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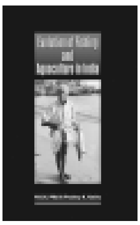

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Adoption of technologies and their impact

Adoption

Freshwater Aquaculture

The type of aquaculture technologies followed by fishers is presented in Table 72.

Table 72. Adoption (%) of freshwater aquacultural technologies

Technology	West Bengal	Orissa	Andhra Pradesh	Karnataka	Uttar Pradesh	Haryana	All India Average
Husbandry of carp fingerling	19.74	-	-	-	-	-	3.29
Carp monoculture	-	3.12	-	-	-	1.35	0.75
Polyculture	23.68	96.88	100	11.11	3.17	4.06	39.82
Composite fish culture	17.11	-	-	-	96.83	93.24	34.53
Integrated fish farming	-	-	-	88.89	-	1.35	15.04
Sewage fed	39.47	-	-	-	-	-	6.58

Source: Survey under the ICAR-WorldFish project.

The fishers adopted only few technologies, namely, carp seed production, carp monoculture, polyculture and composite fish culture, integrated fish farming and sewage fed fish culture. The maximum number of fishers adopted carp polyculture of Indian Major Carps (40%) and composite fish culture (35%). Integrated fish farming was adopted by over 15% of the fishers. The technologies varied significantly across the states. The polyculture of IMC was most common in Andhra and Orissa, while in the northern states of Uttar Pradesh and Haryana, composite fish culture was the most common. The results clearly documented the preference of carp culture and confirmed the observation that carps constituted over 80% of the total inland fish production in India.

According to popularity, financial affordability and area coverage, the most important technologies can be ranked as

1. Semi-intensive carp culture
2. Extensive carp culture
3. Intensive carp culture
4. Livestock based integrated fish farming
5. Paddy cum fish culture
6. Polyculture of freshwater prawn and carps
7. Waste-water fed fish culture
8. Mono and polyculture of air-breathing fishes
9. Aquatic weed based fish culture

As stated earlier, Indian freshwater aquaculture is carp oriented. The characteristics of water resources, constraints in adoption and the impact of processes (hatchery, seed production and carp polyculture) on aquaculturists were analysed at different levels of input use and technological adoption and are discussed below (Table 73).

Table 73. Adoption of freshwater aquaculture systems and their impact on rural development*

System	Characteristics	Level of adoption	Constraint(s)	Impact
Seed Production				
Induced breeding of carps	Capital intensive; hatcheries mostly under private or government agencies; low risk; high market demand; high profit	High	High technical expertise; finance; infrastructure facilities	High
Carp fry rearing	Small private/ government ponds; low investment; high profit; moderate risk; high market demand	High	High technical expertise; infrastructure facilities	High
Carp fingerling rearing	Small private/government ponds; moderate investment; low profit; moderate risk; high market demand	Moderate	Low availability of water bodies; Low B:C ratio	High
Carp polyculture				
Low input or fertilizer-based system	Small holding; community ponds; low investment; open access	Very low	Inability to privatize returns	Low
Medium input or fertiliser and feed-based system	Medium and large ponds; private; moderate to high investments; low risk; high	High	Input scarcity; limited access to infrastructure facilities;low	Very high

	production and profit		Remuneration	
High input or intensive feed and aeration-based system	Medium-sized pond; very high investment; private holding; high risk; high productivity; good market access	High (the input use is higher than recommended for few practices)	Financial; low B:C ratio; low ecological sustainability; high risk	Moderate

* Based on the responses of scientists from CIFA, Bhubaneswar and CIFRI, Barrackpore, and from aquaculturists contacted during the survey under the ICAR-WorldFish project.

Freshwater

Hatchery and seed production

These operations produce fish seed for stocking ponds. The first activity is induced breeding for production of spawn. It is a capital-intensive activity, requiring high technical expertise, considerable finance and sophisticated infrastructural facilities, and is mostly done by private or government agencies. The rate at which these operations are adopted by local farmers, their impact on aquaculture productivity and returns are very high due to high market demand and profits.

The second activity is production of fry from spawn. This activity is generally conducted in small ponds, by private or government agencies. It requires only low levels of investment and carries a moderate risk. However, it requires high technical expertise and sophisticated infrastructure. The adoption rate and impact of this activity is high due to high market demand for fry.

The last activity is the raising of stocking material for grow-out – that is, fingerlings. As is the case with other seed production activities, this activity is performed by either private or government agencies, in small ponds, with moderate investments. Less availability of ponds for this activity and low benefit to cost ratio have resulted in only moderate adoption of this activity. However, high demand for carp fingerlings for aquaculture and culture-based fisheries may lead to higher impact.

