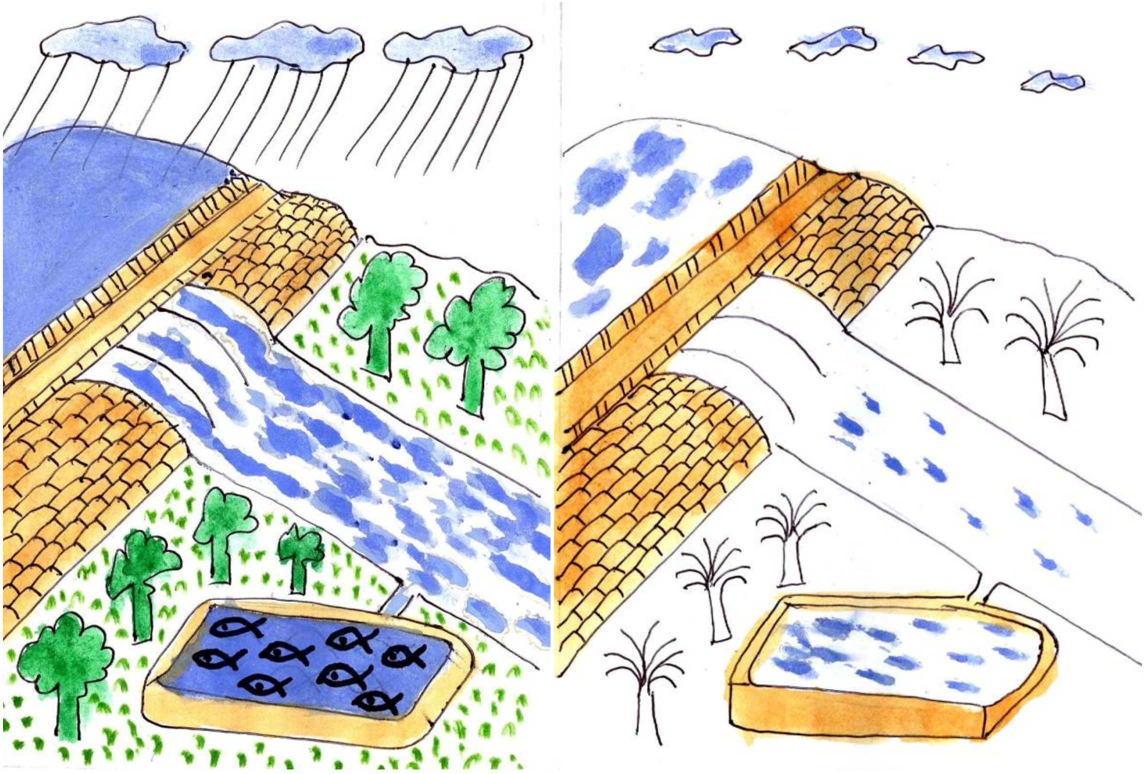
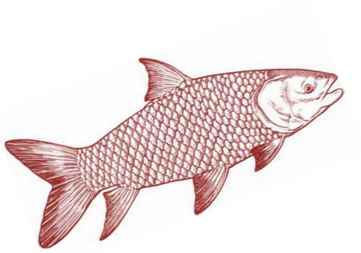
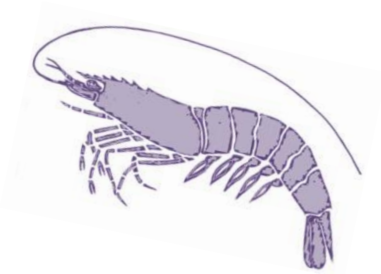
Proceedings of National Seminar on Development of Fisheries in Water Deficient Regions







25-26 February 2014

Organised by

The Fisheries Technocrats Forum, Chennai-600 006

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Inauguration

The two days National Seminar organized by the Fisheries Technocrats Forum was inaugurated by Dr. B. Manimaran, Vice-Chancellor, Tamil Nadu Fisheries University, Nagapatinam, Tamil Nadu.on the forenoon of 25th February 2014. Originally Dr. S. Ayyappan, Secretary, DARE & Director General of Indian Council of Agricultural Research, New Delhi was to inaugurate the Seminar and Dr. S. Vijayakumar, Secretary, Dept. of Animal Husbandry, Dairying and Fisheries, Govt of Tamil Nadu to preside over the function. Due to their urgent official duties, they could not attend the function. Instead, Dr Madan Mohan, Assistant Director General (Marine Fishery) of ICAR, New Delhi presided over the function. The invitees were welcomed by Dr. R. Soundararajan, Chairman of the Forum, who gave a brief account on the theme of the Seminar. The presidential address was offered by Dr. Madan Mohan and the felicitations were offered by Dr. A.G. Ponniah, Director, CIBA, Dr. M. Sakthivel, President, Aquaculture Foundation of India, Dr. Y.S. Yadhava, Director, BOBP-Inter Govt. Organization, Dr. Paul Pandian, Executive Director, NFDB and Dr. S. Santhanakrishnan, Chief Executive Officer, Maritech. Dr. Manimaran, Vice-chancellor, Tamil Nadu Fisheries University gave the inaugural address and Mr. M. Kathirvel, Secretary of the Forum proposed a vote of thanks..

Delegates at Inaugural function

Dr R. Soundararajan-Welcome address

Dr. Madan Mohan-Presidential address

Dr. B. Manimaran-Inaugural addres

Delegates in the Inaugural function

Felicitations

Dr. A.G. Ponniah

Dr. M. Sakthivel

Dr. Y.S. Yadhava

Dr. Paulpandian

Dr. S. Santhanakrishnan

Mr. M. Kathirvel-Vote of Thanks

Opening Ceremony of Fisheries Exhibition

Dr. S. Vijayakumar, I.A.S., Secretary, Dept. of Animal Husbandry, Dairying and Fisheries, Govt. of Tamil Nadu declared the opening of a Fisheries Exhibition. There were four stalls, put up by Central Agricultural Research Institute, Port Blair, Andamans, Central Institute of Brackishwater Aquaculture, Chennai, Madras Research Centre of Central Marine Fisheries Research Institute and Kochi unit of National Bureau of Fish Genetic Resources.

Dr. S. Vijakumar. I.A.S., Secretary opening the Exhibition

Dr. Madan Mohan, Asst. Director General (M.Fy), IICAR explaining R& D programmes of CIBA

Registration of delegates

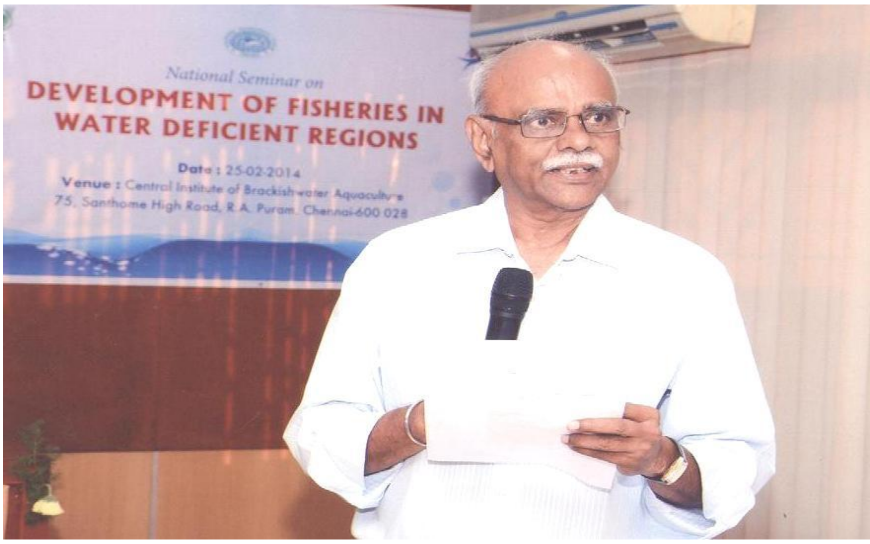
Technical session

Delegates

Valedictory function

Dr. A.G. Ponniah, Director, CIBA, Chennai presided over the function. In his valedictory address, he iappreciated the effort of the Fisheries Technocrats Forum to bring the administrators, scientists and fish/shrimp farmers together to discuss the very pertinent topic selected for the Seminar as "Development of Fisheries in Water Deficient Regions". Dr Ponniah remarked that the short-term and long-term strategies developed by the fish/shrimp farmers from one region, to increase the production in adverse condition would be helpful in drawing appropriate measures for other regions of the country. The forthcoming recommendations will address the shortfalls in undertaking such ventures and to draw appropriate policies by the central/state governments for further R & D and Extension programmes. A panel of experts consisting of Dr. A.G. Ponniah, Director, CIBA, Dr. M. Sakthivel, former Chairman & Director, MPEDA, Dr. V. Sampath, former Advisor, Ministry of Earth Sciences, Govt. of India and Dr. A.R. Thirunavukkarsu, Head & Principal Scientist, CIBA interacted with the fish farmers and the recommendations were finalized.

Fish farmer interacting with the expert panel before finalization of recommendations



Mr. V. Venkatesan, former Director of MPEDA presenting the recommendations

Recommendations

Mr. V. Venkatesan, Former Director, MPEDA, Kochi and one of the members of the Forum presented the recommendations through a power point presentation. Each recommendation was taken up for review and suitably modified after a detailed discussion with the participants and finalised.

Preamble: In India,more than seventy districts have been identified as drought-prone areas. The monsoonal rainfall is the major water resource and nearly 80% of the monsoon rains are received only during four months annually, June – September and the improper management leads to wasteful drainage of a large portion into the sea, making many areas drought affected for many months. The scanty or inadequate monsoon rains in several districts create chronic drought situations. The water deficit states include Tamil Nadu, Punjab, Haryana, Rajasthan, etc. The siltation and unregulated activities like sand mining etc. have reduced the water holding capacity of rivers and other surface water bodies. Over-exploitation of groundwater also leads to water scarcity. Pollution reduces water quality and has made several water bodies unusable. Governments have initiated schemes in drought-prone areas for combating water scarcity for agriculture by introducing technologies, such as, water-shed development, micro-irrigation etc. It is commonly perceived that fish farming requires large supply of water. On the contrary, it is possible to raise fish even in shallow water bodies, seasonally or throughout the year by adopting appropriate technologies and management. While agriculture and animal husbandry 'consume' most of the water they receive, the fish farming has the advantage of 'non-consumptive use' as the nutrient enriched farm water can be recycled without much loss of water and including the need for agri-horticulture. Considering the importance of fish as a quality protein source for combating malnutrition and also as aquaculture offers economic benefits like export trade, the Fisheries Technocrats Forum embarked on the idea of bringing face to face the nationally renowned experts and farmers by conducting a two day National Seminar on 'Development of Fisheries in Water Deficient Regions' to deliberate on the concerned issues and make appropriate recommendations to the relevant stake holders including the major game changers, namely, the Governments. The following recommendations have come out after the seminar held during 25-26 Feb. 2014 at the campus of Central Institute of Brackishwater Aquaculture, Chennai:

I. WATER RESOURCE MANAGEMENT IN RELATION TO FISHERIES DEVELOPMENT

1. The freshwater deficit is caused by many factors, like, poor input due to insufficient rainfall, improper channelization and retention of flowing runoff water, unregulated/over-exploitation of surface flowing and ground water, as the case may be, and poor insight in planning and co-ordination of multiple uses of water for extended availability under scarcity of water. **It is therefore necessary to make a real time assessment of water availability in water deficit prone areas and coordinate the plans and actions for judicious utilization of water including such non-consumptive use in fish farming and harvest.** A joint management programme involving all relevant departments would facilitatethe optimum use of scarce water resources.

2. Since strategies like watershed development would facilitate horizontal spread of water availability in upstream areas and also would slow down the running off water extending the water retention time, there would be ample scope for practicing fish farming in those areas. **Hence the development of watershed areas with appropriate structures and utilization of them for fish seed rearing and short term fish farming should be encouraged along with other agricultural activities.**
3. **The water bodies like the large pools created in the abandoned quarries/mines or seasonal but extensive water logged areas which remain unutlised/under-utilised may be considered for fish farming activities using, for instance, floating cages, on community lease.**
4. The surplus water flowing in the river during rainy season/discharge from dams can be **channelized without compromising the irrigation needs and retained/stored in ponds wherein fish culture and irrigation for agriculture can co-exist** and be optimized appropriately.
5. **The carrying capacity of small water bodies sourced along the rainwater drainage systems should be properly assessed** for planning and development of small scale fish culture.
6. **The river restoration programmes which are undertaken by the states should consider fisheries development** as an important component among multiple uses.
7. There are unusable brackishwater areas, due to several factors, like, stagnation caused by closure of bar mouth of the estuary and lack of exchange of water between the estuary and sea. **Desilting of the estuary and dredging of the barmouth are to be carried out wherever and whenever necessary for facilitating water exchange**. Further, **pollution from sewage and other industrial effluents should be strictly controlled by following control norms.** With the provision of quality brackishwater, shrimp and fish culture can be promoted.
8.

II. IMPROVING PRODUCTION SYSTEMS

1. There are many local varieties of fishes including air breathing fishes, which can be farmed in shallow waters. Depending on the local preference and marketability with a good price, **the indigenous species can be selected for promotion of aquaculture in water deficient regions**. The hatchery systems for producing sufficient quantity of seeds of such species have to be developed with suitable assistance and support from local governments.
2. The exotic fishes, such as, Nile tilapia, *Pangasius* sp., etc., are known to grow fast to marketable size and also have consumer demand. They have favourable characteristics for aquaculture in water deficient regions also and hence **steps should be taken to encourage the fish farmers to adopt farming of such species.**
3. The timely supply of critical inputs like fish seed and feed particularly for locally marketable species is a major constraint. Already the private sector, to a major extent, caters to the need for established farms in water surplus regions, where the demand is high. **Such critical inputs should be available for aquaculture in water deficit regions either through private or public sector.**

4. Integrating aqua-farming with agriculture, horticulture and live-stock rearing has good scope for judicious water use in water deficit areas and should be popularized. **Pilot units of integrated farming systems to demonstrate the techno-economic viability of channelizing, storing and appropriating the water use for multipurpose should be set up**.
5. The **giant freshwater prawn has good demand and can be stocked in seasonal and common water bodies for profitable culture. Good quality seeds should be made available** along with other suitable fish seeds to the farmers for short term culture and harvest.
6. The hatchery seed production technology for sea bass has been developed and perfected by Central Institute of Brackishwater Aquaculture and is available for large scale production of seed by entrepreneurs. The seabass is a high quality fish and can be cultured both in freshwater and brackishwater areas**. It can be popularized in water deficient areas adopting recycled aquaculture systems (RAS), and also in areas where quality of water could be restored under river restoration programmes**.
7. The recent development of large scale culture of SPF *vannamei* shrimp in brackishwater, opens up the possibility of culturing it in freshwater also. **The state governments should permit farming *vannamei* in freshwater systems** An Expert Committee can be constituted to formulate guidelines for the purpose.
8. It has been found advantageous to stock grownup fingerlings and rear them to marketable size in comparatively short term. **Necessary infrastructure for rearing fish seed up to stockable fingerling size (rearing ponds) should be set up** for supply to short period culture.
9. The cage culture of fishes has immense potential for growing fishes in seasonal water bodies, as well as reservoirs. Hence**, deploying cages at appropriate locations in such water bodies may be encouraged,** ensuring that the wastes generated from the cages are carried away by flow of water. **Locating sites for cage culture and appropriate leasing policies are to be put in place**.

III. TECHNOLOGY INTERVENTION

1. Available efficient methods of rainwater harvesting are to be evaluated and **location specific adoptable method(s) should be followed for channelizing, retaining, storing and filling the fish ponds**. Provision for recycling the water would be an added advantage.
2. For helping the farmers in managing the inputs for fish farming and managing the quality of water and the cultured fishes, **aqua-clinics are needed to be set up at suitable centres**.
3. Considering short term availability of water in several locations, **technologies for raising short term crops of fast growing fishes including major carp varieties and shrimps should be demonstrated and propagated.**
4. It appears that in many areas, the cultured major carps are facing in-breeding problems with symptoms of early maturity in small sizes and spawning of smaller sized eggs. Hence **broodstock improvement programmes need to be developed for selected species.** The improved strains like Jayanthi Rohu may be considered for extensive propagation and distribution.
5. To encourage water reuse, **use of probiotics should be popularized**.

IV. FINANCIAL SUPPORT

1. A**dvanced technologies like RAS, aquaphonics etc., though cost intensive, may be popularized especially among progressive farmers**, with appropriate incentives for initial infrastructure requirements and creating marketing network.

2. **Farm insurance should be provided in proportion to the standing crop** to cover the loss due to natural calamities.
3. Financial help may be extended to private parties for setting up Tilapia hatchery and ornamental fish rearing as in the case of fish culture.

V. INSTITUTIONAL MECHANISM

1. Relevant information and data collected by different agencies and departments (e.g., Groundwater Board, Rural dept, Fisheries department, village administration etc.) are **to be collated by a coordinating agency and used for comprehensive planning and implementation of schemes and development programmes**. Linkages between research, development and financial institutions are to be strengthened for improving fish farming in water-deficient localities.
2. **Interdepartmental cooperation is necessary for efficiently utilizing water resources** under multiple control and uses.
3. **Water resource leasing policy and water user's rights have to be taken into consideration before planning development of aquaculture** in consonance with multiple water uses.

VI. RESEARCH

1. **Extended period of carp breeding now practiced by a few farmers should be scientifically assessed** for ensuring production of quality seeds. Same way, there is a need for looking into reasons for small size fishes attaining early maturity in farms.
2. **Technologies for quality seed and feed production for high-value fishes such as murrel and *Pangasius* should be developed** for l commercial adoption.

VII. CAPACITY BUILDING

1. **Fish farmers should be apprised of recent developments in water efficient methods and recycling aquaculture systems** through awareness programmes, training, extension campaigns and demonstration programmes.

VIII. TAMIL NADU FISH FARMERS' SPECIAL NEEDS

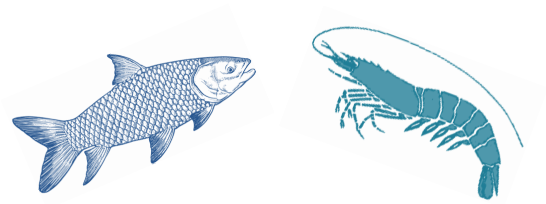
1. **Providing concessional electricity tariff from the date of initial connection of III-A1 may be considered on par with agriculture tariff IV.**
2. **Present 1HP power connection given to the fish farm ponds may be enhanced to at least to 5HP.**
3. **Subsidies for the purchase of generator and aerators may be extended to inland fish farmers in all the districts.**
4. As short seasonal tanks and ponds constitute over 50% of the fresh water resources, it is necessary to assess the water resources (season, period, depth of water availability) through remote sensing and GPS combined with on field study on lease holding rights, leasing authority and methods, social and economic problems, if any before planning development. **To start with, a small number of seasonal tanks located in a close by area in a district may be taken up for survey and improvement. These tanks can be taken up for a trial culture. Government may provide necessary funds for improving the tanks and to set up a common rearing pond for raising big size seeds. The Department of Fisheries has to coordinate the trial culture with the help of other departments and stake holders. Once the trial culture is proved viable, more and more seasonal anks can be brought under short-term fish culture.**

5. For short period culture, Nile tilapia is best suited. **The state government should set up a hatchery for supplying quality Nile Tilapia seeds to fish farmers for socking in long and short seasonal tanks and in cages fixed in reservoirs.**
6. There is a need to lease out the water bodies for longer period-say five years. This method will help the lessee to plan and stock the water body properly so that he can have a better harvest. Already, the State Fisheries Department has formulated policies for leasing out of water bodies for longer period. This may be pursued quickly.

Vote of Thanks

Mr. V. Venkatesan, Former Director of MPEDA, Kochi and one of the Seminar Organizing Committee members proposed a vote of thanks. On behalf of the members of the Fisheries Technocrats Forum and on his own behalf, he thanked Dr. S. Ayyappan, Secretary, DARE and Director General of ICAR for his kind encouragement and financial support and also to NFDB, Hyderabad and Dr. S. Santhanakrishnan, Chief Executive Officer, Maritech, Chennai for financial support, for the successful conduct of this National Seminar. He also thanked Dr. S. Vijayakumar, I.A.S., Secretary, Dept. of Animal Husbandry, Dairying and Fisheries, Govt. of Tamil Nadu, Mr. C. Munianathan, I.A.S., Director of Fisheries, Govt. of Tamil Nadu for the support, help and encouragement and to Dr. A.G. Ponniah, Director, CIBA, Chennai, Dr. A. Gopalakrishnan, Director, CMFRI, Kochi, Dr. J.K. Jena, Director, NBFGR, Lucknow and Dr. S. Dam Roy, Director, CARI, Port Blair for the participation of the exhibition organized by the Forum, in the context of conducting the Seminar.

A list of participants are given in Annexure 1.



SESSION I:STATUS OF FRESHWATER FISHERIESAND CHALLENGES AHEAD IN THE DEVELOPMENT FISHERIES IN WATER DEFICIENT REGIONS

***Lead paper*-I**

NEED FOR INNOVATIVE APPROCHES FOR FISHERIES DEVELOPMENT IN WATER SCARCITY AREAS OF INDIA

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Introduction

Freshwater resources of the country are reported to be fast depleting, mainly due to its multidimensional and indiscriminate use, lack of flows in rivers, annihilation or water bodies including wetlands and large lakes and the incessant tapping of ground water for innumerable purposes. The situation may further be aggravated due to global warming and consequent climate change. Due to population pressures and consequent human encroachment, aquatic ecosystems all over the country are stated to be in a state of stress, largely impacted by pollution from discharge of toxic industrial effluents and domestic sewage. The rivers, the life lines of all aquatic ecosystems in the country, are highly polluted , lack in natural flows and are losing connections to other water bodies. The uncertainty of sustainability of these life giving water bodies puts a premium on fisheries development in water starved areas. In view of the ever increasing demands on freshwater and adverse effects on water resources, there is an urgent need to look into the possible innovative methods to meet the challenges of water crisis, conserve water, rejuvenate the rivers, adapt to climate change and take advantage of species that can thrive in scarce water so that aquaculture can be extended to dry and barren areas of the country. The estuaries need immediate protection from human interference to make them more productive. The. paper highlights some of these innovative methods aimed at conservation of water resources and to increase fresh and brackishwater fish production in the country

Trends in fish production

Total fish production in the country has been estimated to be about 9.10 million tonnes (m.t) in 2013, of which, freshwater fish production accounts or 5.60 m.t. and marine fish 3.50 m.t. It is the author's opinion that freshwater fish production can be stepped up further, if all suitable water bodies in the country can be brought under fish culture, including fully harnessing the vast potential of reservoirs to produce fish by capture and culture. A large nation-wide exercise is necessary to accomplish this. There is also scope to produce more fish from brackishwaters, backwaters and estuaries, harvest wild stocks and culture the endemic high value species by developing hatcheries and conserving juvenile populations. As far as increasing marine fish production is concerned, the situation appears rather bleak. However, marginal increases may be possible by adopting stringent measures of mesh regulations to conserve juvenile populations in coastal waters, regulation of fishing intensity, propagating cage culture in distant waters on economic basis and encouraging only indigenous efforts to harvest oceanic tunas and squids.

Water crises

World's freshwater resources are estimated to be limited to only 3% of total water resources, of which, 2% are locked in glaciers and icicles. The rest are free in rivers, lakes, reservoirs, island seas, and atmosphere and soil moisture. Water is the sustainer of life and livelihoods, renewable but a finite resource. Future of the world depends on water and other natural resources. One of the fallouts of climate change is on water resources. Water availability and usage is interlinked with global warming and consequent climate change, population explosion, diseases, agriculture and other activities, sustenance of aquatic ecosystems, river and deltaic degeneration, floods, erratic monsoons, river valley systems, power generation, etc. World over, reports indicate diminishing water resources creating water disputes and even water wars. This is due to the increasing demands for water, far exceeding the nature's renewable capacity of freshwater. This has also lead to impacts on wetlands, lakes, groundwater resources and biodiversity. Building of dams on international rivers has been causing conflicts between nations as per recent reports. Similarly sharing of river and lake waters has become a bone of contention between competing states in the country.

India depends on the south-west and north-east monsoons for rainfall spreading across the country, some regions receiving copious rainfall and others, scarce rainfall. The rivers criss-crossing the country transport water to the nooks and corners, certain regions often flooded and others parched for lack of flows. In recent years, the weather, monsoons and rains have become erratic and unpredictable to some extent. Apart from the use of large quantities of water for agriculture and allied activities, for industrialisation, urbanization, power generation, (hydro- electric, nuclear, thermal and solar energy), vast amounts of water are needed. The pressure on water resources lead to excess usage of ground and surface water resources and consequent damage to water tables and recharging capacities of water bodies. This ever increasing use of water calls for rationalization, sustainable use of surface water resources, innovative management and conservation. Rainwater harvesting, lake and wetland protection, groundwater management, wastewater treatment, recycling and reuse of water are some methods towards achieving rationalization and conservation of water. Above all there is a need for water litracy and water awareness programmes. Innovative, cost effective and community based solutions to water crisis have to be encouraged and financially supported.

Climate change

According to certain reports, the prognosis that global warming and consequent climate change looming large across the globe would affect water resources, agriculture, fisheries, wetlands and biodiversity should be taken seriously by India and other developing countries. The consequences are stated to be melting of glaciers, rise in sea levels, increase in sea surface temperature, ocean acidification, floods, droughts, violent storms, changes in monsoon patterns, erratic precipitation, abnormal and extreme rainfall, coastal erosion and inundation. Indications of many of this taking place in different parts of the world are recognizable. In India, major impacts are expected on agriculture, water resources, monsoons, fisheries, biodiversity, coastal areas and Island territories. In this context, fisheries development in the country in the coming years could be critical in terms of excess water or its scarcity for inland and costal aquaculture, coastal fisheries, coastal and island communities. In view of these calamities, huge economic losses, impoverished livelihoods and repercussions on food production are expected. Thus, climate change has been looked upon as humanity's greatest challenge. While efforts at mitigation of climate change are considered herculean, adaptations to changing conditions are possible. Adversities of climate change, especially on water resources, have to be turned to advantages in water conservation and management for varied uses, including aquaculture and fisheries development. Revival and extensive use of traditional water harvesting systems in vogue in different parts of the country has great relevance in this context.

The beleaguered rivers

Rivers are sacred and revered in the country but now not maintained and allowed to be polluted. Pollution is today the greatest threat to rivers and other water bodies. They lack the natural flows with quality of water fast deteriorating. In India, water scarcity has been reported in 8 of the major 20 river basins. Since most of the freshwater ecosystems are directly or indirectly connected to the rivers, lack of flows in the rivers makes them defunct. Utter neglect of water bodies by human interference to create landfills and encroachments, construction of dams and barriers, land reclamation, discharging toxic effluents and sewage and destruction of river beds and deltaic systems has been causing scarcity and deterioration of the quality of water and even disappearance of certain water bodies, especially the inland lakes. Habitats of fish, their spawning and nursery grounds bore the brunt of deteriorating water quality. The once famous carp fish seed resources of the rivers completely vanished, aquaculture now dependent only on artificially produced seed through hypophysation. Wild fish seed resources and fish populations gradually vanquished. Environmental interferences like siltation and constriction of river flows, loss of riverine ecology and biodiversity are crucial for the sustainability of riverine fisheries.

It is common knowledge that any damage to riverine ecology has its own impact on the productive deltaic, estuarine and coastal ecosystems. Unless the influx of freshwater from the rivers into the estuaries and coastal waters is ensured, the hydro-biological characteristics of these areas would be drastically altered leading to destruction of the productive ecosystems. Several projects, schemes and authorities have been instituted by the Central Government and attempts made to clean the rivers, including the Ganges and Yamuna, spending lots of money but they have not delivered the goods. Concerted, sincere and well planned efforts to clean the rivers appear to be basically lacking but it is time we learn lessons from famous examples of the success of purification of the Rhine and Thames rivers of pollution to restore the salmon and other fish populations in these rivers. The uncertain and controversial river linking plan, mainly to make water available to drought prone regions of the country, flood management and irrigation may also alter the natural riverine ecology and usher in other adverse consequences. Priority now is to clean the rivers and allow them to flow naturally.

Some innovative water harvesting and conservation methods

Water is not a permanent resource available throughout the year. It comes from rain, and flows through rivers and streams. To make available water round the year, especially in rain fall scarcity regions, dry and barren areas, it is necessary to harvest and store the water when it is available. Rainwater harvesting should be encouraged all over the country. Dead and defunct water bodies have to be revived by storing water to recharge the groundwater. In ancient India, many traditional methods were used to harvest water from different sources. The methods used vary, depending on geographic, climatic, environmental, demographic and economic conditions. Erratic precipitation, and heavy rainfall events caused by monsoon vagaries due to climate change have to be turned to advantage by known traditional practices to harvest, save, store, reuse and recycle the excess water.

Traditional methods of harvesting water from rains, rivers and streams already existing in different parts of the country include construction of embankments along the river side to create large reservoirs or across rivers to divert the water. Such water is used for drinking, power generation, irrigation, agriculture etc. in arid and dry regions. Deep pits are made into which water flows, which is used for drinking. Water from hill streams and glaciers is made to flow into stone lined tanks for drinking and irrigation purposes. Bamboo pipes are used in hilly areas to harvest water from springs and streams for drinking and cultivation. Man made excavations are used to create tunnels in hill areas to tap water and store in tanks to be used for agriculture and other purposes. In view of the impending water shortage in the country, it would be relevant to revive, maintain and extend these small scale methods of water harvesting across the country to meet the increasing demand for water for agriculture and allied activities including aquaculture in water deficient regions, irrigation, power generation, drinking and other domestic use.

River valleys and other large natural depressions in hilly regions alongside rivers or mountain streams can be converted into large reservoirs by construction of stone walled embankments to store water in rainy season. Such receptacles of water already exist in some parts of south India and the northeast. Water stored in such man-made storage tanks can be used for agriculture and all other purposes including drinking. Construction of such embankments may be expensive initially, but taking advantage of the natural topography and terrain of the selected area, the expenditure could be brought down considerably. For large projects, financial support can be sought from multinational companies, information technology firms and other large companies.

Information collected personally at the Singareni Collieries, Kothagudem, Khammam district, Andhra Pradesh Indicates the coal mines in different parts of the country yield huge amounts of water during their operations. It appears, at the coal mines in Kothagudem, only part of this water (about 30%) is used for power generation, drinking and other domestic use, development of plantations over the soil excavated from the mines and dumped around the mines. Personal enquiries indicate the balance of 70% of total water generated can be otherwise used, especially for development of aquaculture in the adjoining dry and barren lands, after a detailed survey of these lands and assessment of suitability from aquaculture point of view. The limited agricultural activities in the area to grow crops like cotton, chilly, groundnut and rice depend on bore wells for water supply. This tapping of ground water can also be dispensed with, once the copious water generated in the mines is diverted for aquaculture and all other uses. Though a novel and promising idea, the potential for water supply appears enormous, especially in view of the possibility of using such water for aquaculture from other similar operating and abandoned coal mines in the countryas in the Jharkhand state. If found feasible, water deficient areas can be literally flooded with water to extend aquaculture into such areas. A national project to survey all the coal mines to assess the possibility of using surplus water for agriculture and other purposes may be undertaken as a preliminary exercise.

In future, mankind may have to look to the sea more and more than the land or outer space for sustenance, especially because it is at our door step. The living and nonliving resources of the sea offer great potential for this, provided they are rationally used, maintained and conserved. Of immediate concern could be desalination of sea water for drinking and other purposes. Several coastal areas are also facing drought conditions and water scarcity. Though desalination would be expensive, it may be inevitable in the long run, in the context of scanty and erratic rainfall and rapid groundwater depletion. It is gratifying to note, Tamil Nadu has already taken the lead in this direction and other coastal states should follow to meet water scarcity. Apart from potable water generation and supply first for drinking such desalinated water can be used for brackishwater and freshwater aquaculture in arid and semiarid areas. Early planning for installation of large plants at strategic locations would greatly help coastal communities to meet their water needs.

In the context of water scarcity and greater demand for water in future, we cannot belittle the importance of wetlands. Fortunately, the country is endowed with a rich Variety of wetlands. They occur in coastal areas, estuaries, lakes, along rivers, in the form of marshes, swamps and bogs and as other waterholding ponds, tanks, reservoirs etc. They are unique, highly productive and act as natures filter beds, cleaning, purifying, regulating water circulation and supporting a rich biodiversity. The wetlands are connected to land people fauna and flora around them and nurture them. They are pre-eminent in recycling matter, providing food for fish and space for their spawning and migration. Wet lands support lives and livelihoods and supply food, fuel and fiber. They play a key role in rejuvenating rivers, improving adjacent aquatic ecosystems, controlling floods, recharge ground water and maintaining water balance. Wetlands in a many parts of the country are reported to be disappearing being encroached upon for human habitation and other anthropogenic activities. For example, the disappearance of lakes in this country has reached appalling proportions to a point of no return. Floods reported right in some cities due to heavy rains are attributed to the disappearance of adjacent wetlands, which otherwise could absorb excess water, regulate floods and recharge groundwater for the benefit of people. There is hardly any public awareness of this important function of the wetlands. In water deficient regions as well as in areas where water is plentiful, wetlands act as store houses of water enabling agriculture and aquaculture. Therefore wetlands of the country have to be jealously protected, maintained and preserved as natures boon to humankind, especially in the context of water scarcity and water balance.

Development of fisheries in water deficient regions

The foregoing account signifies water is going to be a scarcer commodity in view of the ever increasing demand for this precious commodity. Apart from direct human needs, large quantities of water are needed for agriculture, industry, power generation etc. Fisheries development in water deficient areas is already at low ebb and with the above impacts on the water resources of the country, it would be a difficult task to extend it. However, certain attempts, especially to revive and extend the traditional water harvesting methods, rain water harvesting, storing, using, reusing and recycling of water, conservation of water resources, innovative ideas to find new sources of water and halting intense groundwater extraction , destruction of water bodies and aquatic ecosystems can facilitate aquaculture to some extent in such water starved areas. Coupled with these methods to generate water resources in water deficient areas, species selection for aquaculture would also be important and crucial.

Freshwater aquaculture

The air breathing fishes is an ideal group to culture in water scarcity areas because they can survive in very limited quantities of water, hardy and are in great demand. At present, they are mostly captured from the wild and are in short supply in several areas of the country. The climbing perch, *Anabas testudineus*, catfishes like *Clarias batrachus* and *Heteropneustes fossilis* and the murrels, *Channa mauruleuns, C.striatus* and *C. punctatus* can be extensively and intensively cultured in water deficient areas, swamps, muddy and derelict terrains. Other than the above mentioned species, there may be some local species which may also thrive under adverse conditions. Several attempts have been made by several institutions and individuals in this country to breed and propagate the air-breathing fishes over the past few decades but even today, the total package of practices does not seem to be available for adoption by farmers on a commercial scale. The claims for technology breakthrough are not sustained and applied in the field. The gaps in technology have to be bridged so that large scale culture could be done on an economic basis. Hatchery and nursery systems have to be established for large scale supply of seed of these fishes.

Fish culture in recycled water in water scarcity areas has also great potential for development. Tamil Nadu offers great scope to culture the eel, *Anguilla bicolor* in recycled water. The plentiful availability of elvers of this species in coastal areas of Tamil Nadu can be taken advantage of, for production of marketable sized eels (about 35 cm long) in about a year. This has been demonstrated several years ago at the Regional Centre of Central Marine Fisheries Research Institute (CMFRI) at Mantapam Camp but the technology remains to be adopted by the farmers. Since the technology is relevant to water scarcity areas of this state as well as the other adjacent states, extensive demonstrations and popularization of the method would be very useful.

Brackishwater aquaculture

The country is endowed with rich brackishwater resources in the coastal states but all along, only shrimp culture has been advocated because of lack of viable technologies for culture of fin and shell fishes and also because of the short term culture of shrimp and the high price it commands in international market. Only in recent years, focus has been shifted to breed and culture fin and shellfishes. A few technological breakthroughs have been achieved by the Central Institutes (CIBA and CMFRI) but they await commercialization through establishment of hatcheries, supply of seed to farmers and farming in brackishwater and coastal waters. Significant results have been obtained in the case of farming of green mussel in coastal and estuarine areas and for edible oyster in the brackishwaters.

Important fauna of the estuarine areas include fishes (sea bass, sand whiting, mullets, hilsa, carangids, catfishes and eels), crustaceans (shrimps and crabs), and molluscs (clams, oysters and mussels). The life histories of many of these species are dependent on migration between sea and the estuaries. To-day, many estuaries are reported to be in a highly polluted condition hindering the migration of these fishes, affecting their spawning grounds, nursery areas and seed availability . The quality of water deteriorated drastically. Several major industries like those manufacturing chemicals, steel, electricity, paper, oil and gas are located on the banks of the estuaries and river mouth areas discharging effluents containing toxic chemicals into the water causing damage to fisheries resources. Further proposals to develop industrial corridors in certain coastal states will only cause more damage to aquatic resources. Heavy metals that damage the aquatic ecosystems are present in waste water produced in metal cleaning, mining, electroplating, paper, pulp and paint making, textiles , tanneries and e-waste recycling . Besides these, agricultural pesticides, insecticides and herbicides and domestic sewage are let into water bodies harming aquatic life. Construction of dams, barrages, saltwater exclusion barrages across rivers and streams have been constricting fresh water flows down the rivers resulting in stagnation of water, sedimentation and destruction of the highly productive deltaic regions. The country already has innumerous dams and it is understood there are plans for constructing more dams. Expert opinion indicates a thorough review of existing dams and their functioning is necessary before any new dams are constructed and also to decommission some of the old ones if found not useful any more. This is being done in several other countries. It is common knowledge many dams and anicuts in this country do not provide fish passes and ladders for migratory fishes. Populations of hilsa in several rivers are suspected to have declined over years, due to this reason. Many brackishwater areas have also shrunk, reclaimed, encroached and polluted due to human interference for developmental purposes. Unless such interferences are curbed and estuarine areas maintained in a healthy state, estuarine fisheries resources would continue to dwindle, having repercussions in the long run on certain coastal fisheries resources. Creation of public awareness regarding the vital role played by the sensitive estuarine and brackishwater areas between the salt water and fresh water regimes has to be a priority.

Estuarine estates

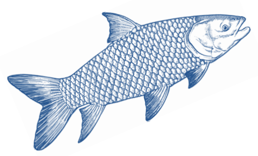
The concept is entirely new, novel and innovative, proposed to protect and preserve the fisheries wealth of the estuaries, Estuaries are considered to be one of the most productive aquatic ecosystems. The plight of the estuaries in the country at this point of time is most miserable in that they have completely lost their purity and original capacity to sustain life. The quality of water deteriorated due to incessant discharge of pollutants into the estuaries and coupled with lack of free flow of fresh water and adequate flushing, they tend to become mere cess pools. It is in this context , it would be desirable to protect the estuaries from adverse human activities and regenerate the living resources. In the simplest form, identified estuaries have to be encircled by embankments without obstructing the free flow of water into and out of the estuaries, not hindering the normal activities and livelihoods of fishermen and other coastal communities ensuring the right of passage and full involvement of local people in fishing and fish culture activities in the estuary and in the adjoining areas. Such enclosed and protected project areas should also provide for hatcheries, nurseries and ranching facilities for various species into the estuaries to maintain their populations. The estuarine estates, when fully operational, would not only protect and preserve the estuaries but also provide food and employment to many rural people. Above all, the estuaries can be managed to maintain good quality of water and rid them of pollution. Since it is expensive to create the estuarine estates, it is suggested that a well planned scheme may be drawn on a sound scientific, public- private, partnership basis that each estate may be adopted by a large multinational company or firm to manage the estuary to produce fish through capture and culture on a continuous basis.

Conclusions

In view of the impending water crisis, fisheries development in water deficient regions of the country would face serious challenges. The situation may further worsen due to the predicted global warming and consequent climate change, impacting among other human needs and the water resources of the country. The situation, therefore, calls for adapting to changed circumstances by resorting to innovative methods and novel ideas.

It is suggested the traditional methods of water harvesting should be revived and strengthened across the country, in different geographic, climatic, environmental and demographic situations. A new and unutilized source of water for fish culture and agriculture in dry and barren lands could be the surplus water from the coal mines. Innovative approaches to conserve, store, reuse and recycling water as pointed out have to be developed for aquaculture and other uses. Air breathing and other hardy fishes eminently qualify for intensive production in water scarcity areas for which a complete package of practices for culture on economic basis should be made available to the farmers.

Excessive human interference with mines and estuaries in the country has wrought untold misery to the livelihoods of people dependent on them, the water resources and the connected aquatic ecosystems. It is imminent that the rivers and the estuaries are cleaned of pollution to restore the pristine nature of these water bodies, to continue to generate valuable fisheries resources. To effectively protect and preserve the estuaries, a new concept of establishment of estuarine estates is proposed on the basis of public- private partnership, with each selected estuary to be adopted, managed and operated by a multinational company.




Lead Paper-2

WATER BODIES IN TAMIL NADU AND THEIR PRODUCTIVITY FOR FISHERIES

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Introduction

Fisheries sector occupies a very important place in the socio-economic development of the country. It has been recognized as a powerful income and employment generator as it stimulates growth of a number of subsidiary industries, and is a source of cheap and nutritious food, besides being a foreign exchange earner. Most importantly, it is the source of livelihood for a large section of economically backward population of the country. Yet, the above said benefits are at risk as the exploitation of natural fish stocks is reaching its limits and aquaculture production has not yet fulfilled its potential. In aquaculture production, freshwater and brackishwater resources are utilized to certain extent. The freshwater aquaculture production is targeting the domestic consumption, while brackishwater aquaculture is contributing towards the major portion of exports and foreign exchange.

Indian fisheries and aquaculture are two important sectors of food production, providing nutritional security to the food basket, contributing to processed fish exportsand engaging about fourteen million people in different activities. With diverse resources ranging from deep seas to lakes in the mountains and more than 10% of the global biodiversity in terms of fish and shellfish species, the country has shown continuous and sustained increases in fish production since independence. Constituting about 4.4% of the global fish production, the sector contributes to 1.1% of the GDP and 4.7% of the agricultural GDP. The total fish production of 6.57 million metric tonnes include nearly 55% from the inland sector and nearly the same from culture fisheries.. There are about 30,000 species of fish in the world, of which, about 18,000 are found in India. Fish also forms an important part of diet of the people living in the coastal areas.

Importance of Fisheries

India places 3rd in fisheries and 2nd in aquaculture based on GDP. The following Table 1 shows the GDP details relating to fish production in India:

Global position	**3rd in Fisheries 2nd in Aquaculture**
Contribution of Fisheries to GDP (%)	1.07
Contribution to Agriculture. GDP (%)	5.30
Per capita fish availability (Kg.)	9.0
Annual Export earnings (Rs. In Crore)	7,200
Employment in sector (million)	14.0

Table 1: GDP contribution by fish production

The importance of fisheries in a country cannot only be measured by the contribution to the GDP, but one must also take into consideration that fisheries resources and products are fundamental components of human feeding and employment. Another aspect that makes fisheries resources important is the self renewable character. Unlike mineral resources, if the fishery resources or any other biological resources are well managed, their duration is practically unlimited. An important conclusion is that the fundamental basis for the conservation and management of fisheries resources stems from the biological characteristics. (This does not mean that social, economic or any other effects are not important for management).

Water Bodies and Fish Production

India's Contribution towards Fish (Global) Production

Table 2 indicates the extent of inland water bodies resources in India.:

Total inland water bodies (lakh ha)	**73.59**
Rivers & canals (km)	1,95,210
Reservoirs (Lakh ha)	29.07
Tanks & ponds (lakh ha)	24.14
Flood plain lakes / derelict waters (lakh ha)	7.98
Brackish water (lakh ha)	12.40

Table 2 : Inland Water Bodies in India

Name of Country	**Capture (tonnes)**	**Culture (tonnes)**	**Total Production (tonnes)**	**% Share**
Total world	8,89,18,040	5,56,80,738	14,45,98,778	-
China	1,49,19,596	3,47,79,870	4,96,99,466	34.37
India	40,53,241	37,91,920	78,45,161	5.43
Peru	69,14,452	-	69,14,452	4.78
Indonesia	50,99,355	17,33,434	68,32,789	4.73
Vietnam	22,43,100	25,56,200	47,99,300	3.32

Table 3 : Fish Productivity in India

Table 3 details of fish production of top five countries. China is contributing 34.37% to global production due to the yield (3,47, 79,870 tonnes from aquaculture. However, the China's captures fisheres amounted to 1/3 of total fish produced. India ranked 2nd place (5.43% of share) and its capture and culture fisheries amounted to 40,53,241 tonnes and 37,91,920 tonnes respectively.

Inland Fisheries of Tamil Nadu

Inland fish production in India has gone about 2.5 times in a span of nearly two decades. It also provides employment to over 11 million people engaged fully or partially. The following Table 4 shows the extent of inland water bodies in Tamil Nadu:

Total inland water bodies (lakh Ha)	6.93
Rivers & canals (Km)	7.420
Reservoirs (Lakh ha)	5.70
Tanks & ponds (Lakh ha)	0.56
Flood plain lakes / derelict waters (lakh ha)	0.07
Brackish water (lakh ha)	0.60

Table 4 : Inland water bodies in Tamil Nadu

Total inland water bodies in India is 73.59 lakh ha, which include rivers, canals, reservoirs, tanks, ponds, flood plan and brackishwater. The extent of total inland water bodies in Tamil Nadu are 6.93 lakh ha..

Year	Andhra Pradesh ('000tonnes)	West Bengal ('000tonnes)	Gujarat ('000tonnes)	Kerala ('000tonnes)	Tamil Nadu ('000tonnes)
2011-12	1,603.17	1,472.04	782.72	693..21	611.49,(184.75)
2012-13	1,675.44	1,490.01	848.79	667.78	620.40,(191.96)

Table 5 : Top Five Fish Production States in India

Table 5 shows the inland fish production from top five Indian states, of which, Tamil Nadu occupies 5th place.

Inland Fisheries Growth Rate

$$\text{Growth rate \%} = \frac{\text{Year 2 production} - \text{year 1 production}}{\text{Year1 production}} \times 100$$

The above table 6 refers that in last seven years growth rate is decreased growth rate was high during 2004 – 2005 is high (50.02%) comparatively. There were zero % growth rates in the year of 2006-07, which increased to 12.11 % In 2011–12..

Year	Inland	
	Inland ('000 tonnes)	Growth rate (%)
2004-05	151.73	50.02
2005-06	`155.04	2.18
2006-07	155.04	0
2007-08	166.09	7.13
2008-09	168.88	1.68
2009-10	181.8	7.65
2010-11	210.2	15.62
2011-12	184.75	12.11
2012-13	191.96	3.90

Table 6: Inland fish production in India during 2004-2012

Reservoirs and Irrigation tanks and their fisheries in Tamil Nadu

The extent of 69 reservoirs of Tamil Nadu is 58,462 ha and that of 8,837 irrigation tanks 3,00,278 ha. Table 7 indicates the fish catch from reservoirs.

Fish Production trends in Stanley Reservoir (Table 7)

Name of Reservoir	Area (ha)	Fish landing
	Average	(t yr^{-1})
Salem District		
1. Mettur	**9 324**	**115**
Periyar District		
2. Bhavanisagar	**3 208**	**179**
Cuddalore District		
3. Veeranam	**38**	**36**
4. Perumaleri	**1 295**	**-**
5. Wellington	**500**	**9**
6. Poondi	**1 402**	**15**
Madurai District		
7. Vaigai	**1 554**	**24**
Thiruvannamalai District		
8. Sathanur	**56**	**126**
Kanyakumari District		
9. Pechiparai	**700**	**9**
Dharmapuri District		
10. Krishnagiri	**768**	**47**
11. Vaniyar	**61**	**3**

Table 7. Fish yield from reservoirs

Mettur Reservoir has the area of 9,324 ha with a yield of 115 tonnes/year, while the Bhavanisagar has a lesser area of 3,208 ha with increased fish yield of 175 tonnes/year.

Stanley reservoir has the water spread area of 15,346 ha. During 1960-61, the total fish production was 405 tonnes. The fish catch comprised 37% of *Catla catla*, 39% of *Cirrhinus*, 5% of *C. mrigala*, 18% of catfishes and 1% of other species. During 1964 – 65, the total fish production was 223 tonnes, which was composed of 17% of *Catla*, 25% of *Cirrhinus*, 8% *C. mrigala* and 50% of catfishes, indicating a wide fluctuation in species composition in different years. The Bhavani Sagar has a water spread area of 7,876 ha with varying water level of 5.46 22.6 m during 1971-1981. Over 14 years of period, fish production reduced to half from 10.19 tonnes to 5.04 ton.nes

Soil of Bhavani Sagar reservoir bed is categorized as salty clay loam and mostly acidic in reaction, judged by the presence of available nitrogen, available phosphorous and organic carbon. During pre-monsoon months, the pH was found to increase towards neutrality.

Scheme and Implementations

IAMWARM scheme for efficient fish production

In an agrarian state like Tamil Nadu, there is a need for intensifying efforts to improve productivity and Income. Growth in agriculture depends on increasing the efficiency and productive use of water. IAMWARM Project is about the efficient of use of water and land resources. It provides 7 ways to improve inland fish production.

1. Fish culture ponds are excavated primarily for rain water harvesting and storage, so that It could be efficiently used for aquaculture. Farmer can get net revenue of Rs.10,000/- per pond. It also helps to increase groundwater table.
2. Aquaculture in Irrigation tanks by establishing fish seed bank will promote sustainable aquaculture in the sub basin.
3. Fish seed rearing in cages:
   Fish seeds will be reared from early try to advanced fingerlings in these cages that will be fixed or floated in irrigation tanks, having water depth of more than 1.5 m.
4. Ornamental fish culture is a fast growing profitable venture like cash crops in agriculture. The domestic and trade potential are high.
5. Improvement to Government fish seed production centres to meet the seed requirement of sub basins areas.
6. Fishing implements such as coracles, nylon nets, etc are provided for effective harvesting of reared fishes.
7. Live fish trade is expected to ensure its quality to the consumer and better price to the producer.

During the year 2007-08, the above activities were implemented in the first phase of 9 sub basins.

Initial observation of IAMWARM project at Varahanadhi

This is one of the potential sub basin identified for inland aquaculture development.

1. **Aquaculture in farm ponds**
   Agricultural farmers of this sub basin were motivated to take up aquaculture in farm ponds through awareness campaigns like IAMWARM days. 16 farmers in Villupuram district and 3 farmers in Thiruvannamalai district expressed interest in taking up aquaculture. All of them were trained in good management practices in aquaculture and related activities. 17 farm ponds were stocked with carp seeds and the culture is in progress. The growth assessments trails showed good growth of reared fishes in the ponds.

2. **Fish Kiosks**
   Two fish kiosks, one at Tindivanam and the other at Vikravandi were established in the sub basin which will ensure better price to freshwater fish and prime quality fish to the consumer.

3. **Fishing Implements**:
   Ten units of fishing implements have been supplied. This will ensure better fishing efficiency in the irrigation tanks and reservoir.

Contribution of 11TH Five Year Plan

Funds availed by the Govt. of Tamil Nadu from NFDB

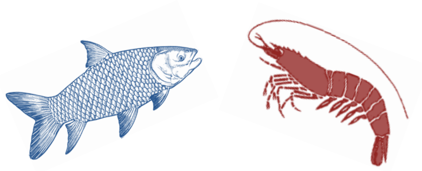
During 11th plan, Rs. 1,627.16 lakhs have been used for better fish culture and production. After the 11th plan, we could see that fish production has been increased. But growth rate is getting decreased. The trend in inland fish production in Tamil Nadu reveals that there is a major shift in inland fish production and a positive trend in the eleventh five year plan period.

Contribution of Fish to the Millennium Development Goals

- ✓ Over 40 million people in the developing world are engaged in fishing and fish farming.
- ✓ Indirect contribution from improved child health and income for wome
- ✓ Fish is shared more equally within the household than other protein – rich foods.
- ✓ Reduces risk of low birth weight, a key factor in child mortality.
- ✓ Improved nutritional status of women.
- ✓ Income from fish can enable the poor to access health services.
- ✓ Good fisheries governance can contribute to sustainable aquatic resource management.
- ✓ Fish is one of the most traded commodities and a major export for many developing countries, offering an opportunity for trade agreements which contribute to the development of poor countries.

Conclusion

Fisheries sector provides the basis for the livelihoods and nutrition of millions of people, and constitutes a significant source of foreign exchange for many developing economics. Despite it has considerable contributions to development, however, it is often not seen as a priority sector by policy makers such as aquaculture are frequently seen as relatively low-priority for the allocation of scare resources such as water. In Tamil Nadu, the total fish production increases but growth rate is getting decreased year by year. Hence, it is suggested that the government can implement appropriate management policies for a eco-friendly and sustainable capture and culture fisheries.



