ICAR-ICLARM Project

Strategies and Options for Increasing and Sustaining Fisheries and Aquaculture Production to Benefit Poor Households in India

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Strategies and Options for Increasing and Sustaining Fisheries and Aquaculture Production to Benefit Poor Households in India

भाकृअनुप
ICAR

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

WorldFish
CENTER

PENANG, MALAYSIA

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Strategies and Options for Increasing and Sustaining Fisheries and Aquaculture Production to Benefit Poor Households in India

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Foreword

Fisheries sector in India has made rapid strides in recent years. Its role in increasing food supply, generating job opportunities, raising nutritional level and earning foreign exchange has been continuously increasing. However, this sector did not receive adequate attention from the social scientists to understand its various socio-economic dynamics.

This publication is an outcome of the research 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. National Centre for Agricultural Economics and Policy Research, New Delhi has implemented this project in collaboration with central Inland Fisheries Research Institute, Barrackpore, Central Marine Fisheries Research Institute, Cochin, Indian Agricultural Research Institute, New Delhi, University of Agricultural Sciences, Bangalore and Gujarat Agricultural University, Junagarh. The publication provides an overview of socio-economic profile of stakeholders (fishermen/women), fishing and aquaculture technologies, demand and expected supply, policies, institutions and support systems. I am sure that this volume would be a useful document to researchers, policy makers, planners and students alike to understand the socio-economic aspect of fisheries sector in India.

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Preface

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 and rapidly changing social structures have had a major impact on the fisheries structure in the country. Fisheries and aquaculture has emerged as an important commercial activity from its traditional role as subsistence supplementary activity.

This report stems from an ADB sponsored ICAR-ICLARM project on **"Strategies and Options for Increasing and Sustaining Fisheries and Aquaculture Production to Benefit Poor Householders in Asia"** in which India is one of the partners. National Centre for Agricultural Economics and Policy Research (NCAP), New Delhi, has implemented this project in India in collaboration with Central Inland Fisheries Research Institute, Barrackpore, Central Marine Fisheries Research Institute, Cochin, Indian Agricultural Research Institute, New Delhi, University of Agricultural Sciences, Bangalore and Gujarat Agricultural University, Junagarh.

The present volume documents the technological profiles of fisheries and aquaculture, socio-economic 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.

The findings of the research project were presented and discussed at the National Workshop held at NCAP during 29-30 January, 2004. We were immensely benefited from the comments and views of the participants. We are grateful to Dr S.A.H. Abidi, Dr K. Gopakumar, Dr P.V. Dehadrai, Dr Dayanatha Jha, Dr S. Ayyappan, Dr Shaktivel, Dr S.N. Dwivedi, Dr S.D. Tripathi, Shri P.K. Patanaik, Shri M.K.R. Nair, Dr Mark Prein and others for providing able guidance and valuable insights. We are also grateful to all the chairpersons, discussants and participants for their significant technical contributions.

We gratefully acknowledge the suggestions and inputs provided by Dr Mahfooz Ahmed and Dr Madan Mohan Dey in planning the study. We are grateful to Dr P.K. Joshi for his support as PI (till August 2003). Our colleagues at NCAP extended all help in the execution of this project. Financial support received from Asian Development Bank and technical support received from the World Fish Center is gratefully acknowledged. We acknowledge the suport received from ICAR. The help and support of the authorities of co-operating institutions is gratefully acknowledged. We hope that this report will be helpful in planning and developing of the fisheries sector in India in a better way.

Research Team

Executive Summary

Fisheries is a sunrise sector in Indian economy and it has witnessed a spectacular growth of over 800 per cent, from 0.75 Mt to 6.2 Mt during the last five decades. After the mid-1980s, the development of carp polyculture technology has completely transformed the traditional backyard activity into a booming commercial enterprise.

Notwithstanding the phenomenal success of the sector, concerns for the economic and nutritional conditions of fisher folk have often been expressed. These become specially important in the context of rising environmental concerns, depressing prices worldover, emerging new economic order following establishment of WTO, IPR & SPS issues, compliance of several multilateral agreements, etc.

The present report is based on a comprehensive study on understanding the fishery sector from the viewpoints of its problems and the potentials, covering concerns for food security, trade, equity, environment and food safety. In such a study, the analysis of technology, trade, stakeholders and institutions, including policies, assumes high significance. In what follows is a brief description of the planning, execution and the outcome of this study.

Both primary as well as secondary data from the published and unpublished sources have been used in this study. The primary data consisted of 138 marine fisheries, 424 inland fish producers, 335 shrimp farmers, and 1002 consumers spread across major Indian cities and towns.

For supply-demand projection, the multi-market fish sector model developed at Word Fish Centre has been used. Fishes have been categorized into species groups. The multi-stage budgeting framework with AIDS model has been used for fish demand analysis.

A socio-economic index has been constructed to compare the socio-economic status of marine fishers under different technologies. Technology prioritization has been attempted through congruence analysis. Net protection coefficient and revealed comparative advantage models have been used for assessing the trade performance. Partial equilibrium analysis has been used for assessing the impact of food safety measures.

Technologies are the main drivers of growth. The outlay for fisheries research in total agricultural research has grown from 2% in the Fourth Five Year Plan (1969-74) to 6% in Tenth Five Year Plan (1997-2002).

Marine fisheries is a renewable resource and is considered to be a pro-poor sub-sector. Marine fish production has been still found as a capture fishery resource registering the highest production (40%) from the north-west coast and the lowest (6%) from the north-east coast, with highest landings being through mechanized craft (64%). Artisanal fishery on which most people depend, has been found to contribute only 8%. The traditional fishing technology (artisanal), which accounted for 37 per cent in 1982 is currently contributing only 8 per cent. It is reasonably known that marine fisheries are probably near the ceiling of the potential. However, scientific opportunities may exist in areas like mariculture of filter feeders. But the development of marine sector is beset with major management problems. To promote this sector, commercialization of hatcheries is needed. Marine sector is also facing the problem of influx of sewage water and other pollutants, causing health hazards. Yet another problem faced relates to global warming. The marine fisheries also have to bear the large-scale destruction of juvenile fishes. From all these angles, institutionalization of conservatory and regulatory / control measures are important in the marine sector.

Information technology, waste reduction, motorization of traditional craft, use of low-cost fish aggregation devices (FADs), species and stock enhancement, improvisations in gears and nets, design of equipments for post-harvest technologies to avoid imports, tuna and tuna-like species farming, identification of new items for export are some of the new opportunities that have been identified in the marine sector.

A paradigm shift has occurred from marine fisheries to aquaculture during the last 20 years. Aquaculture (carp, molluscs, crustacean) may expand significantly in future as it has been found to be profitable as well as less risky. For instance, the B-C ratio has been calculated to range from 1.22 for high-input to 1.79 for low-input carp culture and duck-cum-fish culture and 1.5 and 1.3 for fry and fingerlings production, respectively. Yet another development noticed is a shift towards diversification of fisheries (polyculture), covering carps and others species of fishes, including exotic fishes as well as other enterprises like piggery, poultry, duckery and paddy-cum-fish culture. The new scientific opportunities in aquaculture include cold water fishery, ornamental fisheries, reservoir fisheries, integration of seaweed farming, and culture of mullets into brackish water aquaculture, spiruluna production, lobster fattening, sea ranching, small scale fresh water carp culture in seasonal ponds, catfish culture and use of inland fishing craft (plank–built boats). Notwithstanding these proven benefits, the adoption of aquaculture technologies have been found to be constrained by such problems as lack of skill, capital, infrastructural facilities, availability of water bodies, tragedy of commons, input (feed) scarcity, and high risk.

The sources of growth in fisheries, in general, is through area expansion and/ or yield increase (increased inputs and/ or greater efficiency in use of inputs). However, there are major challenges to exploit the potential of the sector. They include:

- Fresh water will become acutely scarce in future, making aquaculture a difficult proposition.
- The energy requirement particularly in the marine sector will remain a binding constraint.
- The sector faces considerable risk from diseases; thus, disease management will be critical.
- The availability of fish feed (fish meal and fish oil) will be a major constraint.

The above challenges exert pressure on technology for accelerating productivity through:

(a) Stock improvement

(b) Better health management

(c) Water control / management. Water productivity in aquaculture has not even been estimated. Carrying capacity of water bodies have to be kept in view while going for intensification.

(d) Feed management

(e) Energy management

(f) Processing and value-addition

(g) Modification / innovations of feed inputs, and

(h) Fishery credit, marketing and extension machinery.

In all these efforts, with technology as the main driver of growth, the overriding consideration should be that technology and investment target poor people in providing benefits of fisheries development. In respect of technologies, an exercise has been made to prioritize pro-poor technologies using relevant criteria and weightage. The results of the exercise have been provided separately.

In a sector dominated by small-sized poor fishers, with trends towards exports and commercialization, the role of policies and institutions, assumes critical significance. Institutions are mandated to planned and participatory efforts in policymaking, eco-system based management and stronger enforcement of regulations. But we generally find neither a separate policy nor a broad-based institutional success in fisheries.

Policies form a part of the institutional support. Public investment in fisheries sector (at 1993-94 prices) has grown from Rs. 1704 million during TE 1982 to Rs. 4545 million during TE 2001. But the growth rate during 1990s has fallen to 3.89% from 8.54 % during 1980s. In the policies, laws, subsidies, IPRs, and SPS, infrastructures are critical for larger impact. It has been argued that first of all, it is necessary to recognize fisheries at par with agriculture in general, and particularly in providing input subsidies, income tax rebate, etc. We should have more clarity and firmness in policies towards foreign fishing in Indian EEZ. Reduction in import duty on OBM spare parts and sea-safety equipments like eco-sensors may be necessary. Adoption of growth-centred approach rather than spreading of resources thinly to fisheries development has been called for. Marine Fisheries Regulation Acts of States need to be revisited in terms of present-day relevance and compliance. There is also a dire need for framing suitable leasing policies of inland water bodies (reservoirs, Panchayati ponds, seasonal water bodies, check dams, etc.). Further, use of effluents should also be considered in the policy. Similarly, aquarium reforms are needed. In the Water Users Association in the villages, fishers should also be included in the management of water, including rights to fishing. The feasibility of the policy of 'import for export purpose' also has to be assessed; it would help in importing, reprocessing and then exporting. In other words, a blanket ban on imports need not be imposed and import restrictions should be drastically reduced over the years. Further, import tariff rates for fisheries products have been reduced from 60% in 1988-89 to 35.2% in 2002-03. As regards subsidies (cheaper land, hatchery, credit, lower taxes and tariffs on imported inputs etc.), these have to be targeted towards traditional and small-scale fishers.

Environmental requirements are likely to contribute to capital-intensive production as controlling negative externalities from aquaculture often requires expensive capital investments. But capital investment and quality improvement are financially feasible even with risk adjustments, provided there is an increase in the scale of operation. Thus, there arises a dilemma – is aquaculture pro-poor or is it for commerce. We should follow a two-pronged approach catering to promote both high quality mass production for rich people and common quality production for masses of poor fisherfolk.

There is a need to actively involve Panchayati Raj Institutions and Co-operatives, Private sector, NGOs, Self-help groups (SHGs) in promoting fisheries. There are some success stories in respect of few of these institutions. For instance, the marketing initiative of NCDC, Varsova Co-operatives Society, Arnala Cooperative Society, Deogarh Cooperative Society in the Maharashtra state, Mudiyali Cooperative Society, and Saguna Union in West Bengal, Gangotri Cooperative Society in Karnataka, etc. are the shining examples of success. More and more such success stories are necessary for a deeper impact. We may also have to look for successful institutional models outside the country. For instance, in Thailand, an all industry organization consisting of producers, transporters and processors is reported to be doing very well.

Instruments like seed, feed, credit, extension, R&D and database are critical. Seed supply and certification should receive priority attention. Credit supply to not only owners of ponds but also to workers and fishers is necessary. An aquaculture section may have to be opened in Banks. Export credit for packaging is necessary. Similarly, insurance for rejected lots need attention. Medical research on control of diseases due to food poisoning need to be conducted. It is generally opined that there should be a separate department of fisheries, if not a separate Ministry, to give a boost to this sunrise sector. Further, it is strongly felt that the existing fisheries development programs have become stale and stagnating. Revitalizing them is necessary. Similarly, there is a need to establish Sea Farmers Development Agency for providing the needed push to the sector.

India has export competitiveness in exporting fishery products. Trade through exports has bought prosperity to the sector. Since this export is largely dependent on limited / specific species (shrimp) and only to 2 to 3 countries (Japan, USA and EU), the income of the sector faces relatively high risk. It has been predicted that overall, the net export would increase but at a slower rate than now. The export prospects are dependent on secular growth in export prices of 6 to 7% per year. Whether such prices really prevail in future is not known. The export prospects are dependent on compliance of safety measures also. But the compliance may adversely affect competitiveness of our fishery products. It is estimated that the erosion of competitiveness varies between Rs. 7 and Rs. 10 per kg of fish. It is also opined that there is a substantial rise in unit values as a result of observing safety standards. The financial feasibility of capital investment for the upgradation of quality standards to meet EU specifications has indicated that the IRR of such investments varies between 14 and 30 per cent and has been found to be viable. In the absence of some conclusive evidences, this aspect needs a detailed study. Further, it is also necessary to find out ways and means to reduce safety compliance costs. There is a threat of non-tariff barriers of major importing countries like the USA which has recently levied anti-dumping duty to the imports of shrimps from India and Thailand. How such barriers would affect Indian fish production and marketing? Can we follow international standards to counter highly volatile and stringent, non-tariff barriers? The rapid rise in information and documentation requirements of safe handling, processing and origin of fish products are skill intensive and expensive and form yet another barrier for the participation of small scale and poor fishers. These questions need detailed studies.

The relatively higher fish prices have stimulated fish production further. In fact, the real prices of fish, in general, have increased over the past 20 years. The relative prices of fish have soared up compared to the steeply declining meat and grain prices over the same period. It is feared that the poor who used to take small quantities of animal protein through fish eating are likely to substitute it with milk and meat as these have become relatively cheaper. Under such a dynamic situation, the net nutritional impact of fisheries development is not clearly known.

It is reported that Indian fishery, particularly the processed fisheries products are much cheaper than that of the competing countries. But processing companies are facing the problems of complicated exporting procedures, high shipping costs, cut-throat competition in the industry, changing quality standards of importing countries, irregular power and raw material supply, hygiene problems and non-availability of quick transportation facilities from the fishing port to the processing units, etc. Our success in exports in the coming years largely depends on how best and how soon we can overcome these problems. In other words, we should understand whether redirecting our scarce resources to large scale exports would make sense in the long run? Is it an opportunity or a threat? This has been very clear on seeing the growing divide between the poor traditional fishers and large-scale commercial operators. Reviewing of studies on linking fish to the food security of the poor has generally suggested that outlook is not especially good. It is reported that such trade-driven capitalist commercial fish farming however small it is, has reduced the livelihood opportunities for the dry fish processors, petty traders within the communities, widows and other destitute people. As per directives of international conventions like Kyoto Declaration and Code of Conduct of Responsible Fisheries, we should be clear about, whether such a trade-driven sector is promoting food security, not contributing to environmental degradation, not adversely impacting on nutritional rights and needs of the people for whom fish and fishery products are critical to health and well-being. The critical question is do we have institutional structure and process, which can help percolate such gains to poor fishers?

Our studies have shown that domestic market is generally supportive of low-value fishes. A small section of high-income people is also emerging to support high-value fish products. Innovations in product diversification, venturing into the preparation of ready-to-eat food and networking with fast food centres, hospitals, schools, army canteens, railway stations, airports, etc. are necessary. The domestic markets have been found to be highly imperfect, provide marketing services at high cost, follow unfair marketing services, operate under unhygienic conditions, and are devoid of cold chain and storage facilities, etc. They are highly unorganized, particularly at the primary level.

It is feared that increase in production with problems of exports may result in price crash, lower profitability and lower technology adoption. All these suggest that only institutions of collective action with a market-oriented framework with emphasis on timely supply of services and supplies will be critical.

As compared to the total population of about 1.2 billion, fishers are small in number (7 million). Therefore, it is likely that they may not receive priority attention. Our studies in this project have clearly shown that traditional fishers dominate the marine sector and fishers having small pond size are socially deprived, educationally weak with very high occupational rigidity. There is inequity in the distribution of yield and effort in marine fishing. They are unorganized with least social security benefits. The informal social security system in the form of sharing of earnings for the community and social organizations prevailing in the traditional fishing is absent in the mechanized fishing. The productivity on large sized fish ponds is almost double than that on small ponds. There are also huge regional variations in productivity. However, the shrimp farming, unlike freshwater aquaculture, is mainly a commercial enterprise undertaken by educated and skilled individuals and firms/partners. Shrimp farming, particularly on larger scale has been found profitable. Poverty among aquaculture farmers is very high as compared to that in shrimp farmers. Disguised unemployment is very high. They face high risks of life and means of livelihood; for instance, boats are insured, but not the people on boat. Disposal of wastes and pollution around their habitat affect the health of fishers. Generally, alternative livelihood options are very few and therefore, fishers face low and insecured income. Thus, fishers are a socially and economically deprived lot.

The project findings have clearly shown that fish production would increase from its current level of 5.4 million tonnes to 9 million tonnes by 2015. Such a level of fish production will enhance food security by 15 to 19 per cent by 2005 and 25 to 40 per cent by 2015. The increased production would lead to the availability of fish at cheaper prices. For instance, fish prices would be lower by 13 to 17 per cent by 2005 and 21 to 35 per cent by 2015. Obviously, there would be more fish consumption to the extent of 17 to 22 per cent by 2005 and 31 to 66 per cent by 2015. There would be a marginal improvement in the nutritional status as a result of increased fish consumption. The share of fish in the total animal protein supply is only 12.4% now, it may rise a little in the coming years. The lower consumption in India is also on account of our restricted food habits.

The fishery sector is a major foreign exchange earner in the Indian economy. Its foreign exchange earnings have been projected to increase by 16 to 20 per cent by 2005 and 26 to 42 per cent by 2015. In view of higher production in fisheries, producers may lose from price fall in the domestic market; where prices are estimated to fall by 15 to 20 per cent by 2005 and 27 to 54 per cent by 2015. However, the net gain from export has been projected to be substantial; Rs. 16 to 21 billion by 2005 and Rs. 74 to 152 billion by 2015. Nearly 85 per cent of the export benefits are projected from shrimp export alone.

Overall, the income to fishermen at constant prices (1998) would increase in the range of Rs. 264-345 per person per year by 2005 and Rs. 1239 per person per year by 2015. However, the net effect on employment is not clear. It is also reported that capture fisheries is not likely to provide increasing source of employment at any significant scale in the coming years. There is disguised unemployment in the sector; but employment in retail fish trade would be an opportunity to reckon with.

The economic returns from the fishery sector have been found to be highly attractive. On an average, the internal rate of return (IRR) has been estimated as 42 to 55 per cent, B-C ratio as 2.1 to 3.4 and net present value (NPV) as Rs. 82 to 176 billion. In the contributions of the fishery sector, the role of technology is central. The marginal contribution of technology to growth in fishery sector has been estimated to be 19 per cent by 2005, 41 per cent by 2015 ; in inland fisheries it has been projected as 48 per cent and in shrimp farming, 42 per cent. As regards the distribution of economic gains from fishery development, it has been estimated that the producers gain would increase from the present 25 per cent to 54 per cent by 2015. The total social gains from the sector have been estimated to be about Rs. 279 billion by 2015.

The study has shown that technology and trade, reinforcing each other, though ushered in wealth, have raised sustainability concerns in some sub-sectors in recent years. Generally, these technologies and trade interventions have been skill-based, capital intensive and size non-neutral and thus could not have much impact on the socio-economic conditions of the poor fishers. In some cases, institutional and policy failures have also been observed. Keeping these findings in view, the following strategies have been suggested for an accelerated fishery development with focus on poverty alleviation of poor fishers:

- Follow people-centered not commodity-centered approach
- Follow system approach
- Prioritize technology for the poor at national, regional and micro levels
- Innovate and strengthen institutions and policies
- Upgrade skills of the poor fishers
- Enhance investment and reorient policies to facilitate percolation of benefits from trade to all sections of the society, particularly the poor and the women
- Follow ecological principles
- Emphasize domestic market which is a sleeping giant
- Strictly monitor the development programs, make on-course corrections and assess the impacts of all revitalized programs
- Strengthen database and share it for a better planning and policy making in the sector.

An indicative action plan to implement the suggested strategy is briefly presented below:

Aquaculture should be accorded the highest priority in the action plan. Based on the national average productivity of about 2.2 t, the fishery area may be grouped into (a) Traditional states (West Bengal and Orissa, with productivity of 3.5 t), (b) Non-traditional states with high performance (Andhra Pradesh and Punjab, with productivity of 4 t) and with low performance but good potential (Maharashtra, parts of UP and Kerala), and (c) States with large watersheds (Bihar, Karnataka, parts of NE States, Rajasthan, Tamil Nadu and Madhya Pradesh). With regards to traditional states, the suggested treatment is diversification. In this context, the technology of seed production in catfishes is to be improved for upgrading it to the viable level. With regards to Andhra Pradesh and Punjab, the suggested plan includes treating the fisheries at par with agriculture for all purposes (input subsides, income tax rebate, etc.), strengthening of the extension system to upgrade the technical skills of fishers in the production, and processing of fishes, and providing market (since they do not eat fish as much as in traditional states). In the case of other states, there is a need to actively co-ordinate the activities of fisheries and irrigation departments. Since the consumer preferences are changing towards smaller fishes, taking several crops is becoming a reality. For this, seed supply has to be ensured through providing rearing space in the watershed itself. For this, technology has to be perfected. There is also a problem of ownership rights in large watersheds in these states.

As regards the marine sector, fish driers need to be perfected. Fresh water is a problem at the landing centres for cleaning fishes as well as ice making. Use of polythene sheets has been suggested for drying fishes to reduce spoilage.

Formation and making the self-help groups, co-operatives, etc. functional to offer services and supplies, including arranging processing and marketing is necessary.

Since mariculture has big potential, particularly in helping the rural poor and the women, it has to be promoted and strengthened with the simultaneous development of market. Technology to make hatchery and processing multipurpose has to be perfected. Similarly, the policy of leasing amount and rights need to be rationalized. Nearly 80 per cent of the coastal aquaculture is followed on less than 2 ha area. They are small sized enterprises. How they could remain viable as well as eco-friendly, has to be studied or learnt from the success stories of other countries.

1

Fisheries Sector in India — An Overview

Fishing as an occupation is being practised in India since time immemorial and has been regarded as a supplementary enterprise of the fishermen community on the subsistence level with little external input. Fisheries sector, however, has a strategic role in food security, international trade and employment generation. With the changing consumption pattern, emerging market forces and technological developments, it has assumed added importance in India and is undergoing a rapid transformation.

1.1. India's Share in World Fish Production

Fish production in India has touched 5.96 million tonnes in 2001-02 from mere 0.75 million tonnes in 1950-51. The global and Indian fish production during the last 50 years is reported in Table 1.1. The share of India in global fish production has grown gradually, from about 2.6 per cent during the 1960s and 1970s to 4.62 per cent in 2000-01. It shows that growth in fish production in India has been at

Table 1.1. Fish production in India and world, 1950-51 to 2001-02

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
2001-02	129.00	5.96	4.62

Source:Fisheries Statistics, 2000 FAO; Handbook on Fisheries Statistics, 2000, Ministry of Agriculture, Government of India and unpublished data from Department of Animal Husbandry and Dairying, Ministry of Agriculture, Government of India a faster rate than that in the world; mainly due to increasing contributions from inland fisheries.

1.2. Contribution to Indian Economy

Fisheries sector contributes to the national income, exports, food and nutritional security and employment generation. It is a principal source of livelihood for a large section of economically underprivileged population of the country, especially in the coastal areas. The share of agriculture and allied activities in the GDP is constantly declining. The agriculture sector is also diversifying towards high-value enterprises, including fisheries. The contribution of fisheries sector to the GDP has gone up from 0.46 per cent in 1950-51 to 1.47 per cent in 2000-01 (at current prices) (Table 1.2). The share of fisheries in agricultural GDP (AgGDP) has impressively increased during this period from a mere 0.84 per cent to 4.01 per cent. In fact, the fisheries sector is booming and contributing increasingly to the economic growth of the nation.

The role of fisheries in agricultural economy of almost all the states has been increasing as is evident from its enhancing share in the agricultural state gross domestic product (AgGSDP) (Table 1.3). Interestingly, this share has increased

Table 1.2. Contribution and growth of fisheries sector in India, 1950-51 to 2001-02

Period	Per cent contribution to		Per cent annual growth	
	GDP	AgGDP	Fisheries 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
2001-02	1.03	4.01	4.71	3.00
Overall growth	4.31	2.65		

Source: *National Accounts Statistics*, (different volumes) Central Statistical Organization, Government of India

Table 1.3. Share of fisheries in gross state domestic product (GSDP) and in agricultural state gross domestic product (AgSGDP), 1980-81 to 1999-2000

(in per cent)

States	Share of fisheries in GSDP					
	1980 - 81		1990 - 91		2001-02	
	SGDP	AgSGDP	SGDP	AgSGDP	SGDP	AgSGDP
Andhra Pradesh	1.2	2.6	0.6	1.7	2.14	7.69
Assam	1.9	4.0	1.6	3.9	2.05	5.84
Bihar*	1.0	1.9	1.0	2.4	1.63	4.11
Goa	2.3	9.9	2.2	15.8	2.67	23.54
Gujarat	0.8	2.1	1.1	4.3	1.06	6.39
Haryana	0.0	0.1	0.3	0.6	0.27	1.21
Himachal Pradesh	0.2	0.3	0.2	0.5	0.14	0.41
Jammu & Kashmir	0.4	1.0	0.5	1.2	0.48	1.50
Karnataka	0.6	1.3	0.4	1.2	0.37	1.29
Kerala	2.0	5.2	1.8	5.0	1.93	7.81
Madhya Pradesh*	0.1	0.1	0.2	0.4	0.17	0.57
Maharashtra	0.6	2.1	0.4	1.7	0.43	2.95
Orissa	1.1	2.1	2.0	5.2	2.42	7.45
Punjab	0.0	0.1	0.1	0.2	0.37	0.94
Rajasthan	0.2	0.5	0.0	0.1	0.07	0.26
Tamil Nadu	0.6	2.5	0.3	1.3	0.74	4.38
Uttar Pradesh*	0.2	0.3	0.3	0.7	0.52	1.51
West Bengal	3.0	9.4	3.1	9.9	3.14	11.82

Source: Gross Domestic Product of States of India 1960-61 to 2000-01, EPW Research Foundation.

* The figures relate to the undivided states in all the tables.

more prominently in the non-traditional fisheries states like Bihar, Haryana, Punjab, Madhya Pradesh, Uttar Pradesh, etc.

1.3. Fish Production: Structure and Trend

The fisheries production in India during the 1950s was more pronounced in marine fisheries, which remained the major contributor till the early 1990s (Table 1.4). Its share in the total fish production was more than 70 per cent during 1960s, but started declining thereafter and came down to about 62

Table 1.4. Changes in the structure of fish production in India, 1950-51 to 2001-02

(in million tonnes)

Year	Marine fisheries	Inland fisheries	Total production
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	1.56 (59.12)	0.89 (40.88)	2.45
1990-91	2.30 (59.96)	1.54 (40.04)	3.84
1995-96	2.71 (54.70)	2.24 (45.30)	4.95
2001-02	2.83 (47.51)	3.13 (52.49)	5.96

Note: Figures within the parentheses indicate percentage to total fish production

Source: Handbook on Fisheries Statistics, 2000, Ministry of Agriculture, Government of India; and unpublished data from Department of Animal Husbandry and Dairying, Ministry of Agriculture, Government of India

per cent during 1970s and to 59 per cent during 1980s. From the mid-1990s, the fisheries production started witnessing a significant change, and by the year 2000, the share of inland fish production crossed half of the total fish production in the country. 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. The inland fisheries in India include both capture and culture fisheries. The capture fisheries have been the major source of inland fish production till mid-1980s. But, the fish production from natural waters like rivers, lakes, 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 realization of the potential and versatility of aquaculture as a sustainable and cost-effective alternative to capture fisheries. During the past one and a half decades, the production of inland aquacultural fish has increased from 0.51 to 2.38 million tonnes and of inland capture fisheries has declined from over 0.59 to 0.40 million tonnes (Anonymous 1996(a,b); Anonymous 2000; Gopakumar et al. 1999). The percentage share of aquaculture has increased sharply from 46 to 86%, primarily because of 4.5 fold increase in freshwater aquaculture. The share of freshwater aquaculture in total inland fish production has also increased from 28 to 66% (Anonymous 1996(a,b); Anonymous 2000). However, there is still ample scope for enhancing fish production in India.

