the planning process, institutional development and policies of the fishery sector. In this paper an attempt is made to study the socio-economic profile of fisherfolk in Gujarat.

The fishery industry in Gujarat plays an important role in economy of the state and gives livelihood to about 4.50 lakh fishermen, which contributes about 7.53 per cent of the total fishermen population in the India. However, the proportion of active fishermen in Gujarat is 10.88 per cent of the total active fishermen in the country (Table 1). Gujarat with about 32 per cent continental shelf area, 11 per cent of the Exclusive Economic Zone (EEZ) area, 20 per cent of the coastline, 12 per cent of the area of reservoirs, 26

Table 1. Fisheries at a glance in Gujarat and India

Sr. No.	Item	Gujarat	India	Percent Share of Gujarat
1	Area sq. km.	196.00	3287.0	5.96
2	Fishermen Population			
	Marine Fishermen	2.75		
	Inland	1.74		
	Total	4.49	59.59	7.53
	Active Fishermen	1.57	14.43	10.88
	Fishing Gears/ Nets	14.27		
3	No. of Landing Centres			
	Marine	190		
	Inland	613		
	Esturine	78		
	Total	881		
4	Continental shelf area lakh sq. km.	1.64	5.06	32.41
5	Exclusive Economic Zone (EEZ), lakh sq. km.	2.14	20.20	10.59
6	Length of rivers and tributon, km.	3865	171334	2.26
7	Area of reservoirs, lakh hectare	2.43	20.50	11.85
8	Area of ponds and tanks, lakh hectare	0.71	28.55	2.49
9	Area of Brackishwater, lakh hectare	3.76	14.22	26.44
10	Potential area of Brackishwater, lakh hectare	1.87	8.67	21.57
11	No. of Fishing Boats			
	Traditional Boats	12653	191207	6.62
	Motorised (Out of Tradi)	4283	31726	13.50
	Mechanized Boats	8356	46968	17.79
	Total Boats	21018	238125	8.83

Source : Gujarat Fisheries Statistics 1999-2000

per cent of brackishwater area, and 18 per cent of the mechanized boats of the country, should be the largest producer of fish in the country, but it is the second largest producer of fish, after West Bengal.

The fish production in the top ten states of India is inspected in Table 2. It shows that Gujarat ranks first in marine fish production, but it ranks only 11th in the inland fish production in the country. The inland fish production in Gujarat is only about 70 thousand tonnes. West Bengal is at the forefront of inland fish production in the country.

Table 2. Fish production in top ten states of India, 1999-2000

('000)

Marine Fisheries States	Fish Production	Inland Fisheries States	Fish Production
(1) Gujarat	670.51	(1) West Bengal	685.70
(2) Kerala	575.50	(2) Andhra Pradesh	380.58
(3) Maharashtra	397.90	(3) Bihar	254.74
(4) Tamilnadu	363.00	(4) Uttar Pradesh	192.71
(5) Karnataka	165.65	(5) Orissa	135.30
(6) West Bengal	180.00	(6) Assam	159.77
(7) Andhra Pradesh	166.48	(7) Maharashtra	135.39
(8) Orissa	125.94	(8) Madhya Pradesh	127.43
(9) Goa	62.11	(9) Tamilnadu	112.00
(10) Pondicherry	38.62	(10) Karnataka	126.65
(11) Others	88.14	(11) Gujarat	70.32
Total Production	**2833.85**	**Total**	**2823.00**

Source : Handbook of Fisheries Statistics, 2000, Ministry of Agriculture, Govt. of India

The fishing operations in Gujarat are presently confined to the inshore and offshore waters up to 70 m. contour and is carried out from on-board fishing crafts of various types. Table 3 shows that out of 21018 total fishing crafts in Gujarat, 12653 are traditional crafts, constituting about 60 per cent of the total and the remaining 40 per cent are mechanized boats. The proportion of motorized traditional crafts in the total traditional crafts is about 34 per cent. Gujarat ranks second in the number of mechanized boats among all the maritime states of the country. However, the proportion of mechanized boats in the total boats in the respective state was the highest in Maharashtra, followed by Gujarat. In the case of Gujarat, Junagadh and Valsad districts together account for more than 80 per cent of the total mechanized boats, the liberal state aid especially during the early stages, enabled the fishermen of Gujarat to mechanize their boats. The mechanized boats of Gujarat are,

Table 3. Number of fishing crafts in maritime states/UTs

States/UTs	Traditional Crafts	Motorised Traditional Crafts out of Col. (2)	Mechanized Boats	Total
Gujarat	12653	4283	8356	21018
Maharashtra	9988	286	7930	17918
Karnataka	13141	1189	3655	16796
Kerala	40786	12913	4206	44992
Tamil Nadu	32077	5340	8230	40307
Andhra Pradesh	57269	3269	8911	66180
Orissa	10249	2453	1665	11914
West Bengal	4361	270	1880	6241
Lakshdweep	1078	298	443	1521
A & N Islands	1340	160	230	1570
Pondicherry	6265	365	553	6818
Goa	2000	900	850	2850
Total	191207	31726	46918	238125

Source: Handbook of Fisheries Statistics, 1996, Ministry of Agriculture, Govt. of India.

by and large, plank built, varying in length from 7.5m to 14.8m. Since 1982, boats/canoes made of Fibre glass Re-inforced Plastic(FRP) are also in use in the state. These boats vary in length from 9 m. to 11 m. The mechanized boats are fitted with either inboard marine diesel engines or outboard motors (OBMs). The popular makes of such engines are Ashok Leyland, Ruston, Cummins and Kirloskar. The popular brands of outboards motors are Yamaha, Johanson and Mariner of the horse power range of 7 to 15. Kerosene-driven OBMs are preferred to petrol-driven motorized due to economic consideration. The non-mechanized boats are engaged in artisanal fisheries and consists of dugouts, keeled and planked flat bottomed boats.

Fish production in Gujarat

Gujarat produced only 79 thousand tonnes of marine fish during 1960-61, countributing nearly 9 per cent of India's marine fish production (Table 4). A continuous increase in the marine fish production was noticed in the state and it reached to a level of 6.70 lakh tonnes during 1999-2000, accounting for 23.64 per cent of the India's total marine fish production. It is estimated

Table 4. Fish production in Gujarat in comparison to total production in India

(in Lakh tonnes)

Year	Marine fish			Inland Fish			Total Fish Production		
	Gujarat	India	Share of Gujarat (per cent)	Gujarat	India	Share of Gujarat (per cent)	Gujarat	India	Share of Gujarat (per cent)
1960-61	0.79	8.80	8.98	0.00	2.80	0.00	0.79	11.60	6.81
1970-71	1.51	10.86	13.90	0.00	6.70	0.00	1.51	17.56	8.60
1980-81	2.99	15.55	19.23	0.17	8.87	1.92	3.16	24.42	12.94
1990-91	5.00	23.00	21.74	0.46	15.36	2.99	5.46	38.36	14.23
1999-2000	6.70	28.34	23.64	0.70	28.23	2.48	7.40	56.57	13.08

Source: Gujarat Fisheries Statistics, 1999-2000.

that the marine fish production landed by the mechanized boat was the highest in Gujarat. Among the mechanized boat, the trawlers landed a maximum catch, followed by gill netters and bag netters and motorized boats. The inland fish production in the state started only in 1980-81. It rose to 70 thousand tonnes during 1999-2000, but its share in India was only 2.48 per cent. This could be attributed to many reasons. Gujarat is basically a maritime state and the inland fisheries was, by and large, confined to subsistence oriented activities along the peripheries of a few rivers, estuaries and larger water masses. Again there has been a very stiff social resistance to fisheries activities, especially in the rural hinterland, due to strict vegetarian food habits of the local population. During the last four decades, the share of Gujarat in the total fish production of India has increased from about 7 per cent in 1960-61 to 13 per cent in 1999-2000. The contribution of Gujarat in marine as well as inland fish production to India is almost stagnant since 1992-93. This needs a special attention of the policy makers in the interest of fishermen community of the state.