Technical paper-1

GROUNDWATER SCENARIO IN COASTAL TAMIL NADU AND UNION TERRITORY OF PUDUCHERRY

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Introduction

Tamil Nadu is bounded by the Bay of Bengal on the east. With a geographical extent of 1,30,058 sq. km. the state has a shoreline of 998 km with varying widths of coastal tracts. It stretches from Pulicat Lake to Cape Comerin ranging in elevation between 2 and 30 m above mean sea level with beach terraces and broad inter-terrace depressions. Tamil Nadu is drained by a network of major and minor rivers which forms the chief drainage system of the State finally confluence with the Bay of Bengal.

A sequential pile of unconsolidated alluvial sediments of Quaternary age underlies the coastal tract of Tamil Nadu. These sediments comprise sands, clays, silts with admixtures of gravel and are underlain by the older formations ranging in age from Tertiary to Archaean Shore exposures. Charnockites are seen at a few places right on the coast. The data generated from the detailed hydrogeological surveys in the coastal tract of Tamil Nadu, during the past two decades, have revealed the presence of a number of aquifers down to depth of 750 m. A general stratigraphic sequence encountered is given below.

Era	Age	Lithology
Quaternary	Recent	Sand & Sand-Clay intercalations.
Tertiary	Eocene to Pliocene	Sand, Clay, Sandstone & Arenaceous Limestone
Secondary	Cretaceous to Upper Carboniferous	Sandstone, Limestone, Conglomerates & Shale
Azoic	Pre Cambrian & Achaean	Granites, Gneiss, Charnockites & associated intrusives.

Tiruvallur, Kancheepuram, Cuddalore, Villupuram, Nagapattinam, Thanjavur, Tiruvarur, Sivaganga, Pudukkottai, Ramanathapuram, Tuticorin and Kanyakumari are the coastal districts in Tamil Nadu from North to South. In addition, Puducherry Region and Karaikal Regions of UT of Puducherry forms enclave within Tamil Nadu on the coast.

Subsurface Hydrogeology of Coastal Aquifers

The hydrogeological conditions of coastal aquifers from North to South are described in the following paragraphs.

Minjur area (North Chennai) Tiruvallur District

The Coastal area ofMinjur (North Chennai), Tiruvallur district,is underlain by the alluvial deposits of sands and clays in varying propositions. The thickness of the granular zones varies from place to place. The granular zones occur generally between 9 and 15 m bgl and 20 and 47 m bgl (below ground level) towards the Minjur area. Gondwana sandstones occurs between 15 to 200 m in the south-western part of Tiruvallur district.

The major portion of the area is occupied by recent alluvium and groundwater is found to occur in unconfined/semi-confined conditions in these formation. Groundwater is developed by dugwells and tubwells. The depth of the dugwells ranges from 3 to 8 m bgl while the depth of the tubewells ranges from 15 to 80m bgl.

The studies carried out by Central Ground Water Board (CGWB) in the year 2011-12 reveal that denser saline water has intruded the freshwater aquifer in the Minjur-Mouthambedu (on the eastern side) to Vellanoda-Madaravaram village (On the central portion eastern of Tachur). Sea water intrusion is observed between 16.5 to 17.0 km in land. The groundwater level has gone below the mean sea level due to extensive pumping for agricultural and drinking water supply schemes. This has resulted inward movement of the denser seawater to maintain the hydrodynamic balance of the aquifer system.

Thiruvanmiyur Coastal Aquifer in Chennai City

The recent alluvium in Thiruvanmiyur area is underlain by crystalline rocks of Archaean age. Two types of aquifer exists in the area a) Shallow Alluvial aquifer and b) Deeper Crystalline aquifer. The thickness of the alluvium in the shallow aquifer ranges from 10 to 30 m. Productive aquifers occurs as thin granular zones. Weathered and fractured zones of the crystalline rocks constitute the deeper aquifer. Ground water occurs under unconfined conditions in shallow aquifers and semi-confined conditions in crystalline aquifers.

The ground water in the shallow alluvial aquifers is contaminated by seawater intrusion whereas the deeper crystalline aquifer is affected recently. Fluoride content in deeper aquifer has diluted from 5.00 to 0.99 mg/l. as a result of implementation of roof top rainwater harvesting in the area. Rapid urbanization in and around Thiruvanmiyur area during last decade is directly manifested by higher demand and resulted alarming depletion of ground water resources. To meet the growing demand, number of shallow tube wells have been constructed in the study area. The continuous withdrawal of ground water from the shallow alluvial aquifers resulted in the decline of ground water levels and seawater intrusion has been taken place along the coast in Valmikinagar,and Tiruvalluvar Nagar in Thiruvanmiyur.

Kancheepuram District

Along Tiruvanmiyur-Covelong Kalpakkam Coastal Alluvial Tract, it is seen that sand dunes form a good repository of groundwater. A study carried out by CGWB in collaboration with BARC and M.S Swaminathan Research Foundation revealed that formation of water in the sand dunes extending down to 15 m, along the coast has freshwater and in the fractured basement, the water is brackish. The cause of salinity in the formation is not due to seawater intrusion but due to insitu salinity.

A narrow strip of land on both sides of Palar river course in its lower reaches forms the coastal part in Kancheepuram District. The northern side of the river is underlain by crystalline rocks whereas the southern side is underlain by alluvial cover comprising of sand and clay in varying amounts and the thickness of the alluvium is limited. The aquifer at the tail end of Palar River is potentially rich. The studies carried out by UNDP have revealed five aquifers along the river course located at Voyalur, Menapakkam, Pilappur, Pullambakkam and Panapakkam. In general, the thickness of the aquifer varies from 2 to 20 m.

The quality of ground water is fresh and found suitable for domestic and irrigation uses. The quality of groundwater is poor in the areas occupied by saltpan and tidal flats.

Villupuram District

The formations encountered are sands, clays and their admixtures, mottled ferruginous sandstone with lignite seams, shale, siltstone, calcareous sandstone and fossiliferous limestone. Five granular zones were encountered within the explored depth of 450 m bgl. The alluvium is around 40 to 70 m, followed by tertiary aquifers of about 50 m between 220 and 395 m. In general water quality is marginally mineralised with EC of 2274 to 3370 μS/cm along the coast.

Cuddalore District

The formations encountered are sands, clays and their admixtures, mottled ferruginous sandstone with lignite seams, shale, siltstone, calcareous sandstone and fossiliferous limestone. The thickness of granular zones in the shallow aquifer group occurring within 100 m bgl ranges from 15 to 75 m where as in deeper aquifer group between 100 and 450 m bgl is of the order of 30 to 304 m.

The Phreatic aquifer is not used for its ground water depressurization while mining but the leakage from this layer drained into the mine pits is pumped back to natural drains for irrigation purpose. The Semi-confined layer above the lignite seam varies in thickness from 5-10 m and it does not have considerable ground water pressure. The upper confined layer (5the layer) below lignite seam is 30 – 40 m thick. It has good ground water potential and exerts a upward pressure makes the mining activities difficult. Depressurizing technique has been employed by optimum pumping strategy for safe mining of lignite. The sixth layer of 300 m having an upward pressure of 6 to 8 kg/cm^2 is considered as Lower confined aquifer.

Ground Water in Coastal Aquifers occurs under semi-confined to confined conditions. Yield of the successful tube wells tapping productive granular zones within 450 m bgl varied between 20 to 50 (litre per second) (lps) for draw down ranging from 0.78 to 8.0 m.

Hydrochemistry of deeper coastal aquifers is evaluated from the chemical analysis results of samples collected from exploratory wells and during zone well/packer tests from different aquifer depths. In general, quality of ground water tapping the granular zones of Cuddalore sandstones between 100 and 450 m bgl is fresh with electrical conductivity below 1000 micro siemens/cm at 25°c, except the Bhuvanagiri-Chidambaram-Parangipettai.

Along the Coast in North-South Direction, saline water is underlain by fresh water in general below 400 to 450 m bgl from Chavadi to Sankolikuppam. Lenses of saline water pockets from the shallow aquifers between 30 to 99 m bgl all along Chavadi, Cuddalore and Sankolikuppam area have been observed. The quality of ground water improves downwards and become fresh below 200 through a transition zone of brackish from 99 to 200 m bgl at Manjakuppam (Cuddalore).

Cauvery Delta

The Cauvery delta is the major part of the coastal track of Tamil Nadu is encompassed in erstwhile Thanjavur composite district comprising Thanjavur, Tiruvarur and Nagapattinam districts. The shallow aquifer groups occurring within 100 m bgl have one to five granular zones with a total thickness of 3 to 54 m, while the deeper aquifer groups between 100 to 450 m bgl have one to 5 zones with a cumulative thickness of 11 to 103 m.

The fineness of the grain size in the aquifer material increases towards the coast in all three aquifers. Groundwater quality also changes laterally in pattern similar to that of aquifer composition in grain size and its hydraulic properties. Thus, the groundwater type changes from Calcium bicarbonate type in the east to Sodium bicarbonate type in the transition zone to Sodium Chloride type in the east along the coast. In general, the quality of groundwater is potable inland and away from the coast and is observed to deteriorate towards the coast. Electrical conductivity varies from 200 μS/cm in the west to 10000 μS/cm in the east.

Pudukottai District

In Pudukkottai district, sedimentary formations belonging to cretaceous, Tertiary and Recent age occupy the coastal tract. The cumulative thickness of granular zones within 100 m bgl varies from 6 to 39 m, while it varies from 21 m to 250 m in the deeper aquifer between 100 to 450 m bgl. The thickness of the zones in the shallow aquifer tends to decrease towards the coast on the contrary the thickness of zones in the deeper aquifer tends to increase towards the coast. The quality of formation water tends to deteriorate towards the coast. EC of less than 500 μS/cm at 25^{o}C in the west around Gandharvakottai deteriorates to 3000 μS/cm at 25^{o}C at Kattumavadi in the coast.

Sivaganga District

In this district, sediments of Tertiary and Recent age are encountered in the coastal tract. 1 to 8 granular zones were encountered within 100 m bgl with a cumulative thickness of 13 to 58 m and 2 to 12 granular zones of thickness of 23 to 81 m were encountered between 100 to 316 m bgl. The chemical quality of formation water in deeper aquifer in most of the district is good with EC varying from 849 to 2110 μS/cm at 25^{o}C except in Ilayangudi taluk.

Ramanathapuram District

In the district, the coastal area is mostly covered by alluvium of Recent age and a thin cover of Tertiary sediments, exposed in the western part bordering the crystalline exposed as a small patch in the western side of the district. The aquifers within the explored depth in sedimentary areas can be broadly grouped into shallow aquifer group within 100 m bgl and deeper aquifer groups beyond 100m bgl. The exploration has revealed the occurrence of 1 to 6 granular zones with a total thickness of 2 to 73 m within 100m and 2to 14 granular zones with a total thickness of 12 to 305 m in the deeper aquifers. The quality of formation water is highly saline (insitu) in most of the zones as confirmed during exploration. The electrical conductivity is of the order of 36,600 μS/cm at 25^{o}C. Tiruvadanai aquifer at the depth of 348 to 378 m in northern part of Tiruvadanai Taluk is the only aquifer supplying potable water to local population. Chemical quality of ground water is highly saline and is of the order of 11800 to 15400 μS/cm at 25^{o}C. in Ilayangudi taluk on the southeastern part of Sivaganga district.

Tuticorin District

In Tuticorin district, Quaternary alluvium, Tertiary aquifers comprising sandstone and limestone constitute the water bearing formations. The strike fault and dip fault affecting the thickness of the sediments along the coast. The basement was encountered (45 to 125 m bgl) in the shallower depth in the Northern and western part and at deeper depths along the coast in Kundal – Tiruchendur area. The exploration down to a depth of 125 m has revealed that there are 3 to 10 granular zones with a cumulative thickness of 25 to 60 m. The thickness of top Teri sand zone ranges from 7 to 15 m. The fresh water is restricted to the upper zones restricted to 50m and top Teri sand aquifer is tapped by shallow tube wells and the limited extent of freshwater aquifer does not support large-scale development of tertiary aquifers.

Tirunelveli District

Four to five granular zones were encountered in the two exploratory wells drilled in coastal tract of Tirunelveli district with a cumulative thickness of 34 to 39 m. The yield of wells varies from 2.5 6.8 lps for drawdown ranging from 3.49 to 15.48m. Specific capacity ranged from 10.01 to 117.2 lpm/m of drawdown. The transmissivity values vary from 75 to 1070 m^2/day and the storativity is in the order of 1.3 x 10-3. The formation water encountered in the wells drilled in general is potable and EC is less than 500 μS/cm at 25^{o}C. The deterioration of formation water in the confined aquifers occurring in the depth range of 55 to 120 m at Nalumoolaikinar, south of Tiruchendur is noticed.

Puducherry Region, UnionTerritory of Puducherry

In Puducherry Region, the coastal aquifers can be broadly divided into three groups, viz., Alluvial, Tertiary and Cretaceous aquifers. The thickness of alluvial aquifers range from 5 – 34m tapped by wells in the depth range of 25- 50 m, while it varies from 20 to 245 m in Tertiary formations and is tapped by tube wells in the range of 27-366 m depth. In Cretaceous aquifers, the thickness varies from 38 – 92 m and the depth of the wells tapping this aquifer varies from 65 – 400 m bgl. The groundwater exploration has revealed that in general, the groundwater encountered down to 300 m bgl was of good quality with EC less than 600 μS/cm, while the zones beyond 300 had EC about 1500 μS/cm.

In general, the quality of the formation water in alluvial aquifers is good and has EC <750 μS/cm and at Murungapakkam, Kirumampakkam, Kilparikelpet and Uchimedu along the coast at about 5 km from the coast has shown EC>10000 μS/cm. It has also been reported that the deterioration in quality at these places may be due to seawater intrusion.

Groundwater in Tertiary aquifer is good and has EC <750 μS/cm except along the coast at Murungapakkam (8280 μS/cm), Kilparikelpet (6800 μS/cm) and Uchimedu (5100 μS/cm). Similarly, the quality of groundwater in Cretaceous aquifer is also good and has EC <750 μS/cm except at Madagadipet where EC recorded as 7280 μS/cm. Along the coast from Marungapakkam to Kilparikalpet, , the formation water has turned brackish in both Recent Alluvium and Tertiary aquifers in recent years probably due to seawater ingress.

Spatial Distribution of Water level and Water quality

The CGWB had initiated long term groundwater regime studies in order to know the behaviour of the water table and the changes in chemical quality of groundwater by establishing a network of hydrograph stations. The water levels are monitored during January, May, August and November and the water samples are collected during the month of May every year.

The data of water level monitoring in phreatic aquifers show that the depth to water level in the coastal tracts of the State varies from few cm bgl to 5 m. bgl except in the coastal parts of the districts of Villupuram, Puducherry, Cuddalore and Tirunelveli districts where water level in the range of 5-10 m bgl is noticed.

The analysis of the data of quality of ground water in the phreatic aquifers of coastal parts of Tamil Nadu shows that Electrical Conductivity(EC) is in general varied from 750 to 2250 microsiemens/cm at 25^{o}C. Water with high EC is seen in coastal parts of Tiruvallur, Cuddalore, Nagapattinam, Pudukottai, Ramanathapuram, Tuticorin and Tirunelveli districts.

The historical quality data available with CGWB indicate that ground water in a major part of the state is potable and suitable for domestic, irrigation and industrial uses. However, ground water with one or more chemical constituents in excess of maximum permissible limits for various uses, either due to natural or anthropogenic causes occurs in isolated pockets. These include the insitu brackish and saline ground waters in Ramanathapuram and parts of Nagapattinam districts, saline ground waters resulting from sea-water ingress in Minjur area of Kancheepuram district

The brine concentration in the sedimentary formation water of shallow aquifer is reported to be 8 to 18°Be whereas in deeper aquifer it ranges up to 2°Be and quality improves with depth.

Groundwater Resources Estimation

Estimation of Dynamic Groundwater Resources of phreatic aquifer is a prerequisite for planning of groundwater development in an area. Dynamic Groundwater Resources pertain to the part of resources, which get replenished every year due to rainfall, applied irrigation water and seepage from surface water bodies. The methodology adopted for the estimation is the on the lines of Groundwater Estimation Committee (GEC-97 methodology).

The resource estimation reveals that out of 48 blocks falling in coastal Tamil Nadu, 20 blocks are safe, 3 blocks are semi-critical, 4 blocks are critical and 12 blocks are over exploited. Nine blocks of Nagapattinam and Ramanathapuram districts are saline and hence no estimation of groundwater resources carried out for these blocks.

Brine Water Studies in Coastal Aquifers

Eighteen Exploratory wells and eleven Observation wells had been constructed for brine water studies with depths ranging from 12.00 to 200 m bgl in the coastal tract of Chenglepet, Cuddalore, Villupuram, Thanjavur, Nagapattinam, Pudukkotai, Ramanathapuram and Tuticorin districts. Highly concentrated Brine water aquifers have been delineated and established the vertical profile of brine concentration all along the coast. The results are encouraging and boon to the Salt Industry in Tamil Nadu. Successful production wells had been handed over to the user agency ie., Department of Salt, Ministry of Commerce, Government of India, Chennai.

Semi-consolidated and consolidated geological formations *viz*, sand calcareous sandstone, clay, shales, limestone with fossils and laterites overlie the crystalline basement. The crystalline basement has been encountered at different locations in the boreholes between 45 – 65 m bgl.

An exploratory well of 200 m deep drilled at Thangachimadam in Rameshwaram Island reveals that fresh ground water of 25 m thick occur as floating lenses on saline/Brine water at the centre of Rameshwaram Island. A thick layer of clay of 24 m separates the fresh water and brine water aquifers.

Similarly fresh ground water aquifer of 25 m thick also had been identified as floating lenses on saline/Brine water at Nagakanykapuram, Tuticorin district. Generally the concentration of brine in formation water increases vertically with depth from 7 to 13.5 Be in Tuticorin district. Highly concentrated brine occurs in formation waters of deeper aquifers ie, between 40 – 60 m bgl whereas shallow aquifers contain relatively less brine content in Tuticorin District.

This phenomenon is quite opposite in southwestern and eastern parts of Ramanathapuram district ie. brine concentration decreases with depth. Very less brine content (1°Be) occur in the formation water at Theetandatandam, North-Eastern part of Ramanathapuram district.Moderately high concentration of brine in the order of 6-6.5° Be has been observed in the formation water at a depth of 7-52 m at Chunampet and Vayalur in Kancheepuram and Tiruvallur districts respectively.

Hydrochemistry of Brine water in Coastal Aquifers

Salinity is a term used to describe the amount of salt present in a given water sample. It usually is referred to in terms of total dissolved solids measured in terms of milligrams of salts per liter (mg/L). Groundwater with a TDS concentration less than 1000 mg/L is considered as Fresh water. The somewhat arbitrary upper limit of fresh water is based on the suitability of water for human consumption. Ground water with TDS greater than 1000 mg/L is also used for domestic purpose in areas where water of lower TDS content is not available

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Generally ground water is classified as Fresh, Brackish, Saline and Brine depends on the TDS content of groundwater (Table 1). The Residium after fractional crystallization of NaCl (>35°Be) is called as Bitrine.

Table 1. Classification of Ground water

Sl No	Category of Ground water	TDS (mg/L)
1	Fresh	<1000
2	Brackish	1000 -3000
3	Saline	1000 - 10000
4	Brine	>10000

The formation water with a brine density of less than 1 is suitable for aquaculture.

Groundwater Management

There is an urgent need for integrated water resource management strategies for the long-term sustainability of available groundwater resources in the State of Tamil Nadu.

The priorities for a perspective plan for sustainable management would include

1. Preservation of groundwater quality.
2. Preservation of the aquatic environment by prudent abstraction of groundwater.
3. Integration of surface and groundwater into a comprehensive water and environmental management system.
4. Augmentation of groundwater in aquifers by suitable artificial recharge strategies.
5. Regulatory measures for controlling over-exploitation and its environmental impacts.
6. Reuse/recycling of waste water.

Conclusion

The groundwater scenario in coastal Tamil Nadu and U.T of Puducherry has changed considerably in recent years owing to the increasing stress on the available resources due to various factors such as over-exploitation, contamination and erratic monsoon. Considerable desaturation of shallow aquifer zones and reduction in yields of dug/bore/tube wells has been observed in a major part of the State. The threat of seawater intrusion into coastal aquifers in parts of its long coastline. In view of the above, there is an urgent need for coordinated efforts from various agencies concerned to formulate strategies for sustainable management of our precious ground water resources for the sake of future generations.

Figs. 1 to 8 show the diagrammatic view of data on ground water availability in Tami Nadu.

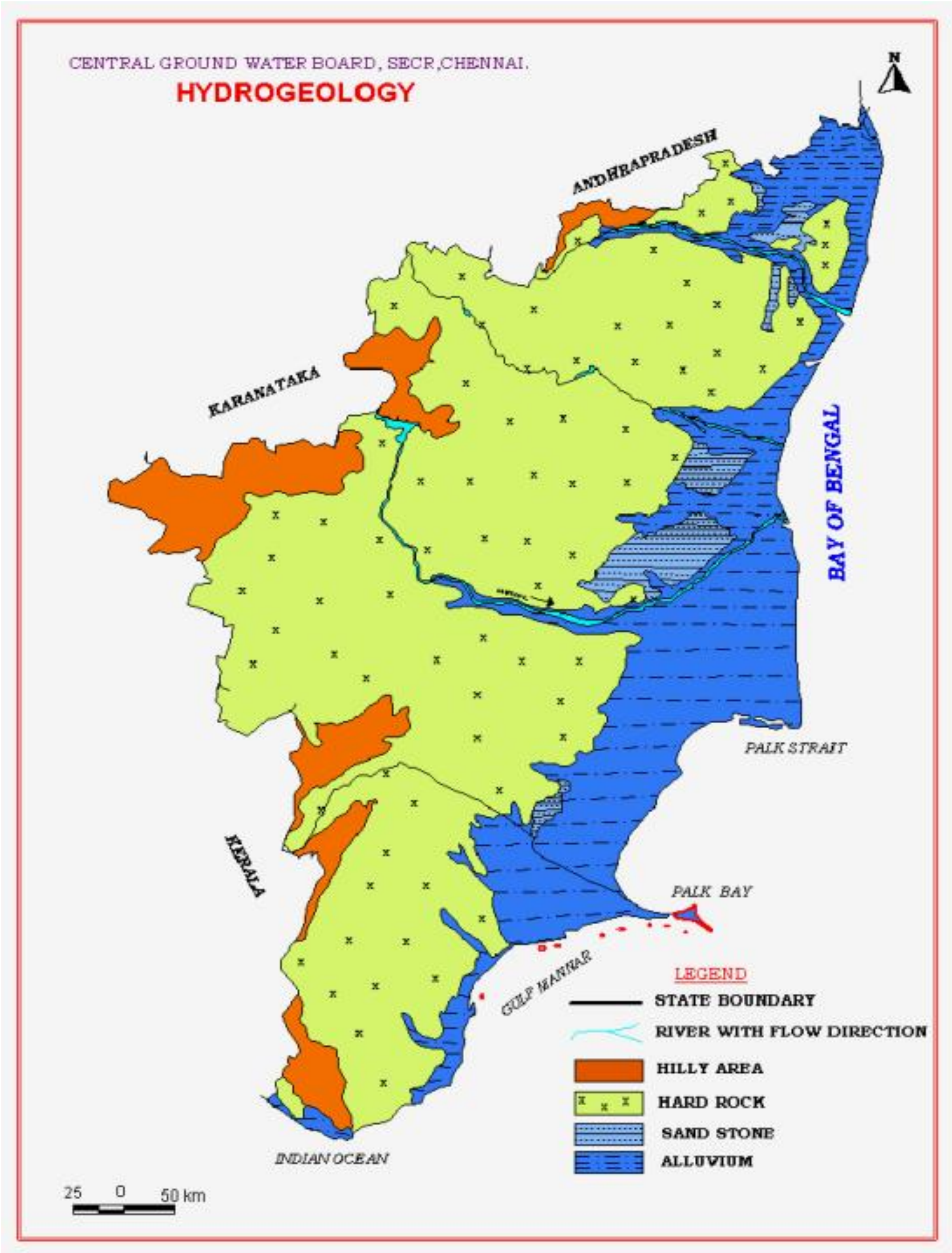

Fig. 1. Hydrogeology of Tamil Nadu

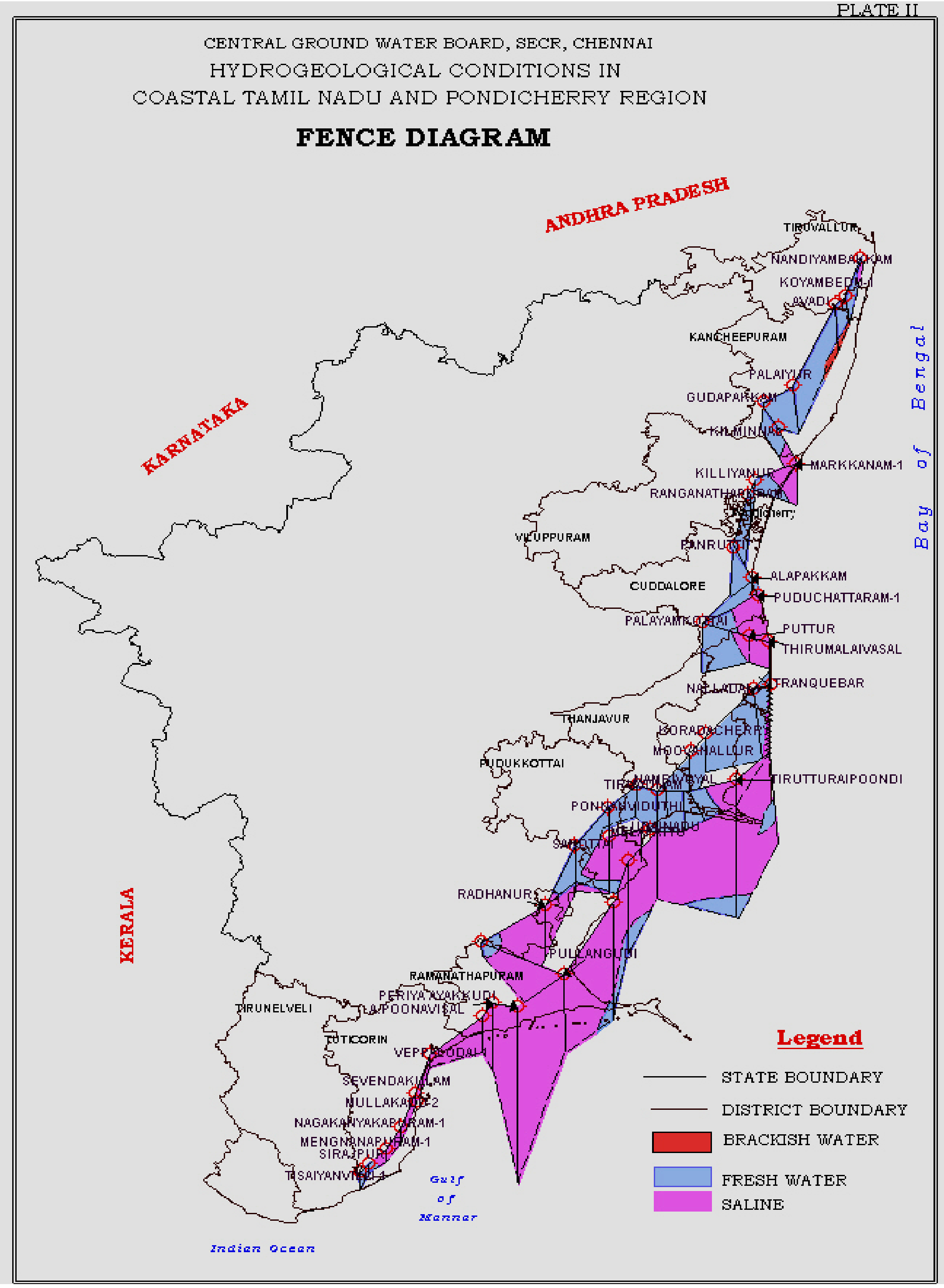

Fig. 2. Fence diagram of Tamil Nadu coast

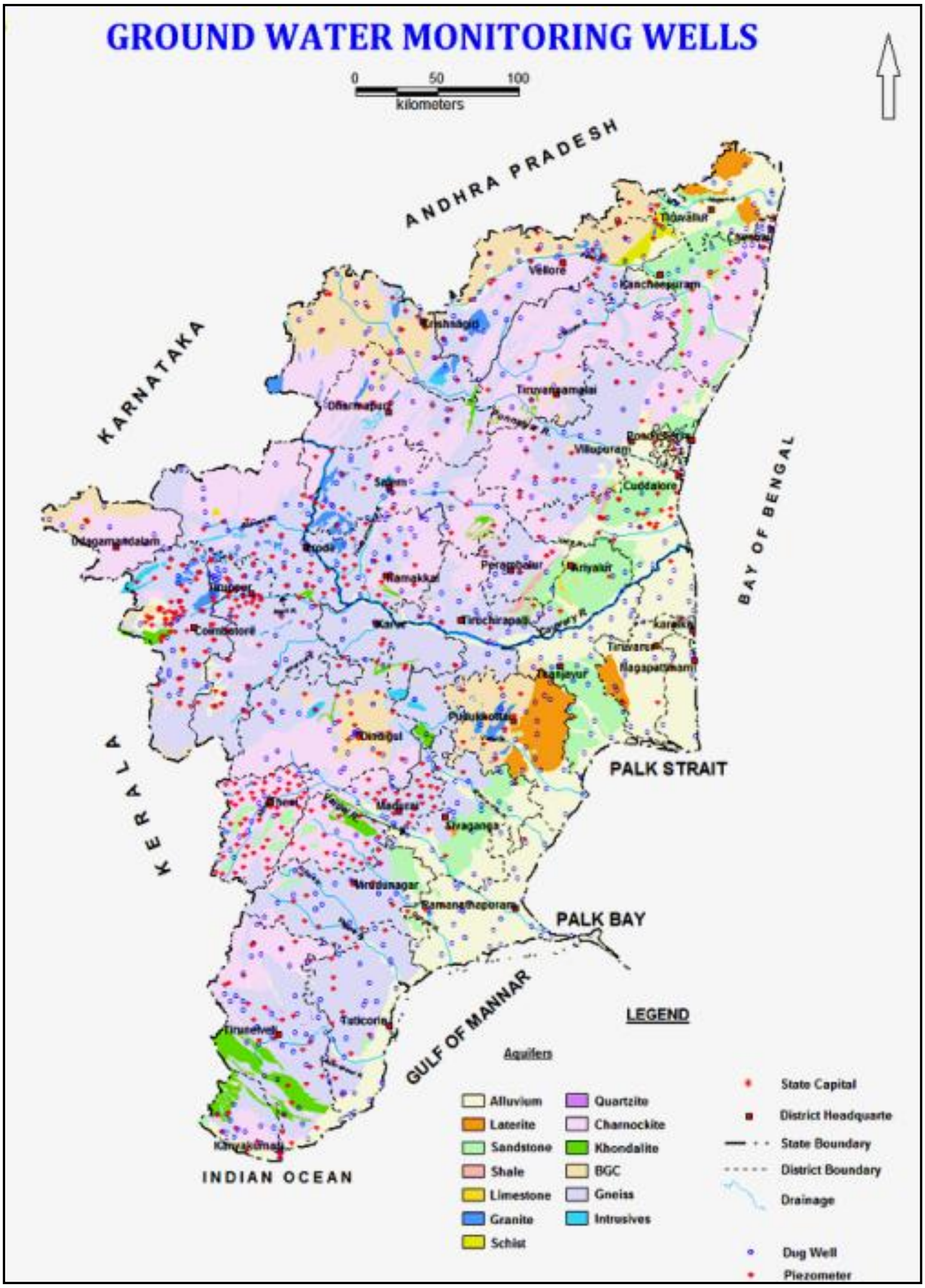

Fig. 3. Ground water monitoring wells in Tamil Nadu

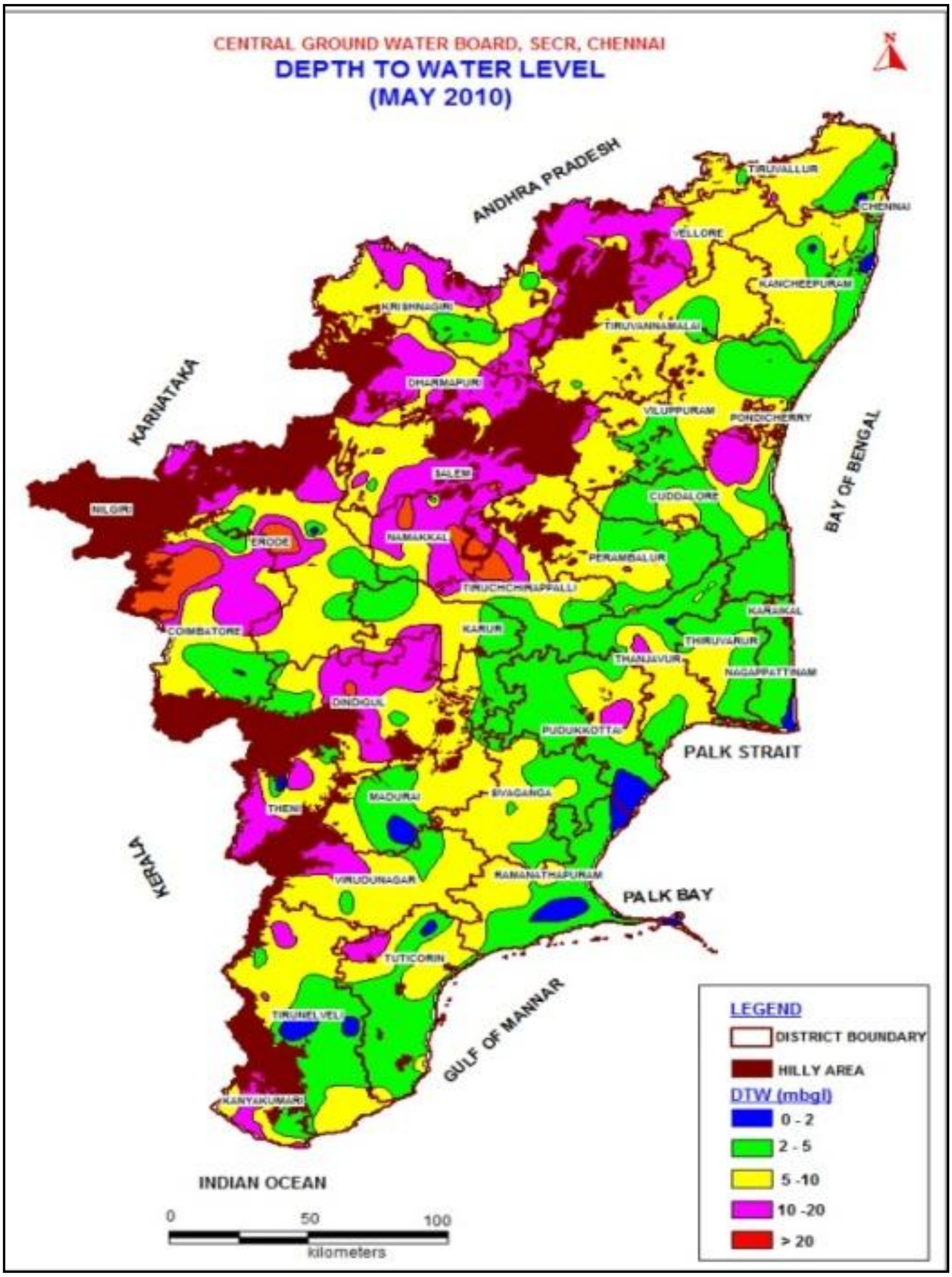

Fig. 4. Depth to ground water level in Tamil Nadu as on May 2010

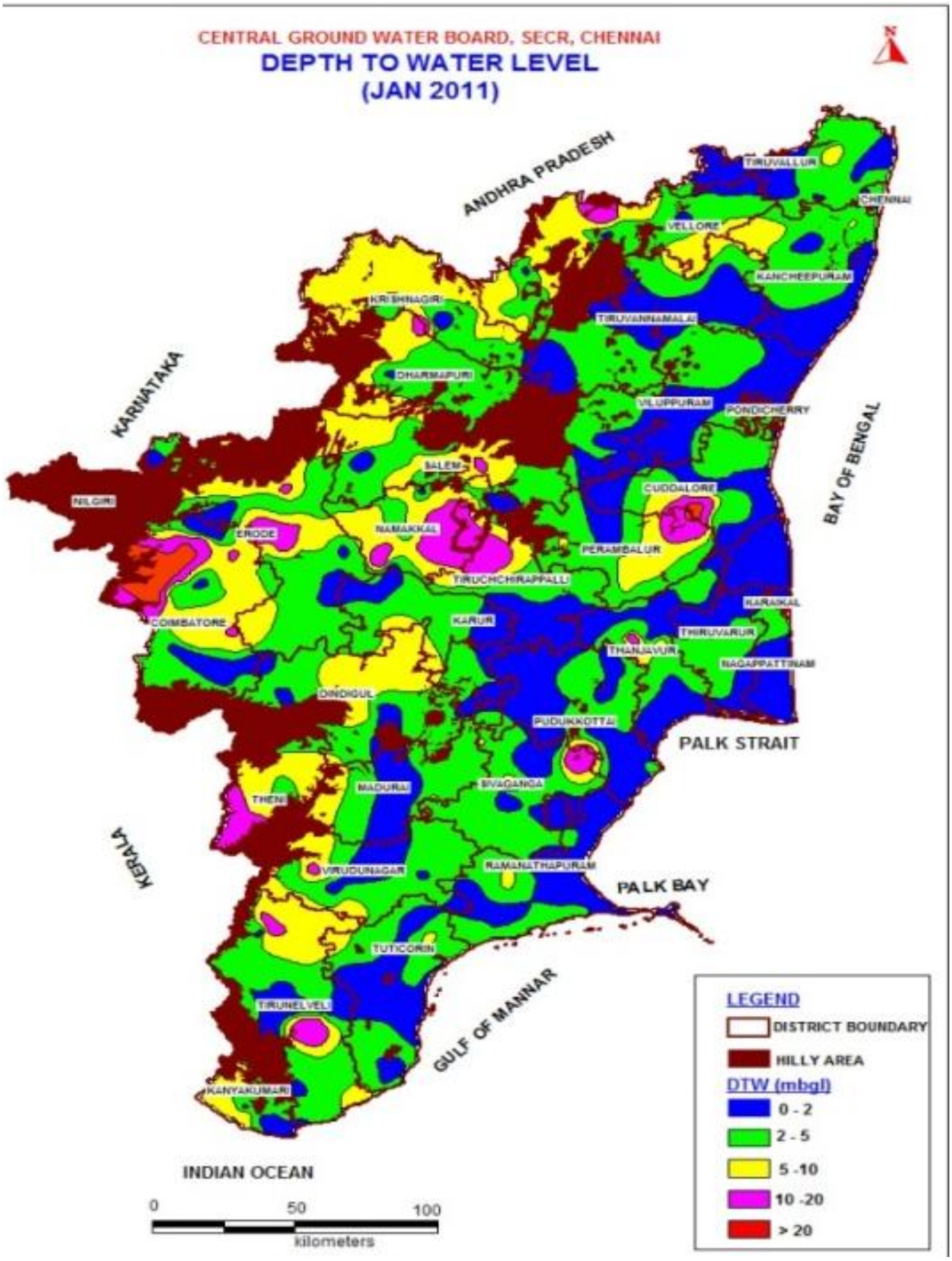

Fig. 5. Depth to ground water level in Tamil Nadu as on January 2011

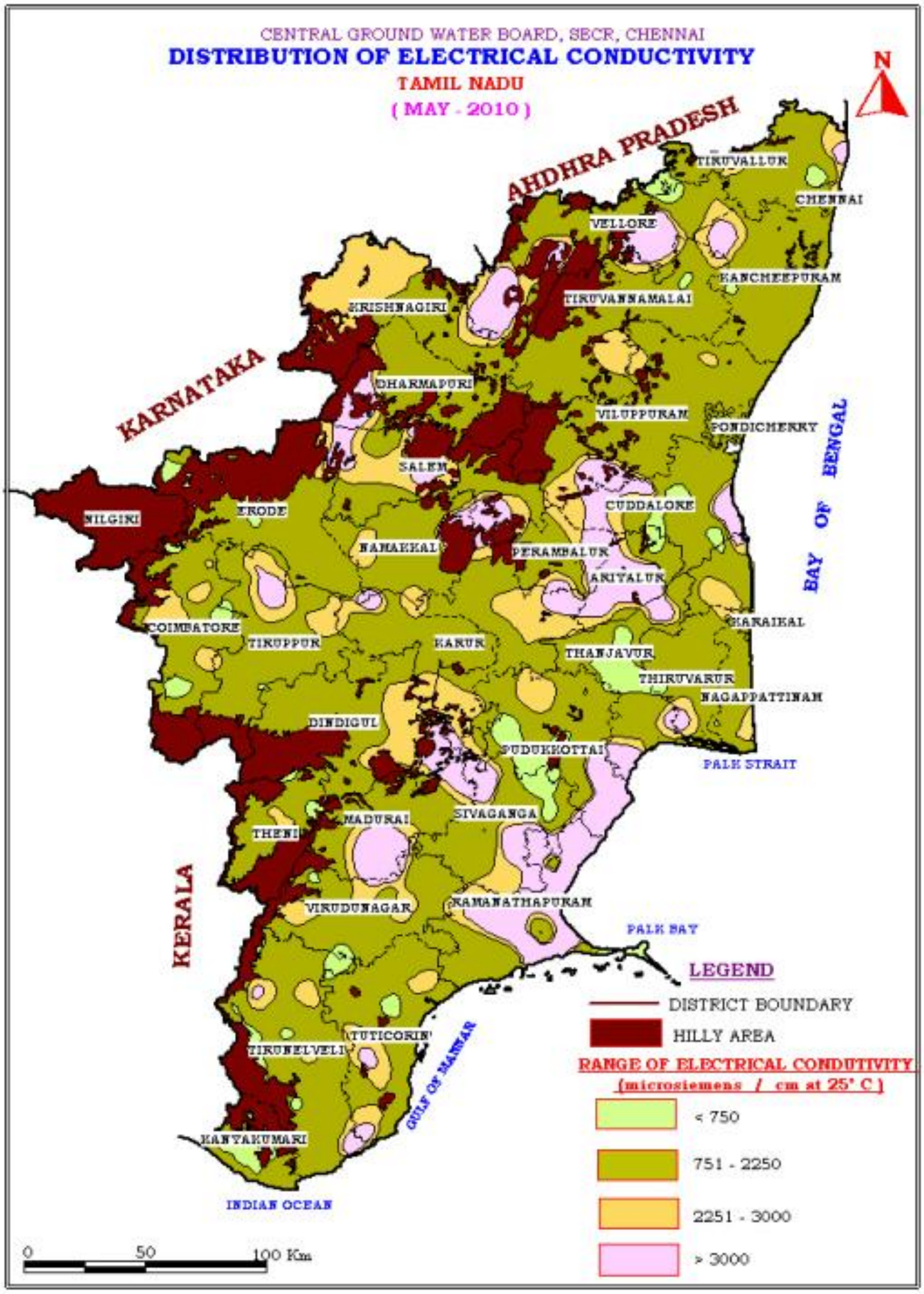

Fig. 6. Distribution of Elecrical Conductivity of ground water in Tamil Nadu as on May 2010

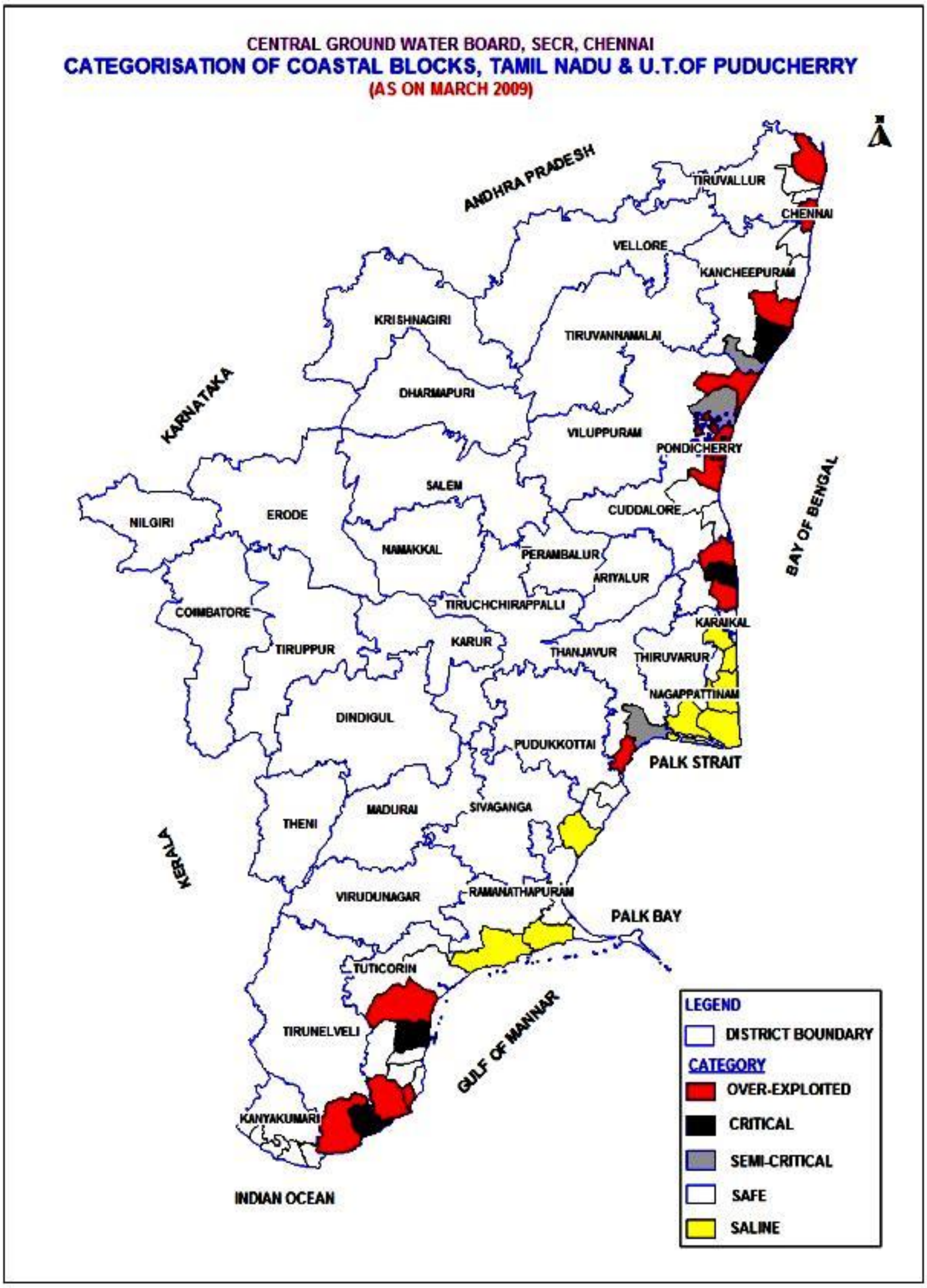

Fig. 7. Categaorization of coastal areas of Tamil Nadu

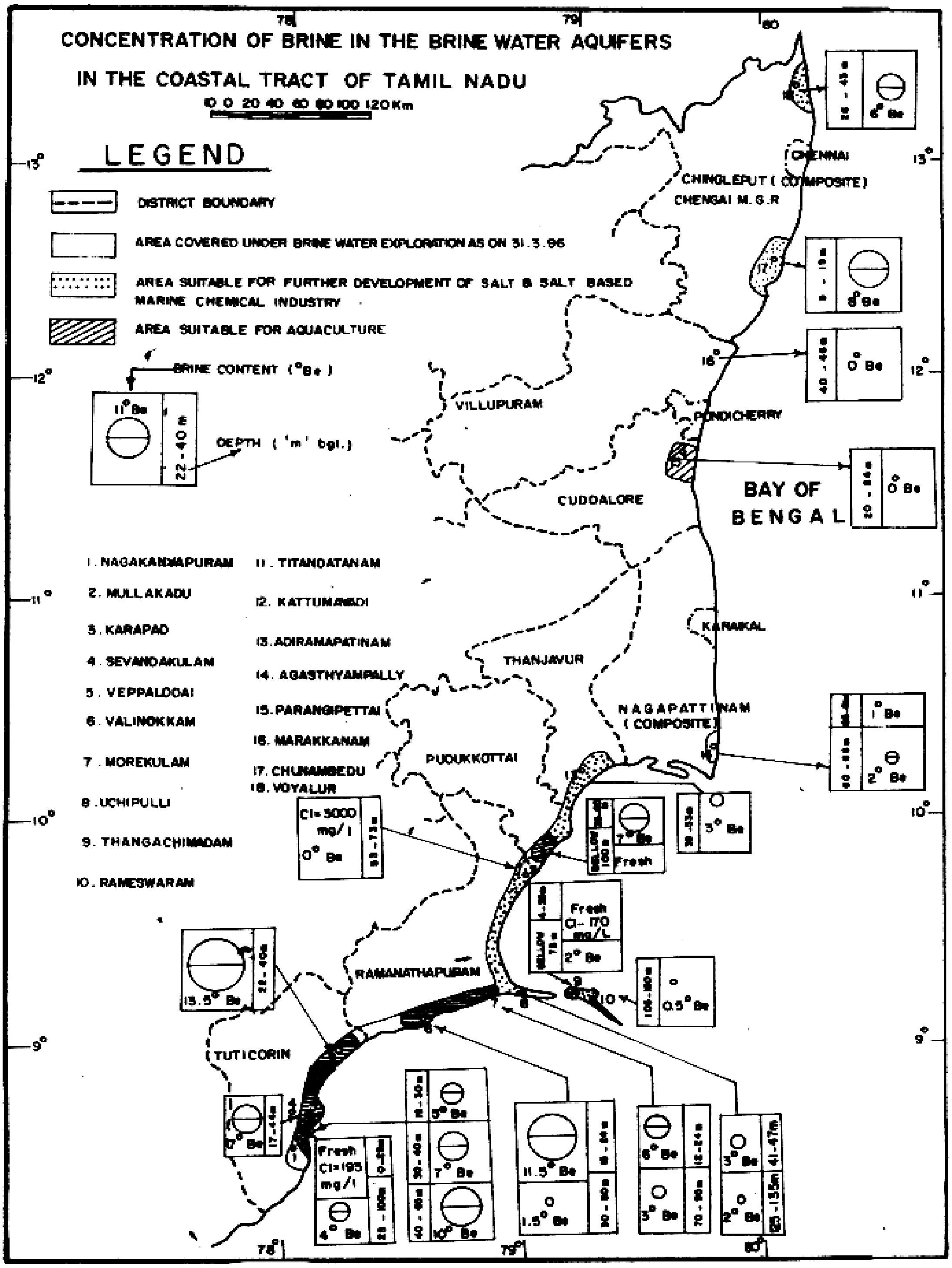

Fig. 8. Concentration of brine water along Tamil Nadu coast

Technical paper-2

PRESENT STATUS OF INLAND AQUACULTUREIN THE CAUVERY DELTA- THANJAVUR, THIRUVARUR & NAGAPATTINAM DISTRICTS OF TAMIL NADU

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Introduction

Originally, the river Cauvery with regular,dependable anduninterrupted water flow through the deltaic system offered immense agricultural productivity to the regions of Thanjavur,Tiruvarur and Nagapattinam districts which were earlier considered as “Rice Bowl “ of Tamil Nadu. But the potentiality of the paddy farming with 2 to 3 crops in a year suffered heavily for the last 35 years due to interstate dispute on sharing of Cauvery river water and also due to the frequent failure of monsoon. From the early eighties, the water discharge in the Cauvery river from the Mettur dam had become highly erratic and the usual reliable and continuous river flow for the period of not less than 8 months from the month of June to February is not existing at present. Now the paddy cultivation is limited to single crop and thousands of acres of paddy field are left uncultivated, resulting in huge fall in rice production. The livelihood of agriculture farmers and the employment of agri labourers are at great stake and hence they started switching over to alternate profession and majority of them shifting to urban areas . The greenary condition of the deltaic area already started fading its colour and now it has become a water deficient region.

The rain fall data (Table 1) and the release of water from the Mettur dam to the Cauvery river. are summarized in Table 1 and 2.

Table 1. Average Rainfall

Year	(mm)
2007	1,205.59
2008	1,404.03
2009	1,138.49
2010	1,371.46
2011	1027.03
2012	705.73
2013	701.44

Dates of Opening and Closing of Mettur dam for Irrigation and the Levels and Storages on those dates.

Normal date of Opening:12th June; Level:120.00 Feet
Normal date of Closing:28th January   Storage:93.47 TMC

Table 2. Opening and clsure and water level in Mettur Dam.

