RAP Publication 1999/21

Rural Aquaculture in India

REGIONAL OFFICE FOR ASIA AND THE PACIFIC
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Bangkok, Thailand

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PREPARATION OF THIS DOCUMENT

This document, prepared under an author's contract, by Dr. V.R.P. Sinha, presents a review of rural aquaculture in India. The opinion expressed in this publication are those of the author's alone and do not imply the expression of any opinion whatsoever on the part of FAO.

Abstract

As a follow-up of the publication on Rural Aquaculture: Overview and framework for country reviews — RAP Publication *1997136*, efforts have been made to review rural aquaculture in some of the major aquacultural countries in Asia and the Pacific region. Rural Aquaculture in the Philippines was the first publication under this new series, and this is the second. It is expected that similar publications on other countries such as China, Bangladesh, etc. would follow.

India, a vast country with an area of 3.3 million sq km and a population of about 1 billion people is endowed with rich freshwater, brackishwater and marine resources. The country produces about 5 million mt of fish of which total aquaculture production is about 1.6 million mt. Aquaculture production has increased three times during the last ten years. Although aquaculture has made very good progress in the last five decades, it is still a very small sub-sector of agriculture. Considering the country's vast potential for aquaculture (both freshwater and coastal), the recent achievements in R&D on various aspects of aquaculture, and the public and private interest in the sub-sector, the future of aquaculture as an economic activity is promising. A Ten-Year Brackishwater Shrimp Farming Development Plan with the aim of developing 0.1 million ha of shrimp farms has been prepared. Similarly, a Five-Year National Freshwater Aquaculture Development Plan has been developed with a view to doubling the freshwater aquaculture production to about 3 million metric tons.

Most of the aquaculture activities in India could be regarded as rural aquaculture as defined by Edwards and Demaine. Freshwater aquaculture in village tanks and ponds follow the improved traditional or semi-intensive composite culture/polyculture system and they serve the household needs for fish and generate some additional income for the family. Only in recent years, commercial pond fish culture have become very successful in the States of Andhra Pradesh, West Bengal, Punjab, etc. In brackishwater aquaculture more than half of the total area (100,000 ha) under shrimp culture is made up of small farms following the traditional improved traditional extensive system of culture and as such they are considered as rural aquaculture.

List of Acronyms

BFDA	Brackwishwater Fish Farmers Development Agency
BV	Biological Value
CIBA	Central Institute of Brackwishwater Aquaculture
CICFRI	Central Inland Capture Fisheries Research Institute
CIFA	Central Institute of Freshwater Aquaculture
CIFE	Central Institute Freshwater Education
CIFRI	Central inland Fisheries Research Institute
CIFT	Central Institute of Fisheries Technology
CMFRI	Central Marine Fisheries Institute
EA	Environmental Assessment
FAO/UTNDP	Food and Agriculture Organization/United Nations Development
FARTC	Programme Freshwater Aquaculture Research and Training Center
FCI	Fertilizer Corporation of India
FFDA	Fish Farmers Development Agency
GDP	Gross Domestic Product
HRD	Human Resource Development
HYV	High Yielding Variety
ICAR	Indian Council of Agricultural Research
ICMR	Indian Council of Medical Research
IDRC	International Development Research Council
JIMA	Indian Institute of Management
IPDR	Intensive Poultry Development Project
KVK	Krishi Vigyan Kendra
MFALS	Marginal Farmers and Agricultural Laborers Scheme
MOC	Mustard Oil Cake
NABARD	National Bank of Agricultural and Rural Development
NACA	Network of Aquaculture Centres in Asia and Pacific
NAFED	National Agricultural Cooperative Marketing Federation
NBFGR	National Bureau of Fish Genetics Resources
NEERI	National Environment Engineering Research Institute
NGO	Non Governmental Organization
NPU	Net Protein Utilization
NRCCF	National Research Centre on Coldwater Fisheries
NSCI	National Seed Corporation of India
OUAT	Orissa University of Agriculture and Technology
PER	Protein Efficiency Ration
PL	Post larva
R&D	Research and Development
SFDA	Small Farmers Development Agency
SFSDC	State Fish Seed Development Corporation
ITC	Trainers Training Centre
USD	US dollar
WFP	World Food Program

Contents

1. INTRODUCTION

1.1. General Introduction

India spans an area of over 3 million sq km with Pakistan in the northwest, Nepal in the north, Bangladesh and Myanmar in the northeast and Sri Lanka in the south. The eastern and western coasts are facing the Bay of Bengal and the Arabian Sea respectively. It has the distinction of having northern and eastern boundaries flanked by the Himalayas, the highest mountain range in the world. Similarly, highly fertile river plains of Indus, Ganges and Brahmputra constitute the northern area of the country. The Deccan plateau is in the south occupying most of the peninsular India, which is dotted with low mountain ranges and deep valleys and bounded in the east and west by mountain ranges of Eastern and Western Ghats.

Most of India experiences tropical climate. Its climate and weather conditions are mostly influenced by the southwestern and northeastern monsoons. Crop production in over 100 million hectares is closely linked to the behavior of the monsoons. These areas suffer chronically due to drought and sometimes due to floods leading to soil erosion. Thus, there is a great variation in annual food production in the country.

India has a mixed economy, most of which is generally in the control of private enterprises. Since 1951, the country has had a steady rate of economic growth. Agriculture is a significant sector of economy. The major crop is rice followed by wheat, sugar cane, tea cotton, jute cashew, coffee and spices. Raising of livestock and birds is also an important sector for beasts of burden, wool, meat and dairy products. Aquaculture has recently become an important sector of agriculture.

The agricultural holdings are generally small, with less than 2 ha size accounting for about 72.6 % of total holdings in number and 23.5% of cropped area. About 100 million hectares, out of the net cultivated area of 145 million hectares, have no irrigation facilities and thus farmers adopt rain-fed agricultural practices.

The country has showed quantum jumps in the production potential of crops and livestock as a result of strain upgrading through exotic germ plasm. High yielding varieties of paddy, wheat, maize, sugarcane for irrigated areas and sorghum, pearl millet, oilseeds, cotton, pulses for dry land farming have contributed for the high production.

A massive social program has been directed during the successive Five-Year Development Plans of the Government of India towards betterment of the rural poor and farmers. This includes providing basic infrastructure for technological know-how of agriculture, animal husbandry and aquaculture, making availability of inputs like fertilizers, improved seeds, water, and assisting them with control measures for pest and conservation of soil. Matching with these, processing and product development facilities and marketing were also organized both in cooperative as well as corporate sectors at the Central, State, District and even at certain Block levels. Credit was arranged through banks and cooperatives apart from subsidies of the Central and State Governments

A massive extension machinery reaching to the grass root levels was organized. The inputs and know-how were extended through various programs such as Small

Farmers Development Agency (SFDA), Marginal Farmers and Agricultural Laborers Scheme (MFALS), Intensive Poultry Development Project (IPDP), Fish Farmers Development Agency (FFDA), etc. Service support for inputs like seeds, fertilizers were made through National Seed Corporation of India (NSCI), Fertilization Corporation of India (FCI), State Fish Seed Development Corporation (SFSDC), etc. Similarly, for assisting in marketing, large net work of Food Corporation of India and cooperative sector godowns, Central and State Warehousing Corporations, National Agricultural Co-operative Marketing Federation (NAFED). NAFED poultry, milk and milk product marketing and fish marketing cooperatives were organized.

At present, a silent technological and social transformation is taking place in rural India. It is however more pronounced in those states, which have assured irrigation and input supply network effectively institutionalized and marketing mechanism perfected. The farmers have more assets; they are more enterprising, with higher labor productivity and a fair degree of mechanization of agriculture and animal husbandry. But many of the measures directed towards social goals of raising the lots of the poor agricultural labors and small land holders have at times been very frustrating, because of many reasons. The results of many development programs have been diluted because of the population growth, which is touching 1 billion marks very soon, with about 73% of the total population living in the rural areas.

1.2 Indian Fisheries - Capture and Culture

Besides its coastline of 8,041 km, and continental shelf of 0.42 million square km, India possesses vast inland aquatic resources in the form of 171,334 km of rivers and canal, 2.05 million ha of reservoirs, 2.36 million ha of ponds and tanks, 1.07 million ha of beels, ox bow lakes and derelict waters and 1.42 million ha of brackish water area. Globally it stands as the sixth largest producer of fish amounting to 4.95 million tons from its fresh and marine ecosystems. Of which about 2.24 million tons of fish is harvested from its inland aquatic resources and thus the country occupies the second position in inland fish production in the world.

During the last 50 years fisheries production in India has increased from about 0.75 million tons of fish and shellfish to over 4.95 million tons in 1995-96. The marine fisheries showed an increase from about 0.53million tons to 2.70 million tons, whereas inland from about 0.21 million tons to 2.24 million tons. Aquaculture both from freshwater and brackishwater has contributed considerably to such an increase. In fact, aquaculture contribution has increased to over three times from 0.51million tons to 1.6 million tons during last decade.

Similarly, contribution of fisheries sector to the GDP has increased considerably compared to agriculture. It showed ten times increase from 1980-81 to 1994-95 compared to the agriculture contribution of five times. The fisheries sector also contributed greatly to the export earning of the country, while adding considerably to the fish availability to about 8 kg/per caput. Table 1 shows general information on fisheries in India whereas Table 2 shows the details of inland fisheries resources of the country.

Table 1. General Information

1	Area of India:	3.3.million sq km
2.	Shelf Area:	about 0.5 million sq km
3	Length of Coastline:	8041 kms
4	Population:	(1991Census)
	Male:	437,597,929
	Female:	406,332,932
	Total:	843,930,861
5	Fisherman population during	(1994)
	Full time fishermen:	2,394,574
	Part time fishermen:	1,443,223
	Occasional fishermen:	2,121,347
	Total:	5,959,144
6	Estimates of production potential:	
	Inland sector:	4.5 million tones
	Marine sector:	3.9 million tones
7	Exclusive Economic Zone 2.02 million km^2	
8.	Fish production during	1995-96
	Inland sector:	2.24 million tones
	Marine sector:	2.70 million tones
	Total:	4.94 million tones
9.	Seed production(95-96):	15,007 million fry
10	Contribution of fisheries to GDP 94-95:	
	At current prices:	Rs.10,963 crores (1.28% of total GDP)
	At constant prices:	(1980-81)Rs.1935crores(0.77% of totalGDP)
11.	Export of marine products 95-96:	
	Quantity:	296.30 thousands tones
	Value:	Rs 3501.11 crores
12.	Primary Fisheries Cooperatives (As on 30th June 1995):	
	No. of Societies:	11,440
	Paid-up capital (000):	170,400
	Membership (Number):	1,250,379
	Working capital (000):	881,300

Table 2. Inland Fishery Resources In India

State/Uts	Length of rivers & canals (kms)	Area of reservoirs (Lakh ha)	Area under tanks & ponds (Lakh ha)	Beels, oxbow & derelict water (Lakh ha)
Andhra Pradesh	11 514	2.34	5.17	
Assam	4 820	0.02	0.23	1.10
Bihar	3 200	0.60	0.95	0.05
Goa	250	0.03	0.03	-
Gujarat	3 865	2.43	0.71	0.12
Haryana	5 000	Neg	0.10	0.10
Himachal Pradesh	3 000	0.42	0.01	-
Jammu & Kashmir	27 781	0.07	0.17	0.06
Karnataka	9 000	2.20	4.14	-
Kerala	3 092	0.30	0.03	-
Madhya Pradesh	20 661	2.94	1.19	-
Maharashtra	1 600	2.79	0.50	-
Manipur	3 360	0.01	0.02	0.40
Meghalaya	5 600	0.08	0.50	Neg.
Nagaland	1 600	0.17	1.14	Neg.
Orissa	4 500	2.56	0.07	1.80
Punjab	15 270	Neg.	1.80	-
Rajasthan	NA	1.20	-	-
Sikkim	900	-	2.24	0.03
Tamil Nadu	7 420	0.52	0.12	5.24
Tripura	1 200	0.05	1.62	
Uttar Pradesh	31 200	1.50	2.76	1.33
West Bengal	2 526	0.17	0.01	0.42
Arunachal Pradesh	2 000		0.02	0.03
Mizoram	1 395	-	0.003	-
Andaman & Nicobar	115	0.01	Neg	
Chandigarh	2			Neg.
Delhi	150	0.04	Neg	
Lakshadweep	-			
Pondicherry	247	-		0.01
Dadra & Naga Haveli	54	0.05		
Daman & Dlu	12			
Total	171 334	20.50	23.553	10.69

NA - Not available
UTs - Union Territories
Neg. - Negligible
Lakh - ‘00000

Source: *Hand Book on Fisheries Statistics, 1993, 1996; Govt. of India*

2. EVOLUTION OF RURAL AQUACULTURE

2.1. Historical Aspect

Kautilya's Arthasastra - one of the oldest Indian epics indicates that fish culture activity in India dates back to 2000 years. Perhaps it started when the human settlement moved away from the riverbanks to the hinterland. Paddy fields and low lying areas in flood plains and those connected to the estuaries and estuarine creeks became the cradle of aquaculture where inundation, caused either by monsoon rain or by tidal water, brought the natural seed of finfish and shellfish which got automatically trapped after the water receded. That eventually gave rise to the operation of "trapping and holding" of fish seed and raising them to table size and thus this marked the beginning of aquaculture in India.

Construction of the ponds either for storing the rain water for dry land agricultural activities or for the earth work for construction of the hut, house, and brick kiln, contributed to the development of aquaculture. Ponds became the nuclei of watering activities including supply of drinking water for human and livestock.

Geographic phenomenon of shifting of river courses resulted in rows of ponds. In fact, the dead river channels were sub-divided into smaller units by putting embankment across, giving rise to a series of ponds, the ownership of which was virtually acquired by the person staying in front of the section of the river channel. Such a series of ponds commonly exists in many parts of West Bengal and Assam.

Ponds (some part of India it is called tanks) are an essential component or rural setting. Similarly, any religious place, whether it is Hindu temple or Muslim mosque or Sikh gurudwara invariably has ponds or tanks and fish. The value of such ponds and of the fish as purifying agent of water was well known to Indians since time immemorial. Thus ponds became an integral part of Indian tradition, culture and religion.

Although aquaculture has been in vogue, its important role in rural development has been rediscovered recently. Soon after the independence in 1947 from the British Empire, India pursued the policy of increasing food production and community development. It embarked on programs such as "Grow More Food" and made considerable investment in irrigation infrastructure and institutions building.

Agriculture universities and research institutions on agricultural commodities and resources, were setup in different parts of India. Agricultural scientists and farmers made great stride in increasing agricultural productivity and thus the country never suffered from any famine after forties and has been able to successfully feed its teeming millions.

Fisheries research institutes were set up for inland resources Central Inland Fisheries Research Institute (CIFRI) and for marine resources Central Marine Fisheries Research Institute (CMFRI). Research efforts of these institutes formed the basis of modern aquaculture. The earlier work carried out at the CIFRI consisted of mainly induced breeding of Indian and Chinese carps, their seed production and pond culture operations, etc. The institute along with the Marine Fisheries Research Institute also contributed in providing the foundation of shrimp seed production and culture.

The perfection of the technique of hypophysation of Indian and Chinese carps and studies on a high yielding combination of Asiatic carps, commonly known as Composite Fish Culture, at CIFRI were of great significance in advancing rural aquaculture in the country. Initiation and remarkable success of the All India Coordinated Research Project on Composite Fish Culture and Fish Seed Production in 1971 had been the turning point in the annals of freshwater fish culture in India (Jhingran 1975). The successful results of which not only instilled the confidence in the State and Central governments but in the farmers also (Sinha 1971). A number of development programs followed; the most notable are the creation of the Fish Farmers Development Agencies, and the World Bank Fish Seed Hatchery Project. Indian Council of Agricultural Research (ICAR) gave great emphasis on aquaculture research and training and established Fresh water Aquaculture Research and Training Center (FARTC) in 1977 under CIFRI at Kauslyaganga, Bhubaneswar, which also housed the Pond Culture Division. The Trainers Training Center (TTC) and Krishi Vigyan Kendra (KVK) were also established there at the same time.

The FARTC made great strides for a decade to establish laboratories and farm facilities for aquacultural and made notable advancement in aquaculture sciences. It adopted multidisciplinary approach for upgradation of freshwater aquaculture technology. The TTC and KVK became deeply involved in transfer of technology to the farmers and extension officers.

The FAO/UNDP supported the ICAR efforts of intensification of fish culture research and training. As a result of which two projects, one on aquaculture research and training and another on the Net Work of Aquaculture Centers in Asia, were started at the FARTC. Both the projects were highly successful. Through these projects the center established very strong scientific capabilities and research infrastructure. It played a crucial role in developing strong bondage between scientists and farmers and also provided scientific leadership in carp culture in Asia.

Considering the emerging opportunities and constraints of aquaculture sector, and future R&D requirements, the ICAR made FARTC a full-fledged institute known as Central Institute of Freshwater Aquaculture (CIFA) in 1986. FAO/UNDP further supported the institute to establish a Center of Advanced Studies on Freshwater Aquaculture in collaboration with Orissa University of Agriculture and Technology.

The CIFA continued the efforts of aquaculture R&D vigorously and consolidated the gains of research into packaging of many technologies and it is considered as one of the premier institutions of fresh water aquaculture research in the world.

The ICAR initiated an All India Coordinated Research Project on Brackishwater Fish Culture in early seventies under CIFRI. The investigations paved the way initially for the development of brackishwater aquaculture in India. The other Fisheries Research Institutes like Marine Fisheries Research Institute and Central Institute of Fisheries Education (CIFE) contributed considerably to further development of aquaculture. Marine Product Export Development Authorities of India played a commendable role in the development of shrimp farming in the country. The Government of India gave all out support for the development of shrimp farming. While the ICAR established the Central Institute of Brackishwater Aquaculture, the Central and the State governments established the Brackishwater Fish Farmers Development Agency.

2.2 Current Status

Availability and ownership of the ponds are prerequisite for undertaking fish farming. Many benchmark surveys undertaken during late seventies and early eighties showed the following general pattern of pond ownership and resources of the owner in the freshwater sector (Table 3).

Table 3. General categories of ponds and ownership

S.N.	Categories of ponds	Size of pond (ha)	Ownership and resources
1	Very small homestead pond	.001-.009	Rural poor with no resources
2	Small homestead pond	.01-.09	Rural poor with meager resources
3	Medium size pond	0.1-1	Rural poor with adequate resources
4	Large size pond	1-5	Rich farmer with enough resources
5	Community pond	Small-5 or more	Vested with religious place without resources
6	Community pond	Small-5 or more	Vested with religious place with resources
7	Community pond	Small-5 or more	Vested with Local Self Government
8	Farm pond / Fish farm	Small-varying size	Farmers with adequate resources

Unlike the freshwater ponds, the brackishwater ponds do not abound much. The traditional aquaculture is still prevalent in paddy fields. Some of the state governments have under different programs of poverty alleviation constructed smaller ponds of about an acre and distributed to landless rural poor for shrimp farming. However because of low input resources they did not do well and at times privately lend them to well to do farmers or entrepreneurs. But during last decade a number of well designed fish farms have come up in many of the maritime states, mostly owned by persons or corporate with adequate resources.