The important fisheries indicators in Gujarat are given in Table 5. The total fishermen population of Gujarat is estimated to be 4.49 lakh, which is about 7 per cent of the total fishery population in India. The total number of fishermen estimated in the marine sector is 2.75 lakh (61.19 per cent) and in the inland sector is 1.74 lakh (38.81 per cent). Among the active fishermen, about 70 per cent fishermen are engaged in actual fishing, 8.49 per cent are

Table 5. Important indicators of fisheries in Gujarat

Sl. No.	Item	Unit No.	Percentage
1	No. of fishermen house holds (as per census 197)	77,162	100
	(A) Marine	42,855	55.54
	(B) Inland	34,307	44.46
2	Fishermen population	449440	100
	(A) Male	230305	51.24
	(B) Female	219135	48.76
	(C) Marine Sector	275005	61.19
	(D) Inland Sector	174435	38.81
3	Sex Ratio (Female per 1000 Male)		956
4	SC to Total fishermen population	2689	0.60
	ST to Total fishermen population	121875	27.12
5	S.E.B.C. To Total fishermen population (O.B.C.)	320465	71.30
6	Literacy (As per census 1997)		
	(A) Male	96246	41.79
	(B) Female	64834	29.59
7	Active fishermen	157742	35.10
	(1) Marine sector	98723	62.59
	(2) Inland sector	59019	37.41
	(1) Male active	104780	66.42
	(2) Female active	52962	33.58
	(A) Actual fishing	109664	69.52
	(B) Net making/ Repairing	13394	8.49
	(C) Marketing	17015	10.79
	(D) Processing / Preservation	8951	5.67
	(E) Others	8718	5.53
	Total	157742	100

Source: Gujarat Fisheries Statistics, 1999-2000.

employed in net making and boat repairing, 10.79 per cent in marketing and about 6 per cent in the processing and preservation activities.

The estimated value of output and GDP of fishing sector in Gujarat are given in Table 6. Out of the total marine fish production of 6.15 lakh tonnes, the highest proportion was used for sun drying (2.46 lakh tonnes). However, a reverse trend was noticed for the average price realized. In case of inland sector, maximum fish was sold in raw form (59348 tonnes). On an average, the price per kg of inland fish could be realized Rs. 37.85 when it is sold in raw form, Rs. 37.71 per kg in case of fish used for salting and Rs. 36.07 per kg for sun drying. Thus, the price of inland fish was much higher than that of marine fish. In value term, the marine sector contributed a total of Rs. 995 crores and the inland sector Rs. 236.32 crores.

Table 6. Estimated value of output and GDP of fishing in quintal, 1999-2000

Sl. No.	Total production	Production in tonne	Avg. price per tonne	Value in (Rs. Lakh)
1	Marine Fish			
	Sold in raw form	178207	16863.50	30052.00
	Used for salting	190497	16647.23	31712.55
	Used for sun drying	245803	15362.27	37760.95
	Total	614507	NA	99525.50
2	Inland fish			
	Sold in raw form	59348	37852.12	22464.63
	Used for salting	2499	37713.70	942.42
	Used for sun drying	625	36072.16	225.35
	Total	62472	NA	23632.40

Source: Department of Fisheries, Government of Gujarat

Fishermen Co-operations

There are 557 fishermen co-operative societies in the state of Gujarat with a total membership of 80,802 as on March, 2000 (Table 7). The number of co-operative societies was maximum in case of Junagadh district (135), followed by in Porbandar (66). However, the total number of members was the highest in Surat district (19710), followed by Junagadh (13038), Valsad (12179) and Porbandar (8070). The total number of tribal co-operative societies in Gujarat is 162 with 30,528 members, the number of non-tribal co-operative societies is 395 with the total membership of 50274. Of the total tribal co-operative societies in Gujarat, Dahod and Surat districts account

Table 7. District wise fisheries co-operative societies as on 31-3-2000

Name of the districts	Total societies (Nos.)	Total members (Nos.)	Tribal cooperative societies		Non-tribal Societies		Kind of Cooperative Societies			
			No.	Members	No.	Members	Marine	Inland	Active	Inactive
Ahmedabad	12	1149	4	678	8	471	0	12	8	4
Banaskantha	9	667	4	253	5	414	0	9	9	0
Sabarkantha	16	2035	12	1787	4	248	0	16	8	8
Mehsana	2	171	0	0	2	171	0	2	0	2
Rajkot	14	923	0	0	14	923	0	14	12	2
Jamnagar	9	1006	0	0	9	1006	5	4	5	4
Bhavnagar	12	872	0	0	12	1152	5	7	10	2
Surendranagar	6	1152	0	0	6	1152	0	6	5	1
Vadodara	16	1082	7	412	9	670	0	16	14	2
Bharuch	18	770	5	134	13	636	3	15	11	7
Surat	50	19710	40	19073	10	637	20	30	20	30
Valsad	22	12179	5	857	17	11322	20	2	15	7
Kheda	14	887	0	0	14	887	0	14	12	2
Panchmahals	14	1359	13	1329	1	30	0	14	10	4
Amreli	36	2827	0	0	36	2827	27	9	20	16
Kutchh	23	2089	2	389	21	1700	16	7	14	9
Junagadh	135	13038	1	0	134	13038	123	12	120	15
Dahod	54	2847	54	2847	0	0	0	54	50	4
Narmada	7	2019	7	2019	0	0	0	7	6	1
Anand	6	290	0	0	6	290	0	6	6	0
Navsari	16	5860	8	750	8	5110	7	9	10	6
Porbandar	66	8070	0	0	66	8070	63	3	46	20
Total	557	80802	162	30528	395	50274	289	268	411	146

Source: Gujarat Fisheries Statistics, 1999-2000.

for about 58 per cent. In the marine sector, the total number of co-operative societies is 289 and in the inland sector it is 268. Of the total co-operatives societies, only 411 are reported to be active.

