INTERNATIONAL SYMPOSIUM ON FISH FOR NUTRITIONAL SECURITY IN THE 21ST CENTURY

4-6 DECEMBER 2001

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(Deemed University - ICAR)
Fisheries University Road, Versova
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The Marine Biological Association of India, CMFRI, Kochi
Indian Society of Fisheries Professionals, Mumbai

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SHRIMP CULTURE - ITS ECOLOGICAL IMPERATIVES AND ECO ETHICAL SOLUTIONS

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Shrimp acquisition for human consumption today cannot be sustained by the harvest from the seas alone. The number of shrimp farming countries grown from 33 in 1984 to 62 in 2001. In 1997, 27% of the shrimp consumed came from aquaculture and percentage in increasing as shrimp catches from the seas world over declines (Primevera, 1977). The total shrimp production in the world stands at approximately 3 million tonnes per annum of which farmed shrimp formed 700,000 tonnes in 1999. Now it stands at 1.114 million metric tonnes, a five-fold increase from 2,13,640 tonnes in 1985. Almost half the international trade is cornered by shrimp and shrimp products produced through aquaculture, with the top five producers being Thailand, Ecuador, Indonesia, China and India. The United States is the single largest importer of shrimp, though India markets a substantial portion of its produce to Japan, Singapore and the European Union Countries. The international trade in shrimp and shrimp products stands at approximately $7billion(USD) (FAO, 1999). With expanding markets in the first world, shrimp aquaculture provides a relatively quick and inexpensive means of income generation for third world farmers and exporters (FAO, 1995) The number of shrimp farms in India exceeds 10,000, covering more than 8,25,000 ha. of its 1, 19,000 ha of brackish water bodies.

To understand the current scenario in shrimp culture practices, its consequences on the environment and local populations as well as its global repercussions, it is imperative to understand the various methods of shrimp culture and the trends of shrimp farming.

Basics of Shrimp Culture

Shrimp has been a cultivated resource in Asian coastal agroecosystems for centuries. An estuarine phase in the metamorphosis and growth of larval penaeid shrimps to juveniles and subadults provides the opportunity for humans to exploit them as a resource within farmable estuarine regions. The 'traditional' method of shrimp farming comprises the simple impoundement of post larval and juvenile shrimp, migrating to the estuaries and river mouths for feeding and growth, until they attain marketable size. This kind of shrimp cultivation has been a part of coastal farming practices in the backwater inundated *Pokkali* paddy fields of Kerala, *bheris* of West Bengal, *khazan* lands of Goa and *khar* lands of Karnataka. These traditional practices remain as low subsistence level systems with modest remuneration from average yield of 100-150 kg/hectare/crop (Panikkar, 1937; George *et. al*, 1968, Alagraraswami,1990). The late 1980s witnessed a revolution in coastal aquaculture with the establishment of export markets in the first world for shrimp grown in tropical regions. The market dictated requirement of substantial quantities of large sized shrimps of preferred varieties ushered in new, commercially oriented, extensive, semi-intensive and intesive culture practices. With it came drastic changes in the resource utilization patterns.

The basic practice involves conversation of suitable regions to shrimp ponds where seawater is available in required quantities through tidal inundation or mechanical pumping. Ponds are prepared after removing extant vegetation, excavation, building bunds, sluice gates and canal systems. Conditioning of the pond includes eradication of natural fauna and fertilization of the pond bottom and water column for the enhancement of plankton growth. The ponds are then stocked with shrimp seed either from the wild and or from seed produced in hatcheries. Stocking may continue over a period of time at high tide. The impounded shrimp are harvested when they reach marketable size,. The method and duration of harvesting depends upon the type of culture practice adopted. In subsequently developed culture methods, namely the modified extensive, semi-intensive practices, the stocking density of seed is higher. Consequently the standing water within the pond has to be exchanged at a much higher rate than in the traditional or extensive methods. Fertilizers are also added to increase plankton production to provide food for the growing seed. In a majority of farms, formulated feed is also provided in addition. Antibiotics are added as prophylactics and curatives. Harvesting is generally done over a short period of time (Rajyalakshmi, 1900; Fast,1992). By the late 1980s,'environmental concerns' regarding shrimp culture began surfacing,which by the early 1990s moved center stage to dominate the trends in culture practices. Mitigative moves became imperative to stem the rampant spread of shrimp diseases in farms across the country and also to counter the peoples movements seeking redress for resource and livelihood losses ascribed to shrimp farming practices