In general, farmers with ponds and with resources were the first to be benefited by scientific technology. However, efforts have been made by different government agencies, ICAR institutes, NGOs to organize the landless, unemployed youth and women in forming cooperative for fish seed production, seed rearing, fish culture, fish marketing with varying degree of success.

The present trend shows that small size homestead ponds belonging to rural poor with some resources, and medium and large size ponds and newly established farms have contributed to the increased production. However, many large size ponds belonging to well to do farmers or rich people are invariably under multiple ownership. Such ponds unlike the land, can not be fragmented into smallholdings, are mostly lying fallow. It is

felt that even newly excavated ponds whether small or large would soon come under the multiple ownership because of the advent of the new generation. Multiple ownership has its own problem of development.

The situation in coastal area is more or less the same but unfortunately not many ponds are available in the sector. But many farms have recently been established. However they do not normally belongs to poor farmers. The poor farmers are still involved in the paddy shrimp farming.

A major national program of Fish Farmers Development Agencies at the district level was initiated in 1973 to provide administrative and infrastructural support, training to beneficiary, mobilization of inputs and extension support to fish farmers and also for arranging institutional finance though bank credits. The FFDA was entrusted to bring all the fallow culture fishery resources under optimum fish production progressively. The agency played leading role in extension of fish culture technology and also created well-organized skilled and enterprising fish farmers communities. The agency selects suitable water area, arranges lease on long-term basis provides incentive for renovation of ponds and input in the first year of fish culture.

Thus, while the FFDAs concentrated on utilizing more of the fallow and unutilized pond resources needing developmental support, the traditional fish farmers culturing carps in ponds upgraded the technology of both seed and fish production and improved aquaculture productivity.

In India shrimp farming has made considerable progress both in rural aquaculture as well as in industrial. Besides the traditional method of trapping and holding of shrimp seed for culture in paddy fields in West Bengal and Kerala, extensive, semi intensive and intensive systems of prawn farming are becoming prevalent in different part of the country. Till 1994-95, 100,700 ha of water bodies were used for shrimp production at 8% utilization of the total potential resources of about 1.2 million ha brackishwater. More than half, about 52,500 ha, is under traditional culture and the rest under extensive or semi-intensive.

Tables 4 and 5 show the state-wise details of shrimp farming. As with the freshwater sector, the government of India has sanctioned 39 Brackishwater Fish Farmers Development Agencies in all maritime states and Union Territory of Andaman and Nicobar Islands. The BFDAs have developed 17,780 ha of brackishwater area and imparted training to about 15,000 shrimp farmers.

2.3 Impact on Socio-economy

National level

Since rural aquaculture covers both fresh and brackish waters, it is important to analyze the impact from both the sectors.

Excepting egg, poultry and potatoes, aquaculture was by far the fastest growing food production sector over the recent past decades. Freshwater aquaculture which is based mainly of carp, contributed over 1.52 million tons of fish and 15000 million fry annually, contributing well over Rs. 40,000 million.

Similarly, 83,000 tons of cultured shrimps contributed to about 40-45 %, in terms of quantity and about 60-65 % in terms of value in the total export of shrimps, which amounts to about Rs.16,000 million.

Village Level

Case Studies

Nakhaurpatana

While the FARTC was being established, the KVK/TTC, Kausalyaganga under its training and transfer of technology programs initiated organizing farmers and farm women to undertake fish farming and seed production after getting them trained in Composite Fish Culture, fish seed production, net making and horticultural crop production at Nakhaurpatana village of Bhubaneswar block in Puri district, in 1979 (Sinha and Venkateswarlu 1983).

Before starting the program, a benchmark survey was undertaken of the socioeconomic conditions of the farmers and inventory of the village resources were made. It was seen that the village has a total of 44 families. Fifty percent of the families were landless and about 48 % were marginal farmers owning very smallholdings (0.001-0.5 ha). The literacy rate for male was about 25%, where as for female about 8.6%. About 89% of the families lived below poverty line with an average income of Rs. 185/month. Employment profile showed that majority worked as labourers, others were involved in fishing from rivers or derelict water, poultry farming, dairy and share cropping, However, most of them were gainfully employed only for about 7 months in a year.

The village had two large derelict ponds of 0.75 and 1.25 ha belonging to the Gram Panchayat (Local self-government). In addition to these, two small ponds of 0.06 and 0.02 ha also existed there in the village but all of them were fallow and were not used for fish farming. Though they were mainly used for water supply to the village and agricultural field but they were full of aquatic weeds primarily water hyacinth.

Over twelve years of concerted technical support along with a great degree of committed involvement of the staff of KVK/TTC, the situation in the village changed considerably.

Composite Fish Culture

The technology of composite fish culture was propagated in the village in 1979. In the very first year a pond of 0.75 ha choked with weeds was cleared by the villagers and composite fish culture was undertaken, which gave a production of about 2.5 ton. @ 4451 kg/ha/yr and the fish was sold @ Rs. 10/kg. The farmers received a sum of Rs. 25,266 with a net profit of Rs. 22,990. This instilled a great confidence in the villagers and thus they extended the technology to two other ponds of 1.25 ha and of 0.08. Over 12 years the fish production ranged between 1717 kg/ha /yr to 4491 kg/ha/yr, though fish production suffered because of the severe flood for one year and outbreak of fish disease in another year. Also farmers could not get the lease from Gram Panchayat for one year and ponds remained unused. The overall average fish production was 2855kg/ha/yr. In

12 years the farmers earned a net profit of over Rs 565,991 from fish. The average percentage return on expenditure on composite fish culture was estimated to be 710 % and profit percentage to turn over was about 81%. The cost return ratio ranged between 0.07 and 0.46. In fact, after introduction of composite fish culture technology in the village, the poverty condition was down to 45.45% in 1990 from 89% in 1979 (Radheyshyam and Tripathy (1992).

Fish Seed Production

Soon after getting trained in fish seed production, the farmers and farm women undertook seed production using brood stock available in composite fish culture ponds. They were able to produce spawn as well as raised fry and fingerlings. The farmers then made use of all the fallow ditches and borrow pits by converting them to nursery ponds. Both men and women have been now actively involved in carp seed rearing. From 1980 to 1985, 1108 million of spawn of Indian major carp and common carp were produced and sold, resulting in a net profit of Rs.12867 with an expenditure of Rs.2165 only, showing a 594% return on expenditure

Similarly, spawn rearing from 1979 to 1985 resulted in a net profit of over Rs. 12,778, showing a 278% return on expenditure.

Net Fabrication

Twenty-four women from the village were trained in fish net fabrication technology in 1980 and were organized under a cooperative society. Radheyshyam et. al (1988) noted that on making 45 kg of net of 67m x 9m the estimated profit of the society was Rs.7203.

Horticultural Crop Production

The farmers were shown to use pond silt and composted aquatic weeds as manure and they were given training in integrated farming. They integrated horticulture and fish culture on the 0.20 ha pond. The embankment was used for production of banana, papaya and a number of a variety of seasonal vegetables .As a result of which farmers earned a net return of Rs.27,365 in total from 1981-90. The cost-return ratio ranged between 0.11 and 0.41 and the average percentage return on expenditure was 415%. During 1988-90 farmer also took up mushroom cultivation, which gave them a profit of Rs.8,427 with the percentage return on investment as 288 %.

In general, the village appears progressive with about 31% male and about 28% of female involved in aquacultural activities, without impairing their previous occupation if any, for generating additional family income. All the 44 families were benefited with additional income, and a small amount was also spent on community development such as road repair and construction of the pond, etc. As a result of this now the village has 12 ponds, covering an area of 2.28 ha and are used for fish culture with an average production rater of 2855 kg/ha/yr.

Sarakana

In 1986 the KVK and TTC carried out a preliminary survey of village Sarakana of Balianta block in Khurda district in Orissa with a view to developing aquacultural activities. There are 4 Gram Panchayat tanks totaling 3.4 ha and 28 private ponds covering an area over 4h a. The Gram Panchayat ponds are leased out to farmers for fish culture.

Initially, the KVK and TTC under its off campus training program motivated and trained 10 farmers in composite fish culture. On completion of the training program the farmers initiated composite fish culture in 1.5 ha pond taken on lease from the Gram Panchayat. The pond was fallow and weed choked. However, weed was cleared and the pond was properly managed after fingerling stocking. This resulted in 1200 kg fish and the fish was sold @ Rs. 22/kg. In fact, in 10 years the total harvest was 14,750 kg till 1996. The income from composite fish culture instilled confidence in them and they diversified their aquaculture activities such as carp spawn production, carp fingerling raising and integrated farming.

Spawn production was initiated in 1987 with great success and resulted with increasing production from 3.5 lakh to 1575 million in 1996 with the annual net income rising to the tune of Rs50,000.

Further, the farmers were trained in fry and fingerling raising. They prepared a small nursery pond of 0.08 ha, which was stocked with spawn and reared for twenty days as a result of which 22 million fry were produced.

The same pond was again used for fingerling rearing and 40,000 fingerlings were harvested and a net income of Rs7,978 was made in seven month. This inspired the farmers further to intensify the activities. They have now 10 ponds of 0.02-0.1ha. each for fry and fingerling production. Within 10 years they produced a total of 123.85 and 16 lakh of fry and fingerling, which fetched a net income of about Rs.495,000. The village has now become famous for quality seed supply (Radheyshyam 1997)

Family Level

About 21 case studies made during 1983 provided detailed information on the farm situation, household details, primary purpose of farming, farm inventory along with farm improvement if any, land use, labor use, cost and return, support services like credit, marketing, technical service, rural organization, constraints, and reason for success and failure along, with possible new approaches to improve the production. The salient points of which show how fish farming is contributing to the farm produce diversification, additional income and employment generation and thus bringing general prosperity to the farmers (Sinha and Venkateshwarlu 1983). The abstract of only six case studies are presented below, but observations given at the end were based on all the twenty one.

Case study No. 1 Farmer undertaking most traditional system of Paddy-fish culture

1. Farm situation and details	Mirakhan,Kakdwip (West Bengal) Size – 0.24 ha, water supply from river and also from tube well
2. Household information	Family members (6),family labor (2 male , 1female), off-farm work - service,
3. Primary purpose	Produce food for family and some additional income
4. Farm inventory	Own land and 1 hut
5. Farm improvement	Nil
6. Land use	Paddy SR 26 B cultivation along with fish and fish, cultivation alone after paddy harvesting from Jan-June Traditional method of culture of P.monodon, Mullet, carp and other fishes
7. Labor use Labor distribution(Family) (Hired)	Paddy (43 man-days/yr) Fish (120 man-days/yr) 100 M + 20 F 30 M + 13 F
8. Earning Net earning	 Paddy Rs.226/- Fish Rs. 800/-

Case Study No.2 Small Farmer undertaking most traditional paddy-fish culture

1. Farm situation and details	Mirakhan, Kakdwip, (West Bengal) Farm size (0.2), water supply through tube well and also through tide
2. Household information	Family member (3), family labor (nil), off-farm work (office)
3. Primary purpose	Produce food for family and also generate income
4. Farm inventory	Own land, and hut (1)
5. Farm improvement	Nil
6. Land use	Cultivation of SR 26 B paddy and Paddy cum Fish culture . July- December – Paddy-fish culture and Jan-June – fish culture
7. Labor use Labor inputs in man-days Labor distribution, family member Hired labour	 Paddy (16), Fish culture (80) Paddy (nil), Fish (nil) Paddy (10 M+6F), Fish (60M+20F)
8. Earning Value of production Net earning	 Paddy and bran (Rs.200/-) Fish (Rs. 850/-) Paddy (Rs.137/-) Fish (Rs.560/-)

Case study No. 3 Small farmer with improved traditional paddy-fish culture

1. Farm situation and detail	Govindpur (Ganeshpur), Kakdwip, West Bengal Farm size (0.6 ha.),water supply from the tideand the impoundment.
2. Household information	Family member (8), Family labor (2), off-farm(service)
3. Primary purpose	To produce food for the family and also for income
4. Farm inventory	One mud house, bullock (2), country plough (1) duster(1), sprayer (1)
5. Farm improvement	Nil
6. Land use	July-Dec.- Paddy and fish Jan-June - Fish alone and vegetable P.monodon, L.parsia,carp and other fishes cultured in the brackish water impoundment.
7. Labor inputs in man-days Labor distribution,family labor Hired labor	Paddy and vegetable (60) Fish (150) Paddy and vegetable (50 M) Fish (80 M) Paddy and vegetable (10 M) Fish (70 M)
8. Earning Value of the produce Net earning	 Paddy (1700 kg) - Rs. 1700/- Vegetable (200 kg) - Rs. 200/- Fish and prawn (500kg) - Rs. 5500/- Paddy and vegetable - Rs. 1200/- Fish and prawn - Rs. 4350/-

Case Study No. 4 Farmer with adequate resources

1. Farm location and detail	Village Mathaur,Manigachi, Darbhanga (Bihar) Ponds (5) of 2.15 ha. Land 8 ha. Water supply by rain and stored water in the pond. Tube well water for drinking
2. Household information	Family member (7), Family labor(2), mostly involved in management, off-farm (teacher 1)
3. Primary purpose of farming	Produce food, income ,and some recreation
4. Farm inventory	Cemented house (1), Bullock (2), Cow (2), Calves (2), Diesel pump (1 of 5HP), Sprayer (1), Plough (2)
5. Farm improvement	Contour the land to catch run off for the pond
6. Land use	Fish (catla, rohu, mrigal and common carp) throughout the year Makhana (Euryale ferox) Oct.-Aug. Pulses and wheat(Sonalika,RR21) Paddy (Padma ,Jaya ,IR8) Fruit trees:Banana(50), Mango (7) Lichi (3), Jack fruit (1)
7. Labor use in man days	Fish 75 + contract labor on 10 % share basis for harvesting Wheat (2ha) 120, pulses (1ha) 40, Rice (8 ha in kharif +2 ha in summer) 880 Livestock 375 Horticulture 75
Labor distribution	Farmer 62 M Family member 80 M Hired Labor 1423
8. Cost and return Value of the produce	Wheat (4 t.), Value Rs. 8,000/- Paddy (16.5t.),Value Rs. 26,000/- Pulses (0.5 t.), Value Rs. 2,000/- Fish (3.3 t.), Value Rs.33,000/- Makhana(0.4t.),Value Rs. 4,000/- Fruit Value Rs.15000/- Milk (1200 ltr), Value Rs.I5000/-
Net income	Wheat Rs.3610/- +Rs. 150/- Paddy Rs.11880/- + Rs. 750/- Pulses Rs. 638/- +Rs. 75/- Fish Rs. 6290/- +Rs. 75/- Makhana Rs. 500/- + nil Fruit Rs. 1690/- +Rs. 300/- Livestock Rs. 3190/- + nil. Wheat Rs. 4240/- Paddy Rs. 13370/- Pulses Rs. 1287/- Fish Rs. 26635/- Makhana Rs. 3500/- Fruit Rs. 13010/- Livestock Rs. 11810/-

Case Study No. 5 Farmer with adequate resources

1. Farm situation and details	Digaru,Sonapur, Kamrup, (Assam) Farm size (3.07 ha. land , ponds (3) of total area of 0.8), water supply through tube well and also from pond
2. Household information	Family member (11M + 11F), family labor (8), off-farm(nil)
3. Primary purpose	Produce food for family and also generate income
4. Farm inventory	Own land, house (1), Jersi cow (6), calve (6), Bullock(4) Duck (20), Power tiller (1), Pumping set (1)
5. Farm improvement	Nil
6. Land use	Cultivation of paddy (1.2 ha), two crops Composite Fish culture (0.8 ha) Horticulture and forestry (1.87) Livestock throughout the year
7. Labor use Labor inputs in man-days Labor distribution, family member Hired labor	 Paddy (200), Fish culture (700),Horticulture (1500), Forestry (100), Livestock (300) Paddy (120 M+30 F), Fish (400 M), Horticulture (600M+550F), Forestry(70 M), Livestock (100M+200F) Paddy - 50, Fish - 300, Horticulture - 350, Forestry -20, Livestock -nil
8.Cost and return Value of production Variable + Overhead costs (Rs.) Net earning (Rs.)	 Paddy and bran (Rs.15000/-) Fish (Rs. 40000/-) Horticulture (Rs.50,000/-) Forestry (Rs.5000/-) Livestock (Rs.18000/-) Paddy (4300/-) + (300) Fish (68000/-) + (200) Horticulture (22000) + (400) Forestry (1000) + (100) Livestock (3800) + nil Paddy (10400/-) Fish (33000/-) Horticulture (27,600/-) Forestry (3900) Livestock (14200)

Case Study No. 6 Dairy farmer undertaking fish culture

1.Farm situation and details	Jangal Mahua , Gorakh pur (U.P.) Farm size : Pond (2) area 0.7, Cattle yard (1) 0.2 ha and 0.6 ha for fodder production. Water supply from rain fed pond and tube well
2.Household information	Family member (19), family labor (6), off-farm work (1),
3.Primary purpose	Produce food for family and also generate income
4.Farm inventory	Own land, house (1), cow (4), buffalo (3), bullock (2),chaff cutter (1), plough (3),
5.Farm improvement	Previously the plot of the land was utilized for wheat cultivation but now dug the pond for fish culture
6.Land use	Dairing and fish seed production and culture Cow (Sahival and Jersi), Buffalow (Murra), Bullock (Haryanavi). Carp culture and Common carp seed production
7.Labor use Labor inputs in man – days Labor distribution, family member Hired labor	 Livestock (425), Fish culture (245) Livestock (200M+100F), Fish (100M+20 F) Livestock (30 M+95F), Fish (120M+5F)
8.Cost and return Value of production Variable cost Overhead cost Net earning	 Dairy (Milk –15,600 ltr Rs.55,200/-) Fish –800 kg (Rs. 12000/-) Fish seed (Rs.3700/-) Dairy (Rs.10,450/-) Fisheries (Rs.3940/-) Dairy (Rs.1200/-) Fisheries (Rs.1000/-) Dairy (Rs.43,550/-) Fish (Rs.10,760/-)

Case studies 1&2 clearly indicate that poor farmers still need considerable amount of extension support to upgrade the traditional systems of rice-fish culture to improve productivity. However, even with this low level of production the farmers get benefited by fish more than rice obviously because the price of fish is many times more than rice. But there is a strong need of improvement not only in package of practices but also in labor productivity, since the labor component has been exceptionally very high in these two cases. The situation improves in case study 3 when farmer undertakes improved traditional method of paddy-fish culture. It is interesting to note that the farmers hired labor, which give them some social prestige. Other case studies undertaken also show that traditional paddy-fish farming leads to higher labor engagement and better net income. The income from fish was as high as in the range of about 80% (primarily due to

high price of prawn) and so is the engagement of labor time, which also ranges to about 80%.

Fish cultivation in the irrigation pond increases income of farmers besides producing some surplus fish protein for his family. Case study 4 showed that fish culture in about 25 % of farm area gave about 50% of net farm income. In fact other case studies not shown above clearly indicated that fish culture in about 30-80% of farm areas, gave 80-90% of total farm income.