The growth rate analysis for various states showed that fish production had a significant growth in all the states, except Rajasthan. In some of the states, like Andhra Pradesh, Gujarat, Karnataka, Kerala, Maharashtra and Orissa, the growth of inland fisheries was found to be higher than the marine fisheries. But in West Bengal and Tamil Nadu, marine fisheries growth was observed to be more than the inland fisheries (Table 1.5).

Table 1.5.Growth trends of fisheries sector in different states of India (1984-2001)

CAGR (%)

S. No.	States	Inland fisheries	Marine fisheries	Total
1	Andha Pradesh	8.84*	4.28*	6.10*
2	Assam	8.76*	-	8.76*
3	Bihar	5.48*	-	5.48*
4	Gujarat	7.31*	5.56*	5.71*
5	Haryana	6.24*	-	6.24*
6	Himachal Pradesh	5.72*	-	5.72*
7	Jammu & Kashmir	4.17*	-	4.17*
8	Karnataka	8.05*	0.08NS	2.41**
9	Kerala	7.45*	4.03*	4.34*
10	Madhya Pradesh	9.27*	-	9.27*
11	Maharashtra	9.95*	1.42NS	2.68*
12	Orissa	7.66*	6.82*	7.28*
13	Punjab	18.42*	-	18.42*
14	Rajasthan	0.38NS	-	0.38NS
15	Tamil Nadu	-0.25NS	2.69*	1.81**
16	Uttar Pradesh	7.94*	-	7.94*
17	West Bengal	5.71*	10.09*	6.22*
18	Delhi	3.87*	-	3.87*
19	India	6.54*	3.72*	5.03*

*Significant at 1%, ** Significant at 5%, NS- Non-significant

1.4. Fish Consumption

According to the National Sample Survey (NSS), the annual per capita fish consumption was 2.45 kg in 1983; it increased to 3.45 kg in 1999-2000. Only 35 per cent population in India was estimated to be fish eater and their annual per capita fish consumption was 9.8 kg in 1999-2000. However, wide regional variations do exist in fish consumption across regions, states and income classes (Table 1.6).

Table 1.6. Changes in fish consumption by different classes in India, 1993 to 1999-2000

(in per cent)

Class	Fish eating sample households				Total sample households			
	1983	1987-88	1993-94	1999-2000	1983	1987-88	1993-94	1999-2000
Rural	6.97	7.54	7.23	9.12	2.39	2.73	2.77	3.35
Urban	8.01	8.57	9.18	11.05	3.87	4.38	4.81	5.48
All	7.30	7.86	7.90	9.79	2.45	2.78	2.93	3.45

1.5. Trade Performance

The data on different indicators of fisheries trade, presented in Table 1.7, reveal that fisheries have been an important component of agricultural exports. The share of fisheries exports in agricultural exports varied from 14 to 20 per cent and in total exports hovered around 3 to 4 per cent during the period 1983-2000. The ratio of fisheries exports to fisheries GDP has been substantial, varying between 17 and 30 per cent. It was satisfying to find that India has been a net exporter of fish and fish products, and the import of these commodities constituted only a miniscule proportion of fisheries exports, both in terms of quantity and value (Table 1.7). The value of fisheries imports to exports was 0.92 per cent, which dipped down to a negligible level in TE 1992. During mid-1990s, especially after the establishment of World Trade Organization (WTO) in 1995, it started showing improvements and in recent years; the value of imports of fisheries commodities as percentage of export varied from 0.58 to 0.94 per cent. In quantity terms also, the ratio of fish imports to fish exports showed a similar

Table 1.7. Share of fisheries exports in the agricultural and total exports of India along with its share in fisheries GDP

Year	Percentage share of Fisheries exports in			Import as % of export	
	Agricultural exports	Total exports	Fisheries GDP	Quantity	Value
1983	14.06	3.80	26.61	0.88	0.92
1986	14.20	3.75	20.34	0.37	0.21
1989	15.02	2.95	17.46	0.01	0.01
1992	16.91	3.13	23.20	Ng	Ng
1995	20.26	3.67	30.11	0.61	0.30
1998	16.83	3.29	23.46	1.95	0.94
2000	19.61	3.12	24.76	1.24	0.58

Note: Year refers to TE average;

Source: Monthly Statistics of Foreign Trade of India; Volume Exports and Re-exports (various issues), Ministry of Commerce and Economic Survey, Ministry of Finance, Government of India and National Accounts Statistics, Ministry of Statistics and Programme Implementation, Government of India.

trend and now it constitutes 1 to 2 per cent of the exports of fish and fish products. It may be inferred from this analysis that fisheries sector has been substantially contributing to national earnings in terms of foreign exchange. The apprehensions of import surge of the fish and fish products after opening up of the economy are not still visible.

1.6. Resource Availability and Potential

India, with diversified agro-climatic regions, is endowed with potentially rich and varied aquatic resources. It is endowed with an Exclusive Economic Zone (EEZ) of 2.02 million square kilometres, a continental shelf of 0.5 million square kilometres and a long coast line of 8119 kilometres with some of the richest fishing grounds in the world. The main inland fishery resources include about 1.20 million hectares (Mha) of brackish water area, 2.38 Mha of fresh water ponds and tanks; about 1.24 Mha. of reservoirs; 0.82 Mha. of beels, oxbow lakes and derelict water bodies; 0.24 Mha. of floodplain wetlands; 0.29 Mha. of estuaries; 1.65 Mha of mangroves, swamps, lagoons, etc. besides about 1, 91,000 kilometres of rivers and canals. These resources offer immense scope and potential for development of aquaculture and fisheries in India.

The potential harvest has been estimated at 3.93 million tonnes per annum from marine resources of the Indian EEZ and 4.50 million tonnes from the inland water bodies. Against this estimated potential, the production was about 2.83 Mt from the marine sector and 3.13 Mt from the inland sector during 2001-02. Thus, against the total potential of 8.4 Mt fish, the production in 2001-02 was 5.96 Mt, which is much below the Ninth Plan target of 7.04 Mt. The projection for the Tenth Plan for the total fish production is based on the assumption of growth rate at 8% in the inland sector and 2.5% in the marine sector, with an average growth rate of 5.5%.

1.7. Institutional Policy Support to Fisheries

India has a huge network of institutes under different organizations to support/ conduct R&D in the fisheries sector. These include: (i) Indian Council of Agricultural Research (ICAR); (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, (vii) Department of Ocean Development (DOD); (viii) Department of Science and Technology (DST); (ix) Department of Biotechnology (DBT); (x) University Grants Commission (UGC); (xi) Indian Institutes of Technology (IITs); (xii) Indian Institutes of Management (IIMs), and (xiii) Several volunary agencies/ private industries. The need for financial 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), a refinance agency for commercial banks, co-operative banks and regional rural banks, has been the major facilitator of credit to the fisheries sector. 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) have also entered into this sector to lend credit. Credit support from financial institutes is available for almost all the activities of fisheries and for creation of infrastructure.

1.8. Constraints in Fisheries Development

There are, however, some weaknesses and threats to the fisheries sector, which need to be addressed if the sector has to achieve the production targets of the Tenth Plan. Some of the critical gaps and constraints that are hampering the growth of the fisheries sector are:

- Lack of a reliable database relating to aquatic and fisheries resources,
- Non-availability of suitable fish yield models for multi-species fisheries for open inland waters and marine resources,
- Weak multi-disciplinary approach in fisheries and aquaculture,
- Inadequate attention to the environmental, economical, social and gender issues in fisheries and aquaculture,
- Inadequate HRD and specialized manpower in different disciplines,
- Weak linkages between research and development machinery,
- Weak marketing and extension network,
- Poor technology transfer and anthropogenic interventions, resulting in loss of biodiversity,
- Decline in fish catch,
- Depletion of natural resources,
- Over-exploitation of coastal fisheries,
- Pollution of water bodies with industrial and domestic effluents,
- Clandestine introduction and spread of exotic fish species,
- Unscientific management of fisheries and aquaculture activities, and
- Contamination of indigenous fish germplasm resources.

2

Profile of Aquaculture and Fisheries Technologies

2.1. Catalogue of Available Technologies in India

2.1.1. Freshwater Aquaculture

The available freshwater aquaculture technologies can be classified into technologies for production of table size fish or grow out and fish seed production. Both types of technologies are for different categories of fishes, *i.e.* carps and catfishes including air-breathing fishes, prawn and ornamental fishes. Their catalogue is mentioned below.

The current freshwater grow out technologies may be classified into: (i) Polyculture of Indian carps or Indian and exotic carps together (Composite carp culture), (ii) Mono- and polyculture of air-breathing fishes, (iii) Mono- and polyculture of freshwater prawns, and (iv) Integrated fish farming. The composite carp culture can further be classified into (a) Low input or fertilizer-based system, (b) Medium input or fertilizer- and feed-based system; (c) High input or intensive feed and aeration-based system; (d) Sewage fed water-based system, and (e) Aquatic weed-based system. Integrated fish farming includes (a) Paddy-cum-fish culture, (b) Fish-cum-cattle farming, (c) Pig-cum-fish farming, (d) Duck-cum-fish culture, and (e) Poultry-cum-fish farming

The technologies for fish breeding and seed production may be categorized as (i) Induced breeding of carps and strain development, (ii) Intensive carp seed rearing, (iii) Breeding and seed production of air breathing catfishes, (iv) Breeding and seed production of giant freshwater prawn, and (v) Ornamental fish.

2.1.2. Brackishwater Aquaculture

The grow out shrimp farming is the most important brackishwater aquaculture technology in India. The other technologies include: (i) Mud crab fattening, (ii)

Edible oyster farming, (iii) Mussel farming, (iv) Clam culture, and (v) Finfish farming.

Hatchery for seed production technologies include (i) Bivalve hatchery of mussel, clam and edible oyster, and (ii) Shrimp and sea-bass hatchery. Hatchery input technologies used were live feed, micro-algae, rotifer and brine shrimp (*Artemia)* culture.

Mariculture

This includes technologies for pearl oyster farming and pearl production, mussel, sea cucumber and seaweed. Hatchery and seed production technologies have been developed for pearl oyster, ornamental fish, clown fish, damsel fish and sea horse.

Post-harvest Technology

Traditional post-harvest technologies include drying, drying and wet salting, smoking, boiling and drying, smoking and drying, fermenting, icing, fish paste. Modern includes freezing, chilling, fermenting, electric and solar drying, curing and rack drying, canning, fishmeal, and fish products.

Aqua feed

Some of the fish feeds developed by CIFA, Bhubaneswar are: CIFACA, CIFAPRA, CIFAMA. Mahima' shrimp feed has been developed by CMFRI, Cochin, using low cost indigenous ingredients. It meets nutritional requirements of post-larvae, juvenile and adult shrimp and are suitable for on-farm production.

2.1.3. Fishing Practices

Inland

The Inland fishing practices primarily include various crafts and gears. The simplest and most primitive types of crafts used for fishing in inland waters are the rafts and dongas, operated in calm waters. In the larger rivers and estuaries, subject to strong current and tidal movements, sturdier planks built boats are used. The types of rafts and various materials used for their construction are: Inflated buffalo skins tied together, Banana stems or shoal bundles tied to form a floating platform, Earthen pots tied together to support a light platform of bamboo and the coracle, a shallow framework of wicker covered with a well-stretched cowhide. The different types of boats are: Dug out boat, Plank built boat, Dinghi and Nauka, Musula boat, Dug out canoes, and Built up boats. Various types of built up boats are: Bassien type, Satpati type, Broach type, Batchary and Chot type.

The different types of gears used are: Dragnet (Chanta-with pocket and Mahajal, Chaundhi, Ghanali and Dodandi-without pocket), Gillnets, e.g. Phasla, Current, Gochail, Ranga jal, Kamel. Kamel net can be further classified as Hooks and Line, Cast net and Traps.

Marine

Artisan crafts include: catamarans, dugout canoes, plank-built canoes, FRP canoes, motorized crafts.

Small outboard crafts (fitted with one OB engine) include: plank-transom canoes (mini/ pelagic trawl units), plank-built canoes, dugout canoes, catamarans, small plywood boats, FRP crafts, and beach landing crafts.

Large outboard crafts (fitted with more than one outboard engine) include: ring seine units, large plywood boats, and beach landing crafts.

Mechanized crafts involve dol netters, trawlers, ring seine units with inboard engine, mechanized gill-netters, purse seiners, pole and line, and long lining.

2.2. Species Involved

The species involved in various technologies have been mentioned in the tables for prioritization of technologies (Chapter 8).

2.3. Farming / Fishing Practices

Inland freshwater aquaculture and mariculture farming practices have been summarized in Tables 2.1 and 2.2, respectively.

Table 2.1. Cultural practices under different aquacultural technologies

System	Species	Stocking (in'000 fingerlings ha^{-1})	Fertilization / Liming ha^{-1}	Feed day^{-1}	Management practices	Duration of rearing (months)	Average yield ($t\ ha^{-1}\ yr^{-1}$)
Carp polyculture							
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 1.5-2.5m	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 1.5-2m, Intermediate liming at 3 month interval @ 100 kg ha^{-1}	10-12	3-6
High input	3-6	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

Cond...

Table 2.1. Cultural practices under different aquacultural technologies — Contd

System	Species	Stocking (in'000 fingerlings ha^{-1})	Fertilization / Liming ha^{-1}	Feed day^{-1}	Management practices	Duration of rearing (months)	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 100-200 g), Maintenance of water depth at 0.7- 1.5 m	8-10	2-5
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	With feed Aquatic weed (Hydrilla, Najas, Ceratophyllum, Duck weeds like Spirodella, Lemna, Wolffia, etc.	Maintenance of water depth at 1.5-2 m	10-12	3-7 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 fertilizer 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

Cond...

Table 2.1. Cultural practices under different aquacultural technologies — Contd

System	Species	Stocking (in'000 fingerlings ha^{-1})	Fertilization / Liming ha^{-1}	Feed day^{-1}	Management practices	Duration of rearing (months)	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	Pelleted 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 0.3-0.5

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

· *Source*: Katiha *et al.*, 2003

SSP –Single super phosphate

Table 2.2. Cultural practices for mariculture technologies

Technology	Edible oyster farming	Mussel farming	Pearl oyster culture
Species	*Crassostrea madrasensis*	*Perna viridis, P. indica*	*Pinctada fucata*
Unit area	300 sq m	64 sq m	Open sea; 6 rafts and 600 box cages
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
Production	5.83 t shell (0.48 t meat)	0.8 t shell	

2.4. Costs and Returns

The cost structure, returns and benefit cost (B:C) ratios for different aquacultural technologies are presented in Table 2.3. The cost structure primarily constitutes 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 include 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, accounting for more than 50% in the total cost. The lease value was found to vary according to the fertility and property and management regimes of the water body. The cost of inputs varied according to intensity of their use across different technologies in accordance with requirements. The maximum cost was in the case of high input carp culture (Rs. 0.31 million) primarily due to feed cost. The lowest cost was for low input carp polyculture (Rs. 41,925), 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 million in the case of prawn culture. The B:C ratio was maximum for prawn culture (1.86); for other technologies, it ranged between 1.22 for high input carp culture to 1.79 for low carp polyculture and duck-cum-fish culture.

Table 2.3. Costs and returns for different freshwater aquaculture technologies

(in Rs ha^{-1})

Particulars	Carp polyculture			Sewage fed		Weed	Integrated				Pen	Air-	Prawn	Carp-
	Low input	Medium input	High input	Without feed	With feed	based	Duck	Poultry	Pig	Paddy	culture	breathing	culture	prawn culture
Costs														
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)							10000	50000	7500					
Fish feed		60000	200000		30000						20000	80000	60000	50000
Sewage cost				7500	7500									
Labour (management, weed collection, 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	3712	6337	3637	4282	7312	4162	3037	7050	12000	11250	8250
Total cost	41925	120400	306375	53212	90837	52137	61382	104812	59662	43537	101050	172000	161250	118250
Fish yield (t)	2.5	6	12.5	3	5	3	3	3	3	1	4	4	1.5	3
Others							Meat 2q Egg 8000	Meat 5q Egg 28000	Meat 16q	5 t				0.5 t

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Table 2.3. Costs and returns for different freshwater aquaculture technologies — Contd

(in Rs ha^{-1})

Particulars	Carp polyculture: Low input	Carp polyculture: Medium input	Carp polyculture: High input	Sewage fed: Without feed	Sewage fed: With feed	Weed based	Integrated: Duck	Integrated: Poultry	Integrated: Pig	Integrated: Paddy	Pen culture	Air-breathing	Prawn culture	Carp-prawn culture
Returns														
Fish/ Prawn	75000	180000	375000	90000	150000	90000	90000	90000	90000	30000	120000	240000	300000	90000
Others							20000	58000	6400	30000				100000
Gross returns	75000	180000	375000	90000	150000	90000	110000	148000	96400	60000	120000	240000	300000	190000
Profits	33075	59600	68625	36787	59162	37862	48617	43187	36737	16462	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

Source: Katiha *et al.*, 2003

The economics of brackish water aquaculture and mariculture technologies are depicted in Tables 2.4 and 2.5. The B:C ratio was found to vary from 2.4 to 7.4 in the case of brackish and between 2.2 to 5.5 for mud crab fattening and farming. For brackishwater, the ratio decreased with increase in intensity.

Table 2.4. Economics of shrimp culture

Shrimp culture technologies	Yield t/ha	Cost		B:C ratio
		'000Rs/ha	Rs/kg	
Extensive	1	5.1	5.1	7.4
Improved extensive	2	26.4	13.2	2.8
Semi-intensive	4	63.5	15.9	2.4

Source: Krishnan *et al.* 1995 (At 1981-82 prices)

Table 2.5. Economics of mud crab farming and fattening

Crab culture technologies	Yield (t/ha)		Cost Rs/kg	B:C ratio
	Crab	Milk fish		
Monoculture	0.8		56.2	3.6
Polyculture	1.1	0.7	42.5	5.4
Fattening	0.6		100.4	2.2

The cost and return structure for inland fishing practices was worked out for different property regimes (Table 2.6). The lower cost in the case of co-operative may be due to lower fishing effort and sharing of inputs. The gross and net annual and per day returns were maximum in the case of open access regime followed by co-operative and private regimes, but the net income per kg of catch favoured co-operatives the most followed by open access, and the least for the private regime. The input output ratios also indicated the superiority of co-operatives and open access regimes over the private regime; the values for these ratios were more than 2.5 times of the estimated ratio for private regime.

Table 2.6. Costs and returns in inland capture fishery

Item	Regime		
	Common property	Private	Co-operative
Costs			
Fixed cost (per year)	2907	3017	1451
Variable cost (per year)	1712	1737	285
Total cost	4619	4755	1737
Returns			
Price received (kg)	24	19	35
Gross returns (per year)	34490	14656	13108
Net returns (per year)	29869	9902	11371
Net returns (Rs/per kg)	21	13	30
Input output ratio	**7.49**	**2.90**	**7.55**

Source: Sinha and Katiha, 2002

It depicted the working efficiency and the extent of remuneration of fish catch for different management regimes and revealed that privatization of the fishing rights in riverine fisheries would accelerate the process of social disequilibria and broaden the income inequalities. It would push the downtrodden more and uplift the economically affluent fish traders.

The costs and returns from marine fishing practices are given in Table 2.7. The B:C ratios were found to be between 1 and 1.2, although the costs and returns per kg varied significantly.

Table 2.7. Economics of marine fishing practices

Fishing technologies	Yield kg/day	Cost Rs/kg	Return Rs/kg	B:C ratio
Ring-seine large	870	5.8	7.2	1.2
Ring seine medium	730	5.7	7.0	1.2
Mini trawler	27	30.0	36.0	1.2
Gill net	68	14.3	16.5	1.2
Pole and line	80	14.2	14.9	1.0

2.5. Factor Shares for Different Aquacultural Technologies

The factor shares for different aquacultural technologies have been worked out (Table 2.8). The factor shares of capital for carp polyculture technologies in gross returns ranged between 36 and 74% in the case of weed-based and high-input carp polyculture, depicting the nature of the technology. Among the constituents of capital, variable inputs had much higher share (20-65%) than the fixed inputs (7-17%). The share of labour varied from 6.67% for low input carp polyculture to over 25% in the case of paddy-cum-fish culture, followed by over 22% for weed-based fish culture. The study revealed that barring few technologies (high input carp, prawn, pen and air breathing culture), investment per hectare was low with major share of variable capital inputs. Very low share (10-15%) was documented of labour for most of the technologies. It was mainly used for harvesting; the number of labourers employed during other operations was very small, and permanent labourers were only a few.

2.6. Investment Needs for Dominant Freshwater Technologies

The micro-level investment needs for adoption of various technologies were calculated on the basis of the gross costs mentioned in Table 2.3. It was found that per hectare investment was highest in high input carp polyculture (Rs 0.3 million) followed by air-breathing fish culture (Rs 0.17 million) and prawn culture (Rs 0.16 million). The lowest investments were in case of low input carp polyculture (Rs 0.04 million) and paddy-cum-fish culture (Rs 0.043 million).

The budget requirements for macro-level adoption and implementation of these technologies were estimated after assessment of their prospects at the national level. The main freshwater aquaculture technologies were predominantly for carps only; therefore, the investments would be restricted to carp culture. The investment needs for intensive, semi-intensive and extensive carp cultures were estimated based on the potential area for different technologies. The estimates revealed investments to the tune of Rs 111.37 billion (Table 2.9). The maximum investments would be in semi-intensive carp culture (66%) followed by extensive

Table 2. 8. The net returns and factor shares for various factors of production under different aquacultural technologies

Item	Carp polyculture			Sewage fed		Weed	Integrated				Pen	Air-	Prawn	Carp-
	Low input	Medium input	High input	Without feed	With feed	Based	Duck	Poultry	Pig	Paddy	culture	breathing	culture	prawn culture
Net returns (Rs/ha)	33075	59600	68625	36788	59163	37863	48618	43188	36738	16463	18950	68000	138750	71750
Net returns (%)	44.10	33.11	18.30	40.88	39.44	42.07	44.20	29.18	38.11	27.44	15.79	28.33	46.25	37.76
Fixed inputs (%)	17.23	10.22	8.37	15.24	10.89	15.15	12.98	11.70	14.69	13.40	7.54	9.17	7.08	9.61
Variable inputs (%)	32.00	48.33	65.33	32.78	39.67	20.56	29.18	48.99	31.64	34.17	64.17	50.00	36.67	44.74
Capital (%)	49.23	58.56	73.70	48.01	50.56	35.71	42.17	60.68	46.33	47.56	71.71	59.17	43.75	54.34
Labour (%)	6.67	8.33	8.00	11.11	10.00	22.22	13.64	10.14	15.56	25.00	12.50	12.50	10.00	7.89

Based on figures depicted in Table 2.3

Table 2.9. Investment needs of the dominant freshwater technologies

(in crore Rs)

States	Intensive carp culture	Semi-intensive carp culture	Extensive carp culture	Total
Andhra Pradesh	6127	13244	2935	22306
Assam		1445	126	1570
Bihar*		4816	1258	6074
Goa			63	63
Gujarat		2408	838	3246
Haryana	1532	482		2013
Himachal Pradesh		36	8	45
Jammu & Kashmir		482	210	691
Karnataka		1204	5869	7073
Kerala		241		241
Madhya Pradesh		2408	2096	4504
Maharastra		1204	838	2042
Orissa		4816	1258	6074
Punjab	1532	241		1773
Rajasthan		1806	2096	3902
Tamil Nadu		2408	3354	5762
Uttar Pradesh*		10836		10836
West Bengal	6128	24080		30207
North-east region		1204	1677	2881
Others		60		60
Total	15319	73420	22627	111366
Per cent of total	13.76	65.92	20.32	100

Source: Modified from Katiha and Bhatta 2002 & Katiha *et al.*, 2002

*Figures refer to undivided states

carp culture (20%) and intensive carp culture (14%). The most potential states for investments were found to be West Bengal, Andhra Pradesh and Uttar Pradesh. The investments for intensive carp culture were depicted in the states of Andhra, Haryana, Punjab and West Bengal, while the investments in semi-intensive and extensive aquacultural technology could cover most of the states of India.

The total investment in marine fishing (Rs 41.170 million) by the marine fisheries sector (Table 2.10) and the estimated total value of the marine landings (Rs 100,200 million) indicated 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 was operating under nearly perfect competitive conditions depended on 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 and other inputs like fuel, food, insurance, etc.), and above all, the marketing avenues and prospects (Sathiadas et al. 1994).

2.7. Production Trends in the Past

There has been a manifold increase in production for both marine and inland fisheries sectors, but growth rate has been higher in the inland fisheries sector.

Inland Fisheries

During the past one and a half decades, the production of inland aquacultural fish has increased from 0.51 to 2.69 Mt, and of inland capture fisheries has declined from over 0.59 to 0.50 Mt (Anonymous 1996(a,b); Anonymous 2000; Gopakumar et al. 1999). The share of aquaculture has also increased sharply from 46 to 84%, primarily because of tremendous rise in production from freshwater aquaculture (0.3 to 2.1 Mt). Its share in the total inland fish production has also increased from 28 to 66%. It still has a large scope for enhancing fish production through horizontal expansion and increasing the productivity per unit area.

In India, aquaculture production has witnessed an impressive transformation from a highly traditional activity to a well developed industry (Ayyappan and Jena 2001). With a rich resource base both in terms of water bodies and fish species, the investments in this sector are depicting a rising trend. There was an increase of 5.5 times in freshwater aquaculture fish production during the last one and a half decades. The recent estimates of freshwater aquacultural production at 2.0 Mt are nearly one-third of the total fish production of India.

Table 2.10. Investments, fixed cost and annual operating costs of the Indian marine fishing fleet during 1995

(in million Rs.)

Fishing fleet	Investment	Fixed cost	Operating cost				Total cost	Fishing cost (Indian Rs/kg)
			Fuel	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) Purse-seiners	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	2.29
(ii) Catamarans	310	90	40	210	90	340	430	10.75
(iii) Total	4060	840	510	2080	870	3460	4300	12.11
3. Artisanal sector								
(i) Canoes & catamarans	2620	–	–	11710	730	2440	3100	10.93
(ii) Plankbuilt boats	–	660	–	–	–	–	–	–
(iii) Total	2620	660	-	11710	730	2440	3100	10.93
Grand Total	41170	16000	10260	22990	5790	29040	39100	14.30

Source : CMFRI, 1997a

The appropriate technologies, financial investments and entrepreneurial enthusiasm primarily propel this outcome. The success stories of intensive fish culture started from Kolleru lake basin in Andhra Pradesh in the mid-1980s and virtually replicated in several states such as Punjab, Haryana, and Uttar Pradesh (Gopakumar et al. 1999).

Brackishwater Aquaculture

The contribution of brackish water capture fisheries is not significant. The national shrimp culture production was estimated at 115 thousand tonnes (Table 2.11) in 2002-03, although, area remained almost the same after 1997-98 when production was only 70 thousand tonnes. It may be due to the adoption of improved culture practices besides horizontal expansion. It clearly indicates the potential for enhancing shrimp production and productivity in India. The tiger shrimp (*P. monodon*) had the major share in this production followed by white shrimp (*P. indicus*) and banana shrimp (*P. merguensis*).

Catch per unit effort for inland capture fisheries

The annual fishing effort (Table 2.12) was found to be the highest for private regime (293 days) followed by open access (281 days) and co-operative (147 days), while annual and per day catch was maximum for open access (1432 and 5.08 kg) followed by private (780 and 2.66 kg) and co-operative (376 and 2.55 kg) regimes. These observations could be attributed to intensity of fishing or the fishing effort put in by the fishermen under different regimes. Fluctuations in the height of water level and fish stock in the rivers also affected these captures over the years.