The impact of shrimp farming on the environment can broadly classified into the ecological and the socio-economic. These allied phenomenona are a product of the direct and indirect modification of the existing ecosystems and resosurce utility patterns and raise issues of sustainability and equity.

Ecological impacts of shrimp farming practices

Shrimp culture poses environmental problems from processes beginning with the construction of ponds to the disposal of the bye product of currently employed post harvest technology. Issues that raise the most concern have been listed below:

a) *Impact on mangrove ecosystems:*

A major management consideration in culture operations is the selection of site for the establishment of shrimp farms. The location of aquafarms is primarily based on the access to surface and underground water sources and consequently, wetlands and floodplains stand high on the priority list. In the 1980s and early 1990s, mangrove areas were perceived as a highly conducive habitat for profitable short term projects due to the expedience of seawater and other ecological parameters conducive for the growth of shrimps, as well as availability of seed for stocking. Recent modifications in the modified extensive and semi-intensive practices do not prefer mangroves *per se* as ideal habitates due the requirements for completely drying out ponds between crops and as also the requirement for proper drainage systems for easy dewatering and drying. However, these farms are located around mangrove areas and their effluents still influence these areas as they are dependent on water from creeks and canals upstream of the mangrove areas. Although mangroves areas do not face threats from aquafarms alone, shrimp culture is the most significant factor behind the destruction of mangrove ecosystems world over (Ong, 1995). In coastal Andhra Pradesh alone, 2838 hectares of mangrove area has been converted to shrimp farms. Ecologically, mangroves are of prime importance as they form the feeding grounds for an inestimable number of marine organisms including fifty or more commercially important species of fishes and shrimps. The impact of the loss of this habitat reflects in further recruitment of these species (Chaudhuri and Chaudhuri, 1994). Mangroves also serve as slit traps, retaining sediment from washing onto and smothering benthos in intertidal regions and coral reefs. They also serve as effective barriers against incursion of seas into the mainland during inclement weather (FAO, 1996). Recorded instances prove that the damages caused by cyclones and tidal waves were substantially higher in the regions that have lost this protective barrier where earlier calamities of similar intensity had caused minimal damage.

b) *Physical alternations in water circulation systems:*

Shrimp farms are constructed by altering available water bodies to suitable culture systems. The conversion necessarily includes restructuring of the water body's physical attributes and its fluid dynamics. The effects of the same impinge on not just the standing water body, but that of the source water as well as the recipient water body. A lack of scientific assessment and planning has been the hallmark of most aqua farms that came up in the wake of the initial aqua revolution. Two types of changes are caused by the water requirements of aqua farms, namely bunding and diversion of seawater. Both cause changes in current patterns which has a cascading effect on siltation, sediment and nutrient dispersal characterstics, erosion patterns in adjoining sediment beds and land,inshore and nearshore current patterns, and flood control and drainage systems (Boyd,1995). Changes in the flow pattern also affect other associated phenomena such as percolation of water and leaching of mineral and salts into the soil. The high demands made on the freshwater sources brings about the second type of change which impinge primarily on water resource morphometry, and on ground water tables, causing probles of salinity incursion into freshwater sources. Lack of planning in water drainage systems in the aqua farms has turned out to be of very serious consequences to the farms themselves as the farms located upstream of the river mouths and tidal have to perforce use the effluent waters of farms further downstream as source water. Over a period of time, as the water quality in the downstream farms degenerated, the farms upstream face severe degradation of water quality leading to further ramifications in the form of disease outbreaks.