Water – Year (June-May)		Opening			Closing	
	Date	**Level Ft.**	**Storage M.Cft.**	**Date**	**Level Ft.**	**Storage M.Cft.**
2002-03	06-09-2002	66.94	30128	19-02-2003	28.16	6812
2003-04	07-10-2003	72.52	34904	05-01-2004	29.99	7519
2004-05	12-08-2004	93.11	56277	28-01-2005	56.26	21285
2005-06	04-08-2005	106.32	73275	28-01-2006	112.24	81632
2006-07	12-06-2006	115.27	86127	28-01-2007	84.56	56653
2007-08	18-07-2007	109.85	78196	28-01-2008	94.67	58152
2008-09	12-06-2008	103.31	69199	28-01-2009	62.23	26378
2009-10	28-07-2009	94.80	58310	28-01-2010	76.81	38851
2010-11	28-07-2010	82.49	44484	28-01-2011	109.39	77547
2011-12	06-06-2011	116.00	87232	05-02-2012	83.33	45.357
2012-13	17-09-2012	84.33	46408	08-02-2013	29.49	7323
2013-14	02-08-2013	109.33	77462	-	-	-

Aquafarming Practices – Present Status

In the early eighties, after the establishment of Fish Farmers Development Agency (F.F.D.A.) in the Thanjavur district, a scientific approach was initiated in the inland aqua farming practices. The concept of composite fish culture with Indian major carps, namely, Catla, Rohu, Mrigal and also with some exotic carps like Silver carp, Grass carp & Common carp, was well accepted and practiced by fish farmers in the ponds owned by Panchayat, Revenue and P.W.D., mostly leased out to them. But, the culture practices in those community tanks were confined to stocking and harvesting only, with little input on feed and manure. The production in those short and long seasonal water sources was ranging from 1000 to 1,500 kg. in a period of 8 to 10 months.

After the successful stories of composite fish culture in village ponds through F.F.D.A. and consequent to the availability of larger number of Indian major carp seeds ,thanks to the phenomenal performances of private carp seed hatcheries, several man-made ponds were constructed mostly with ground water source, substituted by the river water, if available. The individual size of those grow out ponds were from 0.1 to 3.0 ha and most of them around 0.3 to 0.5 ha. As on date, more than 1500 ha. of such ponds are in existence, spread over in these three districts.

The scientific management practices for the aquafarming are meticulously followed by all the farmers with some variations suited to their local condition and on the availability of local inputs. The pre-stocking packages are drying, liming, water harvesting, manuring with organic manures and mineral mix etc. The stocking density with Indian major carps together with small combination of Chinese carps (silver & grass) are @ 2,000/acre. The stocking size of the seeds is from 7 to 10 cm in length and 15 to 25 g in weight, with species combination based on the previous performances of the species in their ponds. Different feeding regime is being followed. Some farmers are sticking on to the conventional feed such as groundnut oil cake + rice bran with vitamin mix. Some use rice bran, soya bean meal, fish meal with vitamin mix. Maize and sunflower oil cake are also included in the feed, subject to availability. Few farmers use only rice bran mixed with minerals and vitamins. Commercial pelletized feed and floating feeds with 24 to 28% of crude protein are also used by some farmers and the cost of the feed is from Rs.22 to Rs.24 per kg.

The water level maintained invariably in all ponds is ranging from 1.0 to 1.5 m. Water loss due to evaporation and seepage was compensated by daily pumping in the early hours of day, when the D.O. level is normally low. Aerators are rarely used in the grow-out ponds. Growth monitoring is done every fortnight and the harvesting process commences from 4th month onwards. Considering the size preference of the local market ,fishes weighing half a kilo or more are alone removed and marketed alive .The harvest is completed at the end of 5th month. The total production with 400-600 g fish is 1,000 kg to 1,500 kg/acre in a period of less than 6 months. The second crop is followed after 15-20 days of pond preparation. The stocking rate and other packages followed ,are similar for the second crop also and the farmers are able to obtain almost identical production and revenue. Mr. C.S.Renganathan, a fish farmer raised 3 crops in a year @ stocking rate of 1,000/acre with 100 g sized carps, producing 500 kg in a crop period of 3 months. Some farmers like Mr. R. Kathiresan of Orathanadu and Mr. Ravichandran of Thirumeni Erie in Thiruvarur district, who also own seed farms, are extending the culture for 10 months by continuous stocking and harvesting of half a kilo fish from 5th month onwards .Number of fishes harvested would be replaced by periodical stocking of advanced fingerlings raised in their own farm. Here, the initial stocking is planned @ 5,000 fingerlings /acre and the production at the end of 10th month is from 2.5 to 3.0 tonnes/acre.

The farmers get a price of Rs.120/kg for the live fish at their farm site and the merchants transport them alive to the nearest market in aerated tanks and it is sold at Rs.150-180/kg. The gross revenue is Rs. 2.5 to 3.5 lakhs/year/acre/2 crops and the production cost for raising 1 kg of fish worked out to be Rs. 45 to Rs. 60, depending upon the size of the farm and the management measures undertaken. A, minimum net realisation of Rs 1.0 lakh/acre/year has been made, consistently. Interestingly , the bunds of almost all the ponds in the district are planted with high yielding coconut @50/acre pond, which is also giving additional income to fish farmers from 4th year.

Apart from this, an interesting instance of culture of loaches was observed in a fish farm owned by Mr. S.Pugalendhi at Vaduvur village in Tiruvarur district. This farmer collected the loach, *Lepidocephalous thermalis*, locally called as " asarai", from the nearby river, Grand Anicut canal and 20 kg of loaches weighing less than 10 g (average) were stocked in a pond of 0.5 acre. The pond was bird fenced over the water surface to avoid the fishes being picked by the birds. They were regularly fed with ground nut oil cake with rice bran and raw cow dung was also frequently broadcasted. Observing the sensitivity of this fish to low D.O, the farmer used some locally fabricated water sprinklers, whenever the surfacing of the fish was noticed. He has also observed breeding of this fish in the pond, a month after stocking. At the end of the 3rd month, he drained the pond and harvested 110 kg , with 10-20 g individual size and sold at a price of Rs.1,000/per kg. This success story of culture of loaches in ponds, may be scientifically monitored and documented for future diversification in freshwater aquaculture.

Fish Breeding Practicesin Thanjavur Dt.-Present Status.

The fish seed sources of Thanjavur district as early in 1960s and 1970s were the natural collection from the river Cauvery and its branches , where the wild bred migratory seeds congregated and available, down below the riverine regulators, seasonally. The season of the availability of the cultivable seeds was depending upon the release of water into the deltaic rivers, which was normally from August to January every year. Yet, around 20 million seeds of Indian major carps and minor carps like *Labeo fimbriatus*, *L.bata*, *L.calbassu*, *L.kontius*, *Cirrhinus cirrhosa*,*C.reba* and also the seeds of murrels were collected, transported and stocked by the Dept. of Fisheries into the water bodies belonging to Revenue, P.W.D. and Panchayaths. But subsequently, the irregular water flow in the riverine system, due to Cauvery water dispute and the failure of the monsoon together, badly affected the natural fish seed production and consequently the availability of them in the riverine sources became highly erratic. Hence, the targeted natural seed collection work had been suspended departmentally, since late 1980s. A, lone Govt.fish seed production unit, established in Karunthattangudi in Thanjavur town limit in 1970s was also entirely depending upon the river flow for brood stock management and spawn production. As a result of the mismatching of water available period and the breeding season of major carps, the seed production work could not be effectively carried out at this centre. Up to 1985, a maximum 0f 5 million hatchlings/year could alone be produced in the district, that too with very great difficulty. Subsequently, In the mid 80s, the concept of breeding of major carps using only the ground water had emerged successfully and consistent results have been achieved by some private seed farms like M/s R.K Fish Seed Farm at Orathanadu and presently, there are 27 fish seed production units , in operation in the district.

From the information received during the discussions and on spot inspections, it was inferred that the breeding technique in all the farms are almost similar with some minor variations. The seed production in this area normally commenced from April and completed in November every year and sometimes up to January as against from June to September earlier. Nearly, 80% of the production are from major carps, 15% by common carps and 5 % by grass carp and silver carps. One farmer Mr. S. Pugalendhi of Vaduvur is also producing seeds from *Labeo fimbriatus* and *L. calbassu*, on demand.

Broodstock Management

The maximum care has been taken invariably in all the farms to maintain a healthy and viable stock of brood fish. From the mixed population of males and females kept in the farm complex or outside, the sexes are segregated and stocked separately in the broodstock ponds of not less than 1/3 acre in size, during February, every year, @ 2 to 3 tonnes/ha. The sex ratio is maintained at 1:1 in number. The water level maintained throughout the pre-spawning months is 1.2 to1.5 meter in depth. Brooders are nurtured in such a way that they are not exposed to low D.O, high organic load and nutritional deficiency. Paddle wheelers, impellers and sprinklers are installed in the brooder ponds, by big and medium scale seed producers. The brooders are properly fed with ground nut oil cake, rice bran, soya bean meal, fish meal, vitamin mix, etc. Commercial pelletised and floating feed are also found effective by some farmers.

One interesting phenomenon found was the use of Black Gram by a farmer for the broodstock in his farm at Palliagraharam. The brooders were fed with rejected quality of Black Gram available in the godowns of Civil Supplies Corporation. According to Mr. M.Selvam, a fish farmer, on the use of this feed, the retention of the gravid condition of the ovary was prolonged and consequently, the resorption stage was delayed for a considerable period. And also the farmer has noticed that the rate of spawning, fertilization and hatching were considerably higher and the resultant spawn produced ,were healthier and bigger in size. He further stated that such breeders fed with black gram have been observed breeding naturally in the earthern ponds, without any hormonal treatment, on two occasisons, during 2008 and 2010. Hence, the efficacy of the black gram as a potential feed for the carp brood stock has to be analyzed and documented.

In a bid to avoid inbreeding stress and also for the production of quality seeds, some farmers arbitrarily mix their brood stock with yearlings brought from West Bengal and Andhra and also with wild stock collected from our riverine system. The farmers have found several instances of early maturation of Rohu and Mrigal in the 1^{st} year age group, with a size, as low as 350 g in weight and also around 600 g in *Catla*. But they generally use only 2 to 5 year age group with a size range of 2 to 6 kg of Catla ,1 to 3 kg of Rohu,1 to 2 kg of Mrigal and more than ½ a kilo size of common carp.

Breeding and Spawn Production

For successful hypophysation, most of the farmers are using synthetic hormone commercially available . They administer single dose of the hormone simultaneously to the selected gravid females and males. Very few farmers are sticking on to the old practice of injecting the brood fishes with a promotive dose to female fishes with the extract from fish pituitary glands . Chinese hatchery system with circular breeding pool and hatchery, is widely used for the production of hatchlings. Some conduct breeding operation in velon hapa fixed in rectangular or square shaped cement cisterns, provided with water flow and water sprinkling arrangements . In the latter case, after breeding, the fertilized ova are manually transferred to the circular hatchery for hatching and spawn production. A maximum of 4 million hatchling are being produced in a single run in a conventional Chinese hatchery.

The relative fecundity of the major carps assessed presently is @ 1.5 to 2.5 lakhs of eggs per kg. body weight. But in earlier references, the relative fecundity was mentioned at less than 1.5 lakhs. Some farmers observed over the years , a gradual reduction of the size of fertilized ova in the substantial population of major carps, which has gone down to 3.5 mm ,against the normal size of 5 mm, in diameter . Delay in water hardening of the fertilized ova has also been observed by some farmers. A detailed study is required to find out the reasons for such variations.

Multiple breeding of major carp is quite familiar among the farmers of the district and they breed few brood fishes in April-May and the same fish respond to second breeding also in October-December, with almost identical results. The farmers also observed delayed maturation of few fishes in their brood stock .The farm of Mr. M.Selvam of Palliagraharam claims that two sets of Catla bred in the month of February, 2013 and produced 4.6 lakhs hatchlings. This delay by 2 to 3 months of maturation has been advantageously utilized by farmers to effect supply of fish seeds to the short seasonal water bodies, fed only by north east monsoon.

An interesting observation was made during the inspection of Tamilnadu Fish Farm at Palliagraharam. 23 Catla, males and females with bright yellowish orange body colouration weighing 2 to 3 kg were found in the broodstock. It is locally called by the farmers as Red Catla. The colour of the whole body and the pinkish eyes are indicating that they could be the albinic strain. Majority of the hatchlings produced from them are having yellowish orange body colouration and the remaining ones, with original colour pattern of Catla. As this strain grows well and also responds positively to multiple breeding, this stock may be preserved and studied for its genetical significance.

Nursery Practices

This involves the routine preparation of earthern nursery ponds–drying, liming, organic and inorganic manuring, application of mineral mix, etc. Stocking is @ 2000 hatchlings/sq.meter and after 15 to 20 days nursery rearing, they are transferred to rearing ponds @ 500 to 1000 fry/sq.meter to raise up to fingerlings/advanced fingerlings size. Mr. R. Suresh Raja of Thittai has stocked 5 lakhs hatchlings velon hapa of 10mX4mX1m fixed in a grow-out pond and harvested fry of 1cm in 5 to 7 days, for stocking in rearing ponds, with 75 to 80% survival. Generally, the stocking rate of the fry in the rearing ponds are depending upon the production and the availability of the rearing space. Feeding in the nurseries are in the form of powdered feed from ground nut oil cake, rice bran, soya bean mixed with vitamin. The stockable seeds are harvested as per the demand. Presently some fish seed farmers of this district could effect supply of fish seeds of any major carp species, in any form, any size and at any point of time. They are also providing transport facilities to deliver seeds at the required spots.Thus, the inland aquafarming has become a commercial enterprise, gained momentum among agriculturists, entrepreneurs, inland fishermen and the unemployed youths in Thanjavur,Tiruvarur and Nagapattinam districts. Now these districts are currently producing more than 6,000 tonnes of fish every year, from around 1,500 ha. of man-made fish ponds alone. Now, there are 27 fish breeding units functioning in the district, with individual production capacity of 10-50 million/annum and in aggregate about 500 million hatchlings are being produced every year and it is further evaluated that if proper and timely disposal of seeds has been arranged, more than 1000 million seeds could be produced and supplied every year from this district, through the private sector.

Now, the inland aquaculture activities were slowly picking up in this district and the on going progress was kick-started from the early 1990s, and the water deficit district has now turned out to be a potential aquaculture trade zone. In short the increase in the fish production may be attributed due to the following reasons.

Broodstock management

Coloured Rohu

Nursery practices at Thittai

1. Non dependence of river water.
2. Availability of potable ground water resource
3. Designing and construction of ponds to use both surface and ground water.
4. Concept of smaller sized ponds for successful water management.
5. Elasticity of breeding season of Indian major carps.
6. Availability of stockable fish seeds throughout the year.
7. Adoption of modular aquafarming and multiple cropping pattern of carps.
8. Selective stocking of carp species suitable to the local conditions.
9. Stocking of bigger sized fingerlings in the grow-out system.
10. Market preferences of carp size around half a kilo size.
11. Substantial increase of price of carps especially for the live ones.
12. Reliable availability of all inputs locally.
13. Improvement of technical awareness among the aquafarmers.

Technical Paper-3

SUCCESS STORIES OF RAISING SHORT-TERM CROPS OF INDIAN MAJOR CARPS

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Abstract

The agriculturists in Trichy, Thanjavur,Tiruvarur and Nagapattinam districts started digging of ponds in their field for fish culture using Cauvery water and/or ground water. Stocking seeds weighing 50 grams to 100 grams each in the well manured ponds. Feeding with combination mashed, pelleted, floating or sinking feeds increased the fish production.

The stocking density vary from 2,500 to 4,000 seeds weighing 50 g to 100 g each per acre, using less cow dung due to non-availability made the farmers to switch over to probiotics is helped in maintaining the water quality. Less usage of inorganic manure and other chemicals improved the quality of fish production.

The culture period is varying from 4 months or 6 months. The size of fish is 400 to 500 grams. The customer preference at Thanjavur district for 2 to 3 fish per kg is enabled for 2 or 3 cultures in a year. Live fish transport fetched very high price in marketing and provided good profit to culturists as well as merchants.

Mr. Fredric Nixon of Carmel fish farm, Mettupatty, Lalgudi is regularly stocking 10,000/ha of 50 g size, using probiotic and cow dung for manuring and pellet feed (Grow Best) for the first crop of 6 months and achieved a yield of 8,000 kg/ha (13,000 kg of feed). The second crop was with stocking density of 5,000/ha and reared for 4 months,with a yield of 4,000 kg/ha,(6,500 kilos of feed). The cumulative yield worked out to 12,000 kg/ha.

It is very common now a days with different stocking density from 2,000 to 5,000/acre,and culture period varying from 5 to 6 month. Also, the feeds are offered with different combinations of rice bran groundnut oil oil cake, coconut oil cake, soya been oil cake, wheat bran, corn flour, soya been flour etc., depending on their availability and price structure.

The manured cultured water is never pumped or drained out of the pond, unless it is necessary. The water is pumped from one pond other ponds to save the water. Economical usage of water taken on a comparative study of fish culture needs, less quantity of water than agriculture like paddy, sugar cane, etc. A comparative study on usage of water for fish culture and agriculture crops like paddy; sugarcane etc. may be undertaken to know the economic feasibility.

Marketing the fish in live condition to the consumer fetching very good price attracts more people in this field. The concessions offered by Tami Nadu government and Tamil Nadu Electricity Department in electricity tariff is also an added booster to the present aqua culturist and new entrepreneurs.

Technical Paper-4

LIFT IRRIGATION SCHEMES OF CHAGALNADU (ANDHRA PRADESH) FOR RAIN-FED AREAS: IMPACT ON FISH CULTURE ALONG WITH AGRICULTURE IN RAIN–FED PONDS

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Introduction

The Chagalnadu lift Irrigation scheme envisages lifting of water from the river Godavari in two stages with a total lift of 51.40 metres (168.32 feet) The waters from one pump house to the other and ultimately to the Main Canal are coveyed over some distance by Gravity channels and the rest of the lengths by pressure mains. Altogether the open excavation covers a length of 5,.415 km, (3,.389 miles) while the pressure mains are over a distance of 2.205 km (1.39 Miles). The structures consist of two pump houses and the foundations are to be taken to a depth of 16.425 Mts. From ground level to get the required bearing capacity. The only costlier and special type of work is the pre-stressed concrete pressure mains. Pumping is resorted to by vertical turbine pumps. (MAP 1)

The service system Of transportation of waters in the system from the river Godavari to the main canal is detailed below.

About 74.16cumecs of waters are drawn with L.W.L. or + 12.00 m from river Godavari through a Head regulator proposed at 425 km, of Akhanda Godavari left Bank and 600 m Upstream of Venkatanagaram village into leading channel – I by gravity flow which transports the waters over a length of 12 km with a section of 7.20 x 1.47 m and a bed fall 1 in of 500 cusects 74.16 cumecs. before it empties into the sump well of first pump house.

The first stage pump house with 3+1=4 Nos. of vertical turbines lift the waters in the sump from + 11 mm in into the Cistern with F.S.L. at + 36 118.08 ft through 3 Nos. of 1300 mm. dia prestresed concrete pressure mains.

The leading channel –II of length 0.50 km with a section of 7.2 m x 1.4 and a bed fall of 1 in 10.000 carries the waters from the Cistern of First Stage pump house at + 36.00 m (118.08 ft) to the sump of second stage pump house at + 35.95 m (117.92 ft).

The second stage pump house with 3+1 Nos. vertical Turbine pumps each of 1,050 H.P. lifts the waters in the sump at + 35.97 m (+117.92) and drops into Cistern – II at the off – take main canal with F.S.L. at + 61.145 m. through the pressure Main-II of length 0.90 km (0.56 miles) consisting of 3 Nos. of 1300 mm dia prestressed concrete pipes. From this Cistern, the main canal takes off and runs to 19.695 km to benefit 14,165 ha, (35.000 acres).

Location of the Project Area

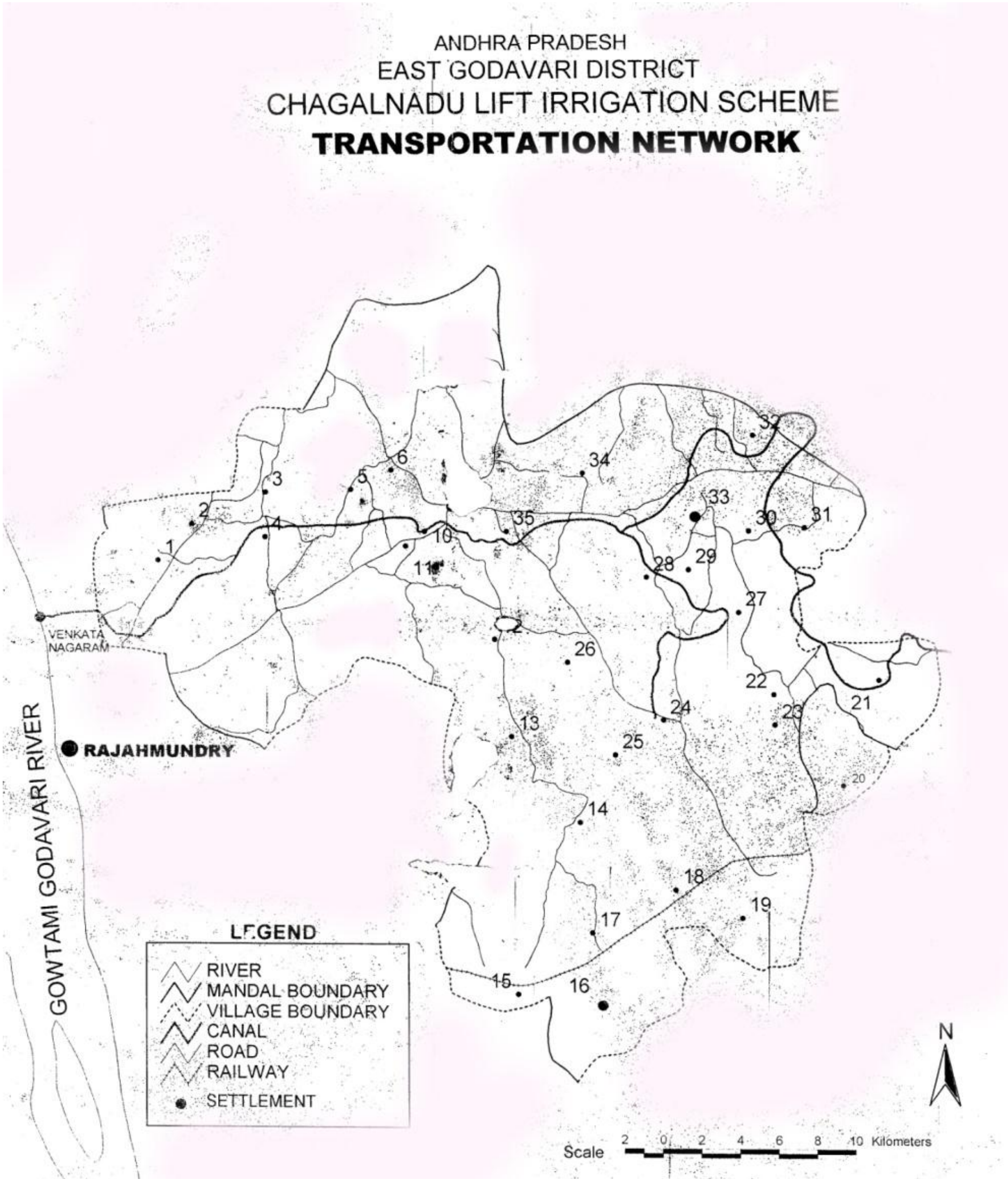
The site of the off – take point, the waters of Godavari are proposed to be drawn, is situated at 16.425 km (10.50 miles) of Akhanda Godavari left Bank in the village limits of Venkatanagaram, which is about 5 km (3.18 miles) from Rajahmundry town, in East Godavari District of Andhra Pradesh. The First stage pump house is located at Palacharla village which is about 7 km from Rajahmundry

The geographical co-ordinates of the project are as follows.

Longitude $81^0 – 45^1 – 18^{11}$ E

Latitude $17^0 – 04^1$ - 03” N

The canal passes through Rajahmundry, Korukonda, Rajanagaram, Rangampeta and Biccavolu Mandals of East Godavari District.



Access to the Project

The two pump house of Head works are situated at a convenient distance from the Rajahmundry town. The proposed first stage pump house in the village Kolamuru is accessible from Rajahmundry – Gokavaram black -topped road, and is at a distance of 0.9 km (0.56 miles) from 6.2 M.M stone of the said road on left side. The proposed second stage pump house in village palacherla is accessible to Rajahmundry – Gokavaram black topped road and is at a distance of 0.90 km(0.50 miles) from 6.2 km tone of the road on right side.

General Description of the Topography and Geology of the Area

The site now suggested for locating the pump houses and other feeding units has excellent facilities to locate a pumping scheme of present magnitude at a relatively cheaper cost. The site is situated just 0.6 km (0.36 miles) uspstream of venkatanagaram pumping shceme on the same river Godavari and 16.425 km (10.5 miles) upstream of the existing Sir Arthur Cotton Barriage. The command area is at a shortest distance of 7.00 km (4.40 miles from the pumping unit of the river). The lift required is minimum. Higher draw down Levels are available in view of the higher pond levels down maintained by Sir Arthur Cotton Barriage. Adequate and sizeable in tanks are available in the vicinity of the pump house so that they can be used with slight modification as balancing reservoirs to feed the canals in case of power failure or trouble in the performance of motors.

The pump houses are easily approachable by black topped roads and soils in the vicinity are suitable for providing good foundation comparatively lesser cost. In the unity the land at the area is gradually sloping with vegetation at the surrounding patches of land. The main soils at the site are sand loams with patches of black cotton.

The geographical area is literally plain with few mounds of soils of sandy loams, red soils and black cotton soils. The soils are very deep and possess well drained facility for Irrigation. The command area mostly is in Rajahmundry and Rangampeta Mandals which are situated in Central Part of East Godavari District, Topography of the area is undulatory with an elevation difference of 40 m. No prominent stream flows through the area except existence of 275 irrigation tanks.

Nearly seventy percent of the Geographical area of these Mandals is occupied by Rajahmundry sand stones. The remaining area which lies north of Rangampeta is underlined by Deccan Traps. No exposures of trap are observed on the surface except for a few well sections. But a few bullocks and rounds of Rajahmundry sand stone formation are observed in the Southern part of the area. The Rajahmundry sand stones are generally brown, red, pink or white in colour and fine to medium grey and interpolated with clays. These sand stones are generally compact..

Ground water in Deccan Trap occurs under water table conditions gathered and fractured zones of the formation, weather and the trap area extends from 10 to 15 m from the ground level. The wells in the traps are mostly used for demand of the partner. The exploitation of ground water in this area is scanty in view of hard and compact nature of the soils.

The parts of ground water is potable and suitable for agricultural supply the ph of the ground water supplies range from 6-7 conductance varies between 2270 micro m/cusec.

Population

The majority of population in the command area are agricultural labour who are economically backward due to lack of dependable irrigation factilities. The people in the area are purely agriculture – oriented, though there are few Rice mills, sago Mills, Flour Mills, Saw Mills, Tile Factories and Crucible Factories in a limited extent. Almost every village is electrified.

One village in Rajahmundry Mandalam, two villages in Korukonda Mandals, Eleven Villages in Rajanagaram Mandals, Fifteen Villages in Rangampeta Mandalam, Three Villages in Biccavolu Mandalam and Two villages in Anaparthy Mandalam and one village in Mandapeta Mandalam are benefited by the scheme when implemented and remove the imbalance in the area, makes the land granary of the East Godavari District. Besides this,the scheme provides drinking water for a population of 1,02,150 in thirty five villages in route the main canal at one hundred liter per capital per day.

LAND USE

The land use of the command area is mostly in Rajanagaram and Rangampeta Mandals. No stream or a Vagu worthy of mention flows in the area. There are 275 tanks in the area to serve ayacut of 4,047 ha. (10,000) acres). These tanks derive water only from rains and most of the time, they are not able to meet even fifty percent of the requirements due to frequent drought conditions. Apart from this, another 10,000 ha (25,000 acres) land is under cultivation mostly depending upon rain fall.

With shortage of waters in tanks, with the hostile nature and frequent drought, people still stick to agricultural land but the activity in the area is but the harvest is poor resulting to in misery to the man who has an unflinching belief in the activities. Poor harvest is leaving the area backward far behind other areas in the East Godavari District itself and other coastal Districts.

State of the Development of the Project

The proposed scheme is a temporary measure to supply waters for 14,165 ha (35,000 acres) of are cut to derive early benefits in the Chagalnadu upland areas covering 35 villages. This ayacut of the scheme will be fully and ultimately covered by 'Rajahmundry Major' of left Main canal of the proposed 'Polavaram Project' the report of which was submitted to Central water Commission for clearance. The Rajahmundry Major of Left Main Canal of Polavaram project takes off at 30. km of left main canal of Polavaram where the full supply level of the canal is 38.35 m (125.79 ft). It is proposed to irrigate 28,158 Hectares. (69,579 Acres) under this out of which 8,051 ha (19,894 acres) is by Gravity. The rest of 20.107 ha (49,685 acres) is by lift. Lift of waters is proposed at 4.8 km of the Rajahmundry Major. The agenda was already developed and irrigation is practiced with available waters mostly rain-fed.

Inter linking of scheme

…

No Inter-linking with the neighboring schemes of waters is resorted to supply of water is only from July to December so that only surplus waters are utilized .

Geographical

\ The scheme is a Lift Irrigation Scheme and therefore does not entail detailed discussions about the river and its hydrology from where pumping is contemplated.

The river Godavari is one of the largest rivers in India, being the second largest in Indian Union. It runs across from the Western Ghats to Eastern Chats. Starting from trickle from the lips of a cow at Triembak, the width of the river grows till it is nearly 6.5 km (4.0 miles) wide at Dowlaiswaram.

The Godavari rises in the Western Ghats at Triambak Nasik about 112 km (70 miles) North – East of Bombay and flows through 1,226 km (766 miles) before it falls into the Bay of Bengal about 80 km (50 miles) East of Rajahumndry. The total catchment area drained by the river is 3,12,812 sq.km (1,20,777 sq. miles) or nearly 1/10th of India.

The main tributaries of the, river are the Manjira, the Pranahita, .. Indravathi and the sabari. The Pranahite in turn is formed by the confluence of the waradha the pengange and the wainganga. Out of the total average annual flow of the river near by 40% is contributed by the pranahitha and the wain ganga and 10% by Sabari and the rest by the other Tributaries of the Godavari itself.

The raising as it does in the heavy rain-fall of the region of western Ghats comes under the influence of South west The region has clearly marked zones with rainfall ranging from 808 mm. (33 inches) to 1.016 mm greater portion of the area drained by the Godavari river which receives Much more rain during south – west Monsoon and (June to September) than in the North – East Monsoon the consequently the river brings down most of its water between June and September. The water level begins to rise at Dowlaiswaram some ten days after the South – West Monsoon sets at Mumbai usually about the middle of June and it remains almost continuously high till the end of September. High floods during October are rare. The flood season ends by October but during the next two months there are occasional floods caused by North – East Monsoon over the part up the catchment which comes under its influence. The maximum floods so far estimated at Dowlaiswaram occurred on the 15th August '86 is 0.934 lakh cumecs. (33 lakh cusecs). After the North East Monsoons have ceased the river gradually goes down and by the end of May, the discharges may be as low as 42.5 Cumecs. (1,500 cusecs).

Topography of the basin and commend area
The Godavari basin is divided into twelve sub-basins
I) Upper Godavari, II) Pravaa, III) Purna, IV) Manjira, V) Middle Godavari, VI) Manar,
VII) Penganga, VIII) Wainganga, IX) wardha, X) LowerGodavari, XI) Indravathi & XII) Saberi

The abundance of all the waters in the Godavari basin either the flow of ground water, is the rain, which falls over the region The dominant natural factor that effects basically the life and economy of the people in the Godavari basin is the rainfall and its regional and seasonal distribution, amount and variability. Like most other parts of the South India, the Godavari basin receives the major portion during the South – West monsoon.

The Godavari basin enjoys a monsoon tropical climate. The mean annual surface temperature in the Godavari basin in the Western Ghat area is about 24^0 c. which increases gradually towards the east and attains maximum of 29.4^0 c on the East Coast.

Soil Surveys

The Command area under this Chagalnadu lift Irrigation scheme is covered under Polavaram Left main canal commands for which soil sample have already been done.

The soil encountered vary from Mandalam to Mandalam. In Rajahmundry Mandalam, sand mixed fertile soils are available while in korukonda Mandalam both Red soils and sandy soils prevail tin.. In Rajanagaram Mandalam sand mixed light soils form the subtrata, while in Rangampeta Mandalam soils are red and black cotton ones. Loamy soils are predominant in Bioccavolu Mandalam while the soils of Anaparthy and the soils vary from the light Yellowish brown to slightly black and red in some parts. These soils are quite deep.

Tanks and Balancing Reservoir

There are altogether two hundred and seventy five No. of tanks in the command area. It is estimated that these tanks are capable of storing a total quantity of about 14.0 cubic m (404.14 cubic ft). This is against the total requirement of 77.44 cubic m (2734 cubic ft). Thus eighteen percent of the total demand in an year can safety as be stored in these tanks. This works out to a quantity that can be pumped for twenty four days. As such, there shall not be any scarcity for water if by one reason or the other the pumping fails for twenty days.

A marginal provision is made in the estimate for the improvements and modification to the tanks to act more effectively as ground reservoirs. Also, a special provision is made for the tanks at the vicinity of Gravity channel-I and II to act as immediate balancing reservoirs.

Canals

One in canal is proposed and its length is 19.695 KM This canal is designed to carry 6.56 cusecs. (232 cubic ft per second). The ayacut proposed is 35,000 Acres. (14.165 ha) located in 35 villages. Drinking water needs will be complied to a population of 1,02,150 for the villages en route at 100 Kts. Per capita per day.

Description of the Canal System including Ridges / Contours/ Lift Canal Capacity and Considerations for Fixed Alignment

One of the special features of the scheme is that the entire ayacut of 14,165 ha (35,000 acres) is already under cultivation either from the insufficient waters from tanks or entirely depending upon the rainfall. Out of the proposed 35,000 acres, an extent of 10,000 acres is already under paddy cultivation under tanks. This extent requires fifty percent supplementation. The remaining Ayacut is situated beyond the periphery of tank ayacut and as such, irrigated dry crops of chillies. Groundnut and Maize are proposed.

Location

The main canal takes off from the Cistern of pressure main-II of second stage pump house in the village limits of Palacherla village. The bed level of F.S.L. of the main canal at this chinnage of the canal is 59.675 m and + 61.145 m respectively. This main canal is having two major distributories by main fall end distributory and Marripudi distributor commanding an ayacut of 6,184 ha. (15,281 acres) and 2,527 ha (6,244 acres) respectively.

Ayacut

The entire ayacut is in the upland areas. The Village wise ayacut that will be irrigated under this scheme is detailed below (in the main report).

The suitability of irrigation water (SIW) can be assesed as :S.I.W : F (QSTCD) in which

Q : Quality of Irrigation water
S : Soil type
P : Salt tolerance characteristics of Plant
C : Climate and
D : Drainage characteristics of the soil

The above factors as are obtaining in Polavaram project are dealt hereunder.

Quality of Irrigation Water

Basing on the data presented above. It can be concluded that the Godavari Water are of low sodium hazard and seasonal low salinity hazard of no consequence and are quite suitable for irrigation on all types of soil and during both the crop growing seasons.

Other uses of water at this zone such as Dhobi ghats. Kotilingalu bathing ghat. Utilization as public lavatory drawl / release or leakages from paper mils effluents are all point source of pollution at this point. Partly acting as fertilizers to the river, these activities are unassessed sources of heavy pollution in the river at this point.

Management along the canal system

Along the canal system which passes through 3 – 4 Mandals of the uplands of East Godavari District, there is only one major way of fisheries Management and that is by way of fish culture, in the seasonal rain-fed irrigation tanks along the way.

It appears that some of these tanks are likely to get a little enhanced water supply from the canal. Some mandals such as Mandapeta, Anaparthi and Biccavolu are comparatively better – off as regards water resources due to the Godavari left bank canal. As few dry upland parts of these Mandals might be poor in water resources.

All these seasonal tanks, whether small or big with available water spread area ranging from 0.5 ha to 5 ha.. are already under fish culture practices. These get shrunk as water is drawn for irrigation needs as the season progresses over the south – west monsoon to North – East monsoon months of June – July followed by occasional gals in February – March viz., over a 6-10 month period.

Once it was realized by 1980s that fish culture yields are more lucrative (with minimum management), than the agricultural crops, people of these villages have started paying greater attention to the traditional fishing operations converting them to more technical management patterns.

East Godavari in general has a better water facility benefitting from both monsoons. The hilly terrain (Eastern Ghats) brings in seasonal streams to replenish the tanks.

The eastern part of the Chugalnadu Project has highly developed fish culture tanks under the control of both Panchayat Raj as well as the Department of Fisheries.

The fish culture management is detailed below.

Fish Culture Mangement in Seasonal Rain-fed Irrigation Tanks

Introduction

Culture of fish in available water spread Area has been anage-long practices in India. Fish, particularly, the freshwater varieties formed part of the staple diet along with rice in almost all the coastal states but more so in west Bengal, Orissa and Kerala. In these states every house – hold has a small easthern tank where fish are grown for daily consumption of the household. Fish the rein – flood waters are trapped and allowed to grow for some months and then harvested and marketed making this a highly lucrative practice. Thus has grown the Concept of 'Fish Culture' viz., catching smell baby fish called 'fry' and, as they grow to an inch or so 'fingerling' which are then introduced or 'stocked' in tanks and other water bodies to grow for certain lengths of time or, till water resource is available.

Aritificial food can be used in ponds provided the tanks are not used for drinking water purposes.

Management

Almost all seasonal tanks in Andhra Pradesh which have a minimum water spread of 1st hand and an average depth of 1 mare under fishing lease now.

These tanks are auctioned or under a fixed rental of the Department of Fisheries. Government of Andhra Pradesh. or under the Panchayat. The village cooperatives usually consisting of 100 or so members of the village undertake the entire fish culture management, some of these villagers might be both agriculturists and fish culturists, In this case the fight for water is much under control, If not, the fight assumes a huge proportions.

The management of fish culture in these seasonally rented tanks is very simple.

The Cooperative societies are not in the habit of any scientific management of the ponds. They stock the ponds with fry/fingerlings purchased from the Department at fixed costs or the private parties. The fry are transported to the site.

Concepts of Fish Culture

As mentioned all tanks where there is water resource for 6-10 months in an year has become a potential fish culture resource.

Species (of fish introduced; Major carps (into the tanks)
Scientific Name Common Name Maximum growth Growth in 8-10 months
Catla catla Catla 35-45kg 750-1000 g
(Most preferred)Rohu 30-35 kg 600-750 g
Lebeo rohita Cirrhinus mrigal 30-35 kg 770-1000 g
Cyprinus carpio or Chinese Carp or common carp
(2nd most preferred)5-6 kg 1000-1500 g

If a ha of water spread area yields a ton of fish with net returns/profit of Rs.10.000, the net returns from a 10 ha, pond are quite high. (Effective water spread area 50%).

But the major consideration here is that the water spread is not quite consistent. Water being drawn out for irrigation needs and, if rainfalls fails in any year, the yields fall/decline.

Therefore it is evident that a supportive increase in water level even if it is by 1% and, this support comes at the end of the season when water for irrigation is no more needed thus giving a longer growth period for fish, there will be a sustainable high yield which would benefit the village at large.

Middlemen (brokers) are the bane of the villages level fish marketing. If this obstruction to the village welfare is done with, more direct benefits to the villages can be predicted.

East Godavari District of Andhra Pradesh is the most productive in fish culture even in seasonal irrigation tanks by virtue of the monsoons which keep the tanks almost full for a length growing season of 8-10 months. Rainfall helps the agricultural crops and therefore less dependence an tanks. Thus water spread is available longer, for fish growth.

Soil quality is good which make the waters productive and thus feed is available for the fish. Enhanced supply from River Godavari water would increase the productivity of these tanks.

The propsed balancing reservoirs at stage II and III pumps might also come under fish culture. Proposals may be made to support the other tanks along the way at Rajanagaram, Rangampeta Mandals by way of 2 – 5% increase of water, Biccavolu, Madapeta Anaparthi Mandal already have additional water resources, Nandalada tank is prone to heavy flood from hill streams which breaches at times and floods the uplands. So protective bunds might have to be raised to prevent water loss.

This art of trapping has grown to high scientific level today and is called aquaculture where fast-growing species of fish are selectively chosen for stocking in ponds; not only this but a system of combining 3 -4 types of fish to grow in tanks termed as ‘Composite culture’ has now been developed, perfected and is now a standard practice to stock at various combinations in tanks.

This combination is to help to take advantage of the available ‘natural food’ in a tank called ‘Plankton’. Some plankton is at the surface of the tank waters; part of it remain at the bottom termed as ‘benthos’.

Different species of fish in combination feed at different levels of the pond, surface, column or bottom, the composite culture helps to take advantage of this feeding habits and also helps prevent competition for food by the chosen species.

The fish most commonly used all over India in composite culture are collectively called as major carps. These fish are indigenous to Indian rivers; Mature and ripe fish (ripe for breeding) are available in monsoon in all the Indian rivers.

In the past two decades some varieties of fish have been imported from abroad particularly china and these fish are called as exotic fish; of these one species called chinese carp has become a most useful combination with major carps in all parts of Andhra Pradesh

Artificial breeding of these major carps has been developed 40 years ago in India called as induced breeding technology. This induced breeding by way of injection of hormones helps to ripen the fish faster and release eggs in time without any loss, under controlled conditions.

The eggs are hatched in open ponds in cloth containers called hapas and fry (baby fish) are thus released. The hatchings are now available in every Government –gun seed farms.

These artificially bred baby fish termed as ‘fry’ when 6 mm to 15 mm and fingerlings at 30 mm – 50 mm size and ‘advanced fingerlings’ above 50 mm in size are used to stock the tanks for further growth

Importance of Fish Culturein Socio–Economics / Industrial Milieu

India, it is reported, has about 18 milion acres of freshwater area available for aquaculture. Fish is a high protein source of food, standing in the table of protein sources fish tops meat. Eggs, pork and all other vegetable sources, easily digestible, with the entire spectrum of Amino acids in its composition; fish also provide a cheaper source of protein food especially in rural areas.

Being very fast growing, with no extra expenditure put into the fish culture practice except for the cost of seed (fry / fingerlings). Farmers prefer this as an additional source of income wherever surplus water is available after the irrigation needs are met

In the 1980s to date freshwater fish found a new ‘export’ market and fish from Andhra Pradesh is the major export commodity to West Bengal and all the North-Eastern states. Daily from Kollair lake alone, 12 lorry loads of fish leave for North (each lorry – load equals 12 – 15 tones). These basket loads are ice-packed

This new export market has revolutionized the traditional fish culture in large or small water bodies whether seasonal or not. In the perennial or newly – excavated ponds fish culture has taken shape as an industry.

Small and Medium Tanks / Reservoirs

The small and medium tanks, natural or man-made are seasonal in nature; monsoon fed from freshwater rivulets. Hill – streams or overflowing river floods (low – flying areas termed as Avis) they range in extent from 0.5 ha (1 ha = 2.5 acres) to 100 ha or more.

Almost all these tanks are traditionally used for agriculture crops; traditionally fish grew in there were naturally recruited during monsoon floods; voluntary stocking of fish has taken shape around 3 decades ago or so

These seasonal tanks are unique ecosystems. Being seasonal they retain water over a period ranging from 6 to 9 months depending on the size of the tank. The irrigated area and, the most important factor, rainfall pattern.

In depth however the tanks may vary from very shallow 0.5 m to an average 3 m (in the mid-point), where the bottom contour is rocky. There may be some very deep areas forming pools giving shelter to fish even if the tank goes dry.

A unique feature is that the drawdown of water for irrigations need… keeps the water highly oxygenated by virtue of its movement and thus acts as beneficial feature for fish culture

Productivity, Depending on the soil status, these small medium irrigation tanks can range from high, medium to low productivity.

The productivity is calculated as Carbon / meter cube / hour (c/m3/hr).
Where productivity is poor fish growth tends to be poor and considerable management would be necessary

Black cotton soils tend be highly productive compared to the sandy loams or red soils; However water retention might be better in the latter

The soil water interface has thus a great role in the water productivity and hence the fish productivity. The fish yield is directly related to the fast growth of fish which is turn, depends on plankton food availability.

Productivity of a water body can be increased by addition of fertilizers (both organgic and inorganic) and feeds (formula feed) which will result in higher planktonic production.

Acknowledgements

This report was prepared for the Agricultural Finance Corporation, Hyderabad, as a consultant for fisheries section during 2003-4. The data pertaining to civil Engineering is provided by the A.P. Government Dept of irrigation to the A.F.C. I acknowledge with thanks both the DEPTS of irrigation and managing Director of A.F.C.

Conclusions as Applicable to Dry Land Farming

Land Use

The lands of the command are as mostly in Rajanagaram and Rangamepeta Mandalam No stream or **vagu** worthy of mention flow in the area. There are 275 tanks in the area service an ayacuts of 4,074 Hect (10,000) acres. These tanks derive water only from rains and most of the time; they are unable to meet even fifty percent of the requirements due to frequent drought conditions. Apart from this, another 10,118 Hect. (25,000 areas) land is under cultivation entirely depending upon rain-fall.

Pumping of waters is resorted to only fro, july to Decemfber during monsoon so that only surplus waters are un utilized.

Tanks and Balancing Reservoirs

It is estimated that these tanks are capable of storing a total quantity of about 14.0 M.cum (404.41 Mcft.) This is against the total requirement of 77.44 M.Cum (2734 M.Cft) Thus eighteen percent of the total demand in an year can safely be stored in these tanks. This works out to a quantity that can be pumped for twenty fourdays. As such, there shall not be any scarcity for water if by one reason or the other the pumping fails for twenty day.

Other consideration:

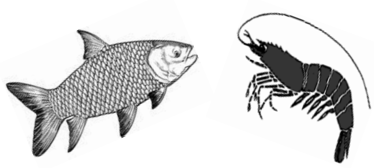
If I have of water spread area yield a ton of fish with a net returns profit of Rs. 10,000/- the net returns from 10 ha pond are quite high. (Effective water spread are 50%)

But the major consideration here is that the water spread is not quire consistent. Water being drawn out for irrigation needs and, if rainfall fails in any year, the yields fall/ decline.

Therefore it is evident that the supportive increase in water level if it is even by 1% and, this support comes at the end of the season when irrigation is no more needed thus giving a longer growth period for fish, there will be a sustainable high yield which would benefit the village at large.

East Godavari District of Andhra Pradesh is the most productive in fish culture even in seasonal irrigation tanks by virtue of the monsoons which keep the tank almost full for 8 Growing seasonal the major season the crips a dependent which of 8-10 months. Rainfall helps the agricultural crops and dependend of tanks. Thus water spread is available longer, for fish growth, soil quality is good which makes the waters productive and thus feed is available for fish. Enhanced supply from river Godavari water increase productivity of these tanks.

The proposed balancing reservoirs at stage If and III pumps might also come under fish culture. Proposals may be made to support the other tanks along the way at Rajanagaram, Rangampeta mandala by way of 2-5% increase already have shown in the main report), Biccavolu, Mandapeta Anaparti AMandal already have additional water resources nandalada tank is prone to heavy flood from hill streams which breaches at times and floods the uplands. So protective bunds might have to be raised to prevent water loss.



Technical Paper-5

POPULARIZATION OF STUNTED CARP CULTURE TECHNOLOGY IN THIRUVARUR DISTRICT BY KRISHI VIGYAN KENDRA, NEEDAMANGALAM

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Introduction

Inland fish culture plays a vital role in upliftment of rural economy of the country. In Tamil Nadu, Inland composite fish culture is a highly economic and profitable subsidiary farm enterprise in Cauvery delta region. It is one of the powerful income and employment generator for farming community in Thiruvarur district. As rice bowl of Tamil Nadu, the farmers of Thiruvarur district have taken up composite fish culture in their own ponds or temple/panchayat ponds which are dependent on canal and rain water. The water storage period is limited to 5-6 months only. Thiruvarur district is located in the tail end of Cauvery delta region and prone to periodical flood and droughts. While demand for fish is on the rise, the production does not commensurate with the demand due to non availability of water for longer period (10-12 months) and use of ordinary carp fingerlings (8-10 g weight). High mortality, low fish weight gain in short period of time, low productivity and less income are major drawbacks, besides predatory fishes, weed fishes, natural enemies and diseases. To realign this gap, Krishi Vigyan Kendra, Needamangalam has taken several planned interventions in Thiruvarur district to transfer the composite culture with stunted carp culture technology. Stunted carp culture technology is an indigenous technology. It has been promoted by CIFA, in 2009, in which, stocking of two to three lakhs of fingerlings in an acre of fish pond and stunt the growth of fish through limited feeding for 9-12 months. Once they reached a size of 80-100 grams, they are released in growout ponds where the weight gain is found to be very high in a shorter period. Main cause is that normally carp have more growth rate in second year rather than first year.

Intervention of Krishi Vigyan Kendra on stunted carp culture technology

- A NABARD sponsored CAT programme on Inland fisheries as remunerative alternate option in Cauvery delta region has been organized between 10-02-2011 to 12-02-2011 at KVK to disseminate the message that inland fish culture can enhance the economic condition of the farmers in Thiruvarur district.
- A two days vocational training was organized between 15-03-2011 to 16-03-2011 in which the stunted carp culture technology has been demonstrated. Exhibition and exposure visit to successful farmers were arranged.
- A NABARD sponsored CAT programme on Integrated Farming System (IFS) for sustainable livelihood has been organized between 20-08-2013 to 22-08-2013 at KVK to disseminate the message that inland fish culture under IFS can enhance the economic condition of farmers substantially.
- A NABARD sponsored CAT programme on Inland fisheries as remunerative alternate farming in Cauvery delta region has been organized between 5-09-2013 to 7-09-2013 at KVK to disseminate the message that inland fish culture can enhance the economic condition of farming community
- A demo unit has been set up in the KVK Farm to demonstrate the technology of stunted fingerling to the visiting farmers, trainees and other visitors.

KVK, Needamangalam has undertaken On Farm Testing (OFT) during 2011-2012 for assessing the feasibility of stunted fingerlings technology in five villages. Ordinary carp fingerlings of 8-10 gram weight (TANUVAS 2005) and stunted carp fingerlings of 80-100 g weight (CIFA-2009) were provided to the OFT farmers.The results are presented in Table 1.

Table 1, has shown that the maximum fish weight gain in six months period of ordinary carp fingerlings was 375 g and stunted carp fingerlings was 900 g. The benefit cost ratio was low for ordinary fingerlings (2.66) when compared to stunted carp fingerlings (3.48). The OFT results revealed that high mortality, low fish weight gain in shorter period of time and low income were disadvantage of ordinary carp fingerlings. Low mortality, more survival rate in grow out ponds, quick growth, higher production and productivity in short period of time were the advantage of stunted carp fingerlings. The fish yield and benefit cost ratio of the trials / testing plots differed significantly due to nature of the pond, availability water, water depth, carp species and feed management. Based on the success of the OFT the KVK, Needamangalam had taken steps to popularize the stunted carp culture technology in Thiruvarur district. During the year 2012-13 one Front Line Demonstration (FLD) was laid out in 5 villages of Thiruvarur district. The results are presented in Table 2

Table No.1 Technology assessed and benefit cost ratio

Technology option	**Technology assessed**	**Fish weight gain in six months period**		**Average fish production in six months period (kg/ha)**	**Net return (Rs./ha)**	**B/C ratio**
		Maximum	Minimum			
1	Ordinary carp fingerlings of 8-10 g weight (TANUVAS 2005)	375 g	150 g	2,500	2,12,500	2.66
2	Stunted carp fingerlings of 80-100 g wright (CIFA 2009)	900 g	350 g	4,500	3,82,500	3.48

Table No. 2 Technology demonstrated and benefit cost ratio

No. of demonstration	**Area (m^2)**	**Fish weight gain in six months period**		**Average fish production in six months period (kg/ha)**	**Yield increase (%)**	**Net return (Rs./ha)**	**B/C ratio**
		Maximum	Minimum				
5	5,000	875 g	250 g	4,500	80	3,20,000	2.83

Table 2 has indicated that the maximum fish weight gain in six months was 875 g and minimum of 250 g. The percentage of yield increase was 80 per cent and the benefit cost ratio was 2.83. The results revealed that the lowest fish weight gain in stunted carp culture technology was due to non availability of water for six months (canal water and failure of north east monsoon during the year 2012-13). The farmers were put in a precarious position of saving the fingerlings and fishes water scarcity situation.

Harnessed efforts of KVK, Needamangalam for popularization of stunted carp culture technology witnessed that number of farmers who were took to stunted fingerlings in Inland composite fish culture showed a significantly increasing trend with the increasing of 250-400 farmers every year. The growing of stunted carp fingerlings provided the way for remunerative income and farmer are overwhelmed with this technology.