Case study 5 showed that a progressive farmer in Assam undertaking carp culture in about 25 % of the farm area got more than 40% of the farm income. Compared to this, 55 % of farm area under horticultural crop contributed to only about 27% of the farm income showing clearly the superiority of fish culture in generating farm income. However, horticultural crop integrates well with fish culture since the former calls for uninterrupted irrigation and yields sizable amount of soft-texture waste, which the fish utilizes as feed.

Case study 6 shows that a dairy farmer abandoned wheat cultivation in preference to fish culture in his land and without having much of experience of culture and seed production, he made a net income of Rs.10,760/- in 0.7 ha pond area in one year.

Rural aquaculture with the rate of fish production of 1500 kg to 3000 kg /ha depending on the degree of culture practices adopted involving more than 200-300 man-days of labor /ha, and generating high net cash income to the farmers, is obviously making substantial contribution to rural socio-economic life.

3. RURAL AQUACULTURE SYSTEM

3.1 Production Systems, Facilities and Species

Unlike the development of mono-culture of common carp (Cyprinus carpio) in Europe and elsewhere, culture of Indian major carps originated automatically as polyculture of catla (Catla catla) rohu (Labeo rohita) and mrigal (Cirrhinus mrigala). This was mainly because culture operation was entirely depended on the wild mixed seeds of carps, which were collected from the rivers during monsoon when they bred and farmers had no means to segregate them. Over the years, farmers learnt better husbandry practices. Scientific research and extension services further improved upon the package of culture practices.

Introduction of three other Asiatic carps namely grass carp, (Ctenopharyngodon idella) silver carp, (Hypophthalmicthys molitrix) and common carp in India as the component of Composite fish culture (Polyculture of Indian and Chinese carp) has resulted in enhancing the productivity of rural aquaculture (Sinha 1972, Sinha et.al 1973, Sinha and Ramchandran 1985). Carps are the main out put of freshwater pond aquaculture production system, which is photosynthesis dependent, most suited to poor resource farmers. The other most prevalent system is trapping and holding system in paddy field, which results in carp, catfish, prawn and shrimp harvest. Integrated production system of crop-livestock–fish has been very old but because of lack of good management skill and ready market of all the products it has not developed as expected.

The Table 6 gives a general picture of different aquaculture systems prevalent in rural India, the rate of production is directly dependent on the extent of input supply and the degree of management (Sinha 1990).

In order to enhance the natural productivity, pond water is fertilized with organic and inorganic fertilizer or wastewater is fed to the pond. Sometime biogas slurry is put in the water. The fish is normally fed with rice bran and oil cake. Formulated feed is given for higher production and pond water is also aerated or changed to support a very high biomass. But normally feeding with formulated feed or aerating the water are beyond the means of common farmers. Polyculture of Indian major carp alone or together with exotic carp as Composite Fish Culture are most popular which are undertaken as with or without fertilization and feed based systems.

Package of practices has been standardized for wastewater-based system, biogas slurry based system, and aquatic weed-based system (Ayyappan, Personal Communication). Cage culture, Pen culture, Running water fish culture are still in the infancy.

Table 6. Systems of production with varying input and degree of management and range of production (estimated)

S.No.	System	Species	Prevalence	Seed	Feed	Fertilizer	Aeration	Production range (kg/ha/yr)
1	Polyculture	Indian major carp	Very common	Fry	-	-	-	100-300
2	"	"	Very common	"	-	Little	-	300-600
3	"	"	Common	Fingerling	-	-	-	600-1000
4	"	"	"	"	-	Little	-	1000-2000
5	"	"	"	"	Rice bran and oil cake	"	-	2000-3000
6	"	"	"	"	"	Adequate	-	3000-5000
7	Composite fish culture	Asiatic carp	"	"	"	"	-	3000-10000
8	"	"	Not common	"	"	"	Plenty	10000-15000
9	Air breathing fish culture Mono or polyculture	Anabus testudineus Clarias batrachus & H.fossilis	Not common	High rate of fry stocking	Rice bran oil cake fish meal etc.	"	-	1000-2000
10	Prawn culture Mono culture	M.rosenbergii M.malcomsonii	"	Post larva	Formulated Feed	"	At times	1000-2000
11	Carp and prawn polyculture	" Asiatic carp and prawn	"	" carp fingerling and prawn post larvae	Rice bran and oil cake	"	-	300-500 of prawn 3000-5000 of fish
12	Rice-fish Culture in freshwater	Carp or/and catfish	"	Wild	-	-	-	100-300 of fish 1-10% increase of rice
13	Fish and livestock	Carp and pig	"	Fingerling 30-40 pig/ha	-	-	-	5000-6000 of fish and 1500-2000 of pork
14	Fish and bird	Carp and duck	"	Fingerling and Duckling 200-300/ha	-	-	-	3000-4000 of fish and 18000-18500 eggs and 500-600 kg of duck meat
15	Rice-fish culture in brackish water	Prawn and mullet and other brackishwater fish	Common	Wild auto Stocking	-	-	-	70-900 of fish and prawn
16	Shrimp culture	P.monodon P.indicus	Common	Post larva	Little	Little	-	1000-1500
17	"	"	Increasing number	"	Adequate formulated feed	Adequate	Adequate	3000-4500
18	"	"	Not common	Very high-density	"	"	Plenty	10000-20000

Culturable Species

The fresh water aquaculture resources in the country comprise of 2.25 million hectares of ponds and tanks, 1.3 m. ha of bheels and derelict waters, 2.09 m of lakes and reservoir as also 0.12 m km of irrigation canal, and 2.3 m. ha. of paddy field. Similarly, brackishwater resources are also vast and varied. The country has a number of lakes, most important of which are the Chilika and Pulicat Lakes and Vemband backwater. An

estimated potential area of 1.42 million ha is available for brackishwater aquaculture. In addition, nearly 2 million ha salt affected soils exist, having a potential to be used for aquaculture.

Indian major carps catla (Catla catla), rohu (Labeo rohita), mrigal (Cirrhinus mrigala), kalbasu (Labeo calbasu) and Chinese carps like grass carp (Ctenopharyngodon idella), silver carp (Hypophthalmicthys molitrix) and common carp(Cyprinus carpio) are the major fish species which are cultivated. Other less important and minor carps such as Labeo fimbriatus, Labeo gonius, Labeo bata, Oxygaster spp, Rasbora spp, Cirrhinus cirrhosa ,Puntius kolus Puntius carnaticus, Puntius pulchellus, Puntius sarana, Puntius sophore, Puntius ticto, and Amblypharyngodon mola are also candidate species for culture since they have regional demand. But availability of seed, is yet a major constraint since the farmers do not know how to produce their seed. Similarly, Wallago attu, Mystus seenghala, Mystus aor, Pangasius pangasius, Rita pavimentata have regional demand in north and north western states but their seed production technology is yet to be perfected. Clarias batrachus, Heteropneustes fossilis and Anabas testudineus are in great demand in eastern and northeastern states. Culture of freshwater prawns Macrobrachium rosenbergii and M. malcolmsonii is getting highly popular under monoculture or polyculture along with carp and at times with Clarius or Heteropneustes.

The tiger prawn Penaeus monodon is the major contributor to the brackishwater aquaculture. Others such as P.indicus, P.merguiensis P.semisulcatus, Mugil cephalus, Liza parsia,Liza tade, Liza macrocephalus, Chanos chanos, Etroplus suratensis, Lates calcarifer are the prime candidate species for aquculture in brackishwater.

3.2 Extent of Rural Aquaculture

As the old saying goes “as you sow so you reap” appears quite apt for aquaculture. The whole system of production is a continuum and it is very difficult to strictly divide in different categories like extensive, semi-intensive and intensive culture systems mainly on extraneous feed supply or off-farm agro-industrial inputs. Similarly, it is difficult to segregate rural aquaculture from entrepreneurial aquaculture, which normally concerns with the intensive cultivation. In fact, many farmers who have been involved in subsistence level production increased their production over the years, with more inputs and better management skill, resulting in enlarging their resource base and gradually becoming entrepreneurial. For example, a farmer who used to stock fry in unprepared pond because of not knowing the technique of pond preparation and usefulness of fingerlings stocking, when came to know, followed the technique strictly and got better harvest and more income. Thus over a period of few years he could afford more inputs and intensified his management and became entrepreneurial. In fact, it is most desirable that the rural aquaculture should be evolved ultimately into entrepreneurial aquaculture and make the resource poor farmers entrepreneurial farmers. Such evolution is already taking place in rural India particularly in freshwater sector.

Shrimp aquaculture in India shows two distinct types of entrepreneurship, one comprised of resourceful farmers and small entrepreneurs another of large entrepreneurs or commercial enterprises. The former practices shrimp farming at low level of intensity which is not very capital intensive or input intensive but the latter undertakes complex commercial aquaculture requiring extensive facilities and management skill with reliable supply of seed and feed to achieve high production. Very high stocking density needs a

considerable amount of freshwater and oxygen. It also requires sophisticated infrastructure to ensure that the products reach the markets in form and quality required by the consumers.

Thus, as per the definition of Edwards and Demaine (1997), fresh water aquaculture and shrimp farming under traditional and extensive systems only should be strictly viewed as rural aquaculture in India.

The status of rural aquaculture in various states is as follows:

Fresh water aquaculture

Andhra Pradesh

Although the state has the distinction of possessing one of the oldest fish farms in the country at Sunkeshula, not much of rural aquacultural activities existed before seventies. However, persistent efforts of the state government, supported by the efforts of the ICAR through its All India Coordinated Research Project on Composite Fish Culture, under CIFRI and later supplemented by the Central Institute of Fisheries Education, resulted in development of entrepreneurial aquaculture in the state and within a very short period it has become the most economic farming practices in the state. The estimated production from aquaculture in the state is about 1,80,000 t. with some farmers producing as high as 5-7 t/ha/yr. and FFDA ponds showing an average production of 3500kg/ha /yr. But the FFDA has covered an area of about 4120 ha only of the total water area available in the state of about 5,17,000 hectares.

Assam

The state is very rich in inland fisheries resources such as ponds, beels, oxbow lakes and derelict water bodies but people were more interested in fishing than fish culture. However, the efforts of the state government, and the work under All India Coordinated Research Project on Composite Culture, helped rural aquaculture to make great progress. Some of the farms started producing fish mainly carp @ 3-4 t/ha/yr. Derelict water is also getting gradually used for airbreathing fish culture, which are also preferred species in the state. In fact, this is partly because of the effort of the All India Coordinated Research Project on Air breathing Fish Culture.

About 23,000 ha of water area is available under ponds and tanks in the state of which 2930 ha has been covered under FFDA, with an average rate of production of about 1885 kg/ha/ yr.

Bihar

The state has a long tradition of rural aquaculture. The estimated production presently is about 130,000 tons of fish. It possesses about 95,000 ha of water area under tanks and ponds. The FFDA has covered about 23,343 ha with an average production @ 2075kg/ha/yr, producing about 1/3 of the total fish production from the state.

Gujarat

The state has very little experience or tradition of rural aquaculture. However, it has picked up in recent years. Gujarat, which possesses about 71,000 ha of water area under ponds and tanks, has already covered 36,983 ha under FFDA producing on an average @ 1,225 kg/ha/yr. The total production is about 45,000 tons of fish.

Haryana

The state had no tradition of rural aquaculture. However, through the persistent efforts and the right strategy of the state, backed by the All India Coordinated Research Project on Composite Fish Culture and then by CIFE, fish culture sector has done exceedingly well. The state has the distinction of becoming one of the most important states of India for freshwater aquaculture. This is by and large entrepreneurial aquaculture.

It is remembered that when WFP/FAO launched a rural development project in collaboration with the state at Mahendragarh district in 1984, it was difficult to convince the farmers to undertake fish culture. In those days fish was not supposed to be touched or cultured by many people in the state.

Now the FFDA farmers have achieved an average rate of production of 2,953 kg/ha/yr, which is one of the highest in India. The state possesses about 10,000 hectares of water area under ponds and tanks. Of which the FFDA has already covered 6807 ha. It is expected that the state will further intensify the aquaculture production.

Himachal Pradesh

The state has hardly about 1,000 hectares of water area available for aquaculture. The FFDA farmers have covered about 300 hectares with an average production of 2 t/ha/yr. The state has no rural aquaculture a few decades ago, however, it is now getting popular and more and more farmers are taking up aquaculture.

Jammu and Kashmir

The state is having a water spread area of about 17,000 hectares as ponds and tanks. But it had no tradition of rural aquaculture before. The FFDA has covered about 3,000 hectares with an average production of 2.5 t/ha/yr.

Karnataka

Although Karnataka has 414,000 hectares of water resources mainly in the form of large tanks, rural aquaculture activity did not exist much before. However, persistent efforts of the state have resulted into FFDA covering an area of about 28,000 hectares with an average production of 1330 kg/ha/yr producing a total of 38,000 tons of fish. The future of aquaculture development will depend on extensive fish culture in large water bodies. Pen culture and cage culture systems need to be immediately popularized.

Kerala

Fresh water aquaculture is becoming an important economic activity in recent years, however, the state has the distinction of being the cradle of rice-fish aquaculture in the country. The FFDA has covered an area of 2,309 hectares of about 3,000 total hectares available under ponds and tanks. The average production has gone up to 1,650 kg/hectare/yr. and thus producing a total of about 3,809 tons of fish.

Madhya Pradesh

The state possesses 1,19,000 ha of water area under ponds and tanks. It has been deeply involved in popularizing rural aquaculture for a long time. It has the distinction of pioneering "bundh breeding" of carp in wet bundh. Through the persistent efforts of the state government and of the ICAR institute (CIFE) Powerkhera, the fish culture activity has been intensified and the state is now poised to take a great leap forward in rural aquaculture.

Maharashtra

Rural fresh water aquaculture was not in vogue in the state. However it has been trying to popularize the same for the past three or four decades. In fact the state has the distinction of producing 10t/ha/yr. in early 70s under AIRCP on Composite Fish Culture at Hadapsar farm at Poona. The results of the project had a conducive effect on the popularization of fresh water aquaculture. The FFDA has already covered an area of 15,071 ha of the total of about 50,000 ha available as ponds and tanks in the state. The farmers are producing an average of 1240 kg/ha/yr.

Orissa

The state has approximately 113634 hectares of water area available as ponds and tanks and has the tradition of freshwater aquaculture. The farmers are also very responsive to improve the management techniques. The FFDA has already covered 27,230 hectares of water area with an average production of 2,105 kg/ha/yr, contributing a total of about 57,319 tons of freshwater fish. The state has always had the best R&D support of the ICAR institute since the establishment of the pond culture division of the CIFRI in 50s, followed by the FARTC in late 70s and then from CIFA since 1986.

Punjab

The state has no tradition of rural aquaculture but has emerged in recent years as one of the most advanced in the sector. The aquaculture production in the state is showing the highest average production in the FFDA ponds touching to about 4,100 kg/ha/yr. The FFDA has already covered 7,148 ha and it appears that there is practically no more fallow water left in the state. The total production of the state is about 29,306 tons of fish. The state has very good potential for further growth.

Rajasthan

The state possesses 180,000 hectares of water area under ponds and tanks, but they are mostly large water bodies. It has no tradition of rural aquaculture but the FFDA has been able to cover 2424 hectares of water area, which is producing on an average @ 2030 kg/ha/yr totaling 4,920 tons of fish.

Tamil Nadu

The state has rich resource of water available as ponds and tanks, which comprises a total of 224,000 hectares. Rural aquaculture has not done very well yet, although it has been giving emphasis for its development. The ICAR has supported the state efforts through its AICRP on Composite Fish Culture at Bhavanisagar during 70s. In recent years it has taken up a vigorous program of aquaculture development. Presently 5114 hectares have been covered under FFDA program with an average production of 1240 kg/ha/yr. totaling 6341 tons of fish.

Uttar Pradesh

There has been an increase in rural aquaculture activity in recent years, although the state govt. has initiated its efforts in the late 60s. Big farms were established by the state administration and with the collaboration of ICAR, the AICRP on Composite Fish Culture and Seed Production was started in 1971 at one of the largest fish farms of the state located at Gujartal. The project was engaged in R&D activities and organized training programs for farmers and extension workers. The farm has the unique distinction of breeding grass carp and silver carp for the first time in the state in 1973 from the brood stock from composite fish culture pond. Presently, 80452 hectares of a total of 162000 ha have been covered under FFDA, which has shown an average of 2320 kg/ha/yr. with a total production of 186,648 tons of fish.

West Bengal

The state has a long history of both freshwater and brackishwater aquaculture and its activities are being progressively intensified. Persistent efforts of the state government and supplemented by R&D support provided by ICAR in 70s through AICRP on Composite Fish Culture at Kalyani, Operational Research Project on Composite Fish Culture at Krishnanagar, National Demonstration Centres, and also though IDRC supported Rural Aquaculture Project, have gone a long way in successful development of rural aquaculture in the state. The state became surplus in fish seed production and farmers are becoming entrepreneurial. Presently, the FFDA has covered about 23,343 ha water area of the total available of 2,76,000 ha with an average production @ 3t/ha/yr and thus producing a total of 305,205 tons of fish.

Northeastern States

Tripura has a long history of aquaculture but now all the Northeastern states have been giving considerable emphasis on the development of rural aquaculture.

These states have about 72,000 hectares of water spread under ponds and tanks and the FFDA has covered about 6,849 ha. The average production rate of the states is 1,928 kg/ha/yr. The total production is 1,328 tons of fish.

Brackishwater rural aquaculture

As it is clear from the tables 4 and 5, very little brackish water resources have been yet utilized, for example, Gujarat with 376,000 ha. of potential brackish water area suitable for aquaculture, is currently utilizes only 700 ha., leaving an unutilized resources to the extent of 98 %. Similarly, utilization is very low in Maharastra (3%), Goa (3%), and West Bengal (8%).

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3.3 Socio-economic Aspects

Access to public water bodies

Generally, landless and rural poor do not have the physical access to infrastructure facilities to undertake fish culture nor have the economic access to procure inputs. It is important that the government should formulate and implement legal framework for water rights and rights to water based resources so as to allow access and user rights to rural poor to undertake aquaculture in such bodies, which are by and large under public domain.

Subsidy and bank loan

They have also practically no asset to offer for collateral as security for obtaining institutional finance, which howsoever directed toward social goal of raising the lots of poor, serves by and large a commercial concept of lending and capital growth. It is therefore necessary to evolve mechanism to provide institution finance without physical collateral. Perhaps farmers` certificate of successfully completion of training in fish culture from a government institution or their actual knowledge of fish culture may act as collateral.

Under the FFDA scheme the subsidy for tank reclamation and inputs, farmers get 25% subsidy whereas banks give 75% loan. But the amount of subsidy and loan are inadequate and farmers normally do not have the means to do adequate improvements or to buy required inputs. Procedural delay in obtaining this amount also creates problems to the farmers and at times they get frustrated and discouraged. The financial institutions also require that the Government release the subsidy before they release the loan and any delay in releasing the subsidy also delays the sanction of the loan and thus adversely affects production.