c) Chemical changes in the soil and water resulting from shrimp farm operations:

The addition of fertilizers, pesticides and antibiotics to further the growth and counter pest and disease attack on the shrimps results in the introduction of these chemicals intó the food web of the shrimp pond ecosystems and effluent recipient bodies. One of the major consequences of water enrichment by nitrogenous and phosphate fertilizers is an increase in the oxygen consumption by heterotrophic microorganisms in the water column and the sediment. When the biological oxygen demand exceeds the threshold limit, anoxia and resultant predominance of anaerobic processes brings about changes in the redox potential of the sediment, shifting it to a reducing type. A second alteration in sediment characteristics takes place because of the reaction of salt in the water column and free radicals of fertilizers in the sediment over prolonged exposure. This results in the formation of 'acid-sulfates soil' with low pH. A lowering of the pH is noticed even in adjoining groundwater tables due to leaching of salts from the sediment of aqua farms. This problem is especially pronounced in mangrove areas due to sediment characters. Liming, used as a short term measure to counter this problems has met but with minimal success, the practice of a majority of farmers is to aband on such farms after they become economically unviable ands relocate to a new area (GESAMP, 1997).

Salinisation of ground water due to leaching from shrimp farms is an ecologicalproblem with immediate and far-reaching consequences. A recent study has recorded 80-300ppm chloride content in potable water sources in human settlements in the vicinity of shrimp farms, as compared to the permissible level of 250 ppm. In Tamil Nadu the problem has reached a rather acute situation with the chloride content ranging from 667.4 ppm to 1604.6 ppm in certain areas (Reddy and Chandraprakash, 2000).

d) Water quality deterioration and consequences:

Pollution of standing water arises within the ponds and their effluent receiving water bodies from eutrophication resulting from the application of large quantities of fertilizers for phytoplankton growth. Deterioration of water quality by the addition of unutilized shrimp feed, antibiotics, pesticides and fungicides is ubiquitous to the existing shrimp culture practices in India. The resultant bioaccumulation of these compounds has had disastrous consequences for both the cultured organisms and the indigenous flora and fauna. Links between water pollution and shrimp disease have been established. In addition to the histopathological changes casused in the cultured shrimp, xenobiotically induced stress further translates into increased susceptibility of shrimp to pathogens, with poor body condition resulting in reduced resistance to fight infections. Even normally benign bacteria found in the natural flora of the shrimp turn opportunistic pathogens in stressed shrimps (Paul *et al*, 2000). Polluted water is also very conducive to the proliferation of pathogenic microbes. As all experienced farmers know, the health of the culture system is primarily dependent on the water quality. In this context, increased pollution of the source waters through industrial and agricultural runoffs has resulted in the nonavailability of unpolluted seawater for shrimp culture in most regions of the country. The problem is bound to increase in intensity should the present levels in the pollution persist in coastal regions (An on 2000). Especially in estuarine conditions, the presence of even trace level of toxicants such as heavy metals, organochlorines and polyaromatics are known to cause reproductive and endocrine-disrupting effects (Colborn *et al.*, 1993; Lye *et al.*, 1999). The deleterious effects of xenobiotics are evident in decreased food absorption efficiency and growth of shrimps (Mannisseri and Menon, *In Press*).

The haphazard, almost chaotic development of shrimp farms in areas conducive to shrimp farming, with little or no attempts at water quality management incorporated in culture practices, has resulted in what is popularly known as the "Taiwanese syndrome" where one shrimp farms effluent becomes another shrimp farms affluent source of water. This is the primary reason underlying the rampant spread of pathogens such as the white spot syndrome virus (WSSV), the mondon bacculovirus (MBV), the infectious hypodermal and haematopoetic necrosis virus (IHHNV) and several bacteria belonging to the genus *Vibrio*. (Bright sing *et al.* 2001). So devastating has been the spread of the white spot disease that shrimp production in India has fallen from 95,816 metric tonnes in 1993 to just 35,808 tonnes in 1999.