Technical Paper-6

ஒருங்கிணைந்த வேளாண் பண்ணையில் மீன் வளர்ப்பு குறைந்த நீர் ஆதாரத்தில் ஒட்டுமொத்த உற்பத்தி அதிகரிப்பு அனுபவ பகிர்வு

பி.எஸ்.மாசிலாமணி
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திருவாரூர் மாவட்டம்
9443865101

இயற்கை சூழல் மாறுபாடு:

உலகின் வெப்பநிலை உயர்வு, பருவமழை மாற்றம் ஆகிய நிலைகளில் திட்டமிட்ட வருமானம் ஒவ்வொரு ஆண்டும் பல்வேறு காரணங்களில் குறைந்த வருகின்றது. வேளாண்மை மற்றும் தொழில்துறைக்கு சமச்சீர் வளர்ச்சிக்கான திட்டங்கள் நிதி ஆதாரங்கள் 1960 வரை இருந்து, பின் வேளாண்மைக்கு ஆண்டுக்காண்டு நிதி ஒதுக்கீடு குறைக்கப்பட்டு வருகின்றது. இத்தொழிலுக்கு அரசின் பாதுகாப்பு இல்லை. வேளாண்மையை தொழிலாக அறிவித்திடவில்லை, ஊருக்கு உண்வளிக்கும் உன்னத தொழில் சேவை தொழில் ஆகுமாம். இதனால் விவசாயிகள் தன் உயிரை மாய்த்து நாட்டிற்கு சேவை செய்து வருகின்றார்கள்.

இச்சூழலில் கூட்டுப் பயிர்களுடன் கலப்பின உயர்ரக மீன் வளர்ப்பு என்பது அவசியமும், முக்கியத்துவமும் பெறுகிறது. இம்முறை என்பது தமிழ்நாட்டில் புதிதல்ல.

முந்திய காலங்களில் விவசாயிகள் தாம் பயன்படுத்தும் பயிர் வகைகள்:

உயிர் வகைகள் எல்லாவற்றையும் சேர்ந்து அதன் அதன் இயற்கை உயிர் ஓட்டத்தில் வளர்த்து பயன்பெற்று வந்தார்கள். புதிய பொருளாதார கொள்கையின் தாக்கத்தால் உலகம் சுருங்கி - மக்களின் எண்ணங்களும் செயல்களும் பாய்ச்சல் வேகத்தில் செல்கிற போது பண்டைய முறைகள் மறக்கப்பட்டு எல்லாம் உடனடி தேவையாகியது. தன் வீட்டில் துளசி, கற்றாழை உள்ளிட்ட மருத்துவ பயிர்கள் - உடல்நலம் பேணும் தானியங்கள் இப்போது உடனடியாக சாப்பிடும் நிலையில் தேடிடும் நிலை உருவாகி வருகிறது.

ஆகவே தான் நிலையான நீடித்த வருமானம் தரும் ஒருங்கிணைந்த வேளாண்மை என்பது தற்போது அவசியமாகிறது. இயற்கை மாறுபாடுகள் எப்படி ஏற்பட்டாலும், ஏதாவது ஒரு பயிர் வருமானத்தை கொடுத்து வாழ்க்கையை நிலைக்க வைக்கும். இதற்கு பல ஏக்கர் நிலம் வேண்டும் என்பதல்ல, ஒரு ஏக்கரில் கூட செய்யலாம் 6ல் ஒரு பங்கில் மீன் வளர்ப்பு குளம், இதில் எடுக்கும் மண்ணைக் கொண்டு இருமடங்கு மேடாக்கி புஞ்சை மற்றும் மரப்பயிர்கள், எஞ்சிய 3 மடங்கு நிலத்தில் நஞ்சை பயிர்கள். இவைகளில் தினசரி வருமானத்திற்கு கோழிகள், முட்டைகள் - இரு மாதங்களில் வருமானத்திற்கு தென்னை மரம் - ஆறுமாதத்திற்கு ஒருமுறை மீன் - வருடம்தோறும் ஆடுகள், மாடுகள், மரம், பழப்பயிர்கள் - என வருமானம் பார்க்கலாம்.

ஒன்றின் கழிவு → மற்றொன்றுக்கு உணவு:

சுழற்சி முறையில் இதன் உணவு → கழிவு → உணவு, ஆடு, மாடு, கோழிகளின் எச்சங்கள் மீன் மற்றும் பயிர்களுக்கு உணவு/உரமாகும். எனவே, இடுபொருள் எதுவும் வெளியில் இருந்து வாங்காமல் உள்ளே இருந்துதான் உணவுப்பொருள் வெளியே (விற்பனைக்கு) செல்லும், இவைகளை நாம் நேரில் பண்ணையிலேயே விற்று வந்தால் வியாபாரிக்குள்ள லாபம் நமக்கு கிடைத்துவிடும்.

நீர் ஆதாரம் குறைந்து வரும் நிலையில் இவைகள் சாத்தியமா என்ற கேள்வி எழும். குறைந்த நீரிலும் இதை மேற்கொள்ளலாம். நிலத்தடி நீர் எடுக்க வாய்ப்புள்ள விவசாயிகள் மீன்வளர்ப்பு குளத்தில் தொடர்ந்து நீர்பாய்ச்சி பயிர்களுக்கு விடுவதால் - பயிர் செழித்து மகசூல் கூடுகிறது. இந்த வாய்ப்பு இல்லாதவர்கள் - மழைநீரை குளத்தில் கூடுதலாக தேக்கி வைத்து சொட்டுநீர், குழல் நீர் பாசனம் செய்யலாம். நஞ்சையில் ஒரு போகம் நெல்பயிர், ஒரு போகம் தானியப்பயிர், ஒரு போகம் தீவனப்பயிர் என முப்போகமும் சாகுபடி செய்யலாம். தானியங்களும் தீவனப்பயிர்களும் கால்நடைகளுக்கும், மீனுக்கும் உணவாகும் தீவிர மீன் வளர்ப்பில் கூடுதல் மீன் குஞ்சுகளை விட்டு ஏரேட்டர் இயக்கி கூடுதல் வருமானம் பெறலாம். நிலத்தடி நீர் பாசனம் செய்யக்கூடியவர்களுக்கு ஏரேட்டரும் தேவையில்லை. மீன்கள் தாவர நுண்ணுயிர் விலங்கின நுண்ணுயிர் மற்றும் கழிவுகள் நுண்ணுயிர் பாசிகளை சாப்பிடுகிறது. அதற்கேற்ப 3 நிலைகளில் வளரும் மீன் குஞ்சுகளை குளத்தில் உள்ள நுண்ணுயிர் அளவிற்கேற்ப வளர்க்க வேண்டும். கிளரியா, சூபா, அகத்தி மரங்களை குளக்கரையில் வளர்ப்பதால் நிழலும் விழும் இலைகளால் பயனும் ஏற்படுகிறது. பனை, தென்னை ஓலைகள் மீனுக்கு உணவாகி விடும். இவைகள் கால்நடைகளுக்கும் உணவாகிறது.

வருடத்திற்கு மூன்று தடவை குளத்தில் உள்ள மீன்களை பிடித்து விட்டு அதற்கு ஈடாக மீன்குஞ்சுகளை குளத்தில் இருப்பு செய்ய வேண்டும். அதற்கேற்ப சிறிய குட்டையில் மீன்குஞ்சுகளை முன்னரே வாங்கி இருப்பு வைத்து வளர்த்து வரவேண்டும்.

நான் விரால் மீன் வளர்த்து வருகின்றேன். தனியாக ஒரு குட்டையில் விரால் மீன் குஞ்சுகளை மட்டும் விட்டுள்ளேன். அதை ஒட்டி இதைவிட சிறிய குட்டை வெட்டி அதில் திலேப்பியா மற்றும் நாட்டு மீன்குஞ்சுகளை விட்டுள்ளேன். தண்ணீரை விரால் மீன் குட்டையில் பாய்ச்சுகிறேன். அந்த தண்ணீர் குட்டை வழியாக வயலுக்கு செல்கிறது. அப்படி செல்லும்போது திலேப்பியா உள்ளிட்ட குஞ்சுகள் எதிர்த்து வந்து விரால் மீன்களுக்கு உணவாகி விடுகிறது. மேலும் விரால் மீனுக்கு போடும் கருவாடு மற்ற மாமிச கழிவகளால் தண்ணீரும் பாதிக்காமல் அப்படியே வயலுக்கு சென்று உரமாகிறது. இப்படியான முறையில் தீவிர மீன் வளர்ப்பு - வருமானம் அடையலாம்; மீன் வளர்ப்பு உள்ளிட்ட ஒருங்கிணைந்த பண்ணையதிற்கு குறைந்த கட்டணம் மின்சாரம் வழங்கிட வேண்டும். மீன் வளர்ப்பிற்கு மிகக் குறைந்த காப்பு தொகையுடன் கூடிய காப்பீடு திட்ட வசதி வேண்டும்.

ஒருங்கிணைந்த வேளாண் கூட்டு மையம்

முகவரி:
பி.எஸ்.மாசிலாமணி
மாங்குடி 610 103
திருவாரூர் மாவட்டம்
9443865101

பண்ணை விவரம்:
6.5 ஏக்கர் - இருபபு
அக்கரை தெரு,
புலிவலம் (அஞ்சல்)
திருவாரூர் மாவட்டம்

வரவு - செலவு - நிகர லாபம் விபரம்

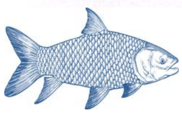
வ. எண்	விபரம்	வரவு	செலவு	நிகர லாபம்
1.	கலப்பின மீன் வளர்ப்பு 1.5 ஏக்கர் (ஆண்டுக்கு இரு தடவை மீன் பிடி) 1000 கி X 100 + 1000 கி X 100	2,00,000	50,000	**1,50,000**
2.	0.5 ஏக்கரில் மீன் குஞ்சுகள் 5 லட்சம் மூலம் ஒரு வருடம் 50 ஆயிரம் குஞ்சுகளிலிருந்து	1,00,000	30,000	**70,000**

3.	நாட்டுக்கோழி 200 குஞ்சுகள் வருடம் 2 முறை 200 x 15.00 x 2 தடவை	60,000	30,000	**30,000**
4.	நாமக்கல் 1 முட்டை கோழி கோழி 100 x 100 முட்டை=10,000 x 6.00	60,000	40,000	**20,000**
5.	கறிக்கோழி வளர்ப்பு மாதம் 100 x 8 பேட்ஜ் 800 x 1.5 கி = 1200 கி x 70.00	84,000	66,000	**18,000**
6.	ஆடுகள் வளர்ப்பு 20 பெண் + 1 கிடா 1 வருடத்தில் 30 குட்டிகள் x 1500 =	45,000	15,000	**30,000**
7.	6 மாதம் 10 பசுங்கன்றுகள் வளர்ப்பு மூலம் 2 வருட முடிவில் கன்று போடும் நிலையில் விற்பனை வரவு = 2,00,000/- ஆக ஒரு வருடத்திற்கு,	1,00,000	50,000	**50,000**
8.	கறவை பசு மாடுகள் 2 சராசரி தினசரி 10 லிட்டர் x 20.00 x 120	24,000	14,000	**10,000**
9.	250 தென்னை - 1 வருடம் = 2000 X 5.00	1,00,000	30,000	**70,000**
10.	நஞ்சை : ஒரு போகம் - நெல் மறுபோகம் - பயிறு, சோளம், காய்கறி. புஞ்சையில் தீவனப்புல்: மரம், பழமரம் மூலம்	50,000	-	**50,000**
	கால்நடைகளின் எச்சம் இங்கேயே எருவாகி உரமாகிறது.	-	-	--
	கூடுதல்	**8.83**	**3.45**	**5.38**

(ரூபாய் இலட்சத்தில்)

வருட கூடுதல் வரவு	8.83
செலவு	3.45
நிகர வருவாய்	5.38
ஆள் சம்பளம் - வருடம் ஒன்றுக்கு	1.08
	4.30
ரூ. 5 லட்சம் முதலீட்டிற்கு வட்டி சேர்த்து மாதம் 11,000 வீதம் x 12 மாதம் (5 வருட தவணையில் திருப்பி செலுத்தலாம்)	1.32
ஆண்டின் நிகர இலாபம்	2.98

மாதம் = ரூ.25,000.00



Technical Paper-7

காவிரி ஆற்றுப்பாசனப் பகுதிகளில் உள்நாட்டு மீன் குஞ்சு உற்பத்தி வளர்ச்சி - கடந்த 20 ஆண்டுகளின் பரிணாமம்

ஆர்.கதிரேசன்
ஆர்.கே.மீன் பண்ணை
ஒரத்தநாடு
தஞ்சாவூர் மாவட்டம்

காவிரி நதியில் ஜூன் மாதம் தொடங்கி பிப்ரவரி முடிய 9 மாதங்கள் தடையில்லா நீர்வரத்து இருந்த காலத்தில் அதாவது 1970க்கு முன் வரை இயற்கையாக குளங்களில் மீன்குஞ்சு அடைவதும் அதனை பிடிப்பது என்ற நிலை கொஞ்சம் கொஞ்சமாக குறைய தொடங்கியது. காவிரியில் முறைப்பாசனம் அறிமுகப்படுத்தப்பட்ட பின்னர் இயற்கை மீன் குஞ்கு வரத்து கிட்டத்தட்ட முற்றிலுமாக நின்று விட்டது என்றே சொல்லலாம்.

1975ல் உள்நாட்டு மீன் உற்பத்தி பெருக்கத்திற்காக மத்திய அரசு மாநில மீன்வளத்துறையின் மூலம் மீன் வளர்ப்போர் மேம்பாட்டு முகமையை (F.F.D.A) தஞ்சை மாவட்டத்தில் முன்னோடித் திட்டமாக ஆரம்பித்தது. தஞ்சை மாவட்டத்தில் முன்னோடித் திட்டமாக ஆரம்பித்தது. 1976ல் நான் ஒரத்தநாடு பேரூராட்சிக்கு சொந்தமான குமணன் குளத்தில் மீன் வளர்ப்பவராக தேர்வு செய்யப்பட்டு மீன் வளர்த்து வந்தேன். 1983 வாக்கில் என்னை போல் சுமார் 500 மீன் வளர்ப்பவர்களுக்கு மேல் ஒருங்கிணைந்த தஞ்சை மாவட்டத்தில் மீன் வளர்த்தனர். மேலும் தமிழ்நாட்டில் 12 மாவட்டங்களில் இத்திட்டம் செயல்படுத்தப்பட்டது. இதனால் குளங்களில் இருப்பு செய்ய மீன் குஞ்சு தேவை அதிகரித்தது. தேவைக்கு ஆந்திரா, கல்கத்தா போன்ற மாநிலங்களை எதிர்பார்க்க வேண்டிய நிலை ஏற்பட்டது.

1983ல் மீன்துறையின் பிதாமகன்களாக திகழ்ந்த இணை இயக்குநர்கள் திரு. M.V.நடராஜன், திரு.இராமச்சந்திர மேனன் நாகை துணை இயக்குநர் திரு.G.ராமதாஸ் போன்றவர்கள் என்னை மீன் குஞ்சு உற்பத்தி மையம் அமைக்க ஊக்குவித்தனர். எனக்கு துரோணாச்சாரியர்களாக இருந்து ஆராய்ச்சி உதவியாளர் திரு. G.சந்திரசேகரனும் பொறியாளர் திரு. S.குமார் துரையும் வழிகாட்டியதால் 3 ஏக்கர் பரப்பில் ஆரம்பித்து 1993ல் 25 ஏக்கர் பரப்பிற்கு விரிவடைந்து ஆண்டிற்கு சுமார் 500 லட்சம் நுண் மீன் குஞ்சும் 60 லட்சம் விரலிகளுமாக உற்பத்தி என்று வளர்ந்தது.

எனது வளர்ச்சி, மீன் குஞ்சு தேவையின் அதிகரிப்பு உதவி இயக்குனர்கள் திரு.அனந்த நாராயணன், திரு.நல்லு சின்னப்பன் ஆகியோரின் விரிவாக்கப் பணியின் காரணமாகவும் சேர்ந்து மீன் குஞ்சு உற்பத்தி மையம் அமைக்க பல விவசாயிகள், மீன் வளர்ப்பவர்கள் ஆர்வமுடன் முன் வந்தனர். அவ்விதம் இணைப்பிலுள்ள பட்டியல்படி 2000மாவது ஆண்டிற்குள் 24 மீன் குஞ்சு உற்பத்தி மையங்கள் காவிரி பாசனப் பகுதியில் அமைக்கப்பட்டு மீன் குஞ்சு உற்பத்தியில் காவிரி பாசனப் பகுதியில் அமைக்கப்பட்டு மீன் குஞ்சு உற்பத்தியில் ஆந்திராவின் நெல்லூர் மாவட்டம் போல் வளர்ந்து விட்டது.

அரசின் பல்வேறு மானியத் திட்டங்களால் புதிய மீன் வளர்ப்பு குளங்களும் பண்ணை குட்டைகளும் அமைக்கப்பட்டமையால் மீன் குஞ்சின் தேவை அதிகரித்து

வந்தது. ஊராட்சி, வருவாய்த்துறை, அறநிலையத்துறை பொதுக்குளங்களிலும் மீன் குஞ்சு இருப்பு செய்தால்தான் மீன்பிடிக்க முடியும் என்ற நிலையறிந்து தொழில்முறை உள்நாட்டு மீனவர்களும் மீன்குஞ்சு வாங்கி இருப்பு செய்ய ஆரம்பித்தமையால் தேவை மேலும் அதிகரித்தது.

2010ஆம் ஆண்டில் தேசிய வேளாண் அபிவிருத்தி திட்டத்தின் (NADP) கீழ் மானிய உதவி வழங்கி ஊக்குவித்தமையால் 8 மீன் குஞ்சு உற்பத்தி மையங்களும் 20 நாற்றங்கால்களும் அமைக்கப்பட்டு மீன் குஞ்சு உற்பத்தி உச்ச நிலையை அடைந்துள்ளது என்றே சொல்லலாம்.

மீன் குஞ்சு உற்பத்தி பருவம் ஏப்ரல் முதல் ஆகஸ்ட் மாதம் வரை உள்ளது. ஆனால் காவிரி நீர் வரத்து தாமதிப்பதாலும் பொதுக் குளங்கள் ஏலம் விடுவது ஜனவரிக்கு மேல் என்பதாலும் பருவமழை பருவம் தப்பி பெய்வதாலும் பின் பருவத்தில் தான் மீன் குஞ்சு கேட்பு அதிகமாகவுள்ளது. குழாய் கிணறு பாசனமுள்ள சொந்த குளங்களில்தான் ஜூன் மாதத்தில் மீன் குஞ்சு இருப்பு செய்யப்படுகிறது. எனவே அனைத்து மீன் குஞ்சு உற்பத்தி மையங்களிலும் தங்களது முழு உற்பத்தி திறன் அளவிற்கு உற்பத்தி செய்து இரண்டு மூன்று முறை நாற்றங்கால்கள் இருப்பு செய்து மீன் குஞ்சு விநியோகிக்க முடியவில்லை. வெள்ளிக் கெண்டை, புல் கெண்டைகள் கல்கத்தாவிலிருந்தே தருவிக்கப்படுகிறது. மீன்துறைக்கு சொந்தமான பண்ணைகளில் இந்திய கெண்டை ரகங்களின் .றப்பத்தியை தவிர்த்து வெள்ளிக் கெண்டை, புல் கெண்டை ரகங்களை உற்பத்தி செய்து விநியோகித்தால் டெல்டா மாவட்ட மீன் குஞ்சு உற்பத்தி மிகு மாவட்டமாகும் என்பதில் சந்தேகமில்லை. தமிழ்நாடு முழுவதற்குமான தேவையை பூர்த்தி செய்யும் அளவிற்கு இங்குள்ள பண்ணைகளில் மீன் குஞ்சு உற்பத்தி திறன் உள்ளது.

தமிழகத்தில் மீன் குஞ்சு உற்பத்தியில் சிறப்பாக செயல்பட்டாலும் அதிலும் சில இடர்பாடுகள் உள்ளன. அதாவது பொதுவாக தென்மேற்கு பருவ காலமாகிய ஏப்ரல், மே, ஜூன், ஜூலை, ஆகஸ்ட் ஆகிய மாதங்களில் தான் மீன் குஞ்சு பொறிப்பகங்களில் தூண்டுதல் முறையில் உற்பத்தி செய்யப்பட்டு வருகிறது. காலப்போக்கில் பருவ காலங்களில் மழை பெய்யாததால் மீன் வளர்ப்போர்களின் மீன் குஞ்சு தேவை பின்தங்கி விடுகிறது. இதனை கருத்தில் கொண்டு சினை மீன்களின் சினை முதிர்ச்சியை தாமதப்படுத்தி அதாவது நவம்பர், டிசம்பர் மாதங்களில் பருவத்திற்கு கொண்டு வர தொழில்நுட்பங்களை பயன்படுத்தி ஆவன செய்திட வேண்டுகிறோம்.

ஆண்டுக்கு ஆண்டு பருவநிலை மாற்றத்தால் மழை பெய்யாமலும், நிலத்தடி நீர் மிக வேகமாக குறைவதாலும் தண்ணீரை எவ்வாறு சேமிப்பது என்றும், அதே நேரத்தில் நீரின் மேலாண்மையை பாதுகாப்பாக வைத்துக் கொள்ளவும், தொழில்நுட்ப வல்லுனர்கள் தகுந்த ஆலோசனை வழங்கிட வேண்டுகிறோம்.

எனது மீன் குஞ்சு உற்பத்தி பண்ணையில் முட்டை அடிக்கும் தொட்டி மீன் குஞ்சு பொறிப்பகம் இவைகளிலிருந்து வெளியேற்றப்படும் நீர் சுத்திகரிப்பு முறையில் பயன்படுத்தி வளர்ப்பு குளங்களிலும் நாற்றங்கால் குட்டைகளிலும் இந்த நீரை பயன்படுத்தி செம்மையாக வளர்த்து வருகிறோம் என்பதனை தங்களது மேலான கவனத்திற்கு கொண்டு வருகிறோம்.

அட்டவணை

டெல்டா மாவட்டங்களில் ஆரம்பிக்கப்பட்ட மீன் குஞ்சு உற்பத்தி மையங்கள்

வ. எண்	பெயர்	ஊர்	வருடம்	பரப்பு	நுண் மீன் குஞ்சு உற்பத்தி திறன் (லட்சம்)	தற்போதைய நிலை
1.	ஆர்.கே.மீன்குஞ்சு பண்ணை	நெடுவாக்கோட்டை	1983	25 ஏக்கர்	600	தொடர்கிறது
2.	ஜெட் மீன் பண்ணை	வெண்ணமுத்தான் பட்டி	1985	10 ஏக்கர்	300	மூடப்பட்டது
3.	பி.எஸ்.மாசிலாமணி மீன் பண்ணை	மாங்குடி	1987	2 ஏக்கர்	200	குஞ்சு வளர்ப்பு மட்டும்
4.	கோல்டன் மீன் பண்ணை	கரந்தை	1988	10 ஏக்கர்	500	தொடர்கிறது
5.	விஜய் மீன் பண்ணை	ஏரி	1988	5 ஏக்கர்	300	தொடர்கிறது
6.	மகேஸ்வரி மீன் பண்ணை	காருகுடி	1988	15 ஏக்கர்	500	தொடர்கிறது
7.	செல்வம் மீன் பண்ணை	பள்ளி அக்ரஹாரம்	1985	3 ஏக்கர்	200	தொடர்கிறது
8.	இளம்கே மீன் பண்ணை	பள்ளி அக்ரஹாரம்	1990	13 ஏக்கர்	500	தொடர்கிறது
9.	பிச்சை மீன் பண்ணை	பட்டீஸ்வரம்	1990	3 ஏக்கர்	200	மூடப்பட்டது
10.	கேவிஆர் மோகன் மீன் பண்ணை	காட்டூர்	1990	5 ஏக்கர்	200	மூடப்பட்டது
11.	ராஜா மீன் பண்ணை	மண்டலக்கோட்டை	1988	7 ஏக்கர்	300	இயங்கவில்லை
12.	செல்வம் மீன் பண்ணை	ஒக்கநாடு கீழையூர்	1989	3 ஏக்கர்	200	இயங்கவில்லை
13.	பிஎஸ்பி மீன் பண்ணை	புத்தூர்	1989	5 ஏக்கர்	100	தொடர்கிறது
14.	ராமசாமி மீன் பண்ணை	ஆம்பலாபட்டு தெற்கு	1995	3 ஏக்கர்	100	இயங்கவில்லை
15.	அரவிந்த் மீன் பண்ணை	திருமேனி ஏரி	1995	36 ஏக்கர்	750	தொடர்கிறது
16.	கண்ணதாசன் மீன் பண்ணை	கொத்தூர்	1998	10 ஏக்கர்	300	தொடர்கிறது
17.	சந்திரசேகரன் மீன் பண்ணை	சிகார்	1993	3 ஏக்கர்	100	தொடர்கிறது
18.	ராமன் மீன் பண்ணை	திருவாலங்காடு	1995	2 ஏக்கர்	100	தொடர்கிறது
19.	ராமமூர்த்தி மீன் பண்ணை	பெரும்புலியூர்	2000	3 ஏக்கர்	100	தொடர்கிறது
20.	வெல்டன் மீன் பண்ணை	கரந்தை	2000	3 ஏக்கர்	100	தொடர்கிறது
21.	எஸ்எஸ்எம் மீன் பண்ணை	சுவாமிமலை	2000	7 ஏக்கர்	300	தொடர்கிறது
22.	இமலாயன் மீன் பண்ணை	திட்டை	2002	3 ஏக்கர்	300	தொடர்கிறது
23.	புகழேந்தி மீன் பண்ணை	வடுவூர்	2005	6 ஏக்கர்	600	தொடர்கிறது
24.	செபஸ்தியன் மீன் பண்ணை	அருண்மொழி தேவன்	2005	4 ஏக்கர்	200	தொடர்கிறது
25.	நச்சினார்கினியன் மீன் பண்ணை	உடையார்கோவில்	2002	2 ஏக்கர்	100	தொடர்கிறது
26.	தங்கசாரதா மீன் பண்ணை	அரசூர்	2010	7 ஏக்கர்	500	தொடர்கிறது
27.	மாநல் மீன் பண்ணை	புதூர்	2010	6 ஏக்கர்	500	தொடர்கிறது
28.	ரவி மீன் பண்ணை	பிள்ளையார் நத்தம்	2010	10 ஏக்கர்	300	தொடர்கிறது
29.	சிவா மீன் பண்ணை	புள்ளவராயன் குடிக்காடு	2010	10 ஏக்கர்	300	தொடர்கிறது
30.	நாதன் மீன் பண்ணை	கண்ணனந்தங்குடி	2010	6 ஏக்கர்	300	தொடர்கிறது
31.	சுந்தர் மீன் பண்ணை	ஆலங்குடி	2010	5 ஏக்கர்	100	தொடர்கிறது
32.	ஸ்ரீராம் மீன் பண்ணை	காளியாக்குடி	2010	5 ஏக்கர்	100	தொடர்கிறது
33.	பொன்.தா. மனோகரன் மீன் பண்ணை	நெய்வாசல்	2013	5 ஏக்கர்	100	தொடர்கிறது

Technical Paper-8

GLASS PRAWN, *MACROBRACHIUMS LAR* (FABRICIUS, 1798), A CANDIDATE SPECIES FOR FRESHWATER PRAWN FARMING IN ANDAMAN AND NICOBAR ISLANDS

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Introduction

The Union Territory of Andaman and Nicobar Islands are located in the Bay of Bengal between 6^{o} 45 N and 13^{o} 41' N latitudes and 92^{o} 12' E and 93^{o} 57' E longitudes and are blessed with plenty of natural and unpolluted freshwater resources besides availability of large areas of brackish and open sea areas around it. All these areas can be put into use for raising fin fishes and prawn/shrimp brooders for quality hatchery seed production. Among the biological resources of Andaman and Nicobar Islands, a freshwater prawn species namely, *Macrobrachium lar* is considered important from the freshwater aquaculture point of view as it grows to around 30-60 g in wild. In India, it is presumed that this species is found only in Andaman and Nicobar islands *(*Sarangi *et al.,* 2001; Sethi *et al*., 2009).

Distribution and Classification

Fresh water prawns of the genus *Macrobrachium* (Crustacea: Decapoda: Caridea: Palemonidae) constitute one of the most diverse, abundant and widespread crustacean genera. *Macrobrachium* is distributed globally across the tropical and sub tropical regions and comprises over 200 described species (Jayachandran, 2001). The greatest diversity of *Macrobrachium* species occurs in the Indo-Pacific region, on the Indian sub-continent and throughout South East Asia in particular. *Macrobranchium*spp. inhabit a wide variety of environments from mountain streams to low land rivers and estuaries and coastal lagoons. The distribution of *M. lar* is restricted to water storage tanks, small reservoirs, streams, ponds and nallahs of Andaman & Nicobar Islands andnot known to occur in the mainland India.

Habit and Habitat

The species is very hardy; adults can thrive well out of water for about 2–3 hours, whereas juveniles can remain in live condition for around 6 hrs. On the dry ground, this prawn moves very fast and during summer days, these prawns were found crawling on the land adjacent to the water resource. *M. lar* is omnivorous and nocturnal in nature. After the sun set, they come out from the hideout for feeding purpose. This species prefers rocky bottom substrates, muddy and leaf – litter substrates, darkness and water pools with slow flow rate. During the day light, it is living either below the boulders or inside holes or crevices. These prawns can be observed moving in 30 cm to 3.0 m deep waters. *Macrobrachium lar* is reported as a diadramous species with adults restricted to freshwater streams. It can also tolerate a wide range of physic-chemical nature of the aquatic systems, i.e., can survive in situations where dissolved oxygen level and water pH are as low as 4.0 ppm and 5.0 respectively.

Morphometric Characters

The adult males are larger than females with narrow abdominal space and the male size varies from 86 mm to112 mm with weight of 30-60 g in natural habitats. The female size varies from 66-106 mm with weight of 14-20 g. The rostrum is short; upturned distally before antennal flaps; first 2-3 rostral teeth are on the carapace. The rostral teeth formula is 6-8 / 2-4 (commonly 7-8 / 2-3). The first and second pair of pereiopods are chelated. Yellow spots are found both sides of abdominal segments except 3rd abdominal segments (Sethi *et al*., 2013a).

Food and Feeding Habits

Earlier study has indicated that prawns eat all types of food living or dead such as algae, planktonic organisms, small muscle pieces of their own kind or fish etc. They are voracious feeders and eat whatever comes on their way. *Macrobrachium lar* feeds on aquatic plants, aquatic insects, filamentous algae, and zooplankton. It is observed that *M. lar* do not attack or eat any of their mates, when active but do so, if they moult or if they are weak or dead. The food is mainly captured by first and second pair of pereiopods. The second pair pereiopod is large and massive and helps in capturing large size food particles, live food and cut them into smaller pieces.

Sexual Dimorphism

The sexes can easily be identified. In matured males, secondary breeding characters like strong and longer chelipeds with large and strong spines on the chelae are present, which are very small in females. In male, there is a hard point on the ventral side of the first abdominal somite, which is plain and smooth in females. Matured males possess appendix muculina adjacent to the appendix interna on the endopod of the second pleopod. Maturing and matured females have brood chambers formed by the first, second and third abdominal pleura. The female undergo pre-mating moult before mating. Moulting is observed mostly in late evening or night hours. Adult females show varied coloration on their chelepeds and uropods.

Breeding Seasons

Breeding season in *Macrobrachium rosenbergii* was found to be from July to September and for *Macrobrachium malcolmsonii*, it is April to December with a peak in August to November; which mainly depends on the monsoon as well as suitable temperature (Ling, 1969). Sethi et al. (2013b) found that *M lar* breeds twice in a year i.e. May to July and October to December with two peaks in June and November respectively. So it can be inferred that twin breeding of *M lar* in a year is influenced by both the monsoon i.e. South-West (May to September) and North-East (November-December) and totally in confirmation with the opinion of Ling (1969).The incubation period of this species varies from 15 to 20 days. The larval cycle requires saline water like *M. rosenbergii.* In respect of fecundity by weight classes, the lowest number of eggs observed was 4,069 and the highest was 8,543. Whereas, in respect of average fecundity (F) by length classes, the lowest and highest number of eggs observed was 3,090 and 8,117, respectively. Average fecundity/total length (L) and average fecundity/ total weight (W) may be expressed by a linear relationship. The adjusted equations are: $F= -1697.47+811.34L$ ($P=>0.01$) and $F= 5632.12+ 4.439W$ ($P=<0.01$), respectively.

Larval Rearing

After spawning, the zoea larvae were collected and kept at different salinity range and were reared for a period of 20 days. The zoea larvae are photo sensitive but the degree to which they are attracted by light decreases as development progresses. The larvae usually swim in an almost vertical position with the head down. There are eleven larval stages in *M. lar* which is similar to *M. rosenbergii* and the last zoeal stage undergoes metamorphosis into early juvenile, which resembles like adults prawn. During the rearing period larvae and berried prawns were fed with yolk from hen's egg and mussel meat respectively. The faecal matter and unconsumed feed were siphoned out regularly, whereas, 30 % water was exchanged in every alternate day.

Results and Conclusion

The incubation period of this species varies from 15 to 20 days. It is observed that the newly hatched larvae thrive well in low saline water. As the development precedes the larvae requires more saline water in progressive manner. Zoeal larvae could be reared for a period of 20 days under laboratory condition.

As the aquaculture sector in the country is dominated by Indian major carps contributing to more than 80% of the production, diversification of aqua crop is essential with inclusion of other suitable alternative cultivable species to sustain the growth of aquaculture sector. Among the fresh water prawns, the most preferred cultivable species is *Macrobrachium rosenbergii*. About 200 species of *Macrobrachium* are recorded in the world and about 30 species are endemic to Indian waters. *Macrobrachium rosenbergii* being the largest species of the genus *Macrobrachium* and due to its fast growth, good demand in national and international markets and hardy nature it has gained considerable attention during recent years in India and abroad. On seeing the bright prospects and also the availability of vast freshwater resources in Andaman, diversification of freshwater aquaculture is considered possible. The local species of Andaman, *Macrobrachium lar*, commonly known as glass or rock / monkey prawn, is an indigenous freshwater prawn found only in streams of Andaman (Fig.9& 10) (Sethi *et al*., 2010) and is well adjusted to the specific ecological conditions of the islands and grows well in nature, prefers rocky bottoms with running water/ streams (Sethi *et al*., 2012). It breeds twice a year i.e. on May to September and November to December. As this species grows to a maximum average size and average wt. of 86 –112 mm and 30-60 g, respectively in natural habitat,.this species would be the new addition for the diversification of freshwater aquaculture in India in general Andaman in particular

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SESSION II
OPTIONS AND STRATEGIES FOR THE DEVELOPMENT OF FRESHWATER FISHERIES IN WATER DEFICIENT REGIONS

Lead Paper-3

INTEGRATING AQUACULTURE IN IRRIGATION SYSTEMS-FEW TECHNOLOGICAL ALTERNATIVES

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Introduction

Sustainable management of natural resources requires optimal management of land and water resources in conjunction with human and livestock resources. However, among all these resources, the water is the critical enabling resource as the efficient utilization of other resources is dependent upon temporal and spatial availability of this resource. Thus efficient and economic use of water becomes an important factor in improving the livelihood of the people. Till now the water systems have been evaluated in terms of their ability to provide water for crop production and valued in terms of the 'crop per drop' produced. However, low prices of wheat, rice and other major crops produced on irrigation systems usually do not lead to substantial increase in overall economic and livelihood scenario of the people involved. With increasing emphasis on sustainable development of natural resources, it is logical to integrate appropriate farming practices to enhance water productivity through multiple use of water leading to a shift from 'crop per drop' to a more holistic concept of 'food per drop'. This has also become important in view of increasing cost of water resource development and growing demand from different sectors, viz., industry and municipalities. Thus the usage of water only for a single purpose can no longer sustain the high cost of creation and management as well as meet the demand of different sectors.

Thus integrated utilization system for water having both consumptive and non-consumptive use is receiving attention. Srivastava *et al* (2004a, 2004b & 2004c) in an study at Directorate of Water Management, Bhubaneswar have reported that in a tank based irrigation system, multiple use of water increases benefit cost ratio from 2.20 to more than 3.50 when components of fisheries in pond, horticultural crops on bunds, and duckery in pond are added beside cultivating two irrigated crops in command area. The jump in B-C ratio was highest (from 2.66 to 3.28) when fisheries was added to crop + horticulture on bunds. Similarly a survey conducted on farmers' field by Directorate of Water Management, Bhubaneswar has shown that farmers are practicing multiple use of water in all ecologies, i.e. waterlogged, irrigated and rain-fed. Aquaculture is a major component of this multiple use system whose contribution in net return was 5 times that of crop in rain-fed ecology. A comparison between different ecologies showed that the returns were least from rain-fed ecologies. This was mainly due to reduced returns from aquaculture which was 47% of that from waterlogged ecology and 70% from irrigated ecology. This shows that non-availability of water round the year reduced the returns from aquaculture in integrated farming systems.

However, most of time, aim of enhancing return from one component do not take in account the impact on other components. Unfortunately irrigation systems including large water infrastructures and water harvesting systems are recognized as common pool resources supplying water for agricultural production, but potential of utilizing water for other uses is often overlooked. This process starts from designing and continues upto its management by the end users. The design of existing systems as well as those in the process do not account for any additional use of water. Similarly the participatory management policies mainly emphasize user's involvement in only irrigation and domestic water supply. While farmers' organizations are being promoted for water allocation among themselves, their membership and structure which is mainly limited to agricultural land holders do not take into account the multiple uses or users of water, which provide challenging opportunities for increasing water productivity at various scales, both under irrigated as well as rainfed areas (supplementary irrigated) by integrating crops, horticulture, fishery, livestock, small scale industries, domestic needs etc. The importance of non-agricultural uses of irrigation water in livelihood strategies has implications for water management and water rights, especially as increasing scarcity challenges existing water allocation mechanisms. There are important gender, and class differences among the water users. In rural and peripheral urban areas, water is used or could be used for productive purposes such as growing vegetable and fruits, livestock, poultry, fishery besides domestic needs. However intensification of multiple use has implications for downstream flow both in terms of quality and quantity. These implications will vary from basin to basin depending upon the water availability and other parameters. Developing technologies and strategies that accommodate different user groups without hampering the rights of downstream users remains a major challenge for improving the overall productivity, as well as equity of water use. This presentation takes a look on available technologies, different constraints in up-scaling of these technologies and strategies for refining design and implementation to harness the huge socio economic potential of multiple use of irrigation systems with special reference to rain-fed ecology which experience the water deficiency for aquaculture.

Assessment of Technologies and Potential of Multiple Use

The assessment of the potential of multiple uses has to be done with first constraint that the multiple uses has to be non consumptive or low consumptive and non polluting. Aquaculture is a major non-consumptive use with high returns. All works on multiple use of the water have this component. An overview of it will give an idea of the potential of this system.

Srivasta and Satpathy (2004) and Sikka and Bhatnagar (2004) have given a summary of multiple use of water in India. This included the multiple use in almost all domains of water, i.e., harvested rain water, canal water after outlet and in the network itself, pumped water from tube well before it is delivered to the fields, seasonally or perennially waterlogged areas in vast inland tracts and saline coastal belt of eastern India. Srivastava *et al*. (2004b) and Samra *et al.* (2002) have reported that multiple use of aquaculture, horticulture etc. in run off recycling based irrigation system increases the returns very significantly for Odisha and Haryana respectively. Based on studies of feasibility of multiple use in field conditions, Srivastava *et al* (2003) have reported that the tanks constructed primarily for irrigation on community as well as private lands could be used for multiple use. However it was found that full potential of aquaculture could not be exploited due to inherent limitations of the system to provide water round the year.

Srivastava *et al* (2004c) has reported that it is feasible to change from surface irrigation system to hybrid pressurized system to increase the irrigation efficiency of the flow based minor irrigation system in plateau by adding a service reservoir as an adjunct. This service reservoir can be used for multiple use and it was found that the annual cost of the pond was recovered with returns from papaya on embankment and fish. The present B-C ratio of the system is 2.55 but if ducks and intensive vegetable on outward slopes could also be integrated, the total cost of the system inclusive of drip and sprinkler can be recovered from multiple use of reservoir itself.

The huge canal network in India can also be used for multiple use. WTC, TNAU, Coimbatore explored this possibility in the cages installed in the Lower Bhawani Project (LBP) irrigation canal. Although not very encouraging results were found for the cage fish culture (grow out fishes) in running water system from economical point of view, but raising up to 4-5 cm fingerlings at the end of the canal supply period has potential in view of very good market demand. The net return from rearing of fish fry to fingerlings in a canal of 1 km length (100 cages) worked out to Rs. 10,000/- (Mayilswami *et al*. 2004).

Exploring the feasibility of integration of secondary reservoir or small tank in the tube well based irrigation system, ICAR-RCER, Patna found it as an effective mechanism for better regulation water as well as enhancing water productivity by raising fish in the reservoir which generates additional income and improves livelihood, Bhatnagar and Sikka (2003) found fish yield of 11.0 tonnes/ha with weekly water exchange. The integration of horticultural crops *viz*., tomato, banana, lemon and guava planted on the bunds has given good results. Duckery, animal husbandry, piggery, poultry can easily been integrated with the system using the secondary reservoir as a central unit.

The rain-fed lowlands of eastern India are one of the least productive land mass. For enhancing productivity of such lands, Central Rice Research Institute, Cuttack has developed an adaptable production technology of rice-fish integrated farming system (Sinhababu and Venkateswarlu, 1996). The system involves construction of dikes and refuge/trench, with refuge/trench being used for growing rice and fish and dykes for growing vegetables and fruit crops. It has been found that the profit over investment is 132%. Similar work in rainfed plains of Bihar, where seasonal water logging is a serious problem have given . encouraging results at initial stage and efforts are being made to evaluate such interventions under different set of conditions (Sikka and Bhatnagar, 2004). In Mekong Delta in southern Vietnam, farmers implement such system of fish trenches connected to the adjacent rice fields.

The multiple use technology is not limited to the research farm alone. The enterprising farmers like S. Darshan Singh in Punjab and Shri Radhakant Sahoo in Orissa, have taken innovative initiatives for multiple use of water using tube well water and seasonally waterlogged area respectively, which has increased the water productivity and their income manifold (Sahoo *et al*. 2003a, 2003b, 2003c & 2005).

In coastal areas of eastern India, WTCER, Bhubaneswar found that properly designed and constructed subsurface water harvesting structures (SSWHS) will mitigate the early drought in monsoon season and provide irrigation during post monsoon and summer season for this chronically waterlogged area having saline ground water. Integration of aquaculture in the system improved the water productivity manifold. Water productivity varied from Rs. 15.84/m^3 to Rs. 80.43/m^3 with an average of Rs. 36.20/m^3 while taking total income from all the structure. If only the benefit is considered then water productivity ranges from Rs. 9.00/m^3 to Rs. 53.70/m^3 with an average of Rs. 23.26/m^3 (Sahoo *et al*., 2003, Sahoo and Verma, 2003).

Constraints in Design and Implementation

It is evident from above that there is immense potential of multiple water use system in all water domains. However, the challenge lies in up scaling these technologies for their adoption on a larger scale taking in account the socio-economic conditions. Based on our experience, farmers' perception and available literature, some of the constraints in adoption of these technologies on a large scale are as below:

1 Social impediments such as religious feelings, poaching especially at remotely located ponds, theft, local conflicts in case of community water bodies or open access water bodies and water rights.
2 Perennial water availability in the streams and water bodies.
3 Mortality of fish fry due to change in environment, intrusion of snakes and carnivorous fishes.
4 Loss of natural fish feed (planktons) due to excessive water flow through fish pond
5 Lack of capital investment and resources in developing the system, provision of aeration & mixing specially for resource poor and socially disadvantaged section of rural population.
6 Lack of awareness, technical know-how and technical and institutional support
7 Lack of multiple use systems and technologies for different bio-physical, agro-ecological and socio-economic conditions and crop – livestock – fish – enterprise combinations

Innovations Required to Overcome these Constraints

To overcome above-mentioned constraints, few innovations in design of multiple use systems and their implementation are required. Based on experience of authors in the field, few of them for each water domain, i.e., water harvesting system, canal water, ground water, and areas having water logging due to water congestion have been identified and listed below:

Water harvesting Systems:

The WHS can be divided in three categories depending upon their location and present use : (i) Near the homestead which can get good management practices; (ii) far off from homestead, which will have to be under poor management practices and will suffer from poaching; and (iii) WHSs located in highly permeable soils where water don't last beyond monsoon season. Different design parameters and utilization strategies are required for optimal utilization of these water bodies.

(i) For WHS, which are near to homestead and can be managed properly, a combination of aquaculture + horticulture (both fruits and vegetables) on embankment+ duck raising + rudimentary livestock raising + irrigation can be adopted. A major constraint in these tanks is the drying up of water by Feb-March. This reduces the growth period of fish and therefore overall productivity. For enhancing the growth period following options can be studied for their efficiency:

(ii)

a) Enhance the capacity of tank by increasing the depth so that sufficient water remains during summer season even after accounting the seepage loss. This can be done only in high rainfall areas and the economics of creating additional capacity for aquaculture has to be worked out. Its implication in overall design of multitank-based irrigation system will also have to be worked out.

b) A lined small adjunct reservoir can be constructed along with the main tank. The fry will be stocked in main tank and will be allowed to grow up to December. By December, the fry will reach to 10-15 cm., i.e., fingerlings stage. These fingerlings can be shifted to small tank for high density stocking where they will remain as stunted fingerlings till next July. In next July these fingerlings will be restocked in main tank along with fresh stock of fry. In December, the grown up fish can be harvested for table purpose and fingerling can be harvested for stocking in small adjunct tank, and the cycle will continue (Fig. 1).

c) In multi-tank and multi-well based irrigation system (Srivastava *et al*. 2004), , the part yield of the open dug-well can be used for maintaining the water level in pond for aquaculture by taking care of seepage and percolation loss. However, this can be possible only when electricity is available for pumping. The overall economics of use of water from well for continued aquaculture and duck rearing should be compared with summer crop cultivation.

(iii) WHS, which are located away from homestead and are prone to poaching , can be put up to multiple use system by exploring the aquatic crops which will spread over the water surface. The product of these crops should not be prone to poaching. Makhana (*Euryle ferox*) and Water Chestnut *(Trapa bispinosa)* are two such crops suitable for Eastern India. Few other crops can also be explored for other agro-ecological conditions. Aquaculture with specific type of fishes can be integrated with these crops. A suitable system both in terms of design as well as cultivation practices need to be developed.

(iv) In plateau as well as hilly areas , the land near the homestead have soils of coarse texture and thus have high seepage rates. Due to this, the unlined tanks are not feasible. WTCER, Bhubaneswar has developed design of LDPE film lined tanks. A multiple use system comprising aquaculture+ duck rearing + rudimentary livestock+ horticulture +domestic water use + vegetable activation on a limited scale can provide a decent livelihood to a farm family. This aspect requires research on proper designing and its evaluation (Fig. 2).

Canal Water

The multiple use of water especially aquaculture in canals has tremendous potential given the vast area available. However given the limitation of water availability, flow rate, and the water velocity, the canal sections will have to be identified where aquaculture can be practiced. Central Institute of Freshwater Aquaculture, Bhubaneswar has developed design of floating cage for controlled aquaculture in large water bodies. There is need of refining this technology for its use in canal system, under varying conditions of flow and water availability.

Some modification in canal sections may also be required to ensure water availability for longer period. DWM, Bhubaneswar has designed small rubber dams which have flexible head wall. The head wall of these dams made of rubber can be deflated during flow season to allow smooth flow. During closure period of the canal, the head wall can be inflated to create sections in canal to store water which will be sufficient for the closure period. The effect of these interventions on canal hydraulics requires detailed study to avoid any adverse effect on overall canal management. This technology has a very significant social impact as it can serve as a tool of increasing the number of stakeholders in canal system by involving landless people in the enterprise. A large-scale adoption of this system can alleviate the stigma on canal irrigation that it serves only landowners and increase the disparity between landowners and landless.

The canal water can also be put for multiple uses below the outlet especially in plateau areas, which have sufficient slope to ensure pipe flow through gravity. An adjunct service reservoir connected to the outlet and then a network of pipes for conveyance of water will ensure highly improved irrigation efficiency. Srivastava et al (2005) have shown that the conveyance efficiency below the outlet is 75% with unlined field channels and a pipe network will improve it to 95-100%. The cost of pipe network and service reservoir can easily be recovered through multiple use of reservoir by integrating aquaculture, duck rearing and horticultural crops. Thus multiple use planning can ensure not only additional returns but also improved irrigation efficiency.

The implementation of multiple use system in all domains will require integration of both consumptive and non-consumptive uses of water to achieve maximum water ruse efficiency in terms of production and money. In view of this, the strategy for managing this vital resource would be two fold: first to get maximum optimal returns from created water resource and secondly to use same water to meet the demand of different sectors in complimenting manner. The first part means integration of water uses for multiple purposes both consumptive and non-consumptive to achieve maximum water use efficiency in terms of production and money. The second part means designing a system where emission/outflow from one user serves the demand of another user with or without any minor treatment. The technologies of integration of water uses for multiple purposes will achieve following:

- Increasing farm productivity/production without any net increase in water consumption.
- Enabling diversification in higher value crops, including aquatic species.
- Enabling utilization of otherwise wasted on-farm resources.
- Reduction in net environmental impacts of semi-intensive farming practices.
- Ensuring diversification of risk, self-employment, flow of income throughout the year.
- Satisfying the needs of various sectors with limited water availability.

The above goals will be achieved by integrating multiple use system in existing water bodies by making suitable interventions without jeopardizing the efficacy of the water body. Both in terms of quantity and quality. , and by modifying the design of future water resources to incorporate multiple use. This will require a very concerted effort of capacity building at different levels starting from farmers to the design engineers.

Water Rights, Conflicts and Solutions

Water rights are at the heart of any water allocation system. Reallocation has to take care of not only efficiency but also fundamental issue of equity. The delineation of water rights is further complicated when we take into consideration multiple uses as well as multiple users. The demands of multiple users may be in conflict both in terms of quantity and time. Each case require a separate understanding of the problem and probably an innovative solution, because just as water is a fluid and dynamic resource the water rights are also fluid and dynamic, rarely a single consistent system.

Conclusion

The technology for multiple use systems are more or less standardized for research farm conditions for different water domains. However, those designs require fine tuning and large scale field testing under different agro-ecological socio-economic and management level conditions, before they are recommended for wide-spread adoption. Further water rights scenario need to be tackled to take care of conflicting interests both in terms of quantity and quality of downstream water. The implementation of the multiple use system will require efforts on two counts, first to integrate them in existing resources and second to modify the design of future projects to make them suitable for multiple use.

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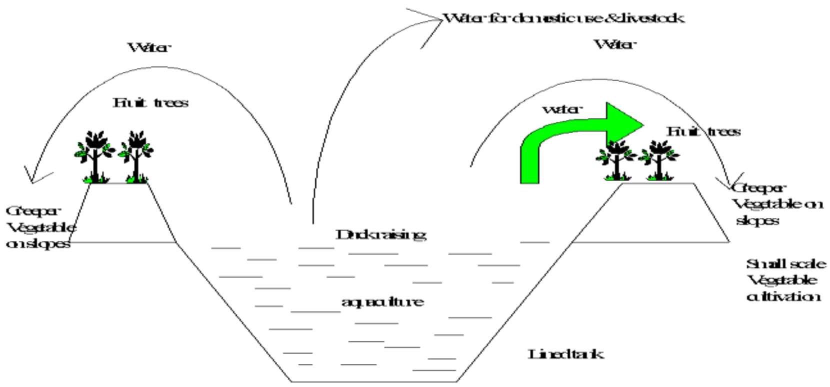

Fig 2 Schematic diagram of multiple use system based on lined tank on top areas of watershed in hills and plateau areas

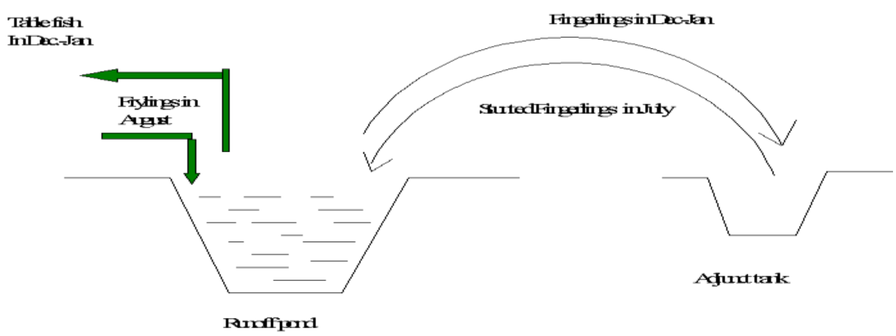

Fig 1 Schematic diagram of adjunct tank system for intensive aquaculture

Lead Paper-4

DEVELOPMENT OF FISHERIES IN WATER DEFICIENT AREAS

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Introduction

Water is the life blood of fisheries including aquaculture. India is fortunate to have two monsoons in the country every year with plenty of rains. Water is a self renewable natural resource with high productivity. The highest potential industry in the next century is aquaculture and not computer science. The carrying capacity of water goes up many times through appropriate technology and the species of culture. The highest production achieved so far is 215 kgs/m^3 (2,150 metric tonnes/ha).