Lease of water bodies

Short duration lease of water bodies has been one of the main constraints. **A** study made by the IMA, Ahmedabad (1991) has shown that at the All India level 87.5% of the ponds were leased out for 5 to 10 years and 9.4% for less than 5 years. Merely 3% of ponds were leased out for more than 10 years. Individuals (30%) and partners (70%) took lease**. U**ncertainty attached in short duration lease discourages the farmers to

undertake major renovation of the ponds and in the last year of the lease they normally do not spend on the inputs also. Banks normally hesitate to lend money in such cases.

Insurance

Insurance scheme is available in certain states, the IMA study (1991) showed that although the percentage of fish farmers who suffered is high, the percentage of farmers taking insurance and claiming for damage is vary small. This is mainly because of the hassles involved in keeping proper record, complexities of preparing claim certification and processing of the claim.

Marketing

It is interesting to note that during 1970s carps from Bangladesh were seen being sold in Calcutta markets but now fish from Andhra Pradesh is said to be sold in Bangladesh. Indian major carps are sold in the U.K markets particularly to those places where Indian population is sizable. However, secondary and tertiary markets are emerging for carps all over India. Yet, strictly speaking poor farmers have to sell their produce in the local market at a very cheap price or to middlemen. Proper mechanism is still inadequate to collect and disseminate information about the prices and markets. Wholesalers and commission agents have the key role in marketing fish for the farmers. However, the farmers share some time as high as 88% of the sale price in the local sale though, it is much lower in the outstation price. In the outstation sale the producers get about 60% of what consumers pay.

It is important that proper infrastructure is created for efficient marketing of aquaculture products. Government should invest more and also encourage private sector investment in market infrastructure development serving farmers and entrepreneurs.

Also creation and expansion of small-scale credit and saving institutions are necessary to facilitate development of aquacultural trading, transportation, and processing enterprises.

3.4 Environmental Issues

Loss of productivity and of water from freshwater ponds

Loss of productivity and of water from fallow ponds is of great concern. With the influx of adequate sunlight, aquatic ecosystem has the potential for a sustained rate of assimilation as high as 4 to 8g biomass/m2/day or about 30 tones of dry weight/ha/yr. If this productivity is not optimally utilized through aquaculture, it disrupts the aquatic environment and with continued nutrient run off from the catchment, results into eutrophication of the ecosystem, giving rise to algal bloom and water hyacinth and other obnoxious weed infestation. It is important to note that animal waste in the form of urine and excreta of 186 million cattle, 77 million buffalo, 45 million goats, 10.8 million pigs and 258 million poultry, continually find their way to aquatic ecosystem.

Aquatic ecosystem shows first sign of disruption when the amount of its oxygen production does not keep pace with its requirements. Scientific fish culture management

improves the oxygen imbalance, otherwise, reduction stage sets in the ecosystem and considerable amount of hydogen sulphide and methane are produced.

Gradual appearance of the aquatic weed from submerged to emergent variety normally shows highly distressed condition of the ecosystem. Because of such weeds, increasing amount of silt is trapped, adversely affecting the total volume of the ecosystem and its carrying capacity. The most noxious weed like water hyacinth (Eichhornia crassipes) starts flourishing. In India 60-70 % of inland water is presently infested with aquatic weed predominantly by water hyacinth.

Considering the capacity of growth and regeneration of water hyacinth, loss of water from the ecosystem is enormous. It registers 5% gain in weight every day. Two parent plants produce about 30 offspring in 23 days resulting in 12000 plants, with a total weight of 470 tons in 4 months (Barrett 1989). At least 80% of the plant body constitutes water i.e., 376 tons of water is contained in 470 tons of water hyacinth. Added to this, loss through transpiration is also considerable and many folds than normal evaporation from the aquatic ecosystem.

Although India is not among the 26 countries of the world which have been declared water stressed, it cannot afford to loose such an amount of freshwater from the ecosystem. In fact, it faces the challenges of water scarcity, the per capita availability of water in the country is 1/3 compared to two decades ago. Also in many places the water table has gone down from 8 meters to 48 meters now.

Thus, because of poor productivity management and eutrophication, aquatic ecosystems to a large extent are stressed and disrupted in the country. Wherever fish culture is taken scientifically, it improves and maintains the oxygen balance which is the lifeline of the ecosystem like that of any plants and animals. Thus fish is to be viewed as a major ecological player and fish culture as a major tool to improve and restore the aquatic ecosystem.

Environmental consequences of brackishwater aquaculture

Loss of mangrove

A great concern has been shown towards loss of mangrove in India because of shrimp farming. A rough estimate indicates that in Andhra Pradesh, the maximum loss of mangroves towards shrimp farming is 8,000 ha, accounting about 40%. Whereas Orissa and Tamil Nadu have lost respectively about 4,000 ha (26%) and 4,000 ha (26%). In West Bengal, a total of about 5,000 ha out of a total of 420,000 ha i.e., about 1.25% of true mangrove areas in the Sundarbans have been cleared for shrimp farms.

Loss of biodiversity

The shrimp culture industry initially relied heavily on wild seed, which resulted in a very serious threat to the natural populations of fish and shellfish in estuaries and rivers. It has been estimated that 18 post larvae of other species of shrimp and fish are sacrificed for every post larva of *P. monodon* collected from the wild. In West Bengal total annual harvest of wild shrimp seed was around 400 million, causing destruction of billions of

other fish and shrimps. This is a colossal loss of biodiversity. However now the situation is improving fast because of the establishment of shrimp hatcheries.

Conversion of agriculture land

No detailed survey is yet undertaken to see the trend of conversion of agricultural land. But a rough estimate indicates that in Andhra Pradesh, about 4,000 ha (about 1.5%) of paddy fields have been converted into shrimp farms. This is followed by 2,000 ha (0.5%) in Orissa and 800 ha (0.8%) in Tamil Nadu (Babu Rao, Personal communication). The trend of such conversion is not very desirable, however it should not be viewed as an alarming situation particularly when the total coastal saline soil of the country amounts to 3.1 million ha. Further, there are reports that about 800-1,200 ha of salt pans have also been converted into shrimp farms in the State of Andhra Pradesh (Sinha 1996)

Salinization of portable water

Salinization of fresh water has been reported because of heavy consumption of ground water for shrimp farming. Freshwater wells have been reported to have turned saline in Nellore. Krishna and west Godavari districts in A.P.

Nutrient loading

Nutrient loading is yet another problem which has been encountered in semi intensive and intensive culture mainly because of high protein food. As much as 7.5% of N and 80% of P from feed are wasted and enter the environment. A rough estimate puts it as one ton of *P. monodon* production results in a loading of 57.31-2 kg of N and 13.0-24.4 kg of P in the pond, causing unmanageable *self pollution.*

Study undertaken by the National Environmental Engineering Research Institute (NEERI), Nagpur on the socioeconomic of the farmers in Andhra Pradesh and Tamil Nadu, suggested that the cost of the ecological and social damage has exceeded the benefits that have accrued to the farmers due to adoption of shrimp aquaculture activities. The validity of the findings needs proper evaluation. Many seriously doubt such inference. Thakur, Reddy and Prakash (1997) clarified many of the points raised regarding pollution being caused by shrimp farming. However, Government of India acted immediately and formulated the guidelines for sustainable aquaculture and also created a regulatory and monitoring body known as Aquaculture Authority of India to regulate and oversee the desirable development of aquculture (Yadav, Personal Communication).

It is important to note that paddy-shrimp culture and extensive system of shrimp farming are environmentally compatible. The problems start with intensification and multiplication of the farms without giving serious thought of the implications.

Loss due to sub-optimal production

Loss due to sub-optimal production becomes very important in the context of rural aquaculture. It should be viewed seriously and all attempts should be made to improve the productivity under traditional culture. For example, about 33,000 ha. in West

Bengal is under the traditional method of shrimp cultivation, with a production range of 70-215 kg/ha/yr., averaging 186 kg/ha/yr. This is about 714 kg/ha/yr less than the production obtained in Kerala under traditional culture i.e., 900 kg/ha. Considering the total bheri area available in West Bengal this low average production amounts to loss of 23,562 tons equal to financial loss of Rs. 4,712 million.

Similarly, in the States of Karnataka, Maharashtra, and Gujarat the average production is in the range of 100-340 kg/ha/yr. Taking into account the area available in three States (Tables 4 and 5), the production/revenue loss is very significant. Thus, there is a strong justification to raise the shrimp production level under the traditional culture system in these states, so as to reach 900 kg/ha/yr as in Kerala.

Environmental Impact Assessment

As per the constitution of India, the aquatic resources management and exploitation except marine resources are under the state control. The Central Government however, provides overall guidance and suggestion for impact analysis of all the projects having an impact on the natural resources or on people's habitat. Aquaculture projects should not violet any customary right and rights guaranteed by the constitution particularly about water resources. The people can challenge the execution of projects on grounds of violation of fundamental right guaranteed under Article 19(1) (g) of the constitution (Sinha 1996). Environment assessment (EA) is not yet mandatory for all aquaculture projects. The Ministry of Environment, Government of India on a case basis examines individual project on its merit to determine whether EA will be required. Certain states have Land Use Board or their own Environment Department, which review the project environmentally. But the Aquaculture Authority of India requires the EA of larger aquaculture projects. However it is important that mitigating plans must be made for any possible adverse impact.

Table 4. Status of state-wise shrimp farming in India

State	Production system (ha)	Resource	Water flow	Total area (ha)	Suitable area for shrimp	Salinity (ppt)	Stocking density (000s/ha)	Feeding	Cycle	Yield (kg/ha/yr)
West Bengal	Extensive (traditional)	Wetland bheries, seasonal & perennial	Saline tidal waters from estuaries	32,930 low saline (9,944 ha) medium (15,613 ha) high (7,472 ha)	32,930	1-10 10-20 up to 37	40-50	No feeding	2	70 214 84
Orissa	Confined and tidal gheries (extensive)	Wetland gheries of 2-50 ha each with constructed embankment	Saline tidal waters from estuaries	31,600	31,600	15-20	10-12	natural food	2	250-450
	Confined ponds (semi-intensive)	0.2-0.5 ha ponds around Chilka lagoon	Monsoon – runoff			L – o-15 M – 10-20 H – 20-32	20-25	MOC + rice bran. crushed land snail	2	730-1,025
	Intensive (case study) Paradeep	In two 0.33 ha well fertilized, manured & aerated ponds	Brackish water canal				15-30	Protein rich supplemen-tary food (imported)	One (116 days)	3,000-5,000

Table 4. (contd….)

State	Production system (ha)	Resource	Water flow	Total area (ha)	Suitable area for shrimp	Salinity (ppt)	Stocking density (000s/ha)	Feeding	Cycle	Yield (kg/ha/yr)
Andhra Pradesh	Extensive (traditional areas 1-5 ha each)	Low-lying	Estuaries	63,663	17,006	L – 0-15 M – 10-30 H – 15-32	15-30	Natural	2	250-500
	Semi-extensive	Slightly elevated areas ,1-2 ha	estuaries			15-20	30-75	Natural 50% Artificial 50%	2	500-1,500
	Semi-intensive	Elevated area, 0.5-1.0 ha each	Estuaries				8,300	Mainly artificial	2	1,500-3,000
	Semi-intensive (case study)	5 well aerated & fertilized ponds of 0.8 ha each	Creek			20-25	250-280	Artificial	2	4,000-5,000
Tamil Nadu	Extensive (traditional)	Backwaters lagoons & mangrove swamps	Pump fed tidal water	56,000	15,000	10-20	10-20	Natural	2	500-600
	Semi-intensive	---do---	---do---			20-45	40-50	Natural + supplementary	2	500-1,500
	Intensive	---do---	---do---			20-45	200-300	Imported	2	3,000-8,000

Table 4. (contd….)

State	Production system (ha)	Resource	Water flow	Total area (ha)	Suitable area for shrimp	Salinity (ppt)	Stocking density (000s/ha)	Feeding	Cycle	Yield (kg/ha/yr)
Pondicherry	Semi-intensive to intensive (under developmen-tal stage)	Brackish-water area	Estuarine tidal water	800	456	15-20		Supplementary		
Kerala	Extensive (traditional)	Backwaters, perenial & seasonal paddy fields	Estuarine	12,987	12,987	5-20	Natural ingress from tidal water	Nautral	2	839-903
	Intensive (case study) Kannur	0.12 h well aerated pond (fertilized, manured & limed)	Pump-fed estuarine waters			15-20	280	Imported	1	3,000
Karnataka	Extensive (traditional)	Khar & low-lying land	Tidal water	8,000	4,200	10-20	Natural ingress	Natural	1	340
Goa	Extensive (traditional)	Khazan paddy fields	Tidal water	18,000	12,500	15-18	---do---	---do---	1	
Maharashtra	Extensive (traditional)	Salt pans	---do---	80,000	14,555	20-25	---do---	---do---	1	325

Table 5. State-wise details of shrimp farming in India

State	Estimated potential area (ha)		Year				
			1990-91	1991-92	1992-93	1993-94	1994-95@
West Bengal	4,05,000	A	33,815	33,918	34,050	34,150	34,400
		P	12,500	13,800	16,300	16,500	25,00
Orissa	31,600	A	7,075	7,417	7,760	8,150	8,500
		P	4,100	3,800	4,300	3,300	4,800
Andhra Pradesh	1,50,000	A	6,000	8,100	9,500	19,500	34,500
		P	7,350	9,700	12,800	26,000	26,000
Tamil Nadu	56,000	A	250	480	530	1,050	2,000
		P	450	700	1,100	2,000	3,000
Pondicherry	800	A	Neg.	Neg.	Neg.	Neg.	Neg.
		P	Neg.	Neg.	Neg.	Neg.	Neg.
Kerala	65,000	A	13,000	13,145	1,3000	13,860	14,100
		P	8,925	9,500	9,750	11,500	12,000
Karnataka	8,000	A	2,500	2,542	2,570	2,600	3,500
		P	1,000	1,100	1,150	15,000	2,500
Goa	18,500	A	525	525	550	575	600
		P	245	300	350	400	450
Maharashtra	80,000	A	1,800	1,869	1,980	2,180	2,400
		P	800	920	1,050	300	400
Gujrat	3,76,000	A	125	231	360	475	700
		P	125	170	200	500*	700
Total	11,90,900	A	65,100	68,227	70,700	82,540	1,00,700
		P	35,500	40,000	47,000	62,000*	74,850

* Apart from this 3,000 tonnes of freshwater prawns are produced from the farm in Gujarat State.

@ Estimates

A Area under culture

P Estimated production

Source: MPEDA

4. National Policies, Plans and Programs for Rural Aquaculture

Indian agriculture has passed through three very distinct phases of development during the present century. Pre-independence period of 1900-1947 was a phase of near stagnation of agricultural development, showing a growth rate of about 0.3% per annum. But after independence, the situation improved with spread of technologies, based on scientific research and supported by wide range of services including increased supply of inputs. This marked the second phase of development during 1950-80, achieving a growth rate of 2.8% in 1967-79. The development was facilitated with the policies of land reform, pricing, procurement and distribution especially in the assured irrigation belts.

The third phase aimed at further improving marketing and trade, providing institutional framework for minimizing constraints of small farmers, and maximizing their benefits through intensive agriculture in small holdings. Marked improvement was seen in land and labor productivity as well as in generation of employment and augmentation of family income.

Of late, sustainability of agriculture production and preservation of environment and of natural biodiversity are of great national concern. Greater emphasis is being laid now on optimizing ecological productive potential revolving around a watershed approach with water harvesting and efficient use of nutrients through recycling for better energy transfer. More stress is given on social and community development

Thus the strategy for development is mainly directed towards more efficient land and water use, based upon soil and water conservation, efficient water harvesting and the optimum utilization of available sources of renewable and non-renewable energy without impairing the environment. Matching with these, provisions are made for the farmers to get adequate credit, inputs, and technology and extension support along with ensuring proper distribution and marketing of their produce.

In general the main national objective of agricultural development is to build a national food security system by stabilizing farm production at higher levels and also creating rural employment and income.

In the above background Fisheries sector is viewed as an important source of earning, livelihood, foreign exchange and food supply. It grew about 7% compound in quantitative terms during mid seventies, then slowed subsequently, picking up in late eighties. It was only in the mid eighties that concerted attention was paid and for the first time in a few years and respectable growth rates were achieved in the real quantum of fish exports. The planners were then dimly aware of the great employment and income potential of the fishery sector in India. However, the appraisal of fishing harbour projects and a few inland fisheries projects by the Project Appraisal Division of the Planning Commission had shown high social rates of return (Alagh 1992).

Fisheries National Policy and Programs

The national policy on fisheries development in general stresses on optimal utilization of natural resources through their rational exploitation, centers round the concept of giving a better deal to socially backward communities, more and better employment opportunities, and increasing aquatic productivity on a sustainable basis.

The national development programs include organization of necessary infrastructure for fish production, storage and distribution, and mobilization of manpower at various levels for production and marketing, thereby accruing maximum assured benefits to the producer and consumer, reducing middle level involvement to the minimum. Earning of foreign exchange through export of fishery products, without adversely affecting domestic requirements is also an integral part of national programs (George and Sinha 1975).

Aquaculture Development Plan

FAO undertook initiative to organize a workshop in 1975 for three weeks in Bangkok where planners and aquaculture scientists from different countries of Asia discussed in depth aquaculture development aspects and formulated a Ten-Year Aquaculture Development Plan 1975-85. This was the first effort ever made to formulate a plan exclusively for aquaculture in India (George and Sinha 1975)

Long term objective

The plan objective was to progressively raise the subsistence level aquaculture activities to the level of an organized industry. To achieve this the plan reiterated the following:

- Establishment of an effective mechanism by which the advances made in the technology of fish cultures could be disseminated for the purpose of increasing fish production in small water areas such as ponds and tanks.

- Adoption of an integrated approach to the problems of development, comprising of filling up the gaps in the technology, organizing training of manpower and provision of necessary inputs.

- Assigning priorities for securing a greater flow of institutional finance for fish culture programs.

Medium term objectives

- Progressive adoption of improved technology of fish production in certain selected areas

- Brackish water fish culture with particular emphasis on shrimp

- Fish seed farms in each district and possibly in each sub-division.

- Developing technique of culture of frogs, mollusks, sea weeds, etc
- Developing running water carp and catfish culture.
- Further research on nutrition and reproductive physiology of cultivated species of fishes and crustacean so as to have better control on their growth and breeding. Formulation of suitable feeds.
- Further research to obtain still better fish production through improved methods of aquaculture
- Developing fish culture in the cold water areas of the country.
- Development of culture technology for the non-conventional species of fish, molluscs and crustaceans to bring them into the orbit of culture programs.

Short-term objectives

- The immediate goal was to reach reasonable production levels through substantial development of aquaculture in the country with available technical know-how, and to adopt improved technology of fish production in selected areas under traditional culture.
- Immediate emphasis to be given on the production of cultivable fish seed and their efficient rearing in selected area in each state to provide the stocking material.
- To create and activate the category of fish farmers all over the country by introducing suitable training programs combined with making water areas and inputs available to carry out fish cultures.
- Making available water areas to the fish farmers on long-range lease, so as to link leasing with production programs.
- To provide basic infrastructure for brackish water fish and shrimp farming by constructing hatcheries for organized production of seed.
- Bringing the financing institutions and fish farmers closer so that they may not be financially handicapped in undertaking scientific fish culture.