2.8. Adoption of Technology

The Indian fresh water aquaculture being carp-oriented, characteristics of water resources, level of technology adoption, constraints in adoption and impact of hatchery, seed production and carp polyculture technologies at different levels of adoption were analysed and are given in Table 2.13. The results of a similar exercise for brackish water aquaculture are presented in Table 2.14.

Table 2.11. State-wise estimated shrimp culture production in India, 1990-91 to 2001-02

(in '000 t)

State	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-2001	2001-2002
West Bengal	12.50	13.80	16.30	16.50	25.00	23.45	19.95	15.12	18.33	19.96	21.08	26.80
	(35.22)	(34.50)	(34.68)	(26.61)	(30.18)	(33.22)	(28.22)	(22.61)	(22.18)	(25.31)	(21.71)	(26.03)
Orissa	4.10	3.80	4.30	3.30	4.80	6.00	6.81	5.00	6.00	3.17	7.36	8.96
	(11.55)	(9.50)	(9.15)	(5.32)	(5.79)	(8.50)	(9.63)	(7.48)	(7.26)	(4.02)	(7.58)	(8.70)
Andhra Pradesh	7.35	9.70	12.80	26.00	34.00	27.14	30.58	34.08	44.86	41.86	53.10	51.23
	(20.71)	(24.25)	(27.23)	(41.94)	(41.04)	(38.46)	(43.26)	(50.96)	(54.29)	(53.08)	(54.69)	(49.76)
Tamil Nadu	0.45	0.70	1.10	2.00	3.00	1.09	1.13	1.20	1.82	2.90	3.79	4.71
	(1.27)	(1.75)	(2.34)	(3.23)	(3.62)	(1.55)	(1.60)	(1.79)	(2.20)	(3.68)	(3.91)	(4.60)
Pondicherry						0.01	0.03	0.02	0.02			
						(0.01)	(0.04)	(0.03)	(0.02)			
Kerala	8.93	9.50	9.75	11.50	12.00	9.00	8.23	7.29	7.66	6.70	7.33	5.54
	(25.14)	(23.75)	(20.74)	(18.55)	(14.48)	(12.75)	(11.64)	(10.90)	(9.27)	(8.50)	(7.55)	(5.38)
Karnataka	1.00	1.10	1.15	1.50	2.50	2.05	2.30	2.64	2.69	2.80	2.73	3.50
	(2.82)	(2.75)	(2.45)	(2.42)	(3.02)	(2.90)	(3.25)	(3.95)	(3.26)	(3.55)	(2.81)	(3.40)
Goa	0.25	0.30	0.35	0.40	0.45	0.55	0.58	0.59	0.59	0.84	0.97	1.20
	(0.69)	(0.75)	(0.74)	(0.65)	(0.54)	(0.78)	(0.82)	(0.88)	(0.71)	(1.07)	(0.99)	(1.16)
Maharashtra	0.80	0.93	1.05	0.30	0.40	0.74	0.52	0.70	0.41	0.33	0.32	0.32
	(2.25)	(2.33)	(2.23)	(0.48)	(0.48)	(1.05)	(0.74)	(1.05)	(0.49)	(0.42)	(0.32)	(0.31)
Gujarat	0.13	0.17	0.20	0.50	0.70	0.55	0.57	0.24	0.26	0.30	0.42	0.68
	(0.35)	(0.43)	(0.43)	(0.81)	(0.84)	(0.77)	(0.81)	(0.35)	(0.31)	(0.38)	(0.44)	(0.66)
Total	35.50	40.00	47.00	62.00	82.85	70.57	70.69	66.87	82.63	78.86	97.10	102.94

The figures with the parentheses represent per cent of the total

Source: Modified Anonymous, 2001, 2002

Table 2.12. Fishing catch per unit effort in riverine fisheries under different management regimes

Item	Regime		
	Common property	Private	Co-operative
Hired labour (mandays/ year)	–	96.28	–
Annual fishing effort (mandays/year)	281.82	293.24	147.63
Catch per unit effort			
Per family (kg/year)	1431.67	780.02	376.46
Per day (kg)	5.08	2.66	2.55

Source: Sinha and Katiha, 2002

Freshwater hatchery and seed production

These operations lead to production of fish seeds to be utilized for stocking in ponds for grow out. The first activity is induced breeding for production of spawn. It is a capital-intensive activity, requires high initial investment in the form of hatchery, high technical expertise and infrastructural facilities and is mostly carried out by private or government agencies. The adoption and impact is very high due to high investments, market demand and profits. The second activity is production of fry from spawn. This activity is generally conducted at small ponds by the private or government agencies. It needs low investments with moderate risk and high technical expertise and infrastructure for disposal. The adoption and impact of this technology is high due to high market demand for fry. The last activity is raising of stocking material for grow out, i.e. fingerlings. This activity is also performed by either private or government agencies in small ponds with moderate investments. The low availability of ponds for this activity and low B:C ratio were the two major constraints resulted in moderate adoption of the technology. But, the higher market demand for carp fingerlings for aquaculture and culture-based fisheries could lead to a high impact of this technology.

Table 2.13. Adoption of freshwater aquaculture technology and its impact*

Technology	Characteristics adoption	Technology	Constraint	Impact
Seed Production				
Induced breeding of carps	Capital intensive, hatcheries mostly under private and government agencies, low risk High market demand, high profit	High	High technical expertise, Financial, infrastructural facilities	High
Carp fry rearing	Small private/ government ponds, low investment, high profit, moderate risk, high market demand	High	High technical expertise, Infrastructural facilities	High
Carp fingerlings rearing	Small private/ government ponds, moderate investment, low profit, moderate risk, high market demand	Moderate	Low availability of water bodies, Low B: C ratio	High
Carp polyculture				
Low input or fertilizer- based system	Small holding, community ponds, low investment, open access	Very low	Social, financial, tragedy of commons	Low high positive
Medium input or fertilizer- and feed-based system	Medium and large ponds, private holding, moderate to high investments, low risk bearing ability, high production and profit	High	Input scarcity, limited access to infrastructural felicities, low remuneration	Very
High input or intensive feed- and aeration-based system	Medium size pond, very high investment, private holding, high risk bearing ability, high productivity, good market access	Moderate, higher than recommended for few practices and vice versa	Financial, low B:C ratio, low ecological sustainability, high risk	Moderate

* Based on the response of scientists from CIFA, Bhubaneswar, CIFRI, Barrackpore, and aquaculturists covered under project

Table 2.14. Adoption of brackish water aquaculture practices — A cross case analysis

Aquaculture system	Characteristics	Technology adoption	Constraint	Extension support
Shrimp Farming				
High–tech corporate farming	Large holdings, high investment and risk taking capabilities, high production and profit, direct access to market	Over use of practices	Social and ecological disturbances	Not preferred
Semi-intensive and improved traditional	Medium holdings, medium investment and risk taking capabilities	Faculty use of practices	Scarcity of seed and feed	Benefited most
Small subsistence including traditional	Low investment and production	Low	Financial	Often by passed
Marine aquaculture	Open access, easily managed, different scales of production, institutional	Low	Lack of laws for use of open waters	
Post-harvest System				
Factory processing	Standard practices and international laws, regulations, direct access to export	High	Financial	Mostly benefited
Small-scale processing	Unorganized low investment capabilities	Low	Financial, inadequate infrastructure	Inadequate

Source: Srinath 2000

Grow out

The carp polyculture technology was found to be adopted at three levels. The first was low input or fertilizer-based system, mostly practised in small community ponds, with multiple uses and open access. It attracted low investments. The level of adoption and impact was also very low due to social and financial constraints leading to tragedy of commons. At the second level, the aquaculture system was medium input or fertilizer- and feed-based system. It was prevalent in medium to large sized private ponds with moderate to high investments. The level of technology adoption and impact was high, although they faced problems of quality input scarcity, limited access to infrastructures and low remuneration. The last system prevalent in carp polyculture was high input or intensive feed- and aeration-based system. These aquacultural practices were generally followed in medium-sized private ponds with high investments and risk bearing ability. The adoption level was moderate as they applied the over doses than those recommended. It led to high risk, low ecological sustainability and B: C ratios. The impact in this case was moderate.

Brackishwater

It was being practised at three scales, namely subsistence-oriented traditional farming by small and marginal farmers, semi-intensive farming in the small-scale sector, and high-tech intensive farming by the corporate bodies (Srinath 2000).

The experiences of adoption of shrimp culture technologies are summarized in Table 2.14. The high-tech farming operations were found by the objectives of immediate profits and short-term gains, with little consideration for the sustainability of the system. High-tech farming relies mainly on imported technological inputs. The public funded extension system that relies on local resources with emphasis on long-term gains and system's sustainability, rarely found a place in this sector. The farmers operating in big or medium scale farms under paddy-cum-shrimp farming system generally practised selective farming of single species as well as supplementary stocking and feeding. These farmers with their information seeking ability tried to avail technical inputs and most of the extension and development efforts were diverted towards them. But, the scarcity of hatchery seeds, social resistance to wild seed collection, faulty use of farming practices and improper investment decisions limited their production, often resulting into economic losses. The small and marginal holdings often faced resource constraints and had less opportunity for development.

2.9. Potential Pipeline Technologies

Inland

Some freshwater technologies are in the experimental stage (i.e. pipeline technologies). These are:

- Cage culture
- Pen culture
- Pearl culture
- Running water fish culture

Marine

Capture fisheries sector

- Conversion of trawlers into longliners using monofilament long lines
- Conversion into or introduction of large plank-built boats (using plywood) with in-board engines (100-120 HP) and power winches for operating large seines along the south-west coast of India.

Culture fisheries sector

- Organic farming technology for the culture of shrimps without the use of drugs and chemicals during any stage of their life-cycle
- Tissue culture of abalone, *Haliotis varia* and pearl oyster, *Pinctada fucata*
- Half pearl production in *Haliotis varia*
- On-shore culture of pearl oyster and pearl production
- Development of alternatives for bivalve culture — Flexible Plastic Strips (FPS) for seeding mussels instead of coir or nylon ropes, pre-stitched cotton nets to put mussel seeds for attachment

- Hatchery technology for cuttlefish, *Sepiella innermis*
- Hatchery technology for ornamental gastropod, *Babylonia* spp.
- Integrated fish and bivalve culture in brackish water ponds — Fishes like pearl spot, *Etroplus suratensis,* can be cultured in cages between mussel or oyster-seeded ropes on racks.
- Mud crab and lobster hatchery technology
- Domestication and selective breeding of selected penaeids .

3

Analysis of Policies, Institutional Environment, and Support Services in Fisheries

In India 'fisheries' is considered to be a sub-sector of agricultural sector. Hence policies influencing fisheries sub-sector are embedded in the agricultural policy documents. Nevertheless, the Five Year Plans contain some broad policies guiding growth and development of fisheries. The main objectives of fisheries policies 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 export of marine, brackish and freshwater fin and shell-fishes and other aquatic species; (e) increasing 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, 2001, 2002).

Until the Third Five Year Plan, the policy focus was on enhancing fish production with little attention on such issues as marketing, storage, transportation, etc. Later, emphasis was also laid on creating facilities for ice-cold storage, processing and canning. With this in view, Marine Products Export Development Authority (MPEDA) was established in 1972 at Cochin with branch offices at the major seafood production and export centres. MPEDA has the responsibility of promoting and regulating the marine products export, serves as a nodal agency for approval of joint ventures in deep-sea fishing, and promotes brackish water shrimp farming. Despite half a century of planning, post-harvest infrastructure remains grossly inadequate (Dehadrai 1996). Marketing, transportation, storage and processing of fin and shellfish are mostly handled by the private sector, yet the development of post-harvest infrastructure has not kept pace with the production trends.

3.1. Outlays for Fisheries Sector

Allocation of funds to a particular sector is an indication of a push given for the development of the sector. The outlay for fisheries sector as per cent of outlay for the agricultural sector over the Five Year Plans has increased from 1.45 per cent in the first Five Year Plan to about 6.52 per cent in the Sixth Five Year Plan (Table 3.1). In subsequent Plans, its share hovered around 4 to 5 per cent. It shows the importance given to the fisheries sub-sector within agriculture sector. Its share in the total plan outlay during different plans periods has been hovering between 0.26 and 0.52 per cent.

The Tenth Plan has proposed a fish production target of 8.19 Mt, envisaging a growth rate of 5.44 per cent per annum (marine, 2.5 per cent and inland, 8.0 per cent). During the Tenth Five Year Plan, new initiatives for development of fisheries are planned to increase production and productivity from deep seas, inland capture fishery resources like rivers, canals, etc. and from culture sources like reservoirs, beels, ox-bow lakes, measures for replenishment of fishery resources through mariculture, etc. Besides, development of infrastructural facilities for a better post-harvest management, technology for sustainable aquaculture, setting up of cold storage and marketing network through viable fishermen co-operatives, etc. are to be taken up to ensure better livelihood for fishers and enhance export promotion for economic development of the country (Tenth Five Year Plan, 2002-07 Documents, Planning Commission).

3.2. Trade Policies in Fisheries Sector in India

Import Policies

Import restrictions

In the case of agriculture, including fisheries, India had followed protective trade policies in the past. Except for a few traditional commercial commodities, trade was being regulated through Quantitative Restrictions (QRs), canalization, licenses, quotas and high tariff rates. All marine and inland fisheries were on the negative list of imports. However, to make trade policies consistent with the new economic policies and the provisions of World Trade Organization (WTO), a number of fish products were moved to the Special Import License (SIL) and freely importable lists in 1997 onwards. In the recently announced exim policy (2002), the import of fisheries commodities has been further liberalized and almost all commodities have been moved to the list of freely

Table 3.1. Outlay for fisheries sector during different Five Year Plans, India

(in crores Rs.)

Five Year Plans	Total outlay	Outlay for agricultural sector	Outlay for fisheries sector	Share of fisheries sector (%)	
				Total outlay	Agricultural outlay
First (1951-1956)	2378	354	5.13	0.22	1.45
Second (1956-61)	4500	501	12.26	0.27	2.45
Third (1961-66)	8577	1089	28.27	0.33	2.60
Annual Plans (1966-69)**	6625	1107	42.21	0.64	3.81
Fourth (1969-74)	15779	2320	82.68	0.52	3.56
Fifth (1974-79)	39426	4865	151.24	0.38	3.11
Annual Plan (1979-80)	12177	1997	-	-	-
Sixth (1980-85)	97500	5695	371.14	0.38	6.52
Seventh (1985-86 to 1989-90)	180000	10525	546.54	0.30	5.19
Annual Plans (1990-92)	123120	7256	292.74	0.24	4.03
Eighth (1992-93 to 1996-97)	434100	22467	1205.39	0.28	5.37
Ninth (1997-2002)	859200	42462	2069.78	0.24	4.87
Tenth* (2002-07)	398890	20668	765.00	0.19	3.70

Source: Handbook on Fisheries Statistics, Ministry of Agriculture, Government of India and Tenth Five Year Plan 2002-2007, Planning Commission, Government of India, New Delhi.

*Allocation of central funds only.

importable commodities, except the five groups of live and Whale Shark (Rhinocodon) (Table 3.2). The restrictions on these items are maintained under the Wildlife Protection Act, 1972, the Convention on International Trade in Endangered Species (CITES). In addition, it appears that the SIL has been discontinued since April 1, 2001 (WTO, 2002, P-41). Some contingency measures pertaining to anti-dumping, countervailing and safeguards are also in operation.

Table 3.2. Status of import policy of fish products

Period	Total number of fishery commodities	SIL	Free	Restricted/ Prohibited
1992-97	121	-	7	114
1997-2002	121	62	21	38
2002-07	127	-	122	5

Source: Exim Policy, Ministry of Commerce, Government of India (various issues).

Standards, testing and certification

In India, the Bureau of Indian Standards (BIS) has been designated as the WTO-Technical Barriers to Trade (TBT) Enquiry Point, while the Ministry of Commerce is responsible for implementing and administering the WTO agreements on TBT. India also accepted the Code of Good Practice on 19 December 1995. Indian standards are formulated by the BIS, who endeavors to align Indian standards as far as possible with international standards and is a founder member of the International Standards Organization (ISO). Indian and foreign manufacturers who meet a BIS standard may carry the BIS certification. The BIS laboratories provide conformity testing for products that require BIS certification. Voluntary certifications are also issued for environment-friendly products, environmental management systems, quality systems and hazard analysis and critical control points (HACCP). The granted licenses are valid for three years and must be renewed. BIS carries out regular surveillance audits and inspections to ensure that the systems and products meet the relevant standards.

Sanitary and phytosanitary measures

These measures are maintained under several Acts, implemented by different agencies. For food safety and quality, the fish and fish products are covered by the Prevention of Food Adulteration Act, 1954. India's legislation on labeling and marking is contained in the Prevention of Food Adulteration Act (PFA), 1955, last amended in 1986 and in part VII of the PFA rules 1995. The Standards of Weights and Measures (Packaged Commodities) Rules were issued in 1977 to regulate packaging and rationalize standard quantities and measures. For imports, a notification was issued recently requiring all packaged products when produced, packed or sold in India, to carry information on name and address of importer; generic or common name of the commodity; net quantity in terms of standard unit of weights and measures; month and year in which the commodity was manufactured, packed or imported and maximum retail sale price. Further, all imports of edible products, for which the domestic manufacture and sale are governed by the PFA Act, 1954, must at the time of importation, have a valid shelf-life of not less than 60% of their original shelf-life.

Import tariffs

The tariff structure in the fisheries sector has also undergone a sea change. The tariff rate applicable for import of fish products was 60 per cent till 1993-94 (Table 3.3). To meet the obligations of WTO after its establishment in 1995, it was reduced to 24 per cent in 1998-99 and further to 21 per cent in 1999-00. In April 2000, India removed QRs on 715 items, which included commodity groups like fish and fish products, meat and other agricultural products. More than 120 items of fish and fish products have been affected by these regulations. After complete dismantling of QRs, tariff rates were perceived as the only instrument for restricting imports. In 2000-01, the tariff on imports of fish and fish products was raised to 44 per cent and, after observing for a year, it was again moderated to the level of 35 per cent. In view of the continuing economic liberalization policies, tariff rate is expected to decline further. Besides, preferential rates of tariff are provided under various regional and bilateral agreements. These are applicable mainly for countries under South Asian Association for Regional Cooperation (SAARC) and Bangkok Agreement.

Table 3.3. Custom tariff rate on import of fish products, 1988/89-2002/03

Year	Tariff rate (%)
1988-89	60.00
1993-94	60.00
1998-99	24.20
1999-00	21.16
2000-01	44.04
2002-03	35.20

Source: Exim Policy, Ministry of Commerce, Government of India (various issues).

Under the Uruguay Round, India has bound all agricultural tariffs: 100 per cent for primary products, 150 per cent for processed products and up to 300 per cent for edible oils. However, bindings were not made for fish and crustacean products (HS 3) in agriculture.

Export Policies

Export procedures and restrictions

Export policies for the fish and fish products were liberal with few licensing restrictions. Exporters are, however, required to register with the Director General of Foreign Trade in the Ministry of Commerce, and obtain an IEC Number before carrying out exports. Licenses are also required for restricted exports and exports under export quotas. In the fisheries sector, exports restricted through licensing include silver pomfrets of weight less than 300 grams and beche-de-mer of sizes below 3 inches. Export of seashells (excluding polished seashells) and handicrafts made out of five specific species, namely *Trochus niloticos*, *Turbo* species, *Lambis* species, *Tridacua gigas*, *Xancus pyrus*, are prohibited. These restrictions have been imposed due to ecological and environmental reasons and for the conservation of exhaustible natural resources.

Quality control and pre-shipment inspection

The Export Inspection Council (EIC) of India ensures quality control of products for the export market. The EIC advises the Government on measures to be taken to enforce quality control and inspection for exports. Pre-shipment inspection and certification services are provided by five export inspection agencies (EIAs) with a network of 44 suboffices, including laboratories located in several industrial centres and ports. The Government, through EIC, also recognizes other government and private sector agencies that provide pre-shipment inspection services for exports based on international standards. Standard specifications for each type of fish and fish products have been laid down and tests for bacteria, virus, heavy metal contamination, etc. are carried out in co-operation with Marine Products Export Development Authority (MPEDA) and the Indian Institute of Packaging. The EIC offers export inspection and certification services under the following systems: consignment-wise inspection (CWI); in-process quality control (IPQC); or self-certification. Any one or more of the systems may be specified in the notifications of individual commodities. However, fish and fish products along with egg products and milk products are subject to mandatory export certification based on Food Safety-Based Management Systems (FSMSC). The FSMSC is based on international standards of food safety management systems such as HACCP/GMP/GHP and involves approval and surveillance of food processing units. The EIC is also working to develop equivalence agreements, as envisaged under the SPS Agreement, with the official import control bodies of its major trading partners. The EIC's certification for fish and fish products is recognized by the EU and the Australian Quarantine and Inspection Service (AQUIS).

Export promotion and assistance

The Marine Products Export Development Authority (MPEDA) is responsible for the promotion and regulation of exports of fish and fish products. In the recently announced Export-Import Policy (2002-07), there are provisions of central assistance to states for the development of critical infrastructure for export. It provides support to export promotion and market development, strengthening of market intelligence and information channels, development of infrastructure and human resource capacity, modernization of processing facilities and research and development in fisheries sector. The Government also provides marketing development assistance to facilitate promotion of exports of Indian products. To supplement the market development scheme, the Market Access Initiative (MAI) was launched in 2001/02. The MAI aims to promote potential Indian exports in selected countries by supporting the collection of marketing intelligence data and helping exporters in display of their products.

Export finance, insurance and guarantees

Domestic banks are required to allocate 12% of total annual lending for exports in addition to their priority sector lending requirements. Export credit may be provided in either domestic currency or one of the convertible foreign currencies. The credit in domestic currency is provided at concessional rates of interest announced by the RBI while the credit in foreign currency is provided at internationally competitive rates. Exporters have the option to borrow money in either domestic or foreign currency. The domestic banks have been directed by the Reserved Bank of India to charge a maximum rate of interest at 1.5% below the prime lending rate.

The Export Credit Guarantee Corporation of India Limited (ECGC), a Government of India public sector undertaking provides insurance to exporters against the risk of non-realization of export proceeds for political or commercial reasons and a range of guarantees for banks and other financial institutions to enable them to extend credit facilities to exporters on a liberal basis.

Non-tariff barriers imposed on exports of fish and fish products from India

India neither has an export tax on fish and fish products nor imposes minimum export prices. However, exports of fish and fish products from India face non-tariff measures (mainly SPS and TBTs) in India's main markets. The US is perhaps the only country which provides information on detention of shipments based on pre-inspection basis. The information based on January 2002–December 2002 shows that 106 Indian shipments of fish products were rejected by the USFDA. This constitutes more than 20 per cent of the rejected Indian shipments of agricultural products. A majority of Indian consignments of fish products were rejected by USFDA on the ground of (a) filthy, i.e. the article appears to consist in whole or in part of a filthy, putrid or decomposed substance, (b) presence of Salmonella, i.e. the article appears to contain a poisonous and deleterious substance, and (c) Insanitary, i.e. an item prepared, packed or held under in-sanitary conditions. On an average, each consignment was rejected on the basis of more than one reasons (Kumar and Kumar, 2003).

Implications of compliance of SPS measures

To evaluate the implications of compliance of food safety measures, an empirical analysis has been made in this section. A partial equilibrium analysis has been used to analyse demand, supply and welfare effect of standards (Paarberg and Lee 1998; Calvin and Krisoff 1998). Econometric approaches have also been used to estimate the effect of standards on trade flows (Moenius, 1999; Otsuki et al. 2001). Here we have assumed that the compliance cost poses an additional burden to the exporters and the cost per unit of the commodity would increase and the domestic producer is faced with the additional cost before being allowed to export the good (For details, kindly refer to Tsakok, 1990).

Cost of compliance of food safety standards

Compliance of stringent hygiene and sanitary requirements in developed countries, particularly the provisions concerning the use of HACCP requires significant investment. The investment requirements for HACCP plants are huge, as most of the capital goods related to the plant are to be bought from the developed countries. The installation cost of HACCP plants vary from Rs 10 million to Rs. 25 million. Further, an export processing firm is estimated to spend about 20 lakhs per year on maintenance of a HACCP plant. The Seafood Exporters Association of India claimed to have spent about Rs 1250 million on upgradation of their facilities to meet the regulations. Appropriate training of the personnel involved in various stages of production and processing are not included in this cost estimate (Jha 2002). All these were found to led to substantial increase in pre-export processing and handling costs. On an average, the pre-export processing and handling increased the cost by about Rs 7 per kg (Table 3.4). The small firms were the worst sufferers. They had to incur an additional cost of more than Rs 10 per kg on pre-export processing of fish

Table 3.4. Cost of pre-export processing with and without HACCP compliance
(Rs/kg)

Categories	Without HACCP	With HACCP	Additional cost due to HACCP
Small (< 10 t/day)	7.84	18.21	10.37
Medium (10-15 t/day)	5.23	12.41	7.18
Large (> 15 t/day)	3.98	9.19	5.20
Overall	5.10	11.89	6.79

Source: Field survey by the authors

products. This was affecting their competitiveness adversely. These had bearing on government revenue, consumer and producer surplus also. However, consistent compliance of the regulatory barriers could bring "good name" to the exporting countries and might fetch a higher price from the importing countries.

Erosion in Export Competitiveness of Fish and Fish Products

The fisheries sector has been quite competitive. The nominal protection coefficients (NPCs) without compliance with SPS measures were found to vary from 0.46 for Sardines to 0.72 for Tuna (Table 3.5). India also enjoyed substantial competitiveness in the export of shrimps and prawn. However, the competitiveness of fisheries exports have been substantially eroded with the additional burden of compliance with SPS measures.

At aggregate level, the fisheries sector lost competitiveness by about 14 per cent. The magnitude of erosion in export competitiveness varied from as high as 24 per cent in the case of Ribbonfish to about 10 per cent in the case of cuttlefish. The shrimps and prawn, the main items of fisheries export, also suffered a serious setback in their export competitiveness. The absolute magnitude of loss in export competitiveness may not reveal the exact picture of its implications on the fish economy of India, but would have profound implications on the domestic consumers, producers, fish exporters etc.

Table 3.5. Nominal protection coefficients (NPCs) of selected fish products

S. No.	Species/Categories	NPC (without HACCP compliance)	NPC (with HACCP compliance)	Erosion in competitiveness (%)
1.	Charyboiscruaie	0.62	0.69	12.58
2.	Crab	0.67	0.75	10.91
3.	Cuttlefish	0.67	0.74	10.08
4.	Shrimp	0.54	0.63	16.70
5.	Octopus	0.52	0.62	20.30
6.	Ribbon fish	0.48	0.59	23.71
7.	Sardines	0.46	0.57	22.20
8.	Squid	0.66	0.75	12.79
9.	Tuna	0.72	0.81	12.11
10.	Weighted NPC*	0.61	0.70	13.82

Source: Field survey by the authors;
*Weighted average NPC for the fisheries sector has been calculated by taking weighted average of different fish species specific NPCs. Percentage share of specific fish species in total value of fish export from India has been taken as weights.

Economic Impact of Application of SPS Measures

Simple welfare analysis was carried out to assess the impact of food safety measures on the fisheries sector. The demand of fish and fish products has been found to be very sensitive to the change in price while the supply was observed to be inelastic. The estimates of producers' and consumers' surplus conform to the conventional theory that 'there is producer surplus loss and consumers surplus gain'. With the additional cost of compliance with food safety measures, the country was losing foreign exchange equivalent to Rs 9.6 billion. The net efficiency loss in the consumption turned out to be Rs 2.5 billion. The efficiency in production did not decline, as the supply of fish was observed to be price inelastic. The consumer surplus increased by about Rs 10.2 billion. On the other hand, producer surplus declined by Rs 12.2 billion, leaving a negative net social gain of about Rs 2.0 billion (Table 3.6).

Table 3.6. Implications of compliance of SPS measures

(in million Rs)

Particulars	Value
Change in foreign exchange	–9638
Change in net efficiency in consumption	–2558
Change in net efficiency in production	3923
Change in consumer surplus	10260
Change in producer surplus	–12234
Change in net efficiency	–2166
Net social gain	–1974

The study has shown that the compliance with food safety measures is a costly proposition; the net social gain is negative. However, food and health safety concerns are vital and the exporting countries have to comply with the same to promote export. The efforts should be made to bring down the high compliance cost by bringing more efficiency in utilizing HACCP process in the country. Further, maintaining of high quality in food and fish should be propagated as a strategy to stay ahead of other competing countries in the world market. However, it is extremely difficult to bring all the small producers who are scattered throughout rural/coastal areas to HACCP processing plants.