Grow-out

Carp polyculture is conducted at three levels. The first is a low input or fertilizer-based system, practiced mostly in small community ponds, with multiple uses and open access. It requires only low levels of investment. The level of adoption and impact are also very low since aquaculture is practiced mostly in community village ponds with multiple uses. These are utilised as common pool resources and it is difficult to adopt all culture practices recommended in the technology. Further, privatization of aquaculture activity in general and the returns from it in particular is constrained by management and property regimes for these water bodies. At the second level the aquaculture system is a medium input or fertilizer- and feed-based system. This system is prevalent in medium-sized to large-sized private ponds with moderate to high investments. The levels of adoption and impact are high, despite problems of scarcity of quality input, limited access to infrastructures and low remuneration. The last system prevalent in carp polyculture is a high input or intensive feed and aeration-based system. This practice is generally followed in medium-sized private ponds with high investments by agencies with risk bearing ability. These agencies generally use inputs higher than recommended levels, and therefore, the adoption level is very high. It leads to high risk, low ecological sustainability and low benefit cost ratios. The impact in this case is moderate.

Brackishwater

The most important brackishwater aquaculture operation is shrimp culture. It is also practiced at three scales, namely, subsistence-oriented traditional farming by small and marginal farmers, semi-intensive farming in the small-scale sector, and 'high tech', intensive farming by corporate bodies (Srinath, 2000).

The experiences of adoption of shrimp culture systems are given in Table 74. The high-tech farming operations are guided by the objectives of immediate profits and short-term gains rather than the sustainability of the system. High-tech farming relies mainly on imported technological inputs. The publicly funded extension system that relies on local resources, with emphasis on long-term gains and sustainable systems, rarely finds a place in this sector. The farmers operating big- or medium-scale farms under paddy-cum-shrimp farming systems generally practice selective farming of a single species, as well as supplementary stocking and feeding. These farmers, with their information-seeking tendencies, try to avail themselves of technical inputs, and most of the extension and development opportunities, as a result all the developmental efforts are diverted towards them. But, the scarcity of hatchery seed, social resistance to wild seed collection, faulty use of farming practices and improper investment decisions limit their output – often resulting in economic losses. Small and marginal holdings often face resource constraints and have less opportunity for development.

Table 74. Adoption of shrimp farming practices-a cross case analysis

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

Source: Srinath K., 2000

The experiences of adoption of shrimp culture technologies are summarised in Tables 74 and 75.

Impact/ Potential Impact of the Technologies

Inland

The potential impact of different technologies in terms productivity, sustainability, employment, equity, export enhancement, nutrition and resource conservation was assessed on the basis of rapid survey of the scientists, fishers and extension personnel. The potential impact of technologies was assessed on 10 scale with maximum potential 10 and the decrease as the assigned number decreases. The results of the survey are summarized in Table 76.

The results indicated that induced breeding and seed production has the maximum potential for increased productivity and sustainability of fish production and resources. In the case of grow-out technologies extensive and semi-intensive carp culture technologies may have the highest potential

Table 75. Adoption of brackishwater aquaculture and sea farming technologies

Technology	Year of generation	Adoption pattern	Potential areas	Constraints
Shrimp farming	1985	1988 cultured shrimp accounted for 28,000 t and in 2000 it is about 98,000 t	Area under culture has increased to 0.14 million ha but is still only 12% of the estimated potential area. States like WB,AP,TN,Kerala,Karnataka,Goa and Gujarat are potential areas for developing modified extensive shrimp farming activity.	Disease problems CRZ regulations Availability of disease-free hatchery seed
Shrimp Hatchery	1980	By 1990 many small (10 million PL/year) and large scale (> 20 million PL/year)	Ideally large and medium scale hatcheries where there is availability of broodstock (collected from offshore trawlers), monsoon effects are minimum. Small scale backyard shrimp hatcheries with minimum capital investment to meet local demands ideal for south west coast.	Indigenous shrimp feed industry not yet developed Ready availability of broodstock from wild.
Crab farming/ crab fattening	1995	Popular in the past few years in TN, AP and Kerala especially crab fattening	Can be done in all brackish water areas along the entire Indian coast where water crabs are available for stocking and trash fish is cheap to be used as feed	Alternate technologies for captive rearing of broodstock are being developed
Lobster fattening	1998	Limited adoption in Gujarat	Practiced in intertidal sand pits on the coast. Ideal for Gujarat, Maharashtra and Tamilnadu coast.	Seed availability. to be improved; non availability of feed, water quality management protocols. has to be encouraged.