Schemes for Poor Fishermen

The Government of India as well as National Co-operative Development Corporation (NCDC) have evolved several schemes, which inter alia, help in economic upliftment of poor fishermen and fish farmers. The schemes implemented by the Government, along with the pattern of sharing and budget are given in Table 8. During the ninth Five Year plan (1997-2002), the total budgetary allocation for all the schemes by the state and Central Governments was Rs. 95.17 crore, of which the maximum budgetary allocation for the

Table 8. Annual plan 2001-2002 Centrally Sponsored Schemes (sharing basis)

(Rs In Lakh)

No	Centrally Sponsored Scheme (Sharing Basis)	Pattern of Sharing	State Share	Central Share
1	Fish Farmer Development Agency	50:50	670.00	45.00
2	Brackish Water Fisheries Develop.	50:50	285.00	285.00
3	Development of Fisheries Harbour	50:50	3000.00	3000.00
4	Mechanism of Fishing Crafts (Out Board Motor)	50:50	30.00	30.00
5	Development of Marine Coastal Area Through Motorisation of Traditional Fishing Crafts	50:50	6.0	6.0
6	Introduction of Fibre Glass Re-inforced Plastic/ Wooden Boats for Pelagic Fishing	25:75	10.00	30.00
7	Value Addition to low value fish	50:50	30.00	30.00
8	Strengthening Extension Service in fisheries sector	20:80	–	–
9	Fish Drying through Fishermen/ Women Co-operatives	50:50	20.00	20.00
10	Group Accident Insurance Scheme	50:50	25.00	25.00
11	National Welfare Scheme (Housing)	50:50	985.00	985.00
	Total		5061.00	4456.00

Source: Commissionerate of Fisheries, Gandhinagar.

Development of Fisheries Harbour (Rs.60 crore), followed by National Welfare Scheme (Rs.19.70 crore), Fish Farmers Development Agency (Rs. 7.15 crore) etc.

The National Welfare Scheme has three components : (i) Development of Model Fishermen Villages, (ii) Saving-cum relief scheme and (iii) Accident insurance scheme for active fishermen. The Fish Farmers' Development Agencies (FFDAs) are registered under the Registration of the Societies Act (1897) and function as an autonomous body. The main objectives of the FFDAs are (i) to popularize improved techniques of fish culture to enhance the fish production from fresh water resources, (ii) arrange leasing of water sheets lying with the panchayats and such other agencies to fish farmers to function as a nucleus agency in making water sheets suitable for fish culture, and (iii) increasing average productivity of fish from tank and ponds to a level of 3 tonnes per hectare per annum. The schemes for development of Marine Coastal Area through motorisation of traditional fishing crafts, Mechanisation of Fishing Crafts, Development of Fisheries Harbours, Introduction of Fiber Glass Re-inforced Plastic (FRP) for pelagic Fishing etc. are implemented in costal districts. The Group Accident Insurance Scheme was initiated in Gujarat during 1982-83. It gives insurance coverage

Table 9. Year wise sales–tax diesel assistance given for fishing operations (Fishing Fleet)

Year	No of Beneficiaries (Card holders)	Qty. of Diesel up take (KL.)	Sales tax budget availed Rs. Lakhs	Tax benefit per Boat Rs.	Average lift/per Boat KL.
1990-91	3792	50776	483.52	12751.05	13.39
1991-92	4175	63662	664.32	15911.86	15.25
1992-93	4311	76610	926.48	21491.07	17.77
1993-94	4850	857.45	1123.07	23156.08	17.68
1994-95	6012	102959	1431.09	23803.89	17.13
1995-96	5442	126900	1481.85	27229.88	23.32
1996-97	6934	131628	1908.6	27525.24	18.98
1997-98	6941	126601	1835.71	26447.34	18.24
1998-99	8127	129646	1879.86	23131.04	15.95
1999-00	7592	121883	3412.72	44951.58	16.05

Source: Commissionerate of Fisheries, Gandhinagar.

to the fishermen who are members of the co-operatives and the annual premium is contributed by the State & Central Governments.

Fuel is one of the major variable input costs in fishing operations. The Government provides sale tax benefit to the fishermen for the diesel. The number of such diesel beneficiaries was 1679 in 1982-83 which rose to 7592 in 1999-2000. With the increase in the quantity of diesel uptake from 7031 KL in 1982-83 to 121883 KL in 1999-2000, the amount of saving due to sales tax benefit availed has also increased from Rs.14.26 lakh to Rs.3412.72 lakh during this period. The average lift of diesel per boat increased about four fold during this period, while the tax benefit per boat has increased substantially from Rs. 849.32 in 1982-83 to Rs.44951.58 in 1999-2000, i.e. an increase of benefit by 53 times. Since it is a heavy financial burden on the Government's exchequer, an alternative needs to be explored.

Fish Based Industries

The fish-based industries are well developed in Gujarat as can be observed from Table 10. There are 724 ice factories spread across the state with a total capacity of 9384 TPD. The significance of preservatives in handling fish-driven home to the fishing population of the state by the erstwhile states

Table 10. Fish based industries in Gujarat

Type of industry	Number	Capacity (Tonnes/day)
Ice factory	724	9384
Cold storage	235	11534
Freezing plant	60	2631
Frozen Storage	60	22184
Fish Pulveriser	54	885
Boat Building Yard	37	784 no. / yrar
Fish Meal Plant	3	43
Net Making Plant	7	767
Service Station	106	—

Source: Techno-Economic survey for fishermen community in Gujarat, 2001
Commissionerate of Fisheries, Government of Gujarat, Gandhinagar, 2001.

of Saurashtra and Bombay. The Government had established five ice plants during 1960-61 but none of the plants is in existence today. However, these plants were instrumental in establishing the concept of fish preservation among the fishermen of Gujarat. As a result, many ice and cold storage plants have come-up in the private and co-operative sectors, which cater to the needs of the fisheries sector. At present, there are 235 cold storages with a storage capacity of 11534 TPD in Gujarat. Freezing plants were installed in the state in the late 1960s on account of the establishment of demersal trawling and the resultant increase in the shrimp landing in the state. The state has now 60 freezing plants with a freezing capacity of 2631 TPD and 22184 tonnes frozen storage capacity. All these plants are mostly confined to Veraval and Porbandar and are mostly in the private sector. There are 54 fish pulveriser units in the state with a capacity of 885 TPD.

Table 11. National Co-operative Development assistance to fishermen in Gujarat

(Rs Lakh)

Year	No: of societies	No: of units	Vessels	Loan	Subsidy	Share Capital
1997-98	29	95	M.F.V.	574.48	104.45	156.67
		20	Fibre Re-inforced Plastic	30.68	10.19	7.98
		Total		605.16	114.64	164.65
1998-99	9	36	M.F.V.	217.80	39.60	59.40
			Fibre Re-inforced Plastic	0	0	0
		Total		**217.8**	**39.60**	**59.40**
1999-2000	4	6	M.F.V.	52.31	9.51	14.26
		10	Fibre Re-inforced Plastic	23.71	5.93	5.93
		11	Gill Netter	23.73	4.32	6.47
		Total		**99.75**	**19.76**	**26.66**

Source: Commissionerate of Fisheries, Government of Gujarat, Gandhinagar, 2001.