Plan Projections

The development plan made realistic projections to increase aquaculture production. Matching with this, detailed projection of total inputs requirement was indicated. It also assessed the initial development cost and floating capital for stocking material, organic manure, inorganic fertilizers, feed etc. Estimates were made of additional manpower requirement and increase in employment potential etc. The document also provided certain basic information on production cost and possible return.

Considering the difficulties in procurement of adequate stocking material and other constraints, it was assumed that only 5% of the readily available freshwater would be utilized for carp culture annually from 1975. However for air-breathing fish and brackishwater fish and shrimps the starting date was indicated as of 1979, since both the systems of culture were not that ready for easily adoption in the field and also because of other associated problems. It was thus envisaged that in 1985 average production rate for carp would be about 1300 kg/ha/yr (ranging from 600-2000 kg/ha/yr) whereas for air breathing fish and brackishwater shrimp and fish @500kg/ha/yr.

According to the plan, it was expected that in 1985, aquaculture production from carp would be about 0.776 million tons, from airbreathing fish about 0.26 million tons and brackishwater fish and shrimps about 0.45 million tons. However, while carp total production reached a figure of 0.672 million tons in 1986, air-breathing fish and brackishwater fish and shrimps did not contribute as expected.

The plan document significantly identified one of the major constraints in attaining the objective of aquaculture development, as the lack of an advanced center for aquaculture research, with properly designed experimental fish farms both for freshwater and brackish water where aquaculture systems could bedeveloped. It was estimated that approximately Rs 30 million would be needed to establish the center by 1984. However, for such center, external assistance was required in terms of equipment, consultancy and fellowships and the thus the plan identified specifically those components.

While the Govt. of India/ICAR initiated establishing the FARTC at Dhauli/ Bhubaneshwar in 1977, which became functional in 1979 under CIFRI, a FAO/UNDP project was formulated on the basis of the above plan on Intensification of Fish Culture and Training and was implemented at FARTC in 1979. The project had three major components such as consultancy services, fellowships and certain equipment, costing a total of about USD 0.5 million. On completion the Center not only became a national asset, but also played a significant role in carp farming research and training in the region under a UNDP/ FAO Regional Project on the establishment of a Network of Aquaculture Centers of Asia.

The Ten-year Aquaculture Development Plan was formulated most meticulously with highly realistic assumptions and matching with these, the priority programs undertaken in the subsequent Five-Year Govt. of India Development Plans enabled the nation to achieve the objectives as set out in the plan. However, in any development planning, the need to synchronize the various aspects of development cannot be over-estimated. In case of aquaculture, these aspects were development and transfer of basic technology, training of manpower at various levels, availability of inputs at reasonable cost, provision of credit and financing facilities and to give effective supervision and leadership. These will, naturally be required in a continuous manner in future also for further development.

Brackishwater Rural Aquaculture

Brackishwater aquaculture development in general got a boost in India only during the mid eighties with the expanding world demand and high price for shrimps in the overseas market. However the focus became more tilted towards export earning rather than the rural development through traditional shrimp farming. Unfortunately the

country relied on technology import from other countries particularly from Southeast Asia. Entrepreneurs followed the high energy intensive coastal aquaculture technology which increased the production level from 1-2 t/ha/yr to over 10-20 t/ha/yr. This resulted in creating certain environmental problems as indicated in para 3.4.

A Ten-Year Plan has been recommended for the development of brackishwater shrimp farming in 0.1 million ha comprising 75,000 ha under extensive 20,000 ha under semi-intensive and 5,000 ha under intensive culture system.

While efforts were being made to achieve such a target, the sector suffered a serious turbulence because of disease epidemic and certain environmental problems. However, it is expected that with the establishment of Aquaculture Authority of India, systematic development will take place and also traditional aquaculture will get priority attention. However, it is important to adopt the following site specific development strategies to have a balance development (Ghose and Sinha 1991).

1. Area having large resources where traditional trapping and growing is undertaken, the farmers need to be given support for:

   - Scientific innovations to upgrade their traditional methods to achieve average production 900kg/ha/year;
   - Ensuring availability of pollutant free water from estuaries creek and sea;
   - Infrastructure at public expense for marketing and to ensure quality of produce for better return.

2. Areas where fisherman population and resources are both high such as Chilka lake and Pulicat lake

   Such large areas having traditional fish farmers need to be developed into cluster of fish farms. Support services as shown above should be provided by the Government.

3. Areas with no tradition of brackishwater farming but having a fairly stable and developed sea fisheries such as all along the coast of Gujarat, Maharashtra, Goa, Karnataka and southeast coast of the country

   These areas to be increasingly used for semi intensive farming by entrepreneurs and industrial houses, which could afford to invest to develop infrastructure and facilities required for commercial culture of shrimps.

5. INSTITUTIONAL ASPECTS

5.1. Governments and NGO

Although fisheries including aquaculture is a state subject, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, assists and coordinates the developmental activities in the states and provides finance for central sector schemes. Each state has a full-fledged department of Fisheries, which looks after aquaculture development in the state. The last Five-Year Development Plan (VIII Plan) had an outlay of Rs.11,723 million for fisheries sector.

In general, in early days, aquaculture development in India emphasized on public sector development of large-scale carp hatcheries for meeting seed requirement. The World Bank and its affiliates provided developmental aid and soft financing for hatchery development. Other international projects for aquaculture R&D were confined mainly to strengthening infrastructure for research, Human Resource Development (HRD) and extension support.

Development of aquaculture through FFDA had been a unique endeavor. This important program is being implemented through the states. The scheme was started in 1973-74. Initially Government of India financed the setting of FFDAs on 100 % basis, but later revised to 50:50 basis shared between Central/ State governments. The number the FFDAs has been progressively increasing with improvement in pond productivity. Presently 414 FFDAs are in operation with an average rate of fish production to 2183 kg /ha/yr during 1996-97.

The FFDA provides a package of technical, financial and extension support to fish farmers. The agency arranges suitable water area on lease on long term basis to identified beneficiaries, provides incentives for construction of ponds and tanks, and also inputs for first year of fish culture operation. The following are the subsidy and details of other supports, given to the farmers.

- Subsidy @ 20% with a ceiling of Rs. 20,000/- per ha for construction of new ponds
- Subsidy @ 25% with a ceiling of Rs. 25,000/- ha for renovation, reclamation of ponds and tanks
- Subsidy @ 25% with a ceiling of Rs. 4,000/- ha for first year inputs (fish seed, fish feed, fertilizers, manure etc.)
- Subsidy @ 25% with a ceiling of Rs. 2,000/- ha per unit of 1500 sq ft with 3 ft depth of running water fish culture.
- Subsidy @ 25% with a ceiling of Rs. 10,000/- ha for integrated fish farming with piggery, poultry, duckery, etc.

- Subsidy @ 25% with a ceiling of Rs. 50,000/- for establishment of freshwater prawn and other finfish hatchery with 5-10 million fry production capacity.

- Training programs of fish farmers provide a stipend @ Rs.25/- per trainee per day and Rs. 40/- as lump sum for the cost of travel during field trip.

- For establishing fish farmer training center - A one-time grant of Rs.500,000/- to any state to establish one such training center .

- Under the program 50 % of the salaries provided of the incremental staff @ one extension worker for 100 ha water area and one extension officer per 10-extension worker.

In order to encourage the scheduled tribe fish farmers, they are given twice the amount, for items as shown above in first to four bullets.

Subsidy for construction of new ponds, renovation of existing ponds, and first year input to an individual beneficiary up to 10 ha is given with or without institutional finance.

Since inception of the scheme, the progress made by the FFDAs is as follows:

- Water area covered: 0.422 million ha
- No. of farmers and fishermen trained: 0.538 million
- No. of beneficiary covered: 0.780 million

The other details about FFDAs are given in Table 7.

Table 7. Activities of Fish Farmers Development Agencies (FFDAs) during 1996-97

State/UT	Number of FFDAs	Water area covered (ha)	Fish Farmers trained (#s)	Number of Beneficiaries	Average production kg/ha/yr
Andhra Pradesh	22	4120	11927	5805	3500
Arunachal Pradesh	2	308	1450	1775	1100
Assam	23	2930	14908	9332	1885
Bihar	49	23343	23311	18151	2075
Goa	1	0	0	0	---
Gujarat	17	36983	13255	13600	1225
Haryana	16	6807	9490	9692	2953
Himachal Pradesh	2	292	2082	1146	2000
Jammu & Kashmir	2	3140	1713	1803	2550
Karnataka	18	28602	9428	6198	1330
Kerala	14	2309	7669	11506	1650
Madhya Pradesh	45	67633	29169	67148	1705
Maharashtra	29	15071	9628	56401	1240
Manipur	8	2059	3473	6195	1450
Meghalaya	2	325	749	749	700
Mizoram	5	286	816	959	1750
Nagaland	8	1724	2751	7513	2500
Orissa	30	27230	41747	110324	2105
Punjab	17	7148	13218	9557	4100
Rajasthan	15	2424	8792	1970	2030
Sikkim	1	14	687	821	3500
Tamil Nadu	17	5114	7386	9654	1240
Tripura	4	2133	60185	19305	2500
UP	56	80452	78183	75161	2320
West Bengal	18	101735	185485	335122	3000
Pondicherry	1	99	454	563	1100
Total	422	422281	537956	780450	2183

UT - Union Territories
UP - Uttar Pradesh

Source: Yadav - Personal communication 1998

The scheme had an outlay of Rs. 420 million during the Eighth Five Year Plan against which Rs.438 million were released by the Central Government to the States/Union territories for development of freshwater aquaculture.

Besides the efforts of the Central and State Governments, many NGOs and private organizations are also involved in rural aquaculture development, the most notable are Ramkrishna Mission and M.S.Swaminathan Research Foundation for Sustainable Agriculture. In fact, The traditional, social and religious outlook of Indian way of life being service to poor and needy, which gained momentum under Gandhiji has created a number of national and regional service organizations deeply involved in the development of rural poor, and many of these social organizations promote development of rural aquaculture.

5.2 Support Services

Education and Research Institutions

The Indian Council of Agricultural Research (ICAR), New Delhi is the apex national body for research, education and extension education in agriculture, animal sciences, agricultural engineering and fisheries including aquaculture. India has the distinction of having the Central Institute of Fisheries Education, Mumbai as a deemed University, the first of its kind in the Indian Sub-continent. The Institute imparts education at masters and doctoral levels in fisheries including aquaculture and also conducts post-graduate diploma courses. It has six campuses and eleven departments. The Central Institute of Freshwater Aquaculture, Kauslyaganga, Bhubaneshwar also offers Post graduate programs of Master in Fisheries Science and Ph.D. in Freshwater Aquaculture.

Fisheries Colleges under different State Agricultural Universities at Berhampur, Cochin, Dholi, Mangalore, Pant Nagar, Tuticorin are involved in teaching fisheries and aquaculture at the graduate level. Recently, the University Grants Commission, New Delhi has sponsored degree courses on Industrial Fisheries (which includes aquaculture) at different Science Colleges in many parts of India.

Although, all the eight fisheries research institutes under ICAR namely Central Institute of Fisheries Education (CIFE), Mumbai, Central Institute of Freshwater Aquaculture (CIFA), Kauslyaganga, Central Inland Capture Fisheries Institute (CICFRI), Barrackpore, Central Institute of Brackishwater Aquaculture (CIBA), Chennai, Central Marine Fisheries Research Institute (CMFRI), Cochin, Central Institute of Fisheries Technology (CIFT), Cochin, National Bureau of Fish Genetics Resources, (NBFGR) Lucknow, and National Research Center On Coldwater Fisheries (NRCCF), Haldwani, are involved on different aspects of aquaculture, the CIFA and CIBA are totally devoted to undertake aquacultural research respectively in freshwater and brackishwater. ICAR under certain schemes also funds research on aquaculture at different universities. Research laboratories of universities at Aligarh, Bhagalpur, Calcutta, Delhi, Kalyani, Nagpur, Sagar, Santiniketan, Varanasi and many more, are engaged on different aspects of aquaculture.

The Central Institute of Freshwater Aquaculture, Kausalyaganga, established in 1986, is the premier institute in the country with the mandate of conducting research on different aspects of freshwater aquaculture and of undertaking specific programs for transfer of technology. The Institute serves as the Lead Center on Carp Farming under the Network of Aquaculture Centers in Asia-Pacific (NACA), now an

intergovernmental regional body. The institute has six centers in different parts of the country to cater to the specific needs of the region. It is also deeply engaged in disseminating aquaculture technologies through organizing training programs at its regional centers, KVK/TTC at Kausalyaganga and also at Centers of Operational Research Project located in different states of India.

The Central Institute of Brackishwater Aquaculture, Chennai, established in 1986, is engaged in conducting research on different aspects of brackishwater aquaculture as a national institute and also mandated to undertake transfer of technology through training, education and extension education programs. The institute has three research centers located at Kakdwip in West Bengal, Puri in Orissa, and Narakkal in Kerala.

Extension and Training

Each State Government has a full-fledged Department of Fisheries fully responsible for extension and training. As many as 422 FFDAs and 39 BFDAs have been sanctioned by the Government of India, and are entrusted with extension and training activities pertaining to aquaculture. While FFDAs trained about 780450 fish farmers, BFDAS trained 15000 shrimp farmers.

The KVK/TTC at Kausalyaganga have been deeply involved in extension and training activities on modern aquaculture technologies for the benefit of farmers and trainers, since their inception in 1977. In-service training programs for middle order executives and extension personnel on different aspects of aquaculture are organized at the CIFA and CIBA

For providing training to funding/ financing personnel in agricultural sector including aquaculture, the Reserve Bank of India runs regular courses at the College of Agricultural Banking, Pune. Similarly ad hoc training programs are organized by National Bank of Agricultural and Rural Development (NABARD), State Bank of India and also by other banks for managers, trainers and beneficiaries involved in aquaculture projects. The National Council for Cooperative Training organizes training programs for cooperative managers.

5.3 Package of Training Programs

Though the efforts are afoot for transfer of technologies, it is still a difficult task to organize effective training programs at the grassroots to create skilled fish farmers. Effective and uniform curriculum of the training programs is seldom followed. In fact, at times it is seen that different organizations not only differ in their approach in imparting training but the course contents also differ considerably. Keeping these in view, the followings are some of the examples of training packages that are currently being used for promoting rural aquaculture development.

1. Pond Construction and Renovation

Location: Well-laid out fish farm.

Duration/Season: 3 days during summer.

Resource Person:	Irrigation Engineer.
Clientele:	Group of 15-20 fish farmers, farm women, and landless rural poor
Method of Instruction:	Demonstration and discussion
Course Content:	Logistic of the site selection, water supply, soils and waters quality, shape and size of the pond, water inlet and outlet structures and drainage facilities. Embankment construction, turfing of the embankment, plantation on the embankment. Leveling of the pond.
Renovation of ponds:	Desilting, use of silt, control of seepage, materials for sealing, use of silt and maintenance of pond.

2. Carp Seed Production in Hatchery and Nursery Raising

Location:	Carp Hatchery complex and farmers` ponds.
Duration/Season:	4 days at hatchery and 2 days at farmers pond during breeding season.
Resource Person:	Fish Breeder.
Clientele:	Group of 10 fish farmers, including women.
Method of Instruction:	Demonstration and involvement in step to step methodology of brood selection, induced breeding, and seed production.
Course Content:	Selection of healthy carp for brook stock, raising of brood stock, stocking density, feeding, breeding cycle, identification and selection of the mature mother-stock, secondary sexual character, spawning habit, breeding behavior, courtship, spawning techniques. Induced breeding through hypophysation, extraction of pituitary grand, preparation of pituitary extract, intra-muscular injection, hydration, gain in weight after injection of pituitary. Stripping of males, fertilization of eggs, care of eggs, good and bad eggs, oxygenation of eggs, incubation of eggs, measures to avoid predators, incubation chamber/plastic pool. Prophylactic measures, hatching.

Nursery preparation, eradication of weed, insects and molluscs, fertilization and stocking, duration ofrearing, stocking density.

Feeding and harvesting, conditioning/acclimatization, oxygen packing.

Method and mode of transportation. Economics of seed production.

3. Carp Culture in Ponds

Location: Government fish farm/Entrepreneurs fish farm/Farmers` pond.

Duration/Season: Initially 3 days followed by one day each time to show major management techniques throughout the grow out period, and 2 days during final harvesting.

Resource Person: Fish Culturist /Extension worker and Agricultural Chemist

.

Clientele: Group of 15-20 Fish farmers, farmwomen, entrepreneurs, unemployed youth and landless rural poor having access to pond

Method of Instruction: Demonstration and actual involvement in different procedures.

Course Content with Appropriate Demonstration:

Principle of fish culture, selection of suitable species, food chain in the pond, role of sunlight and of oxygen, role of vegetation in ponds, desirable microphyte and macrophyte, common (submerged, floating and emergent) weed, photosynthesis, production and consumption of oxygen in pond, how to increase oxygen in the water, stress in fish because of low oxygen.

Algal bloom and method of control, manual method and biological control.

Application of lime in the pond, advantages of lime application, doses, litmus paper test.

Composting of manure, amount and frequency of manuring depending upon the nutrient status, advice on quality and quantity of inorganic fertilizers, recycling of pond bottom nutrient.

Fingerling stocking, time of stocking, size of stocking, stocking density, advantage of polyculture, different proportion for stocking.

Need for feeding the fish, effects of environmental factors (like temperature, oxygen, over crowding), different type of artificial feeds, agricultural by-products.

Sanitation and fish health, causes of fish health problem, Fish kill by weather conditions and depletion of oxygen because of algal bloom or bacterial bloom.

Common fish disease, prevention and cure, method of treatment, chemical treatment through water, through feed or direct dipping, doses and frequency of treatment.

Harvesting, different methods , time and duration of harvesting.

Transportation and marketing. Economics of fish culture

The above course content can be modified for air breathing fish culture.

4. Rice-fish Culture

Location:	Suitable paddy fields with rice cultivation and also after harvesting and be
Duration/Season:	3 days for concurrent fish-rice cultivation and 3 days for alternate fish-rice cultivation.
Resource Person:	Agricultural Scientist, Aquaculturist and Irrigation Engineer.
Clientele:	Group of 20 rice cultivators and aquaculturists and farmwomen.
Method of Instruction:	Demonstration and farmers involvement
Course Content:	Principle of rice-fish culture, paddy as a pasture ground for fish, role of fish in supply of oxygen and nutrient to paddy.
	Commonly occurring fishes in rice field, desirable species, their food and feeding habit
	Commonly occurring insects in rice field and their role and control.
	Preparation of rice field for raising of fish seed or undertaking fish culture.

Strengthening of dykes/bunds, determination of width and height of bunds, level of water needed, construction of trenches, enclosures, water control structure, methods of manipulation of water level during and after weeding.

Method of safe application of pesticides and fertilizers, measure to reduce the effect of pesticides and fertilizers, measures for protection from predators.