3.3. Overview of Support Services

Development Programmes

The development programmes 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 by strengthening fisheries to fight famine. After independence, it was decided in 1948 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 is being done 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:

Development of inland fisheries

In recognition of the increasing role of inland fisheries in the overall fish production, the Government of India (GOI) has been implementing two important programmes in the inland freshwater sector since the Fifth/Sixth Plan. These are the Fish Farmers' Development Agencies (FFDA) and the National Programme for Fish Seed Development. A network of about 430 FFDAs is functioning today covering all potential districts in the country. The FFDAs have covered about 5.67 lakh hectares of the total water area under scientific fish culture and trained 6.51 lakh fish farmers. But the average productivity from waters covered under this programme remained almost static, about 2.2 tonnes/ha/year during the Ninth Plan period. This scheme was revised during the Ninth Five Year Plan by increasing the unit costs and adding new components such as freshwater seed prawn hatcheries, laboratories (at state level), soil and water testing kits to each FFDA, integrated units including hatcheries for ornamental fishes, etc.

In coastal areas, 39 Brackishwater Fish Farmers Development Agencies (BFDAs) have also been established; these provide a compact package of technical, financial and extension support to shrimp farmers. About 6240 ha was brought under brackish water aquaculture activities during the Ninth Plan through these BFDAs (Planning Commission, Government of India). The performance of the programme has been affected due to environmental concerns. 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 fries in 1973-74 to about 17,000 million fries in 2000-01.

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, mechanized 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 included construction of 30 minor fishing harbours and 130 fish landing centers, apart from five major fishing harbour, viz. Cochin, Chennai, Visakhapatnam, Roychowk and Paradip. They provide landing and berthing facilities to fishing crafts. There were 1,81,284 non-motorized traditional crafts, 44,578 motorized traditional crafts and 53,684 mechanized boats in India in 2000-01. The Government also provides subsidy to poor fishermen for motorizing their traditional craft. 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. About 18,000 such vessels are being benefited per annum under this programme for the last few years.

Welfare Programmes for Traditional Fishermen

The welfare programmes presently being carried out can be broadly divided into two categories: protective and promotional. The former is concerned with the short-run task of preventing a decline in standards of living and the latter with enhancing the long-term general living standard by improving the basic capability of the people. There are three important programmes for the welfare of traditional fishermen: (i) Group Accident Insurance Scheme for Active Fishermen, (ii) Development of Model Fishermen Village, and (iii) Fishermen insurance — Rs 50,000 in case of death or permanent disability, and Rs 25,000 in case of partial disability. About 12.2 lakh fishermen were insured during

2000-01 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. Concomitantly, both the protective and promotional social security schemes were on the increase over the years (Verghese 2001).

Programmes with international aid

Several international organizations, including 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 up to December 1999.

3.4. Fisheries Management under Different Property and Management Regimes

The inland waters vary significantly in nature and magnitude of their resources. Therefore, these are managed differently for fishery activities under various property and management regimes; a brief discussion on these aspects has been attempted below:

The Rivers

Traditionally, the rivers are managed as a common property resource and have multiple uses for riparian area population. Rivers are the State property and various river stretches within or between the states belong to departments of fisheries, revenue, forestry, village panchayats, etc. These departments adopt varied policies for fishing in these stretches. The rivers being fluvial and fish being migratory renewable resource, it is difficult to apportion the fish biomass in territorial limits. From the fisheries viewpoint, most of the rivers are in open access with few exceptions where these are leased to co-operatives or private parties. A comparative account of fishery activities under these management regimes has been made, selecting one stretch in each of these management regimes and is presented in Table 3.7.

In open access, the riverine fish biomass has a free access to every one. There are regulations, however, under Fisheries Act for fishing and responsibility of conservation of fish stock lies with the State governments. Due to the vast magnitude of this natural resource, institutional systems and authority systems inevitably cease in this regime. Under the co-operative management regime, State governments lease out the stretch to fisheries co-operative societies, and confer all the rights and powers of decision-making regarding fisheries in the stretches on the co-operatives. Generally, the stretches are leased for one year but likely to be renewed every year, unless there were some serious complaints about fisheries management by the cooperatives. The members of the co-operative society have the right to fish and exclude non-members from fishing. The non-members have the duty to abide by this exclusion.

The only difference between the co-operative and private management regimes is that the fishing rights and power to transfer fishing rights and decision-making rests with the individual to whom the stretch was leased out in the latter case. An open auction system is followed for leasing fishing rights. The lessee or contractor transfers the fishing rights to the fishers on his terms and conditions. In all the regimes, fishing rights rest with fishers, but they have to perform the fishing activities within socially acceptable limits and allow the non-fishing people to use water to meet their day-to-day requirements.

The Reservoirs

The reservoirs are mainly the irrigation or hydroelectric power projects and fisheries in these water bodies is considered as a secondary activity. These water bodies mostly belong to the irrigation departments or are under the control of boards or authorities. The department of fisheries or other fisheries agencies

Table 3.7. Riverine fisheries under different property rights and management regimes

S. No.	Item	System		
		Common property	Private	Co-operative
1.	River stretch	Ganga: Kanpur to Farakka	Yamuna: Yamuna Nagar to Panipat	Ghagra: Ghagra barrage to Faizabad
2.	Property rights regime	State departments of revenue/forestry/ village panchayat	State departments of revenue/forestry/ village panchayat	State departments of revenue/forestry/ village panchayat
3.	Management system	Individual fisherman /fishermen group	Contractor	Fishermen co-operatives
4.	Whether in multiple uses, if yes in			
	(i) Fishing	Yes	Yes	Yes
	(ii) Bathing	Yes	Yes	Yes
	(iii) Washing clothes	Yes	Yes	Yes
	(iv) Drinking water	Yes	Yes	Yes
5.	Duration of lease	-	One year	One year
6.	Harvesting period	Round the year with lean period in monsoon	Round the year with lean period in monsoon	October to January and March to June
7.	Arrangements for fisheries requisites	Individual/shared	Self + Contractor	Co-operative
8.	Time and mode of payment	In cash, on the day of disposal of catch	In cash, Daily/ Weekly/Monthly basis	In cash, Daily/ Weekly basis
9.	Remuneration for the fish catch	Within the group, based on pre-decided percentage share	Based on prefixed labour charges/ royalty per kg of catch	Based on fixed/% of market price per kg of catch
10.	Distribution of profits	Only as remuneration	Solely of contractor	Among members

Source: Sinha and Katiha (2002), Management of Inland Fisheries Resources in D K Marothia (eds) *Institutionalising Common Pool Resources*, Concept Publishing Company, New Delhi.

obtain the fishery management rights from the owners of the reservoirs, by either paying some royalty/nominal amount (Rihand in Uttar Pradesh and Kansbati in West Bengal) or even free (Govind Sagar and Pong Dam in Himachal Pradesh). Some of the fisheries transfer the fishing rights to other government/ co-operative /private agency and receive the royalty with/without rendering any fisheries development services.

Leasing system is one of the most important institutional management options for the exploitation of fisheries in reservoirs. The leasing system may vary within the State or even for the same reservoir over time.

Ponds and Tanks

The FFDA is specifically responsible for ensuring that public ponds in various states are leased for fish culture and all lease payments are made. State government ponds are generally large and are mostly leased to fishermen's co-operative societies. Community ponds, usually smaller, are owned by the village panchayats for use by all the villagers, and their fishing rights are leased to either fishing co-operative societies, small informal groups of fishermen or individual fishermen. Although the FFDA has no jurisdiction over private ponds, the changes it effects in community ponds do influence fish culture in them as well. Owners either use their ponds for fish culture themselves or lease them out privately (Marothia 1997). The leasing policy of these water bodies varies in different states. But, in most of the cases, the priority for allotment of common village ponds is given to local co-operatives, fishermen groups or individual fishermen belonging to the SC/ST category and operating below the poverty line. The lease rent varies according to size, leasing period, ownership, perennial or seasonal water availability, weed population and extent of maintenance. The socio-economic, cultural and political structure and location of pond are other important factors considered while fixing the rent of common village ponds (CVPs) (Katiha and Sinha 2002). The studies (Singh and Bhattacharjee 1994; Marothia 1995; 1997) have favoured management of CVPs by co-operatives. Marothia (1995 and 1997) suggested institutional modification over the existing practice, by reserving close-in ponds for common village use and the more distant for aquaculture to resolve the spatial and temporal conflicts.

The Estuaries

Most of the estuaries in India are in open access regime. The winter migratory fisheries locally known as "been jals" in the lower zone of the Hooghly estuary is a typical example of open access regime in inland fisheries (Paul et al.1997). A large number of fishing groups migrate from different areas of the Hooghly estuary during the winter season and establish transitory fishing camps at suitable spots on the surface in the lower zone of the estuary and remain engaged in bagnet fishing from the end of October to early February. But due to open access system accompanied with an unchecked and unlimited increase in the fishing effort, the catch per unit effort has shown a gradual decline after 1994-95 (Katiha and Bhatta 2002). It seems that the fishing efforts have already surpassed the maximum sustainable harvest level and, if not checked, would prove detrimental for future fisheries.

Flood Plain Lakes

The flood plain lakes are distributed mainly in the states of Assam, Bihar and West Bengal. In Bihar, most of the lakes are public property, barring a few with private ownership (Sinha and Jha 1997; Katiha and Sinha 2002). The government had classified them into two categories: (i) lakes with *Makhana* and lotus; and (ii) lakes without *Makhana* and lotus. The fishing rights in both the types of lakes vest with the department of fisheries, although, the former categories of lakes are with the revenue department. These are auctioned annually to local fishermen co-operatives by the fisheries department. The auction amount varies according to the area and pattern of the fish catch of the lake. However, many of the lakes could not be adopted for fisheries due to unsettled disputes and claims of co-operatives (Katiha and Sinha 2002).

Fisheries Cooperatives

In the fisheries sector there are 11,847 Primary Cooperative Societies with a total membership of about 13.78 lakh. The total business operation in these societies revolves around Rs 150 crore (Planning Commission, 2001). These fisheries cooperatives in the country have developed a 3-tier structure, operating at the village, district and state levels.

National Cooperative Development Corporation (NCDC)

NCDC started promoting and developing fishery cooperatives after its Act was amended in 1974 to cover fisheries within its purview. In order to discharge these functions effectively, NCDC has formulated specific schemes and pattern of assistance for enabling the fishery cooperatives to take up activities relating to production, processing, storage, marketing, etc. Assistance is being provided to fishermen cooperatives on liberal terms, treating the activities as weaker section programmes.

National Federation of Fishermen Cooperatives Limited (FISHCOPFED)

It is the apex organization of fishermen cooperatives in India. It came into existence in 1980 and started its activities in 1982. Its goal is to facilitate the fishing industry in India through cooperatives. The major activities of FISHCOPFED can be classified into three categories: (i) promotional, (ii) welfare, and (iii) business.

Credit

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 major facilitator of credit to the fisheries sector. In view of the brackishwater 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) have 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. Nevertheless, the critical role of the middlemen, merchants and occasional moneylenders in the chain is still in vogue. The present liberal status of the banking sector does hold a considerable hope for further improvement in credit disbursement to the fisheries sector.

Training, extension and transfer of technology

Fisheries development is a state subject in India. The centre, however, promotes fisheries development through state level programme planning and implementation units. At the national level, the Fisheries Division of the Ministry of Agriculture and Cooperation, 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 offering training and extension work as part of their curriculum. The Department of Rural Development promotes fisheries through its 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.

During 2000-01, an amount of Rs. 130.60 lakh was released to various state/ organizations for training of 1183 fish farmers, setting up / upgradation of 6 training centres, establishment of 4 awareness centres, preparation of 15 extension manuals, production of a documentary film and organization of 5 workshops and seminars.

3.5. Linkages

National

Several Ministries / Departments in the Union Government have included fisheries in their respective Rules of Business. The marine fisheries development in particular needs the sharing of responsibilities between the Ministries of Agriculture, Commerce and Surface Transport, through a well-organized coordinating mechanism. Establishing cooperative linkages with the Ministries of Surface Transport and Industry for coordinating the activities of ancillary industries such as mechanical engineering, refrigeration, electronics, etc. with the marine fisheries is an important aspect.

Regional and International

The 1990s witnessed important international agreements and accords relating to the achieving of sustainable fisheries. These agreements represent milestones in international efforts and include Chapter 17 of Agenda 21 of the UN Programme of action which covers programmes relating to coastal areas and the oceans; the 1992 International Conference on Responsible Fishing (held in Cancun, Mexico) and the 1993 Agreement to promote compliance with International Conservation and Management Measures by fishing vessels on the high seas.

All these contemporary global initiatives, to which India has been a signatory, call for concurrence and compliance and a greater interaction with the countries in the sub-region, region and international levels. These developments also call for a more prominent role for India, especially in the existing sub-regional (e.g. SAARC) and regional mechanisms (e.g. BOBP, IOTC, BIMST-EC)

3.6. Other Infrastructures

The other infrastructures and support system include more than 375 freezing plants, 13 canning plants, 150 ice plants, 15 fish meal plants, 900 shrimp peeling plants, 450 cold storage units, and 3 chitison plants. To assist marine product processors, fishing harbours are being developed at both major and minor ports to provide adequate infrastructure, including brackish-water dredging, wharf reclamation, auction halls, workshop facilities, canteens, and hygiene and sanitation facilities to European Community standards. Under this scheme, 100% central grant is given to Port Trusts for construction of major fishing harbours and 50% grant to state governments for minor fishing harbours. Since inception of this scheme, the central government has approved two major fishing harbours, 45 minor fishing harbours and 153 fishing harbours. Currently, all major harbours are operational and construction of the minor harbours is about 80% complete and of landing centres is in progress.

3.7. Fisheries Regulations of the States

Fishing vessels operating in territorial waters in the sea along the coastline of an Indian state are regulated by the laws passed by the Legislative Assembly of that state. All maritime states in India have similar laws for fishing and other fisheries' related activities for enforcement of closed seasons, mesh regulation, welfare of fishermen, aquaculture, etc. A unified regime is expected to impose an annual closed period of 65 days on the west coast and 45 days on the east coast. India's EEZ has been closed to foreign vessels.

3.8. Laws and Regulations in Aquaculture

Aquaculture is largely practised in private water bodies and public bodies leased to private or cooperative bodies and the rights of use rests with the investor. Aquaculture was developed as a commercial activity in 1980s and the shrimp culture attained the status of an industry in the 1990s. The laws relating to prawn farming in Kerala followed filtration of prawn and fish based on lunar cycles. Some of the laws relating to aquaculture are:

- Environment Protection Act, 1986
- 1955 Amendment to Land Reform Act, 1974 making land leasing for aquaculture an exception
- 1997 Court Directive to establish a Coastal Zone Management Authority to enforce the principle of 'precaution' and 'polluter pays'
- Constitution of Aquaculture Authority to issue license for traditional and improved aquaculture within Coastal Regulated Zone (CRZ) 1997
- Restriction on use of certain chemicals, antibiotics, pesticides and explosives, as per Government of India Notification 2002.

4

Profile of Stakeholders in Fisheries

Several indicators such as educational status, experience, family size, type of house and possessiōn of other consumer durables, consumption expenditure, public service, social amenities, etc. were considered in judging the socio-economic status of stakeholders in fisheries.

4.1. Socio-economic Profile of Marine Fishers

The average level of education among all categories of fishers (mechanized, motorized and traditional) was observed to be low. It was relatively higher in the mechanized category followed by the fishers in the motorized category. In the traditional category of fisheries, the level of education was the lowest, but experience in fishing was the highest. There was no significant difference in the average age and family size in different categories of fishers. About 27-28 per cent of family members in the mechanized and motorized sectors and 35 per cent in the traditional sector were engaged in actual fishing. Similarly, very few women in mechanized fishing families were involved in fish vending (1.68 %) compared to those in traditional fishing (6.58%). Further, 20 per cent of the family members in the mechanized fishing unit stayed in other villages compared to only 3.4 per cent among traditional families. The mechanized fishing families had more diversified sources of income (Table 4.1). There was no significant difference in availing the civic amenities like independent drinking water sources (bore well), LPG connection, own transport, television set and health facilities, etc. among fishers working in different technological scenarios (Table 4.2).

Sharing of Risks and Returns in Marine Fishing

The sharing system, although common in all fishing technologies, has certain differences in fishing methods based on capital intensity, type of fish harvested, social structure and ownership pattern. Some of the prevalent sharing patterns in the study area are depicted in Table 4.3. The ownership

Table 4.1. Socio-demographic profile of fishers

Particulars	Mechanized	Motorized	Traditional
(1) Average age (years)	36.89	38.94	38.79
(2) Education (years)	8.36	6.68	4.31
(a) Illiterate (%)	12.50	16.98	41.38
(b) Primary (%)	10.72	33.96	31.04
(c) Secondary (%)	69.64	45.28	27.59
(d) Higher secondary (%)	7.14	3.78	0.00
(3) Experience (years)	18.62	21.00	23.93
(4) Family size (number)	6.35	7.21	5.76
Adult (number)	4.6	4.8	4.0
(a) Male (%)	54.4	50.7	57.8
(b) Female (%)	45.6	49.3	41.9
Children (number)	1.7	2.4	1.8
(a) Actual fishers (%)	26.96	27.82	35.32
(b) Fish vendors –only women (%)	1.68	3.50	6.58
(5) Diversification of occupation			
(a) Family member staying in other villages (%)	19.64	5.66	3.44
(b) Families with other enterprises (%)	16.07	1.79	6.89

Source: Primary data, 2003

of fishing vessels and nets is usually shared by 2-3 partners in the case of mechanized vessels, owned by 20- 25 partners in the case of motorized boats and 3-5 partners in the traditional sector. The crew income was found to depend on the sharing system and the total income generated in fishing. It was important to note that there were shares for the community and social organizations in the traditional fishing system, which was absent in the mechanized fishing. Thus, an informal social security system was prevailing under the traditional system to some extent, which was totally overlooked in mechanized fishing. The government, however, has introduced several schemes of social security nets to provide support to vulnerable sections of the fishing community.

Table 4.2. Household access to basic amenities

(in per cent)

Particulars	Mechanized	Motorized	Traditional
(1) Water			
(a) Piped	55.36	92.45	79.31
(b) Well	32.14	3.77	17.24
(c) Bore well	12.50	3.77	2.45
(2) Sanitation			
(a) Public	16.07	22.64	24.14
(b) Owned	62.50	62.26	41.38
(3) Electricity	85.71	88.68	89.66
(4) Domestic fuel			
(a) Firewood	48.21	84.91	72.41
(b) LPG	41.07	11.32	13.79
(c) Other	10.71	3.77	13.79
(5) Entertainment			
(a) Radio	58.93	52.83	34.48
(b) Television	58.93	52.83	31.03
(6) Own transport	28.57	9.43	0.00
(7) Proximity to PHC			
(a) Less than 5 km	87.50	77.36	96.55
(b) More than 5 km	12.50	22.64	3.45

Source: Primary data, 2003

Table 4.3. Sharing pattern in marine fishing

(in per cent)

Particulars	Mechanized		Motorized		Traditional	
	Owner	Crew	Owner	Crew	Owner	Crew
Commission charge	50	50	50	50	50	50
Fuel charge	100	0	50	50	-	-
Food charge	50	50	50	50	-	-
Net Profit	70	30	40	60	34	66

Source: Primary data, 2003

4.2. Socioeconomic Profile of Inland Fishers

Freshwater aquaculture

Selected socio-economic characteristics of inland fish farmers (freshwater) are given in Table 4.4. Fishers have been classified as small, medium and large based on the total pond size. The average household size was six members with little variation across different categories. The average number of earning members per household hovered around 2. The level of education of the fish farmers was dismal. The average completed education period by fishers was 5 years, which was almost same for all the categories of fish farmers. However, they had more than 9 years of experience in aquaculture. The average pond size of small fishers was 0.43 ha , medium 1.29 ha and large, 7.49 ha, with an overall pond size of 2.61 ha. Not much variations were observed in the socio-economic features of fishers in different states, except in the case of pond size.

Table 4.4. Socio-demographic profile of aquaculture farmers

Items	Size of aquaculture farm			
	< 1 ha	1 – 2 ha	> 2 ha	All farms
No. of adult family members	6.16	6.41	5.90	6.06
No. of earning members	2.27	2.14	2.20	2.13
Period of education (years)	5.27	4.41	5.37	5.14
Experience of aquaculture (years)	8.73	9.32	10.02	9.31
Area under aquaculture (ha)	0.43	1.29	7.49	2.61

Source: Primary data, 2003

Economics by size of operations

On an average, fish farmers produced 2624 kg per ha per production cycle and incurred a total cost of Rs 47,072 (Table 4.5). The productivity of large fishers (2795 kg/ha) was about double than that of the small fishers (1698 kg/ha). The medium fishers harvested 1934 kg fish per ha per production cycle. There were regional variations in the productivity; it was higher in Andhra Pradesh and Karnataka. The overall productivity was less than half of the potential yield

Table 4.5. Economics of fish production in India

Items	Size of aquaculture farm			
	< 1 ha	1 – 2 ha	> 2 ha	All farms
Gross income (Rs)	56072	60926	84656	80106
Yield (kg/ha)	1698	1934	2795	2624
Share of Inputs (%)				
Seed	14	12	14	14
Feed	22	21	23	23
Labour	38	42	39	39
Fertiliser	3	5	4	4
Lime	3	2	#	1
Others*	20	18	20	20
Total costs (Rs/ha)	22880	29075	51517	47072
Net income	33192	31852	33140	33034
Benefit cost ratio	2.45	2.10	1.64	1.70
Cost (Rs /kg)	13	15	18	15
Price (Rs /kg)	33	31	30	31

* Others include cost on diesel, electricity, health management, etc
# denotes negligible share
Source: Primary data, 2003

(6790 kg/ha) and was only about one-third of the average productivity of China (12,000 kg/ha). Rohu and Catla were the major species harvested at all categories of aquaculture farms in all the states under study (Table 4.6). On an average, they accounted for 68 and 19 per cent of the total production, respectively. In AP, Rohu (84 per cent) and Catla (16 per cent) were only species being harvested. But, in Haryana, Orissa, West Bengal and Uttar Pradesh, Mrigal also constituted a significant proportion (14-27 per cent) of total fish production at aquaculture farms. Like productivity, the total cost incurred per hectare also varied significantly across farm size. The large farms incurred a total cost of Rs 51517 and small farms Rs 22880 per hectare per production cycle; the medium fishers spent Rs 29075. Significant regional variations were observed in costs incurred in aquaculture. The major components of total cost were feed, labour and seed, accounting for 76 per cent of the total cost. It varied slightly across farm size.

Table 4.6. Share of various species of fish in total quantity and value
(in per cent)

Species	Size of aquaculture farm							
	< 1 ha		1 – 2 ha		> 2 ha		All farms	
	Q	V	Q	V	Q	V	Q	V
Rohu	31	33	38	38	74	72	69	68
Catla	27	28	33	33	19	18	20	19
Mrigal	23	20	15	13	4	3	5	5
Prawn	0.1	0	0.5	3	0.3	3	0.3	3
Others*	19	18	14	12	3	3	5	5
Total**	1.70	56.07	1.93	60.93	2.80	84.66	2.62	80.11

* Others include common carp, grass carp, silver carp, etc.
**Q = Quantity in quintal and V = value in thousand rupees
Source: Primary data, 2003

On an average the unit cost of production of fish was Rs 15 per kg which varied from Rs 13 at small farms to Rs 18 at large farms. The average price received per kg of fish by the small farmers was Rs 33, by medium, Rs 31; and large farmers Rs 30, with the overall average price of Rs 32 per kg. The average net farm income of the fishers was Rs 33034 per ha per production cycle with little variation across pond size. However, the benefit cost ratio and the net income varied significantly across different states under study.

4.3. Socio-economic Profile of Shrimp Farmers

The shrimp farming unlike freshwater aquaculture is purely a commercial enterprise undertaken by educated and skilled individuals and firms (partners). The completed years of education ranged from 9 to 13 years, indicating that they had minimum education up to secondary level. Their experience also showed that most of them had been practising shrimp cultivation for the last 5-8 years. The size of shrimp farms of the sampled farmers ranged between 0.9 and 13 hectares, representing a wide variation and constituting of small and marginal farmers on one hand and capitalistic firms on the other. Since shrimp farmers specialized only in shrimp cultivation, the entire land area was utilized for shrimp ponds, leaving little area for other activities (Table 4.7).

Table 4.7. Socio-demographic profile of shrimp farmers

Particulars	Size of shrimp farms			
	< 2 ha	2 – 5 ha	> 5 ha	All farms
Period of education (years)	10	12	13	11
Experience in shrimp farming (years)	5	7	7	6
Area under shrimp farming (ha)	1.0	3.4	12.8	6.2
Total land area (ha)	1.6	4.0	13.6	6.9
Capital investment (Rs / ha)	52945	51206	39154	41533

Source: Primary data, 2003

The shrimp farming is highly capital intensive, compared to fish farming, due to the capital required for pond construction, electricity, aerators and other pipeline systems. The capital investment required per hectare decreased as the farm size increased (Table 4.7). The per hectare capital investment was the highest in Karnataka (Rs 57203 per ha) and lowest in West Bengal (Rs 18176 per hectare).

Economics of Shrimp Farming

The average productivity of shrimp was 740 kg per ha per crop. It was the highest on medium farms (793 kg/crop/ha) and the lowest on large farms (730 kg/crop/ha). Small farmers produced 765 kg/ha in a crop cycle. The average productivity was found highest in AP and was almost same in Karnataka (620) and West Bengal (626 kg). However, the largest proportion of respondents under large categories availed two crops in a year followed by medium categories of shrimp farmers. On the average, the total costs incurred in shrimp farming was Rs 98339 per ha per crop. The major components of cost were seed and feed, which together accounted for 69 per cent of the total cost. The labour constituted 10 per cent. The total cost of shrimp production did not clearly indicate a scale bias. With an average market price of Rs 314 per kg and production cost of Rs 133 per kg, shrimp farming was considered to be highly profitable. The average net farm income of the shrimp farmers was 1.34 lakh per ha per crop.

However, shrimp farming at small scale was not that profitable as the large ones (Table 4.8).

Table 4.8. Cost profile of shrimp farms

Particulars	Size of shrimp farm			
	< 2 ha	2 – 5 ha	> 5 ha	All farms
Gross income (Rs in lakh)	2.12	2.42	2.33	2.33
Yield (kg/ha)	765	793	730	740
Share of Inputs (%)				
Seeds	17.5	15.4	18.4	17.9
Feed	43.6	53.4	51.2	51.1
Labour	13.6	10.1	9.7	10.0
Fertilizers	0.3	0.5	1.1	1.0
Chemicals for pond preparation	3.4	2.3	2.3	2.4
Hormones and vitamins	0.5	1.0	0.2	0.4
Fuel	6.1	4.0	5.3	5.2
Rent (farm & equipment)	2.4	1.8	2.9	2.7
Depreciation and interest *	10.9	8.9	8.2	8.4
Incidentals	1.7	2.4	0.6	1.0
Total cost (Rs. in lakhs)	0.97	1.15	0.96	0.98
Net income	1.15	1.27	1.37	1.34
Benefit cost ratio	2.19	2.10	2.43	2.37
Cost (Rs /kg)	127	145	131	133
Price (Rs /kg)	277	305	319	314

* Depreciation @ 10% & interest @ 10%
Source: Primary data, 2003

4.4. Profile of Stakeholders in Post-harvest Fisheries

The post-harvest fisheries sector consists of different types of functionaries working at different scale. Over the years, although the structure of marketing and the role of functionaries have changed, the basic supply chain has remained more or less the same. Some of the important stakeholders in the post-harvest sector alongwith their respective roles are shown in Table 4.9. These are the broad categories and their role and functions were found to differ depending on the region, level and type of market.