The traditional boat building craft of Gujarat is well known from time immemorial. In fact, traditional boat building centers are scattered all along the Gujarat coast. The number of organized boat building yards is expected to be 37, with a total capacity of building 784 numbers of boats in a year. The first ever fish meal plant in Gujarat was established at Jaffarabad in

1962, with an installed capacity of ten tonnes per day. But this plant ceased functioning from 1966. Presently, three fish meal plants are working with a total capacity of 43 TPD. There are 7 fish net making factories in the state with a total production capacity of 767 TPD. Another important shore facility made available to the marine fisheries sector in the state is service stations, which takes care of the installation, repairs and servicing of the motors and engines of the fishing boats. There are presently 106 service stations in the state.

NCDC Assistance

The development of the fisheries sector by providing institutional credit to the fisheries co-operatives of the state under the NCDC programme was initiated in Gujarat in 1975-76. The financial assistance consists of soft loans, subsidies, share capital contributions and repayment rebates in the total project cost. At the initial stage, the coverage was limited to some infrastructure facilities (such as godowns, diesel pumps, etc.) and share capital to the co-operatives. Subsequently, the coverage widened to other areas, like purchase of operational inputs such as fishing boats, net and engines, creation of infrastructure facilities for marketing, (transport vehicles, cold storages, retail outlets, etc), establishment of processing units, including ice plants, development of inland fisheries, seed farms, hatcheries,etc.

The financial assistance provided by NCDC to the fishermen of Gujarat during 1997-98 to 1999-2000. It can be seen from this Table that the major financial assistance of NCDC was in the form of loan, followed by share capital and subsidy. A perusal of this Table also shows that the number of societies given financial assistance and the amount of assistance have drastically declined during last three years due to increased strain on the exchequer of NCDC.

Social Infrastructure

To conduct a Techno-Socio-Economic Survey for fishermen community in Gujarat, the commissionerate of fisheries, Government of Gujarat (GOG) had availed the services of the Management Consultancy Division (MCD) of Dalal consultants and Engineers Limited (DCEL). The study was conducted in 184 fishery villages and 5335 fishermen households were selected for the study, spread across the state in both the marine and inland sectors. The study on the availability of various facilities in fishery villages indicated that about 95 per cent of the total villages surveyed were without electricity and about two-thirds of the villages did not have access to medical facilities (Table 12). The safe drinking water facilities were available only to 72 per cent villages. In terms of other facilities, while 46 per cent villages were found to have banking facilities, only 25 per cent have cinema halls, 8 per cent have community halls and about 14 per cent have access to housing schemes.

Table 12. Availability of social infrastructure in fishery in villages

Facility	Inland Fish Villages	Marine Fish Villages	Total
Electricity	130 (94.9)	44 (93.6)	174 (94.6)
Medical facility	84 (61.3)	37 (78.7)	121 (65.8)
Drinking water	99 (72.3)	33 (70.2)	132 (71.7)
Banking facility	59 (43.1)	25 (53.2)	84 (45.5)
Cinema hall	33 (24.1)	12 (25.5)	45 (24.5)
Housing scheme	19 (13.9)	7 (14.9)	26 (14.1)
Community hall	7 (5.1)	7 (14.9)	14 (7.6)
Total no. of villages	137	47	184

Figure in parentheses are percentage to the total number of villages (Based on the survey by Dalal consultants & Engineers Ltd.)

Source: Techno-Economic survey for fishermen community in Gujarat, 2001
Commissionerate of Fisheries, Government of Gujarat, Gandhinagar, 2001.

Educational Status

The results of the survey conducted by DCEL indicated that the literacy rate among the fishermen in Gujarat was poor in comparison to Gujarat averages. It has been found that about 37 per cent of the fisherwomen and 53 per cent of the total fishermen are literate (Table 13). Among the literate population, 53 per cent male and 56 per cent female have education only up to the primary level. About 17 to 19 per cent have education up to the middle school level, 10 per cent up to secondary level. It is quite surprising to note that only 2 per cent of the fishermen population was found to be graduates or with other higher qualification.

Table 13. Educational status of the fishermen family members

Educational status	Inland Fisheries				Marine Fisheries				Total			
	Female		Male		Female		Male		Female		Male	
	No.	per cent	No.	per cent	No.	per cent	No.	per cent	No.	per cent	No.	per cent
Below School going age	1067	15.7	1188	15.3	930	14.3	1095	14.1	1997	15.1	2283	14.7
Illiterate	3249	47.9	2521	32.5	3102	47.8	2501	32.2	6351	47.9	5022	32.3
Literate	2468	36.4	4049	52.2	2451	37.8	4182	53.8	4919	37.1	8231	53.0
Literate without formal education	311	12.6	349	8.6	248	10.1	313	7.5	559	11.4	662	8.0
Up to Primary Level	1425	57.7	2233	55.1	1326	54.1	2092	50.0	2751	55.9	4325	52.5
Up to Middle Level	358	14.5	700	17.3	486	19.8	851	20.3	844	17.2	1551	18.8

Source: Techno-Economic survey for fishermen community in Gujarat 2001
Commisionanerate of Fisheries, Government of Gujarat, Gandhinagar, 2001

Supply Change in Inland and Marine Sectors

The stakeholders involved in the supply chain of inland fish catch and marketing includes the fishermen, 'mandali', wholesaler, dealer, retailer and cusumer (Figure 1). The inland catch in some areas is sold to the 'mandali' (fishermen co-operative society). The 'mandali' has yearly contract with the wholesale sellers. Wholesale sellers collect the fish from 'mandali' and dispatch it to the big markets mainly in north India and West Bengal by trains or refrigerated vans. In certain cases, it was observed that most of the small fishermen sell their catch in the local retail market or in the markets nearby villages.

In the marine sector, the supply chain is almost similar except that the processor is involved in the marine sector (Figure 2). Most of the catch is purchased by the commission agents directly from the fishermen and then