Table 76. Assessment of impact potential and prioritization of different technologies

Technology	Increasing productivity	Sustaina-bility	Employ-ment	Equity	Post harvest	Export potential	Nutrition	Conser-vation	Total
Induced Breeding									
Carps	9	9	2	2	0	1	0	9	32
Catfish	9	9	1	1	0	1	0	5	26
Freshwater prawn	9	9	1	1	0	1	0	4	25
Ornamental fish	6	6	4	4	0	7	0	3	30
Seed production									
Carps (Fry & Fingerling)	9	9	4	4	0	1	0	5	32
Catfish	9	9	3	3	0	1	0	4	29
Freshwater prawn	9	9	3	3	0	2	0	4	30
Grow-out Carp									
Extensive/low input	6	9	9	9	5	2	9	8	57
Semi intensive/ Medium input	7	9	8	9	6	3	8	8	58
Intensive/ High input	8	7	7	6	6	3	8	7	52
Sewage fed	5	8	7	7	7	4	6	7	51
Aquatic weed based	3	5	3	4	1	1	5	4	26
Husbandry Grow out									
Air-breathing									
Mono-culture	5	6	4	4	2	1	7	5	34
Polyculture	7	8	7	8	2	5	7	8	52
Prawn									
Mono-culture	5	5	4	4	9	9	8	6	50
Polyculture	5	7	7	7	8	7	7	8	56
Integrated fish farming									
Paddy cum fish	5	5	5	6	1	1	6	7	36
Cattle cum fish	5	6	4	6	1	1	6	8	37
Piggery cum fish	4	5	2	6	1	1	6	5	30
Duck cum Fish	5	5	3	6	1	1	6	5	32
Poultry	6	5	5	6	1	1	5	6	35
Ornamental fish culture	9	9	7	7	1	9	0	9	51

Increasing productivity –Role of technology in increasing production of commodity / category of fish at national level
Sustainability – The role of technology in sustaining the fish production, productivity, environment, etc
Employment – The role of technology in employment generation for rural poor
Equity – Role of technology in addressing the equity issue particularly for rural poor
Post harvest – The role of technology in value addition
Export potential - The role of the technology in exports
Nutrition – The role of technology in improving the nutritional status of rural poor
Conservation – The importance of technology in resource conservation
Source: Survey ICAR-WFC project.

impact on sustainability, employment, equity and conservation, while intensive carp culture has the potential for increased productivity, but is more capital intensive and does not address the employment and equity issues. The sewage fed aquaculture can address sustainability, employment and equity issues, but scope for higher productivity is less. The polyculture of prawn addresses most of the issues uniformly including the export potential. The integrated fish farming may have the impact potential for equity, nutrition and conservation.

The Issues and Constraints

Inland

The inland fisheries sector in India is endowed with rich aquatic and fishery resources. The sector offers ample scope for fisheries and aquaculture development. But there is wide gap between actual fish production and potential as open water bodies are not utilized to the optimum. The potential fishery resources and areas are untapped. Generally, culture practices are highly eco-sustainable and compatible with other farming systems. Therefore, there is scope for intensification and diversification of aquaculture practices for optimal utilization of aquatic resources.

The major constraints to achieve the objective of optimisation are

- lack of reliable data base relating to resources;
- non-availability of suitable fish yield models for multi-species fisheries for open inland waters;
- weak multi-disciplinary approach in fisheries and aquaculture;
- concept of diversification in culture practices unadopted;
- environmental, economical, social and gender issues in fisheries and aquaculture are not given adequate attention;
- aquaculture not treated at par with agriculture;
- research inputs on harvest and post-harvest technologies in the inland sector are very less.

Futhrer, the inland fisheries sector has the threats of

- anthropogenic interventions resulting in loss of bio-diversity, decline in fish catch, depletion of natural resources;
- man made alterations – construction of dams and barrages;
- increased water abstraction and deforestation;
- pollution of water bodies with industrial and domestic effluent;
- possible environmental degradation due to intensification of culture practices;
- clandestine introduction and spread of exotic fish species;
- unscientific management of fisheries and aquaculture activities;

- unplanned and unregulated development of fish /shrimp farms;
- contamination of indigenous fish germplasm resources;
- inadequate manpower in specialized disciplines and HRD;
- linkages between Research and Development machinery are weak;
- weak marketing and extension network for technology transfer.

Marine

Capture fisheries

Declining CPUE and idling fleets

The annual growth rate of marine fisheries sector increased from 4.3% during the seventies to 4.8% during the eighties and declined to 4.0% during the nineties (CMFRI, 1997a) The fall in growth rate is reflected in the annual catch reaching the maximum levels in the inshore fishing grounds upto a depth of 50 m of about 0.18 million sq.km area. The substantial increase in fishing effort since the 1970s has resulted in the decrease of area availability per active fishermen and per boat in the inshore fishing grounds. The CPUE also has decreased, which in turn has given rise to conflicts among different categories of fishermen, especially artisanal and mechanised sectors (Sathiadhas,1996). Technological improvements in capital intensive fishing implements have also rendered the existing older units less economical or non-operational, leading to substantial idling of fleets and underemployment (Sathiadhas *et al.*, 1999).