Table 4.9. Stakeholder groups in Indian post-harvest fisheries

Player	Role
Fishermen's assistants	Mainly the wives of the fishermen are involved in helping the fishers in collecting the catches from the nets for sale after landing. No payment is involved.
Head loaders	Carry fish from the landing centres to the auctioning site, from auction site to godowns or transport systems. Some of them come from non-fishing communities.
Poor people collecting fish	Extremely poor people, collect fish from fishers either for free or in a barter system involving sweetmeats, etc.; and either sell the fish for money or use for domestic consumption.
Money lenders	Lend money for business and personal purposes to the fishers and traders. Some moneylenders are involved only in money-lending activities, while others are involved in fish trade also.
Auctioneers	Auction catches which are landed. In traditional fish landing centres, in places like Chennai, it is exclusively women who act as auctioneers; in some others, it is only men. Some auctioneers are also moneylenders.
Boat owners	Own different size boats, possibly driver-cum-owner. Operating major mechanized centres.
Companies/ Exporters	Buyers of fresh fish from the port/landing centre for export or sale within the country (>100 km).
Agents	Act on behalf of buyers of fresh/dry fish. Accumulate economic lots to be sent elsewhere. Some agents buy in bulk and retail to cycle/moped traders on credit.
Tricycle and auto-rickshaw owners and operators	Hired by the fishers for transporting fish to the wholesale and retail markets.
Cycle/moped traders	Buy from the landing centre and sell in markets in and around the site (up to 50 km); Generally not from the fishing caste.
Petty traders (headload)	Buy and sell fish (fresh & dry) within 30 km of the site, mostly women, coming from the fishing caste.
Fish collectors	Appointed by the commission agents, they are paid employees for taking care of collection, storage and transport of the catches from the villages too difficult for the agent to access on a regular basis. Could be men or women, almost all of them are from non-fishing communities.

Source: SIFFS (2000)

4.5. Economics of Inland Fish Merchants

The inland fish marketing as a business is controlled by a few families in each market, both at wholesale and retail levels. A survey of fish wholesalers and retailers revealed that the profit margin was generally kept high to cover the risk factors. The cost and returns of fish marketing as an enterprise are given in Table 4.10. The marketing operation of inland fish was normally restricted to a district; the inter-district movement was only during the glut season. The price spread and cost of marketing were very high. The retail price of locally

Table 4.10. Cost and returns of inland fish merchants

Particulars	Wholesaler	Retailer
Purchasing price (Rs/ tonne)	19881	23444
Selling price (Rs/ tonne)	36375	39209
Fixed cost (Rs/ tonne)		
Rent	15	6.00
Electricity cost	2.46	3.17
Cost of family labour	162	643
Labor cost	304	511
Total fixed cost (TFC)	483	1163
Variable cost (Rs/ tonne)		
Total purchasing cost	19881	23444
Transportation cost	2333	823
Ice cost	1433	594
Packaging cost	466	151
Handling loss (kg/ tonne)	35	9
Loss of revenue due to handling	1313	350
Total variable cost	25428	25363
Total cost	25911	26527
Total revenue	36375	39209
Net revenue (Rs/ tonne)	10463	12681
Benefit cost ratio (TR/ TC)	1.40	1.48
Price spread (Rs/ tonne)	16493	15765
Value addition (Rs/ tonne)	6030	3083

Source: Primary data, 2003

sold fish doubled as per the price received by the fishers. A perusal of Table 4.10 shows that the fish purchased at Rs 19/ kg by a wholesaler was sold at Rs 39/ kg in the local market itself, with a price spread of Rs 20/ kg. The cost of transport, ice, packing, handling losses and other fixed costs together at wholesaling and retailing was around Rs 8/ kg. Thus, there was a vast scope for reducing the price spread and increase the producer share in consumer rupee. Further, in the case of exportable species, producers' share in export proceeds varied from 31 per cent to more than 83 per cent. Possibly in the case of items whose processing cost was low, the share of producers in the export proceeds was higher (Table 4.11).

Table 4.11. Producers' share in export price 2001

(Rs/kg)

Species	Raw material	Export	Producer's share (%)
Cuttle fish	74	95	78.0
Mackerel	27	46	58.1
Shrimp	154	274	56.4
Kerrikady	93	283	32.8
Poovalan	80	255	31.4
Tiger shrimp	387	690	56.1
White prawns	293	536	54.6
Brown prawns	201	453	44.5
Squid	55	109	50.2
Black pomfrets	65	78	83.3
Crabs	75	182	41.0
King fish	85	123	68.8
Ribbon fish	14	34	42.2
Seer fish	61	84	72.3
Reef cod	54	126	43.2

Source: Primary data, 2003

4.6. Dietary Pattern and Expenditure

The information on the dietary pattern of the fish eating households at the national level is provided in Table 4.12. The cereal consumption which is the

Table 4.12. Annual consumption of food in India

Item	1983	1999	Growth (% per annum)
Annual per capita consumption (kg)			
Cereals	167.2	149.0	-0.72
Pulses	10.3	12.8	1.34
Milk	33.1	61.2	3.91
Eggs(n)	15.8	31.3	4.38
Meat	4.1	5.0	1.26
Fish	4.2	5.6	1.84
Price of commodity (Rs/kg)			
Cereals	2.8	10.0	8.29
Pulses	5.1	19.8	8.81
Milk	3.1	8.8	6.69
Eggs(n)	0.6	1.7	7.16
Meat	13.7	54.7	9.04
Fish	8.7	31.8	8.46
Annual per capita expenditure (Rs)			
Food	1097	4720	8.73
Non-food	556	3454	8.03
Total	1652	8174	8.46

Source: NSSO data

staple food in Indian diet has shown a declining trend, from 167 to 149 kg / capita/year during the period 1983-1999. The declining trend in the cereal consumption was basically due to the structural shift in tastes and preferences on account of the increasing availability of a variety of food items. The growth in per capita consumption during 1983-1999 was 1.3 per cent in pulses, 3.9 per cent in milk, 4.4 per cent in eggs, 1.3 per cent in meat and 1.8 per cent in fish. The consumption of meat and fish for the non-vegetarian population was almost equal, 5.6 kg for fish and 5.0 kg for meat per capita per annum. The price of various food items were found growing at the annual rate of 7-9 per cent. At the aggregate, the expenditure on food and non-food had increased with annual growth rate of 8.7 per cent and 8.0 per cent, respectively.

4.7. Fish Consumption Pattern

The fish consumption pattern was examined for the fish-eating households for the coastal and non-coastal states, geographical locations (rural and urban, regions), and four income groups. Food of animal origin accounted for 13 per cent of the total food expenditure. The share of fish in the animal origin food was about 12 per cent. Fish contributed more than half of the non-vegetarian food among the fish-eating households in India (Table 4.13). The share of fish in food expenditure at the national level was estimated to be only 1.55 per cent in the non-coastal states and 3.51 per cent in the coastal states in the year 1999-2000. Only 35 per cent population in India was estimated to be fish eater; 46 per cent in coastal states and 27 per cent in non-coastal states. The share of fish in the total non-vegetarian food in non-coastal states declined from 57% in 1983 to 51% in 1999. The reverse trend was observed in maritime states. At all India level, fish constituted about 58% of the total non-vegetarian food.

Wide regional variations were observed in fish consumption, it was higher in southern, eastern and north-eastern states and lower in western and northern states, the lowest being in the western states. The fish consumption depicted an increasing trend; during the period 1983-2000, it increased from 6.97 kg/year/capita to 9.12 kg in the rural areas and from 8.01 kg/year/capita to 11.05 kg in urban areas. The level of fish consumption was influenced by income and its easy availability. The growth in fish consumption was higher in non-poor and rich households and was stagnating in poor households (Table 4.14).

The fish prices were found to be higher as we moved from very poor to non-poor, rural to urban and coastal to non-coastal states (Table 4.15). This reflected that apart from other factors, quality consideration in purchase of fish was high for rich households. The higher consumption of fish in coastal states was also because of easy access and lower price.

4.8. Fish Consumption by Species

The dietary pattern based on the project survey was consistent with the NSS survey data (Table 4.16). The average annual per capita consumption of Indian major carps for rural consumers was 4.23 kg, which ranged from

Table 4.13. Status of fish consumption in Indian diet

Year	NSS sample households			Fish-eating households		
	Number of sample households	Share of fish in food expenditure (%)	Share of fish in total meat, fish & eggs (%)	Share of fish eating population in total (%)	Share of fish in food expenditure (%)	Share of fish in total meat, fish & eggs (%)
Non-Maritime States						
1983-84	59,281	1.43	32.9	23.2	5.71	57.1
1987	66,069	1.76	33.3	26.2	6.39	53.8
1993-94	58,075	2.07	32.9	28.2	7.10	50.0
1999-00	61,556	1.55	30.7	27,3	5.54	50.9
Maritime States						
1983-84	53,336	2.77	44.5	45.7	5.61	59.2
1987	58,189	3.35	47.6	46.7	6.81	62.0
1993-94	51.935	3.82	43.4	48.2	7.50	56.4
1999-00	54,052	3.51	46.7	45.6	7.16	62.6
All India						
1983-84	1,12,617	2.03	39.3	33,6	5.65	58.4
1987	1,24,258	2.48	40.8	35.4	6.64	58.0
1993-94	1,10,010	2.88	38.6	37.1	7.34	53.8
1999-00	1,15,608	2.42	39.4	35.2	6.49	57.9

Source: NSSO data

Table 4.14. Changes in fish consumption in different classes in India, 1993 to 1999-00, India

Class	Fish-eating sample households				All sample households			
	1983	1987-88	1993-94	1999-00	1983	1987-88	1993-94	1999-00
Rural	6.97	7.54	7.23	9.12	2.39	2.73	2.77	3.35
Urban	8.01	8.57	9.18	11.05	3.87	4.38	4.81	5.48
All India	7.30	7.86	7.90	9.79	2.45	2.78	2.93	3.45
Non-maritime states of India: Classified by region								
East	5.63	5.35	4.97	5.72	2.66	2.90	2.75	3.39
West	3.86	3.62	3.40	3.45	0.46	0.37	0.43	0.37
North	5.25	4.25	3.83	4.68	0.50	0.30	0.29	0.46
Hills	4.12	3.59	4.04	7.44	0.30	0.34	0.25	0.20
N-E states	5.85	6.13	6.77	13.56	3.75	4.46	4.95	8.94
All states	5.37	5.30	5.37	7.78	1.25	1.39	1.52	2.13
Maritime states of India: Classified by region								
East	6.93	8.62	7.92	8.58	5.41	7.27	6.98	7.47
West	6.49	7.60	8.10	9.44	1.48	1.84	1.96	2.04
South	10.52	11.44	12.31	15.04	4.55	4.75	5.13	5.97
All states	8.45	9.64	9.72	11.37	3.87	4.50	4.68	5.18
Income class of the sample households in non-maritime states of India								
Very poor	3.60	3.45	3.28	3.57	0.64	0.71	0.69	0.98
Poor	4.69	4.04	3.81	5.70	1.13	1.04	1.10	1.74
Non-poor	5.05	4.72	4.93	7.64	1.34	1.32	1.52	2.26
Rich	7.43	6.99	7.23	9.53	1.69	1.89	2.02	2.35
Income class of the sample households in maritime state of India								
Very poor	5.03	4.86	4.44	4.10	2.08	1.94	1.73	1.71
Poor	6.41	6.68	5.80	6.12	2.98	3.16	2.79	2.80
Non-poor	8.21	8.75	8.26	9.06	3.85	4.16	4.09	4.24
Rich	12.77	13.90	13.96	14.97	6.08	6.77	6.98	6.79

Source: NSSO data

2 kg for poor to 7.89 kg for higher expenditure classes. The average marine fish consumption of rural consumers was dominated by low value pelagic, which ranged from 1.11 kg for poor to 2.20 kg for rich class. Among the marine fishes, the next important species group was low value demersal,

Table 4.15. Fish price in the maritime and non-maritime states of India

(in Rs/kg)

Year	Very poor	Poor	Non-poor low	Non-poor high	All India
			Maritime States		
Rural					
1983-84	5.7	6.2	6.3	7.0	6.5
1987	9.2	9.8	10.4	11.0	10.6
1993-94	17.2	18.5	18.6	19.4	19.0
1999-00	27.2	27.9	27.1	30.2	29.2
Urban					
1983-84	5.4	7.1	8.5	11.0	9.1
1987	9.0	10.2	12.1	16.2	13.6
1993-94	17.2	18.3	20.4	25.7	22.9
1999-00	27.6	28.8	30.5	36.2	34.3
			Non-Maritime States		
Rural					
1983-84	7.9	8.8	11.3	11.7	10.4
1987	11.8	13.8	17.4	20.8	17.8
1993-94	22.8	26.5	30.4	34.5	30.8
1999-00	27.0	22.2	25.7	31.9	27.8
Urban					
1983-84	9.8	11.7	15.8	16.5	15.5
1987	12.8	15.9	23.0	26.4	24.5
1993-94	26.1	29.5	33.7	40.6	38.1
1999-00	37.7	36.0	26.9	51.1	45.3

Source: NSSO data

Note: Fish-eating population

which ranged from 110 grams to 280 grams for rich classes (Table 4.17). Among the urban consumers, the Indian major carps dominated the consumption basket of fish. The lowest expenditure classes in urban areas consumed 2.90 kg annually, which was slightly higher than their counter part in rural areas. However, the consumption of Indian major carps was only 3.18 kg for rich class in urban areas compared to 7.98 kg for their counterparts in rural areas.

Table 4.16. Consumption pattern based on project survey and NSS data

Item	NSS Survey, 1999-00	Project Survey, 2002-03
Food consumption (kg/capita/annum)		
Cereals	149.0	162.3
Pulses	12.8	11.4
Milk	61.2	46.5
Eggs (No.)	31.3	29.4
Meat	5.0	6.8
Fish	5.6	7.5
Percent of total expenditure		
Food	57.7	70.3
Non-food	42.2	29.7
Total expenditure (Rs/capita/year)	8174	7338

Source: NSSO data

The diversification of fresh water aquaculture had significantly increased the accessibility of fish in rural areas and hence the consumption of fish had replaced other substitutes. On the other hand, in the urban areas carps were one among the many varieties of fish and hence there was more uniformity in its consumption. Among the marine fishes, the consumption of pelagic low value fishes ranged from 210 grams for poor to 1.78 kg for the rich class. It was clear that consumption of all types of fishes tended to increase significantly with increase in per capita total expenditure, indicating that fish consumption could increase significantly under higher income scenarios.

The shares of individual fresh water and marine fish species in the total fish consumption are given in Table 4.18. Among the rural consumers and producers, carps constituted 70 per cent of the total consumption followed by pelagic low-value fishes. The demersal high-value fishes were consumed by only rich class and it constituted only 1.3 and 2.5 per cent of the total quantity of fish consumed by the rural and urban consumers, respectively. Indian major carps and pelagic constituted a major share of total fish consumption. Further, the fish consumption generally tended to increase with income and also the share of total expenditure on fish had increased by two-fold between poor and rich classes.

Table 4.17. Annual per capita fish consumption by species, 2002

(in kg)

Fish Group	Expenditure Group				
	I*	II*	III*	IV*	All groups
	Rural consumers				
Freshwater fish					
Indian major carps	2.04	3.47	4.83	7.98	4.23
Other carps	0.66	0.87	0.96	1.66	0.97
Prawn	0.02	0.07	0.07	0.13	0.07
Marine fish					
Pelagic (high-value)	0.01	0.31	0.45	0.88	0.37
Pelagic (low-value)	1.11	1.03	1.43	2.19	1.35
Demersal (high-value)	0.00	0.07	0.18	0.19	0.10
Demersal (low-value)	0.11	0.31	0.17	0.28	0.22
Shrimp	0.00	0.06	0.16	0.19	0.10
Crabs	0.01	0.15	0.06	0.39	0.13
Molluscs	0.02	0.21	0.42	0.65	0.30
	Urban consumers				
Freshwater fish					
Indian major carps	2.90	2.56	2.37	3.18	2.80
Other carps	0.67	1.33	1.03	0.99	1.04
Prawn	0.06	0.15	0.29	1.15	0.57
Marine fish					
Pelagic (high-value)	0.01	0.16	0.49	1.17	0.63
Pelagic (low-value)	0.21	0.70	1.54	1.78	1.28
Demersal (high-value)	0.02	0.04	0.17	0.23	0.14
Demersal (low-value)	0.13	0.13	0.24	0.23	0.20
Shrimp	0.02	0.05	0.13	0.23	0.14
Crabs	0.07	0.14	0.26	0.12	0.15
Molluscs	0.00	0.00	0.00	0.01	0.00
	All sample households				
Freshwater fish					
Indian major carps	2.23	3.22	4.00	5.17	3.72
Other carps	0.66	1.00	0.98	1.27	1.00
Prawn	0.03	0.09	0.15	0.72	0.25

Contd...

Table 4.17. Annual per capita fish consumption by species, 2002 — *Contd*

(in kg)

Fish Group	Expenditure Group				
	I*	II*	III*	IV*	All groups
Marine fish					
Pelagic (high-value)	0.01	0.27	0.46	1.05	0.46
Pelagic (low-value)	0.91	0.94	1.47	1.95	1.32
Demersal (high-Value)	0.00	0.06	0.18	0.21	0.12
Demersal (low-value)	0.11	0.26	0.19	0.25	0.21
Shrimp	0.01	0.06	0.15	0.22	0.11
Crabs	0.02	0.14	0.13	0.23	0.14
Molluscs	0.01	0.15	0.28	0.27	0.19
Total per capita income (Rs/year)	4508	7652	12951	26796	13185

Source: Primary data 2003

*I : Quartile 1- Per capita weekly expenditure < Rs 85

II : Quartile 2- Per capita weekly expenditure Rs 85 - 122

III : Quartile 3- Per capita weekly expenditure Rs 122 - 170

IV : Quartile 4- Per capita weekly expenditure > Rs 170

Table 4.18. The share of different fish species in total fish consumption, 2002

(in per cent)

Fish group	Expenditure group				
	I*	II*	III*	IV*	All groups
	Rural consumers				
Freshwater fish					
Indian major carps	51.2	53.0	55.3	54.9	54.1
Other carps	16.6	13.3	11.0	11.4	12.4
Prawn	0.4	1.1	0.8	0.9	0.9
Marine fish					
Pelagic (high-value)	0.3	4.7	5.1	6.0	4.7
Pelagic (low-value)	28.0	15.7	16.3	15.1	17.2
Demersal (high-value)	0.0	1.1	2.1	1.3	1.3
Demersal (low-value)	2.7	4.7	2.0	1.9	2.8
Shrimp	0.1	0.9	1.8	1.3	1.2

Contd...

Table 4.18. The share of different fish species in total fish consumption, 2002— *Contd*

(in per cent)

Fish group	Expenditure group				
	I*	II*	III*	IV*	All groups
Crabs	0.3	2.2	0.7	2.7	1.7
Molluscs	0.4	3.3	4.9	4.5	3.8
Urban consumers					
Freshwater fish					
Indian major carps	71.1	48.7	36.4	35.0	40.3
Other carps	16.4	25.3	15.8	11.0	14.9
Prawn	1.4	2.8	4.5	12.6	8.2
Marine fish					
Pelagic (high-value)	0.2	3.1	7.5	12.9	9.0
Pelagic (low-value)	5.1	13.4	23.6	19.6	18.4
Demersal (high-value)	0.4	0.8	2.6	2.5	2.1
Demersal (low-value)	3.3	2.4	3.6	2.5	2.8
Shrimp	0.5	1.0	2.0	2.5	2.0
Crabs	1.6	2.6	3.9	1.3	2.2
Molluscs	0.0	0.0	0.0	0.1	0.0
	All sample households				
Freshwater fish					
Indian major carps	55.8	52.0	50.1	45.6	49.4
Other carps	16.5	16.1	12.3	11.2	13.2
Prawn	0.7	1.5	1.8	6.4	3.3
Marine fish					
Pelagic (high-value)	0.3	4.3	5.8	9.2	6.1
Pelagic (low-value)	22.7	15.1	18.3	17.2	17.6
Demersal (high-value)	0.1	1.0	2.2	1.9	1.6
Demersal (low-value)	2.8	4.1	2.4	2.2	2.8
Shrimp	0.2	0.9	1.9	1.9	1.5
Crabs	0.6	2.3	1.6	2.0	1.8
Molluscs	0.3	2.5	3.5	2.4	2.5

Source: Primary data 2003
*I : Quartile 1- Per capita weekly expenditure < Rs 85
II : Quartile 2- Per capita weekly expenditure Rs 85 - 122
III: Quartile 3- Per capita weekly expenditure Rs 122 - 170
IV: Quartile 4- Per capita weekly expenditure > Rs 170

The fish species groups based on the survey are presented in Table 4.19. The Indian major carps contributing almost half of the total consumption followed by pelagic low-value (17.6 per cent), the fresh water carps (13.2 per cent), shrimps including freshwater and marine (6.6 per cent), pelagic high-value (6.1 per cent), demersal (4.4 per cent) and molluscs (2.7 per cent).

Table 4.19. Basic characteristics of different fish groups, India, 2002-03

Groups	Average price (Rs/kg)	Share of different fish groups in total fish consumption in the sample households, %	Major species
I : Indian major carps	43	49.4	Rohu, Catla, Mirgal
II : Other freshwater fish	39	13.2	Common carp, Silver carp, Tilapia, Mangur Grass carp, fresh water captured fish
III : Prawn/Shrimp	107	6.6	High-value Crustaceans (Prawn, Shrimp, Lobsters), Crabs
IV :Pelagic high-value	91	6.1	Pomfrets, Seerfish, Pelagic sharks, Tunas
V :Pelagic low-value	25	17.6	Anchovies, Bombay duck, Sardines, Mackerel, Clupeid, Horse mackerel
VI :Demersal high-value	67	1.6	Rock cods, Snappers, Lactarius, Threadfins
VII: Demersal low-value	31	2.8	Catfish, Goat fishes, Silverbellies, Nemipterids, Lizard fishes
VIII: Molluscs	29	2.7	Mussels, Oysters, other low-value fishes

Source: Primary data 2003

4.9. Poverty Assessment among Fishermen

The poverty among fishing communities, fish farmers and shrimp farmers is an important part of the transition. The results of the study clearly indicated that the traditional fish workers, migratory fishers of inland water bodies and culture-based fisheries were the poorest of the poor. It was observed that 75 per cent of the fish farmers were living with an income of less than a dollar per day. However, as the farm-size and intensity increased, the level of poverty decreased. Most of the shrimp growers were better off, although farmers with less than 2 ha pond area were relatively poor. It was difficult to exactly quantify the level of poverty in the post-harvest fisheries sector. The PRA results indicated that there were many different groups who were poor and the study had identified several such groups who could be considered as poor. Among the fish consumers, it was observed that the poor consumers tended to spend 50 per cent of their total food expenditure on fish, which was almost equal to the shares of food expenditure of rich class, indicating higher dependency of the poor on fish in their food basket. Hence, even a small increase in fish price was likely to affect their food, security.

5

Fish Demand and Supply Analysis

The fisheries sector in India which provides livelihood to a large section of economically underprivileged population of the country, was undergoing a transformation. The emerging production technologies, higher economic growth, population explosion and shifts in dietary pattern are driving rapid growth in production and demand for fish. Available projections of demand and supply for the fish sector are limited by their high degree of aggregation and lack of empirical basis for the underlying elasticities of supply and demand. Multi-market fish sector model developed at World Fish Center by Dey et al. (2003) has been implemented for India also. The model is divided into producer, consumer, and trade cores. Fish species are grouped into species groups with the help of experts, based on biological species, commercial value and market destinations. The time series data on fish production and farm survey data on fish farming at regional level was used to estimate producer core, following the dual approach. The multi-stage budgeting framework with AIDS model was used for fish demand analysis based on consumer survey data. Armington (1969) approach was used for the trade core. The model was closed with a set of equilibrium conditions between supply and demand. Following Dey et al. (2003), Indian Fish Simulation Model (IFSM) was structured and computer-based instructions under GAMS were developed by U-Primo E. Rodriguez. IFSM was run under various scenarios of technological changes. Projections were made for fish price, supply, domestic demand, and export by species.

The study generated the disaggregated and empirically-based projections of supply, demand and export of fish by species group for India and generated the numerical projections on prices, quantities by the year 2015. The conclusions were also drawn for the welfare of fish-dependent sectors, based on probable and alternative scenarios for demographic, technological, and institutional trends. The results of the study would be used to develop the national plan for improving the socio-economic condition of the poor fisherman and accomplished growth of fisheries sector.

5.1. The Data

The time series data on fish production (species-wise) and their prices at state level were compiled from various sources. *Handbook on Fisheries Statistics* published by Ministry of Agriculture, Government of India and state specific publications on fisheries statistics were the important sources of data for this study. Some unpublished data were culled out from the state government files personally. The data on input prices (wage, fertilizer, feed, fuel) were obtained from the Agricultural Prices in India, Reports of the Commission for Agricultural Costs and Prices and Economic Survey, published by the Government of India and Fertilizer Statistics published by the Fertilizer Association of India. The export data on quantity and unit value of various species of fish were compiled from Marine Products Export Development Authority, Kochi. The data on fishery water resources were collected from Central Water Commission. The Indian Livestock Census provided the data on fisherman population and fishery resources. The data used in the study are classified as follows:

- Marine fish production by species for states/ union territories, their quantity and prices
- Inland fish production by species for states/union territories, their quantity and prices
- Prawn production by states/union territories, their quantity and prices
- Exports of marine products by species, their quantity and value
- Inland fishery resources by states/union territories: Length of rivers and canals, area under reservoirs, ponds and tanks, water bodies, brackish water
- Coastal length by states/union territories
- Fisherman population by states/union territories: It included total number of members, number of family members engaged in fishing operations (full time and part time), family members engaged in fishing-related activities like marketing of fish, repair of fishing nets, processing of fish, etc.
- Data on fishing crafts viz. traditional, motorized traditional, mechanized boats — gill-netters, trawlers, liners, etc. and on fishing gears, viz. dragnets, gill nets, trawl nets, cast nets by states/union territories.

The data on inland fish production, inputs and their prices were compiled for the period 1991-92 to 1998-99 covering 27 states/ union territories of India. The data on inputs, viz. land, labour, feed (rice bran, oil cake, etc.), fertilizer (cow dung, poultry manure, chemical fertilizers), seed and specific costs (diesel, medicine, etc.) were also compiled[1]. The data on marine fish production and its value by species were compiled for the period 1986-87 to 1998-99, covering 12 maritime states. The data on labour and fuel were also compiled from various published sources. The quantity of diesel used was worked out by taking into account various types of crafts, number of fishing days, hours of work per day with the norms that 200 millilitres of diesel would be used per HP. The total HP utilization was worked out in consultation with experts.

Classification of inland fish species

The freshwater fish species are grouped as follows:

Indian Major Carps	:	Catla, Rohu, Mrigal, Calbasu
Other freshwater fish	:	Silver carp, Grass carp, Common carp, Murrels, Hilsa (inland), and other unspecified inland fishes
Prawn/Shrimp	:	Penaeid shrimp

Classification of marine fish species

The marine fish species are grouped as follows:

Pelagic fishes– high-value (PHV): Seerfish, oceanic tunas (yellowfin tuna, skipjack tuna), large carangids (*Caranx* sp.), pomfrets, pelagic sharks, mullets

Pelagic fishes – low-value (PLV): Sardines, mackerel, anchovies, Bombayduck, coastal tunas, scads, horse mackerel, barracudas

[1] The time series cross-section data at the state level on specific inputs were not available. The input-output coefficients for aquaculture fish were reviewed from various studies. The time series and cross-section information on the use of various inputs were generated and used in the analysis. The data for the missing years were interpolated. For the missing states, the information from the neighbouring states were used.

Demersal fishes – high-value (DHV): Rock cods, snappers, lethrinids, big-jawed jumper (*Lactarius*), threadfins (Polynemids)

Demersal fishes – low-value (DLV): Rays, silverbellies, lizard fishes, catfishes, goat fishes, nemipterids, soles

Crustaceans – high-value (Shrimp): Shrimps, lobsters

Molluscs and others (Molluscs): Cephalopods (squids, cuttlefishes and octopus), mussels, oysters, non-penaeid prawns, etc.