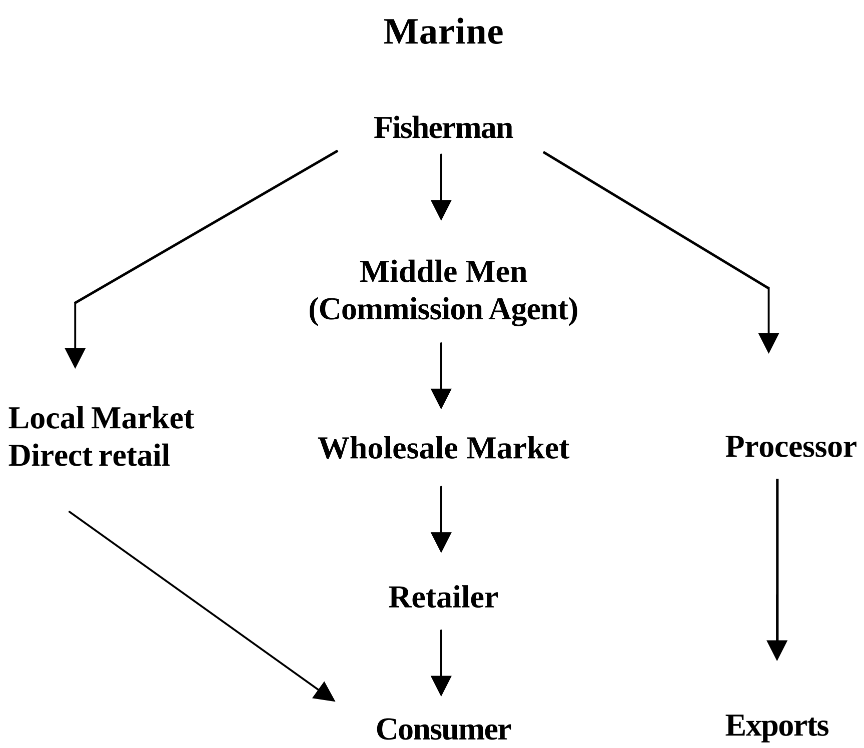

Figure 1. Profile of Fishermen Households

sold it to the processors or wholesale sellers. Some fishermen even directly sell their catch to the processors or consumers. The processed fishes are sold mainly in the export market, where they get a good profit margin for the value addition. The processed fish is also sold in the domestic markets through the wholesale-seller-retailer chain.

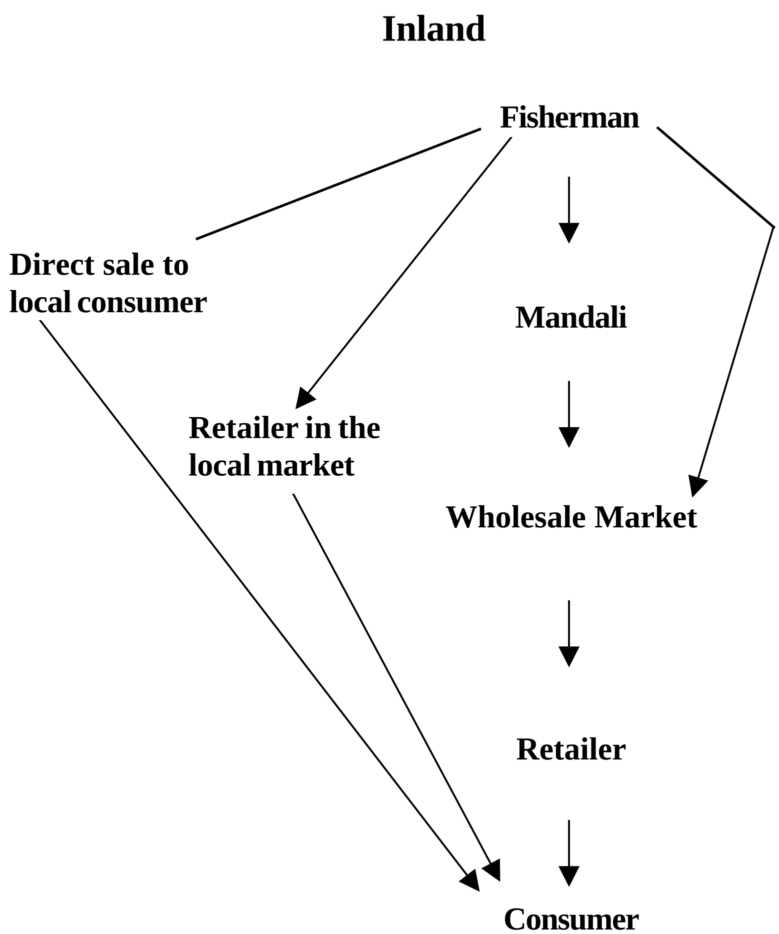

Figure 2. Profile of Fishermen Households

7

Management of Fisheries of Floodplain Wetlands: Institutional Issues and Options for Assam

Nagesh K. Barik and Pradeep K. Katiha*

Introduction

Floodplains are the flatlands bordering rivers, which are subjected to flooding and tend to expand along the lower reaches of rivers. These can be divided into (a) plains which include the river channel(s) and (b) the permanent or semi-permanent standing waters that the receding floods leave in various forms. These water bodies expand and contract with response to flood and dry seasons. The wetlands are the transitional zones between the permanently wet and generally dry environments and share the characteristics of both these environments. The wetlands have one or more of these attributes: (a) they support predominantly hydrophytes, at least periodically, (b) substrate is predominately hydric soil, and (c) substrate is non-soil, saturated with water or covered with shallow water for some time during the growing season of tropical vegetation.

Floodplain wetlands are important fishery resources and contribute significantly to the Indian inland fisheries. These resources are primarily distributed in the states of Assam, Bihar, West Bengal and Manipur (Table 1) and are locally known as *mauns, chaurs, beels, jheels* and *pats, etc.*

*The authors acknowledge the support and guidance provided by Dr. V. V. Sugunan Director, Central Inland Fisheries Research Institute, Barrackpore, in carrying out this research work.

Fisheries and Floodplain Wetlands in Assam

The state of Assam is rich in fisheries resources. With the total area of 3.47 lakh ha, the total fisheries resource of Assam is highest in the country (Table 2). The total population of the state is 266 lakh (Anonymous 2001a) and 95 per cent of them are fish eaters (Anonymous 2000a).

Table 1. Floodplain wetland resources of India

	Wetland resources	
State	**Local name**	**Area (ha)**
Assam	*Beel*	1,00,000
West Bengal	*Beel Charha & Baor*	42,500
Bihar	*Maun, Chaur & Dhar*	40,000
Manipur	*Pat*	16,500
Arunachal Pradesh	*Beel*	2,500
Tripura	*Beel*	500
Total		2,02,213

Source: Sugunan 1995a

Table 2. Fisheries resources of Assam

Resource type	Area (ha)
Rivers	2,05,000
Beel or open water	1,00,000
Forest fisheries	5,017
Derelict water bodies	10,000
Reservoir fisheries	1,713
Ponds	25,423
Total	3,47,153

Source: Department of Fisheries, Government of Assam

At present, the annual fish production of the state is about 1.6 lakh tonne against the demand of about 2.78 lakh tonnes. During 1999-2000, the percentage share of fisheries was 2.10 per cent in total net domestic product of the state at constant price of 1993-94 (Anonymous 2000b). It provides livelihood to 4.7 lakh people besides providing indirect employment. The gross value of fish was estimated around Rs. 640 crore. The contribution of *beel* fisheries to the state annual fish production was about 16 per cent (Anonymous 2000c) valued at approximately Rs. 100 crore.