The lack of assessment of pollution arising from shrimp culture on the coastal environs is universal phenomenon. Nutrient runoff, with associated eutrophication and periodic anoxia are major concerns not only within the shrimp culture system and their adjoining water sources, but also in the effluent receiving nearshore regions. The few studies done on increased contamination by nutruient and suspended particulate matter load have provided increased evidence of changes in inshore phytoplankton communities, such as shift from diatoms to flagllates (Smyada,1990). Though moderate levels of enrichment in originally nutrient limited nearshore can result in increased production, it generally promotes an increase in bivalves and smaller low value fishes at the expenses of larger fishes and crustaceans (UNEP, 1996; Jeftic, 1998)

e) *Effects on capture fishery resources:*

An estimated 20 % of the 35 million tonns of fish used for producing fish meal globally is utilized by the aquaculture industry as feed for its cultivars. On an average, three fold the amount of fish meal is required to produce one ton of shrimp. The destructive practice of biomass fishing is also sustained by the fish meal industry. This conversion of low economic value fishes into feed for commercially valuable produce is a dichotomous issue in terms of economics. However, its ramifications on biodiversity and hence ecological costs are indisputable.

Larsson *et al* (1994) assessed that one hectare of semi intensive shrimp culture system in Columbia, producing 4000 kg of shrimp per annum, required the reproductive and assimilative capacity of 38-189 hectares of natural ecosystem per year. Such estimates are not available in the Indian context but may be comparable, as culture practices adopted are similar. Environmentalists raise issues of "ecological footprints" left behind by the shrimp culture industry, in terms of the minimum area of productive ecosystem required to sustain resource inputs and assimilate waste outputs from shrimp culture operations.

The capture of shrimp seed from the wild for stocking in farms is hitherto an unassessed impact on recruitment fishery of commercial shrimps. This intensive fishery along the intertidal regions for black tiger shrimp seed employing nonselective gear results in much destruction of other commercial shrimp postlarvae and fish fry, which are discarded as byecatch (Somayajulu *et al.*, 1993). Though laws pertaining to mesh size regulations in most states ban the practice, the fishery continues unchecked due to severe difficulties in implementation of the laws and market demand.

f) *Biodiversity concerns:*

The extermination or depletion of indigenous flora and fauna inhabiting areas chosen for shrimp culture is inevitable. Construction of farms, especially in habitat such as mangroves and wetlands that intrinsically

have high diversity indices, causes habitat and niche destruction in both direct and indirect manners. Pond preparation and culture activities include direct removal of noncultivated organisms by sundrying, ploughing the substratum and by direct application of toxins. The trend among aqua culturists to utilize any suitable wetland for culture purposes violates the objectives of the Ramsar Convention, of which India is a signatory. Awareness of conservation need is marginal amongst aqua culturists. Almost all major coastal bird sanctuaries in India, from Nalabana in Chilka to Pulicat in Tamil Nadu and Kumarakom in Kerala face problems of habitat loss, direct poaching or poisoning of resident and migratory birds by shrimp farmers annually. Apart from the conflict over shared wetland resources, the shrimp farms undoubtedly introduce toxins and antibiotics into the food chain of the local fauna. There has been no assessment of the effects of the same in India. Also not assessed are the impacts on the indigenous gene pool through introduction of exotic species or the risk faced by wild shrimp stocks from hatchery bred escapes from shrimp farms. Wild stocks are increasingly at risk from diseases originating at farm sources. Introduction of certain shrimp diseases in India is suspected to have been through seed supplied from abroad, imported during acute shortage of locally produced seed along the East Coast. The results have been catastrophic.