5.2. Fish Balance Sheet and Market Margin

To run a model, a *benchmark data set* must be assembled consistent with equilibrium conditions for the endogenous variables. That is, actual data on the endogenous variables of the model for a given base year is assumed to represent the model equilibrium. The benchmark data set would contain, for a given year, information on quantity supplied and demanded by the fish type. Furthermore, initial values for exogenous variables, as well as some of the model parameters, must be *calibrated* for consistency within the benchmark data set. The fish balance-sheet and market margin are the important component of the general equilibrium model and are given in Tables 5.1 and 5.2, respectively. The balance sheet by species was constructed based on production, import, export and consumption at the national level. The import of fish in India was very small. However, export played a major role in the Indian fish sector. Shrimp constituted one-third of total export and two-thirds of the total export earnings from the fish export. Demersal high-value was also important fish group contributing significantly to the fish export. The market margin across species had moved in the narrow range from 20 to 25 per cent. It was highest for the shrimp and was around 20 per cent for others species.

5.3. Demand Elasticity

Income elasticities of different fish food groups across income groups are given in Table 5.3. The income elasticities were found to vary substantially across fish species by income group. But at the aggregate level for all the households,

Table 5.1. Balance Sheet: Production, import, export and domestic consumption (in million kg) in TE 1998, India

Item	Production	Import	Export	Domestic consumption
Quantity (million kg)				
Indian major carps	1418.26	0	0	1418.26
Other fresh water fish	1047.26	0	0	1047.26
Prawn	383.93	0	4.93	379.00
Pelagic (high-value)	374.13	65.28	25.051	414.36
Pelagic (low-value)	931.42	0	0	931.42
Demersal (high-value)	367.67	0	108.556	259.11
Demersal (low-value)	216.24	0	0	216.24
Marine shrimp	255.77	0.1	102.484	153.39
Molluscs	486.89	5.27	66.843	425.31
Total prawn (freshwater and marine)	639.70	0.10	107.41	532.39
All	5481.56	70.65	307.864	4771.34
Price (Rs/kg)				
Indian major carps	30.85			37.00
Other fresh water fish	24.60			29.50
Prawn	63.58		320.3	76.30
Pelagic (high-value)	27.69	27.69	97.7	33.20
Pelagic (low-value)	14.15			15.79
Demersal (high-value)	18.61		45.6	21.19
Demersal (low-value)	14.01			16.80
Marine shrimp	40.35	40.35	326.4	48.40
Molluscs	14.97	14.97	110	18.00
Total prawn (freshwater and marine)	54.29	40.35	326.12	68.26

income elasticities ranged with narrow difference, 1.61 for shrimp/prawn to 1.66 for molluscs. Income elasticities for all the fish groups consistently fell with an increase in per capita expenditure (income) level of the household above the poverty line (Quartile II to Quartile IV). None of the groups under study became an inferior good at the highest income quartile. This suggested that even a very rapid increase in aggregate per capita income in the projected period, fish consumption was not likely to turn an inferior good in India. The results revealed

Table 5.2. Market margin by species, India TE 1998

Species	Producer price	Consumer price	Market margin (%)
Indian major carps	30.85	37.00	19.93
Other freshwater fish	24.60	29.50	19.91
Shrimp	54.29	68.26	25.78
Pelagic (high-value)	27.69	33.20	19.89
Pelagic (low-value)	14.15	17.00	20.14
Demersal (high-value)	18.61	22.30	19.85
Molluscs	14.97	18.00	20.32

Table 5.3. Income elasticity of demand for different groups of fish in India

Fish group	Expenditure Quartile				
	I*	II*	III*	IV*	All
Indian major carps	1.63	1.79	1.54	1.36	1.62
Other freshwater fish	1.64	1.80	1.54	1.36	1.62
Prawn/Shrimp	1.14	1.72	1.54	1.39	1.61
Pelagic (high-value)	0.72	1.76	1.54	1.37	1.62
Pelagic (low-value)	1.66	1.81	1.54	1.34	1.62
Demersal (high-value)	1.56	1.79	1.54	1.36	1.62
Demersal (low-value)	1.64	1.80	1.54	1.36	1.62
Molluscs	3.75	2.01	1.55	1.12	1.66

*I : Quartile 1- Per capita weekly expenditure < Rs 85
II : Quartile 2- Per capita weekly expenditure Rs 85 - 122
III: Quartile 3- Per capita weekly expenditure Rs 122 - 170
IV: Quartile 4- Per capita weekly expenditure > Rs 170

that when total income increased, people tended to spend more on fish, and relatively less on other types of meat (Kumar and Dey 2004).

The uncompensated and compensated own-price elasticities of various groups of fish species, evaluated at the expenditure quartile-specific mean, are given in Table 5.4. Uncompensated elasticities of demand represented changes in quantity demanded as a result of changes in prices, capturing both price effect and income effect. Compensated elasticities of demand refered to the portion of change in quantity demanded which captured only price effect. The own-price elasticities varied in the range -0.88 for DLV to -1.00 for molluscs. The own price elasticities did not vary across income group, except for demersal groups. Compensated own-price elasticities were almost half in absolute terms as compared to un-compensated elasticities for IMC, reflecting its larger share in total fish food expenditure. The compensated own price elasticity was estimated –0.97 for molluscs, followed by PLV (-0.95), DHV (-0.92), shrimp (-0.88), OFWF (-0.87), PHV (-0.86), DLV

Table 5.4. Own-price elasticity of demand for different groups of fish in India

Fish group	Expenditure Quartile				
	I*	II*	III*	IV*	All
	Uncompensated own-price elasticity				
Indian major carps	-0.99	-0.99	-0.99	-0.99	-0.99
Other fresh water fish	-0.99	-0.99	-0.99	-0.99	-0.99
Prawn/Shrimp	-0.96	-0.99	-0.99	-1.00	-0.99
Pelagic (high-value)	-0.78	-0.98	-0.99	-0.99	-0.99
Pelagic (low value)	-1.04	-1.06	-1.04	-1.05	-1.05
Demersal (high-value)	-0.46	-0.92	-0.96	-0.95	-0.95
Demersal (low-value)	-0.88	-0.93	-0.85	-0.82	-0.88
Molluscs	-1.01	-1.00	-1.00	-0.99	-1.00
	Compensated own-price elasticity				
Indian major carps	-0.36	-0.45	-0.50	-0.60	-0.52
Other fresh water fish	-0.83	-0.84	-0.89	-0.89	-0.87
Prawn/Shrimp	-0.95	-0.93	-0.90	-0.83	-0.88
Pelagic (high-value)	-0.78	-0.91	-0.87	-0.81	-0.86
Pelagic (low-value)	-0.90	-0.97	-0.93	-0.96	-0.95
Demersal (high-value)	-0.46	-0.90	-0.93	-0.92	-0.92
Demersal (low-value)	-0.86	-0.90	-0.84	-0.81	-0.86
Molluscs	-0.99	-0.96	-0.96	-0.97	-0.97

*I : Quartile 1- Per capita weekly expenditure < Rs 85
II : Quartile 2- Per capita weekly expenditure Rs 85 - 122
III: Quartile 3- Per capita weekly expenditure Rs 122 - 170
IV: Quartile 4- Per capita weekly expenditure > Rs 170

(-0.86) and minimum for IMC (-0.52). Fish demand was sensitive to price changes, except IMC.

5.4. Aquaculture Fish Supply and Input Demand

Three output and three variable inputs over the time span of the study were considered. These were output of IMC, OFWF, Shrimp and inputs included: feed measured as crude protein, fertilizer measured as nitrogen, and labour measured as man days. The fish supply and input demand models maintained the homogeneity and symmetry hypotheses. Input demand and fish supply were sensitive to their own prices. The elasticities calculated at mean data values are given in Table 5.5. The own-price elasticity estimates had the expected sign; they were greater than unity for IMC and OFWF and less than unity for prawn/shrimp. The prawn cultivation was capital intensive as compared to other species. The short-run price effect on supply would be sharp and quick for IMC and OFWF as compared to shrimps. IMC price would affect the prawn supply negatively. The cross price elasticity of IMC and prawn was negative and highly elastic (-4.03). The input price had the

Table 5.5. Aquaculture fish supply and input demand elasticities

Item	Fish supply			Input demand		
	Indian major carps	Other fresh water fish	Prawn	Labour	Feed	Fertilizer
Fish price						
Indian major carps	1.560	0.294	-4.032	0.174	0.032	-0.013
Other fresh water fish	0.157	1.716	-0.224	0.254	0.818	0.637
Prawn	-0.645	-0.221	0.727	0.127	0.043	0.171
Input price						
Wage	-0.046	-0.185	-0.210	-0.746	0.047	0.270
Feed price	-0.048	-0.415	-0.417	0.272	-0.872	-0.138
Fertilizer price	0.001	-0.088	-0.113	0.107	-0.009	-1.544
Area in ha	0.731	0.737	0.73	0.717	0.794	0.626

mild effect on IMC supply whereas supply of prawn and other freshwater species would be affected sharply. Since the acreage effect on fish supply was quite high (0.7) for all the species groups, it could be used as an instrument for increasing fish supply to meet the domestic demand and export till new technological breakthrough in fish comes about. The inland fish supply was not sensitive to input prices as the cross input price and fish supply elasticities were highly inelastic, except for feed price in the case of prawn and OFWF. The higher fish price would not attract higher use of inputs. The input demand elasticities with respect to own prices were estimated as -0.75 for labour, -0.87 for feed and -1.54 for fertilizer demand. This way complementarity between labour and material inputs was observed. In India, fish culture was found to be largely practised in village ponds, tanks and cages with low level of input use, lack of good quality fish seed, lack of access of poor farmers to fish nurseries and unorganized system of fish marketing. Fish productivity was quite low. The majority of fish producers belonged to socio-economically backward community. Any improvement in fish production practices through institutional efforts would increase the demand for quality inputs and supply of fish. This would reduce the cost per unit of production and increase the income level and quality of life of these poor households.

5.5. Marine Fish Supply and Input Demand

Six output and two variable inputs over the time span of the study were considered. These were output of PHV, PLV, DHV, DLV, shrimp, and molluscs and inputs, namely fuel and labour. While estimating the normalized quadratic profit function labour was used as the numeraire. The supply system was estimated using the cross-section time series data described earlier. Estimates of the model were obtained using Zellner's generalized least squares with correction for serial correlation and heteroscedasticity in the disturbance term. The elasticities calculated at mean data values are given in the last column of Table 5.6. The own price elasticity of fish supply was highest for shrimp (0.49), followed by DHV (0.45), PLV (0.32), molluscs (0.28), PHV (0.28) and minimum for DLV (0.20). The effect of diesel price on shrimp supply was more negatively pronounced than that on the supply of other species groups. The effect of wage on fish supply was highly inelastic. It is because, the labour input was almost fixed for marine fishing for a given technology. The

Table 5.6 Marine fish supply and input demand elasticity

Fish supply and input demand	Own fish price	Fuel price	Wage	Coast length	Year trend
Fish supply					
Pelagic HV	0.28	-0.06	-0.004	0.44	0.32
Pelagic LV	0.33	-0.24	-0.003	0.31	0.6
Demersal HV	0.45	-0.14	-0.01	0.37	0.03
Demersal LV	0.2	-0.37	0.002	0.53	0.58
Shrimp	0.49	-0.96	0.537	0.37	1.1
Molluscs	0.28	-0.27	0.576	0.71	0.28
Input demand					
Fuel	0.1	-1.1	-0.002	1.08	1.64
Labour	0.01	-0.001	-0.016		

diesel price elasticity of fuel demand was highly elastic (-4.6). The fuel price inflation would hinder the process of modernization from traditional non-mechanized boats to modernized boats.

5.6. Total Factor Productivity (TFP) Growth

The fish input, output and TFP indices for aquaculture farming revealed that the input index had moved 20 points during 1992-1998 with the growth rate of 2.1 per cent per annum. The output index of fish had jumped 45 points with the annual growth rate of 6.1 per cent. The TFP index had moved with the annual growth rate of 4.0 per cent (Figure 5.1). The TFP growth in aquaculture was much higher than the crop sector. The TFP growth rates in the aquaculture sector much above the rate of growth in TFP not only in the Indian and Pakistan crops sector (around 1 per cent) but also in the U.S. post-war agriculture (around 1.5 per cent)(Rosegrant and Evenson 1992). Pond area was probably the most limiting factor in the output growth. Intensification in package of practice would involve either higher use of inputs or a number of other methods and technologies or both. The growth in TFP, was likely to decelerate in the projected period.

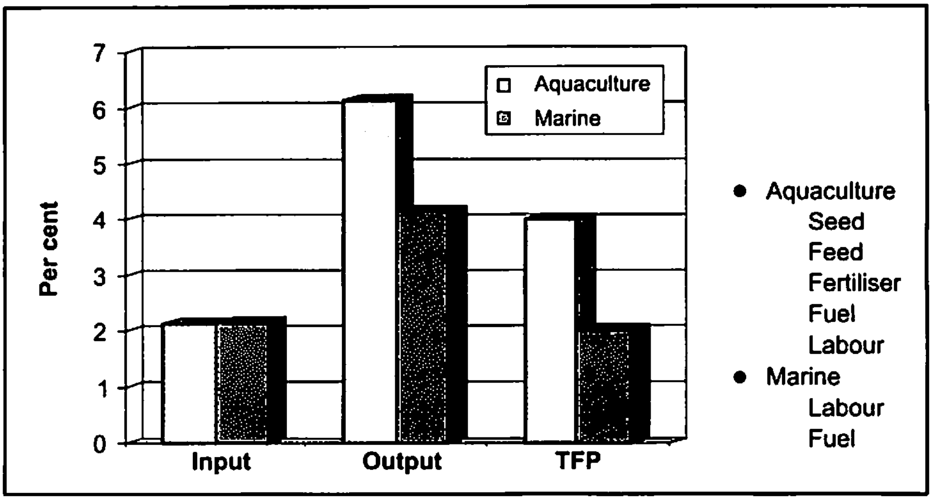

Figure 5.1. Total factor productivity for aquaculture and marine fish in India (1991-98)

Input index for the marine sector had moved 25 points during 1987-1998 with annual growth rate of 2.1 per cent. The fish output index increased from 62 points in 1991 to 83 points in 1998, with the annual growth of 4.1 per cent per year. The TFP growth had moved 47 points with 2.0 per cent annual growth (Figure 5.1). The growth in marine sector was also higher than the TFP growth in the crop sector.

A careful examination of TFP indices showed the decelerating index for both aquaculture and marine sectors. In the light of growing demand, overfishing poses greater environmental threat. Supply remains stagnant and the profitability of capture fisheries declines. This would decelerate the growth of TFP. It would be the likely scenario in the projected period of the capture fish supply.

5.7. The Trade Core

Data on foreign trade are typically available only at the country level. Data by fish types, over an extended time series, may simply not exist for most developing countries. The formulation of the trade core must therefore recognize these data constraints, while modelling trade elasticities in a flexible manner. One such formulation is the Armington approach (Armington 1969), commonly adopted in applied market modelling with trade. In the Armington approach, the foreign and domestic versions of a good are first combined into a foreign-domestic aggregate, which is the object of consumption or production. The foreign and domestic versions are deemed imperfect substitutes. Flexibility is gained by specifying the aggregating equation as a constant elasticity of substitution (CES) function for the demand side, and as constant elasticity of transformation (CET) function for the supply side. Given foreign and domestic prices, imports (exports) can be determined conditional on the total quantity demanded (supplied). In the present fish modelling, the values of CES and CET were assumed as 0.50 and 1.0, respectively for all the exportable species groups (shrimp, PHV, DHV and molluscs).

6

Projections of Fish Supply and Demand

To run the fish model, a *benchmark data set* must be assembled consistent with equilibrium conditions for the endogenous variables. That is, actual data on the endogenous variables of the model for a given base year is assumed to represent the model equilibrium. The benchmark data set would contain, for a given year (TE 1998), information on quantity supplied and demanded by fish type. Furthermore, initial values for exogenous variables, as well as some of the model parameters are *calibrated* for consistency within the benchmark data set. The data and parameters of the model are given in Dey *et al.* (2003). Variables (exogenous) included into the baseline model are:

(i) Trends in technological progress,

(ii) Increases in fixed inputs,

(iii) Changes in the prices of primary and intermediate inputs,

(iv) Growth in per capita income,

(v) Inflation rates for non-fish consumer items,

(vi) Population growth in urban and rural areas,

(vii) Improved marketing efficiency (decline in the price mark-up), and

(viii) World prices on the import and export sides.

When the exogenous shock is introduced, the model in computational form is solved by using model-solving GAMS software. All prices and quantities were determined in live-weight equivalents. The base year solution of the model was replicated with the benchmark data set under various scenarios. Projections over time were generated and examined for studying the implications of exogenous variable trends on fish prices, demand, supply, prices, and trade, producer welfare, and consumer welfare. Under the base line assumption, it was assumed that the growth in the exogenous variables in the projected years would be the same as observed in the past, except per capita income and population growth which have been assumed at 5% and 1.5%, respectively. Given a time horizon (2005 – 2015), projections for supply, demand, export and their prices were generated under the following technological scenarios:

S1 = Base line assumptions with the existing past growth in TFP for marine capture (2%) and aquaculture (4%)

S2 = Base line assumptions with 25 per cent deceleration in TFP growth by the year 2015

S3 = Base line assumptions with 50 per cent deceleration in TFP growth by the year 2015

S4 = Base line assumptions with 75 per cent deceleration in TFP growth by the year 2015

S5 = Base line assumptions without TFP growth during the projected period.

The projected growth of TFP towards 2015 for marine and aquaculture sector was computed under various scenarios and are presented in Figures 6.1 and 6.2.

A comparison between scenarios 1 to 4 and scenario 5 would provide an assessment of the impact of fish technology (measured in term of TFP) on fish

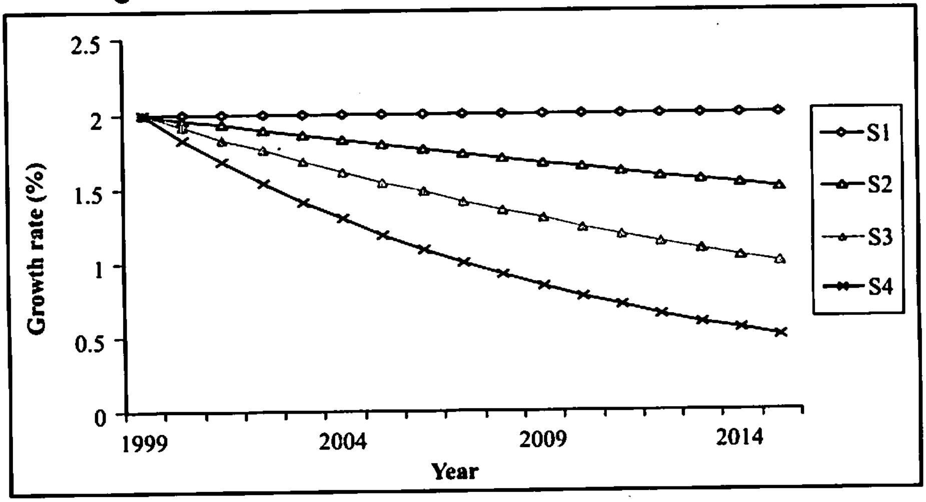

Figure 6.1. Projected TFP growth for marine sector in India

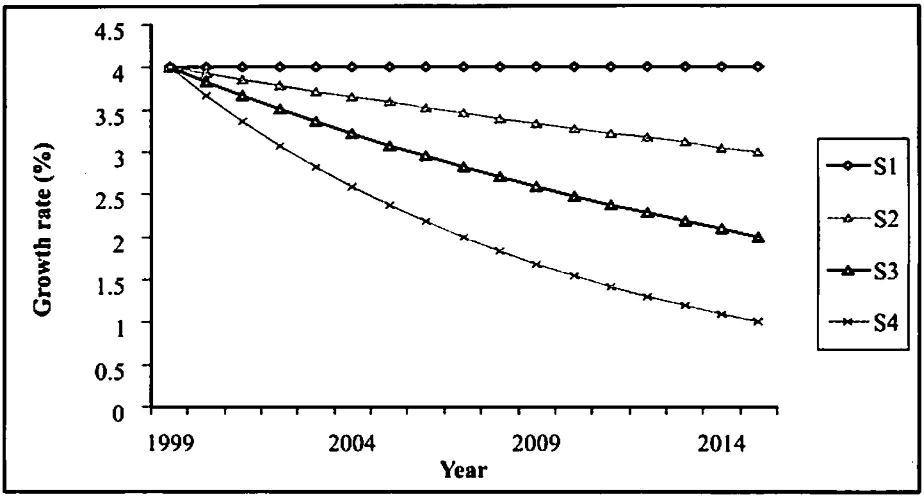

Figure 6.2. Projected TFP growth for inland sector in India

supply, demand, export and prices. The first three scenarios would be the most likely ones and are assumed to prevail in the future, taking into consideration the existing technology in the field and future technologies in the pipeline (for details, *see* the report of the activities 1 to 3 of the present study). The prices, production, demand, trade by species groups were projected up to 2015 under different scenarios and are presented in the subsequent sections.

6.1. Supply Projections of Fish

The projected growth of fish supply during the period 2000-15 is given in Table 6.1. The results revealed that the fish production would grow at the rate of 3.0 per cent corresponding to the baseline scenario (with existing growth in TFP), would decline to 2.2 per cent in scenario 3 (with 50 per cent deceleration in the existing TFP) and would stagnate in the absence of technological growth (scenario 5). The supply would steeply decline with the deceleration of TFP growth. Across the species, the growth in supply varied significantly. It was highest for inland fish (Indian major carps and other freshwater fish), which would range between 2.7 to 3.9 per cent per annum. The supply of shrimp would grow at the faster rate with annual growth of 2.5-3.4 per cent. The supply of marine fish species is projected to grow in the range of 1.4-1.9 per cent per annum during

Table 6.1. Projected growth in fish supply and price, India, 2000-2015

	Scenario 1	Scenario 3	Scenario 5
Supply			
Indian major carps	3.88	2.78	-0.09
Other freshwater fish	3.81	2.71	-0.18
Shrimp	3.40	2.51	0.18
Pelagic high-value	1.95	1.40	-0.05
Pelagic high-value	1.95	1.40	-0.05
Demersal high-value	1.92	1.36	-0.09
Demersal low-value	1.99	1.43	-0.01
Molluscs	1.98	1.42	-0.03
All	3.04	2.17	-0.06
Producer Price			
Indian major carps	-2.85	-1.80	1.03
Other freshwater fish	-2.72	-1.67	1.17
Shrimp	2.07	2.62	4.10
Pelagic high-value	-0.06	0.39	1.60
Pelagic high-value	-0.76	-0.22	1.21
Demersal high-value	1.61	1.99	2.99
Demersal low-value	-1.31	-0.75	0.73
Molluscs	1.66	2.09	3.24
All	-0.33	0.38	2.24

Scenario 1: Baseline TFP growth
Scenario 3: 50 per cent deceleration in TFP growth by 2015
Scenario 5: Without TFP growth

2000-15, except shrimp. The scenario 5 revealed that the fish production would stagnate if the technological growth does not take place in future. To maintain the supply at the desired level, there is a need to put concerted efforts for improving the efficiency of fish production and catches and enhancement of the growth of TFP through appropriate policies of research and development, extension, etc.

The rise in supply growth and shift in supply curve towards right had not declined the price for all the species. The mixed effects were observed on the real prices. For the species that were not entering in the export market, the prices would decline with the increase in supply. These species were IMC, OFWF from inland source of fish where prices of these species would decline in the projected period with the growth rate of 1.7-2.8 per cent per annum. Among the marine species which were of low value, fish price would decline less than –0.76 per cent per annum for PLV and –0.75 to –1.31 percent for DLV. The price of export-oriented fish species would continue to rise with the increase of their supply. The higher growth in fish supply for the species used in the domestic market would benefit the common man, as this fish species would be available at cheaper price in future. The fish species, which are export-oriented, the rise in supply would not cut down the price in the domestic market substantially, and the price would keep rising and would benefit the production. The price of shrimp, which was the most important exportable fish, would rise from 2.1 per cent to 2.6 per cent annually. Other exportable fish species were: PHV, DHV and Molluscs for which also the price would rise from 1.6 per cent to 2 per cent. But taking all the species together, the impact of positive supply growth on fish prices would be mild only, 0.33 in Scenario 1 and 0.38 in Scenario 3.

Under the base line scenario, with the increase in fish supply (as projected in various scenarios), the producer prices in the domestic market would decline at an annual rate of 2.9 per cent for IMC, 2.7 per cent for OFWF, 1.3 per cent for DLV, 0.8 for PLV (Figure 6.3). These are the species meant mostly for the domestic market. Shrimp, PHV, DHV and molluscs (high-value) are important exportable species. A part of their output is retained for domestic consumption also. Their prices in the domestic market are unlikely to decline even after the increase in their supply. Rather their prices may increase, the rate of increase is projected to be 2.1 per cent for shrimp, 1.6 per cent for DHV and 1.7 per cent for molluscs. Prices of PHV group are likely to remain unchanged. Exports would help producers stabilize fish prices in the domestic market (at the aggregate level). Taking all the species together, the fish prices would move in a very narrow band with an annual growth ranging from –0.3 to 0.4 per cent at constant prices.

Based on the projected growth rate, the supply of fish has been projected under various scenarios using TE 1998 as the base year supply (Table 6.2). The

[2] The projected production was arrived at after subtracting the projected import from the supply projection.

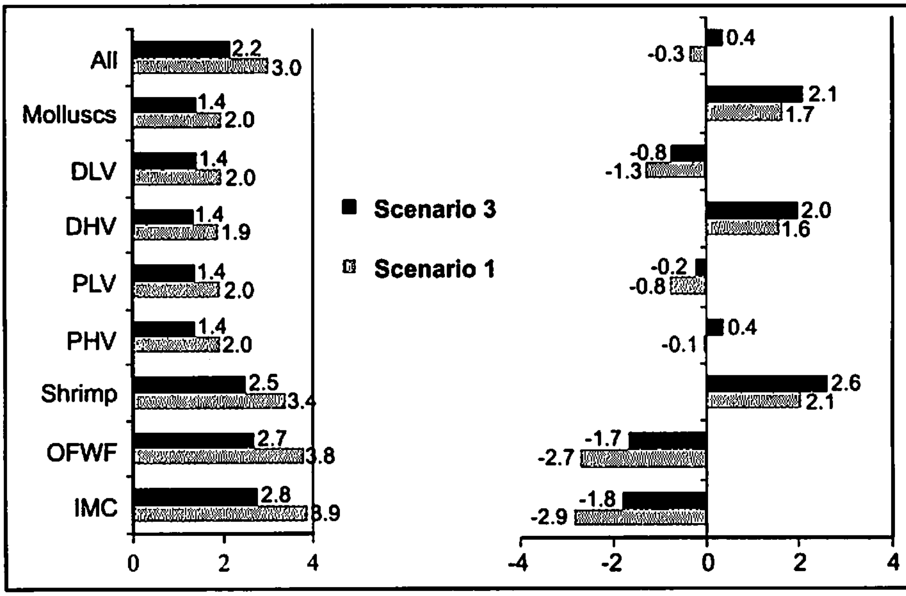

Figure 6.3. Projection growth (%) in fish supply and price 2000-2015 in India

scenarios 1, 2 and 3 are the most likely scenario to prevail in future, these have assumed that the maximum decline in TFP growth of fish production would be 50 per cent in the year 2015. Under the most optimistic scenario (S_1), the production of fish[2] would be 6.67 million tonnes in 2005 and will grow to 9.04 million tonnes in 2015. Considering the other scenarios, the fish production has been projected to be 8.4 million tonnes under scenario 2, 7.8 million tonnes in scenario 3, and 7.1 million tonnes under scenario 4. For the scenario without TFP growth, the production would be stagnant almost at the current level. The import of fish would be quite marginal and may not vary in the projected years. A perusal of Table 6.3 reveals that the annual production of inland fish in the year 2005 would be in the range of 3.6-3.7 million tonnes, and would reach 4.6-5.5 million tonnes by 2015, with an annual growth rate of 2.9-4.0 per cent under different scenarios. The share of inland fish in total fish production, which was about 50 per cent in the year 2000, would increase to 61 per cent by 2015. The production of marine fish has been projected as 2.9-3.0 million tonnes in 2005, and 3.2-3.6 million tonnes in 2015. The fish production would grow at the annual rates of 2.9-4.0 per cent for inland and 1.2-1.8 per cent for marine fishes. The

Table 6.2. Projected supply, import and production of fish, India

(million kg)

Year	Scenario 1*	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Supply					
1998(base)	5481.6	5481.6	5481.6	5481.6	5481.6
2005	6741.8	6669.0	6576.3	6441.2	5460.1
2010	7833.7	7575.0	7275.5	6893.9	5445.0
2015	9119.4	8519.5	7894.1	7199.4	5430.1
Import					
1998(base)	70.7	70.7	70.7	70.7	70.7
2005	75.6	75.4	75.1	74.7	71.6
2010	79.3	78.7	77.9	76.8	72.3
2015	83.3	81.9	80.3	78.5	73.0
Production					
1998(base)	5410.9	5410.9	5410.9	5410.9	5410.9
2005	6666.3	6593.6	6501.2	6366.5	5388.5
2010	7754.4	7496.3	7197.6	6817.1	5372.7
2015	9036.1	8437.6	7813.8	7121.0	5357.1

*Scenario 1: Baseline TFP growth
Scenario 2: 25 per cent deceleration in TFP growth by 2015
Scenario 3: 50 per cent deceleration in TFP growth by 2015
Scenario 4: 75 per cent deceleration in TFP growth by 2015
Scenario 5: Without TFP growth

share of marine fish in the total fish production would decline from 50 per cent (in 2000) to about 40 percent by 2015.