Stocking of fry and fingerling, stocking density, duration of culture.

Harvesting, packing and method of transport. Cost-benefit of seed rearing.

Stocking fish seed for culture, desirable species, proportion and density, period of cultivation.

Fabrication of suitable traps and gears, harvesting. Cost and benefit of rice- fish culture

5. Integrated Fish-Livestock Farming

Location:	Integrated fish- livestock farm.
Duration:	Six days, 2 days initially and then field visits on different occasion to see major management techniques
Resource Person:	Aquaculturist and Animal Husbandry Expert
Clientele:	Group of 10-15 Livestock farmers, small entrepreneurs, farm women, aquaculturists and unemployed youth.
Method of Instruction:	Discussion and actual demonstration.
Course Content:	Principle of integrated fish-livestock farming. Relationship between different production sub-systems. Different methods and models of integration.
	Designs and construction of integrated fish farm. Selection of plants which should be cultivated in the farm and on pond embankment, their farming techniques. Construction of the birdhouse and pigsty.
	Faecal matters of pig and bird dropping. Plant and animal waste treatment, method of decomposition and composting.
	Preparation of the pond, selection of the fish species, stocking density and proportion of different species, their

culture techniques. Depending on the nutrient status of soil and water the amount of organic manure required for fish culture and accordingly to determine the number of pig/birds to be raised on the embankment.

Pig fattening and marketing. Duck/chicken rearing, egg production and marketing. Vegetable/crop production and marketing. Fish harvesting and marketing. Profitability of integrated fish farming.

6. Shrimp Culture

Location: Coastal farm, bheri or pokkali field.

Duration/Season: 4-5 days in the beginning and then one-day each for major management techniques

.

Resource Person: Aquaculture Engineer, Aquaculturist, and Extension worker.

Clientele: Group of 10-15 progressive aquaculturists and entrepreneurs.

Method of Instruction: Discussion and demonstration.

Course Content: Principle of shrimp farming. Types of shrimp farming, (traditional, extensive, semi intensive and intensive).

For traditional shrimp farming Improvement in management practices, preparation of field, water channels and other structure, sun drying, ploughing and leveling of the bottom. Liming for soil pH correction.

Stocking, size/age of PL/density, maintenance of natural food, plankton production, control of disease and surveillance on shrimp health.

Harvesting and post harvest handling of shrimps. Profitability of shrimp farming.

For extensive system: Site selection, availability of good quality fresh and brackishwater, soil quality, land elevation, salinity, temperature, tidal amplitude. Design, construction and maintenance of farm pond.

Pond preparation, cleaning of pond, eradication of predators, sun drying, ploughing and leveling of pond bottom. Liming for soil pH correction. Application of organic and inorganic fertilizers.

Stocking, (size/age of PL/density). Pond management, aeration and change of water. Stock management and manipulation.

Production of natural food, Artificial feeds and feeding, different types of feed, feeding rate and frequency. Water quality management, plankton bloom, water temperature, pH, control of disease and surveillance on shrimp health.

Harvesting and post harvest practices. Economics of shrimp farming

5.4 Credits

Credit servicing is fairly organized for aquaculture with refinancing by NABARD, and financing by scheduled banks, rural banks, cooperative banks. The situation has improved considerably and poor farmers are now having access to credits. However, simplification of procedural mechanism to obtain credit in time is essential. Also to service more to the ladndless and resource poor farmers, policy needs to be evolved directly that the credit allocated (minimum of 16%) for the fisheries sector should be advanced to rural aquaculture sector as a priority, and this should be done with lower interest rate for the poorer section of the fish farming community. But farmers should also spend the amount for the purpose for which the credit is obtained; at times this is not the case obviously because of their more pressing demands and other social obligations, effecting adversely both production and loan repayment.

6. RURAL AQUACULTURE DEVELOPMENT PROGRAMME AND PROJECTS

As indicated in para 2.1. the Indian Government directed its efforts through many agencies to support aquaculture development in general and rural aquaculture development in particular. The ICAR institutions played a major role in R&D, since the beneficiaries were especially small and marginal farmers and land less labourers. Since 1971, the technology of Composite Fish Culture has been extended to various states of India through the All India Co-ordinated Research Project. The technology was also demonstrated though an IDRC/ICAR Project in two villages in West Bengal and Orissa. Many R&D Projects were started which were highly instrumental in supporting and developing rural aquaculture. However, some of the major projects are indicated below.

6.1. Projects on Freshwater Aquaculture Research and Development

- FAO/UNDP/ICAR Project on Intensification of Fish Culture and Training at FARTC

The facilities and expertise were strengthened at the Center with the assistance through this project in terms of equipment, consultants and fellowships in relevant disciplines. The Project was started in 1979 and continued for a period of about five years. The project provided a strong support which result in the evolution of the Center into a full-fledged institution known as CIFA (Central Institute of Freshwater Aquaculture, in Bhubaneswar, Orissa).

- FAO/UNDP/ICAR Project on Network of Aquaculture Centers in Asia (NACA) at the FARTC

Another regional project was started at the FARTC to further strengthen it to serve as a Lead Center for Carp Farming in Undrainable Ponds under NACA. Another Center of NACA was on Integrated Farming at Wuxi in China and the third on Brackishwater Farming at SEAFDEC in the Philippines and the fourth one on Catfish Culture and Macrobrachium Farming at the National Inland Fisheries Institute, Thailand. The research programs of all these centers were formulated to serve the national as well as the regional needs. Training courses were arranged for technician and senior aquaculturists to adopt, initiate and expand such technologies in their respective countries. NACA in the present form as an Inter-governmental Organization is deeply engaged in aquaculture development in the region. Activities of NACA through CIFA have lasting contributions to the development of appropriate technologies for the development of rural aquaculture in India.

- FAO/UNDP/ICAR/OUAT Project on Establishment of a Center for Advanced Study on Freshwater Aquaculture at FARTC and Fisheries College, OUAT.

Since1986 the FARTC/CIFA has been engaged in HRD in Freshwater Aquaculture for M.Sc and Ph.D degrees.

6.2 Freshwater Aquaculture Development Projects

During the past three decades, almost all the states of India embarked on various development projects. However, the most significant ones are mentioned below.

- Programme on Fish Farmers Development Agency

One of the most important and effective national programme for the promotion of rural aquaculture development was the Fish Farmers Development Agencies (FFDAs), which was started in 1973-74 and is still going strong. During its 25 years of operational life, the programme has established 414 FFDAs and trained 537,956 fish farmers. The programme has achieved an average production of 2,183 kg/ha/yr.

The FFDAs provide a package of technical, financial and extension support services to fish farmers. The agency arranges suitable area on long-term lease, identify beneficiaries, provides incentives in the form of subsidies/grants for pons construction/rehabilitation and input supplies.

- Inland Fisheries Project with World Bank Assistant (1980)

Aquaculture in India was facing the same problem as agriculture faced few decades back about High Yield Variety (HYV) seed. The quality seed of fast growing carp was essential to develop fish culture in ponds, tanks and reservoirs. Therefore, Govt. of India initiated an Inland Fisheries Project in 1980 for developing fish farming in 117,000 hectares of water areas in 58 districts in the states of West Bengal, Bihar, Orissa, Madhya Pradesh and Uttar Pradesh.

The project was meant for carp seed production under controlled conditions in the hatchery with the help of induced breeding technique, along with providing farmers with proper extension support, technical assistance and credit for pond improvement and inputs.

The program was implemented by the joint participation of respective State Governments`State Fish Seed Development Corporation and Government of India. National Agricultural Bank for Rural Development provided credit for pond improvement and inputs as well as for setting up of fish seed hatcheries.

The project had the following main components:

<u>Establishment of commercial carp seed hatcheries</u>

The fish seed hatcheries in selected areas in the states of West Bengal, Bihar, Orissa, Madhya Pradesh and Uttar Pradesh were set up. Selection of the sites normally involved proper soil and water conditions for fish growth, assured water supply of good quality, convenient accessibility to the market and also good potentiality for fish culture activities in those areas.

State Fish Seed Development Corporation at the state level supervised and administered construction of the hatchery, nursery and rearing ponds along with brood

stock ponds. It also administered the linkage of the project with the Fish Farmers Development Agency.

Establishment of fish farmers development agencies under the project

A total of 97 FFDAs was established in the project area by 1985 and they developed a total area of 159,693 hectares. However, by that time a total of 200 FFDAs was already got established in all over India developing 192,439 hectares. The rate of average fish production achieved in the project area was @ 1728 kg/ha/yr as against 1560kg/ha/yr. in the country.

Establishment of extension training centre

The centers were established to cater the demand of the project area. In eight years, 1170 extension workers and 117 extension officers were trained under the project.

- FAO/WFP Project for Rural Development in Mahendragarh, Haryana, India

The project was initiated in 1984 to supplement the state efforts for rural development in the district of Mahendragarh. Although the project had a small component of rural aquaculture, it had a crucial role to play not only for fish production but also for supplying water for the cattle, particularly for water buffaloes.

The WFP assistance criteria for selection was on the basis of the project being labor intensive and creating employment opportunity besides assisting agricultural diversification and increased productivity and also strengthening the infrastructure for sustained rural development.

The fish culture component involved rehabilitation of rural ponds, establishment of infrastructure for fish seed production, establishment of Fish Culture Demonstration Centre and institutional support for technical matters pertaining to pond construction, fish culture and seed production ctc.

Since rural aquaculture had no tradition in the states the ponds were used primarily for cattle washing. In fact, over the years cattle population has increased many folds, but ponds were not dug in that proportion and whatsoever were existing were full of silt and organic matters reducing alarmingly the volume of the pond and the water. In fact all the perennial village ponds were highly eutrophic and invariably had Microcystis bloom creating adverse effect on water quality.

All the ponds needed extensive renovation in terms of enlarging of the total area, deepening, desilting, turfing of the embankment and then proper aquatic productivity management through fish culture to keep the water in good condition and prevent Microcystis bloom.

The project was very effective to bring rural prosperity. It is highly essential to have an in depth socio-economic study to assess the role of aquaculture on the overall performance of the project and its real contribution in relative term in rural development. This becomes most relevant and important particularly now when Haryana State has emerged as one of the most progressive states of India in fresh water aquaculture.

6.3 Brackishwater Aquaculture R&D and Development Projects

- ICAR initiated an All India Coordinated Research Project in 1973 under CIFRI to develop and test culture systems of brackishwater fish farming. To give further scientific support the ICAR established the Central Institute of Brackishwater Aquaculture in 1986.

- A national program of Brackishwater Fish Farmers Development Agencies (BFDAs) on the pattern of the FFDA was first started in West Bengal, Orissa, Andhra Pradesh and Kerala and then in other maritime states of the country to arrange inputs and credits along with the training of the farmers.

- The Marine Products Exports Development Authority (MPEDA) enlarged its activities in 1980s and established Prawn hatchery in Kerala, Orissa and Andhra Pradesh.

- Government of India/UNDP project supported the Central Institute of Coastal Engineering and Fisheries in setting up five prawn hatcheries and developing farm design for brackishwater aquaculture.

- The BFDA in Orissa promoted traditional prawn farming in over 2000 ha around Chilka lake and elsewhere, where farmers started producing 300-500 kg/ha/yr. Similarly, Bay of Bengal Project of FAO promoted large area in Tamil Nadu for traditional culture.

- World Bank funded project on Shrimp and fish culture is operative in certain states of India. Three ICAR institutions viz., CIFA, CIBA and CICFRI are involved in this World Bank funded project. In addition to these, they are also engaged in carrying out investigations on various aspects of aquaculture. The ICAR and other national organizations such as Department of Biotechnology, Department of Non-Conventional Energy Sources, Ministry of Environment and Forest and National Bank of Agriculture and Rural Development are providing funding supports for specific projects. It is hoped that knowledge generated through these projects would also experience and help accelerating the development of rural aquaculture in the country.

7. CONTRIBUTION OF RURAL AQUACULTURE TO RURAL DEVELOPMENT.

7.1 Contribution to Food and Nutrition

Aquaculture unlike agriculture does not yield in comparable quantitative terms but qualitatively it has no parallel. It is well known that fish is a wholesome food and highly nutritive. It is a rich source of protein (crude protein in the range of 14.2-22.8 %.) with all essential amino acids. Besides being a good source of calcium and vitamin A, fish is also having vitamin B 12. It contains fat as high as 6% and also has high energy content. It is also a rich source of essential fatty acids and polyunsaturated fatty acids. It is said that those eating adequate amount of fish, have shining eyes and hair, a sign of better health. This is well reflected in the population of the fishing villages.

Present aquaculture production in the country not only increased export earning, but also added domestic supply, resulting in 8 kg per capita consumption as compared to only 2.8 kg annually in 1974(George and Sinha l975). However, the Indian Council of Medical Research has recommended 12 kg. So, the country has a long way to go in meeting the recommended standard.

Table 8. Monthly per capita consumption of fish in different states of India

State/UT*	Quantity (0.00 kg)	Rural No. of household reporting fish consumption per 1000 household	Quantity (0.00 kg)	Urban No. of household reporting fish consumption per 1000 household
Andhra Pradesh	0.07	240	0.08	221
Assam	0.43	894	0.44	750
Bihar	0.0.8	291	0.13	336
Gujarat	0.02	79	0.02	87
Haryana			0.02	36
Himachal Pradesh	0.01	24	0.02	36
Jammu & Kashmir	0-0.2	69	0.05	119
Karnataka	0.08	116	0.07	114
Kerala	1.06	829	1.59	812
Madhya Pradesh	0.0,41	143	0.05	143
Maharashtra	0.08	160	0.14	253
Manipur	0.21	637	0.25	856
Meghalaya	0.18	584	0.37	777
Nagaland	-	-	0.22	547
Orissa	0.20	517	0.32	614
Punjab	-	5	-	4
Rajasthan		5	0.01	32
Sikkim	0.01	41	0.08	176
Tamil Nadu	0.12	206	0.11	320
Tripura	0.60	921	0.68	937
Uttar Pradesh	0.04	109	0.02	52
West Bengal	0.47	848	0.66	784
Andaman &-,Nicobar	1.52	806	1.06	723
ArunAchal Pradesh	0.30	569	0.28	521
Chandigarh	-	-		5
Dadar & Nagar Haveli	0.12	569	-	-
Delhi	-	34	0.03	44
Goa	1.22	926	1.38	723
Lakshadweep	4.26	888	3.38	736
Mizoram	0.08	252	0.04	148
Pondicherry	0.31	806	0.44	809
All India	0.15	282	0.17	262

* UT - Union Territories

Source: Hand book on fisheries statistics 1996, Gov. of India

It is encouraging to note (Table 8) that fish consumption level between rural and urban sectors is comparable, indicating clearly that fish is a significant food item of rural population, adding to their nutritional requirements.

In certain states like U.P., Andaman Nicobar, Arunanchal Pradesh and Lakshwadeep and Mizoram, the consumption level is higher in rural sector whereas in Bihar, Kerala, Orissa, WestBengal, Maharashtra, Megalaya, Sikkim and Pondicherry urban sector consumes more. These disparities may be related more to the tradition, or socio-religious reasons, or on the degree of market development. In fact, the Haryana and Rajasthan the consumption is entirely in the urban sector where people migrated from other states form the major consumer group. This is also true for Chandigarh and Nagaland

7.2 Contribution to Employment

After achieving self-sufficiency in food production, agriculture development in the country has been directed to improve the productivity, and to attain sustainability. It also stressed on to generate rural employment and income to increase the rural purchasing power. In this context aquaculture becomes an important sector in providing rural employment.

Labour use by type and enterprises based on some case studies involving aquaculture and other farming systems is shown in the following tables, which indicate the potential of labor engagement in rural aquaculture.

Case studies (Labour use in man day/ha/ye)

a) Paddy-cum fish culture labour use in man day/ha/yr

	Farm size (ha)	Farm labour	Family/hired	Gender/ Male/female	Enterprise/ labour	Potential requirement
1.	0.24	163	120/43	130/33	Paddy/43 Fish/l20	179 500
2.	0.60	264	194/70	228/38	Paddy/48 Fish/216	80 360
3.	0.40	432	344/88	266/166	Paddy/32 Fish/4OO	80 1000
4.	0.20	96	80/16	70/26	Paddy/16 Fish/80	80 400

b) Horticulture (Coconut plantation on Embankment) and fish

	Farm size (ha)	Farm labour	Family/hired	Gender/ Male/female	Enterprise/ labour	Potential requirement
1.	0.40	120	120/nil	60/60	Fish/100 Horticulture 50/20	250

c) Fish and dairy

	Farm size (ha)	Farm labour	Family/hired	Gender/ Male/female	Enterprise/ labour	Potential requirement
1.	0.7Ponds 0.8Land	720	420/300	500/220	Fish/245 Dairy/475	350 593

d) Fish-paddy-vegetable

	Farm size (ha)	Farm labour	Family/hired	Gender/ Male/female	Enterprise/ labour	Potential requirement
1.	0.75 Pond 0.153 Land	272	272/nil	217/55	Fish/110 paddy & vegetable/154	157 1006
2.	0.6	210	130/80	210/nil	Fish/150 vegetable & paddy/60	250 100

e) Livestock-fish and plantation

	Farm size (ha)	Farm labour	Family/ hired	Geder/ Male/female	Enterprise/ labour	Potential requirement
1.	0.70 Pond 0.01 Cattleshed 0.09 Orchard	625	50/575	420/155	Fish/550 Livestock/50 Plantation/25	785 * 277
2.	0.3 Pond 0.05 Cattleshed 0.15 Orchard	280	80/200	230/50	Fish/140 Livestock/70 Plantation/70	466 * 466
3.	1	2040	400/1640	1540/500	Fish/940 Livestock/500 Plantation/600	940 * 600
4.	0.24 Pond .040 Plantation	151	151/nil	91/60	Fishseed/10 Livestock/32 Plantation/109	416 * 2725
5.	0.4 Pond 0.2 Plantation	750	4/746	664/84	Fish/100 Livestock/450 Plantation/200	250 * 100
6.	5 Pond 4 Orchard	1000	Nil/1000	620/380	Fish/300 Livestock/350 Plantation/350	60 87
7.	OA Pond 0.8 Lnad	880	180/700	880/nil	Fish/380 Livestock/400 Plantation/100	950 * 125
8.	0.4 Pond	1200	490/710	Mostly male	Fish/50 Livestock/80 Plantation/350	125 * **

* Potential man day was not calculated because it is not related with hectarage.

** Because of paucity of data potential requirements were not calculated.

f) Fish-crop-horticulture-livestock-forestry

	Farm size (ha)	Farm labour	Family/hired	Gender/ Male/female	Enterprise/ labour	Potential requirement
1.	0.8 Pond 3.07 Land	2800	2080/720	2000/800	Paddy/200 Horitculture/1500 Forestry/100 Fish Culture/700	Fish 875
2.	0.4 Pond 0.4 Land	1340	870/470	1135/205	Livestock/800 Horticulture & Forestry/370 Fish/170	- 925 425
3.	0.8 Pond 1.6 ha for Horticulture & Forestry 1.33 Paddy	1650	500/1150	Mostly males	Fish/400 Livestock/750 Horticulture & Forestry/400 Paddy/100	500 - - -

The above case studies indicated that under extensive paddy cum fish/shrimp culture, fish culture component engaged as high as 1000 man day/ha. compared to about 179 man days for paddy. Similarly, coconut plantation and fish culture showed more or less the same ratio.