Aquaculture is basically farming in water. It can be in freshwater, brackishwater and sea water. Fresh water is a finite resource and vulnerable to pollution. Water scarcity is invariably defined with a focus on fresh water for drinking and sanitation purposes by human beings. Water scarcity for the development of fisheries (both capture and culture) has to be properly understood since the scarcity can happen due to a lack of sufficient quantity and quality of water. Scarcity in terms of quantity is due to high population growth and economic development, increasing per capita consumption, rainfall variability, high solar radiation, lack of water harvesting and saving devices of runoff water during rainy season especially to store a large quantity of water for survival of fisheries and aquaculture. All storages including dams and irrigation tanks in the villages focus mainly on agriculture, drinking and washing. Fisheries do not find a prominent place like agriculture though it forms part of Agriculture in India. Scarcity in terms of quality is due to pollution as many water bodies are polluted due to the discharge of untreated domestic and industrial pollutants. Surface water such as rivers, tanks and lakes are easily affected by pollution. Even in areas where ground water is rich, it becomes unusable due to the seepage of pollutants. Though the government tries to control pollution through a Pollution Control Board, the public do not take adequate care and industries too discharge untreated water to avoid extra cost on treatment.

Sources of water for aquaculture

India experiences two monsoons per year. The average annual rainfall varies from a minimum of 313mm in Rajasthan to a maximum of 3456mm in coastal Karnataka. The states which receive good rainfall are mentioned in Table 1.

Table 1. States receiving copius rains

State	Rain fall in mm	State	Rain fall in mm
Kerala	3055	Nagaland, Manipur, Mizoram, Tripura	1881
Konkan & Goa	3005	Uttar Pradesh	1667
Andaman & Nicobar	2967	Lakshadweep	1515
Assam & Meghalaya	2818	Orissa	1489
Arunachal Pradesh	2782	Himachal Pradesh	1251
Sikkim	2739	Madhya Pradesh	1338
West Bengal	2739		

Maharashtra, Bihar, Andhra Pradesh, Jammu & Kashmir, Gujarat and Tamil Nadu also have fairly good rainfall. The estimation of the total area of reservoirs is 3.1 million ha, tanks and ponds is 2.36 million ha, bheels, ox-bowlakes, derelict water bodies as 2.36 million ha and brackish water area as 1.2 million ha. Thus India is considered as a wet country with plenty of water resources for aquaculture. Unfortunately these water resources are not properly utilized for aquaculture production. The inland fisheries sector of Tamil Nadu has about 3,70,000 ha of waterspread area, comprising about 52,000 ha of reservoirs, 97,700 ha of major irrigation tanks, 158,100 ha of short seasonal tanks and ponds and 63,000 hectares of estuaries, brackishwater and swamps. At present the area utilized for both freshwater and brackish water aquaculture is hardly 10,000 ha with a production of about 2.0 lakh tonnes. Most of the potential water bodies are yet to be utilized for aquaculture. Thousands of irrigation wells have a perennial water source. It is possible to set up RAS utilizing a small area and small quantity of water in every agricultural field. The income from aquaculture production will be a great boost to a farmer who depends totally on agricultural crops with low income. There is not even one such well water based aquaculture in Tamil Nadu. When compared to cereal production aquaculture production is negligible.

There are thousands of village panchayat tanks which get water during the rainy season for a short period of three to six months. Some of these tanks are stocked with fish fingerlings, while many are not stocked. Since the tanks get dried in dry season, even the fast growing fishes stocked in the tanks could not grow to a harvestable size. As a result, when these fishes are harvested at an early stage, the quantity and the value of the fish is low. If the same quantity of water available in the tank is utilized for RAS, it is possible to grow the fish for a longer period allowing them to grow to a harvestable size and produce a larger quantity of bigger fish which will fetch a much higher value.

The policy for agriculture development focuses mainly on agricultural crops without adequate importance to fisheries. Fisheries is invariably treated as a part of agriculture in the Ministry of Agriculture. While planning agricultural crop production in thousands of irrigation wells and tanks, a provision can be made for fish culture through RAS in a small area of every agricultural land. In this system the crops will be able to absorb the organic waste of RAS and enhance the productivity and yield. RAS also eliminates the risks of diseases and reduce the application of antibiotics. Farmers will get more income through aquaculture production and enough fish for human consumption. When this new system is applied, the fish production will greatly increase and the society as a whole will be able to eradicate the problem of malnutrition and related diseases. The average fish production in reservoirs is not even 100 kgs per ha. The low productivity is attributed to the under utilization of water deficient seasonal tanks which are in very large numbers. We are producing about 4 to 5 million tonnes of fresh water fish as against the estimated potential of 15.0 million tonnes. Diversification in terms of latest technology such as RAS and Aquaponics to utilize water deficient areas should be promoted.

Aquaculture in water deficient areas requires the following

- Species which grow to commercial size in short duration
- Species which can tolerate environmental parameters such as variations in temperature, dissolved oxygen, salinity and other water quality parameters
- Species which can tolerate crowded conditions
- Species which are hardy and tolerate pollution
- Species which are disease resistant
- Species which fetch good price with persistent demand

Countries like Israel with acute water shortage utilize the reservoirs rationally to store rain water for irrigation and aquaculture. Aquaculture production goes up to 15 tonnes per ha area of reservoir in Israel as against <100kg/ha in Indian reservoir. Their concrete or plastic lined ponds are stocked very heavily with a production of 600 tonnes/ha.

Criteria to manage fresh water scarcity

- Improve the use of water efficiency to enhance the productivity of water
- Reuse waste water through treatment
- Set up of water saving devices to store rain and river water
- Set up water capture and storage systems
- Prevent salt water intrusion to reduce the impact on freshwater aquaculture

Quality water in adequate quantity for aquaculture is one of the most pressing development challenges of the 21st century. Both physical and economic scarcity can affect aquacultural productivity, especially water quality environment and healthy growth of cultured organisms. Innovations that could substantially reduce water scarcity are:

- Cost effective technology for use in low resource settings
- User centered design in technology development
- Efficient supply chain and distribution network
- All innovations must be financially, environmentally, technologically and socially sustainable.

Recirculation Aquaculture System (RAS)

Reuse of waste water through treatment of RAS is found to be ideal to utilize the areas of water scarcity. The technology for RAS is well advanced with aeration, removal of particulate matter, biological filtration to remove ammonia and nitrate and buffering of pH. In terms of BOD production of 1.0 tonne of fish generate organic waste equivalent to the untreated sewage load from 20 people. Organic waste products are broken down through bacterial decomposition. This is called the next generation closed containment aquaculture system with 10 times more efficiency than conventional fish farms. Since 99% of the effluent is recirculated, there is no problem of waste disposal. There are no chemicals or antibiotics. It can be sited close to the market assuring the supply of very fresh products consistently at a reasonable cost. The RAS has to be prepared in such a manner that there is a balance between waste production and assimilation capacity. Either tapioca powder or molasses is used to enhance the bacterial population. Water probiotics consisting of *Bacillus, Nitrosomonas, Nitrobacter, Rhodobacter* could be used to improve the culture system. The best and the world's largest RAS is functioning in Abu Dhabi.

Aquaponics

Aquaponics is a food production system that combines conventional aquaculture with hydroponics i.e cultivating plants in water.The main inputs are water,dissolved oxygen,light feed and electricity to pump water.Freshwater fish is invariably raised in aquaponic system.Tilapia, Asian sea bass, silver perch and catfish are the preferred species.This is a highly productive system for fish and vegetables in water deficient areas.

Environmentally tolerant fishes and micro organisms for culture in water deficient areas

Asian Sea bass (*Lates calcarifer*) & Sea Perch (*Psammoperca vagansis*)

Sea bass and Sea Perch are hardy fishes capable of withstanding wide environmental variations. It can be farmed in fresh water, brackish water and sea water.

Milk Fish (*Chanos chanos*)

It is the most tolerant marine fish and ideal to culture in water deficient areas. It tolerates temperature variations in the range of 23-33^{o}C, salinity variations in the range of 0to 158 ppt and crowded conditions.

Grey Mullets

Mugil cephalus occurs worldwide from 42'N to 42'S in estuaries, freshwater and marine habitats tolerating a wide range of environmental variations. (*Mugil cephalus*, *Liza ramada*)

Tilapia (*Oreochromi*s sp)

Tilapia grows fast and farmed in a wide range of salinities with a short production cycle.It breeds almost every month. Countries like Israel where water scarcity is acute, tilapia is the preferred species with a production of >17,000 tonnes. USA also produces Tilapia in 40 aquaculture farms which are located in desert regions. Global production has reached 3.0 million tonnes to the value of Us$ 4.0 billion.

Catfishes

There are several species of catfishes.*Pungassius suchi* is intensively cultured in Vietnam with a production ranging from 133 tonnes to 600 tonnes per ha with a net income of $ 4000 per year.9000 ha are under farming with an annual turnover of about 1.0 billion dollars.

Clarias batracus
Heteroneustes fossilas
Pangassius pangassius

Climbing Perch-*Anabas testidineus*

Murrels (*Channa* spp.)

Channa has special adaptation to manage water scarcity. If the area dries up, the fish moves over land to another pond or survives for many months buried deep down in the mud. Snake heads possess a cavity above the gill chamber which functions as an accessory respiratory organ that allows to breathe atmospheric air. The mucus cells are densely packed with skin to keep it moist and reduce water loss. They are capable of building simple nests with weeds and arrange them in a circle. Murrels are cultured in cages in Cambodia with a production of 75-100kg/m^3. A cage of 12x8x2.2m can yield 10 tonnes/crop. According to Prof. Haniffa, a pond of 600-700m^2 can generate an income of Rs 50,000 to Rs. 70,000 per year.

Ornamental fish

The culture of ornamental fish requires less water and small area. Since many ornamental fishes are in the range of 2 to 15 cm , the volume of water is small to rear the fish when compared to edible fish culture.

Cyano bacteria

They are photoautotrophic prokaryotes and are known for their remarkable ability to grow and survive in varying environmental conditions. *Spirulina platensis* occurs in alkaline, brackish and saline water ecosystems. It has a salinity tolerance level of upto 60% pH in the range of 8.5 to 11.0 and temperature between 25-40^{o}C

Dunaliella salina

It is a dominant phytoplankton of all seasons in high saline areas and can tolerate upto 330 ppt, dissolved oxygen zero to super saturation, temperature 5-31 ^{o}C ^{o}C. Moina is also highly tolerant like Dunaliella.

***Artemia* (Brine shrimp)**

Artemia occurs world wide in hyper saline condition. It is extremely osmotolerant. It is capable of living in brackish water as well as in supersaturated saline water of 340g/litre.It tolerates temperature in the range of 6 to 35 ^{o}C and pH from neutral to alkaline upto 8.9. Cysts are formed to withstand extreme harsh condition. Brine shrimps die quickly in freshwater.

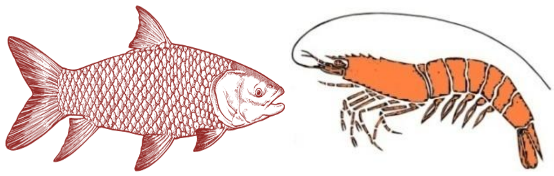
Rotifers

Temperature tolerance of each strain is different and it is in the range of 20 to 30.6c *Brachionus plicatilis* able to tolerate salinity in the range of 1.0 to 97 ppt and oxygen as low as 2.0 mg/litre

Policy for promoting aquaculture in water deficient areas with recommendations

- ✓ All freshwater bodies should be protected from pollution and reserved for fish culture wherever it is possible.
- ✓ Reservoirs and tanks should be set up to store water during rainy seasons and utilized for fish culture
- ✓ Water should not be wasted and used economically.
- ✓ Productive capacity of water for various economic uses should be properly understood and fully utilized by following the latest technology.
- ✓ Water recirculating system(RAS) and Aquaponics shold be popularized to make use of water deficient areas.
- ✓ Broodstock for cultivable species must be available for hatchery seed production throughout the year.
- ✓ Nursery rearing fecilities should be setup to raise fingerlings for stocking in growout tanks and reservoirs.
- ✓ A licensing system should be evolved for leasing common water bodies for a minimum period of five years.
- ✓ Aquaculture should be treated on par with agriculture as an essential food production system and equal priorities should be given while utilizing the available water resources.
- ✓ The importance of aquatic food to reduce the burning problem of malnutrition of a large population should be realized while planning aquaculture development in the country .
- ✓ Diversification in terms of available technology,species of culture and areas of different environment should be promoted to local farmers through training and demonstration.
- ✓ Reservoires should be utilized for cage culture of fish wherever possible.
- ✓ Village panchayat tanks should be adequately stocked with suitable species according to the availability of water so as to avoid the juvenile harvest.
- ✓ Sustainability of aquaculture in terms of economically, socially, culturally and environmentally should be established.

The misconsumption that aquaculture is possible in water rich areas should be wipedout since reuse of water is possible in aquaculture and the same is not possible in agriculture.World fish production has reached 156.2 million tonnes in 2010 in which India,s contribution is 8.3 million tonnes. The share of Aquaculture is estimated to be 40%(62.7 million tonnes).Though India is ranked second in world aquaculture production the progress is slow in terms rich natural water resources,species diversity,size of the country and its huge population.The Govt. is yet to recognize the huge untapped potential for aquaculture production to reduce the malnutrion problems of the country.Unless a separate Ministry for Fisheries is formed with proper planning and budgetting to treat fisheries on par with agriculture, the present status will continue.Physical and economic access to sufficient fish food to a large malnourished population of the country is the need of the hour.



Technical Paper-9

ALTERNATIVE 'RAS' TYPE AQUACULTURE SYSTEMS FOR ADOPTION IN WATER DEFICIENT INLAND REGIONS

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Introduction

Although India is blessed with diversified inland water bodies abundantly comprising reservoirs, lakes, riverine systems, tanks, ponds, etc, inland aquaculture is yet to develop fully to its potential. The prime factors responsible for this state of affair are: inadequate skill in inland aquaculture practices among fish farmers; lack of confidence among fish farmers to implement innovative aquaculture technologies; reluctance in accepting new species and advanced culture systems and collective failure of all concerned for showcasing effective and viable technologies to the fish farming community. Further, the inland aquaculture sector is not able to produce viable technologies which could deliver adequate economic returns. Therefore for the inland aquaculture sector to deliver, it is inevitable that new, intensive and innovative culture systems suitable for various species and geographical locations are to be introduced. A few such farm-tested culture systems which can be adopted in our water bodies are discussed in the paper.

I. Raceways

Raceway technology was standardised for the first time in India for raising shrimp crops under the DBT funded project at Fisheries College and Research Institute, Thoothukudi. One of the major problems facing the fish farming sector today is the poor survival and production predictability when juvenile fish are stocked in growout ponds. To tackle this, an advanced management strategy has been developed to increase juvenile fish survival and production predictability through raceway rearing of juveniles and then grow them in Limited Water Exchange Grow out (LWEG) ponds for further culture period. The raceway technology to raise fish crops have been put to use effectively and successfully for past the few years in countries such as USA, Mexico, Hawaii and in many South East Asian Countries It has been proved experimentally in India that raceways with limited / zero water exchange can be used to raise fish as a full crop or in a two phase systems, in order to help to minimize the crop loss. Nursery systems have advantages over direct stocking, which increases control over stock inventories, water quality and feed management (Samocha and Benner, 2001). The feasibility of utilizing this system for ornamental fish and scampi rearing also have been proved successful here at Fisheries Research and Extension Centre, Madhavaram, Chennai.

A. Concept

Fish farming technology is currently taking up an entirely new dimension with biosecured nurseries, super intensive floc - driven culture systems, zero water exchange and integration with constructed wetlands. More specifically, the system comprises a synergistic interaction between algae and bacterial population in an aqueous medium for in-situ waste treatment and the production of a live nutrition source, free from pathogens and an adaptable nutrition source to support water quality and prevents the buildup of toxins.

- For better survival and yield of fish larval rearing, raceways are built from concrete, fibre glass, plywood or simply by lining with HDPE membrane under a green house system.
- Zero limited water exchange system to enhance fish production.
- Bioremediation using microbial, algal and fermented product supplements as a concentrate.

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The system has been divided into its component parts, namely, a): zero water exchange system, b) an aqueous medium, microbial population, fish population, growout tank and associated equipment, a nutrition source and c) a method for using the system to achieve fish growout.

Zero water exchange system

The biosecure system accomplishes the intensive culture of fish with zero aqueous medium exchange (zero-exchange). The concept of zero-exchange refers to a system wherein new aqueous medium is introduced into the system only to replenish water lost for physical reasons, specifically evaporation and experimental sampling and not for chemical or biological dilution. The concept of zero-exchange also relates to metabolites and solids provided to, or formed in the system during growout. If these solids and metabolites are retained in the system during the growout cycle, it would be critical for the growth of the fish stock and for the maintenance of a synergistic microbial population. The systems recognize the importance of maintaining solid residues, faecal matter, particulate matter, metabolites and uneaten feed in an intensive zero-exchange growout system to provide an environment favorable for higher growth rates and yields of fish. The system is sufficiently isolated to prevent the introduction of pathogens to the microbial population and in the presence of a zero-exchange during the entire growout cycle. When combined these individual components form a balanced system, wherein the fish growth rate will be increased by 100% to 500%, compared to "clean water" systems, and provides low cost production of high quality, disease free and commercially desirable fishes.

Bioremediation in raceways

Bioremediation is a biotechnological process of using selected micro or macro organisms to reduce harmful wastes to less hazardous levels. The principle is that to use selected microorganisms outside the host to create the healthy environment. *Bacillus* sp, *Vibrio* sp, *Nitrosomonas* sp, *Nitrobacter* sp, *Rhodopseudomonas* sp, *Aerobacter aerogenosa*, *Cellulomonas biazotea*, *Saccharomyces* sp, and several other algae are biological agents recognized for their bioremediation abilities.

Accumulation of unconsumed high protein feed, fish excretion and microbial degradation processes of organic matter result in increase of ammonia level. Introducing active aerobic bacterial populations could be an effective strategy in rapid degradation of complex organic compounds and overall improvement of health status of cultured organisms. Algal inoculation as well as introduction of indigenous fermented products also will be of more use.

The aqueous medium

The building block of the aqueous growth medium is specific pathogen free water. The aqueous medium is based upon water that is disinfected, and further treated to provide a medium suitable for the growth of microorganisms and fish. The aqueous medium is usually the water in the culture system. The water used in the aqueous medium may come from a variety of sources. For example, the water may be open well water, subsoil water from bore wells, river or lake water, spring water, brackishwater, or even tap water.

B. Design and construction of raceway farm complex

Major components of a raceway system:

i. Raceway tanks
ii. Green house structure for raceways
iii. Storage and mixing tanks

Iv Filtration systems (Biological filter, U.V. and Pressure sand filters)
V Generator, Blowers and Paddle wheel aerators
Vi Indoor and outdoor algal culture facilities
vii Farm Laboratory
viii Water and pumping facility
ix Limited water exchange grow out systems

Greenhouse enclosure

It is an enclosure constructed using cast iron pipe pillars, framing with a gentle semicircular roofing of iron pipes coated with non-corrosive paint. The dimension of the greenhouse could be 20 x 10 m. The roof is made up of white transparent HDPE sheet. The side walls were made of removable green shading net material fixed to wooden frames. The structure is large enough to maintain two 40- 50 m^3 raceways with pumps and sand filters. The greenhouse is equipped with adequate light fittings arranged in rows. Building raceway facilities under a greenhouse helps to maintain the ambient water temperature and other water quality parameters like DO, pH, ammonia, nitrite, microbial load, algal density, *etc*.

Raceway outlets and filter pipes

The drain outlets of the raceways are located towards the drain end, half way between the end of the partition and the end wall of the raceways. The raceway water level can be controlled by an external standpipe positioned inside the harvesting tank. Each raceway is provided with a different set of perforated filter pipes covered with different screen sizes (600, 800, 1,000 and 2,000 mm). Perforated filter pipes are mounted on the outlet to avoid losing fish during water draining. Filter pipes can be changed as the fish grows.

Harvesting tank

Raceways should be designed in such a way to allow harvest by draining. Towards the drain end of raceways, a harvesting tank (2 x 1.5 x 2 m) is provided for the purpose of water exchange, bottom waste clearing and for harvesting. The drain pipes of raceways are connected to the harvesting tank, and the outlet of the harvesting tank in turn is connected to the constructed wetland (CW) to treat the water for recycling.

Pressure sand filters

A pressure/rapid sand filter (*Waterco*, Australia) with manual backwash and filtration capacity of about 10,000/20,000 litre per hour (LPH) was provided for each raceway. The sand filter can be used to filter the incoming seawater as well as the raceway water. The multiport valve in the pressure sand filter is a multi-position valve with six operational modes, namely, sand filter, back wash, rinse, circulation, waste and closed.

UV sterilising system

UV sterilisers (*Rainbow Lifeguard*, India) were installed to treat the incoming water to the raceways. The UV sterilisers were connected in the water intake system and the filtered water from the rapid sand filters will be passed through these UV sterilisers.

Airlift system

Water circulation in the raceways depends primarily on airlift systems. In this system, air is introduced 30 cm below the water level in order to attain a maximum uplift of water through a vertical PVC pipe which has a 90^o PVC elbow at the upper end. The air lifts the water through the pipe from the bottom and sends it through the elbow in the desired direction by which unidirectional water flow is ensured. Air is supplied by three 5 HP blowers that operate alternatively every 3 hours. Air pressure, air lift pipe diameter, submergence depth and the type of airlift system are the major factors affecting the pumping rate and water circulated. In the raceway, airlift systems are arranged in six sets, three on each side of a central baffle and each set is provided with three airlift pipes. The airlift pumps are fixed to cross-wooden beams with adjustable stainless steel screws, which facilitate the adjustment of the height of the airlift pumps in the raceways when water level is low.

Water intake

Water is pumped to a sump of 100-tonne capacity and from there the water is pumped into the raceway tank through two pressure sand filters of capacity 10,000 LPH, filled with sand/activated charcoal.

Water quality monitoring

Biofloc settlement volume, dissolved oxygen (DO), temperature, pH, ammonia, nitrite, total suspended solids (TSS), total dissolvable solids (TDS), etc. are the main parameters needed to be monitored continuously in the raceway tanks.

Species suitable for raising in Raceways

i. Tilapia ii. Gold iii. Koi iv. Carps, etc.

Feeding management in raceways

Feeding with dry feed to be started on the first day of stocking. Under-feeding always results in poor growth and increased cannibalism. Over-feeding causes bad water quality and increased cost of production. Hence, growth sampling for biomass evaluation should be done weekly once or twice and feed ration should be revised accordingly. Seeds should be fed thrice a day with three rations.

Preparation of fermented product for raceway system

Materials such as flour, jaggery, molasses and yeast are used in the fermentation process. The yeast is boiled in the water and then added to the other mixtures prepared in the fermentation tank. The required amount of water is added and sufficient aeration is provided overnight. The fermented mixture is then added to the raceway tanks.

2.Lined fish culture ponds

Earthen ponds, conventionally used for fish farming have several disadvantages *viz*. a) continuous water seepage; b) complications with soil-water chemistry (which have not been understood properly till date); c) difficulties in determining the causes of water quality related problems; organic load accumulation (which cannot be removed during culture); and d) unavoidable reduction in aeration efficiency and a huge energy loss.

Lined ponds, on the other hand, have many advantages. The advantages being the seepage can be arrested, pumping cost is reduced, complications due to soil-water interactions can be avoided and for undertaking advanced farming practices (flocculent, green water, etc.) lined ponds are more suitable. The slightly higher initial investment will be largely compensated for by the huge advantages in terms of net profit. Lining needs to be done with a material that is long lasting and cost-effective. A wide range of materials have been tested and found certain materials such as silpaulin (LDPE) and SFF liner (HDPE) are more effective.

(a) LDPE lining materials

This material is available in the market (*Silpaulin India*) and is cost-effective too. It is available in thicknesses of 200-400 gsm and is relatively cheap. It needs to be protected carefully to retain its durability. The cost of the material is around Rs. 2.0/m^2.

(b) **Synthetic fibre fabric (SFF) liner material**

This is a special quality reinforced material proven to be ideal for lining earthen ponds. It is available in various thicknesses (400–700 gsm) and the cost ranges from Rs 4-5/m^2.

3.Inland 'Pond in pond' culture systems

Cages for inland water bodies made up of FRP (fibre reinforced plastic) were tried for inland aquaculture practices. Two types of cages of different sizes and shapes were fabricated. FRP is advantages because they are relatively cheaper to HDPE and long lasting than many other materials.

FRP floating cage

The multi-shaped FRP cage is fabricated in pieces so that it can be fixed with joints in different sizes and shapes. The provision of a walkway around the cage enable farmers to walk on it and to manage the cage better. The dimensions of the cage is 12.5 m long x 4 m wide x 1.5 m height..

The multiple shaped cage is ideal for rearing bigger size fishes viz. Pangasius catfish, hybrid tilapia, gold fish, Koi, Cichlids, etc. The performance of these cages were studied to confirm their durability, economic viability and technical feasibility.

FRP cages have several advantages over conventional cages. They are highly durable, with a life span up to 10 years. They are cost effective as the initial investment cost can be recovered within the first two years. Even if we could engage half of the existing natural water bodies (at 10% level) for cage farming the overall fish production scenario of the country could witness a positive boost in the near future.

Conclusion

Raceways, lined ponds and cages are few intensive and innovative culture systems which can be adopted effectively in inland water bodies to raise fish with good economic returns. Choosing suitable high-value fishes for farming and using technically-advanced culture systems and better management practices (BMPs) can go a long way towards providing a much needed boost to India's inland aquaculture sector.

Inland Raceways system

SFF liner (400gsm) ponds

Multi-shaped FRP floating cage

Technical paper-10

RATIONAL USE OF WATER RESOURCE IN AQUACULTURE PRACTICES

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Abstract

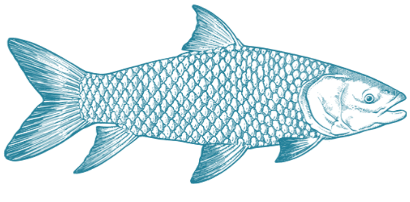
In the Tamil Nadu state, the total rainfall is less by 46% this year and we had similar in the state for the past five years. This combined with belated and poor quantum of release of water from Mettur Dam resulted in lesser flow in the Cauvery river system and recharge of ground water was adversely affected .To deal with this problem, we had to change our fish culture practices from the traditional ones as done in agricultural practices. Hence, rationality in the usage of water in aquaculture became highly essential and inevitable.

Earlier prior to 1995 fish farm practices included the manuring packages with cow dung, poultry manure, urea increased the organic load which in turn many times ended in eutrophication stage in the pond requiring frequent water exchange or top up of water.

Application of probiotics and biofertilisers a recent concept in the inland aquaculture has been found improving the water and soil quality of the pond and also reduces the frequent renewal of the water in the pond. This has become a reguar practice in this water limited zone. Switching from conventional wet feed like groundnut and other oil cakes, rice & wheat brans to the pelletised formulated feed is also advantageous to reduce the water budgeting in the aquaculture pond.

Two tier system of fish culture in the pond using floating/fixed cage in the culture pond itself resulted in overall increase of fish production per unit area of the pond. Both the cage nurseries and the cage grow-out system in a culture pond is being adopted for the rational and effective utilization of water giving many fold raise in fish production.(both in pond and cage in the same pond)

Water used for breeding of major carps and the water released from hatcheries are stored in a reservoir for the use in the nurseries and the grow-out ponds, at a later stage. Use of aerators has also already been found effective in the high stocking density in a limited water area to maintain optimal DO and the other favourable parameters with less or no water renewal. In our farm it has been found that on the use of Aspirator type of aerators, the rate of water evaporation has been found lesser compared on the use of Paddle wheelers.



Technical Paper - 11

CULTURE OF FISHES IN CAGES

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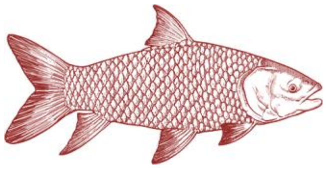
Points to be considered

- ✓ Cage size: 6 X 4 X 4 m.
- ✓ Minimum depth required: 5 m.
- ✓ Arrangement of cages: 2 battery of cages with 24 cages in each battery.
- ✓ Materials to be used:
  Netting: Inner cage material for seed rearing with 5 mm mesh knotless HDPE webbing and for grow-out, 10 to 12 mm mesh with knotless HDPE or Polypropylene and outer cage material with 20 mm mesh knotless nylon material; surface cover net with 30 mm mesh.
  Frame: G.I. or HDPE pipe, 1" or 40 mm diameter; for G.I. frame cage with appropriate floats.
- ✓ Seed stocking: Fry (30 to 40 mm) rearing reared for 2 months; Tilapia and Common carp @ 500 nos per m^3 and Pangassius, Rohu & Grass carp @ 300 nos per m^3; survival 70 %.
- ✓ Feed; Pelleted feed with 30 to 60 % protein; crumbles for initial 15 days; less than 0.5 mm for another 30 days; feeding rate 20 to 30 % of body weight; 2 month rearing.
- ✓ Late fry of Common carp, Amur carp, Nile Tilapia, Pangassius and Grass carp to be stocked in cages floated inside the pond.
- ✓ Size at stocking 100 mm in total length/25 g.
- ✓ Stocking rate: Nile Tilapia or Common carp 10,000 to 12,000 nos; Pangassius 8,000 nos; Grass carp 5,000 nos.
- ✓ Feed for grow-out (8 months): 5 to 6 % of body weight for first months; 4 to 5 % during second month; 3 to 4 % during third month; 1 to 3 % during fourth month; 2 % during fifth to eighth month.
- ✓ Protein content: 25 to 30 % for first month; 20 to 25 % during second, third & fourth month; 4 to 6 % during fifth to eighth month.
- ✓ Size of pellet: 2 mm for 1 to 2 months; 3 mm for 3 to 4 months; 4 mm for 5 to 8 months.

- Requirement of feed for grow-out: 8 tonnes per cage to harvest of 5 tonnes of fish.
- Feeding schedule: 3 to 4 times per day for 1-2 months; 2 to 3 times per day for 3-4 months; 2 times per day for 6 to 8 months.
- Cage maintenance: Regular cleaning of cages to prevent blocking of lumen; regular physical examination of fishes to observe external parasites and fin rot diseases; colour of fishes to be observed.
- Expected survival 90 %.
- Size at harvest: 300 g at he end of 6 to 8 months.
- Cost estimate

S.No.	Expenditure	Rs. Lakhs
1	45 cages	80
2	Input (seed, feed & other)	144
3	15 cages for seed rearing	15
4	One FRP boat with OBM	2
5	One 125 KV Genset	8
6	Two floating platform/raft for maintenance of cage	4
7	Contract payment for 4 unskilled persons for 10 months	2.4
8	Contingency	3
9	Fuel & hiring of vehicles	3
	Total	**262.4**

- Returns
  4,500 kgs X 2 crops + 9,000 kgs per cage
  9,000 kgs X 48 cages + 4,32,000 kgs per year
  4,32,000 kgs X Rs. 60 per kg + Rs. 259.2 lakhs



Technical Paper - 12

ENHANCING THE ADAPTIVE CAPACITY OF FISHERIES TO CLIMATE CHANGE WITH SPECIAL REFERENCE TO WATER RESOURCE

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Introduction

Recognising that climate change is one of the largest challenges facing mankind, governments are looking for sensible mitigation and adaptation strategies. Adaptation to the impacts of climate change is a complex, difficult and multi-dimensional. However, it is a prerequisite for lessening the impacts of climate change in a dangerously warming world. Our oceans are the earth's main buffer to climate change, absorbing 95% of heat and 30% of atmospheric carbon emitted, and thus are subjected to the double effect of warming and ocean acidification (IPCC, 2007). Changes in air and water temperatures, rainfall, ocean acidification, sea level, and wind patterns are all contributing to changes in productivity, distribution and phenology of aquatic species, impacting ecosystem processes and altering food webs (Vivekanandan, 2011). It is essential that we develop sensible adaptation pathways to improve outcomes for our aquatic ecosystems and fisheries. For this, metrics need to be developed and validated at four levels: (1) biological, (2) social, (3) economic, and (4) governance (see also Rosenzweig and Tubiello, 2006).

Approach to develop metrics

The objectives to develop metrics should be (i) for enhancing adaptive capacity of fisheries to climate change; (ii) validate the robustness of the metrics by SWOT analysis; and (iii) suggest governance plans for resilience of fisheries.

The approach to develop and validate metrics, and suggest governance plans is given in Figure 1.

1. ***Biological**: Use an objective qualitative modelling approach to determine the vulnerability and adaptive capacity of key commercial fish species to climate change*

   Understanding the impacts of climate change on the key species will require an understanding of the physiological responses of these species as well as an understanding of their interactions with the environment. While such an understanding can be used to select the species, rigorous existing baseline data for the majority of species is lacking. Biological approach will be based on expert opinion as research on most exploited species has focused on fisheries parameters pertinent to the assessment of fish stocks (e.g. observed growth rates, fishing and natural mortality estimates etc) rather than linking these parameters to physical parameters such as temperature. Similarly, social, economic and governance information is also relatively poor as most fisheries programmes have focused on biological issues. Management of marine resources has also been largely underpinned by biological sciences to the extent that performance indicators for marine resources have focused on biological systems rather than combined biological and human systems (socio-ecological systems) (FAO, 2008).

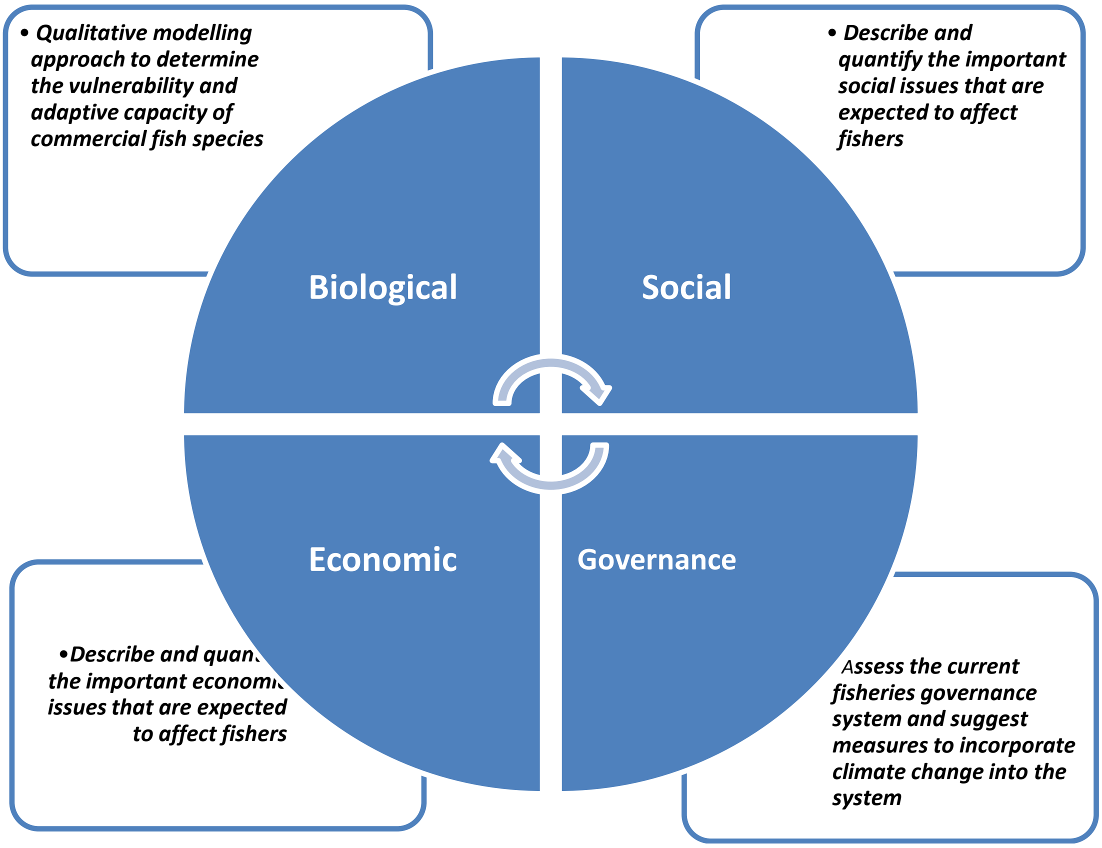

Fig. 1. Approach to develop climate change adaptation metrics

2. ***Social**: Determine a suite of social metrics that can be used to describe and quantify the important social issues that are expected to affect fishers and their rural communities as climate change impacts develop*
   To enhance adaptive capacity at community level, the key elements to be assessed are: livelihoods, perception of risk, social capital, history of fishing (including generational fishing), diversity of cultures involved, technology used to fish, types of fishing, importance of locations, motivations, attitudes and values. The approach to develop societal metrics are: (i) social impact assessment, well being, vulnerability, sustainability assessments, equity and gender issues; (ii) population information, environmental quality, Infrastructure and services, skills, experience, knowledge and communication; (iii) community dynamics, investment levels, media coverage, social indicator frameworks such as dependence, vulnerability, resilience etc. and (iv) adaptive capacity of smallacale fishers.
3. ***Economic***: *Determine a suite of economic metrics that can be used to describe and quantify the important economic issues that are expected to affect fishers and their rural communities as climate change impacts develop*
   The fisheries economic outcomes and performances are expected to change under climate change, which needs to be assessed. An understanding on (i) fishers' behaviour, the way fishers make economic decisions about fishing activity (*i.e.,* participation, investment, location, effort, compliance etc); (ii) understanding seafood markets (buyer and seller behaviour) and the effect of supply chains on climate change adaptability; and (iii) relative performance of resource access such as input and output controls under climate change and impacts on economic efficiencies.

4. ***Governance***: *Assess the current fisheries governance system and suggest measures to incorporate climate change into the system*
The emphasis on fisheries governance is shifting now from development to sustainability. This approach is emphasized by climate change impacts. We have to assess the perception and capacity of the existing stakeholders to imbibe the current and future needs of the governance system. The future governance system has to take into consideration integration with other associated elements in the ecosystem, find out how to incorporate climate change into the current system, evolve diverse management regimes, and ensure participation of stakeholders like the fishers, scientists, traders, exporters and managers.

Vulnerability of water resources to climate change

The many impacts that a changing climate is likely to have on water resources, both freshwater and coastal resources, include (IPCC, 2007):

1. Increases in water pollution problems as air and water warm.
2. More extreme weather events;
3. Changes to water availability (rain and snow level and distribution);
4. Sea level rise/storm surge and water body boundary movement and displacement;
5. Collective impacts on coastal areas; and
6. Indirect impacts resulting from changes in energy and fuel production.

One of the major impacts of climate change will be changes in demand, availability and quality of freshwater in the following way (www.water.ca.gov):

- Due to increase in atmospheric and water temperature, evaporation will increase, which will increase demand for water in freshwater aquaculture practices.
- If the monsoon is erratic, as has been predicted, the freshwater supply also will be erratic. Unseasonal rain could result in changes in the timing of floods, which will effect changes in reservoir storage.
- Coastal aquifers will be subject to seawater intrusion, especially in aquifers with high pumping rates.
- Droughts are expected to be more severe and potentially more frequent.
- Eutrophication is expected to occur more often in surface waters as water temperatures increase.
- Longer low-flow conditions may lead to higher contaminant concentrations
- High turbidity is expected to become more of a concern as storm severity increases
- Pollutant loads may increase with more intense storms
- Other water quality issues that typically accompany severe storms (such as *E. coli*) are expected to become more frequent
- Increased salinity intrusion into estuaries and brackish environments as seasonal freshwater flows decrease and sea levels rise.

Changes in precipitation quantity, location and timing that alter water availability will alter fish migration and recruitment patterns as well as in recruitment success (WFC, 2007). This will in turn alter the abundance and composition of wild stocks and impact seed availability in aquaculture.Low water availability and quality for aquaculture will lead to increase in production cost, and loss of opportunity as production will dwindle.

Potential adaptation options

Recognizing the impacts that a changing climate is likely to have on water resources generally, and quality water more specifically, we have to consider in defining “priority actions” to respond to these impacts by recognizing the need of other powerful water user sectors such as agriculture, hydroelectric power generation and domestic consumption (Hall and Stuntz, 2007). Integrated water resources management should be an instrument to explore adaptation measures to climate change, but so far it is in its infancy. To adapt to the stress of climate change, water resource policy must emphasize water conservation and protect fisheries and wildlife habitat in changing conditions.

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Technical Paper - 13

BLUE GREEN ALAGA *SPIRULINA* – A BOON FOR WATER DEFICIENT AREAS

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Introduction

Spirulina is a spirally coiled, multicellular, filamentous blue green alga. The coils may be tight or relaxed. *Spirulina* is naturally found in freshwater, brackishwater, sea waters, inland saline lakes, hot springs and moist soils. *Spirulina* is well known in among the cyanobacteria due to its economic importance. *Spirulina* is one of the most frequently used microalgae in aquatic animal feeds (in farming of molluscs, shrimp and fish) due to its high contents of protein, vitamins, essential amino acids, minerals, essential fatty acids and antioxidant pigments such as carotenoids (Kim *et.al*., 2013). *Spirulina* (species *S. maxima* and *S. platensis*) are also used as human food. *Spirulina* is used as a food supplement to combat malnutrition and is cheaper. It has extremely high protein content, with 60-70% of its dry weight consisting of a balanced mix of various essential amino acids. Further it is very rich in beta carotene (to produce vitamin A), iron, vitamin B12, ganna-linolenic acid and other micronutrients. It has no cell wall and is therefore very easy to digest.

It improves physical growth as well as cognitive development. It also improves immunity, and therefore helps in fighting and preventing HIV/AIDS and anaemia. Studies show that it is also effective against arsenic poisoning, a condition which is extremely hard to combat. It can be consumed directly as the paste which is harvested or dried. This is highly useful for cheap, local distribution in rural areas. Further it is also suitable to be produced industrially for the middle class. This is in the form of pills sold in pharmacies or combined with various food products such as rice, milk products, energy bars, candy, noodles, etc. *Spirulina* grows in solutions of specific minerals with the correct chemical balance and a pH of 8-11 which is a limiting condition for other microorganism to grow in opened reactors. It needs a minimum of 20˚C to grow substantially, though a temperature of 35-37˚C is most effective. A good amount of sunlight is useful if the culture has a reasonable temperature and concentration.(Antenna Techologies, 2013).

China is using this micro alga as a partial substitute of imported forage to promote the growth, immunity and viability of shrimp. There has also been comprehensive research on the use of *Spirulina* as aquaculture feed additives in Japan (Orio and Orsola. 1985).

Methods of Mass Culture of *Spirulina*

Literature indicates that mass culture of *Spirulina* was started in Mexico city, Taiwan Germany, France ,Japan and Israel. The first major attempt to cultivate *Spirulina* in India was carried out in Navsari (Fox,1973).The Chad isolate *S.platensis* was grown in a closed respiratory basin of 10mx2mX15cm.The total cost was estimated to be around Rs.30,000. The recorded yield was 7.5 g/m^2 day in the beginning in a medium containing full Zarrouk's chemicals. The cost of production of I kg. *Spirulina* protein could be around Rs. 500/-. In India, National Environmental Engineering Research Institute, Nagpur, Central Food Technological Research Institute, Mysore and National Botanical Research Institute, Lucknow were first to start preliminary culture experiments. Later since 1977 Shri. AMM Murugappa Chettiar Research Centre, Chennai (MCRC) had initiated *Spirulina* cultivation in rural areas using low cost methods to supplement the protein requirement in the villages. (Seshadri *et.al*.,1980).

Spirulina cultures are available in well known culture collections and it is very easy to acquire them. The laboratory experiments works out expensive for rural folk and some economical methods replacing inorganic chemicals by other cheaper sources such as effluents, bone-meal, sea salt, sea water etc., were evolved for transferring the technology to villagers.(Seshadri *et al.,* 1980). Jeeji Bai and Seshadri have suggested using plastic basins of 40 litres capacity for carrying out culture operations and adding urea, NPK and sea salt regularly and intermittently.

Jayasurya, (2003) has suggested using large FRP tanks containing 150 l. of fresh water and kept under sunlight. The medium was enriched with agricultural fertilizers *viz*.groundnut oil cake 3.5 g, super phosphate 10 5 mg. and urea 1 g. per litre. All the fertilizers were dissolved in 50 ml. of fresh water filtered using bolting silk and the filtrate was added to the medium. Regular harvest of *Spirulina* sp. after the first day to fifteenth day can be done economically by removing the third of the culture medium and replacing with equal quantity of fresh water and nutrients.

Spirulina is cultured on large scale in artificial ponds or tanks. Relatively simple and economical media have been used for this purpose. Open Circulating system: An open circulating system is a man-made open tank or shallow pond of brick or concrete and the interior is lined with a sheet of polyvinyl chloride (PVC). The tank may be circular or rectangular in shape with size ranging from 500 sq.m. to 5000sq.m. The depth of the tank should be between 25 and 30 cm. In circular tanks a stirrer with a rotating arm is arranged and in rectangular tanks a paddle wheel is kept in the tank to stir the culture. Usually the culture tanks are kept open while functioning. Sometimes, they may be covered with transparent glass or plastic to prevent contamination and excess illumination during hot seasons. Economic media are used for culture of *Spirulina*. Liquid effluents taken from well digested human excreta, modified sea water and Zarrouk medium are used for this purpose. This method is generally practiced in rural villages and municipalities in developing countries.

Oxidation Pond System: In this method all solid wastes and suspended particles are removed from the sewage. This sewage water is allowed to flow in to an oxidation pond. A few litres of *Spirulina* culture is inoculated into the pond as a starter culture. *Spirulina* grows in the natural system and produces a dense mat on the surface of the sewage water which is harvested by using special devices that can filter a large amount of sample (Kumarasan, 2004).

Experiments conducted at Indian Agricultural Research Institute, New Delhi on the growth potential of *Spirulina* in the digested slurry effluent from the cow dung gas plant and in cattle urine, respectively, with and without bicarbonate fortification gave interesting findings. The slurry effluent supported algal growth at all dilutions even in the absence of added bicarbonate, although addition of bicarbonate (18 g NaHCO3/l) stimulated algal growth to the level of algae grown in synthetic inorganic nutrient medium. In contrast, pure cattle urine failed to support algal growth in the absence of bicarbonate, presumably because the urine lacks an available carbon source. Supplementation of cattle urine with bicarbonate supported the growth of the algae up to a level of 3 per cent urine, beyond which the urine per se seemed to inhibit algal growth even with addition of bicarbonate (Rao and Venkataraman, 1979) .

Aeration of the medium is done mechanically by stirring a bucket or using paddle wheels and the temperature is maintained at 35-40°c which is ideal. *Spirulina* grows rapidly and forms a bloom in the culture. *Spirulina* filaments develop gas vacuoles in the cells and hence they float making the harvest easy. The biomass is harvested by filtering through a fine meshed cloth or using a fine mesh. This way about 12-20 g. of *Spirulina* /m^2 /day can be harvested from a pond. The harvested biomass of *Spirulina* is washed with tap water to remove the acidity of the acid water. The washed biomass is spread on a polythene sheet in the sunlight. The dried flakes are collected and made in to powder. This dried biomass is packed in aluminium lined bags or sealed bottles for marketing. Spray drying is followed if the biomass is to be made in to pills along with vitamin A and C.

Spirulina is most nutritious in its wet form. However this lasts at most for a few days if refrigerated, and only a few hours at room temperature. Hence if it needs to be transported or stored it must be dried. If dried and packaged well it can be stored for at least a year without losing nutritional value. However if dried it acquires an unpleasant smell and taste, and is inconvenient to use. It can then also be combined with various other food products or simply packaged on its own.

The main costs involved in the local production of *Spirulina* are labour, nutrients, packaging, capital and administration. The costs of course depend on the local availability of materials. An estimate for the total costs however is Rs. 450 to 600 per kg of *Spirulina*.In India for example, the cost of building a tank of 18m² is Rs.1500 and a feeding programme here produces *Spirulina* at a cost of Re. 1/- per child per day. 1 tank of 18m2 produces approximately 150g of *Spirulina* per day.

***Spirulina* sp.**

Field Experiences

One example of a successful business initiative revolving around *Spirulina* production can be seen in Madurai, India. Here 15 women run a production facility of 40 *Spirulina* tanks. They work to produce 150kg of *Spirulina* per month. The construction of a tank and accessories costs between Rs.9000/-and18,000 per m² (depending on size).

Production of *Spirulina* costs between Rs. 1300/-and Rs. 1700/-per kg. They pack the *Spirulina* in dry form of 2 g. sachets and sold to two local NGOs. The *Spirulina* is also combined with millet, jaggery, and sesame to produce “chikki” a type of energy bar to feed 2000 children per day from slums in the neighbourhood. At this scale of production, the facility is extremely efficient, and produces at a cost of Re. 1/- per child per day. They currently do not sell in the open market, as this requires more management and marketing skills; however this is being worked out. (Antenna Technologies, 2013). In 1821, itself the *S. platensis* products are sold as biscuits by name dihe in the markets of Mexico. Many Pilot plants for the production of *Spirulina* powder have been established in Japan, USA and European countries. Sosau Texcoco is the Mexican company to set up the first pilot plant in 1973 to produce 1,000 tonnes of *Spirulina* powder by 1982.This company exported powder to United States to prepare lozenges and capsules by adding vitamin A and C.The company also made supplies to government institutions to prepare biscuits and confectionery with higher protein content, meant for public distribution (Sivakumar, 2011).

The United Nations, Mexican National Institute of Nutrition, French Petroleum Institute and National Institute of Nutrition, Hyderabad have formulated four algal recipes as a weaning substitute for infants. At MCRC the products are distributed to the local under-nourished children. The MCRC has for the first time launched the project as health and baby food and multivitamin powder and tablet under trade name “Multin” and “Multinal”.They are also trying to use *Spirulina* slurry along with the popular south Indian dishes like idly, dosa, poori and sago wafers and in bread sand witch to enhance flavour, colour and acceptability of dishes. The trials of feeding *Spirulina* to cattle, canines and fish gave very encouraging results.(Seshadri *et.al*., 1980).

Though much work has been done on this important blue green alga *Spirulina*, the recent advancements in the field of molecular biology, genetic engineering, molecular modelling, drug designing and nano technology methods have to be taken up to optimize the techniques for better utilization in human welfare.

The *Spirulina* culture can be developed as a cottage industry and the product can be collected from the farmers by an Agency for large scale marketing.

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Technical Paper - 14

AQUACULTURE IN WATER DEIFCIT REGIONS – AN ISRAELIAN WAY

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Introduction

With the increasing population, the demand for freshwater has increased considerably. India, benefited by both the monsoons, taps and traps rainwater by storing it in reservoirs, lakes, irrigation tanks, ponds etc. Many of the perennial rivers and tanks have now become seasonal due to growing consumption. The available surface water has become inadequate to meet the total needs of various water users and conflicts develop. Bore wells which are banned in several countries are commonly used in India for agriculture, industries and domestic consumption. Poor recharge of ground water, caused due to poor rainfall and concrete jungles leads to lowering water table. Since water is the basic input for fish culture, it is high time to find out appropriate technology to undertake sustainable aquaculture in lesser usage of water. Israel, one of the water scarce countries, is doing aquaculture in deserts also. The technologies adopted by them may be an eye opener to improve productivity of our short seasonal waters.

Profile of Istrael

Israel, a small West Asian country, is approximately diamond shaped and has a land area of 20,770 sq.km. including 440 sq.km of natural freshwater resources. The northern half of Israel is receiving annual rainfall of about 400 mm while the southern half receives just 70 mm only. The arable land is just 13.68% only. According an estimate in 2011, the total renewable fresh water of Israel was 1.78 cu.km whereas the consumption (all purposes) was 1.95 cu.km. The agricultural labour force of Israel is just 2% out of the total labour force of 36 lakhs, according to another estimate in 2012. Therefore, Man and Material in Israel are very much costlier while Money and Management are available adequately.

Aquaculture Systems of Israel

The commercial aquacultural systems of Israel may be divided into the following four categories

1. Lentic water bodies
2. Enclosures in natural water bodies
3. Lotic water bodies / Flow through systems
4. Recirculating systems

Depending upon the intensity of aquaculture in these systems, the initial water quality deteriorates causing concern not only to the growth and survival of the cultured fish but also to the aquatic environment. As a word of caution, the Israelian technologies need not necessarily be adopted in toto by aquaculturists of India but can appropriately be modified to suit our needs and Environmental Laws of India.