The supply of IMC, which contributed 25 per cent to the total supply, has been projected to be 1.79 -1.85 Mt by 2005, 2.04 - 2.24 Mt by 2010 and 2.26 - 2.71 Mt by 2015. The supply of other categories by 2015 has been projected as 1.6 - 1.8 million Mt for pelagic fish, 0.7- 0.8 Mt for demersal fish and 0.6-0.7 Mt for mollusks, etc. The changes in the share of different species in total production during the period 2000-2015 have been depicted in Figure 6.4.

The share of IMC in total fish production would increase to 30 per cent by 2015 from 25 per cent in 2000 and of OFWF to 22 per cent from 19 per cent. The

Table 6.3. Projected growth and supply of fish by source

	Inland		Marine	
	Scenario 1	Scenario 3	Scenario 1	Scenario 3
Annual growth % during 2000-2015	4.0	2.9	1.8	1.2
Supply of fish (million kg)				
2000	3082	3077	2732	2729
2005	3749	3636	2993	2942
2010	4562	4164	3272	3111
2015	5554	4657	3566	3238
Share of inland and marine fish in total production, %				
2000	53	53	47	47
2005	56	55	43	45
2010	58	57	42	43
2015	61	59	39	41

Scenario 1: Baseline TFP growth
Scenario 3: 50 per cent deceleration in TFP growth by 2015

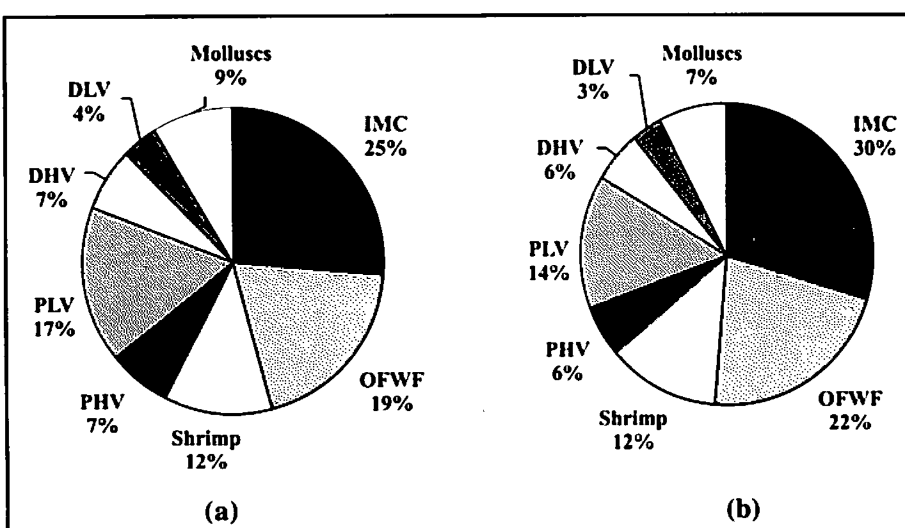

Figure 6.4. Changes in the share of different species of fish in total population (a) 2000, and (b) 2015

share of shrimp, however, is likely to remain almost unchanged. The shares of pelagic, demersal, and molluscs have been projected to decline during this period.

By thé year 2015, the incremental production has been projected to be 3.3 million tonnes (Figure 6.5). In this additional production, IMC would contribute maximum (36 per cent) followed by OFWF (26 per cent), pelagic (14 per cent), shrimp (13 per cent), demersal (6 per cent) and molluscs (5 per cent).

A comparison of scenarios 1 and 5 provided the effect of TFP growth on fish supply (Table 6.4). The production of fish would decline substantially with the deceleration in fish technological growth. The contribution of TFP to fish production has been projected as 1.3 Mt in 2005, 2.4 Mt in 2010 and 3.7 Mt in 2015. In percentage terms, its contribution in total production would be 19 per cent in 2005, and 41 per cent in 2015. The contribution of TFP has been projected the highest (48 per cent) in the inland fish sector by 2015. The technological change (measured in terms of TFP) would contribute about 29 per cent to the total marine fish production, except shrimp, by 2015. In the case of shrimp, it would be about 20 per cent by 2005 and 42 per cent by 2015.

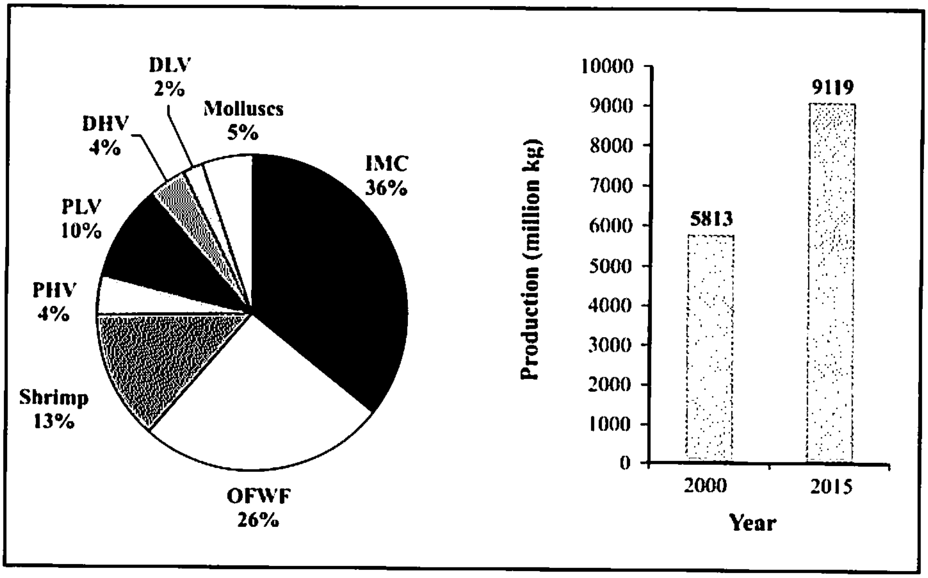

Figure 6.5. Share of different species in their incremental production by 2015

Table 6.4. Projected production of fish by species and TFP contribution, India

Year	Production (million kg)			TFP contribution	
	Scenario 1	Scenario 3	Scenario 5	Quantity (million kg)	Per-centage
Indian major carp					
2005	1851.7	1793.6	1409.2	442.5	23.9
2010	2240.2	2039.7	1402.7	837.5	37.4
2015	2710.3	2260.9	1396.2	1314.0	48.5
Other freshwater fish					
2005	1360.6	1317.8	1034.3	326.3	24.0
2010	1640.3	1493.0	1025.1	615.2	37.5
2015	1977.5	1648.4	1016.0	961.5	48.6
Shrimp (marine and freshwater)					
2005	808.2	787.6	647.8	160.4	19.8
2010	955.2	885.1	653.7	301.4	31.6
2015	1128.8	974.3	659.7	469.1	41.6
Pelagic high-value					
2005	428.4	421.5	372.9	55.5	13.0
2010	471.9	449.8	372.0	99.9	21.2
2015	519.9	473.8	371.1	148.7	28.6
Pelagic low-value					
2005	1066.5	1049.3	928.4	138.0	12.9
2010	1174.8	1119.8	926.3	248.5	21.1
2015	1294.0	1179.7	924.2	369.9	28.6
Demersal high-value					
2005	419.9	413.1	365.4	54.5	13.0
2010	461.7	440.1	363.8	97.9	21.2
2015	507.7	462.7	362.3	145.4	28.6
Demersal low-value					
2005	248.2	244.2	216.0	32.1	12.9
2010	273.8	261.0	215.9	57.9	21.2
2015	302.1	275.4	215.8	86.4	28.6
Molluscs and others					
2005	558.4	549.4	486.0	72.4	13.0
2010	615.8	587.0	485.4	130.4	21.2
2015	679.1	619.0	484.8	194.3	28.6
All fish categories					
2005	6666.3	6501.2	5388.5	1277.8	19.2
2010	7754.4	7197.6	5372.7	2381.7	30.7
2015	9036.1	7813.8	5357.1	3679	40.7

Scenario 1: Baseline TFP growth; Scenario 3: 50 per cent deceleration in TFP growth by 2015
Scenario 5: Without TFP growth

6.2. Demand Projections of Fish

The increase in supply will make the availability of fish to the consumers at a cheaper price, which would increase the fish consumption in the food basket. The demand of fish would grow at the rate of 1.6-2.4 per cent per annum (Table 6.5 and Figure 6.6).

The domestic demand for fish under the baseline scenario is likely to grow at an annual rate of 2.4 per cent during the period 2000-2015. Highest growth in

Table 6.5. Projected growth in fish demand and price, India, 2000-2015

(in per cent)

	Scenario 1	Scenario 3	Scenario 5
Demand			
Indian major carps	3.88	2.78	-0.09
Other freshwater fish	3.81	2.71	-0.18
Shrimp	-1.07	-1.61	-3.05
Pelagic high-value	1.07	0.62	-0.56
Pelagic high-value	1.95	1.40	-0.05
Demersal high-value	-0.86	-1.21	-2.12
Demersal low-value	1.99	1.43	-0.01
Molluscs	-0.72	-1.02	-1.82
All	2.40	1.55	-0.60
Consumer Price			
Indian major carps	-2.85	-1.80	1.03
Other freshwater fish	-2.72	-1.67	1.17
Shrimp	2.07	2.62	4.10
Pelagic high-value	-0.06	0.39	1.60
Pelagic high-value	-0.76	-0.22	1.21
Demersal high-value	1.61	1.99	2.99
Demersal low-value	-1.31	-0.75	0.73
Molluscs	1.66	2.09	3.24
All	-0.33	0.38	2.24

Scenario 1: Baseline TFP growth
Scenario 3: 50 per cent deceleration in TFP growth by 2015
Scenario 5: Without TFP growth

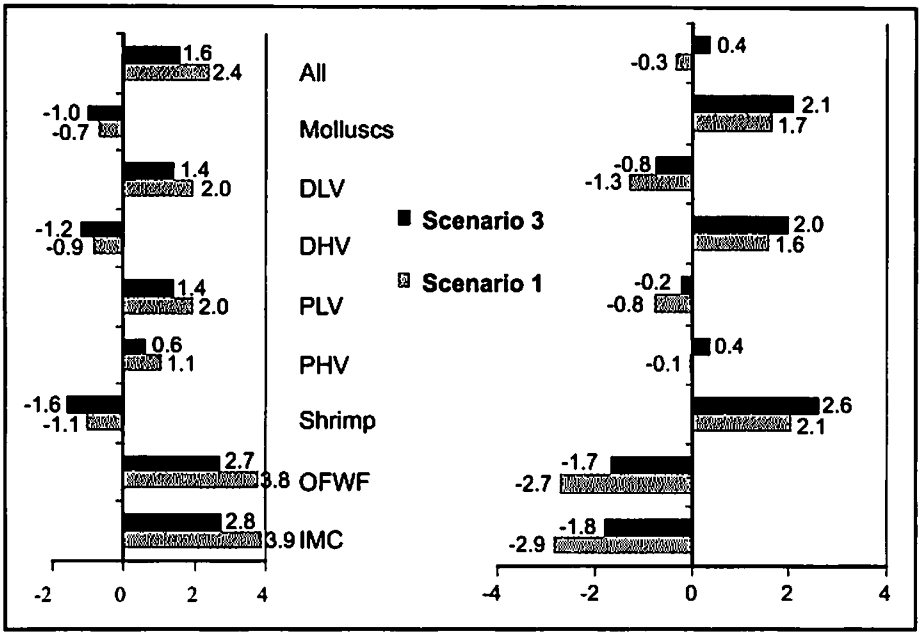

Figure 6.6. Projected growth in fish demand and price during 2000 - 2015, India

demand has been projected for IMC (3.9 per cent), followed by OFWF (3.8), pelagic low-value and demersal low-value (2.0 per cent each). Declining consumer prices have been found as the major drivers of demand growth. However, domestic demand for various species meant for international market is likely to decline due to increase in their prices. Between 2000 and 2015, the consumer demand has been projected to decline at an annual rate of 1.1 per cent for shrimp, followed by DHV (-0.9 per cent) and molluscs (-0.7 per cent).

The domestic demand of fish would be in the range of 5.9 – 6.0 Mt by 2005 and 6.7-7.7 Mt by 2015 (Tables 6.6 and 6.7).

Under the baseline scenario, consumption of fish has been projected to increase from 5.2 Mt in 1998 to 6.0 Mt in 2005 and 7.7 Mt by 2015. Out of this, home consumption would be about 66 per cent. The annual per capita consumption at national level has been projected to be 5.6 kg in 2005 and 6.2 kg by 2015. With about 35 per cent of Indian population eating fish, the annual per capita

Table 6.6. Projected fish domestic demand in India: 2005-2015

(million kg)

Year	Total demand			Household demand	Home away demand
	Scenario 1	Scenario 3	Scenario 5		
Demand					
1998 (base)	5174	5174	5174	3350	1824
2005	6040	5899	4945	3911	2129
2010	6813	6342	4801	4411	2402
2015	7741	6719	4671	5012	2729
Annual per capita demand (kg) at the national level					
2005	5.6	5.3	4.6	3.6	2.0
2010	5.8	5.3	4.1	3.8	2.1
2015	6.2	5.4	3.7	4.0	2.2
Annual per capita demand (kg) for the fish eating population					
2005	15.1	14.6	12.3	9.8	5.3
2010	15.8	14.7	11.1	10.2	5.5
2015	16.7	14.5	10.1	10.8	5.9

Scenario 1: With existing growth in TFP
Scenario 3: 50 per cent deceleration in existing TFP growth
Scenario 5: Without growth in TFP

consumption of fish eating population would be about 15 kg in 2005, and 16.7 kg by 2015. In-home annual per consumption would increase from 9.8 kg by 2005 to 10.8 kg by 2015. Similarly, per capita annual home away demand would increase from 5.3 kg by 2005 to 5.9 kg by 2015.

These estimates are consistent with the estimates of NSS survey for the year 1999-2000, which are 3.45 kg/capita at the national level and 9.8 kg/capita for the fish eating households.

The IMC would continue to consolidate its share in total domestic fish consumption, as is evident from Figure 6.7, with its share becoming 34 per cent by 2015 from 27 per cent (in 2000). By 2015, the inland fish species would contribute more than 60 per cent to the total demand. The share of shrimp in the total demand would decline from 10 per cent (in 2000) to 6 per cent by 2015.

Table 6.7. Projected demand of fish by species, India

(million kg)

Year	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Indian major carps					
1998(base)	1418	1418	1418	1418	1418
2005	1852	1826	1794	1746	1409
2010	2240	2147	2040	1904	1403
2015	2710	2489	2261	2011	1396
Other freshwater fish					
1998(base)	1047	1047	1047	1047	1047
2005	1361	1342	1318	1283	1034
2010	1640	1572	1493	1393	1025
2015	1978	1815	1648	1466	1016
Shrimp (marine and freshwater)					
1998(base)	532	532	532	532	532
2005	494	490	486	479	429
2010	468	458	446	430	367
2015	443	424	404	380	315
Pelagic high-value					
1998(base)	349	349	349	349	349
2005	376	374	371	367	336
2010	397	390	381	371	326
2015	418	404	388	369	317
Pelagic low-value					
1998(base)	931	931	931	931	931
2005	1066	1059	1049	1035	928
2010	1175	1150	1120	1081	926
2015	1294	1239	1180	1112	924
Demersal high-value					
1998(base)	259	259	259	259	259
2005	244	243	241	239	223
2010	234	230	226	221	200
2015	224	217	211	203	180
Demersal low-value					
1998(base)	216	216	216	216	216
2005	248	246	244	241	216
2010	274	268	261	252	216
2015	302	289	275	259	216

Contd.

Table 6.7. Projected demand of fish by species, India — *Contd*

(million kg)

Year	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Molluscs and others					
1998(base)	420	420	420	420	420
2005	399	398	396	393	369
2010	385	381	375	368	337
2015	372	363	353	341	307
Total fish					
1998(base)	5174	5174	5174	5174	5174
2005	6040	5978	5899	5783	4945
2010	6812	6594	6342	6021	4801
2015	7741	7240	6719	6141	4671

Scenario 1: Baseline TFP growth
Scenario 2: 25 per cent deceleration in TFP growth by 2015
Scenario 3: 50 per cent deceleration in TFP growth by 2015
Scenario 4: 75 per cent deceleration in TFP growth by 2015
Scenario 5: Without TFP growth

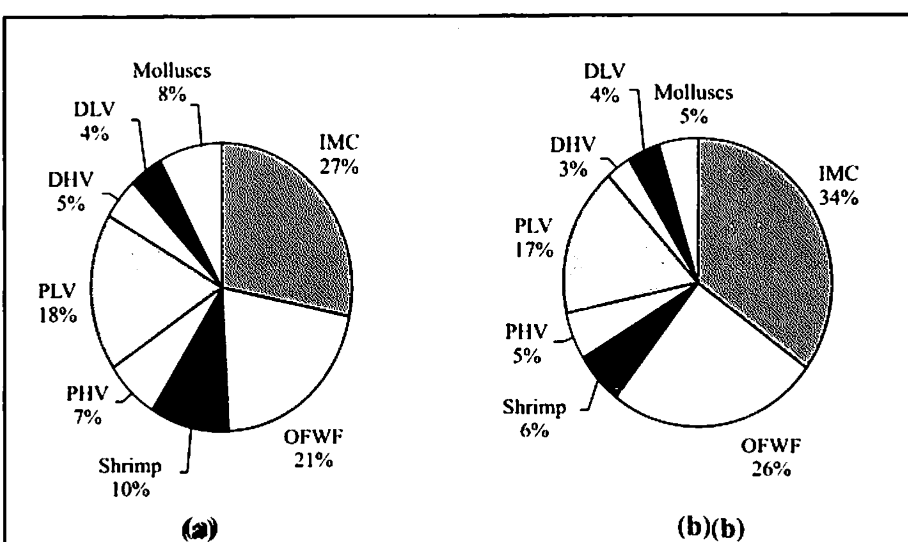

Figure 6.7. Changes in share of species in total fish demand, India (a) 2000, and (b) 2015

The marine fish species would contribute about one-third to the total demand by 2015.

Under the baseline scenario, the additional fish demand during the period 2000 to 2015 would be about 2.3 Mt (Figure 6.8). Of this, 50 per cent would be met from IMC, followed by OFWF (36 per cent), pelagic (14 per cent) and demersal (3 per cent). The consumption of shrimp, DHV and molluscs species would decline by 9 per cent.

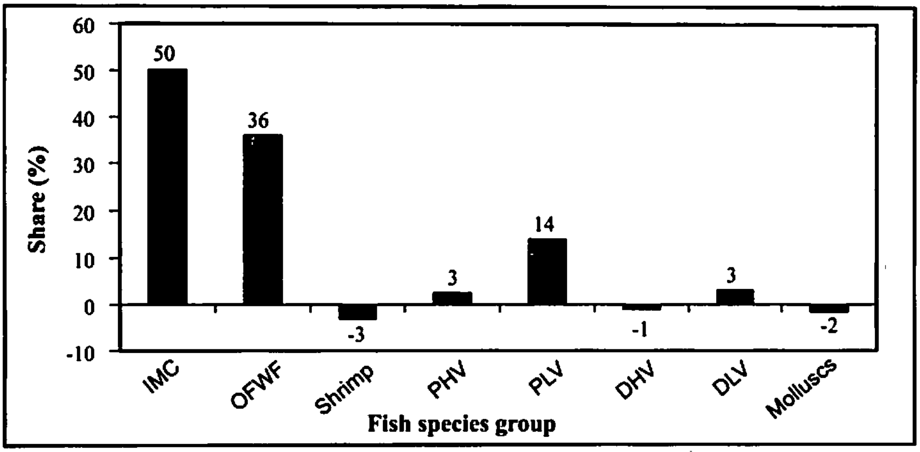

Figure 6.8. Share of fish species in additional demand by 2015

6.3. Export of Fish

Shrimp, PHV, DHV and molluscs are the major species of fish that are being exported from India. The export of these species has been projected to grow at a rate of 4.6-5.5 per cent per annum (Table 6.8 and Figure 6.9), with the highest value for shrimp (5.8–6.9 per cent), followed by pelagic (4.4-5.4 per cent), demersal (3.8-4.6 per cent) and molluscs (3.5-4.3 per cent). The export price would also increase at the annual growth rate of 6.1- 6.5 per cent per annum at constant prices. The higher export price will benefit the fish producers substantially. The export would affect the domestic price of these species at higher level, safeguarding the interest of producers. The technological development in the fish sector with export-orientation would induce higher fish production, demand and export, and would stabilize the domestic market. The

Table 6.8. Projected export of fish from India, 2000-2015

	Scenario 1	Scenario 3	Scenario 5
Export growth (%)			
Shrimp	6.94	5.79	2.77
Pelagic high-value	5.36	4.42	1.96
Demersal high-value	4.55	3.80	1.85
Molluscs	4.23	3.47	1.49
All	5.49	4.55	2.12
Export Price growth (%)			
Shrimp	6.68	6.92	7.56
Pelagic high-value	0.81	1.17	2.13
Demersal high-value	4.46	4.64	5.12
Molluscs	4.42	4.61	5.13
All	6.08	6.47	7.29
Export ('000 kg)			
1998(base)	307.9	307.9	307.9
2005	445.5	433.9	356.3
2010	582.3	538.5	395.7
2015	763.5	655.6	439.9

Scenario 1: Baseline TFP growth
Scenario 3: 50 per cent deceleration in TFP growth by 2015
Scenario 5: Without TFP growth

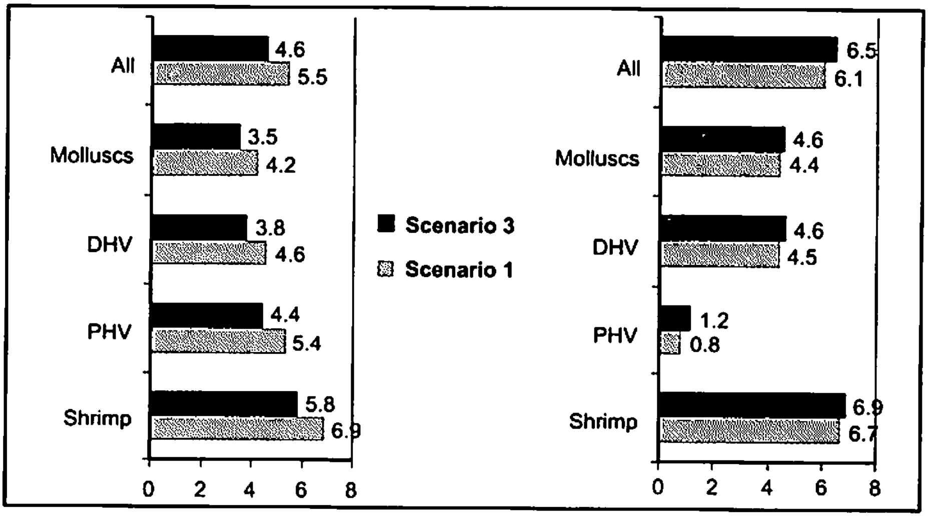

Figure 6.9. Projected growth in fish export and prices during 2000 - 2015, India

benefit of the technological development in the fish sector will be transmitted substantially to both the producer and the consumer.

The fish export was 0.31 Mt in the year 1998 (base year). Under the baseline scenario, the export of fish has been projected to grow at an annual rate of 5.5 per cent during the period 2000 and 2015 and the exports would increase to 0.45 Mt in 2005 and 0.76 Mt by 2015. The export price is likely to increase at an annual rate of 6.1 per cent during this period. Under the baseline scenario,

Table 6.9. Export projection of fish by species, India

(million kg)

Year	Shrimp*	Pelagic high value	Demersal high value	Molluscs & others	Total
Exports in base year					
1998	107.41	25.05	108.56	66.84	307.86
Scenario 1: With existing growth in TFP					
2005	171.82	36.11	148.24	89.31	445.48
2010	240.34	46.90	185.18	109.84	582.26
2015	336.18	60.90	231.33	135.10	763.50
Scenario 2: 25 per cent deceleration in existing TFP growth					
2005	169.39	35.69	146.85	88.46	440.39
2010	230.11	45.24	179.94	106.67	561.96
2015	308.13	56.66	218.40	127.40	710.59
Scenario 3: 50 per cent deceleration in existing TFP growth					
2005	166.32	35.15	145.08	87.37	433.93
2010	218.38	43.32	173.83	102.99	538.53
2015	279.33	52.25	204.72	119.28	655.58
Scenario 4: 75 per cent deceleration in existing TFP growth					
2005	161.85	34.37	142.50	85.79	424.51
2010	203.58	40.88	165.98	98.25	508.69
2015	247.87	47.34	189.25	110.12	594.58
Scenario 5: Without growth in TFP					
2005	130.02	28.70	123.43	74.11	356.26
2010	149.04	31.63	135.28	79.79	395.73
2015	170.83	34.86	148.27	85.89	439.85

*Both marine and freshwater

shrimp exports would witness the highest annual growth (6.9 per cent), followed by PHV (5.4 per cent), DHV (4.6 per cent) and molluscs (4.2 per cent). The export price of each species has been predicted to keep on increasing. A steep rise has been predicted in the price of shrimp, whose exports would also increase at a much faster rate, compared to other species. The export projections by species under various scenarios are given in Table 6.9.