Socio-economic Problems arising from shrimp culture:

a) *Resource use conflicts:*

Traditional fishers and marginal farmers are the most affected communities with the advent of shrimp culture. Clashing interests arising from new resource use patterns with the development of shrimp farms in coastal regions have resulted in loss of life and property, growing in frequency and extent over the past decade. The agitation by the fishers of Chilka lake against the continuance of shrimp farms in the Chika lake is the most glaring example of such confrontations. A loss of livelihood due to conversion of agricultural land and mangrove areas has promoted migration of affected populations to urban slums (Kurien, 1997). Unplanned development of shrimp farms has resulted in blocking of access of fishers to landing centers and traditional fishing grounds. In Andhra Pradesh alone 6 % of fishing villages have lost their direct access to the sea due to the development of shrimp farms (ASF, 1998). Such conflicts are the direct outfall of a total lack of planning in the development and propagation of the shrimp farming sector. The snowballing of these conflicts into mass movements have brought about landmark amendments to the Coastal Zone Regulation in 1995, which defined land use, especially the methods to be adopted by shrimp farms. This legislation, though welcomed by the affected populations, was strongly opposed by the aquaculture, real estate and tourism industry. Loss of access to fishing grounds, deterioration of water quality of water bodies involved in shrimp culture, shrinkage and drying up of water bodies used by traditional fishers are the main reasons for fisher unrest with regard to shrimp culture. The figures of affected artesanal fishers could be up to 10 million (Mahapatra, 2001).

Non fisher coastal populations also stand equally affected by shrimp farms due to salinity incursions into ground water tables and the soil of arable land. As cited earlier, the problem has reached acute proportions in certain states. An acute shortage of freshwater may result in areas where erstwhile tiger shrimp farmers either switch over to scampy (*Macrobrachium* spp.) farming or attempt farming tiger shrimp in freshwater in an attempt to tide over epidemics such as white spot disease, which have hitherto not appeared in shrimp grown under freshwater conditions. Whether widespread adoption of this technology would pressurize available groundwater and surface freshwater resources has not been assessed.

b) *Marginalisation of rural populations :*

Alienation of marginal farmers from agricultural land acquired for shrimp culture results in rural unemployment. The shrimp culture industry does not employ as much labour force as it displaces (Shiva, 1995). However, a small percentage of the local population is usually employed as temporary labour on the shrimp farms which provides an alternative in such regions where self employment is the norm. These factors contribute to severe conflicts especially when local populations are not beneficiaries of even a small percentage of the huge profits reaped by the shrimp farmers. Such conflicts are relatively nonexistent in areas where traditional shrimp farming is practiced as it is a more participatory enterprise.

c) *Risks involved for small scale shrimp farmers:*

The lure of quick money has brought a substantial number of small investors in shrimp farming to bankruptcy. An evanescent export market and the patterns in shrimp epidemiology does not create a circumstance for steady income. A phenomenon peculiar to semi intensive shrimp farmers and farmers investing in small sized holdings is speculative thinking, which most often translates into unsustainable culture practices.

d) *Secondary effects on capture fisheries:*

Sea faring fishers are increasingly subjected to the fall outs of over fishing in terms of rapidly declining wild stocks. In course of time they would be unable to complete with shrimp farmers in terms of capital investment and maintenance costs. Opposition to seed collection fishery and capture of spawners from the sea for supply to hatcheries, as witnessed in coastal Kerala, arises from such concerns of both traditional fishers and small mechanized and trawler sectors. Destruction of mangroves also results in loss of habitat for the nurture of larval and juvenile commercially important shell and finfishes with predictably deleterious effects on stock populations (Barbier and Strand, 1998).