Carp culture and dairy showed that compared to dairy, fish culture needed about half the labor requirement. Farming of paddy/fish/ and vegetable showed high labor engagement in vegetable growing than fish. But, in any case, fish culture showed as high as 950-man days/ha.

Labor engagement indeed depends on many factors such as supervision, skill, degree of management and input supply etc. But almost all case studies involving fish culture showed considerable amount of labour engagement. On the basis of which it could be fairly said that fish culture in one hectare pond would provide at least 1 man full time employment. Estimated direct full-time regular employment in culture operations alone should, therefore, be about 0.8 million persons.

Estimate of additional employment

About 0.844 million hectares are presently under fish culture with the national average rate of fish production of 1.8 ton/ha/yr (Ayyappan-Personal communication) and a total fish production of 1.52 million tons of which, the FFDA program has covered 0.42 million of water area with an average rate of production of 2183kg/ha/yr, resulting in a total production of 0.921 million tons. Thus, farmers other than those trained by the FFDA are producing the rest of about 0.6 million tons of fish from another 0.42 million hectares.

Though, FFDAs have trained 0.53 million farmers but the program has benefited over 0.78 million and it is assumed that they have been gainfully engaged in rural aquaculture

` On the basis of the above, the estimation of employment generation in this sector is as follows:

Employment generation through freshwater rural aquaculture

		Million person / yr
1.	Regular full-time employment to operate the total 1.2 million ha of fish ponds (assuming 1 person per ha)	1.2
2.	Casual labourer on daily payment basis for pond perair /preparation, stocking and harvesting 0.844 million ha @ 110 man-day/ha/yr	0.25
3.	Marketing of fish, assuming that marketing of 11 tons of fish per yr provides full-time job or one person	0.138
4.	Production and supply of input such as fingerlings, feed, fertilizer, etc. estimation based on cost of imput of production and supply, and the labour costs as a pecentage of that cost	0.10
	Total Estimated Employment	**1,688**

Employment in brackishwater rural aquaculture

Mr.Tharakan, President of Seafood Exporters Association of India, in 1996, estimated that over Rs.20, 000 million have been invested by small and medium scale Indian entrepreneurs in brackishwater aquaculture in recent years. And over 200,000 unemployed labourers were gainfully employed in the sector. However this estimate seems to be for the whole sector and not necessarily for the rural aquaculture.

However, it is estimated that traditional shrimp culture in over 52500 ha yielding about 21000 tons of shrimp would generate the following employment opportunities:

1.	BFDA trained farmers	15000 Jobs
2.	Fish farmers undertaking traditional culture @1 ha/1 person in 52500 ha	52500 Jobs
3.	Daily wage labourer at least @ 110 manday/ha/yr	15,600 Jobs
4.	It is assumed that marketing of 2 tons of shrimp would generate one full-time employment.	10500 Jobs
	Accordingly, marketing of 21000 tons of fish would generate job for	10500 Jobs
	Total jobs in brackishwater rural aquaculture	**93,000 Jobs**

Thus, an estimated total of about 0.093 million jobs are expected to be in the brackish water sector. However, traditional culture may not create much job opportunity because not much renovation or excavation is involved. Similarly, employment through support services for seed and/or feed would be negligible because of the whole operation depends upon natural seed and feed.

7.2 Contribution to income generation

Generally, farmers who possess small land holding, pond and a few cattle do not concentrate only on one commodity or enterprise, rather they undertake some sort of integrated farming where by product of one subsystem becomes the input of other and vice versa. Thus, they achieve increased productivity from land, labour, water and waste (Sinha 1991). Similarly, water in the pond meant for irrigating other agriculture crop, when utilized simultaneously for fish culture it results in augmenting farmers' income and productivity of terrestrial crop. Fish culture concurrent with paddy cultivation, yields fish and also increases paddy production to about 10 percent.

Chapter 2 and 3 dealt with certain case studies that clearly indicate the income generation capacity of fish culture. However, still more case studies have been analyzed and presented in the following tables showing a comparative account of net income, cost return ratio and percentage return through different commodities with which farmers are involved.

The following tables show enterprise, net income, cost return ratio and percentage return on expenditure under rural aquaculture:

Case studies

a) Paddy cum fish culture

No.	Enterprise	Value/Cost of Production (Rs)	Net Income (Rs)	Cost return Ratio	% return on expenditure
1	Paddy	300/154	146	1.05	94
	Fish	1600/700	900	0.77	128
2	Paddy	1698/600	1098	0.54	199
	Fish	11998/400	798	0.50	199
3	Paddy	1000/650	350	1.85	53
	Fish	2300/1950	350	5.57	17.9
4	Paddy	200/63	137	0.45	217
	Fish	850/270	580	0.46	214

b) Horticulture (Coconut plantation on embankment and fish)

No.	Enterprise	Value/Cost of Production (Rs)	Net Income (Rs)	Cost return Ratio	% return on expenditure
1	Horticulture (not yet harvested)	--	--	--	--
	Fish	2100/350	1750	0.2	500

c) Fish and dairy

Sl No:	Enterprise	Value/Cost of Production (Rs)	Net Income (Rs)	Cost return Ratio	% return on expenditure
1	Dairy	55200/11650	43550	0.26	373
	Fish	15700/4940	10760	0.45	217

d) Fish-paddy-vegetable

No.	Enterprise	Value/Cost of Production (Rs)	Net Income (Rs)	Cost return Ratio	% return on expenditure
1	Paddy + Vegetable	4047/1573	2474	0.63	157
	Fish	25000/947	24053	0.039	2530
2	Paddy + Vegetable	1900/700	1200	0.58	171
	Fish	5500/1150	4350	0.26	378

e) Livestock-fish and plantation

No:	Enterprise	Value/Cost of Production (Rs)	Net Income (Rs)	Cost return Ratio	% return on expenditure
1	Fish	20000/6250	13750	0.45	220
	Livestock	2000/1600	400	4	25
	Plantation crop	1000/650	350	1.87	53
2	Fish	10000/3480	6520	0.53	187
	Livestock	3000/1900	1100	1.72	57
	Plantation crop	3000/600	2400	0.25	400

f) Fish-crop-horticulture-livestock-forestry

No.	Enterprise	Value/Cost of Production (Rs)	Net Income (Rs)	Cost return Ratio	% return on expenditure
1	Fish	33000/6865	26135	0.26	380
	Wheat	8000/3760	4240	0.88	112
	Paddy	26000/12630	13370	0.94	105
	Pulses	2000/713	1287	0.55	180
	Plantation & Forestry	19000/1990	17010	0.11	854
	Milk	4100/3190	900	3.5	28
2	Fish	40000/7000	33000	0.21	471
	Paddy	15000/4600	10400	0.44	226
	Horticulture	50000/22400	27600	0.81	123
	Forestry	5000/1100	3900	0.28	354
	Livestock	18000/3800	14200	0.26	373
3	Fish	20000/3500	16500	0.21	471
	Horticulture	8000/2775	5225	0.53	188
	Forestry	1000/100	900	0.11	900
	Livestock	12000/4800	7200	0.66	150

Farmers undertaking brackishwater paddy-fish culture showed the range of cost return ratio varying between 0.46 to 5.57 for fish and 1.85 to 0.45 for paddy. Exceptionally high value of 5.57 in case of fish was mainly because of poor supervision of the labor component. However, net return ranging Rs. 350 to 900 was an additional income from the same paddy field without any input except of labour.

Farmers who bought the desired seed and fed the fish to a limited extent made a net profit of Rs.1750 and obtained a cost return ratio of 0.2 and percent return on expenditure as 500. Similarly, dairy farmers who undertook carp culture obtained the cost return ratio of fish as 0.45 with 217 % of return on expenditure.

Paddy farmers undertaking fish culture and also growing vegetable around pond embankment obtained cost return ratio ranging from 0.039 to 0.26, with percentage on return ranging from 378 to 2530. Exceptionally high percentage of return on expenditure is mainly because of massive extension support to farmers to undertake scientific fish culture.

Livestock farmers undertaking fish culture and horticulture obtained cost return ratio for aquaculture in the range of 0.21 to 1.35 and percentage return on expenditure as 73 to 475. Similarly, farmers undertaking horticulture, forestry and fish culture obtained same range of rate of cost return ratio and percent return on expenditure for aquaculture.

These case studies conclusively indicated fish culture role in increasing the income of farmers who undertook aquaculture along with other agricultural activities. The magnitude of the income depended on many factors such as infrastructure facilities, skill of the farmers, intensity of management and the quantum of input but in all most all cases fish culture gave a better return.

7.3. Women in Rural Aquaculture

Women form about 48 % of the total population in India. About 78 % of them are economically active and are engaged in agriculture and allied fields. They are deeply involved in food related activities including food production and thus they are more concerned towards food security of their families by way of producing/procuring food, feed and fodder, maintaining live stock and raising kitchen garden and orchids.

Some recent estimates showed that India possesses about 314.9 million total work force of which 91.4 million are women workers. Of which 81.5 million are in the rural sector and 9.9 million in the urban sector.

All the rural work force is not always employed for about 240 days in a year. Hardly about 285.4 million are employed for about 180 days work/year. Of which about 16.2 % are female. Among them 34.6 % are cultivators, 43.6 % farm labourers and 4.6 % are engaged in sectors like livestock, fisheries, poultry etc.

Mechanization of agriculture sector with increasing use of tractors, transplanter, weeder, harvestors, thrasher and dehulling mill etc has threatened the women's employment opportunities. In this context, aquaculture sector opens up the possibility of alternate employment for men and women alike.

Analyses of some case studies have been presented below to show the type of labour and gender involved in rural aquaculture.

Table showing labour use by type and gender

Labour by type and sex

No.	Hired			Family		
	Male	Female	Total	Male	Female	Total
1	50	20	70	130	16	146
2	40	40	80	200	120	320
3	Nil	Nil	Nil	60	20	80
4	65	Nil	65	10	Nil	10
5	Nil	Nil	Nil	60	40	100
6	Nil	Nil	Nil	115	Nil	115
7	Nil	Nil	Nil	150	Nil	150
8	120	5	125	100	20	120
9*				450	100	550
10*				120	20	140
11*				940		940
12	Nil	Nil	Nil	6	6	12
13	Nil	Nil	Nil	88	12	100
14	220	80	300	Nil	Nil	Nil
15	350	Nil	350	30	Nil	30
16	300	Nil	300	400	Nil	Nil
17	70	Nil	70	100	Nil	100
18	350	Nil	350	50	Nil	50

* *Not separated between hired and family labourers.*

The analyses showed that hired labor mostly consisted of males for aquaculture activities. The party, which took care of harvesting on crop sharing basis, consisted entirely of males. However, of 18 case studies only in 4 cases females were involved and in only one case involvement was as high as 50 % but in other cases it ranged from 4 to 40 %.

Family labor showed much more women involvement. Of 18 cases 9 cases showed female involvement and male to female involvement went as high as 40 %. However, possibility of their involvement has been considerable. Sinha (1990) indicated the following areas where women could be involved profitably.

- Net making
- Carp breeding
- Hatchery management
- Carp fry rearing
- Composite fish culture
- Paddy cum fish culture

- Air breathing fish culture
- Prawn seed raising
- Prawn culture
- Aquarium fish breeding
- Aquarium keeping
- Integrated fish farming

In 1997, the KVK/FARTC, for the first time, organized training programme in aquaculture for women. Since then organization of such programmes became a regular practice. The KVK also operated a science and technology project for training of women in villages of Puri district in Orissa during 1986-89. Under the project women were trained in different aspect of aquaculture including net mending.

The CIFA also successfully completed a special project on aquaculture funded by the United Nations Development Fund for Women (UNIFEM) in three districts of Orissa viz. Keonjhar, Nayagard, and Malkangiri during 1992-96. The project enhanced the technical skills in aquaculture of over 300 women (Bhanot et.al 1998).

8. OPPORTUNITIES FOR FURTHER DEVELOPMENT

8.1 Highlights of past development projects

As has been set out in para 6, aquaculture has been recognized as an important sector of rural economy of India. The R&D Projects undertaken by the national government, state governments, either by their own resources or though extraneous funding support, provided strong support to the development of institutional, financial, technological and infrastructural aspects of rural aquaculture and with successful results.

Soon after the technologies of fish seed production and hatchery management, and composite fish culture were operational, the ICAR launched an All India Coordinated Project for their nationwide adoption. Government of India initiated the FFDA and BFDA and with the World Bank support under took carp and prawn hatchery projects to provide quality seed. Fish farmers responded wholeheartedly and undertook successfully fish seed rearing and culture activities for which R&D support continued. Entrepreneurs came forward and contributed immensely in farming of fish and shrimp and in their seed production. Matching with these developments, institutional building projects were started with the support of UNDP/FAO, which further strengthened aquaculture research and training base in the country. The ICAR strongly supported the efforts and created important institutions particularly CIFA and CIBA.

The Department of Agriculture Research and Education /ICAR constituted a committee in 1997 under Dr.P.C. Sarma, Member of Parliament to assess the impact of aquaculture research and technology development. The committee studied the scenario of R&D with detailed analysis of the data and information available from different sources. The committee pointed out that the direct impact of technology of induced carp breeding resulted in a major shift from riverine seed collection to hatchery seed production. This technology made possible the development of over 900 hatcheries in the country producing 15,000 million fry annually. Packages of practices of Composite Fish Culture for producing 5 to 15 t/ha/year are now available and are increasingly being adopted by farmers and entrepreneurs (Ayyappan personal communication). The committee also made the following recommendations.

- Multilocation testing and technology transfer should be stressed, with special emphasis given to eastern and northeastern regions of the country for strengthening of research and development activities.

- Resources management and data management involving primary and secondary data should be given utmost importance and a national aquaculture development plan for the country should be formulated.

- further support should be given to infrastructure development, inputs availability, mobile laboratories for soil and water analysis, fish health monitoring, credit financing to farmers and aquaculture insurance schemes.

- While emphasis on aquaculture programs for small and marginal farmers was given, the committee felt the necessity of adequate financial support for strengthening of aquaculture research and development.

- Research and development linkages should be strengthened and special attention should be given to programmes related to HRD and public awareness.

As indicated in Chapter 7, there has been a marked increase in inland fish production with increasing rural earning and employment.

Freshwater aquaculture presented very little or no environmental problems because of low production and little extraneous material input. In fact, it is highly environment friendly enterprise. However, intensification of shrimp farming resulted in certain environmental problems as discussed in section 3.4. However, it is expected that with the establishment of Aquaculture Authority of India the development and intensification of aquaculture will be properly regulated.

While the national expectation from the sector is high, which is rightly so, the aquatic resources themselves are in state of great stress as discussed in para 3 and need rehabilitation and restoration. Many of them have been in existence for varying period of time and are in trophic depression. Some are still productive but are full of weeds and trash fishes.

Growing population of human and animals around water bodies will put further demand for water in quantitative term and deteriorate its quality with increasing load of the nutrients and particularly organic matters.

8.2 Planned Projects

A. Freshwater Sector

a) National Freshwater Aquaculture Development Plan

CIFA as a premier national institution on freshwater aquaculture in the country prepared a Five-Year National Freshwater Aquaculture Development Plan, which envisages doubling of the fish production to the tune of 3.31 million tons from freshwater sector (CIFA 1998). The plan popularly known as Operation Aquagold examines in depth the prevalent levels of production in ponds and tanks in different states, their agro-climatic conditions, extent of aquaculture in each states, present and future demand, achievable production levels, and market demands etc.

The plan assumes that the present utilization of 826,230 ha would be increased to 11,99,500 ha with varying degree of productivity. It further assumes that the present national average @ 1.8 t/ha/yr would be increased to 2.762 t/ha/yr with production rates ranging from 0.5 t/ha/yr to as high as 8t/ha/yr.

After carefully analyzing the situation of each states it puts 3.67% of the total of 11,99,500 ha yielding @ 8t/ha yr, 0.5% @6t/ha/yr, 16.18 % @ 5t/ha/yr, 34.08 % @ 3t/ha/yr, 18.07 % @2t/ha/yr, 19.17% @ 1t/ha/yr and 8.33 % @0.5 t /ha/yr (Table 9).

The summary of the plan is shown below (CIFA 1998):

1.	Country:	India
2.	Water area available under ponds and tanks (ha):	23, 58,634
3.	Present annual inland fish production (t):	22,42,170
4.	Present annual freshwater aquaculture fish production (t):	15,12,000
5.	Proposed area to be brought under fish culture (ha):	11,991-500,
6.	Projected annual freshwater aquaculture fish production (t):	33,12,800
7.	Projected mean productivity (t/ha/yr):	2.762
8.	Requireme nt of fry (million):	15,362.60
9.	Requirement of feed (t):	52,04,500
10.	Projected production details:	

Target production (t/ha/yr)	Area coverage (ha)	Percentage of area covered (0/0)	Estimated production	Requirement of fry (million)	Requirement of f eed (t)
8	44,000	3.67	3,52,000	1320.0	880,000
6	6,000	0.50	36,000	144.0	72,000
5	1,98,000	16.51	9,90,000	3960.0	1980,000
3	4,11,800	34-33	12,35,400	4941.6	18,53,100
2	2,09,700	17.48	4,19,400	2297.0	4,19,400
1	2,30POOO	19.17	2,30,000	2100.0	-
0.5	1,00,000	8.33	50,000	600.0	-
Total:	11,99,500	100	33,12,800	15,362.6	52,04,500

11.	Present and projected production	Present	Projected
a)	Total estimated area under freshwater aquaculture (ha)	8,26,230	11,99,500
b)	Total fish production from freshwater aquaculture (t)	15,12,000	33,12,800
c)	Productivity (kg/ha/yr)	1830	2762

12. Strategic requirements of Operation Aqua-Gold (Matsyavardhan)

a)	Required increase in area:	3,73,270 ha; 45.18%
b)	Required increase in pons productivity:	932 kg/ha/yr; 50.9%
c)	Seed requirement (million)	
	Q Spawn:	45,000
	1) Fry:	15,000
	n) Fingerlings:	7,500
d)	Requirement of pond area	
	Area for broodstock management (@2 t/ha):	45,000 ha
	Nursery area (@10 million/ha):	4,500 ha
	Rearing area (@100,000/ha):	75,000

About 7500 million fingerlings of 3-4 inches would be required for stocking. Though presently about 15007 million fry are being produced for both culture and

culture-based fisheries but to achieve such production as envisaged in the plan 15000 million fry would have to be produced for culture only. With the present capability of farmers and capacity of the hatcheries, spawn production will not pose any problems, but raising of fingerlings will need nursery space.

The plan indicates that about 5.2 million tons of carp feed would be required annually to achieve the indicated rate of production from at least 72.5 % of the projected water area which is supposed to yield over 2t/ha/yr (Table 10). It is assumed that formulated feed will not be required for fish production at this rate. The ponds will have proper manuring and fish will be fed with conventional feed like rice bran and oil cake. However to produce cheap feed for carp it is necessary to establish such feed mills which presently are non existent.