Table 3. ***Beels*** **of Assam**

Category	Number	Area (ha)	Condition		
			Good	Semi-derelict	Derelict
Registered	423	40,000	10,000	15,000	35,000
Unregistered	969	60,000	Nil	10,000	30,000
Total	1,392	1,00,000	10,000	25,000	65,000

Source: Department of Fisheries, Government of Assam

There are about 1392 listed *beels* in Assam (Table 3) of which 423 are registered and 969 are unregistered. The number of *beels* under the control of government is 505 and under non-government is 464. These *beels* are distributed over the valleys of Brahmaputra in the northern and central Assam and Barak valley in the southern Assam.

Potential and Status in utilization

The *beels* are considered to be one of the most productive inland water system owing to their characteristic interactions between land and water system. The flow of organic matter from the catchment area bring nutrients in large amount and increase fish productivity of the *beels*. The average *beel* fish yield potential across the region has been estimated between 1050 and 1250 kg/ha. By even the most conservative estimate, we may say that yield potential of the *beels* of Assam is 1000 kg/ha. This level of productivity, however, can be attained with the moderate level of management interventions (CIFRI 2000).

The present level of fisheries production from these *beels* is very low (14 to 488 kg/ha) with average of 173 kg/ha (CIFRI 2000). This shows that only one fifth of the fisheries potential is being realised from these waters. The utilisation of full potential in *beels* will add up to 82,000 tonnes of fish per year in Assam. The annual net economic gain will be around Rs. 328 crore with a moderate assumption of Rs. 40 per kg of fish.

Fisheries in Wetlands

The wetlands control many environmental functions, *viz*. maintenance of stability in low land ecosystem, effective floodwater retention, recharging of ground water, etc. These also provide water for drinking and irrigation besides serving as habitat of aquatic organisms and migratory birds and maintaining aquatic biodiversity. Floodplains also provide vital breeding and nursery ground for numerous fish species of riverine and other open waters.

Fishery is an important economic activity. It exploits aquatic organisms for human use. It involves catching of edible aquatic organisms from natural and manmade aquatic ecosystem and value addition to many aquatic organisms, Thus, manipulation and utilisation of the aquatic ecosystem, management inputs, creation of utilities, etc. are the parts of fisheries activities of the *beels* of Assam.

Stakeholders and Management of the *Beels*

There are a large number of stakeholders which are associated, directly and indirectly with *beels*. These include fishers, lessees, state government, NGOs, etc. Each of them operates at different level of management. At the ecosystem level, state government is associated through resource use polices for production and protection. At the resource level, lessees or managers are responsible for the management; and at the fishing level, individual or group of fishers are managing the resources. Therefore, various management domains exist with different components and different outputs as enumerated in Table 4.

The multi-stakeholding and multiple uses of the resources generate conflicts across diverse users and uses. Therefore, the objective of the management is the trade-off across these conflicts. These conflicts of interest and objectives are summarised in the following paragraphs.

Management Objectives

The wetlands are managed for various broad objectives like economic benefit, conservation of biodiversity, protection of habitat, maintenance of the ecosystem, etc. Most important amongst them is the economic objective. Profitability and higher economic return is the prime objective of the managers. There are a large number of people directly dependent on *beels* for their livelihood. Food and livelihood security is another important objective of management of *beels*. As these resources are state-owned or community-owned, equity considerations also influence the

Table 4. Management domains of *beel* fisheries

Domains of Analysis	Components	Outcomes
Natural process	• Level of nutrients • Auto stocking • Closed or open *beels* • Biodiversity	• Productivity potential • Production possibilities • Technological and management options
Human interventions	• Management • Fishing efforts • Fishing practices • Stocking • Weed control etc.	• Production sustainability • Increase in productivity
Agencies of interventions	• Individuals • Informal groups • State agencies • Formal organisations	• Income • Employment • Food security • Equity
Institutions	• Property relationships • Social institutions • Social reciprocity • Collusion with other market agencies	• Rules and norms • Bargaining outcomes • Access to resources • Social security • Information exchange
Policies	• Leasing policy • Control of efforts • Infrastructure development • Institution building • Security mechanisms • Development policies	• Allocation of resources • Regulations of fishing practices • Input support • Sustainability • Growth and equity

management. Sustainability is the fundamental objective of *beel* resource management.

The delineation of these objectives provides the basis of evaluation of the appropriateness of the institutional and management framework. The efficiency and effectiveness are the main criteria of this evaluation. Development strategies and alternative institutional set-up are the measures and tools to improve them (Carney and Farrington 1998). In this context, the institutional issues are being analysed.

Technological and Management Options

Technology is the fundamental means to attain the management objectives. The options are based on the nature and ecological circumstances of a *beel* and depend upon water renewal cycle, species spectrum of the parent river, connection with parent rivers, etc. (Sugunan 1995a). The management options accordingly, vary from the highly controlled to no human intervention in the production process. Based on the level of human interventions, the fisheries of the *beels* are categorised into capture, culture and culture-based fisheries.

Capture Fisheries

Capture fisheries is generally undertaken in open *beels*, which are invariably connected to the rivers. The management interventions in these *beels* are limited to conserving and protecting the brooders and juveniles, identification and protection of breeding ground, allowing free migration of brooders and juveniles from *beel* to river and *vice versa*, protection of brooders and juveniles, etc. Other measures include increasing the minimum mesh size, controlling of fishing effort, close season observance to protect the brooders, checking at recapture for the minimum size, diversity and selectivity of gears for harvesting the diverse fish species.

Capture fishery is practised in *beels*, which are large. Their management and control are difficult. The property rights are not exclusive and there is predominance of free access, etc. These *beels* are highly degraded and then productivity is much less than other types of *beels*.

Culture Fisheries

These fisheries are highly controlled. Their ecosystem and aquatic environment is controlled in the typical pond culture fashion. This is practised in small (1-5 ha) and closed *beels* (no connection with the parent river). These practices are sensitive to the ecological damages. Such management practices are not widely prevalent in the *beels*.

Culture - based Fisheries

This is the most important and widely prevalent management system. The fish harvesting depends mainly on artificial stocking (Sugunan 1995b). The main focus of management is on stocking and recapture. The management options are eradication /control of predatory and pest species, macrophyte control, liming, fertilisation or bottom raking, optimum stocking size and density, selective fishing, *etc*.

Importance of Institutions in Management of *Beel* Fisheries

Low adoption of technology is the prime reason for such a low productivity realisation. The low adoption of technology is due to lack of incentives as well as support, which are constrained by inappropriate institutional set up and support system. Therefore, the institutional framework is the critical determinant of the management and outcome of the *beel* fisheries. The institutional framework governs the relationship between resources and stakeholders and amongst the stakeholders (Table 5). It forms the behavioural norms and enforcement mechanisms for the organisations involved. It provides the basis for the agents to react and interact and help in the flow of information. It enforces property rights, contracts and manages competitions. Organisations implement rules and codes of conduct to achieve desired outcomes. These institutions provide opportunities and incentives and remove constraints so that more people could engage themselves in these fruitful activities. The institutions directly affect the access to the productive assets and supports.

The institutional analysis explores

- Existing relationships and their appropriateness
- Rules and their enforcement mechanism
- Role of framework in promoting the management objectives
- Development of other options and strategies needed to meet the management objectives.