Lentic Water Bodies

Naturally formed lakes, man made impoundments such as irrigation tanks and ponds are falling under this category. These water bodies are perennial or short seasonal. Monoculture of Jordan Tilapia (*Oreochromis aureus*) or common carp (*Cyprinus carpio*) is preferred. However, polyculture of common carp with Jordan tilapia or all male hybrid tilapia (female *O.niloticus* x male *O.aureus*) and grey mullets (*Mugil* sp.) are also prevalent in natural water bodies. The preferred culture species are Jordan tilapia (*Oreochromis aureus*), hybrid tilapia, sex inverted tilapia, red tilapia (red color inherited tilapia) and Israeli carp (a cross breed of Common carp introduced from central Europe in mid 1930s, Chinese race of common carp introduced from Taiwan in 1970 and Yugoslavian line of common carp introduced from Croatia in mid 1970s). Stocking of 5 - 10 seeds of 50 g. each/cu.m. is done and fed artificially. Need based aeration is done especially during the latter period of culture. The average yield is 1 - 2 kg / cu.m./ 5-6 months. The average growth of harvested fishes is 500 - 750 g. each in 5 months. Kibbutz Sde Eliahu cultures tilapia in a 20 ha reservoir, an irrigation water body to produce 200 tonnss/annum. The reservoir has a small inbuilt pond for collection of fish during dry season. Through a conduit, the collected fishes reach a small concrete pond outside the reservoir wherefrom all the fishes are taken into trucks by fish pump. Thus, 200 tonnes of fishes are harvested in just two weeks with a very little manpower.

Enclosures in Water Bodies

The Aquaculture enclosures such as floating cages and fixed pens in lakes and tanks (seas in case of mariculture) come under this category. The stocked fishes are fed artificially. The uneaten feed and faecal wastes reach the soil bottom below the enclosures.While the wild fishes in the water body feed on this trickling down food, the microbes decompose the rest. Keeping sufficient space between the bottom of the enclosures and the soil will keep the grown fishes healthy. Aeration of water within the enclosures is done by water currents formed by wave action.

Ardag company, Eilat owned by a Kibbutz undertakes cage culture of sea bream (*Sparus aurata*) with 40 cages. Each cage encloses 1,000 cu.m. of water and stocked with 60,000 fingerlings of hatchery bred sea bream which are fed with sinking pellet feed from feed blowing machines stationed on the shore. In a culture period of 10 months each fish grows to 400 g. when it is harvested. The company claims to produce about 800 tonnes of fish/annum by this floating cage culture.

Lotic WaterBodies / Flow Through Systems

The flowing rivers and channels constitute natural lotic water bodies, while the flow through systems are man made enclosures for fish culture purposes. For intensive culture of trout at Kibbutz Dan Trout Culture Station, Sde Eliath, water is drawn from River Dan and used in flow through system at 15 - 16°C. Eyed ova of RainbowTrout(*Oncorhynchus mykiss*) are imported from Europe and U.S.A., hatched and reared here. The culture period is 10 - 12 months. The fishes are grown in cement cisterns of size 20 x 5 x1m. Water exchange is done @ 400 cu.m/hr. Feeding is done by computerised automated feeder. Formulated feed is given to the juveniles with 45% protein and to the bigger fishes with 40% protein. Water exchange is temporarily stopped at the time of feeding alone. The FCR reported is 1.4 - 1.5.

\ Bacterial vaccination of cultured fish is carried out by automatic fish vaccine machine (from Denmark). Fishes of about 20 g. are conveyed to the vaccination table thro' a fish counter. Each fish is manually kept in vaccination box but vaccinated automatically by the machine. Then the box is opened by just pressing on one side and the fish slips down to reach the nursery again.

Harvesting of fish from grow out ponds is also done by mechanical automation. The harvested fishes are pumped out from the seine, counted by the fish counter using photo sensors and graded mechanically. The smaller fishes are released back for further growth. The Station claims to produce 500 tonnes of trout/yr

The discarded pond water is treated using drum filters and then by centrifugation before releasing into the river back.

Recirculation Systems

The super intensive, intensive and semi intensive aquaculture systems in water deficit Israel use water recirculation technologies to meet their water demand to grow monoculture of Red tilapia, hybrid tilapia, sex hormone treated AMT and Israelian common carp. Since diurnal variation of temperature is high in Israel, the recirculation systems are located in green houses and conducive temperature is maintained. Water parameters such as dissolved oxygen, temperaure, pH, EC, ammonia etc. are monitored and regulated with computers by connecting the sensor equipments with probes hung in the aquaculture ponds. Feeding is also automated and monitored by computers. The computer suggests various alternative measures also from which the aquaculturists can opt for the best course of action such as water exchange, reduction of stock to the appropriate levels, etc. This minimises the loss of stock due to mortality and ensures better production.

Stocking in super intensive aquaculture systems is 100 fingerlings/cu.m. which yields about 60 kg/cu.m. A small closed recirculating system in Israel with four concrete grow out ponds of 500 cu.m each (totally 0.2 ha) could produce 39.0 tonnes of tilapia (195 tonnes/ha) with an input of 67.3 tons of 30% protein feed. Water is recirculated after purification with mechanical filters, oxygen trickling, bio filtering, etc and water quality testing. About 10 - 20% of water is exchanged daily depending upon the need and the aquaculture technology adopted.

In case of super / semi intensive aquaculture systems, the precautionary measures and water purification measures are mandatory and insurance is compulsory. Therefore, such aquaculture units are having emergency alert systems also.

Aquaculture in Deserts

Nearly half of Israel is desert. The southern half of Israel is the Eastern part of Sahara desert, namely Negev desert. The annual rainfall is just 70 mm only. The land locked Dead sea, situated below - 400 m MSL has the salinity of 200 ppt. sandwiched by Negev desert and Jordan. The soil is slightly loamy and surface water is very rare. However, at several places, hot water springs are available and hence pumping is not necessary to tap it. This hot springs are not sufficient to undertake aquaculture/agriculture on a sustainable basis. Therefore, groundwater is drawn from a depth of 1000 m right from 1970s and they found that this geothermal water is available in plenty. In the borewell, due to pressure, the water column rises upto 300 m depth from land surface. The borewell water is hot (38 - 40°C) and is slightly salty (5 - 10 ppt.). The desert soil is light and loamy and leaching is simple. After leaching, the soil becomes suitable for several salinity tolerant agriculture. By using drip irrigation, several plants such as tomato, melon, strawberry etc. are grown in green houses. Thus, the constraints were made stepping stones for achievements. Seeing light at the end of long tunnel, Desert Aquaculture Growers Association was formed. Desert aquaculture, using Flow Through System and Recirculation System were attempted successfully with the assistance of R & D Station, Ramat Negev.

In flow through system, the geothermal water is drawn from 1000 m deep borewells and stagnated in reservoir to cool down. During night hours , the water gets cool easily. Then the water is drawn into fish ponds located within green houses for rearing tilapia or common carp. Since the framed green houses get corroded quickly, inflated green houses (aqua bubbles - a type of tent made up of reinforced PVC sheet) are commonly used. As said earlier, the water quality parameters are monitored by computers and sensor equipments. In grow out ponds, 100 g tilapia juveniles are grown upto 500-600 g.in a period of about 5-6 months at 28° C water temperature. The fully automated farm has only 2 or 3 personnel to handle a farm with 100-150 tonnes production capacity. The fish pond water then flows through a reservoir where the solid pollutants are allowed to settle. Then the water is pumped to pass through drum filters. Fertilizers are then dissolved in water (fertigation) and drip irrigated/sprinkled to agricultural plants. The desert aquaculture yields about 100-150 tonnes of fish/ha.

In recirculation system, the water is reused for aquaculture instead of agriculture. The grow out ponds are connected to sedimentation ponds and biofilters where the algal blooms assimilate dissolved phosphate and ammonia and the microbes transform organic nitrogen into inorganic. On improvement of water quality, the water is recirculated for aquaculture.

Suggestions

When compared to Israel, India is well blessed with freshwater which can be put into optimum use judiciously.The Israelian models of aquaculture may not be commercially viable in India since the cost of production will exceed the returns in the present economic scenerio. However, we can learn some lessons from their experience. The following suggestions are made to improve our inland fish production.

1) The production potential and the carrying capacity of our farm water should be monitored to optimise the productivity scientifically. To achieve this objective, the water parameters should be regularly monitored scientifically. At least one Aquaculture Laboratory per District should function immediately in each District to benefit the private fish farmers.

2) Majority of the irrigation tanks have become short seasonal and retains water for 5 - 6 months only. In Israel, majority of the freshwater aquaculture are undertaken for a period of 5 - 6 months only. Stocking of advanced fingerlings with the age of at least 3 months will enable faster growth of fish in the culture period of 5 - 6 months in the grow out system.

3) Introduction of fast growing hybrid/mutant/monosex tilapia and cross bred carps with better qualities shall be done.

4) The introduction of Amur carp (a variety of *Cyprinus carpio*), *Pangasius sutchi* and hybrid tilapia by the Government of Tamil Nadu has not deeply percolated to the commercial fish farmers. This shall be expedited

5) Enhancement of productivity by fertilising the waters, ploughing of soil, food supplementation, addition of trace elements, aeration etc. which facilitate faster growth and better stocking density.

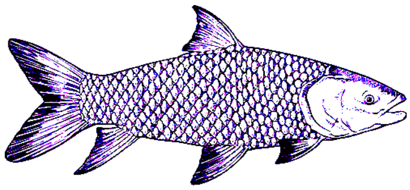
6) All the fish seed farms shall be subjected to seed certification as being done in Agriculture to retain the good qualities in the future progenies.

7) The fish breeders Association shall be formed to discuss the various pros and cons in a common platform and to share their broodstock to control inbreeding.

8) The Government of Tamil Nadu has started Water Users' Associations in all the Major Irrigation Tanks. The Major Irrigation Tanks constitute the major chunk of inland water resources for fish production which retain water for a longer period. But the fishery lessees have not been included as water users. Therefore, they have no voice in the decisions of the Association which frequently go against the interest of fish farming. The Government shall be insisted to order to include them as water users to continue fish farming.

9) From the field experience of Israelian fish culture in natural lentic waters, 10-15 tonnes of fish/ha can be harvested under extensive fish culture. If the above suggestions are taken care of, nearly 5-8 lakh tonnes of fish can be harvested from the Major Irrigation Tanks of Tamil Nadu alone even in water deficit conditions. Since the extensive fish culture technologies adopted in Israel do not pollute the environment, all the State Governments as well as Central Government shall plan to achieve this goal within the decade.

10) Automation of Aquaculture shall be encouraged since the agricultural labour force is becoming dearer and Agriculture gets redirected to cost effective agricultural implements.



Technical Paper - 15

OPTIONS AND STRATEGIES FOR THE DEVELOPMENT OF FRESHWATER AQUACULTURE IN WATER DEFICIENT REGIONS IN INDIA

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Introduction

Aquaculture is the fastest growing food producing sector in the world when compared to other food producing sectors such as agriculture, animal husbandry etc. The average annual growth rate of aquaculture is about 7% in last few decades (FAO, 2014). Freshwater aquaculture contributes a major share in the total world aquaculture production. The present freshwater fish production of world is about 39 million tonnes which is about 62 % of the world total aquaculture production (FAO, 2013). Most forms of freshwater aquaculture is also sustainable in comparison with marine and brackishwater aquaculture. Water especially freshwater has become a precious commodity worldwide because of the population growth, urbanization, industrialization, etc. and in the 21st century water deficiency prevails in most regions of the world and ever increasing day by day. India being the second largest producer in aquaculture with a present production of about 4.6 million tonnes in the year 2011 (FAO,2011) which has grown from just 2.1 million tonnes in 2002. Freshwater aquaculture production contributes a major share to total aquaculture production of the country. Freshwater aquaculture in India faces problem of water deficiency for its further development at present across the country. In India, water deficiency prevails almost everywhere. As per the National Institute of Hydrology reports the completion of usage of water between urban and agriculture sector will be a major issue in coming future (NIH,2014). Since, freshwater aquaculture in India is major trust area for providing protein rich food and also good alternative commercial venture to agriculture and allied sectors, water scarcity should not be a hurdle in for its further development in India. The various options and strategies for development of freshwater aquaculture in water deficient areas are reviewed and discussed in the paper.

Various options and strategies for development of fresh aquaculture in water deficient areas

The various fish species suitable for the development of fresh water aquaculture in water deficient areas in India are Indian Major Carps: Catla (*Catla catla*), Rohu (*Labeorohita*), Mrigala (*Cirrhinus mrigala*), Common carp (*Cyprinus carpio*), Pangasius (*Pangasianodon hypophthalmus*) and Tilapia (*Oreochromis* sp.) as they are comparatively hardly and can withstand intensive conditions compared to other freshwater species and of commercial importance. In general, the feed used in the system should have high digestibility and should have higher water integrity. The various options for development of freshwater aquaculture in water deficient regions such includes the following aquaculture techniques which are followed in various countries of the world inclusive of India are as follows:

1) Intensive Pond Culture

Intensive carp culture in pond has been reported by ICAR (2011), in which the production can be up to 15 tonnes/ha/year. Intensive pond culture of freshwater species such as Indian Major carps especially rohu is being followed in Andhra Pradesh especially in Kolleru lake area where a locally developed technology called zero input technology is followed by almost all farmers. The stunted yearlings are grown at a density of 20,000 to 25,000 nos./ha. Aeration is given in this type of culture whenever necessary. Bag feeding is followed which consisting of mixture of locally prepared feed and artificial pellet feed. However, feed with float feed is also followed by group of farmers. The water deficiency prevails in the last few years in Kolleru lake region. In order to reduce usage of water farmers use probiotics for assimilation of waste materials instead for going for water exchange. Probiotics are used to tune of 1-20 litre/ha on weekly or fortnightly basis, based on the prevailing pond water quality conditions. The harvest takes place in 7-9 months in shorter span. Phased harvest is also followed in some areas. This type of culture gives an average production of 20-30 tonnes/ha/crop. Similarly, *Pangasius* is also raised in the similar way, but the stocking density of *Pangasius* is as high as 50,000 to 60,000 nos. per ha and production is around 60 tonnes/ha/10 months. This method of farming is developed by farmers and needs urgent scientific intervention for making the technique sustainable.

2) Raceways

Raceway is channel or tank with a continuous flow of water constructed or used for high-density fish production. Fish raceways are generally constructed as 1) linear channels where water flows in at one end and exits at the other end or 2) as circular, rectangular, or oval tanks where water enters through nozzles or jets in a manner that creates a rotary circulation within the tank and discharge typically is through the tank center by means of a standpipe or bottom drain. The high rate of water movement gives raceway systems distinct advantages over the other culture systems. Advantages of raceways include higher stocking densities, improved water quality, reduced manpower, ease of feeding, ease of grading, ease of harvest and most importantly less use of water in zero and partial water exchange system. In closed raceway system the water is reused after treatment in wetlands, biofilters etc. which is used in culture of Trout (*Oncorhynchus mykiss*), Channel catfish (*Ictalurus punctatus*) at present (CAAR, 2008). Raceway aquaculture was initially developed as flow through aquaculture system which is of open type which is suitable in place like hilly areas where water flows continuously. Now-a-days this technology is modified into partially or zero discharge system for using it in water deficient areas. Culture of fish in raceways are reported by number of authors including freshwater species like trout (Cain and Garling, 1993), Tilapia (Abdel, 2006), Common carp (FAO, 1986). Presently zero raceways system is followed mainly for shrimp culture. Since, the technique uses comparatively less water it can be applied for freshwater species carp species in near future. Lin, Y.F *et al*., (2002) constructed a artificial wet land system in Taiwan for treatment of used water from milk fish ponds which shows encouraging results and the constructed wetlands may be applied in India for freshwater aquaculture production in combination with raceways aquaculture system for freshwater fish production.

3) Recirculating aquaculture systems

As compared with traditional culture methods, recirculating systems consume less water (approximately 250–1000 litre for production of 1 kg of fish) and are operated with less effluent discharge. In a recirculation system, five major components for culturing of fish are: 1) fish tanks, 2) water pumps, 3) a way of removing solid waste (*e.g.* bead filter), 4) a method of nitrification (*e.g.* trickle filter), and 5) a method of gas exchange (*e.g.* aeration) (Fig. 1). Closed Recirculation System treat water and reuse. So that only small percentage of water is discharged daily (ranging from 1% to 10 % of System Volume per Day). Various aquaculture species such as Tilapia (*Oreochromis niloticus*), Eel (*Anguilla anguilla*), Barramudi (*Lates calcarifer*) are cultured in RAS system worldwide (CAAR,2008). The advantages of recirculating system are less water needed, compact system, less land needed, temperature control, water quality control, waste retention, better FCR, less labour etc.. The various constrains faced are high initial investment, technically demanding, short response time etc. The various types of RAS include *Serial Re-Use*: water from one system – enriched with O_2& sent to a subsequent one. *Partial Re-Use*: additional treatment of portion of system water volume and then re-used. *Fully Recirculating*: which finds in application comparatively higher and involves high degree of re-use and separate water treatment system is used

. Benefits associated with RAS have led to explore their potential not only for high-valued fish species but also for lower-valued ones such as tilapia (Timmons *et al.,* 2004). Site-independency and consequent market-vicinity, has been the main drive for the development of lower-valued recirculating systems especially in urban areas in developing and developed countries.

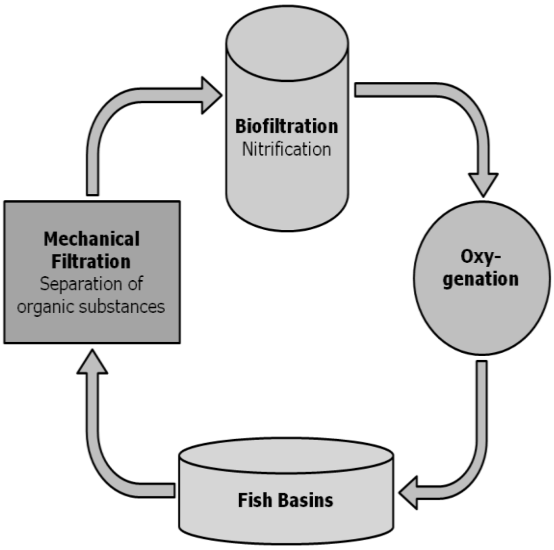

Fig. 1. General schematic diagram of RAS

Design and performance of a zero-discharge tilapia recirculating system (Nadav *et al*., 2002):

Navdav *et al.* (2002) designed and evaluated the performance of a zero discharge recirculating system for tilapia hybrid (*Oreochromis niloticus×aureus).* The schematic presentation of the Genosar recirculating system which was developed by them, it's characteristics, the experiment details like the fish stocking density over period of time and growth performance of tilapia are given in Fig. 2. :

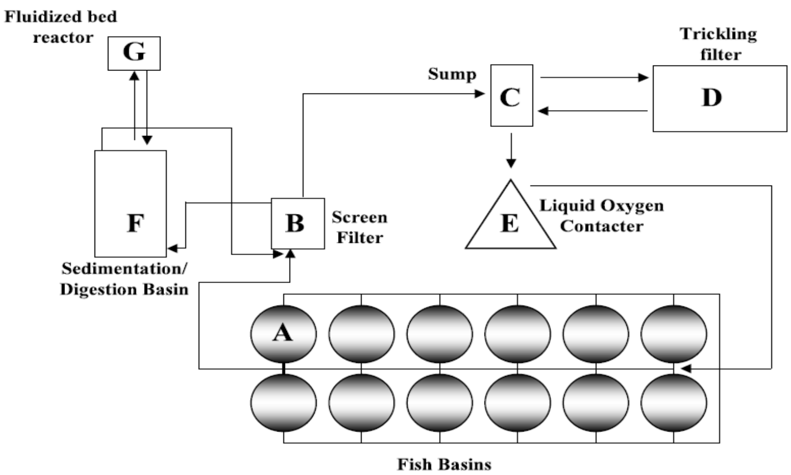

Fig. 2. Schematic presentation of the Genosar recirculating system (Israel). Arrows indicate the direction of water flow (not to scale).

Performance paramets of tilapia in RAS

Table 1. Performance of RAS

Growth period (days)	331.0
Initial average tilapia weight (g)	28.4
Final average tilapia weight (g)	500.8
Total tilapia biomass produced (kg)	4868.0
Specific tilapia yield (kg m^{-3})	81.1
Specific growth rate (%)	0.87
FCR	2.03
Survival (%)	94.7
Average daily water evaporation (% of total water volume)	2.3
Average daily water losses (% of total water volume)[a]	1.7
Specific water consumption (liters kg^{-1} fish produced)	190.0

It can be seen from the results that only 190 litres of water is needed to produce 1 kg of tilapia. This type of RAS system is highly suitable for Asian countries including India for increasing the fish production with lesser utilization of fresh water. Further, Timmons *et al*., (2002) reported that production of Tilapia in ponds 17,400 Kg/ha/y for which water required is 21,000 litre/Kg where as in Tilapia in RAS the production is 1,340,000 Kg/ha/y and water required is only 100 litre/kg. It evident that recirculating aquaculture system is the best solution to reduce the water usage in aquaculture.

4) Urban aquaculture

Urban aquaculture may be defined as the practice of aquaculture in Urban settings or areas subject to urbanization, and peri-urban areas (Bunting and Little, 2007). Worldwide urban aquaculture is practiced in countries like Nigeria (Adeogun *et al*., 2007), United States (Barry *et al*., 2005) India (Abhijit, 2011), England (Bunting and Little, 2007) , Thailand (Barry. *et al*., 2005), Germany (Stefan Guettler *et al*., 2011). In India too urbanization is developing at a faster rate, which demands supply of more food at concentrated place. Aquaponics cum fish culture has also been reported by Rakocy *al..* (2006) for treatment of waste and for production of fish in urban areas. Various intensive aquaculture system should be developed successfully in India for development of urban aquaculture which has wide potential. Culture of *Pangasius* in small tanks with probiotics with filtration system is developed in Andhra Pradesh which can be taken up in household level in urban areas.(personal observation). Aquaculture in artificially developed wetlands in urban areas are reported by Abhijit (2011) in Calcutta which needs significant development for its commercial application.

5) Use of Bio Floc Technology (BFT) in Aquaculture

A relatively new alternative to all previous approaches is the bio-flocs technology (BFT) in aquaculture. In these systems, a co-culture of heterotrophic bacteria and algae is grown in flocs under controlled conditions within the culture pond. The system is based on the knowledge of conventional domestic wastewater treatment systems and is applied in aquaculture environments. Microbial biomass is grown on fish excreta resulting in a removal of these unwanted components from the water. The major driving force is the intensive growth of heterotrophic bacteria. They consume organic carbon; 1.0 g of carbohydrate-C yields about 0.4 g of bacterial cell dry weight-C; and depending on the bacterial C/N-ratio thereby immobilize mineral nitrogen. As such, Avnimelech (1999) calculated a carbohydrate need of 20 g to immobilize 1.0 g of N, based on a microbial C/N-ratio of 4 and a 50% C in dry carbohydrate In integrated aquaculture systems using bacteria as additional nutrient trapping stage, the increase in retention by the use of bacteria is rather small. Schneider *et al.* (2005) stated that hardly 7% of the feed nitrogen and 6% of the feed phosphorus were retained by conversion in microbial biomass. However, when carbon and nitrogen are well balanced in the water solution and microbial assimilation of the ammonium is efficiently engineered, a complete retention can be obtained. A concentration of about 10 mg NH4 + –N L−1 could almost completely be removed within 5 h after the addition of glucose at C/N ratio 10, and this without the accumulation of nitrite and nitrate. (Avnimelech,1999). This transformation, achievable by adding different types of organic carbon source, resulted in a production of microbial proteins that could be reused as fish food. As such, nitrogen recovery in the form of tilapia biomass from a tilapia breeding facility could be increased from 23% in normal operation to 43% when the system was operated with BFT. This increase was based on the internal recirculation of nutrients through the formation of new microbial biomass, which was subsequently grazed by the fish (Avnimelech, 2006). It has been established that the removal of nitrogen from the culture water by means of BFT can be regulated by balanced addition of carbon. The added value that bio-flocs may bring to the aquaculture. BioFloc Technology has the advantage that it is cost effect in comparison with other intensive aquaculture systems. Hitide Seafarm's Innovative approaches to Shrimp Farm Mr. B.Suryakumar (CIBA, 2014). CIBA Success Story can be extended to fresh water fish species also.

Comparison of freshwater availability and Freshwater aquaculture Production of different countries

Table 2. Country level estimate of renewable

Country	TNRF	AP	AFR
China	2829.6	20781065	7344.17
India	1907.8	3342039	1751.78
Israel	1.7	19250	11323.53
Vietnam	891.2	1771000	1987.21
Taiwan	67	161027	2403.39
Denmark	6.1	22661	3714.92

Boyd and Li (2011), compared the freshwater availability and freshwater aquaculture production worldwide and the results of selected countries are presented below. It is understood from the results that Israel efficiently uses the freshwater resources for the freshwater aquaculture production and the values are far better than India. Israel uses the freshwater resources for the freshwater aquaculture production 6.5 times better in comparison with India. And the china the world's largest aquaculture giant, even uses freshwater resources for freshwater aquaculture production at the rate of 4.1 times better than India. It is also seen that there is no very vast difference between the India and China in terms of freshwater resources, however there is vast difference in freshwater aquaculture production. Thus, there is a wide scope and need for countries like India to increase the freshwater aquaculture by efficiently utilizing freshwater resources available in the country.

Country- level estimates of annual total natural renewable freshwater (TNRF), Annual freshwater aquaculture production (AP), and ratio of freshwater aquaculture production (AFR) (Boyd and Li (2011)

Present Challenges

1) **Financial Challenges**

Raceways and Recirculating aquaculture system demand high initial investment in comparison with other aquaculture systems. The operational cost for re-use of water is also high. However, the situation gaining momentum at present will push the entrepreneurs to overcome the challenge. A few Recirculating aquaculture system may be setup in public-private partnership mode. Government may also grant subsidy for the development of RAS. Supply of electricity at subsided rate is need of the hour for the saving most of the operational cost. Group of small farmer can combined for the taking up of the RAS, so that the financial hurdle for the development of RAS may be overcome.

2) Technological Challenges

Even though lot of technical development had been taken place in intensive pond culture, raceway fish culture, recirculating aquaculture systems, use of biofloc in aquaculture, there still remains certain technical difficulties. Technological complexity was the major reason for the development of these technologies in the past. Development of disease peculiar to intensive aquaculture should also be monitored and suitable techniques for its control should be developed. However, focused research on the aquaculture system development and it's management will overcome the technological challenges.

3) Extension Challenges

Extension of the aquaculture technology for its development in water deficient areas is a major challenge. Even if the results are promising in experimental conditions and on trial culture experiments. Extension of the technology to the public is one the greatest hurdle. Various methods of the extension such as Trickle down system developed by FAO and which has been successfully adapted in Bangladesh (FAO, 1993; ICAR, 2011) for the development of may taken into consideration for the development of aquaculture in water deficient areas.

Future Perspectives

1)Economics:

Cutting down initial and operational cost of Intensive aquaculture systems is the major future perspective for the development of aquaculture in freshwater deficient regions.

2) Extension methodologies and Plan:

The system of the extension should be empowered and strengthen. Proper extension methodologies should be developed for the efficient dissemination of technologies

3) Development of Industrial aquaculture hub:

Industrial aquaculture hub are being operated in various countries such as Spain, USA. Industrial aquaculture hub is highly suitable for the RAS and the steps may be taken for development of such hubs in Asian countries like India.

4) Technological advancements:

Scientific research is need of the hour for the development on aquaculture in water deficient areas apart from aquaculture engineering aspects, technological advancement in water chemistry, fish physiology, nutrition and disease management will boost the development of freshwater aquaculture in water deficient areas.

5) Water resource planning and conservation:

Generally, water resource planning is very important, rules should be framed for use of water especially for farming, pollution should be avoided, various water conservation programs such as watershed management programs followed by govt of India should be extended.

6) Climate change and aquaculture:

Climate change is the huge importance for the development of aquaculture in water deficient areas. Since, the studies on effect of climate change are at the basic level the same should be carried in high level.

Conclusion

In the present Indian condition, most of the regions are not having sufficient quantity of fresh water for fish farming activities and hence, significant attention should be focused to for development of freshwater aquaculture in water deficient areas. Even though the intensive aquaculture systems involves high investment, they require significantly less quantity of water. Technical difficulties should be overcome in the near future by focused research on the subject, which will enhance the future freshwater aquaculture production of the country.

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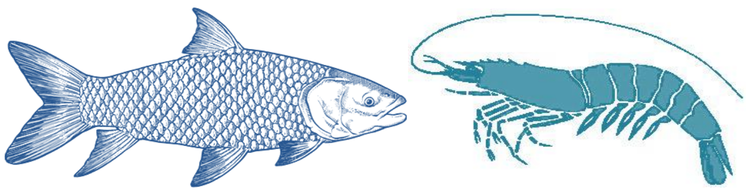

Technical Paper - 16

BIOREMEDIATION AND WATER QUALITY IMPROVEMENT IN AQUACULTURE THROUGH PROBIOTICS

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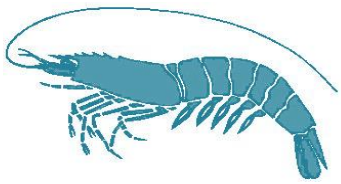
Abstract

Semi-intensive and Intensive aquaculture practices increases the concentration of toxic gases like hydrogen sulphide, ammonia, nitrite and other organic wastes at the pond bottom. This toxic material reduces the plankton growth, dissolved oxygen levels and alters the water quality parameters which affect the health of the culture organisms. Reduced survival, size variations, slow or no growth, parasite and bacterial infection, etc. are some of the common problems that occur as a result. Water exchange, addition of chemical binders, sludge removal through pumps, central drainage system, addition of aerators, are generally followed to improve the pond bottom (soil) and water quality. They are mostly expensive and unpredictable methods. Application of probiotics has been proven beyond doubt to be one of the best alternative and economical strategy to get rid of the above problems. Many beneficial bacterial strains are used in aquaculture in various forms (liquid, powder, pellet, etc.) for different functions, viz, removal of toxic gases, breakdown of organic matter and fecal waste, anti-vibrio, etc), and different targets (soil, water, gut, etc).



Technical Paper - 17

DESIGNING AND CONSTRUCTION OF AQUACULTURE PONDS FOR ECONOMIC WATER BUDGETING

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Introduction

The average rainfall in the Cauvery deltaic region is getting reduced and the flow of water in the Cauvery river system is also much reduced nowadays. Consequently the groundwater table is also going down year by year. In these condition usage of both available river water and ground water need to be rationalized. Hence, the fish farm in this area are designed to get more canal water through gravity flow and little ground water resources.

Construction of fish ponds using ground water alone

One fresh water fish pond was constructed in 10 acres of land by excavating the soil from 1.0 acre elevated portion of site. and the bunds were constructed with proper slope, top width and height. Three ponds each with 0.08 ha area were constructed with proper sluice with shutters. The water was supplied from bore well and the water drained from those ponds used to irrigate agriculture lands located in the down stream of the ponds. A total of 300 coconut trees were planted over the bunds of the pond which started giving additional income to the fish farmers. Every year from the month of February to June, paddy/pulse cultivation was carried out in each pond. After the harvest of the paddy/pulse, the fish culture is taken up for the period of 6 to 8 months from July to January.

Construction of Ponds with peripheral trenches

The construction of pond with peripheral trench with 3 m width and 1 m depth was introduced in the early nineties .Here, the soil excavated for the formation of trench was used for the construction of the bunds. In such farms , the farmers draw water from the bore well just to fill the trench portion and inundate the elevated platform area sufficiently enough for direct sowing of paddy in the month of June. Fish fingerlings are stocked in the trenches in the month of July and those fish fingerlings only are fed with feed. After the paddy harvest during September, the water level is raised to 1 m from the platform bed level either by using the bore well or from canals or both. The fish harvest is completed after 8 months on attaining 0.6 kg size and above.

Construction of Fish Ponds using both surface and ground water

In 10 acres of land located in a village in Pattukottai taluk, adjacent to a drainage canal, 2 acres of land had been excavated overall for a depth of 2 m to receive the water through gravity flow to maintain water depth of not less than 1.5 meters and this was serving as a reservoir. By the use of the excavated earth, the bunds for six ponds of 1.25 acres each, had been constructed without disturbing the earth surface of the pond. The river water collected and stored in the reservoir then pumped to the six fish ponds which were in the elevated portion. One bore well is also provided to top up the water level in the ponds during the dry months. Thus, the fish culture is being taken up for 6 to 8 months mainly with the surface water sources.

Since the top soil of the six ponds were not disturbed, the productivity of the pond is also maintained sustainably. During summer after the fish harvest, the farm ponds were used for short term paddy/pulse crop. Those undersized fish collected during fish harvest are stocked in the reservoir pond for further growth. In such farms the usage of ground water is reduced and the available surface water is effectively used for fish production. Here the fish culture is from September to April and the paddy/pulse crop is from June to August. Earlier the water drained from the fish hatcheries are discharged to the nearby canal. Now it is diverted to a stagnation pond, specially constructed. The water is passed through a bio filter and the water is reused for nurseries, ,breeder ponds and grow out ponds. In such farms this water is pumped to the over head tank, recycled and used to run the hatcheries.

Conversion of low lying lands into fish farm using canal /surface water only

In deltaic districts, Thiruthuraipoondi,and Vedharanyam taluks are in the tail end of the Cauvery river system. In those taluks, there was no quality ground water and the river water released from Mettur dam also reaches very late. Hence, the paddy cultivation could not be undertaken in time. So, every year the peasants of those areas were suffering heavy loss as they kept the land fallow. One of those farmers came forward in Thillaivilagam village to convert his low lying land into a fish pond to the extent of four acres, by further excavating the earth. He was making use of river water only when it became available from October, on the onset of northeast monsoon. After his success, 300 acres of low lying lands had been converted as fish farms in Thillaivilagam, Melaperumazhai and Udhayamarthandapuram villages. The river water drained in to sea is now diverted and stored in 300 acres of land which were lying fallow has been effectively used for fish culture. In the bunds of ponds coconut crop is also raised successfully. Similarly in Thalaignayeeru area of Vedharanyam Taluk nearly 200 acres of fallow low lying land are converted as fish farms .Due to the storage of fresh water in larger volume in this area, the salination of top aquifer during summer is minimized and portable water is made available in shallow pumps for the. community use.

Size of the pond effective in the water deficient area

One corporate company started Cat fish farm in 250 acres in Needamangalam area in Thanjavur district with individual pond size of 5.0 ha. Nine bore wells were erected and also several vertical flow pumps to lift the river water for the farm use. As required water level could not be maintained, the project was suspended. Now, the part of the farm ponds were reconstructed to 1 ha. size and leased out to farmers for fish culture. In the last one decade, the successful individual size of the farm pond is from 0.5 to 1 acre. Hence, the construction of 1 acre and lesser sized ponds are highly suitable for maintenance of required water level. Fish ponds with the reservoir system collecting the surface water is considered suitable for Cauvery delta area.



Technical Paper - 18

INLAND FISHERIES DEVELOPMENT AND SUSTAINABLE WATER RESOURCE USE IN ANDAMAN AND NICOBAR ISLANDS

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Introduction

Aquaculture is the fastest growing food production sector in the World with annual growth in excess of 10 percent over the last two decades. Much of this development has occurred in Asia, which also has the greatest variety of cultured species and systems. Asia is also perceived as the 'home' of aquaculture, as aquaculture has a long history in several areas of the region and knowledge of traditional systems is most widespread. Furthermore, the integration of livestock and fish production is best established in Asia. The Andaman and Nicobar Group of Islands are situated as a dissected chain in accurate fashion oriented in N – S in the Bay of Bengal off the Eastern Coast of India and extended between 6° and 14° North Latitudes, and 92° and 94° East Longitudes covering a geographical area of 8249 sq. km. These islands form two major groups, popularly known as Andaman Group or the Northern Group of Islands and Nicobar Group or the Southern Group of Islands, which are separated by 10° channel. The A & N group of islands fall under hot humid to par humid island eco region designated as agro- ecological region 21. The Union Territory of Andaman and Nicobar group of Islands comprises around 572 islands formed by a submarine mountain range, which separates the Bay of Bengal from the Andaman Sea. The islands receive copious rainfall to the tune of about 3000 mm/year whereas at Port Blair is 3180 mm. The latest report of rainfall recorded in A & N Islands till September 2013 is 2798.27 mm (Table 1). The area enjoys tropical humid climate due to its geographical location. Relative humidity ranges from 79 % to 89%, average wind speed is 7 to 10 km/hr, maximum temperature varies between 27° to 33 °C and minimum temperature fluctuates between 21° to 25°C. Evaporation rate is very high, i.e. 1500 -1800 mm/year.The climate of the islands is generally tropical and receives high rainfall, undulating terrain and backwater creeks are very conducive for faunal and floral diversity.

Table 1. Rain fall data of Andaman and Nicobar islands

Comparative Statement showing average(total) rainfall (mm) of A&N Islands of last three years (2011 to September, 2013)								
Month	2011		2012		2013		% Variation in monthly Rainfall	% Variation in cumulative Rainfall
	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative		
January	244.53	244.53	146.9	146.9	98.23	98.23	(-)33.13	-
February	99.02	343.55	47.07	193.97	53.30	151.53	13.24	(-)21.88
March	298.63	642.18	41.87	235.84	49.38	200.91	17.94	(-)14.81
April	103.97	746.15	64.40	300.24	44.92	245.83	(-)30.25	(-)18.12
May	300.65	1046.80	531.58	831.82	478.08	723.91	(-)10.06	(-)12.97
June	408.42	1455.22	407.55	1239.37	757.57	1481.48	85.88	19.53
July	563.73	2018.95	318.32	1557.69	536.05	2017.53	68.40	29.52
August	447.68	2466.63	342.82	1900.51	326.57	2344.1	(-)4.74	23.34
September	**703.77**	**3170.40**	**812.18**	**2712.69**	**454.17**	**2798.27**	**(-)44.08**	**3.06**
October	193.72	3364.12	197.30	2909.99				
November	141.77	3505.89	320.67	3230.66				
December	265.75	3771.64	197.88	3428.54				

Source: Directorate of Economics and statistics, A & N Administration, Port Blair.
http://andssw1.and.nic.in/ecostat/2013/averagerainfall.pdf

The weather is warm and sultry in summer. These islands receive rains from both the south-west and north-east monsoons. There is no extreme climate except rains and tropical storms in late summer, which often cause heavy damages to the islands. Three distinct seasons experienced are; monsoon-wet season from May to November, cool dry months from December to February and hot dry months from March to April.

Surface Water Bodies Including Springs

As the area in the active orogenic belt involving frequent uplifts, there is no well-developed surface water system. Moreover the topography is very rugged with major trend of the mountain chain along the length of the island; there is no scope of well-developed drainage system or canals.

Rivers/ Streams

The islands are devoid of large river system and obviously without vast catchments. However, a few perennial streams such as Mithakari, Protheropore Nala, Burma Nala, Pema Nala, Karmatang, Betapur, Korang, Rangat, Dhanikari etc. drain into the area.On the other hand Andaman is blessed with just one river named as **Kalpong**. The Great Nicobar is the only island of the Nicobar group with five perennial rivers.In the Great Nicobar you can come across the rivers Alexandra, Amrit Kaur, Danes, Galathea and Dogmar and each of them has its origin in the Mount Thullier.

Kalpong River in Andaman

Galathea river of Great Nicobar

Source:

http://www.trekearth.com/gallery/Asia/India/East/Andaman_and_Nicobar_Islands/Diglipur/photo874829.htm

Lakes: There are no natural lakes worth mentioning, however, at places some water tanks are present and used for irrigation purposes.

Springs: Several springs are encountered in the area due to its rugged topography with steep sloping valleys and abrupt mountain chain. It has been revealed from the studies that the average discharge of the springs in the lean period was in the order of 10-50 Lpm (litre per minute)

Canal: There are no major irrigation projects tapping surface water resources and canals are not feasible in the area. The only major dam in the area is the Dhanikhari dam, which is the source of drinking water to Port Blair. The dam is 132 m long and 32 m height.

Freshwater Fishery resources (Table 2)

Freshwater aquaculture plays a very important role in livelihoods of local communities. Indian major carps, catfishes and freshwater prawn mainly contribute to the total freshwater fish production in the Islands. On an average island produces about 100-120 t/yr of freshwater fishes. At Present Island consists of 1870 minor irrigation ponds with total water spread area of 114.35 ha used for pisciculture purpose and 367 ha of reservoir area (7 numbers). The main fish culture areas practice are concentrated in Port Blair, South Andaman (488 ponds, 26.13 ha) and in Diglipur, North Andaman (473 ponds, 28.97ha) and due to higher demand and for harvesting rain water number of ponds are increasing day by day.

Though freshwater aquaculture has been practicing by farmers of Andaman from early settlement days, scientific method of fish farming and the availability of quality seeds (spawn, fry and fingerlings) are the main problems hindering the development of aquaculture in the Islands. Integrated fish farming can be a better option for the people of Andaman due to their higher economic return; open and bank space can be utilized for agri-horticultural crops production and water can be utilized for other activities like irrigation etc. Rearing of group of cultivable fishes with different feeding niches and living in different strata; in order to obtain high production per unit area of water body is called composite fish culture. CARI has successfully developed and demonstrated composite fish culture technologies, techniques for fish breeding and integrated farming practice etc. to the farmers of Andaman. Demonstration of all these techniques in the farmer's field as a potential means of livelihood options is very much essential for development of potential entrepreneurs as well to satisfy the demand of freshwater fishes in Andaman. A serious issue concerning bio-security that has to address in freshwater fisheries is import of fishes from mainland which may enter into natural water bodies and pollute the gene pool. Since freshwater aquatic systems are also pristine and polluted free, the introduction of fishes from mainland may accidentally introduce diseases which may disrupt the native system of Islands.

Brackish water Fishery resources (Table 2)

The brackishwater areas in A & N Islands are estimated to be around 33,000 ha. However capture fishery is very limited and mainly pertains to catching of prawns, crabs and fish like mullets from creeks and bays. Central Island Agriculture Research Institute, Port Blair have developed eco-friendly brackishwater aquaculture of mullets (*Liza tade*), milkfish (*Chanos chanos*), Seabass (*Lates calcarifer*), prawn (*Penaeus monodon, P. merguiensis*), Scat (*Scatophagus argus*), and mud crab (*Scylla tranqubarica* and *Scylla serrata*) offers an immense scope for brackishwater aquaculture in Islands. After tsunami hits these islands, low lying coastal areas where seawater reaches during high tide and recedes during low tide. For these types of problems, preventive measures like alternate land use by adopting plantation cum brackishwater fish culture in trench model and coconut and salt tolerant grasses on the embankment, and brackishwater fish like milkfish, mullet, crab, shrimp on the trenches can be developed. In low-lying coastal areas where there is permanent stagnation of seawater and the depth of impounding increases with high tide, there, raised and sunken bed method of cultivation involving paddy cum fish cum vegetables cum fodder cum livestock can be used as a preventive measure. Based on the macro-level survey conducted earlier, the A &N Islands has total brackish water area of 618.806 ha, of which 17.65 ha is located in the Nicobar District. Around 380 ha of this brackish water are under private possession. As this survey was conducted more than a decade back, it is essential to undertake a fresh survey to establish the area most suitable for brackishwater aquaculture. In general most of these areas are located near mangrove forests.

Table 2. Fish production in last seven years in A & N Islands:

Year	Inland Fish Production		Marine Fish Production		Total Fish Production		Fish seeds Produced
	Inland (Rs 000 tons)	Growth rate (%)	Marine (Rs 000 tons)	Growth rate (%)	Total production ('000 tons)	Growth rate (%)	In million fry
2004-05	0.08	-11.11	32.60	4.96	32.68	4.91	1.29
2005-06	0.04	-50.0	12.05	-6.04	12.10	-62.97	0.71
2006-07	0.09	125.0	28.60	137.34	28.69	137.11	0.58
2007-08	0.09	0.0	28.60	0.0	28.69	0.0	0.51
2008-09	0.16	77.78	32.33	13.04	32.49	13.25	1.50
2009-10	0.17	6.25	33.00	2.07	33.16	2.06	1.00
2010-11	0.19	11.76	33.74	2.24	33.92	2.23	0.56
2011-12	0.19	0.0	35.07	3.94	35.26	3.95	0.56
2012-13 (Provisional)	0.19	10.53	36.42	5.84	36.61	5.87	1.06

(Courtesy: www.dahd.nic.in)

Assessment of Island Water resources potential and uses

The water resource potential and per capita water availability for A & N islands is 26.2 billion Cubic Meter and 57,970 m^3/year. It indicates very high per capita water availability of 22,380 m^3/year even in 2051 compared to national availability and availability in other countries like China, Pakistan, Bangladesh, UK, and USA. Surface water is water in river, lake or fresh water wetland. Surface water is naturally lost through discharge to the ocean, evaporation, evapo-transpiration and sub- surface seepage. In A&N Islands water is mostly stored for drinking water purposes, of course a fraction of total annual precipitation. Natural surface water can be augmented by importing surface water from another watershed through a canal or pipeline. In the island condition it is economically not feasible and technologically most challenging. The great challenge for the coming decades will be the task of increasing food production with less water, particularly in countries with limited water and land resources. Conservation of available water resources for agriculture and other water uses is the overall aim.

Technology for the degraded land and water

Diversification of the traditional farming in the coastal areas has a tremendous scope. The present system of mono-cropping with rice offers only sub optimal resource utilization and instead of rice in kharif, paddy-cum-fish culture may be introduced in many areas for higher profitability, food security, employment generation and for reducing the risk factor. The following technological intervention in the coastal affected land and other suitable location may results in the increased water productivity and livelihood security.

1. Farm pond
2. Three tier system
3. Broad bed furrow system
4. Ridges and furrow system
5. Paddy-cum-fish system

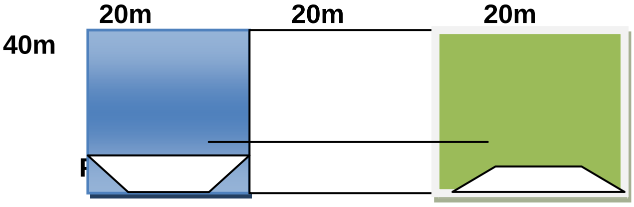
Farm pond

Farm Pond

Farm ponds, as one of the suitable option of land manipulation, form the centre of integrated farming system. Farm ponds may store *in-situ* rainfall or harvest surface runoff from surrounding areas depending upon the available rainfall in a region. The important characteristics to be taken into account on designing and constructing a farm pond are: i) rainwater availability, ii) crop water requirements, iii) design dimension of farm pond, iv) location of the farm pond, v) lining requirement for seepage control.

Three tier system

This system involves the shaping of land into pond. One third land area to pond, one third as original or mild land (2nd portion) and one third as raised land (3rd portion) is the low lying areas. The dug out soil should be taken to 3rd position for raising the land. It can be used for water harvesting, fish cultivation and supplemental irrigation during wet season (dry spell). The rain water stored the furrow is sufficient to keep the root zone soil of the bunds and mid land moist for the few initial months of the dry season and for life saving irrigation.



Three tier system

Broad bed furrow (BBF) system

BBF System

During monsoon season, the excavated area i.e furrow can be used for rice and fish cultivation while vegetables/fodders crop will be cultivated on raised beds. The use of BBF reduces the average annual runoff to one half and the soil loss as one forth as compared to that of that traditional system. The paddy varieties viz., C14-8, Jaya, Krishna Hamsa, Bhavani or any other long duration variety are generally best for cultivation in the furrows along with fishes. The fish species suitable for freshwater paddy fields are magur (*Clarias batrachus*), singhi (*Heteropneustes fossilis*), catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirhinus mrigal*), bata (*Labeo bata*), Javaputhi (*Puntius javanicus*), silver carp (*Ptenopharyrngodon idella*), giant fresh water prawn (*Macrobrachium rosenbergii*)and common carp (*Cyprinus carpio*) can also hold good for BBF. Air breathing fishes like magur and singhi are most preferred because they can tolerate wide fluctuation of the environmental parameters mainly water temperature and low dissolve oxygen conditions due to presence of accessory respiratory organs i.e they can breathe in air. They also fetch a good price (Rs. 200/kg) in local market or even more in lean seasons.

Ridges and furrow system

Ridges and furrow system

It is an archaeological pattern of ridges and troughs created by a system of ploughing typically in the open field system. The term describes a distinctive pattern of peaks and troughs in a field giving a rippled appearance. As one effect of the system was for water to drain via the furrows, the land in these troughs could become damp which is good for the vegetation on the ridges and that in the furrows.

Paddy cum Fish

Paddy cum Fish

In this system, trenches of about 3 m width and 1.5 m depth will be dug around the field. The excavated soil can be used for making raised bunds of about 1.5 m width at the top around the field to protect the fishes to be grown in the system. Ridges can be used for growing vegetables and other high value crops cultivation around the year and the rain water harvested in trenches can be used for irrigation purposes. Trenches will serve as shelter for fishes. During wet season, the centre land can be used for paddy cultivation while in dry season; vegetables can be grown on the same land. Due to this technique, it is expected to improve the total net income, besides the regular income from the scale of vegetables.

Composite fish culture

Rearing of group of cultivable fishes with different feeding habits, in order to obtain high production per unit area of water body is called composite fish culture. These species are selected so that they do not compete for food among them having different types of feeding habitats. The fishes which are feeding on the phytoplankton or zooplankton can get maximum stored energy and therefore grow fast compared to the carnivorous fishes. Also all fishes do not stay in the same strata and feed.. Hence, if we culture these three species together, utilization of food and space will be optimum and there will be no competition among the culture fishes. For example, fishes used in this system include Catla and Silver carp(surface feeders), Rohu (column feeder) and Mrigal and Common carp(bottom feeders). Other fish will also feed on the excreta of the common carp and this helps contribute to the efficiency of the system which in optimal conditions will produce 3,000–6,000 kg/ha/year. This is the principal behind the concept of composite fish culture, which involves judicious exploitation of all the niches available in the pond as well as utilizing the whole strata of the pond. In these islands, major carp proved to be the best in terms of demand and consumption. Hence composite fish culture holds the appropriate aquaculture practice.

Stocking management:
High fish production in stocking ponds is attained by maintaining species combination and rate of stocking. The pond carrying capacity depends on pond fertility, availability of natural food, D.O. of water, fish biomass and feeding. When the pond carrying capacity of pond is approaching maximum sustainable level, the growth of fish reduces. But this can be achieved by providing balanced diet, congenial environment, aeration etc.

1) **Stocking**: The fishes are stocked at 5000- 6000 nos/ha of pond. The size of the fingerlings or yearlings should be 10-15 cm in length because it will grow very fast and mortality rate also will be low. However, when stock fishes are brought from other places, they should be treated first in Potassium permanganate (5%)
2) **Feeding of fishes**: Generally planktons are being produced after application of organic and inorganic fertilizers. However, when we are stocking more number of fishes, supplementary feeding becomes necessary. This feed is prepared by mixing rice bran and oilcake (mustard oil cake or groundnut oil cake) at 1:1 ratio and given to the fishes. Also, vitamin-mineral mixture can be added at 1% of the total feed.
3) **Method of feeding**: Feed may be broadcast during first two months of stocking, there after a feeding basket/tray/bag should be used in two fixed positions of the pond. Feeding has to be given in a fixed time of the day and quantity has to be adjusted as per the body weight of the fish (2-3%)

   Example: feeding of grass carp; aquatic weeds such as *Hydrilla, Najas*, etc or chopped green cattle fodders such as Napier grass, maize leaves etc are provided to the grass carps.
4) **Harvesting**: Harvesting is done by drag net either during summer months when the water level drops or during monsoon depending on the demand of the market or total dewatering of the pond in the dry season. The estimated production may be 3-3.5 tonnes from one ha pond.

Problems of Fish Culture

As in any other farming system, in fish culture also a number of problems of its own kinds are encountered. Serious efforts need to be made to resolve them either improving the management or taking appropriate measures immediately. Otherwise it may cause loss by fish kill even in short period. Therefore, a fish farmer need to be a keen observer of the pond water and stocked fish, so that the problem is detected at its early stage and is resolved by taking even simple measures. In any fish pond, different types of aquatic weeds, insects and other higher animal's e.g. wild fish, snake and birds are very common to see. Out of these animals, the insects are harmful as they prey on the small fries and fingerlings. Some of the predator e.g. wild fish can be minimised or avoided by improving the management.

Integrated Livestock- fish Farming system

In case of multiple usages of water resources integrated fish farming offers an enormous scope to increase productivity and sustainable usage of water. The use of animal waste to fertilize fish ponds leads to greater fish yield, as the manure provides active nutrients (NPK) for the metabolic cycle in the ponds and promotes the growth of plankton which is natural food for fish. Cattle, poultry and ducks can be raised on the embarkments or in the vicinity of the ponds.

Cattle-Fish Farming

Fish farming can become more production-oriented by integrating it with cattle farming. Cattle are allowed to graze on pond banks and grassy areas in the vicinity and manure is either collected or washed directly from the cattle sheds into the ponds. It has been proved that in the composite fish culture, when the ponds are manured with cow dung at the rate of 15,000 kg/ha/year, an excellent yield of 5,000 kg fish/ha/year can be obtained.

Poultry-Fish Farming

It is an excellent method, poultry droppings are served as an excellent fertilizer for fish ponds. The joint farming operation requires little space, low capital investment, quick returns and distributed turnover. Poultry droppings are the richest in highly soluble inorganic salts and have the highest N and P values as compared to other manures.