The plan reiterates the following issues:

- Resource Management

While the plan recommends minimum periods of 5years lease, it also recommends incentives for establishment of the fish farms and aquaculture estates. Reclamation of swamps and derelict waters is highlighted for utilizing them for aquaculture operations.

Table 9. Requirements for seed, feed and other management measures for various production projections in carp polyculture

Productivity (t/ha/yr)	Stocking density fish/ha	Fry requirement No./ha (1:2)	Spawn requirement No./ha (1:3)	Survival (%)	Mean wt. (g)	Production (kg/ha/yr)	Feed (ratio)	Feed Qty. (t/ha/yr)
8	15,000	30,000	90,000	70	800	8,400	1:2.5	20
6	12,000	24,000	72,000	70	800	6,720	1:2	12
5	10,000	20,000	60,000	70	800	5,600	1:2	10
4	6,000	12,000	36,000	70	800	3,360	1:1.5	4.5
2	5,000	10,000	30,000	70	600	2,100	1:1	2.0
1	5,000	10,000	30,000	50	500	1,250	-	-
0.5	3,000	6,000	18,000	50	500	750	-	-

Other management measures:
1. Fertilization: Cowdung 10-15 t/ha/yr or poultry litter 2-4 t/ha/yr; Urea 212 kg/ha/yr @100 kg N/ha/yr; Single super phosphate 312 kg/ha/yr @50 kg P/ha/yr, liming 200 kg/ha where necessary.
2. Aeration: For maintaining disolved oxygen levels of 3-5 mg/l.
3. Water exchange to maintain disolved oxygen level of 3-5 mg/l.
4. Fish health management measures.
5. Periodical checks for fish growth and survival.

Source: CIFA 1998.

Table 10. Projected areas for ponds and tanks under different production levels ('000 ha)

States	8 t/ha/yr	6 t/ha/yr	5 t/ha/yr	3 t/ha/yr	2 t/ha/yr	1 t/ha/yr	0.5 t/ha/yr	Total
Andhra Pradesh	20	-	50.0	60.0	-	70.0	-	200.0
Assam	-	-	6.0	6.0	3.0	-	-	15.0
Bihar	-	-	10.0	30.0	30.0	-	-	70.0
Goa	-	-	-	-	1.5	-	-	1.5
Gujarat	-	-	-	20.0	20.0	-	-	40.0
Haryana	2.0	3.0	4.0	-	-	-	-	9.0
Himachal Pradesh	-	-	-	0.3	0.2	-	-	0.5
Jammu & Kashmir	-	-	-	4.0	5.0	-	-	9.0
Karnataka	-	-	-	10.0	20.0	50.0	70.0	150.0
Kerala	-	-	1.0	1.0	-	-	-	2.0
Madhya Pradesh	-	-	-	20.0	50.0	-	-	70.0
Maharahta	-	-	-	10.0	10.0	10.0	-	30.0
Orissa	-	-	10.0	30.0	30.0	-	-	70.0
Punjab	2.0	3.0	2.0	-	-	-	-	7.0
Rajasthan	-	-	5.0	10.0	-	20.0	30.0	65.0
Tamil Nadu	-	-	-	20.0	20.0	60.0	-	100.0
Utta Pradesh	-	-	10.0	80.0	-	-	-	90.0
West Bengal	20.0	-	100.0	100.0	-	-	-	220.0
North Eastern States	-	-	-	10.0	20.0	20.0	-	50.0
Others	-	-	-	0.5	-	-	-	0.5
Total	44.0	6.0	198.0	411.8	209.7	230.0	100.0	1199.5

Source: CIFA 1998.

- Intensification and diversification of Culture practices

Fully aware of the environmental hazards, the plan envisages no such problems in increasing the production to higher levels. However farmers are already fully aware of such problems and perhaps they are much better prepared than few years back when Ulcerative Fish Disease Syndrome took them by surprise.

Considering the growing demand of prawn, minor carp and cat fishes and of certain species having regional demand it recommend to increase the spectrum of culture species.

- Aquaculture inputs.

Considering the paucity of rearing space for fingerlings it recommends to ear mark proper nursery space at block level and to ensure proper rearing of fry to fingerling. Also it is recommended that farmers should stock their ponds with improved varieties of seed like CIFA-1R 1 -Jayanti and triploid grass carp.

- R&D supports and Linkages

Strong linkages between research and development agencies are reiterated. Similarly, strengthening of extension machinery is highlighted. Training for all levels of farmers, entrepreneurs, bank officials and development officials are recommended.

- Infrastructure Development

The plan recommends increasing involvement of government in providing infrastructural support to the aquacultural sector in the development of farms, hatcheries, fed mill and other ancillary industries such as manufacturing aerators, feed dispenser. The government should also support marketing facilities.

- Data Management

It is emphasized that a census is commissioned for compiling primary data on water resources, fish production levels, population of aquaculturists, marketing channels etc. for establishing proper information systems for aquaculture.

The above plan is under consideration of concerned authorities for implementation.

b) Further projects on specific R&D topics and projects on developing specific infra structural support services are needed to be formulated to expand and support rural aquaculture activities.

(i) R&D Project on Intensification of Studies on Fish Biodiversity and Training

There is a growing awareness and appreciation of the value of genetic diversity to aquaculture, and the need for demarcation and protection of rich biodiversity areas and conservation of endangered fish species. Development taking place in river basin environments and coastal areas has often had adverse effects on the aquatic ecosystem and its biodiversity. The degree of damage has seldom been assessed. Also, efforts were not made to seriously address the task of mitigating the adverse effects.

There is a need for an early assessment of the aquaculture species to evaluate and catalogue their salient characters for efficient utilization in aquaculture and to provide guidelines for timely conservation. The future of sustainable rural aquaculture will depend on the understanding of vast and varied gene pool of candidate species, and selection of desirable traits and their propagation.

The National Bureau of Fish Genetic Resources under ICAR is already engaged in similar activities. However, further strengthening in terms of infrastructural facilities and a high degree of technical and managerial capabilities will be essential to provide the following results as soon as possible;

- Scientific leadership and guidelines to protect rich fish biodiversity
- Action Plan for mitigating adverse effects on fish biodiversity
- Methodology for propagating threatened species
- Documentation of Fish Genetic resources

- Provide training to Researchers/Extension Officers and to the progressive farmers on fish biodiversity collection and evaluation

(ii) R&D Project on Aquatic Productivity Management and Optimum Utilization

Since rural aquaculture is being carried out by resource poor subsistence farmers who do not have money for inputs, it is important to develop aquaculture technology specifically suited for them. Such technologies should depend on the primary productivity of the land and water and their optional utilization.

For such technologies, for example, 3550 kg of alga production would require 224 kg of nitrogen and 31 kg of phosphate. However, if phosphate were available half the amount i.e., 15.5 kg, alga production would be theoretically restricted to 1775 kg. Further, it is seen that the utilization efficiency of nitrogen in fish pond ranges only between 20-30 % depending upon volatilization, fixation, seepage and management of ponds. Thus, even to have an entirely photosynthesis dependent systems the farmers have to spend considerable amount on fertilizers. Therefore technology where a part of nitrogen coming from nitrogen fixing algae becomes most relevant for rural aquaculture. In this regards CIFA studies on blue green algae and duck weed, and their use in fish culture should be further elaborated for wide scale adoption.

Similarly, it is also important that government undertake major development projects to rehabilitate derelict water bodies full of water hyacinth and other aquatic weeds. This is essential not only to accelerate the pace of aquaculture development but also for the conservation of water and maintenance of water quality through judicious management of primary productivity as discussed in para 3.4.

(iii) R&D Project on Aquaculture and Waste Management

Recycling of nutrients through aquaculture and integrated farming is an established practice. Recycling of wastewater through aquaculture popularly known as sewage-fed fish culture is prevalent in West Bengal since 1925. It is also estimated that there are about 130 such farms in and around Calcutta wet land, spanning an area of about 4000 ha. Scientific packaging of the technology for countrywide application is important with the increasing amount of human, animal, and domestic wastes. However, such packaging should take care of not only of all aspects of productivity, but also aesthetic sense and heath and hygiene aspects of producers and consumers.

Similarly, packaging of different models of integrated farming is essential for up gradation of loosely interwoven integrated farming presently practiced by the farmers.

(iv) R&D Project on Running Water Fish Culture

Although India possesses mountains and hills all along its boundary and thus having considerable number of hill streams offering opportunities for running water fish culture; not much has been done to utilize such resources. Hill area development programs need to have running water fish culture as an integral component, particular in view of its rural population who are amongst the poorest of the poor. It is heartening to note that researches done so far in the high altitude regions of the country is being packaged for pilot scale demonstration by the National Research Center on Coldwater

Fisheries. However the efforts need to be further strengthened in terms of infrastructure and manpower so that the R&D program should forge ahead vigorously.

Similarly cage and pen culture technologies haven't been popularized so far, although many research results have shown their viability, both financial as well as social. Much more serious efforts through an R&D project are needed to popularize such culture systems, which are ideally suited for many long water bodies. Moreover, such culture systems offer opportunities for land less to own something like cages or pens for production of fish particularly when they do not have ponds.

c) Development Projects

(i) Backyard hatchery project

Advances made recently in rearing technologies of fish spawn to fry and fry to fingerlings, have resulted in very high percentage of survival rate of high quality seed, which is a prerequisite for successful rural aquaculture. The greatest constraint is the paucity of rearing space and therefore it is important to have suitable areas developed district wise and to produce sufficient trained manpower to undertake raising fingerlings. Similarly, the raising of post larvae of shrimp and prawn need considerable amount of space and manpower. Thus it is essential that government encourage establishment of backyard hatcheries in large numbers for raising fingerlings and post larvae of prawn and shrimp. Preference may be given to women to operate such ventures.

(ii) Establishment of Fish Feed Mills

Supply of supplementary feed, which is nutritionally rich and economically affordable by the poor farmers, is important for rural aquaculture. Entrepreneurs have spent sizable amount of money for establishing feed mills for shrimp feed, but carp feed being cheaper it is difficult to attract private sector investment. One medium size feed mill having a capacity of 0.5 ton per hour would cost at least about IRs 5 million. Considering feed requirement of about 5.2 million tons in another five years to produce 3.3 million tones of fish (CIFA 1988) government financial support in the establishment of Feed Mills is inevitable.

B. Brackishwater Sector

The expansion and intensification of shrimp farming was somewhat haphazard and unregulated which resulted in certain conflicting social and environmental issues. The proposed development plan for a ten-year period faced certain unavoidable uncertainties. However the governments both at the Center and State levels are determined not to allow short-term gains over long-term sustainability. They are keen to upgrade the traditional farming, while giving stress on higher productivity without impairing the environment. The newly established Aquaculture Authority of India is responsible for promoting sustainable aquaculture, especially brackishwater shrimp culture.

It is thus hoped that India will certainly be promoting development of environmentally sound and sustainable aquaculture well integrated into rural, agricultural

and coastal development plans in consonance with the Rome Declaration on Food Security and the World Food Summit Plan of Action 1996.

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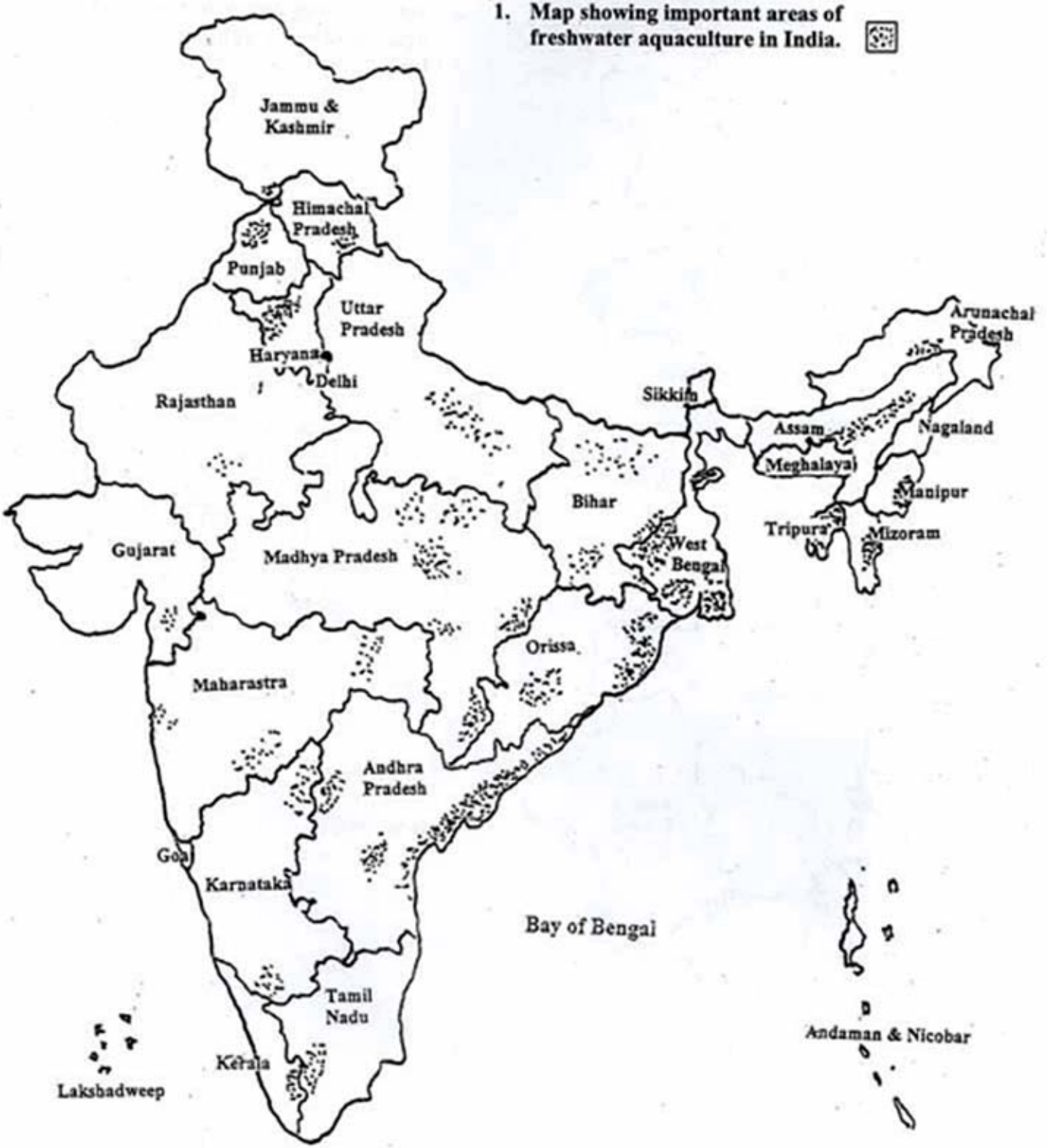
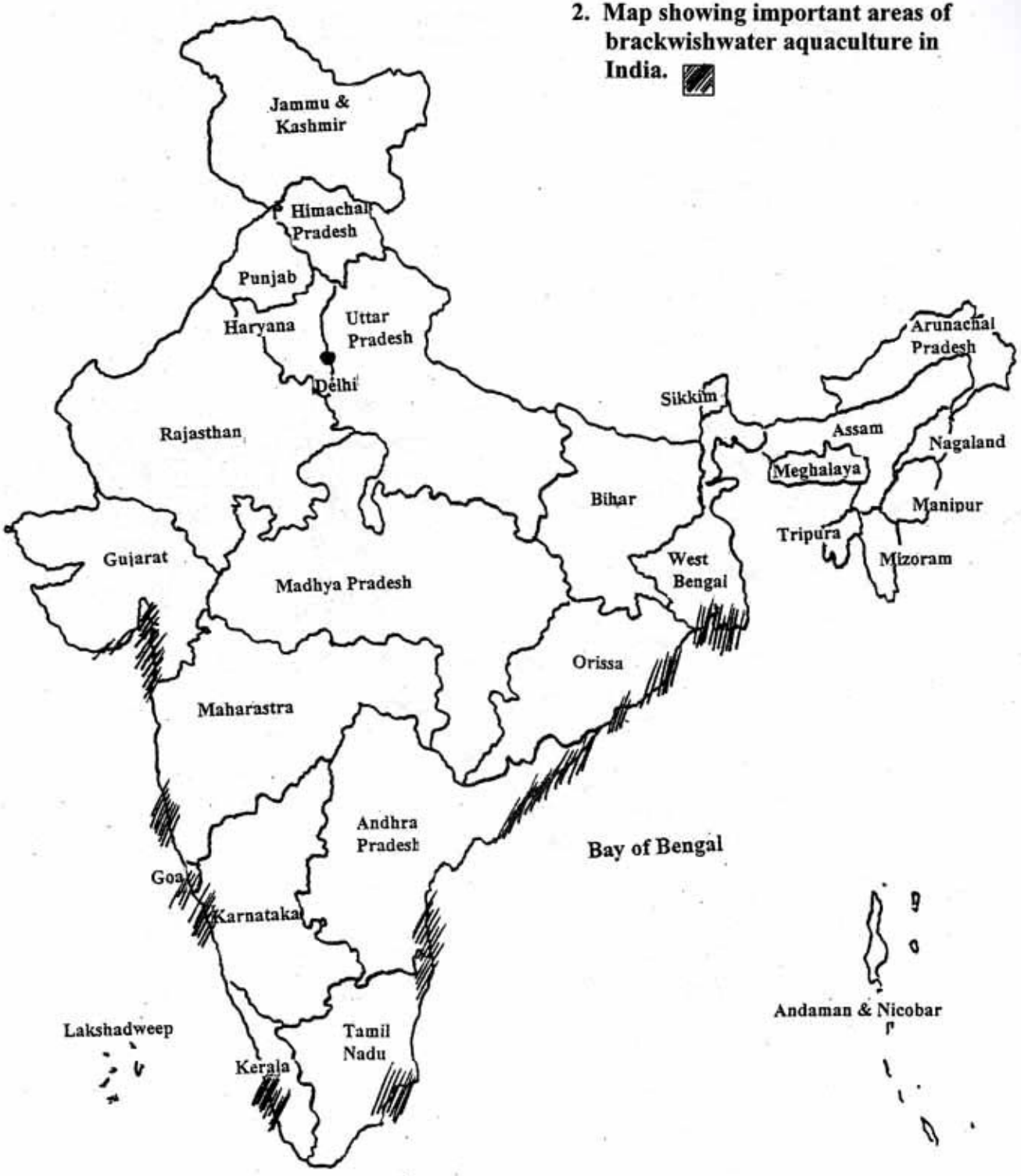
1. **Map showing important areas of freshwater aquaculture in India.**



2. Map showing important areas of brackwishwater aquaculture in India.



1. Removing aquatic weeds.

2. Liming pond water.

3. Seed production in 'hapa' inside a pond.

4. Transporting fish seed in earthen jars.

5. Harvesting fish seeds from a rearing pond.

6. Harvesting bountiful major Indian carps.

7. Fish culture in paddy field.

8. Duck-cum-fish culture.

9. Fish culture training in a village.