Table 5. Relationships and interactions among institutions/ stakeholders involved in beel fisheries management

Relationships	**Determinants (rules, policies, institutions)**
Beels and managers	Leasing policy Property regimes Traditional rights
Managers and fishers	Sharing arrangements Terms of entry
Fishers and fishers	Formal and informal groups Community groups Social reciprocity
Fishers and middleman	Previous commitments Backward integration of middleman Market structure Multiple functions like credit supply, wholesale, auctioning, etc.
State and fishers State and managers	Policies to promote fishers welfare Social security Policies to develop group action Mesh size regulation Human resource development
Research organisations and others	Technology development Technology transfer Human resource development

Property Relationship and Fishing Rights

The property rights are the fundamental institutions of allocation and access. These are wide and varied across the state. These vary from the highly controlled exclusive private properties to the open access *beels*. Various factors like size of a *beel*, traditional and customary rights, physiographic dimensions, physical accessibility and connectivity to the rivers, etc. are the determining variables for the nature of property rights.

The *beels* with greater expanse (300 - 1000 ha, stretch of 2 - 10 km) are under open access. The exclusion of free riders from fisheries exploitation of these waters is practically difficult and involve huge costs. There are many unclaimed and unsettled water bodies, which are used by the fishers as open access resources. Similarly, the impounded waters beyond the demarcated margins of a *beel* are open to every one.

In most of the *beels*, customary rights of the tribals and other indigenous ethnic groups are safeguarded legally (Anonymous 2001b). These rights are for species, gears and purpose specific. The use of small gears like scoop net, dip net, hook and lines, and other small nets are free from any control. These rights are for the purpose of fishing of unstocked and trash fishes and are limited to self-consumption only. Fishing after the main harvest season is also open. The marginal areas of *beels* are also recognised as open access after the harvesting season and women fishers usually fish in these areas.

The lessee fixes a nominal amount of rent for small-scale fishers. These fishing rents vary from Rs. 10 to Rs. 20 per day for fishing with small nets like scoop net, deep net. The rents depend upon the amount of catch availability across *beels* and season, but these are not proportional to the catch.

The Assam fisheries rules recognise these fishing rights as non-exclusive to other use rights like checking navigation, irrigation, drinking water, etc. They also have no rights over land, crops, trees, grass etc. Similarly, the destructive fishing practices are also not included in the fishing rights. Practices like catching juveniles, use of small mesh size, use of poison, jute retting, putting in other uses like agriculture, etc. fall under cognizable offence.

There is a provision of punitive action if the above rights are infringed, especially with regards to destructive practices like small meshed net, destruction of juveniles, etc. The power to take punitive action is vested with the Deputy Commissioners and Sub-Divisional Officers. However, these measures are not working effectively in the state.

Ownership and Control

The natural resources contribute largely to the *beel* fisheries system. Therefore, those who own and control these resources, enjoy returns without any investment effort or intervention in the production process. Political and legal processes largely determine the ownership and control. The owners gain the benefits in the form of lease amount, which varies from 20 to 30 per cent of the fisheries output.

More than 67 per cent of the *beels* are under state ownership. These *beels* are most productive. These are owned by three state departments, viz., Assam Fisheries Development Corporation (AFDC), the Revenue Department and the Forest Department. The *beels* under AFDC are used for fisheries purpose. The AFDC leased 192 beels for the period of 5 years to the co-operatives or individuals. A small number of *beels* are also leased out by the Revenue Department. But *beels* under Forest Department are not utilized for fisheries as these are located in the forest areas like national parks and reserve forests.

The non-government agencies like community bodies, autonomous tribal bodies, panchayats, schools, etc. control about 33 per cent of the *beels*. These are leased out to individuals or group of individuals. They follow their own procedure of leasing. The lease amount or the rent is generally used for the social cause like school management, road building and contributions towards religious institutions, etc. Sometimes, the proceeds are used for providing assistance to the poor within the community or for social functions like marriages, funerals, etc.

There is a shift in property regimes towards exclusivity over the years in *beels* of Assam. A transition phase of shift of open access fishing to ownership and control of a group and further to exclusive rights holder like lessee has been observed. This shift is mainly due to two reasons. Firstly, the marketing potential has increased as the demand and consequently price are increasing. Secondly, the scarcity of resources has converted the open access community resources to exclusively owned resources. This shift has benefited the state government, which is able to earn a higher amount, though at the cost of implications on social equity.

Leasing Policy

The leasing policy determines the access and the allocation of the *beels*. It has an important role in *beel* fisheries management as a large proportion of the *beels* is under the control of the state.

According to the policy, fisheries co-operatives are preferred for leasing out the *beels*. The number of *beels*, which can be leased out to the co-operative societies, is not to exceed 60 per cent. The co-operatives are given the chance to take the bid at a lower rate than a private party. In the absence of the co-operative, lease is preferred for members from the fisherman community or backward classes. A concession of 7.5 -10 per cent is given to the individual lease under the specified conditions. The lease period varies from 3-5 years. The short span of the lease period is detrimental to the fisheries and it encourages complete extermination of brooder fish. The lessee is neither interested nor encouraged to undertake long-term management measures.

Formal Institutions

The Department of Fisheries, AFDC and FISHFED are the important formal institutions associated with fisheries development. Their role has already been mentioned in above paragraphs. The role of co-operatives is discussed below.

Co-operatives in Fisheries

There are approximately 200 registered fisherman co-operative societies in Assam. Out of these, only 7 are functioning. These co-operatives are organised under the fold of Assam Apex Co-operative Fish Marketing and Processing Federation Limited (FISHFED) under Co-operative Department of the state. The FISHFED was designed to provide an institutional mechanism to input and technological support. Its mandate is to organize the marketing of fish through developing necessary infrastructure. The promotion of exports and value addition is another important objective of FISHFED. But at present, it is more or less defunct and is conducting limited activities like marketing of fish amounting to Rs. 5 to 6 lakh per annum. Therefore, the role of co-operatives is not important in *beel* fisheries at the moment.

Informal Institutions

These institutions are non-government organisations (NGOs), informal groups, social institutions, village communities, self-help groups, etc. involved in fisheries activities. These institutions emerged with the need for a collective effort or a legacy of the past. These are mostly based on the social relationships and perform other functions also besides fisheries. They are efficient in terms of mutual reciprocity, information flow and accountability within the system. These organisations are very flexible and therefore, highly efficient in their operations.

The Family of Fisherman

A family is the most important informal institution in fisheries. The works and responsibilities of the fishers are distributed within the family members based on the capacities and opportunities. The womenfolk are involved in net preparation, selling of fish, supplying food to menfolk at the fishing sites, drying and preservation of fish, etc. They also catch fish in the open waters during leisure time.