It has been experimentally indicated that droppings of 500 birds is enough to fertilize one hectare pond area. The yield of about 3.9 t/ha/yr has been obtained in composite culture system stocked @ 8,000 fish/ha. High survival rate and faster growth were recorded when a mixture of cow dung and poultry droppings was used.

Integrated pig-fish farming

It is highly profitable fish culture system, where pigs are reared adjacent to the fish ponds, preferably on the pond embarkment from where pig urine, excreta and spilled pig feeds are introduced into the pond water. This is the direct integration system and most efficient one. In one harvest cycle of fish (one year), two batches of pigs are raised in six months.

Duck-fish culture system

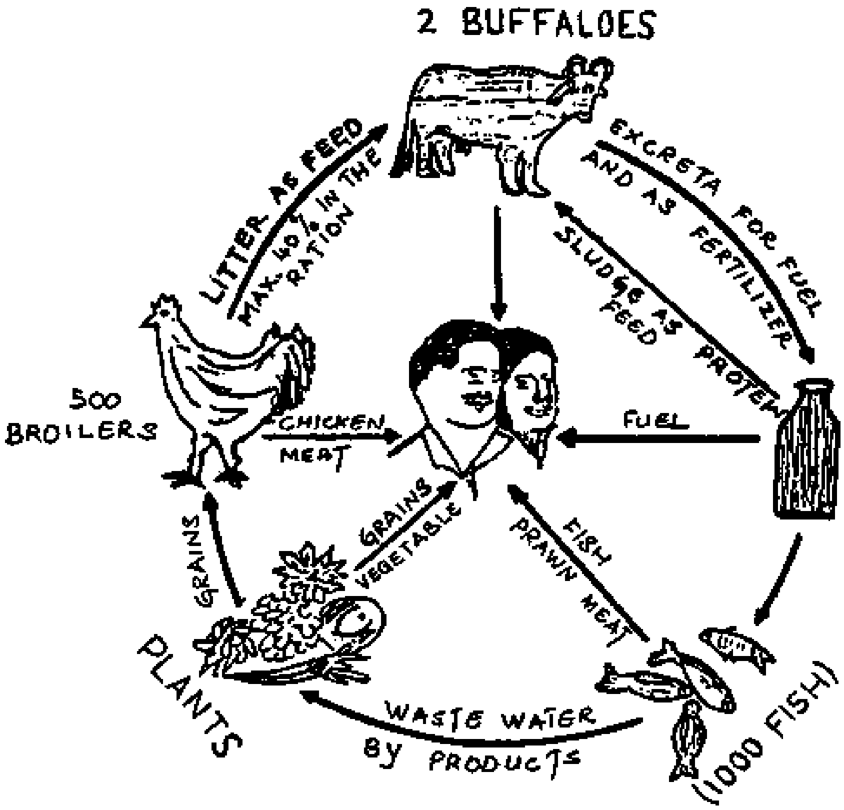
Extensive rising, in which only small amount of supplementary duck feed is provided and the number of ducks is limited by the food they can find in the pond water (150-500 ducks/ha). Intensive raising , in which the ducks are fed at the same rates as on land and held at a much higher densities per unit of pond area (750-1300) ducks/ha).

Integrated farming system for livelihood security

Livelihood security can be measured in terms of economic security, health security, educational security and employment security and employment generation which can be achieved through integrated farming system which is marked by various strengths such as low investments, high profitability, maximizes production per unit area and recycling wastes and residues from one farming system to other and also gives opportunities to establish agro-based and allied cottage industries.

Integrated farming system in Islands:

The topography of A & N Islands is characterized by longitudinal hills covered with forests, undulating land, filled in valley and coastal low lands. Dry season extending from December to April, high temperature and evapo-transpiration leads to water shortages for crop production. Due to intensive rainfall and remoteness of Islands, only **rice** is grown in **valley lands** while **coconut and areca nut** plantations in **sloppy lands**. In **hilly areas**, **coconut and areca nut** are the main crops along with the fruits like jackfruit, guava and sapota as intercrops in backyard of homesteads. In hilly region soil is poorly fertile and subject to erosion. Ponds are present in the lower reaches of slope. Fish ponds are also present at the end of slope. In **low-lying valley or coastal valleys** only long duration paddy is cultivated due to water lodging during rainy season and poor drainage. Various IFS models are developed for each agro ecological situation like **lowland valley**, **medium upland** valley, **hilly upland** and hills.



Integrated farming system (IFS) for hilly upland:

In order to develop water resources at hilly upland, lined tanks can be constructed. This has been standardised by CIARI, Port Blair, which involves lining by Silpauline covered by reinforced plaster (1:6) on sides and 15 cm thick soil layer at bottom.

Integrated farming system (IFS) for medium upland valley:
The normal cropping system was Paddy-vegetable-vegetable, Paddy- sugarcane, Ginger- leafy vegetables-ginger, vegetable-vegetable-vegetable, coconut, areca nut + black pepper along with dairy and backyard poultry. But no resource flows were observed between the crops or components. Modifications were made on existing cropping pattern based on resource availability, market demand, and integration of fish, poultry and diary.

IFS for medium upland valley

In this system, 0.90 ha was used for cropping and 0.036 ha was allocated for fishpond cum poultry shed. The polyculture fingerlings are preferred for this system because growth rate of fishes is more as compared to monoculture. In the pond, 200 fingerlings were released in an area of 0.036 ha. No other feed was added apart from poultry droppings and farm waste. **Ducks** and **Guinea fowl** were also integrated into the system. Duck has been introduced to check the unwanted fish called **tilapia** and **guinea fowl** is reared for meat and to control of weeds, snake, and pests in the field.

Integrated farming system (IFS) for low-land valley areas:
In these types of land, the paddy fields should be properly bunded to store the rain water. Balanced water management by systems of ridges and furrows are the basis of these systems.

Water budgeting for success of integrated fish farming
Integrated farming or integrated production is an integrated approach to farming as compared to existing monoculture approaches. It refers to agricultural systems that integrate livestock and crop production and may sometimes be known as **Integrated bio systems**. Livestock and poultry manure are the organic fertilizers and good for fish farming.

Water budgeting is the amount of water we get from the rain and the amount of water we use in our day to day life. It represents trend of water availability and water requirement according to the anticipated availability and proposed usage i.e. indoor and outdoor requirements. Water budgeting in development of IFS will certainly pave the way to understand the water requirement of each component in the system. The concept of water budgeting is to describe the relation between production and water loss, is the ratio between dry matter produced and the amount of water evaporated and transpirated.

Water Harvesting and resource development in A & N Islands

Watershed management programme provides attention for development and management of dry land/ rain fed areas, wastelands and degraded lands for sustained production and enhanced biomass. Water resources are affected after tsunami hit these Islands. Due to which the fertile soil is lost through run off to the sea which settles in the coral reefs and affects the life of flora and fauna of the islands. Despite of large rainfall farmers face problems for water for irrigation and domestic use in post monsoon period (December to April) almost 50 to 70 percent of rainwater which is being lost as run off can be conserved in the form of small storage structures across suitable watersheds. By using **Salayur watershed**, which is of 266 ha and has a capacity to store surface water through construction and rejuvenation of percolation ponds, construction of check dams and desilting of existing water harvesting systems in the watershed. This helps in increase of ground water table, perenniality of wells, and recuperation/ water yield that ultimately resulted in increased area under irrigation and crop diversification.

1. **Ex-situ rain water harvesting**
   The drainage network of A & N islands should be used for developing the water resource plan. A three tier water resource development plan should be developed on a drainage line. This includes **Plastic lined tanks** on the top of the hills, recharge structure cum system in mid hills and development of open dug wells in the valley areas. These technologies are successfully practised at CIARI, Port Blair.

Plastic lined tanks

2. **In mid-hill** areas, recharge structure cum well system can be adopted for water resource development. Small ponds or check dams can be constructed in the stream itself at appropriate sites where storage of about 1000-5000 m^3 can be created. The surface storages can be used for providing water for initial period of dry season whereas water from dug well can meet the water requirement in the rest of the season. This system has been constructed at **Garacharma** farm, CIARI. At **Sippighat** farm, CIARI also has the drainage lines which are used for irrigation of about 20 ha of plantation crops. In **Manjeri** village, gabion structures in the stream has enhanced ground water recharge which is used to irrigate 7 ha vegetables land and also used for domestic purposes.

3. **In-situ rainwater harvesting**

   In A & N Islands, about 8,000 ha of land is coastal low-lying land out of 50,000 ha cultivable land. The coastal land faces problem during monsoon season where water logging occurs and during post-monsoon season, very less water available for irrigation. So, in low-lying areas farmers are using land manipulation techniques like BBF, rice-cum-fish culture and ridge and furrow system.

CONCLUSION

Freshwater aquaculture can be a well-paid business in Andaman and Nicobar Islands due to its high demand and also offers sufficient employment generation to rural youth thus can serve as an excellent source of livelihood improvement. Proper management practices and appropriate marketing strategies have to be done to educate the farmers in order to make freshwater aquaculture as a commercial business in these islands. An integration of agriculture with aquaculture can be achieved through land shaping activities which can offer maximum profit to the farmers. As the market potential of fisheries is very high, freshwater aquaculture will definitely serve as an excellent source for livelihood enhancement of the farmers of Andaman and Nicobar Islands. Moreover, the development and management of wastelands through Integrated Watershed management with active participation of local community is a successful method. Water harvesting structures have contributed in enhancing the productivity and production of agriculture, livestock and other sectors in the watershed. This has helped in capacity building of local level people’s institutions to ensure smooth take over and future maintenance and sustenance of the programme. Since A & N Island is blessed with both the south west and north east monsoons, the rain water id available for 9 months in a year. Taking this opportunity, water harvesting technology must be attempted by ths farmers of A & N Islands in order to increase agricultural production, not only in terms of rice production but also vegetables and freshwater fish culture which will increase their socio-economic level and also increase production level decreasing import of agriculture products from the mainland.

The integration of fish culture with livestock and agriculture needs to be seriously viewed because this activity can go a long way in the uplift of rural life through manifold increase in return on investment. Although the information concerning production data does not exist, it appears that with proper management and technical skills, integrated farming could become a profitable and viable industry in a country like ours where the economy is largely based on agriculture. Integrated fish farming offers tremendous potential for food security and poverty alleviation in urban and rural areas. It is an efficient way of using the same land resource to produce carbohydrate as well as animal protein and important micronutrients concurrently or serially. It is the optimization of available natural resources use, diversification of income generating activities. It also helps in improvement of soil fertility and pest control with less use of chemicals (pesticides, fertilizers).

Technical Paper - 19

DIVERSIFICATION OF SPECIES FOR AQUACULTURE IN WATER DEFICIENT AREAS

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Introduction

India is endorsed with very rich freshwater fish diversity, harbouring more than 750 species and rich freshwater fishery resources, comprising 2.3m ha ponds and tanks, 1.3 m ha of beels, jheels and derelict waters and 3.0 million ha of reservoirs. Despite these, India's freshwater fish production is almost a stand still over few years, ranging from 2.0-3.0 million tonnes. It was calculated that India's freshwater fish production potential is around 6 million tonnes. The demand for fish however would increase in the coming years and at the present level of GDP, the demand will be around 9.5 million tonnes. This means the country has to almost double its fish production by 2020 A.D. in order to supply fish at the present level of fish consumption. The production levels from 1951-2010 reveal that the share of marine fisheries has decreased from 70 % to 66% whereas; Inland sector has increased from 30% to 48% indicating the potential of inland sector. The share of inland fisheries sector increased to almost 50% in 1998-2010. However, the ever-increasing population needs more fish in the coming days. Aquaculture holds the key for fish production in the country. But in recent years the scarcity of water became one of the main issue in agriculture in general and aquaculture in particular. In this juncture, the researchers opened up new areas for the technologies that suits to culture of the fishes with low volume of water.

Freshwater aquaculture in India

The freshwater aquaculture water resources of the country are huge in terms of 2.3 million ha of ponds and tank and 1.3 million ha of beels, jheels and derelict waters, in addition to 0.12 million km of canals and 3.0 million ha of reservoirs, that could be put to different fish culture practices or even culture-based capture in case of large water bodies.

Carps, catfishes, prawns and mussels form important components of culture practices in the country in terms of cultivable species and shellfish. India being basically a carp country, about 90 percent of current aquaculture produce comes from the culture of Indian major carps viz., catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*) and Chinese carps, silver carp (*Hypophthalmicthys molitrix*), grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*). In India, Catla, rohu and mrigal, are predominantly cultured and diversity of species taken up for aquaculture is comparatively less. With the present utilisation of species and the coverage of area, for increasing aquaculture production, we have to explore the possibilities of introducing new potentially cultivable species to aquaculture system, where water resources are less.

Potentially cultivable species for aquaculture

Though there are a number of potentially cultivable and economically important indigenous species *viz*., *Labeo bata*, *L. dussumieri*, *L. calbasu*, *L, gonius*, *L. fimbriatus*, *Barbodes carnaticus*, *Cirrhinus reba*, *C. clirrhosa*, *Puntius pulchellus*, *P. sarana*, *Pangasius pangasius*, *Aorichthys aor*, *A. seenghala*, *Wallago attu*, *Horabagrus brachysoma*, *Channa marrulius*, *C. punctatus*, *C. striatus*, *Clarias batrachus, Heteropnuestes fossilis, Anabstestudineus* etc., which fetch higher price in several parts of the country, contribution of these species to aquaculture production is negligible. Some of the native food fish species of regional importance, its advantages and knowledge gaps are given in Table 1.

Table 1: Native food fish species for region-specific aquaculture

Species	Advantages	Key knowledge gaps
P. sarana subnasutus	Reaches up to 1 kg; preferred minor carp; fetches better price; captive breeding protocols available; reproductive biology studied.	Culture aspects to be studied in detail
Horabagrus brachysoma	Reaches up to max. 1.5 kg; preferred catfish in Kerala; fetches better price; captive breeding protocols available; reproductive biology studied; stock structure studies carried out; juveniles ornamental.	Culture aspects to be studied in detail
Channa spp.	Reaches up to max. 3.0 kg (*Channa marrulius)*; preferred fish in Kerala; fetches better price; captive breeding protocols available; reproductive biology studied; stock structure studies carried out; juveniles ornamental.	Mass production of seed and its rearing technology is required
Clarias dussumieri	Reaches up to max. 3 kg; captive breeding protocols available; reproductive biology studied;	No information on abundance, distribution
Clarias batrachus	Reaches up to max. 300 g; highly preferred by local people; fetches better price; captive breeding protocols available; reproductive biology studied;	Mass production of seed and its rearing technology is required
Heteropnuestes fossilis	Reaches up to max. 200 g; highly preferred by local people; fetches better price; captive breeding protocols available; reproductive biology studied;	Mass production of seed and its rearing technology is required
Anabas testudineus	Reaches up to max. 200 g; highly preferred by local people; fetches better price; captive breeding protocols available; reproductive biology studied.	Mass production of seed and its rearing technology is required

Among minor carps, *Labeo calbasu* is having wider distribution and relatively faster growth rate and is already a minor component of composite fish culture in several parts of the country. Information on reproduction biology, feeding and production of hybrids were available. Despite this, the species did not get much attention in culture system. It may be due to lack of studies regarding specific requirement of this species in culture system. *Labeo bata* and *Cirrhinus reha* are two economical important fish species, which are having commercial culture potential. Though the growth rate of these fishes is less, these are highly preferred in West Bengal and North East India, even if the fish sold less than 100 g in size. The importance of diversification of aquaculture with minor carps viz., *Labeo bata* and *Cirrhinus reba*. Was alreadt stressed. Central Institute of Freshwater Aquaculture (CIFA) has also done induced breeding of *Labeo bata*. Efforts have also been made by other workers to grow the fish in sewage fed ponds. However there is no package of technology for farmers for culture of these species either in monoculture or composite culture.

Puntius sarana is another species, which is having potential for culture and enjoying wider distribution. This fish attains up to 400 g in size and fetches higher price in market. Though biological aspects of the species have been studied, no report on induced breeding is available.

Among the major catfishes, *Aorichthys seenghula*, *A. aor*, *Panagsius pangasius* and *Wallago attu* are important species which can be taken up for culture. Research on these target species is limited to food and feeding and biology. CIFA had done some studies on breeding and culture of *Wallago attu* and *Pangasius pangasius* with limited success.

Culture of air breathing fishes

Air breathing fishes such as giant murrel *Channa marulius,* stripped murrel, C. *striatus* and spotted murrel C. *punctatus, m*agur *Clarias batrachus,* singhi *Heteropneustes fssilis* and koi *Anabas testudineus* can be cultured in low volume waters. The advantage of air breathing fishes include shallow waters with a depth upto 1 m, no chemical fertilization, amenable for cage culture in running water systems like streams, canals and unmanageable waters like reservoirs and those water bodies unsuitable for conventional culturable species of carps as well as in carp culture ponds. Shallow ponds are useful for fishes, in which the fish has to spend less energy in raising to surface for intake of atmospheric oxygen. These fishes even can be cultured in derelict waters.

Channa is one of the important species which can be cultured in low volume waters. Murrel culture started in CIFRI in All Indian Co-ordinated Project of Air breathing fishes is now about four decades old in our country. Further, Centre for Aquaculture Research and Extension (CARE), Palyamkottai, Tamil Nadu developed technology package for murrel culture and successfully demonstrated. The system developed and adopted involves all aspects of murrel culture *viz*., brood fish nutrition, mass seed production, rearing of young ones and culture. The CARI is providing training on commercial murrel culture to fish farmers. Some of *Channa* speces, *Channa murrulius* can grow up to 3.0 kg in culture conditions. The breeding and culture technology is available for culture of all species of *Channa*. It can be cultured even in small, plastic lined, earthen ponds of different dimensions (20 m x 5 m x 1 m). Ponds are filled with water for a maximum depth of 1 m and the cultured murrels attain 300-500 g in 6 months with 70-90% survival.

Exotic species

The other possibility to increase production from freshwater is the introduction of fast growing exotic fish species, for which, proven technology of breeding and culture is available. A number of species introduced in India for aquaculture production.. However, the consumer preference is a problem for these species in several parts of the country. Farmers are in search for those species, which are fast growing, more profitable and consumer friendly.

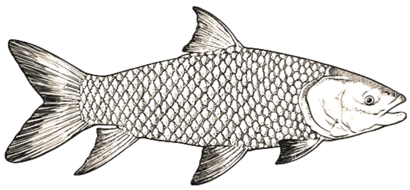
During the late 1990s, African catfish (*Clarias gariepinus*) and Malaysian catfish (*Pangasius sutchi*) introduced in India, illegally by farmers in several parts of the country. The advantage of African catfish is that it is a fast growing species and can thrive in adverse water conditions. Malaysian catfish is also a fast growing species and in many parts of Andhra Pradesh the species is being cultured successfully. However, there are lots of problems persisting regarding exotic fishes. In several water bodies where tilapia got established and totally changed ecology of water bodies. In some places, it is replaced native fish species. Govt. of India has banned *Clarias gariepinus* for culturing in India, for safeguarding native fish species. In recent survey, it was found that in several water bodies fishery of this species is thriving. Though *Pangasius sutchi* is thriving well in freshwater, there was no report of escape this species to natural water bodies but this species is not legally permitted for culture yet. A review on 1354 purposeful introductions of exotic fish into inland water has indicated that 73% had little or no effect on the receiving systems because they were unable to spawn naturally or became established to a limited extent, 3% went through boom and bust cycles, 17% became established with beneficial or neutral effects, and only 7% had discernible harmful effects. As many fishes introduced in India, it is very difficult to take decision, whether the species to be cultured continuously, as there is no or enough data is available on deleterious effect of the introduced fish.

Conclusion

We have a number of potentially cultivable species which fetch higher price than major carps in many parts of the country. Major problem for taking up the indigenous species for culture is lack of breeding technology and steady seed supply of these species. Culture technology as well as detailed growth studies are also lacking for most of these species. More studies are required on breeding, seed rearing and culture of these species. The need of the hour is the proven technology of captive breeding and rearing for economically viable operation and easy for application.

Consumer preference and marketability is also one of the problems for taking up the species for culture. States like, Andhra Pradesh and West Bengal produce Indian major carps and catfishes (mostly *Pangasius sutchi*) but their domestic market is limited and they have to find out market outside their states. State like Kerala is having less preference towards major carps and developing major carp based culture may not be economical. In such places, indigenous species, like *Etroplus* or murrels may be preferred. A new species may be introduced, whether indigenous or exotic fishes preference may be studied, so that there will not be any problem for marketing.

Though we have number of technologies for higher fish production, the real impact of tedchnologies have not been studied in detail. The use of water for aquaculture is not quantified properly. There are many species available but proper biology, breeding, seed production and commercial feasibility studies are not carried out. Farmers have to be trained to take up such species which needs less water and less area for culture. Murrel and magur are the best examples. Even if we have technologies such as use sewage for aquaculture, it is not properly implemented in the country. If such technologies, properly implement in the country we can double our aquaculture production.



Technical Paper - 20

WATERSHED-BASED FISHERIES DEVELOPMENT TO PROMOTE FISH PRODUCTION IN WATER DEFICIENT REGIONS IN INDIA

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Introduction

The status of fishes and fisheries resources need to be understood by all the stakeholders. The very existence or survivability and sustainability of fishes, their habitats and fisheries resources invariably depend on the interactions between upland watersheds and downstream reaches.The righteous management of catchment and its components including the drainage lines, rivers and other aquatic resources *per se* through effective soil and water conservation measures, conservative farming technologies and policy refinements are essential to improve health of watersheds, water resources and rivers. Thus, Integrated Watershed Management (IWM) has emerged as an effective tool for conservation of natural resources, particularly the soil and water and rural development to cope with the increasing food and fodder demands of human and animal population and declining resource base. It has been well recognized in the present political and administrative system of India that participatory IWM has potential to achieve holistic development of agriculture and allied sectors. Most of the watershed management programmes give solution to address water scarcity, drought, problems of rainfed farming etc.

Fish production under watershed management programmes can be an incentive for resource conservation, as it constitutes an additional benefit to the local community. Any thrust to promote watershed-oriented aquaculture and fisheries activity would optimize planning of land water resources. The opportunities for water harvesting and fish farming under IWM are immense especially in medium to very high rainfall zones (750-2500 mm). Prevailing agro-climatic conditions of most region of the country allow 6-9 months of fish culture in small earthen dams or Water Harvesting Structures (WHS), which can produce 3.5-4 t ha^{-1}. Even if a fraction of the harvestable water is used for aquaculture may be in integration with other sectors of development, protein requirement of every watershed will be realized to a greater extent. However, risk of water scarcity, especially after 33rd week of the year or summer is experienced in western Himalayas. Similarly, fish farming potential in harvested water may be limited where scanty rainfall-runoff yield exist particularly in arid and semi-arid regions (50-750 mm rainfall), ravine lands (700-800 mm rainfall) and Bundelkhand regions (750-1200 mm rainfall).

About two decades of watershed-based fisheries research and development at Central Soil and Water Conservation Research and Training Institute (CSWCRTI), ICAR, Dehradun have evolved or refined technologies for identification, characterization and management of fisheries-sensitive watersheds and streams for their conservation and fish based farming technologies. The Fisheries Section at CSWCRTI has advanced the knowledge on traditional farming, fishing and their impacts on rivers & watersheds and introduced Watershed-based Fisheries Development Plans (WFDP) in India as a new approach with immense potential for development of water resources and fisheries, especially in mountainous, water deficit and fisheries-sensitive watersheds.

A plea to include fisheries aspects in water, watershed and river management programs is tagged to various programs of CSWCRTI, which continuously advocates the WFDP to the stakeholders of water resources. Giving thrust to incorporate fisheries in watershed management programs would comprehend the ongoing and forthcoming resource conservation, watershed management and rural development programs that are executed by various agencies under different schemes with huge financial outlay could mutually benefit both fisheries production and the performance of the programs as such. In this pursuit, the CSWCRTI offers regular long-term and short-term tailor-made training programs on WFDP to various stakeholders and organizes a conference with the focus on farmers in March 2014 at Dehradun.

An attempt has been made in this paper to assess the water yield potential and consequently the scope of fish farming in various agro-ecological situations in the context of enhancing fish production through IWM programmes along with the needed research, policy and strategies to improve fisheries production. The need to incorporate fisheries dimensions into ecosystems and water management approaches has been discussed drawing references and projections made for western Himalayas.

Till recently, fisheries production in water deficit areas was mainly addressed by non-fisheries professionals, general farmers and water or resource conservationists, who in general have inadequate knowledge and many myths on fisheries development (Muruganandam *et al.,* 2011; Muruganandam, 2014). Also, the quantity and quality of the goods and services from the available water resources are greatly affected by the growing water stress, which is predicted to increase up to 60% by 2025 globally including India (except Brahmaputra basin and few elsewhere) by World Water Vision. One of the most pressing problems is decreasing dry season stream flows and perennial springs becoming seasonal or even drying up entirely in most parts of the country. At the present rate of exploitation and resource degradation, within few couple of decades existing water resources would have completely depleted (Anantharaman and Sehgal, 1998). All these imply that even in Himalayas (Water Tower of India) water stress would occur as seen prominently in Himachal Pradesh (HP), Jammu and Kashmir (JK) and Uttarakhand, where number of springs are reported to dry (Kelkar *et al.,* 2008) which would affect necessary environmental flows or ecosystem and deprive sustainability of fisheries as well. At this context, this seminar on fisheries development in water deficit area by the Fisheries Technocrata Forum, Chennai and the fisheries professionals is rightly conceptualized.

The existing fish supply-demand gap suggests the need for many-pronged strategic approaches and effective research and development interventions to generate innovations, transform the fisheries sector and boost fish production by expanding area, improving technologies and strategies of fish farming through various means such as application of biotechnological principles and promotion through IWM. Introduction of fish farming suitably into existing farming systems or with little modification, it can alleviate food related problems like prevalent malnutrition that are rampant in the whole of Asia and increase the present national per capita food grain productivity (220 kg). The seemingly unattainable proposition of the 1996 World Food Summit's target of halving the number of hungry people by 2015 and the first Millennium Development Goal of halving the prevalence of hunger and poverty (Prasad, 2009; Wani *et al.,* 2009) can materialize if watershed-based fish farming and fisheries management are considered. The existing interface between stakeholders of water and fisheries resources, the need of effective Integrated Watershed Management Programs (IWMP) and WFDP, categorical needs of technological, policy and societal reforms for fisheries development including developmental & extension needs, policy reforms, fishing regulations and rivers management, institutional support, research needs, capacity building and the experiences at the CSWCRTI are discussed in Muruganandam *et al* (Undated).

About two decades of watershed-based research at Central Soil and Water Conservation Research and Training Institute (CSWCRTI), ICAR, Dehradun have evolved or refined many technologies for soil-water conservation and integrated farming. Also, the institute has advanced the knowledge on traditional farming, fishing and their impacts on watershed basis. The accrued knowledge at the CSWCRTI have been shared with various stakeholders including developmental agencies, farmers etc. through different outreach programmes. Considering the limited research on the long neglected potential of fisheries development especially under watershed perspectives and the importance of water deficit region for fish production, the present review was undertaken. A plea to include fisheries aspects in to water, watershed and river management programmes has been tagged in the communication.

Potential of micro-water harvesting

Although, India's water availability in various forms is reasonably good (Table 1) as it receives 117 cm of average annual rainfall, which is **LITTLE ABOVE** the world average (110 cm) the per capita water availability in India has drastically reduced from 5300 m^3 in 1955 to 1700 m^3 in 2000 owing to population pressures. Watershed management and water harvesting from the available potential (Table 2) are widely suggested to mitigate the water stress. The water harvesting largely implies small-scale concentration, collection, storage and use of rainwater/stream water for both domestic and agricultural purposes. The water harvesting can be suitably achieved through various kinds of impoundments like dugout or embankment ponds and off-stream ponds. The water harvesting potential is higher if decentralized network of WHS (with more number of ponds in series or in-groups) is used than a single larger pond. Since construction of micro-WHS would suffice the local water demands, water needs from other sources and ultimately the debated problem of surpluses or deficiencies of water in basins may be greatly reduced.

Table 1. Water resource availability in India

S.No.	Water resource availabilityin India	Quantity
1.	Average annual surface water resources	1869 billion cubic meter (bcm)
2.	Utilizable surface water resources	690 bcm
3.	Annual replenishable (dynamic) ground water resources	432 bcm
4.	Total utilizable annual surface water and groundwater	1122 bcm
5.	Average annual precipitation	4000 bcm
6.	Average monsoon precipitation	3000 bcm
7.	Per Capita Water Availability India Tamil Nadu Brahmaputra basin World average Asian aaverage	2200 m^3 380 m^3 18,400 m^3 7400 m^3 3240 m^3

Source: Compiled

The water harvesting and water resource augmentation at micro level (watershed) would provide opportunities for water-based developments on one hand and reduce water abstraction for various purposes and flood potential in higher-order streams in the downstream reaches on the other. Micro-water harvesting along with drainage-line treatment and stream stabilization would ultimately help to reduce silt load and water contamination in higher-order rivers that serve the country in many ways. Albeit watershed ponds have many inherent advantages, they may have some disadvantages also thereby restricting organized fish culture, which need scientific solutions or management.

Table 2. Water Harvesting potential in different regions of the country

Sl. No.	Region/location	Approx. catchment (ha) needed for 1 ha-m water yield	Reference
1.	Bundelkhand region: Catchment with flat lands Catchment with sloping lands	25 12.5-16.6 3 - 6 (from 10-70% storm wise rainfall)	Sharda and Ojasvi (2005) -do- Tiwari *et al.* (1999)
2.	Southern hilly region	8 - 20 (from 14-67.8% of annual rainfall)	Sharda and Ojasvi (2005)
3.	Northwestern Himalayas	10 (from 10-20% of total precipitation)	Sastry *et al.* (1981) Samra *et al.* (1996)
4.	Northeastern Himalayas (Barapani)	1.95 (from 19.9% of annual rainfall (2130 mm))	Sharda and Ojasvi (2005)
5.	Red soil region	40 (from May rains)	-do-
6.	Shiwalik region	4-7 (15-50 % of 82% monsoon rainfall)	Samra *et al.* (1996)

The potentials of water harvesting and fish production: Projects from Uttarakhand

Watershed ponds are found to be suitable for both composite carp culture towards table size fish and raising fish fingerlings/yearlings from fries either simultaneously or subsequently depending on demands and water availability. Practically, aquaculture needs abundant non-consumable water, which provides justification and opportunity for water resource generation and its conservative utilization. Indeed, aquaculture induces WHS and *vice versa*. In turn, WHS improve hydrological cycle and resource base in watersheds. Besides tangible benefits of cash and fish protein, many intangible benefits like improvement of water quality, pond ecosystem and species endangering pressure in wild aquatic environments can be realized from fish culture. Accounting all nominal fish production potential of 30,532-34,420 t including the present fish production range of mere 2,534-6,422 t year^{-1} would not meet the empirically estimated demand of 41,127 tonnes for 50% of the >7 years-old fish consumers based on average recommended consumption rate of 200 g per individual per week and leave a deficit of 6707-10,595 tonnes annually.

The present highest production level of 6422 tonnes in Uttarakhand is over 6 times lower than the demand of 50% of fish consumers in the State. The composite carp culture and paddy-fish culture under IWM programs can narrow down the supply-demand gap since they yielded 4.5 t ha^{-1} year^{-1} and 0.6 t ha^{-1} year^{-1}, respectively in Garhwal Himalayas (Photo 1 and 2). An empirical projection on water harvesting potential based on published information indicated that about 52,662 ha-m of rainwater can be harvested even if 10% of the total catchment area and the reported rate of 1 ha-m water yield from every 10 ha of catchment in Dehradun (Uttarakhand) are considered, which would produce a total of 1,18,490, 59,245 and 23,698 tonnes additional fish per annum at50%, 25% and 10% of the experimentally observed average fish production rate (4.5 t ha-m^{-1}), respectively. Considering the existing limited assured irrigation facility and land constraints, paddy-fish culture can be integrated in at least 5% (14,411 ha) of the total paddy fields (2,88,225 ha) present in Uttarakhand, which would produce about 4,300 t of additional fish at 50% (*i.e.,* 300 kg ha^{-1}) of the production achieved in experiments.

The existing or projected demand can be met by either increasing the area of production from 10% to 20% of harvested water or by increasing the production potential to 20% of the observed production. Fish demand of 50% consumers (41,127 t) may also be achieved if the ultimate potential of the State contemplated (44,000 tonnes) in NABARD (undated) is realized mainly by harnessing running water area for trout production and low-lying area in plains for carp production in Uttarakhand. The projected total fish production of 1,18,490 tonnes from 10% of the harvested water area at 50% production level of the observed potential would meet the demand of 90% of >7 years-old fish consuming population of the State leaving a surplus of 36,235 tonnes for export to other regions. Further at national level, if a fraction of about only 20% of the projected water resources developed (4.8 M ha-m) as contemplated is used for fish culture, an additional yield of about 2.4 million tonnes annually in the country is possible even at a modest rate of 0.5 tonne ha-m^{-1}.

Photo 1. A watershed pond in Doon Valley for multiple uses

Photo 2 a-d. Fish harvested from a watershed pond in Doon Valley: Incentive for resource conservation

Regional observations on fish farming in harvested water

Based on the extensive field surveys on regional performance of watershed-based fish culture and expert judgment accounting for prevailing strengths and weaknesses in different agro-ecological situations, logical conclusions on the status of limitations *versus* opportunities have been drawn (Muruganandam and Sharda, 2007; Table 3). The water harvesting and fish farming have wide range of potential and suitability in different agro-ecological situations of the country. The opportunities are immense especially in medium to very high rainfall zones (750-2500 mm) including northwestern and northeastern Himalayas, Shiwalik regions and hills in southern peninsular India.

Generally, from every 5-10 ha watershed area, 1 ha-m water can be harvested in high rainfall regions. Often, 2 or 3:1, watershed: pond ratio is also possible in areas where high rainfall occurs. However, fish farming potential in harvested water may be limited in arid and semi-arid regions (50-750 mm), ravine lands (700-800 mm) and Bundelkhand regions (750-1200 mm). In areas having high opportunities, various fish farming techniques should be promoted. In areas where limitations outweigh or equal the opportunities, planned introduction of short-duration fish culture activities like fish seed production in watershed ponds that contain water only for a brief period of 3-4 months after monsoon rainfall can be undertaken.

Watershed-based Fisheries Development Plans (WFDP): A proposal

Despite the potential, fisheries sector has suffered a neglect in the past ignoring the untapped potential for food production and income generation nationally. Majority of the existing water resources and ponds are not used for fish production optimally in the country. Despite the presence of good amount of water yield and economically viable and ecologically sound fish farming technologies suitable for WHS and harvested water (Muruganandam and Sastry, 1997; Muruganandam and Samra, 2001; Muruganandam and Sharda, 2007; Muruganandam, 1999; 2010), fish farming interventions and management of aquatic ecosystems have not been adequately emphasized or accommodated in IWDP executed in the country.

Survivability and sustainability of fishes and fisheries resources invariably depends on the righteous management of catchment, land resources, farming activities etc. through effective soil and water conservation or management interventions besides the management of drainage-line, rivers and other aquatic resources *per se*. In effect, existence of fishes and their habitats depend on management of catchment and their resources. The challenge of improving fisheries lies in bringing out meaningful strategies and workable action plans making necessary adjustments in agricultural production systems, keeping in view the social and developmental priorities, needs and traditional wisdom of people. The gap in potential and production or demands and supply of fisheries resources, especially in under-developed regions like Himalayan States and water deficit States or regions like Rajasthan, parts of Andhra Pradesh, Tamil Nadu, Karnataka, Orissa and Bihar and rainfed or dry land areas warrants multifarious developmental plans, which again necessitates comprehension, categorization and management of aquatic resources by all the stakeholders. This can be achieved through IWMP, which normally internalizes ecosystem principles and approaches.

The IWMP aims to control soil erosion, silts and sediments reaching river courses or water bodies, land degradation and extension of torrents and improve productivity of arable or stabilize non-arable lands. Also, optimum use of water resources, marginal lands and farming opportunities through integration of various farming systems or components incorporated effectively into existing land-use pattern as innovative multi-tier farming for production of multi-commodities from common infrastructural bases is contemplated. In the IWMP, multi-tier, ridge-to-valley approach progressing from first-order streams to higher-order rivers and integration of various bioengineering structures for soil-water conservation (Gabion structures, check dams, retention walls, spurs, retards, stonewall, vegetative barriers, geo-jute layering, water harvesting ponds etc.) or approaches and practices for conservation or accommodative agriculture with low inputs in arable & non-arable lands, grassland & protective forest-cover management, development of agro-forestry, Integrated Farming Systems (IFS) etc. involving various disciplines are usually planned or accommodated to sustain benefits out of available or developed resources.

Accommodation of fisheries issues in water or watershed management programs promote thrusts to reduce loss of soil and water resources, water harvesting etc. in watersheds and river management, which in turn improve health of watersheds and rivers benefiting many other production avenues. Here, strengthening of fisheries management capacity, especially under IWMP is another fundamental need in developing countries like India, particularly at a time when increasing population growth and declining natural resources are experienced. Overall, multidisciplinary experts and various stakeholders including farming communities and government machinery who plan or execute various activities in the catchment need to consider the plight of fishes and fisheries resources and cooperate radically to bring multidisciplinary interventions in catchment, drainage-line and aquatic resources towards the betterment of society and environment. The WFDP introduced in British Columbia (BC), Canada as a new approach to the management of fish stocks and fish habitats in 2001 (Tamblyn and Croft 2003; Muruganandam, 2012) is worth emulating to India and the water deficit region. In the plan, watersheds, associated processes and inter-connections of both in-stream and upland are planned and managed with “fish first approach”. Trade-offs between upstream and downstream is internalized in the approach, wherein the restoration or management of streams or watersheds and opportunities within them are identified for promotion of sustainable fisheries development.

The approach recognizes that ecological, social, political and economical factors influence the status of fishes and habitats, which need categorical consideration. The WFDP is necessary since watersheds, rivers, oceans and all aquatic ecosystems are interconnected through upstream-downstream cords and riparian-upland ecosystems affecting one another and in-stream conditions. Various basins, watersheds, habitats, fish species etc. need to be prioritized under WFDP for protection, restoration and sustainability enhancement with the principle of “**prevention is better than cure or restoration**”.

composition of aquatic organisms and other biotic components. More specifically, fisheries-sensitive watersheds and streams or rivers maybe identified by looking at the presence of erosion-proneness, excessive water yields or runoff potential, rich fish resources and fish demands for their specific and categorical management. The needed effective IWMP and WFDP along with the immediate needs of multi-dimensional interventions, technological, policy and societal reforms for fisheries development and the contributions of the CSWCRTI are detailed in Muruganandam *et al.* (undated). The following general recommendations may be considered to increase fisheries production.

General recommendations for fisheries development

Policy issues for State Governments

1. **Value addition of water harvesting structures & ponds:** Partitioning of bigger size ponds over 2 ha for easy management, strengthening bunds, strong & tall inlet & outlet net lines in required heights, provision of tube well or supplementary water source, water diversion channel for safe disposal, if surplus water exist, small nursery pond near main pond, approach road, outdoor entertainment facilities like boat etc.
2. Fish farming should be brought under agriculture to use electricity and canal or irrigation water at a concession rate instead of commercial & industrial purview and values.
3. Suitable insurance provisions should be devised to tackle eventualities like that of the heavy loss incurred by all pond or lease owners during last year (2013) due to flood in Uttarakhand.

Recommendations for research organizations

1. Research to promote fish farming in irrigation canals, small streams (*gad* and *gadhera*) and reservoirs suitably by providing engineered structures like cages, net barriers, supports and flow regulators to accommodate fish farming.
2. Evaluate, demonstrate and promote situation specific IFS technologies including all suitable components. Farming of trout in upper mountains, catfishes and other suitable fishes in plains, required farming & marketing facilities, farming of local cold water species like masher, snow trout and spiny eel need to be further researched in Uttarakhand.

Recommendations for extension agencies

1. Input support: Supply bigger size fish seeds or yearlings for nominal stocking density of 1-2 per m^2 and reschedule culture period to March-Dec. instead of usual July-Dec.
2. Expand training programs to include various tailor-made courses to introduce & improve fish farming activities in new and existing ponds or tanks.

Conclusion

Innovations, technologies and policy refinements towards water conservation or management are the needed continuum. The existence of fishes and their habitats depends on righteous management of catchment and their resources besides the management of drainage-line, rivers and other aquatic resources *per se*. Thus, multidisciplinary experts and various stakeholders including farming communities and government machinery need to consider the plight of fishes and fisheries resources and cooperate radically for the betterment of society and environment. The Watershed-based Fisheries Development Plans (WFDP) and participation of local people seem to have immense potential for development of water resources and fisheries in India, particularly in water defiant region. At present, various components of the WFDP are executed in bits and parts by various agencies or groups in India, which needs consolidation through concerted effort towards the unified approach. Normally, above 3rd-order rivers are subjected to intense fishing with the maximum in 5th-order onwards, particularly in Himalayan region and hence they are more important for fishing and fisheries management. Nonetheless, all the streams or rivers need to be managed including the feeder or lower-order streams since they contribute immensely to higher-order Rivers for their geomorphic conditions, riparian features, water chemistry, flow characteristics, sediment regimes, nutrients, silt loads,

Table 3. Strengths-weaknesses for water harvesting and fish farming in various regions of India (Muruganandam and Sharda 2007)

S. N.	Region	Rainfall (mm)	Major areas (States/regions)	Major weaknesses for fish farming in harvested water	Major strengths for fish farming in harvested water	Status of limitations *Vs* opportunities
1.	Arid and semi-arid regions	50-750	Rajasthan and part of Maharashtra (Mah.), Gujarat, Madhya Pradesh (MP), Uttar Pradesh. Bihar and Deccan plateau	Scanty and erratic rainfall High intensity showers in brief period Poor or brackish underground water Uneconomical WH High evaporation losses (50-90%)	High intensity rainfall favoring WH.	Limitations outweigh opportunities Need strategic planning
2.	Black soil region	750-1200	Central peninsular India (Parts of Maharashtra, MP, Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu (TN), Rajasthan and Orissa).	Seepage rate (1-10 cm/day) Evaporation losses	Medium to high rainfall Low infiltration rate	Limitation equal opportunities Need planning
3.	Bundelkhand region	750-1200	6 District of Madhya Pradesh and 5 Districts of Uttar Pradesh	High evaporation losses (1400-1700 mm), greater than annual r/fall	Low infiltration rate Medium to high rainfall	-do-
4.	North-eastern Himalayan region (NEH)	1300-2800	Sikkim, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Tripura, and parts of Assam and West Bengal.	Extensive cold period High seepage Acidic red soils with low clay content	High to very high rainfall Sustained surface- and subsurface-water flow Situation of fish demands outweighing supply (90-100% fish eaters)	Opportunities outweigh limitations Need effective fish farming programmes
5.	North-western Himalayan region	500-3500	Jammu & Kashmir, Himachal Pradesh, hills of Punjab, Haryana and Uttaranchal	High seepage (up to 10 cm/day) Intensive cold period	High to very high rainfall Sustained surface- and subsurface-water flow through more number of springs/small streams (High drainage density) Brief colder period (2-3 months)	-do-
6.	Ravine region	700-800	Parts of Uttar Pradesh, Madhya Pradesh, Rajasthan, Gujarat and Bihar	High infiltration rate High seepage losses (up to 45 cm/day). Poor scope for farm ponds	Medium rainfall	Limitations outweigh opportunities
7.	Red soil region	830	Semi-arid parts of South India (Parts of Karnataka, TN, Andhra Pradesh)	High seepage loss (25-158 $l/m^2/day$)	Good fish demand	Limitations equal opportunities
8.	Shiwalik region	1100	Low range hills of Jammu & Kashmir, Uttaranchal, Punjab, Haryana and Himachal Pradesh	Steep slopes, sparse vegetation and resultant flash flood High seepage (up to 40%)	Good water yield Presence of more number of WHS (over 150 small water reservoirs)	Opportunities outweigh limitations
9.	Southern hilly region	500-6000	Regions in Western- and Eastern-Ghats (Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Orissa)	Not reportable	Good water yield Good fish demand	-do-

In the light of above discussion, the effective water harvesting and fish farming systems under IWM programmes are expected to provide massive nutritional security in the country either directly or indirectly if confronting problems are suitably addressed in a planned manner to harness available water resources for productive purposes. Watershed ponds that are developed for multiple objectives to achieve flood moderation, create sources for irrigation, recreational etc. can be very well put to fish farming with appropriate structural improvements or provisions. However, presently, inclusion of fish farming in IWM efforts is of very subsistence nature and this needs reorientation of watershed programmes and policy aspects to promote fisheries through renewed and effective approach.

Overall, regulation of fishing, stabilization of streams & rivers, development of situation-specific integrated farming systems, fish farming, value addition to existing ponds, water harvesting structures by providing proper inlet, out let etc., production & distribution of bigger size fish seedlings for culture, networking farmers and consumers to facilitate production & distribution of fish seeds & culture, marketing or market development for fish production and capacity building should become thrusts areas for WFDP. Policies for leasing of land resources, ponds or specific stretches of streams for farming or fishing need to be evolved. At present, various components of the WFDP are executed in bits and parts by various organizations or groups in India, which needs consolidation for unified approaches and organizations.Networking of all fisheries related organizations into a **single window agency**, provisioning of resources like water and power for fish farming at par with agriculture and reviewing of the Indian Fisheries Act, 1897 in line with needs of present days' development and relevance would help promote fisheries production in India.

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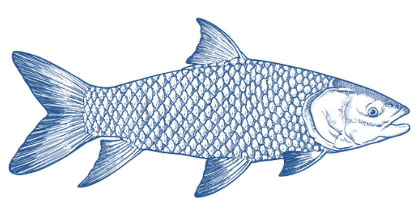

Technical Paper-21

TECHNOLOGICAL OPTIONS FOR OPTIMUM UTILIZATION OF FRESHWATER RESOURCES WITH SPECIFIC FOCUS ON WATER DEFICIENT AREAS

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Salient points from Power Point presentation

- Inland fish production from India: 2.8 lakh tonnes in 1960-61, increased to 56.32 lakh tones in 2012-13.
- West Bengal & Andhra Pradesh share in total inland fish production: 48.3 %; seed production shre 59.8 %.
- Assam, Odisha, Bihar & Uttar Pradesh: 26.1 %; seed production 22.2 %.
- Hill states: 2.3 %; seed production: 6 %.
- Other coast states: 10.2 %; seed production 6.7 %.
- Other states: 13.1 %; seed production: 5.3 %.
- 42 crores of Indian population eat fish (34.2 % rural; 27.8 % urban)
- Consumption rate 7.02 kg (rural) and 9.06 kg/capita (urban).
- Indian Council of Medical Research recommends 11 kg.
- Islands states: 13-45 kg; Kerala: 28 kg; Other coastal states: 12.7 kg; North-East states: 5-14 kg; Other states: 3-5 kg.
- Developed countries: > 25 kg/head/year; Japan 70 kg.
- Water resources in rain-fed areas: Community ponds, small reservoirs, farm ponds, rice fields, minor irrigation structures, streams & rivulets.
- Period of water: retention: 3 to 12 months.
- Present status of fish culture in rain-fed areas of Odisha: .Only 47 % of pond area under culture; poor fish yield (200-700 kg/ha); Ignorance of scientific farming; shortage of seed; non-availability of inputs such as feed, fertilizers, lime etc; multiple use of community ponds for domestic purpose and fish culture; conflicts with the irrigation or house-hold use of water.
- Technological interventions: Portable carp fry hatchery to meet the fry requirement of fish farmers; from 2-3 crors spawn, 1 crore fry can be produced, which is sufficient for 10 ha seasonal ponds for 1-month fry rearing; 30 lakhs fingerlings for 50 ha rearing ponds for 2-4 months, sufficient for 500-700 ha grow-out ponds.
- Women Self Help Groups involved in nursery rearing and grow-out culture.
- Govt. schemes to help rural livelihood projects.

Session III

STATUS, CHALLENGESAND STRATEGIESFOR THE DEVELOPMENT OF BRACKISHWATER FISHERIS IN WATER DEFICIENT REGIONS

Lead Paper -5

MITIGATIONS OF REDUCED WATER AVAILABILITY – BRACKISHWATER AQUACULTURE

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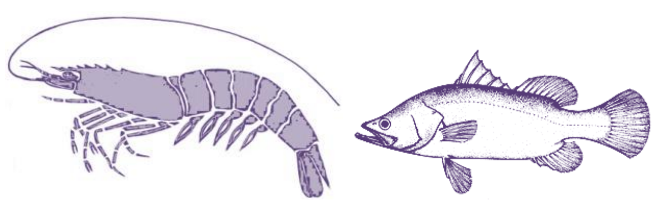
Salient points from power point presentation:

- Potentil area for brackishwater aquaculture: 1.2 million ha.
- Annual cultured shrimp production during 2013 about 1.1 lakh tonnes.
- Shortage of quality brackishwater due to less tidal effect, high saline condition and contamination of industrial and agricultural effluents.
- Shortage of quality water resulting very high saline condition, thereby poor growth, stress to reared animals, disease out-breaks, loss of crops and finance invested.
- In the case of Tamil Nadu coast, most of the estuaries have less flow of freshwater due to monsoon failure, resulting in the non-availability of quality water for cultue throughout the year.
- Technological interventions: 1) Zero water exchange system of farming with reservoir for storage of water, 2) Optimization of integrated Agriculture-Aquaculture systems, 3) Incorporation of biofloc, 4) Plastic line ponds, 5) Recirculation Aquaculture systems, 6) Aquaponics., 7) Research on alternative species tolerant to high salinity, 8) Basic 6esearch on physiology and genetics of abiotic stress caused by reduced water availability, 9) Development of feeds for candidate species cultured at higher salinities, 10) Mineral supplementation during culture period of varying salinities, 11) Mitigate impact of climate change on water availability and 12) Flooding due to extreme climatic events – impact on water quality and availability.



Technical Paper-22

DIVERSIFICATION OF SPECIES: AN OPTION FOR FARMING WITH OPTIMUM WATER UTILIZATION

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INTRODUCTION:

The world fish production is around 152 million tonnes supporting the nutritional security of the growing population of the world. Out of the total fish production, aquaculture contributes around 42%. The capture fisheries, though intensive efforts are made for exploitation in many cases is static or declining. In some areas through continuous unregulated over exploitation it has often exceeded the MSY (Maximum Sustainable Yield) and the aquaculture has to necessarily support the fish production. Aquaculture is considered as one of the potential growth sectors showing annual growth rate between 8 and 10%. and is dominated by Asian countries. India is in the second position after China, however, the contribution is only to the extent of 5% compared to that of 70% by China. The present total fish production in India is to the extent of about 7.8 million tonne of which, around 3.8 million tonnes is contributed by marine fish production including through coastal aquaculture and the rest is by the fresh water sector. The present production has to make a quantum jump in the coming years to meet the demand. The present per capita consumption of fish in India is around 9kg where the global average is in the order of 15kg. Considering the population of India, which will be around 1200 millions by 2020 and of which 60 % of the population will be fish consumers, the domestic need itself will be in the order of 11-12 million tonnes. Aquaculture is considered as a source for nutrition security, livelihood for million, provide employment, social security for improving the economic status and social uplift in India. It would help in reducing the pressure on wild stock and culture of organisms lower in the food web like seaweeds and molluscs would help in environmental quality improvement. Aquaculture can also be integrated with other farming systems like agriculture, animal husbandry and dairying

However for developing aquaculture quality is important but this can become a scarce in states like Tamilnadu which experience less rainfall . Water renewable resource foundation for the life, food and health security, human prosperity, economic stability and ecological security but has become a scarce commodity, It has been estimated that about 48 countries with the population of 2800 million face water crisis.

- Some Causes for water scarcity are:
  - 1. Failure of rains/monsoon,
  - 2. Inadequate storage capacity,
  - 3. Contamination of open water bodies,
  - 4. Population increase,
  - 5.Unrestricted, unregulated and luxurious use of water in an unaccountable manner,
  - 6. Lack of appropriate technologies for less water usage in day to day life,
  - 7. Salinization of ground water due to extraction,
  - 8. Population explosion and expansion and
  - 9. Competition for economic growth

- For Tamilnadu water source is complemented by the South west and North west monsoons.
- Average rainfall of 1170 mm per year (ranging between 100 mm Rajasthan and 10000 mm in Cherapunji) .
- Available sweet water is estimated around 4000 billion cubic metres per year
- The utilisable water is around only 1123 billion metre cube. Only 18% is used effectively and about 48% enters the sea.
- It is estimated that India will be facing water stress by 2020, the per capita availability will get reduced to 1341 tonnes by 2025 and it will further reduce to 1140 tonnes by 2050.

- Tamil Nadu has become one of the water starved state with frequent failures of monsoon. Average rainfall is around 1300 mm, out of which the north east monsoon contributes around 830 mm
- Inland Aquatic resource of Tamil Nadu is about 6.93 lakh ha includes 7400 km of rivers and canals, 5.70 lakhs ha of reservoirs, 0.56 lakhs ha of ponds and tanks, 0.60 lakh ha brackishwater and 0.07 lakhs ha of flood plain/derelict waters.
- Tamil Nadu which was enjoying copious water resources for centuries together has become one of the water starved state due to various natural ,,man made socio political changes. The networking of water courses are like reservoirs, irrigation channels, storage tanks have become water deficient.