Preferred Eco-Ethical Scenario:-

Despite the above environment and socioeconomic concerns, the fact remains that shrimp culture creates economic opportunity. Also explicit is that uncontrolled and unplanned development and a lack of efficient management are the main factors responsible for the above social and environmental concerns. Low-income food deficit countries contribute to more than 80% of the worlds aquaculture produce. The gravity of remuneration in terms of foreign exchange need not be emphasized. Therefore it is imperative that these countries develop a means of preserving this source of income by ensuring the sustainability of their available resources. The administration has, over a period of time, provided for control, safeguards and mitigation in the form of legislation. Some of the prominent laws which address aquaculture related activities are the Wildlife Protection Act, 1972, the Coastal Regulation Zone notification published in " The Law Relating to Protection of Coastal Areas", amended by notification dated 18.8.1994 and the Supreme Court judgment dated 18.04.1996, the Environmental Protection Act, 1986 and the various laws effected by individual states with regard to mesh size regulations for fishing nets. Further safeguards for wetlands and mangrove biodiversity as well as prevention of introduction of exotic species is envisaged in National Biodiversity Strategy and Action Plan and the Biodiversity Bill being currently finalized. The provisions made under the CRZ law requires a total ban of shrimp farming activity within 500 metres of the high tide mark on the coast. Shrimp farmers all over the country have sought the amendment of the CRZ law and the introduction of the Aquaculture Authority bill which will allow them to continue shrimp culture albeit in a more controlled and planned manner and to reclassify aquaculture under agriculture and not industry. The debate over this Bill continues.

Policy guidelines:-

The implementation of legislation requires high inputs for effective monitoring of regulatory controls. In this context the success of regulatory policy instruments in terms of legal measures is limited. More effective are economic policy instruments such as taxation and penal charges which internalize unaccounted social costs and environmental costs (Barbier, 1992) i.e. it emphasizes the "polluters pay" principle. However, in the Indian context the most important perhaps is to foster voluntary action through environmental awareness and public will to alleviate the socio-environmental problems. A high degree of commitment is required from both the state and the community for the success of this approach. The devolving of planning and implementation to the lowest level, stakeholder dialogue and vertical integration between management levels should form the mainframe of such exercises. A holistic approach for the management is imperative and can be effected through integrated coastal zone management.

Shrimp culture holds great potential for food production and poverty alleviation. Coastal aquaculture enterprises have so far been plagued with unsuccessful development of the poorer sectors of coastal populations and the vulnerability of farms to pollution and disease. Over-rapid development has also resulted in environmental and social issues over resource use, labour problems, disease and marketing hurdles. The additive and cumulative nature of these problems can only be addressed through more effective planning and management through integrated coastal zone management. An attempt at such planning has thrown up preliminary problems, which have to be addressed in subsequent planning. Though investors have responded to management efforts with more rigorous project appraisals and governments with specific regulations, these have often been found to be ineffective. The main cause for this is a neglect of the cumulative effects as mentioned and inconsistency in the assessment of environmental quality standards and impacts. Even elaborately conceived ICM plans have met with only marginal success. The significant social and political barriers and sheer power of vested financial and economic interests are the main barrier to integrated and participatory approaches (GESAM, 2000). No universal models can be proposed for shrimp culture development. Management measures such as micromanagement of location specific requirements is of paramount importance. However, broad based guiding principles have been arrived at by consensus at global summits of cooperating countries. A precautionary approach while assessing development plans, the principle of polluters must pay, integration of parallel sectors with shrimp culture, public involvement and promotion of effective representative organizations, assessment of financial, economic, social and environmental costs and benefits, a critical assessment of environmental carrying capacity, effective controls and regulations and interactive approach of monitoring and adaptation have been recommended. Economic viability and social acceptability will define the extent of applicability of any management initiative. The need for the formulation and implementation of cross sectoral management plans aimed at coordinated land use and resource development, particularly inclusive of existing and projected capture fishery resources in the area will result in maximum acceptability in rural coastal areas (Barg, 1992).