Fishing Groups

The large-scale fishing is a group activity, particularly in large water bodies, which require bigger nets and group-based fishing practices. For this purpose, permanent and semi permanent groups are operating in the area. These groups generally consisting of 10 to 14 members belonging to same caste and area. They either own or hire crafts and gears collectively. The collective assets of many groups vary from Rs. 50,000 to Rs. 2 lakh. These groups are locally known as *hawal*. The seniormost man having more knowledge and experience in fisheries is made group leader, locally called *hawaldar*. This leader acts as a representative for negotiations and bargaining for share in fishing. Sharing among the group members is equal after deducting the fixed and variable expenses. The cost of food during fishing is also deducted from the collective pool. The share of the occasional absence due to ill health or other emergencies is also accounted. Even, smaller contingencies like accidents, healthcare cost, etc., are also met from the collective pool.

Management Groups

The functions like lease taking, managing, investing, control, organising for selling in the suitable markets are performed as a group. Membership in such groups varies from 2 to 4. The individual responsibilities vary from place to place. The share is based on relative contributions to the management and does not follow any uniform pattern. At many places, the informal group operates within the formal group. It is more so, within the co-operatives. A few members of the co-operative manage the *beel* in the name of the co-operative. They pay amount of Rs. 10,000 to Rs. 20,000 for common facilities like contributions to religious institutions like Namghar (religious institution), temple, repair of roads, etc.

Caste Groups

The Caste groups are important means of social reciprocity and sharing information. These are also important for collective bargaining, especially for ensuring free access rights, percentage sharing and negotiating for the terms of entry. These groups also help in facing other caste groups. There are various caste groups belonging to different communities like, Hindu fishers groups, Maimal community groups, Bangladeshis' fishers groups, Bihari fishers groups, Muslim groups, *etc*.

Condition of Entry

The conditions for entry to fishing in a *beel* vary widely across the state. In the community-owned *beels*, only the fishers belonging to the same community are allowed to fish. In most other cases, the groups having previous contracts are preferred over others. In some places, the fishing groups from the outside state are preferred as they are more efficient and less demanding in the negotiations. In few localities, like *Majoli* Island, the fisher groups have to pay Rs. 5,000 to Rs. 10,000 as entry fees, in addition to the share from the fishing catch.

Sharing Arrangements

The proceeds of a fish catch are shared between the fishers and the *beel* manager or lessee as per the agreement between them. The agreement involves catching as well as porting to the market.

The share of fishers varies between 30 and 70 per cent, depending upon the availability of fish, ease of catch, type of catch, prevailing practices, provision of craft and gear, provision of food and utensils, membership in fishing group, etc. Some of the sharing patterns are as follows.

- When the fish is not abundantly available, the ratio of share between fisher lessee is 50:50.
- When the availability of the fish is sufficient, 60 per cent goes to the lessee.
- When the fish is quite abundant and easy to catch, lessee gets 70 per cent.
- In case the fish is moderately available and *beel* is weed-choked, 60 per cent goes to the fishermen.
- In extreme difficulty to catch, low availability of fish and highly weed choked situation, fishers demand 70 per cent share.

The above arrangement is followed when the fishers use their boat and net. Lessee takes 20 per cent more when he provides boats and nets.

Within the group, the *Hawaldar* takes 60 per cent when he provides food, utensils, boats, nets, other essential fishing requisites and the remaining 40 per cent is distributed among the fishers. In case the fishing equipment are collectively owned or hired, the share is equally distributed among the members after deduction of the cost of operation and food. In certain cases, *Hawaldar* engages additional group for fishing and in this case, he takes 20 to 30 per cent of the contract money as the organiser.

Regulations in Fisheries

The role of Fisheries Department of the state is very important as it makes crucial decisions and performs important functions in *beel* management. The large and interconnected system needs a public body to control and monitor, e.g. mesh size regulations, protection of the juveniles from destruction, etc. The state is empowered with legal provisions to punish the defector but there is no effective mechanism to enforce it. Similarly, fishing holidays in the rivers in breeding season is another option. The mechanism needs to be developed for such conservative measures. The flow of agricultural chemicals poses threat to the *beel* fisheries, as these are connected to the agricultural systems. The government needs to develop priorities and the means to restrict the use of these chemicals within acceptable limits.

Input Supply System

External input use is an essential component of scientific management of *beels*. The most crucial among them is seed. The appropriate size of seed at the time of stocking is costly. The seed cost per hectare varies between Rs. 3000 and Rs. 4000. Quality seeds are not available in adequate quantity at the time of stocking. Therefore, government needs to take appropriate policy measures for the production of the fish seed. Besides, the managers need to invest for clearance of weeds, construction of fish screen, provisions for crafts and gears. The credit supply from the institutions is very poor. The non-institutional credit is very costly and not available easily. Therefore, the institutional credit supply systems need to be improved for developing *beel* fisheries. The linkage of the institutional credit with the informal fishing group would help in developing fisheries and fishers simultaneously.

Technology Supply System

Another weak link in the development of *beel* fisheries is technology innovation and technology transfer. The diversity of the resources needs specific technological prescriptions for different *beels*. Therefore, the interaction of the *beel* mangers with the research institutions is a pre-requisite for the scientific management of the *beels*. At present, the Department of Fisheries and AFDC are involved in the technology transfer process. The extension workers are not adequately trained and there is limited coverage of departmental programme. Therefore, the institutional linkages with the research institutions and technology transfer programmes are to be strengthened on priority basis.

Public Support System

The onus of the efficient and scientific management of *beels* lies in the institutions and organizations involved in fisheries with public support. The related options in brief are as follows.

The infrastructure for value addition and export needs to be developed. The infrastructure development like road, ice factory, hatchery etc., need to be promoted by the state departments. This also promotes investment in the *beels*.

Another important area of attention is the market regulation and development. The share of middleman is high (50 to 60 per cent). Therefore, the regulation of price and marketing practices is important to benefit the fishers. The measures like organisation of the market functionaries, supply of market information and development of market yard will also help in linking the production with export and urban domestic markets in India.

The policy to link the institutional credit with *beels* is essential for greater flow of investment. The main hurdle of collateral security may be removed by making a policy to extend the credit against the deed of lease. The informal fishing group also needs to be recognised as management entity and they should be extended the credit so that they can take up the management functions.

Conclusions

The floodplain wetlands are the prime fisheries resources of Assam. Although, it is a sensitive ecosystem, it contributes significantly to the stability and sustenance, if managed efficiently. The vastness and responsiveness to the manipulations, generate enormous opportunities to harness their economic benefits. This can be gauged from the existing gap between the potential and realised productivity. The two options to realise the potential viz. technological and institutional are complementary to each other. But, the institutional set-up holds the key in the attainment of other management objectives besides the potential realisation. The role of government is limited only to ownership and lease, despite the complex system of diverse institutions and organisations. Much is to be done towards active participation of state machinery in setting and implementation of policies, regulations and providing incentives for productivity and efficiency. The appropriate functioning, co-ordination of other institutions like fishing groups, lessees, bankers, commission agents, etc.; are vital in management of *beels*. This can be achieved through development of institutional mechanism for the information sharing and collective action. Above all, the orientation towards shared interest will go a long way in realising the management objectives of this resource. These will in turn, generate larger economic and social benefits to the state in general and people, in particular.

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