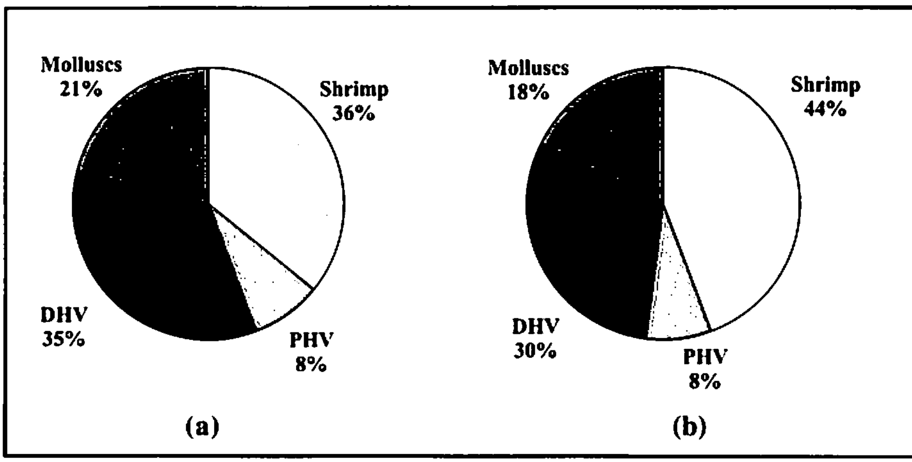

Figure 6.10. Changes in share of fish export, India (a) 2000, and (b) 2015

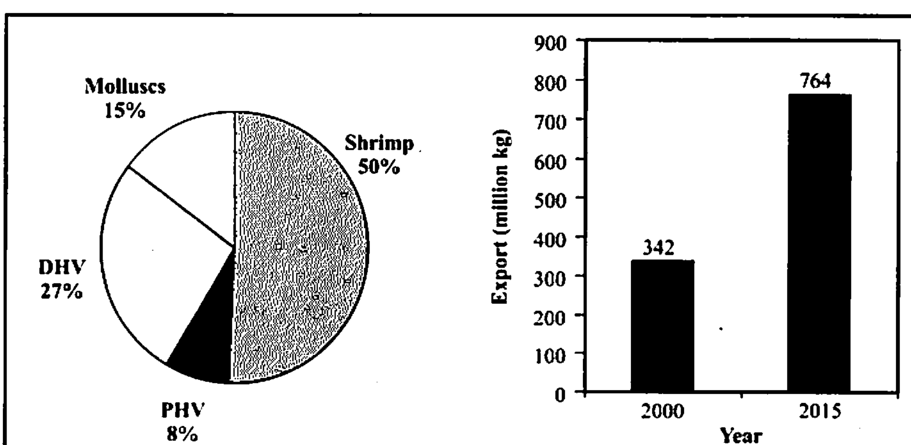

Figure 6.11. Fish species contribution in incremental export during 2000-2015, India

The shrimp exportable species, generating two-thirds of the total export value in the past would continue to hold the major share in future also. Its share in total export has been projected to increase from 36 per cent in 2000 to 44 per cent by 2015 (Figure 6.10). The share of other species in the export market would witness a declining trend. The next important exportable species is the demersal fish whose share has been projected to be 30 per cent by 2015, followed by molluscs (18 per cent) and pelagic (8 per cent). India is likely to increase its fish exports by 0.42 Mt that is up by nearly 123 per cent during the next 15 years, by 2015. To this, the shrimp contribution has been projected to be nearly half (Figure 6.11).

7

Potential Impact of Various Technologies and Policy Options

The socio-economic impact of fish technology on consumers and producers of fish was examined by comparing Scenarios 1 to 3 with Scenario 5 (without TFP growth). The salient features are presented below:

7.1. Impact on Fish Consumers

The consumers are likely to be benefited due to lowering of prices, which have been projected to decline by 17-20 per cent by 2005, and 28-36 per cent by 2015 in comparison to the prices they would have paid if there would have been no growth in TFP (Table 7.1).

The technology-driven decline in consumer prices would induce growth in the fish consumption, which would increase in the range of 17-22 per cent by 2005 and 31- 66 per cent by 2015, compared to no TFP growth scenario. With the technological progress, per capita annual fish consumption of the fish eating households would increase by 2.4-2.7 kg in 2005 and 4.4 - 6.6 kg by 2015. As a result of technological progress in fish production, the annual income gain for

Table 7.1. Impact of fish technology on consumer, India

Year	Price (%)		Per capita additional fish consumption (kg/year)		Per capita gain (Rs/year)	
	S1	S3	S1	S3	S1	S3
2005	-20	-17	2.7	2.4	99	86
2010	-36	-28	4.7	3.6	181	138
2015	-54	-37	6.6	4.4	274	183

Scenario 1: With existing growth in TFP
Scenario 3: 50 per cent deceleration in existing TFP growth

fish consumers (as a result of price effect) is expected to be in the range of Rs 86 to Rs 99 per person in 2005, and Rs 184 to Rs 274 per person in 2015. At the national level, these gains are huge. The consumer gains projected under the baseline scenario would be Rs 40 billion in 2005, and Rs 127 billion by 2015 (Table 7.2).

The consumers will derive maximum benefit from the IMC, followed by OFWF and shrimp. Inland fish would contribute more than 70 per cent to the total gains. The contribution of shrimp has been projected to be 13 to 14 per cent.

Table 7.2. Impact of fish technology on social gains, India

(in billion Rs)

Year	Consumer gains		Producer gains		Total social gains	
	S1	S3	S1	S3	S1	S3
2005	39.8	34.6	20.5	17.9	60.3	52.5
2010	78.1	59.8	61.3	47.1	139.4	107.0
2015	127.1	84.9	152.3	102.2	279.4	187.3

Scenario 1: With existing growth in TFP
Scenario 3: 50 per cent deceleration in existing TFP growth

7.2. Impact on Fish Producer

Technological progress would add 17 to 19 per cent to the total fish output by 2005, and 31-40 per cent by 2015 (Table 7.3). Nevertheless, producer prices of the exportable fish are likely to remain stable, and fish exports would increase by 17-20 per cent by 2005 and 33-42 per cent by 2015. Addition to output due to technological change would dampen down the producer prices in the domestic market to the tune of 17-20 per cent by 2005 and 37-54 percent by 2015 (Table 7.4). Technology-driven reduction in producer prices in the domestic market would adversely affect farm profitability. At the aggregate level, the producer would incur losses in the range of Rs. 0.17 to 0.19 billion in 2005 and Rs. 0.39 to 0.53 billion in 2015. However, the producers would gain from fish exports to the tune of Rs 18–21 billion in 2005 and Rs 103–152 billion in 2015. Thus, taking domestic and export markets together, the fish producer would be benefited

Table 7.3. Impact of fish technology on additional fish availability in domestic and export market of India

(in per cent)

Year	Domestic		Export market	
	S1	S3	S1	S3
2000	5.8	5.7	6.1	6.0
2005	19.0	17.0	20.0	17.9
2010	30.5	25.2	32.0	26.5
2015	40.4	31.2	42.4	32.9

Scenario 1: With existing growth in TFP
Scenario 3: 50 per cent deceleration in existing TFP growth

Table 7.4. Impact of fish technology on producer fish price from domestic and export market of India

(in per cent)

Year	Domestic market		Export market	
	S1	S3	S1	S3
2000	-5.4	-5.3	-0.7	-0.7
2005	-19.9	-17.4	-2.0	-2.2
2010	-36.1	-27.9	-3.6	-2.8
2015	-54.1	-36.7	-4.9	-3.5

Scenario 1: With existing growth in TFP
Scenario 3: 50 per cent deceleration in existing TFP growth

substantially with the adoption of fish technology (Table 7.5). Shrimp's contribution to the producer's income would be about 85 per cent in the projected period under the baseline scenario.

Under the baseline scenario, in 2015, the gains of fish producers would be Rs 152 billion, of consumers, Rs 127 billion, and the total social gains would be Rs 279 billion. The producers' share in total gain would increase to 54 per cent in 2015 from 25 per cent in 2000. Initially, the consumers would benefit more than the producers. However, with the adoption of modern technology and

Table 7.5. Impact of fish technology on producer income, India

(in billion Rs)

Year	Domestic market		Export market		Total income	
	S1	S3	S1	S3	S1	S3
2005	-0.19	-0.17	20.7	18.1	20.5	17.9
2010	-0.35	-0.28	61.7	47.4	61.3	47.1
2015	-0.53	-0.39	152.9	102.8	152.3	102.4

Scenario 1: With existing growth in TFP

Scenario 3: 50 per cent deceleration in existing TFP growth

sound support of export market, the share of producers in total social gains would become higher than that of consumers. At the national level, technological progress in the fish sector would enhance per capita national income by Rs 56 in 2005, and by Rs. 223 in 2015. The consumer would be benefited much more from the cultivation of fresh water fish (IMC, OFWF) whereas from shrimp and marine fishes, the producer would derive much higher benefits than the consumer (Figure 7.1).

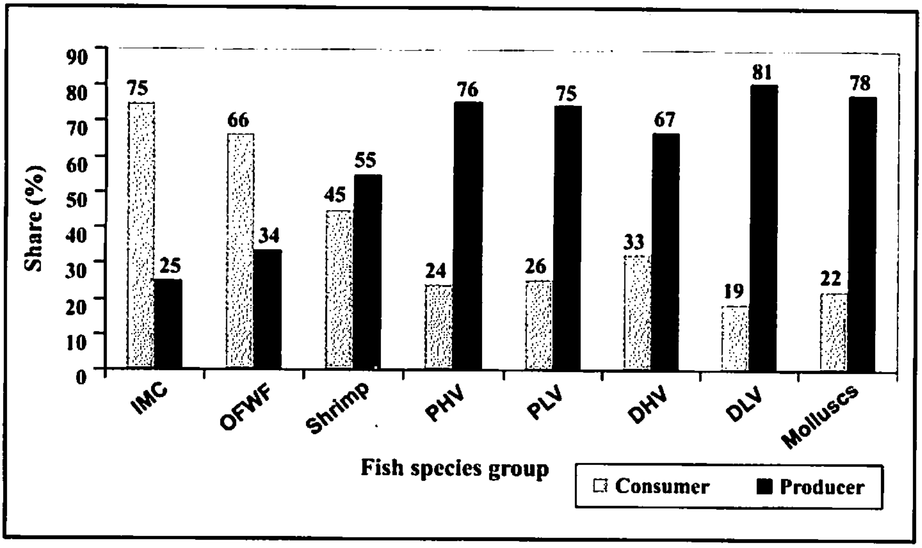

Figure 7.1. Distribution of total surplus between producer and consumer by species, India

7.3. Impact on Fishermen

The head count ratio of the fishermen below the poverty line was 32 per cent in 1999, much higher than the national average of 26 per cent. The fishermen were found to be highly deficit in calories and protein (Table 7.6). Fish technological development can help the fishermen in improving their income and social economic status and quality of life.

As is evident from Table 7.7, with the adoption of modern fish technologies, the annual income of the fisherman (at 1998 prices) would increase in the range of Rs 283 to 325 per person in 2005, and Rs 996-1480 in 2015. The annual income per fish worker would increase in the range of Rs 727 to 835 in 2005 and Rs 2615-Rs 3889 in the year 2015. Thus, the income of fish worker will increase substantially with the adoption of modern fish technology.

Table 7.6. Household poverty and nutrition status of the fishermen in India

(Percent)

Fishermen population	Year 1983	Year 1999
Below poverty line	57.5	31.8
Calorie deficit	44.6	37.7
Protein deficit	42.1	41.4

Table 7.7. Impact of fish technology on annual income, India

(Rs)

Year	Scenario	Per fish eater consumer	Per fishermen	Per fish worker	Per capita at national level
2005	S1	99	325	835	56
	S3	86	283	727	48
2010	S1	181	760	1975	119
	S3	138	585	1519	92
2015	S1	274	1480	3889	223
	S3	183	996	2615	150

Scenario 1: With existing growth in TFP

Scenario 3: 50 per cent deceleration in existing TFP growth

7.4. Returns from Investment on Fish Research and Development

The internal rate of return from investments on fish research and development would be in the range of 42 to 55 per cent under different TFP scenarios. The benefit-cost ratio would vary between 2.1 and 3.4. The net present value (NPV) is estimated to be in the range of Rs. 82 to 176 billion under various TFP growth scenarios (Table 7.8). The gains of technology will be shared as 60 per cent by upper income group and 40 percent by the poor; among poor, 12 per cent will go to the persons below the poverty line.

Table 7.8. Returns to investment from fish technology in India

	Baseline scenario (existing TFP growth)	Deceleration in TFP by 2015		
		25%	50%	75%
IRR (%)	55	52	48	42
NPV (billion Rs)	176	149	119	82
Benefit-cost ratio	3.4	3.0	2.6	2.1

IRR: Internal rate of return
NPV: Net present value

Some measures that need to be adopted to promote fish production are:

- The analysis has shown considerable impact of the fisheries sector development on the social welfare. Technological developments in fisheries would make the fish available at cheaper rates to the consumers and thus improve their nutrition security.
- In aquaculture, awareness should be created to improve the feed and input management practices by way of integrating fish culture with agriculture, animal husbandry, horticulture and forestry, which serve as complementary enterprises, thus reducing the cost and risk.
- Development of export market would be crucial to realize the gains from technological progress. The absence of export market would discourage producers to adopt modern technologies, as the fish prices in the domestic

market would be descending with increase in fish production, unless domestic fish demand increases at a faster rate. The results have also pointed towards a need for value-addition and product diversification for the domestic consumers.

- Globalization is creating both opportunities and challenges for fish producers. The opportunities lie in rising fish trade. Nevertheless, there are challenges that need to be addressed. Sanitary and phyto-sanitary concerns are becoming important in the world fish trade in the wake of implementation of WTO agreement. Efforts should be made to bring down the cost of compliance of food safety concerns by increasing the efficiency of the quality control processes. This could be achieved by bringing together the small producers scattered throughout the country. Vigorous efforts would be needed to educate producers, processors and exporters in clean production.

- Expansion of existing Export Zones to include other reliable fish exporting zones will go a long way in stimulating exports. Brand promotion in different countries by means of market access initiatives, increased marketing efforts, high food safety standards will have to be undertaken. Also, there is a need to develop and transfer eco-friendly yet economically viable technologies that could produce fish conforming to the international standards.

- Development of infrastructure for transportation, storage and processing would be a key to compete in the international market, and this would require considerable public and private sector investments. These efforts need to be supported by appropriate fiscal and regulatory policies.

8

Prioritization of Fish Technologies and Management Options to Benefit Poor Households

An exercise was conducted to identify key indicators and finalize the criteria for prioritizing the pro-poor aquacultural technologies and fishing practices. These criteria and key indicators are mentioned in Table 8.1 along with their respective weightages. These were based on their contribution to benefit and uplift the poor fishers. The results of prioritization exercise for aquaculture technologies and fishing practices in various aquatic eco-systems and post-harvest technologies are given below.

8.1. Aquaculture Technologies

Freshwater

Under the freshwater aquaculture, recognised as one of the most potential sectors for enhancing fish production in India, 17 technologies were identified and prioritized (Table 8.2). The extensive polyculture of Indian major carps ranked the highest followed by semi-intensive polyculture of IMC and other minor carps in sewage-fed waters. Most of the intensive technologies involving monoculture ranked low, may be due to high investment, less diversification, equity issues for poor fishers and high risk factors.

Brackish and marine waters

These were prioritized simultaneously, considering almost the same area of distribution for these waters and almost the same clientele. The extensive mud crab fattening in brackishwater ranked the highest followed by extensive farming of mussel and extensive brackishwater culture of shrimp (Table 8.3). As in freshwater aquaculture, technologies with higher intensity culture ranked low primarily due to investments which were high for poor fishers.

Table 8.1. The criteria, indicators and weightages assigned to different indicators for prioritization of technologies

Criteria	Aquaculture	Weightage	Fishing practices	Weightage	Post-hravest	Weightage
Efficiency	Gross return/ total cost	12	Gross return/ total cost	10	Gross return/ total cost	15
	Operational cost/ kg fish produced	12	Operational cost/ kg fish caught	10	Minimum loss during the processing (%)	10
	Vulnerability to natural hazard and diseases (score)	6	Adverse effect on catch of poor fishers: Rank 1-9	5		
	Total	**30**	**Total**	**25**	**Total**	**25**
Food/ nutrition security	Retail price of fish produced through the technology	7.5	Retail price of fish caught through the technology	6	Retail price of the processed product through the technology	8
	Share (qty) of the fish produced in the system to poor's fish consumption (%)	7.5	Share (qty) of the fish caught by the technology to poor's fish consumption (%)	9	Share (qty) of the processed products by the technology to poor's fish consumption (%)	8
					Food safety – scoring (lesser weightage - 2:2:1)	4
	Total	**15**	**Total**	**15**	**Total**	**20**
Employment	Labor factor share (%)	8	Labor factor share (%)	10	Labor factor share (%).	10
	No. of jobs generated (Man-days / $100 invested, or scoring)	8	No. of jobs generated (Man-days / $100 invested, or scoring)	10	No. of jobs generated (Man-days / $100 invested, or scoring)	10
	Higher share of women in the total employment (% or scoring)	4			Higher share of women in the total employment (% or scoring)	5
	Total	**20**	**Total**	**20**	**Total**	**25**
Environment	Degree of waste discharge (scoring)	5	Adverse impact on biomass: Rank 1-9 (including by catch)	10	Impact on environment (waste coming from post-harvest) – scoring	15
	Risk of disease spreading	5	Adverse impact on ecosystem: Rank 1-9	5		
	Adverse impact on biodiversity (scoring) Rank 1-9	5				
	Total	**15**	**Total**	**15**	**Total**	**15**

Contd...

Table 8.1. The criteria, indicators and weightages assigned to different indicators for prioritization of technologies — *Contd*

Criteria	Aquaculture	Weightage	Fishing practices	Weightage	Post-hravest	Weightage
Acceptability (by poor)	Low investment need (total fixed + operational capital, $ for Minimum Initial Scale; or scoring)	6	Low investment need (total fixed + operational capital, $ for Minimum Initial Scale; or scoring)	7	Low Investment need (total fixed + operational capital, $ for Minimum Initial Scale; or scoring)	4
	Simplicity of technology: Rank 1-9	6	Simplicity of technology: Rank 1-9	7	Simplicity of technology: Rank 1-9	4
	Social, cultural & legal acceptability: Rank 1-9	4	Social, cultural & legal acceptability: Rank 1-9 .	6	Social, cultural & legal acceptability: Rank 1-9	2
	Compatibility with natural resources endowment accessible to poor; Rank 1-9:	4	Promotion of community participation (Scoring)	5	Utilization of locally available raw materials (fish) - scoring	5
	Total	20	Total	25	Total	15

Source: Survey under the project.

Table 8.2. Prioritization for inland freshwater aquaculture technologies

Technology	Species	Score	Rank
Polyculture extensive	Indian major carps, *Catla* catla, Labeo rohita, Cirrhinus *mrigala*	160	1
Sewage fed semi-intensive	Indian major carps, *Catla catla, Labeo rohita, Cirrhinus mrigala* with minor carps	290	2
Integrated semi-intensive	IMC	324	3
Polyculture extensive	IMC, catfish	360	4
Polyculture semi-intensive	IMC, catfish	388	5
Rice farming monoculture extensive	Carps	394	6
Rice farming polyculture extensive	IMC Prawn	446	7
Rice farming monoculture intensive	IMC, catfish, Chinese carp, common carp	472	8
Polyculture extensive	Prawn, IMC	485	9
Polyculture semi-intensive	Catfish, IMC	532	10
Polyculture sewage fed semi-intensive	Prawn, IMC	532	10
Monoculture intensive	IMC	562	11
Polyculture intensive	IMC	604	12
Monoculture semi-intensive	Prawn	618	13
Monoculture semi-intensive	Catfish	626	14
Monoculture semi-intensive	Pearl	638	15
Monoculture intensive	Catfish	685	16
Monoculture intensive	Prawn	730	17

Source: Survey under the project.

8.2. Fishing Practices

Inland fisheries

The fishing practices for capture, culture-based and culture fisheries in Indian rivers, reservoirs, floodplain wetlands ponds and tanks were considered

Table 8.3. Prioritization of brackishwater aquaculture and mariculture technologies

Technology	Species	Score	Rank
Brackishwater extensive	Crab fattening	297	1
Mariculture extensive	Mussel	303	2
Brackishwater extensive	Shrimp	328	3
Mariculture extensive	Seaweed	331	4
Brackishwater extensive	Fin fish culture	344	5
Brackishwater extensive	Edible oyster	354	6
Mariculture extensive	Pearl Oyster	355	7
Brackishwater improved extensive	Shrimp	376	8
Brackishwater semi-intensive	Shrimp	430	9

Source: Survey under the project.

simultaneously and are reported in Table 8.4. In most of the waters, only wooden or tin indigenous/traditional country boats were prevalent. Therefore, the craft-gear combination was included in this type of boat. Among the gears gill net was ranked as one due to comparatively its easy *modus operandii* and selectivity. The cast net and hook and line ranked second with minor difference in scores, probably because of similar factors.

Culture-based fiseries

India is endowed with vast inland open waters in the form of reservoirs, lakes, floodplain wetlands, etc. These waters are well suited for enhancement of culture-based fisheries. The process of development of culture-based technologies has already been initiated in India. It is primarily limited to stocking enhancements, that can be taken up in small reservoirs, accounting for nearly 47% of the area under this resource. It has been recognised as the priority sector in the Tenth Five Year Plan. Therefore, the culture-based fisheries enhancements are high priority technology benefitting the rural poor fishers.

Brackishwater fisheries

In brackishwaters plank built boats and canoes, found very common alongwith gear combination of three gears (Table 8.4), were considered for prioritization.

Table 8.4. Prioritization of inland and marine fishing practices

Resource	Type of craft	Type of gear	Score	Rank
Inland	Indigenous / Traditional craft	Gill net	220	1
	Indigenous / Traditional craft	Cast net	228	2
	Indigenous / Traditional craft	Hook and line	228	3
	Indigenous / Traditional craft	Trap	300	4
	Indigenous / Traditional craft	Drag net	303	5
Brackishwater	Canoe, plank built boat	Gill net	145	1
	Canoe, plank built boat	Cast net	160	2
	Canoe	Stake net	245	3
Marine	**Non-motorized**			
	Canoe, plank built boat	Gill net	209	1
	Canoe, plank built boat	Hook and line	219	2
	Canoe, plank built boat	Cast net	246	3
	Canoe, plank built boat	Beach seine	263	4
	Canoe, plank built boat	Shellfish and seaweed collection	288	5
	Canoe, plank built boat	Trap	293	6
	Motorized			
	Small Scale			
	Plank built boat / Beach landing craft	Gill net	215	1
	Plank built boat / Beach landing craft	Hook and line	215	1
	Plank built boat / Beach landing craft	Ring seines or Ring nets	234	2
	Plank built boat / Beach landing craft	Mini trawl	336	3
	Commercial			
	Mechanised boat	Gill net	142	1
	Mechanised boat	Hook and line	160	2
	Mechanised boat	Pole and line	172	3
	Plank built with 2-3 OB engines	Ring seine	179	4
	Mechanised boat	Trawl	187	5
	Mechanised boat	Purse seine	195	6
	Mechanised boat	Dol net or Set bagnet	247	7

Source: Survey under the project.

The gill net ranked first followed by cast and stake net. The prioritized fishing practices for brackishwater were almost same as for freshwater inland fishing.

Marine fisheries

The capture fisheries were found to contribute the maximum to the marine sector. The fishing practices were more important than mariculture in this sector. There existed different types of fishing boats and gears. These were broadly categorized into non-motorized and motorized ones. The motorised crafts were further divided as small scale and commercial, depending upon the energy utilization and resource targeted.

Non- motorized practice

The canoe and plank built boats (non-motorized crafts) were prioritized with different gears. Gill net received the highest place followed by hook and line and cast net. The destructive fishing practices received low rankings.

Motorized

The motorized category was further classified into small scale and commercial based on the depth of operation, targeted resources, and level of resource exploitation, i.e. inshore/offshore, pelagic/demersal.

Small scale

Under small scale fishing sector, plank built / beach landing crafts were found the most prevalent. These crafts appeared in all the craft gear combinations. Low energy gears got the highest priority, i.e. gill net and hook and line. Comparatively high energy gears like ring seines and mini trawls got low priority.

Commercial

In the case of commercial, mechanized boats with inbuilt engines were found prominent for most of the gears, except for plank built boat without board engine (2-3) in combination with ring seine. In this case also, gill net ranked the best followed by hook and line, pole and line, ring seine, trawl, purse seine and dol or set bag net.

Artificial fish habitats (AFH) technology

Artificial fish habitats to attract and hold finfishes and shell fishes in the coastal waters were found becoming increasingly popular among the artisanal fishers, as a mode of getting better catches. Therefore, it could also be considered as a high prioirty technology for poor coastal fishers.

8.3. Post-harvest Technologies

In the prioritization of post-harvest technologies, both traditional and modern technologies were included. The technologies that ranked high for the poor included drying, processing of fish products, salting and drying, boiling, drying and smoking (Table 8.5). Most of the traditional technologies received higher ranking, may be due to low investment, simplicity of technology, local availability of raw material, etc.

Table 8.5. Prioritization of fisheries post-harvest technologies

Technology	Score	Rank
Drying	282	1
Processing of fish products	311	2
Salting and drying	325	3
Boiling, drying and smoking	328	4
Icing	333	5
Electrical and solar drying	343	6
Chilling	360	7
Freezing	367	8
Processing of seaweed products,	412	9
Canning	418	10
Fish meal processing	430	11

Source: Survey under the project.

9

Recommendations / Suggested Action Plan

The study has shown that technology and trade, reinforce each other, though ushered in wealth, have raised sustainability concerns in some sub-sectors in the recent years. Generally, these technologies and trade interventions were skill-based, capital intensive and size non-neutral and thus could not have deep impact on the socio-economic conditions of the poor fishers, as was intended. In some cases, institutional and policy failures have also been observed. Keeping in view these learnings, the following strategies are being suggested for an accelerated fishery development with focus on poverty alleviation of the poor fishers.

- Follow people centered not commodity centered approach
- Follow system approach
- Prioritize technology for the poor at national, regional and micro level
- Innovate and strengthen institutions and policies
- Upgrade skills of the poor fishers
- Enhance investment and reorient policies to facilitate percolation of benefits from trade to all sections of the society, particularly the poor and the women
- Follow ecological principles
- Emphasize domestic market which is a sleeping giant
- Strictly monitor the development programmes, make on-course corrections and assess the impacts of all revitalized programmes
- Strengthen database and share it for better planning and policy making in the sector

An indicative action plan to implement the suggested strategy is presented below: Aquaculture should be accorded the highest priority in the action plan. Based on the national average productivity of about 2.2 t, the fishery area may be grouped into (a) Traditional states (West Bengal and Orissa, with productivity of 3.5 t),

(b) Non-traditional states with high performance (Andhra Pradesh and Punjab, with productivity of 4 t), and with low performance but good potential (Maharashtra, parts of UP and Kerala), (c) States with large watersheds (Bihar, Karnataka, parts of NE States, Rajasthan, Tamil Nadu and Madhya Pradesh). With regard to traditional states, the suggested treatment is diversification. In this context, the technology of seed production in catfishes is to be improved for upgrading it to the viable level. For Andhra Pradesh and Punjab, the suggested action plan includes treating the fisheries on par with agriculture for all purposes (input subsides, income tax rebate, etc.), strengthening the extension system to upgrade the technical skills of fishers in the production, and processing of fishes, and providing market (since they do not eat fish as much as in traditional states). In the case of other states, there is a need to actively co-ordinate the activities of fisheries and irrigation departments. Since the consumer preferences are changing towards smaller sized fishes, taking several crops is becoming a reality. For this, seed supply has to be ensured through providing rearing space in the watershed itself. For this, technology has to be perfected. There is also a problem of ownership rights in large watersheds in these states.

For the marine sector, fish driers need to be perfected. Fresh water is a problem at the landing centres for cleaning fishes as well as ice making. Use of polythene sheets for drying fishes is suggested to reduce spoilage.

Formation and making of the self-help groups, co-operatives, etc. should offer services and supplies, including arranging processing and marketing.

Since mariculture has big potential, particularly in helping the rural poor and women, it has to be promoted and strengthened, with the simultaneous development of market. Technology to make hatchery and multipurpose processing has to be perfected. Similarly, the policy of leasing amount and rights needs to be rationalized. Nearly 80 per cent of the coastal aquaculture is followed on less than 2 ha area. They are small-sized enterprises. How they could remain viable and eco-friendly, has to be learnt from the success stories of other countries.

10

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The International Center for Living Aquatic Research Management (ICLARM – The World Fish Center) has initiated this study on "Strategies and Options for Increasing and Sustaining Fisheries and Aquaculture Production to Benefit poor Households in Asia" with research grant from the Asian Development Bank for three years (March 2001 – March 2004). The project is implemented in collaboration with nine Asian countries namely Bangladesh, PR China, India, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand and Vietnam. ICLARM was responsible for the over-all planning, implementation and coordination among the nine participating countries. The project aimed at developing appropriate strategies and options for increasing and sustaining fisheries and aquaculture production, targeting the poor producers and consumers in Asia. In India, this study is co-ordinated by the National Center for Agricultural Economics and Policy Research (NCAP) in collaboration with Central Inland Capture Fisheries Research Institute (CICFRI), Central Marine Fisheries Research Institute (CMFRI), Indian Agricultural Research Institute (IARI), University of Agricultural Sciences, Bangalore .and Gujarat Agricultural University. This report is an outcome of the study conducted in India.

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