The recently formulated Code of Conduct for Responsible Fisheries, promoted by the United Nations lays down the legal, institutional and consultative framework for sustainable shrimp culture. Planning and regulatory methods and tools along with economic incentive schemes, the development of a voluntary code of practice and effective monitoring of implementation by participating countries are some of its main features.

Effective management of culture systems:

The relevance of correct management practices and adoption of policy by farmers is best illustrated by the example of a recent comeback story. Thailand has rebound to its 1994 status in shrimp production after languishing for more than six years due to heavy crop loss brought about by rampant spread of diseases. The impressive success achieved this year has been a result of the adoption of environmentally compatible practices, which arose out of sheer necessity. Legislation laid down by the Thai government and the adoption of a code of conduct amongst farmers has gone a long way in effecting this recovery. Shrimp cultivation in paddy fields is restricted to coastal provinces. Epidemics have been arrested to a large extent by strict enforcement of screening brooders and postlarvae with the help of PCR and stressor tests. Above all, very strictly enforced water quality management has paid dividends. Storage of water supply in reservoir ponds has become imperative. In addition usage of filter feeders and seaweed to reduce organic particulate and nutrient load, deployment of long arm paddle wheel aerators to concentrate suspended particles in the pond center so they settle and form sludge which is then confined there with barrier nets, shortening the grow out period to four months or less and harvesting immediately on the outbreak of disease instead of using antibiotics have been the scientific practices incorporated in successful farming practices (Yap, 2001).

Practical suggestions for integrated management to Indian conditions:

There is an urgent need to develop land-quality indicators that will assist in organizing existing data and information on land availability in India. This would identify key indicators for monitoring land use patterns and land resource distribution, providing the back ground for new policies. A reclassification and earmarking of wetlands, agricultural lands and "wasteland"s is in order.

Energy availability is a pivotal constraint in achieving food security and environmental protection, playing the central role in increasing efficiency of labour and diversifying the range of economic activities possible in rural areas. Regeneration of degraded mangroves becomes an opportunity for growing biofuels. It provides a powerful incentive for rural people to be involved reappropriating and managing common wetland resources. The conservation of mangroves is vital for continued replenishment of shrimp and other commercially important fish stocks in the wild.

Equitable resource distribution holds the key to prevention of conflict and social decline. Infrastructure should be organized and improved keeping in mind environmental concerns. Production methods should be optimized to provide maximum yields from minimum area without environmental degradation.

Sustainable culture pond effluent management practices would arise from ecological waste treatment technologies and input management with assimilative concepts of input and waste management and sewage treatment.

Diversification of resource to arrest the spread of diseases is recommended. Rotation of *M. rosenbergii* with *P. monodon* crops to overcome white spot disease has been reported as successful and is being widely accepted by farmers.

Full support should be provided for R & D for application of suitable advances in science and technology and adoption of the same after required modifications for use by the industry. Development of specific pathogen free stocks of shrimps, as is done in livestock management can check the spread of diseases (Wyban et al., 1993). The domestication of shrimp is being attempted worldwide and breakthroughs are expected shortly. The PCR technology is revolutionary in improving the quality of hatchery produced shrimp seed and arresting the spread of diseases. Competitive displacement of bacterial pathogens by probiotics is another emerging fields.

An important and immediate goal should be the improvement of post harvest technology and establishing a domestic and international market for value added products.

The acute need for an environmental and socio-economic audit in the Indian context has been emphasized by various agencies since the 1994 decline of shrimp production. The same will provide baseline data for policy framework.

Application of economically sustainable technology with minimum impact on the environment should be the focus of efficient resource use. If shrimp culture is to become a pivotal component use of natural resources, instead of competing with other sectors, there has to a paradigm shift in the focus of research and development from increasing production and performance of shrimps to improvement of integrated production systems. The sporadic high remuneration from current shrimp culture practices is a major impediment in the implementation of this kind of an approach in scientific thinking and social implementation. Only stringently enforced legislation and participatory management of resources can bring about sustainable and meaningful change.

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