Impact of bottom trawling on sea bottom and its benthic biota

At present about 42000 bottom trawlers operate (mainly targeting shrimps) in the coastal stretch, against the optimum number of 20000.This kind of excessive bottom trawling is feared to have far reaching consequences such as degradation of the sea bed ecosystem and its biodiversity as a large number of non-target groups comprising of juveniles and sub-adults of economically important finfishes and shellfishes, and benthic organisms, most of them with little edible value but occupying key positions in the marine food web, are also destroyed (CMFRI, 2000).

Discards

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

Credit facilities

With most of the traditional fishermen belonging to socio-economically weaker sections and adoption of advanced fishing methods becoming a necessity, availability of credit becomes crucial. Currently only about 30% of the active fishermen have ownership of fishing equipments. Indebtedness is a serious issue in rural areas, where money lender and middlemen provide loans at exorbitant interest rates to purchase crafts and gear and almost confiscate the catches in return.

Coastal zone management

Coastal zone management in India poses several problems owing to the extent and diversity of the habits, development needs, population pressure, urbanization, conflicting user interests, seasonal natural disasters, diverse socio-cultural habits, socio-economic status of coastal communities especially of the fisherfolks and the economic and political agenda of each maritime state. The surveys conducted by the International Ocean Institute (India) have identified 17 problems that threaten the management and sustainable development of coastal zone. In order to resolve these, an Integrated Coastal Zone Management Plan (ICZM) need to be developed and implemented taking into consideration the interests of all stakeholders.

Constraints of small scale fishing sector (technical, economic and social) need to be looked into critically by research organisations and fishery development agencies and methods to overcome the same have to be formulated which shall be reflected in the National Fisheries Policy.

Mariculture technologies

- Fragmented holdings and poor socio-economic conditions of small farmers for whom aquaculture is a livelihood activity, prevent adoption of advanced technologies. Group farming approach, which relies on synchronized farming operations and collective management by the farmers of a locality is found to help increase the production by improving the farmers' access to required inputs and reduce the cost of cultivation. Shrimp farming, being more economical and rewarding than any other agricultural farming, suitable areas for shrimp culture may be identified by an Integrated Coastal Area Management Authority. Further it should be eco-friendly and suitably integrated with other activities in the coastal region to avoid conflicts.

- Mariculture of finfishes, bivalves and crustaceans like mud crab are potential technologies to improve the living conditions of poor fishermen. However the seed is mainly from the wild, which is insufficient to meet the rapid development of coastal aquaculture. Constraints and limitations in collection from natural beds and lack of hatcheries on the other hand need to be mitigated through development of hatchery technology hand in hand with development of grow-out technologies.
- Market intelligence and buy-back agreements have to be facilitated so that coastal aquaculturists get adequate returns.
- Extension activities in fisheries sector need to be strengthened.
- Artisanal fishermen are evincing keen interest in seaweed culture especially the high value carageenan yielding seaweeds for which culture technologies are available. However, lack of processing facilities is a serious constraint for which the government has to take initiative. Buy-back agreement will facilitate sustained interest in seaweed farming by fishermen groups.
- Although molluscan culture has got great potential there exists a limitation – farmers expect as high profit as in shrimp culture, which may not be possible. Moveover, bivalue seafood has only a limited market in India. Promotion and marketing of value added molluscan products are important to encourage in India.
- Marine finfish culture in the country is still at its infancy. Attempts have been made to use the wild seed of milkfish and mullets for farming.
- Asian seabass *Lates calcarifer* is an important candidate species suitable for farming in ponds and cages in the fresh and saline water ecosystem. CIBA has developed the technology for the captive seed production in the hatchery. Commercial seabass farms are becoming popular in recent years. Culture of seabass in the saline water ponds as an alternate species has also been found to be viable and this can be popularized.

Direction for future technology generation

- Resource assessment through remote sensing and GIS
- Development of interactive management models for all maritime states

- Studies on biodiversity and taxonomy to conserve and sustainably utilise the marine living resources which are of vital importance to the ecosystem and fisheries
- GIS platform map of potential mariculture sites along the Indian coast
- Organic farming of cultivable organisms
- Genome mapping of penaeid shrimps
- Waste management and zero water exchange system for shrimp farming
- Development of captive broodstock of shrimps
- National referral collections of bacterial pathogens
- Cost effective molecular diagnostic kits for disease monitoring
- Hatchery seed production technology for grouper, lobster and crab
- Identification of threats to fisheries presented by climate change and the management responses required (research with an emphasis on global networking)