- Frequent failure of monsoon and insufficient inflow of water
- Reclamation of many water storage systems
- Percolation and recharging of water have been hampered.
- Urbanisation has also resulted in closure of the deeper water bodies and canals leading to water scarce.

- These water bodies can be effectively integrated with other activities through fisheries.
- Marginal areas of small water bodies can be cordoned and made as pond or small pens for growing fishes.
- Deeper central portion can be used for the capture fisheries.
- The shrinking water bodies in deeper areas is forcing the utilisation of derelict water bodies for fisheries development to augment production.
-

FRESHWATER AQUACULTURE:

Due to the above reasons naturally the areas with scanty rainfall will experience water deficiency. Species which may not require deep water can be considered for culture. Some of them are:
Air breathing fishes like Murrel (*Channa marulius*, *Channa punctatu)*, Catfishes (Clarius batrachus, *Hettropnuestes fossilis)*, Climbing Perch (*Anabas testudenesis),* Chital(*Notapterus* sp)

Murrel **catfish**

Chital

Gourami (*Ospheronemus gourami)*, Aaral (*Mastocemphalus sp.),* Tilapia (*Oreochromis mossambicus,Oreochormbis nilotica)*, Loaches(*Leptocephalusthermalis)*

Gourami Mastocemphalus

Tilapia **Loach**

Ornamental fishes which is now forming a livelihood for small rural folk can be reared in this type of small water bodies.

Ornamental fish

BRACKISHWATER AQUACULTURE:

Brackishwater aquaculture though traditionally practised in the coastal states in recent years the practice has been improved through more interventios. The technology advancement helped in the establishment of more than 380 hatcheries with a production capacity of 5–300 million seeds totalling around 20 billion and more and new areas were brought under shrimp farming. The present area of operation in the coastline is around 160,000 ha and producing around 200,000tonnes of shrimp.

The brackishwater aquaculture which witnessed a phenomenal growth during 1980s and in the mid of 1990s has to face a set back later part of 1990s due to many socio-economic and environmental issues coupled with the outbreak of uncontrollable diseases like White Spot Syndrome Viral (WSSV) disease on shrimp. The reasons attributed for this are the unregulated development and dependence on a single group of organisms (shrimp) for farming. The effect of this has brought the pronounced impact on the farming sector questioning the very sustainability of the coastal aquaculture.

Many options are put forth for sustaining the brackishwater aquaculture industry. Since, the viral diseases is transmitted both vertically and horizontally to reduce the transmission, SPF broodstock development/import was suggested and in this direction limited success has been achieved. For restricting the transmission of disease through environment improved farming practices (BMP, GMP) where advocated. These measures are expected to help in improving the coastal aquaculture. But, the recent problems like Early Mortality Syndrome (EMS) and the Slow Growth Syndrome (SGS) are making these issues more complex. One of the easiest options for the sustainability of the aquaculture can be diversification of species and practices of farming.

Diversification to fish culture in coastal waters:

Indian brackishwater aquaculture, though in the initial phase, have not aimed at any specific species or group of organisms, later has emerged with the orientation for particular group (shrimp). However, the experiences gained for the past three decades have shown that for a sustainable aquaculture supporting better production diversification to other groups of organisms like fishes is highly desirable.

Most of the species which can be commercially farmed in brackishwater eco system are suitable for farming in marine and fresh water also. Some of the candidate species identified suitable for commercial aquaculture are Seabass (*Lates calcarifer*), Groupers (*Epinephelus* sp.), Cobia (*Rachycentron canadum*), Pearspot (*Etroplus suratensis*), Milk Fish (*Chanos chanos*) and Grey Mullet (*Mugil cephalus*). For the aquaculture development and expansion, the most important pre-requisites are the seed and feed. Seed production technologies have been developed for some species like Seabass, Cobia, Pampano and Pearlspot and for other species like Groupers, Snappers, Grey Mullet and Milk Fish, efforts are made by different R&D Institutions in India to develop and standardize seed production technology. For brackishwater fish farming feed has been developed for species like Seabass which has been tried and proved to be viable under pond culture system. However, the commercial cost effective feed is yet to be developed for brackishwater fish culture.

SEED PRODUCTION TECHNOLOGY FOR SOME IMPORTANT FISHES

ASIAN SEABASS:

Comprehensive technology for controlled breeding of seabass was developed in 1997 and since then the technology has been further refined and validated. The technology includes captive brood stock development, acceleration of maturation, providing optimum conditions like water quality management, health management and feed management, induction of spawning through hormonal administration and facilitating natural spawning in the Recirculation Aquaculture System (RAS). Larvae are reared feeding with live feed like Rotifers up to 9^{th} day followed by Artemia nauplii up to 20 days and afterwards weaned to formulated diet or shrimp/fish meat. The fry are further reared in nurseries.

Nusery Rearing in Ponds

Nursery ponds can be around 200-500 m^2 area with provision to retain atleast 70 – 80 cm water level. The pond is prepared before stocking. If there are any predator/pest fishes they have to be removed. Repeated netting, draining and drying the pond are done. In case where complete draining is not possible, water level is reduced to the extent possible and treated with Derris root powder @ 20 kg/ha added or mahua oil cake (MOC) @ 200-300 kg to eradicate unwanted fishes. Use of other inorganic chemicals or pesticides is avoided because these may have residual effect. After checking the pond bottom quality water is filled. If the pond bottom is acidic, neutralization is done with lime application.

In order to make the natural food abundant, the pond is fertilized with chicken manure @ 500 kg/ha keeping the pond water level 40-50 cm. The water level is gradually increased. After 2-3 weeks period when the natural algal food is more, freshly hatched *Artemia* nauplii are introduced. Normally 1 kg of cyst is used for 1 ha pond. These stocked nauplii grow and become biomass in the pond forming food for the seabass fry. Seabass fry is stocked @ 20-30 Nos/m^2. Stocking should be done in the early hours of the day. Fry should be acclimatized to the pond condition.

Innovative farmers have developed easy method of nursery rearing wherever in the adjoining open system abundant zoo planktons like A*cetes*, *Mysids* and other zooplanktons are available. In well prepared nursery ponds of 100-150 sq.m early fry are stocked @32-40,000/ha and reared feeding them with zooplanktons collected from natural waters, in these process within 20-25 days period with a survival rate of 60-70% fingerlings of 8-10 cm could be harvested.

Nursery Rearing in small net cages/Hapas

Floating net cages/hapas can be in the size of 2x1x1 to 2x2x1 m depending upon necessity. Cages are made with nylon/polyethylene webbing with mesh size of 1 mm. Fry can be stocked @ 400 – 500/m^2. Feeding rate can be as that described to tank nursery. The net cages have to be checked daily for damages those may be caused by other animals like crabs. The net cages will be clogged by the adherence of suspended and detritus materials and siltation or due to foulers resulting in the restriction of water flow. This would create confinement in the cages and unhealthy conditions. To avoid this, cages/hapas should be cleaned everyday. Regular grading should be done to avoid cannibalism and increase the survival rate. Even in higher stocking density @ 500/m^2 farmer could get survival of 80% in the farm site when the fry were reared in happas adopting the trash fish feeding and other management strategies mentioned above

GROUPERS

Groupers also migrate for maturation and spawning to deeper waters in the sea. The groupers attain maturity after 2 years at their age when they are around 2-3 kg in size. Groupers are protogynous, herbivorous where many are females in the early period and reverse to male when they are larger in size. In hatchery operations, for obtaining male some times require intervention through exogenous hormone administration. Successful breeding of some species of groupers have been reported from different R&D Institutions like CMFRI, CIBA and RGCA.

The techniques for reverting female to male and retaining them as male has been developed in CIBA through oral administration (through feed) of 17 α methyl testosterone hormone in the dose @ 2mg/kg body weight at on every alternate days. The breeding protocols include the selection of females with ova diameter of above 450 µm and administration of HCH hormone @ 750-1000IU /kg body weight for females and LHRHa @ 40 µg/kg body weight Successful spawnings were observed after 72-144 hours of hormonal administration. Hatching took place after 22-24 hours of incubation. Rearing the larvae feeding with rotifers SS strain where the size is less than 80 µmm following green water technology has been succeeded. However, survival rate is very less (around 5%) in many cases for a months rearing. Though Grouper culture in an organized manner has not been taken up, trials are being carried out by various R&D institutions on the viability of culture in cages and ponds.

GREY MULLET (*Mugil cephalus*)

Grey Mullet *Mugil cephalus* is a herbivorous fish. Considering its high potentiality for farming along with other fishes and shell fishes with low cost inputs the good market demand in some parts of India like Kerala, West Bengal. It is felt that it will be highly useful for a sustainable farming in traditional coastal farms. However, breeding of grey mullet under controlled conditions, though being attempted for some years, is yet to take off as a standardized technology for commercial venture.

Gravid Fish ready for spawning **Hatched out larvae**

Grey mullet in the size of 300 gm – 1.5 kg collected from the wild catch or farm reared stock could be maintained in earthen ponds or broodstock holding tanks feeding with formulated feed @ 2-3% of body weight daily providing with quality sea water with the desirable parameters prevailing in the open sea and taking care of the regular health monitoring protocols. Matured fishes could be obtained during the spawning season, normally in the months of October-January. Breeding protocols include selection of females with ova diameter around 0.58 mm-0.6 mm and administration of a prime dose of HCG @ 1000 IU and a resolving dose of LHRH @ 40-50 µg/kg body weight and half the dose for the males was found to make successful spawning. The larvae also could be reared following the protocols as for other marine fish larvae. In India though success in captive broodstock development, maturation and spawning has been achieved, the technology for commercial venture is yet to be developed. Grey Mullet culture is practiced in a more extensive way as a poly culture along with other fish and shrimp species. Experiences have indicated poly culture of shrimp and Mullet is desirable to reduce the risk of shrimp disease outbreak since Grey Mullet as a detritus feeder is useful in improving the eco-system condition on reducing the shrimp pathogens.

MILKFISH (*Chanos Chanos)*

Milk Fish breeding and seed production has become a house hold activity in countries like Philippines, Indonesia and Taiwan. However in Indian context, breeding of milk fish under captivity is yet to make a beginning. Captive broodstock of milk fish developed after feeding them with formulated feed @ 2-3% body weight after 5 years of holding under captive conditions have shown male maturation and the female fishes have not attained gonadal maturity. Milk fish culture in India is being carried out along with shrimp as poly culture and mono culture of Milk Fish is tried. The market price for milk fish is less compared to other fishes the cost effective farming system has to be developed with low cost feed and farm management.

PEALRLSPOT

Pearlspot (Etropluss *suratensis*) an indigenous chichlid having a high market value in some parts of India like Kerala is considered as a highly suitable table fish which can be farmed in ponds or cages with low input in shallow/freshwater/brackish water systems. Pearlspot breeds in the confinement. After pair formation selecting a suitable hard substrate for the egg are laid in a mosaic manner by the female and fertilized by the sperm released by the males by following the course of the female. Eggs are guarded and cleaned periodically for a period of 6-7 days after which they are transferred to nests (pits), at the time of hatching; the hatchlings subsist with yolks for 3-4 days after which the hatchlings are guarded by the parent fishes till they attain the advanced fry or fingerling stage. To increase the survival rate in the early stages, the eggs at the time of hatching is transferred to tanks and maintained with good aeration through which the hatching rate is improved. Afterwards the juveniles are fed with live zooplankton initially and / or later with egg custards and formulated feed.

Pearlspot (Etroplus suratensis)

Due to the high value Pearlspot could fetch in some parts of India farming of this table fish which is considered as a delicacy is practiced traditionally especially in Kerala. This indigenous chichilid fish can be bred in confined waters. However, producing large quantity of seed in a single place poses problem due to the low fecundity and involves large number of broodstock management. Breeding and seed production in small units in large numbers may be useful in solving the problem. The state of Kerala has given priority to Pearlspot farming and conservation and lot of efforts are made under various schemes for promoting home state pond culture system which will serve as a livelihood option for thousands of fisher folk in increasing fish production.

COBIA

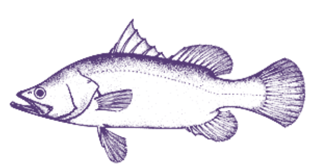
Cobia, *Rachycentron canadum* has also been identified as a potential candidate species for farming in cages in the open waters. Initial trials have shown encouraging results. In India, within 8 months duration marketable size fish could be grown. Considering the palatability, texture and the market demand, interest is shown by many for the farming of Cobia. Success has been achieved by CMFRI and RGCA and CIBA in controlled breeding and seed production At CIBA matured fishes could be obtained from the broodstock maintained in earthen pond conditions wherein the routine protocols like water exchange to the extent of 30% daily feeding with forage fishes @ 5% of body weight and following the routine health management protocols for ectoparasitic infection through treatment with 100-150 ppm formalin for one hour and/or dip treatment in freshwater for 5 minutes providing with the water quality conditions of salinity ranging from 24-32 ppt, pH 7.5-8.2, ammonia less than 1.5 ppm, dissolved oxygen 4.8-6.2 ppm. Fishes in the size range of 5-15 kg were maintained in a earthen pond at the density of 1kg/m^3. Fishes of size 12 kg introduced in the pond during the month of March 2010, after 8 months of maintenance, following the above mentioned protocols showed maturity, where females with ova size of 0.5-7 mm and oozing males could be obtained. An effort made under controlled breeding with exogenous hormone of HCG administration @ 300 IU intramuscularly in a fish with ova diameter of 0.7 as a priming dose and after 36 hours with a resolving dose of LHRH hormone @ 10µgm/kg body weight for females and a single dose of LHRH at half the rate that of female yielded successful spawning after 20 hours of hormonal administration where about a million eggs were spawned with 30% fertilization. This success has showed that broodstock can be maintained in small ponds also which will simplify the operation of hatchery for Cobia.

Trials carried outt on Cobia farming in cages have shown very promising results showing a growth rate of 6-8kg in a year of culture in the open sea net cages by CMFRI and RGCA. The culture possibilities of Cobia in low saline brackishwater ponds were evaluated in brackishwater pond with the salinity range of 5-15 ppt. Cobia juveniles stocked in the pond system fed with low valued fish grew to a average size of 2.54kg from the initial size of 20g indicating the viability of Cobia farming in the brackishwater culture system.

ACTION PLAN FOR USING SMALL WATER BODIES FOR FISH CULTURE:

Small water being an unique eco system with its characteristic of high productivity, low depth, with infestation of weeds and plants needs special management. For use of these water bodies in Tamil Nadu, the following points may be considered:

- Micro level survey on the small water source, the quality, the extend of the area, availability of water in different seasons have to be carried out.
- Most of these small water systems may be adjoining the rivers, channels, estuaries, backwaters, the ownership may be with the government. In such cases appropriate leasing policies for fish farming has to be evolved since, these areas may not suitable for other agro horticulture operations.
- The small water areas are mostly infested with bushes, thorny plants, water weeds etc, the system has to be categorized appropriately as derelict areas. Different stake holders associated with the utilisation of these areas like fodder areas, grazing lands, forestry etc and a comprehensive policy for the utilisation has to be developed in consultation.
- Public awareness campaign about the small water body eco system, the necessity of the conservation and restoration and their utilisation has to be created.
- Monitoring of the small water bodies and stopping of reclamation for other activities will only ensure ecological safety and environmental security for other system too. Hence, stringent regulatory measures have to be taken up and implemented immediately.
- Pilot scale projects on the integrated use of small water bodies in deficient areas for Aquaculture-Agriculture-Horticulture, Forestry and Dairy have to be taken up on priority with public participation mode.



Technical Paper - 23

INTEGRATED SHRIMP (SPF *LITOPENAEUS VANNAMEI*) NURSERY AND FARMING USING BIOFLOC TECHNOLOGY (BFT)

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Introduction

Intensive production of fish and shellfish with minimum impact on the environment is the goal of the aquaculture industry. Maintenance of water quality in culture systems and disposal of untreated water to environment are challenging issues for sustainable aquaculture. Simultaneously, the industry is looking towards the production of nutritionally balanced and economically profitable food for the cultivable species. The situation is critical in countries like India, where the aquaculture development is in transitory phase, i.e., moving from extensive systems towards the semi-intensive and intensive systems. Application of advanced technologies is the need of the day. Biofloc technology (BFT) is one of advanced technologies for the sustainable development of aquaculture in India.

The same technology can be applied to fish farming also. Even fish fingerlings are raised in the biofloc nursery. The main advantage of biofloc technology is zero-water exchange. So it can be implemented at any remote place where shortage of water as well as land exists. Some marine as well as fresh water fishes can also be cultured in this technology.

Objective:

The main objective is to establish a commercial viability of biofloc technology for vannamei nursery and grow out. This will help in enhancing productivity, profitability and sustainability of shrimp farming in India.

Executive summary

Challenges

The world shrimp production from aquaculture estimated to reach 4.1 million metrc tonnes in 2013 whereas India contributing only 4%-5% of it(Global outlook for Aquaculture leadership).The main drawbacks are due to present production systems. It has large earthen ponds (occupying more space), only 2 crops per year (annual production is less), long turnaround time of 30 to 60 days between two crops (waste of time), un-predictable harvests due to low biosecurity (various disease outbreaks), variable quality and quantity of harvest(no proper technical management), high power requirements 3 HP per tone (high capital and working capital). So all these problems can be overcome by applying the new emerging technology in aquaculture which helps India to contribute more towards global shrimp production with low power consumption. Thus, it increases exports and to earn foreign exchange leading to appreciation of Indian rupee value.

Solution

Biofloc technology is the state of the art technology in the field of aquaculture. This technology has the solutions for the above problems. There will be continuous and intensive production and better management in the smaller (500 to 1000 sq.m) PVC lined ponds. Use of liners to reduce seepage and turn around time of 3 to 7 days between two crops, zero or low water exchange for higher biosecurity,use of Aero-tube diffusion and Air lift system for better dissolved oxygen (DO) and low power consumption.

Technology:

Biofloc technology has become a popular technology in the farming of Pacific white shrimp (*Litopenaeus vannamei*) in some countries such as Indonesia, Malaysia and Australia. It is a technique of enhancing the water quality through balancing the Carbon and Nitrogen in the system using bacteria. It is based upon zero or minimal water exchange to maximize biosecurity. Mixing and aeration is required. It produces unicellular, proteinaceous feed *in situ*. So it helps to reduce the investment on feed and also the energy cost for water pumping.

Biofloc is made of bacteria, other organisms and organic particles such as left over feed. It helps in removing excess of inorganic nitrogen level in water (ammonium excreted by shrimp). Biofloc also forms an important part of food chain. It is fed by shrimp. According to the research done by many scientists, it is found that biofloc consists of more than 2,000 bacterial species.

For more benefits, farming is integrated with the biofloc based nursery technology which reduces crop period. According to the research done in China, Malaysia, Indonesia, Vietnam, the Philippines and other countries, it is found that biofloc nursery and grow out helps in overcoming Early Mortality Syndrome (EMS) problem in vannamei farming.

Requirements

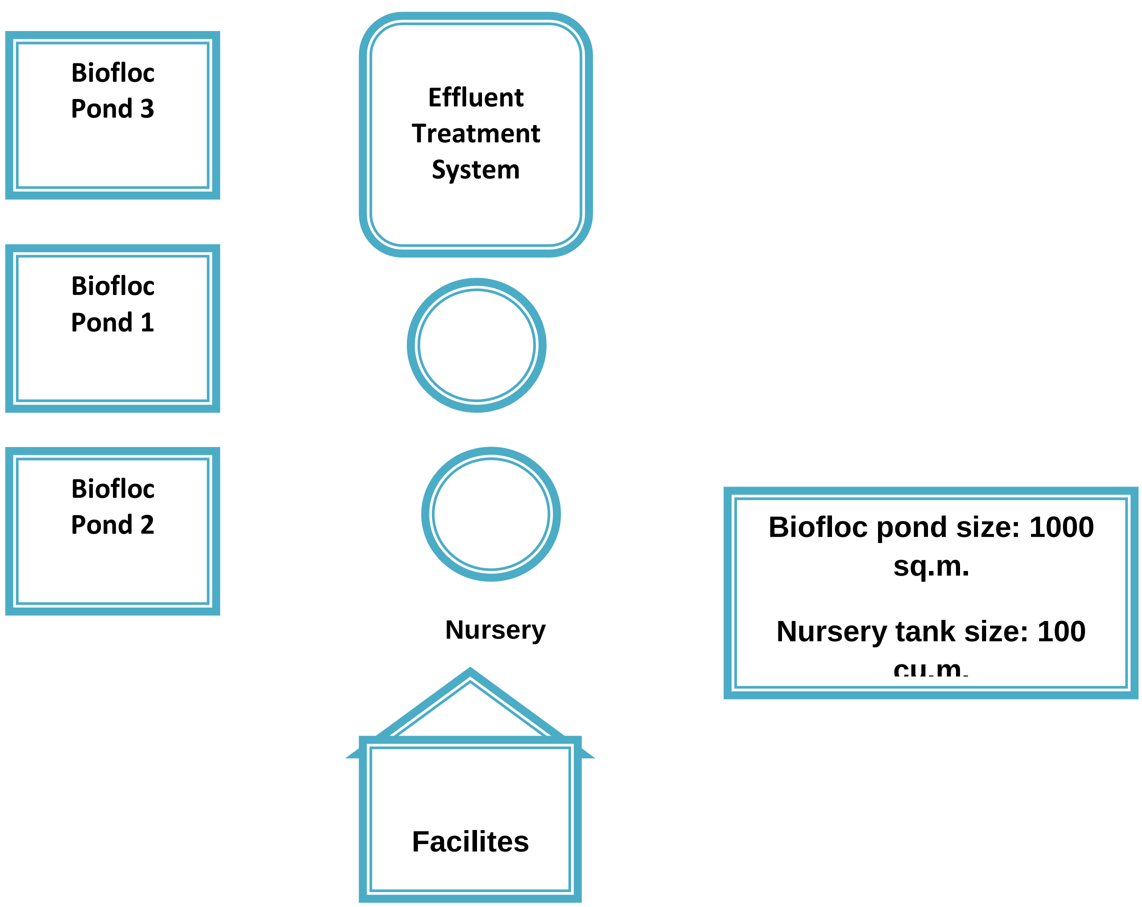
1. Two acres (0.8 hectare) land of minimum salinity 15 ppt
2. Two Nursery tanks – RCC circular tank capacity of 100 cub.m
3. Three grow out ponds – 0.5 mm thickness HDPE lined square pond area of 1000 sq.m and capacity of 1,500cub.m
4. Central drain from each tank and pond
5. Effluent Treatment System (ETS)
6. Lab facilities for daily testing of water quality
7. Store room
8. Technician and boy's room
9. Harvest platform
10. Agitators and aerotubes
11. Two air blower (10HP) - one with motor and other with engine
12. Saline water bore pump set
13. Fresh water bore pump set
14. Submergible pump (7.5 HP)
15. Generator (25 KV)
16. PVC pipe line (6'' for central drain, 4'' for air grid)
17. Five Dissolved oxygen (DO) meter with GPRS
18. Three Auto feeders

Methodology

Nursery

Probiotic inoculum is added to the nursery tank before 1 day of stocking the postlarvae (pL) at the density of 5 000 postlarvae per cub.m . Nutrients, minerals, carbon source (sugar/jaggery) and also ammonia source (shrimp feed) for bacteria are added. Feeding is done at every 3 hour interval and its quantities will be adjusted by monitoring the gut and average body weight (ABW) of the postlarvae or juveniles. The water quality parameters like pH, dissolved oxygen and temperature have been measured daily at 06.00 and 18.00 hours using calibrated, sensitive equipments. The total ammonia nitrogen and nitrite were measured using detection kits. Alkalinity has been determined using standard chemical techniques. Biofloc is measured using imhoff cone and is maintained up to 5 ml per liter. Juvenilea are raised in the nursery till the ABW reaches 200 milligram (15days).

Farming

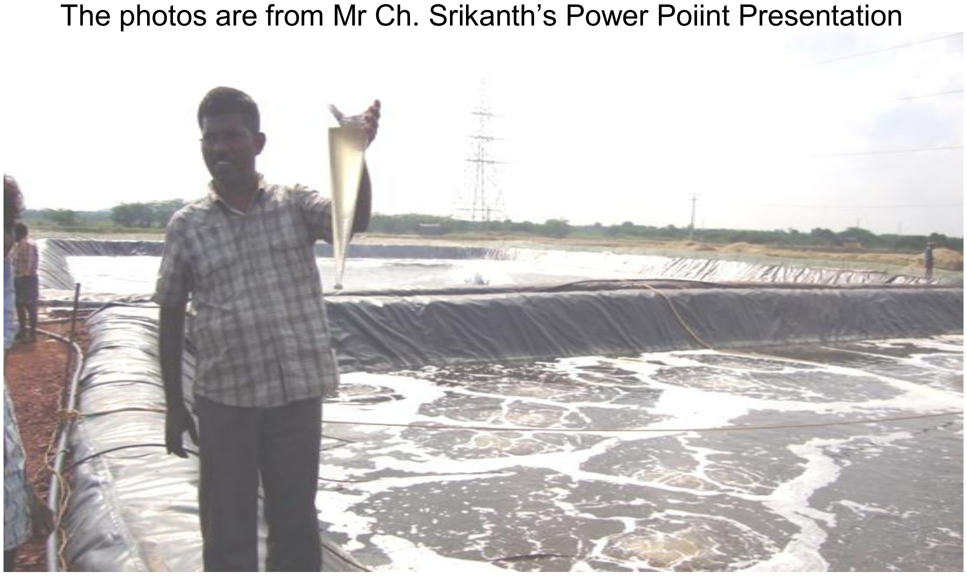


Probiotic inoculum is added to the pond before 2 days of stocking the juveniles at the density of 250 juveniles per sq.m. Nutrients, minerals and also carbon source (molasses/grain pellets/jaggery) for bacteria are added. Feeding is done at every 4 hour interval and its quantities will be adjusted by monitoring the check trays. Temperature, Salinity, DO, pH, Ammonia levels in the ponds will be noted down at 6 A.M. and 6 P.M. daily. Salinity of 15 to 20 ppt is maintained.DO levels should be maintained above 5 ppm; pH in the range of 7.5 to 8; Ammonia level less than 1 and a maximum of 2. DO levels will be maintained by increasing aeration. Ammonia (TAN) will be controlled by sludge removal and addition of carbon source. Biofloc is measured using imhoff cone and is maintained up to 10 ml per liter. Feed quantity is adjusted according to the biofloc levels. Shrimps of 50-60 count/kg (17-20g) harvested within 70days.

Thus, Biofloc technology is a sustainable technology which maximizes biosecurity, minimizes environmental effects and also develops cost effective production systems supporting economic and social sustainability. It facilitates super intensive cultures while reducing investment, maintenance costs and incorporating the potential to recycle feed. The combination of two methods i.e., partial harvesting and biofloc method can help in healthy and sustainable production with increased carrying capacity.

In any business as defined by economics, savings are also considered as profit. Savings such as from feed, time, energy (power) can be calculated as profit which can be achieved by biofloc technology.

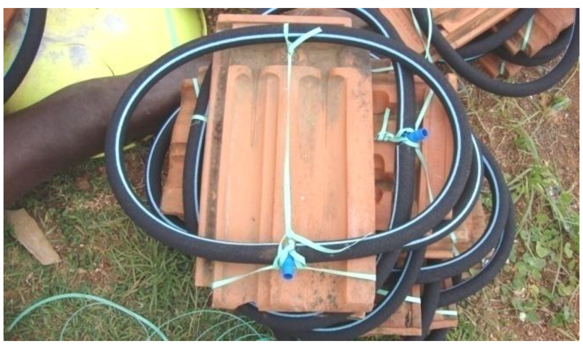
The photos are from Mr Ch. Srikanth’s Power Poiint Presentation



Biofloc ponds at Gee Kay Farm at Nellore, Andhra Pradesh

Aero-Tube diffusion aeration at Biofloc ponds

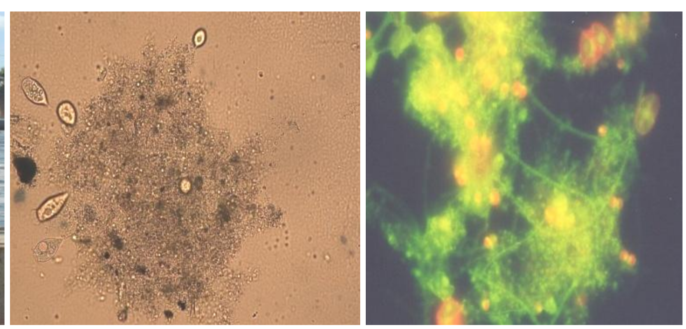
Air distribution by HDPE pipes



Aero-Tube for diffusion

Dissolved Oxygen &Temperature continuous monitoring through GPRS

Bioflocs : Imhoff cone



Biofloc: Microscopic view

Raising juveniles in Biofloc nursery

Juveniles for stocking

***L. vannamei* grown in Biofloc pond**

National Seminar on
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Session IV
FRAMING POLICIES AND PROGRAMMES FOR THE DEVELOPMENT OF FISHERIES IN WATER DEFICIENT REGIONS

Techincal Paper–24

POLICY ISSUES TO BE ADDRESSED IN THE FRESHWATER CULTURE FISHERIES

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Introduction

Aquaculture is one of the fastest growing food production industries in the world and is an important part of the seafood continuum. Together, the aquaculture and fishing industries and related service sectors generate significant wealth and socio-economic benefits for our society.

The contribution of aquaculture to world fisheries production has been growing steadily over the past decade. and now accounts for almost half of the total fish supplies for human consumption. The FAO projects that by 2030, aquaculture will dominate fish supplies, with more than half of the fish being consumed originating from aquaculture operations. Indeed, by 2025, annual demand for seafood will outstrip the capacity of wild fisheries by some 55 million metric tonnes, presenting tremendous opportunities for the aquaculture sector. It is also projected that aquaculture will provide close to two thirds of global food fish consumption by 2030 as catches from wild capture fisheries level off and demand from an emerging global middle class, especially in China, substantially increases. According to FAO, at present 38 percent of all fish produced in the world is exported and in value terms, over two thirds of fishery exports by developing countries are directed to developed countries. Asia including South Asia, South-East Asia, China and Japan — is projected to make up 70 percent of global fish consumption by 2030. It is also predicted that 62 percent of food fish will come from aquaculture by 2030 with the fastest supply growth likely to come from tilapia, carp, and catfish. Global tilapia production is expected to almost double from 4.3 million tons to 7.3 million tonnes a year between 2010 and 2030.

One of the major challenges facing aquaculture is producing and sustaining the fish supply without depleting the productive natural resources and damaging the aquatic environment. Unlocking the potential of aquaculture could have long-lasting and positive benefits. With the world's population predicted to increase to 9 billion people by 2050 - particularly in areas that have high rates of food insecurity — aquaculture, if responsibly developed and practiced, can make a significant contribution to global food security and economic growth.

Policy and Governance in Aquaculture

Effective governance of modern aquaculture needs to reconcile ecological and human well-being so that the industry is sustainable over time. Lack of an effective mechanism for governance might lead to misallocation of resources, and a possible irreversible environmental damage.

There is a consensus that modern aquaculture has a business orientation, similar to any small or medium-sized enterprise. This requires that aquaculture is not only profitable but also environmentally neutral, technically feasible and socially acceptable.

There are four governance principles – accountability, effectiveness and efficiency of governments, equity and predictability of the rule of law – which are necessary for sustainable development of the aquaculture industry. Based on these four principles, administrative and legislative frameworks can assist aquaculture to develop sustainably. In addition to governments, there are other participants in aquaculture governance such as communities, non-governmental organizations and producers. Particularly with market and participative forms of governance, these other actors can assist with monitoring and enforcement of regulations, and legitimize decisions. Their role in coastal zone management is critical because they provide the social licence that is so necessary for aquaculture to prosper (Hishamunda, *et al*., 2014).

Aquaculture contributes to the Millennium Development Goals by providing protein and increasing the availability of food. It generates employment income and enhancing accessibility to food. It increases economic growth, tax revenues and foreign-exchange earnings. On the environment, aquaculture can have positive effects by reducing the pressure on overexploited fish stocks. However, there are potential costs. For example, potential hazards of cage culture include benthic enrichment, eutrophication of the water column, escapees and aesthetic loss. While some of these detrimental effects are reduced through the learning curve and technological advances, and through the self-interest of farmers themselves, many are intrinsic to the industry itself. For this reason, the industry is subjected to regulations or voluntary codes of conduct such as the FAO Code of Conduct for Responsible Fisheries (the Code), which are commonly referred to as “governance tools”. Their aim is to harmonize human and ecological well-being by internalizing externalities that result from short-sighted behaviour.

The challenge of aquaculture governance is to ensure that the right measures are implemented to ensure environmental sustainability, without destroying entrepreneurial initiatives and social harmony. Risks to society must be reduced.

Sustainability is the principal goal of aquaculture governance because it enables aquaculture to prosper over a long period. Sustainability incorporates four aspects: economic viability, environmental integrity, social licence and technical feasibility. This is explicitly provided in the aquaculture policy of Norway, which reads “a sustainable aquaculture industry is an industry that is competitive, market-oriented and environmentally and resource-friendly, and that supplies safe seafood of good quality” (Norwegian Ministry of Fisheries and Ocean Affairs, 2008). Economic viability requires that aquaculture operations be profitable over time, and be competitive. Profitability underlines market orientation of aquaculture ventures and implies an enabling business-friendly approach by governments. Environmental integrity requires that negative impacts be mitigated, thereby influencing consumer acceptance of farmed products. Social licence, which means the degree to which aquaculture is accepted by neighbouring communities and the wider society, is an integral part of governance and will become an increasingly critical sustainability factor, determining where aquaculture development occurs (Hishamunda *et al*., 2009a & 2009b). Technical feasibility requires inputs such as seed and growing conditions which are adapted to local conditions. Therefore, governance of aquaculture must aim at sustainability. Principles such as accountability, effectiveness and efficiency of government activities, equity, and predictability are means to achieving sustainability.

Although sustainability is the common goal of aquaculture governance, the means to achieve this depend on traditions and values. There are different types of aquaculture governance viz. Hierarchical governance ; Market governance and participatory governance (this is being increasingly applied in aquaculture).

Policy instruments

Most policy instruments to promote aquaculture focus on supply because that is often where there is a constraint. There may be no feed industry in some places or insufficient seed. There may also be diseases and limited funds to curb them, owing to a shortage of investment capital.The usual tool for stimulating supply is a fiscal lincentive such as a tax holiday. This may be made available to the investors. Fiscal policies are less expensive to administer than monetary policies; custom exemptions and land tax exemptions.

To assist with the shortage and/or the high cost of capital, policy instruments used in aquaculture have been cash grants,as in Canada, and credit subsidies, as in Indonesia or both pond construction and first year input subsidy as in India. Policy instruments that do not involve direct budgetary expenditures have also been implemented. This is the case of government loan guarantees in Europe and state assistance with business plans in Madagascar, which improved access to bankcredit. There may also be the potential for extending the same insurance available to agriculture, which would reduce the risk premium on bank loans and encourage banks to lend.

Other constraints to development of aquaculture include access to credit (and the interest rate charged) and the availability and quality of seed. In most developing countries, access to credit can be more limiting than feed. Many policy options exist to alleviate these constraints.

Policy instruments to encourage more and better feed production include explicit incentives for foreign investment, as in VietNam. Other policies include encouraging livestock companies to diversify into aquaculture and feed production (as Jamaica did) ,lowering tariffs on imported feed (as in the Philippines), promoting large integrated operations (as in Zimbabwe), and undertaking research to substitute imported fish meal with local ingredients (as in Malaysia).

Seed availability can be increased by offering hatcheries tax holidays, as is the case in Malaysia. Another example is VietNam with its plan to increase marine seed production. VietNam also used soft loans, exemptions from value added tax, and reduced land taxes. Government funds are also available to send students abroad to learn the technology of marine seed production. To improve the quality of seed, research has been promoted in many countries in public fish stations. However, research can also be undertaken by private companies on site, or in the c as e o f the GIFT tilapia strain in the Philippines, in collaboration with a university.

Aquaculture governance is likely to become even more important in the future if the sector is to remain sustainable. This is because all four factors of sustainability – economic, environmental, social and technical – will face challenges. Environmentally, aquaculture activities will face deteriorating ecosystems also used by other sectors. Non-point pesticide runoff from agriculture, and industrial and urban waste, is likely to threaten the pristine water needed for marine finfish and shellfish. Freshwater aquaculture will be jeopardized by a growing scarcity of freshwater and land (Hishamunda, *et al*., 2014).

Aquaculture may also need to combine with other resource sectors in order to influence policies, because as a relatively small sector, it lacks a "voice" in international discussions on climate change policy, in spite of its vulnerability, and its contribution to food security.

Examplesofthedemand-sidepolicyinstrumentsusedin aquaculturegovernance are given below:

Category	Issue	Cause	Examples of action required	Time frame
Maintenance of quality standards	HACCP and fish quality standards	Restrictions from importing countries	Set internationally accepted standards ,and control by a competent authority	Shortterm
Trade	Promote export oriented aquaculture	High transport costs Lack of market information	Improve logistics at airports Obtain trade shows Ascertain import details	Shortterm Shortterm
Communication	Poor research dissemination	Low technology	Media broadcasts Improve extension	Short term Medium term
Marketing	Small holders Unable to sell	Roads and absence of refrigeration	Encourage producer cooperatives Provide trading markets (to be privatized later)	ShorttermMe diumterm

Source: Adapted from FAO-NACA (1997).

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The photos are from Dr V. Sampath's Power Point Presentation

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Technical Paper - 25

FISHERIES SECTOR IN INDIA: STATUS, PROSPECTS AND POLICIES

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Introduction

Fisheries, a sunrise sector in India, , has recorded a faster growth than that of crop and livestock . The sector contributes to the livelihood of a large section of economically-underprivileged population of the country. It has been recognized as a powerful income and employment generator as it stimulates growth of a number of subsidiary industries and is a source of cheap and nutritious food besides being a foreign exchange earner. With the changing composition pattern, emerging market forces and technological developments, it has assumed added importance in India. It is undergoing rapid transformation and the policy support, production strategies, public investment in infrastructure, and research and extension have significantly contributed to the increased fish production. Particularly, after the mid-1980s, the development of carp polyculture technology has completely transformed the traditional backyard activity into a booming commercial enterprise.

Fish production in World and India

Approximately 50 million people worldwide depend on fishing for all or most of their family earnings, while another 150 million depend on fish processing and the fleet servicing industry. More than 10 million work on 2.5 million small-scale fishing vessels and account for 50% of world's catch (FAO 2001).

Fish production in the world rose from 23.50 million tonnes in 1950-51 to 159.69 million tonnes in 2011-12. Correspondingly, the fish production in India has touched 8.67 million tonnes in 2011-12 from a mere 0.75 million tonne in 1950-1951 (Table 1). The share of India in global fish production has grown gradually from about 2.66% during the 1960s and 1970s to 5.43% in 2011-12.

Year	World	% change	India	% change	India's share
1950-51	23.50	-	0.75	-	3.19
1960-61	43.60	85.53	1.16	54.67	2.66
1970-71	66.20	51.83	1.76	51.72	2.66
1980-81	72.30	9.21	2.44	38.64	3.37
1990-91	98.26	35.91	3.84	57.38	3.91
2000-01	129.00	32.35	5.66	47.40	4.39
2011-12	159.69	23.79	8.67	53.18	5.43

Table 1. Fish production in World and India, 1950-51 to 2003-04 (Million tonnes)

Source: 1. ICAR-ICLARM Project on 'Strategies and Options for Increasing and Sustaining Fisheries and Aquaculture Production to Benefit Poor Households in India, 2004 and Economic survey 2006-07, GOI; 2. Annual Report 2012-13 Provisional Estimates

Growth in fish production in India has been at a faster rate than in world; mainly due to increasing contribution from inland fisheries. In the pre-WTO period of 1990-91, the share of India's fisheries was 3.90, which rose to 4.56 in the post-WTO period of 2003-04 (Fig. 1). Overall, the share of developing world in the total world fish production increased from 43% in 1973 to about 73% in 1997 (Fig. 2), which has been mainly due to the increasing contribution from countries like China and India.

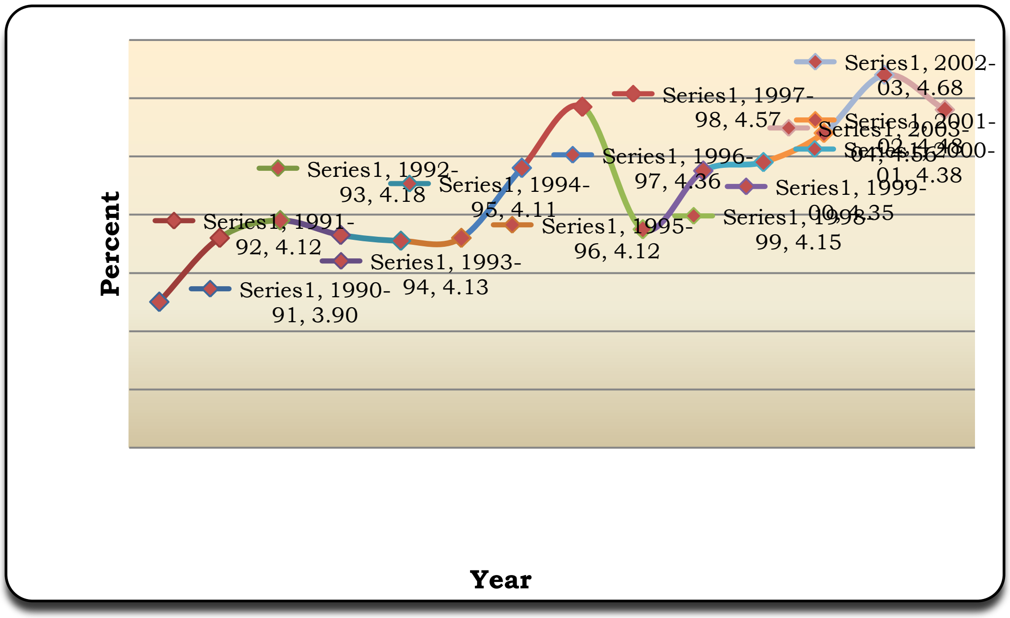


Fig. 1. India's share in World fish production

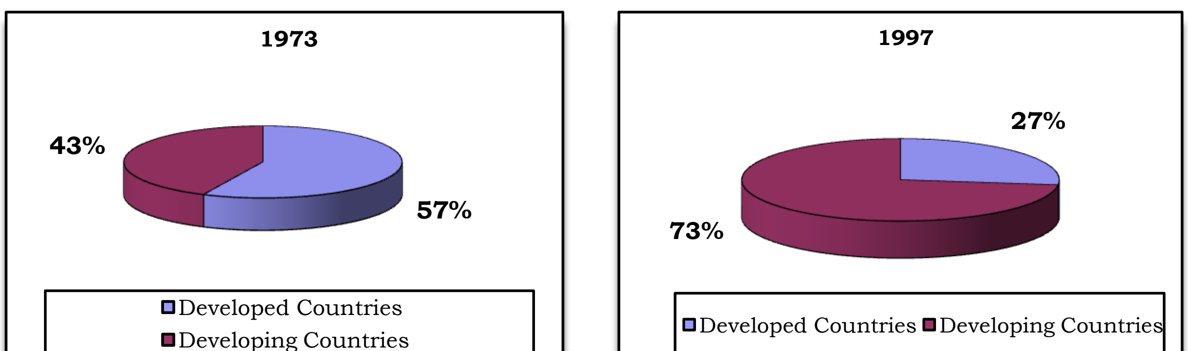


Fig. 2. Changing Share of Developing Countries in the Production of Fish for Food, 1973 and 1997

Contribution to Indian economy and prospects of fisheries growth

With fisheries sector comprising marine fisheries, freshwater and brackishwater aquaculture and inland fisheries consisting of tanks and reservoir, the potentiality of this sector as a whole remains to be fully tapped and it remains a sector of much promise. The fisheries sector in particular is more complex enterprise that functions under integrated network of natural resources, other enterprises with forward and backward linkages with fisheries and other socio-political variables. The major functions of fisheries enterprises, *viz.* production, transportation, storage and processing involve value addition from labour, capital and management, which significantly influence the rapid economic development of the country.

In the last 25 years, unlike agriculture, the contribution of fisheries sector to Gross GDP continued to grow at a rapid pace because of expansion of culture fisheries enterprise. The share of agriculture and allied activities in the total GDP is constantly declining. It was 34.69% in 1980-81 and declined gradually to 17.62% in 2004-05. In contrast, the contribution of fisheries sector to the total GDP has gone up from 0.75% in 1980-81 to 1.04 in 2004-05 (at current prices).

Similarly, the share of fisheries in agriculture GDP (AgGDP) has increased robustly from 2.17% in 1980-81 to 5.93% in 2004-05 (Table 2). This sector is in fact pushing the agricultural growth upward for the past five and half decades.

Period	**Percent contribution of**		
	Agriculture to Total GDP	**Fish to Total GDP**	**Fish to Ag GDP**
1980-81	34.69	0.75	2.17
1990-91	28.42	0.96	3.37
2000-01	22.26	1.18	5.32
2004-05	17.62	1.04	5.93

Table 2. Comparison and growth of fisheries sector
Source: National Account Statistics, CSO, GOI

Fish production: Structure and composition

The fish production in India witnessed a spectacular growth since independence. It rose from a mere 0.75 million tonnes in 1950-51 to over 8.42 million tonnes in 2010-11 (Table 3). In the initial years, marine sector used to contribute more to total fish production then inland sector. In the 1950-51, marine production contributed about 71.01%, which fell gradually to 38.29% in 2010-11, while inland sector started contributing from 28.99 to about 61.71% during the corresponding period. In fact, by the year 2000, its share crossed 50% and continues to improve its share further in the coming years.

Year	**Fish production (Mt)**		
	Marine	**Inland**	**Total**
1950-51	0.534	0.218	0.752
1960-61	0.880	0.280	1.160
1970-71	1.086	0.670	1.756
1980-81	1.555	0.887	2.442
1990-91	2.300	1.536	3.836
2000-01	2.811	2.845	5.656
2010-11	3.225	5.198	8.423

Table 3. Fish production by source in India

Expansion of fleet capacity, technological innovation, and increases in investment all led to explosive growth in the exploitation of marine fisheries through the 1960s, 1970s and 1980s. But from the late 90s onwards, the marine fisheries production has reached a plateau and it seems that it can register only marginal increase in the near future. With most wild fisheries near maximum sustainable exploitation levels, capture fisheries will most likely to grow slowly.

On the other hand, inland fish production was on constant rise. The inland fisheries include both capture and culture fisheries. The capture fisheries have been the major sources of inland fish production till mid-1980s. But the fish production from natural waters like rivers, lakes, etc. followed a decling trend, primarily, due to proliferation of water control habitat degradation (Katiha and Bhatta, 2002).The depleting resources, energy crisis and resultant high cost of fishing etc. have led to increased realization of the potential and versatility of aquaculture on a sustainable and cost-effective alternative to capture fisheries.

Trends and current patterns of fish production

To assess the trend of fish production in the country, the last 30 years data (from 1980-81 to 2011-12) was used. The total fish production in India has been following a linear trend (Figure 3) and it is likely proceed further in the same direction. The trend pattern of marine and inland fish production revealed that while the marine sector's production was increasing at a decreasing rate, the inland sector's production was higher at an increasing rate, the possible reasons for which are that inland aquaculture activities are gaining much importance in some of the states like Uttar Pradesh, Andhra Pradesh, Punjab etc. in recent years. The trend equations for both marine and inland fish production, as well as total fish production are given below:

Marine: $Y = -1.8709X^2 + 121.2X + 1152.4$
Inland: $Y = 3.5132X^2 + 23.022X + 886.19$
Total: $Y = 198.4X + 1731.7$

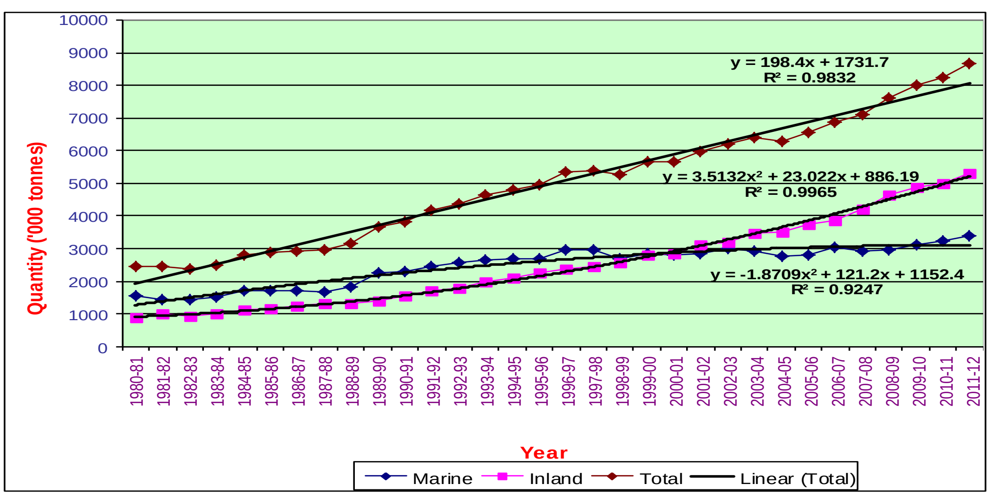


Fig. 3. Trend in fish production, 1980-81 to 2011-12

In the coming decades, aquaculture will likely be the greatest source of increased fish production, as fish farmers expand the water surface area under cultivation and increase yields per unit of area cultivated. But the sector must overcome several major challenges, if it has to sustain the rapid growth of the past 25 years.

- Aquaculture has to face competition from others users of land and water, as these resources would become more scarce in future (Rosegrant *et al*, 2002)
- Marine sector would face energy crisis as it would expand fossil fuels for further expansion.
- The aquaculture production would be restrained by diseases as the sector expands (Subasinghe, *et al.,* 2001).
- The availability of fish meat and fish oil would be less and feed inputs may also become a limiting factor.

Yield increases can come either from increased inputs or greater efficiency of inputs. It is likely that in the next several decades, aquaculture production will benefit from both these sources of yield growth. Greater use of compounded aquaculture feeds along with improvements in rearing technology and selective breeding has the potential to significantly increase the productivity of many farms of aquaculture.

In the last 25 years, total fish production has been growing at an annual growth rate of about 4.60%, in which marine sector was growing at a rate of 3.24 and inland sector was growing at a rate of 6.20%.

Table 5. Compound Growth Rate in Fish Production, 1980-81 to 2005-06

Year	Marine	Inland	Total
1980-81 to 1989-90	3.80	5.28	4.39
1990-91 to 1999-00	2.33	6.55	4.13
2000-01 to 2005-06	-0.21	5.37	2.75
1980-81 to 2005-06	3.24	6.20	4.60
1980-81 to 1980-91 (Pre-WTO)	4.35	5.43	4.78
1991-92 to 2005-06 (Post-WTO)	0.84	5.71	3.18

In all, inland sector fared better in all the periods, viz. 1980-81 to 1989-90, 1990-91 to 1999-00 and 2000-01 to 2005-06. There seem to be a slower pace in growth of this sector in the recent times. In contrast, marine sector is witnessing a negative growth rate in the period 2000-01 and 2005-06, which indicates the exhaustion of marine resources especially in the inshore waters, where maximum harvest has happened. About 90% of the present production from the marine sector is within a depth range of up to 50-70 m and the remaining 10% from depth extending upto 200 m. While 93% of the production is contributed by artisanals and motorized sectors, the remaining 7% is contributed by deep see fishing fleets. Their operation is mainly in deep see areas where the shrimps abound in the upper east coast. Hence, in order to enhance and sustain the contribution from this sector, we need to go deep sea for targeting its untapped potential that is supported by enhanced investment in mechanized vessels, capacity strengthening of artisanals and probably a proper institutional structure to share the benefits.

The growth rates in pre and post WTO periods were also estimated. It is noticed that the pre-WTO period witnessed an impressive growth rate of about 4.78 as compared to post WTO period (3.18). This trend was mainly due to the marine sector, which is understandable by the fact that the country's fish export basket was dominated by marine species and buoyance of marine export might have propelled the growth of marine catch, and vice versa. The post-WTO period imposed many quality regulations in terms of SPS measures on developing countries like India, which couldn't create huge investment in the infrastructures required to produce export-quality marine fisheries products that are acceptable to our trading partners, especially EU, USA and Japan. In contrast to the marine sector, inland sector continued to grow better in the post-WTO period also, which is possibly because of enhanced public and private investment for inland fisheries sector especially though different development programmes and research by the Government of India since IV plan onwards that started delivering results continuously.

The Fig. 4 clearly depicts the dominance of inland fisheries sector in the contribution to total fish of the country, particularly from 1990s.

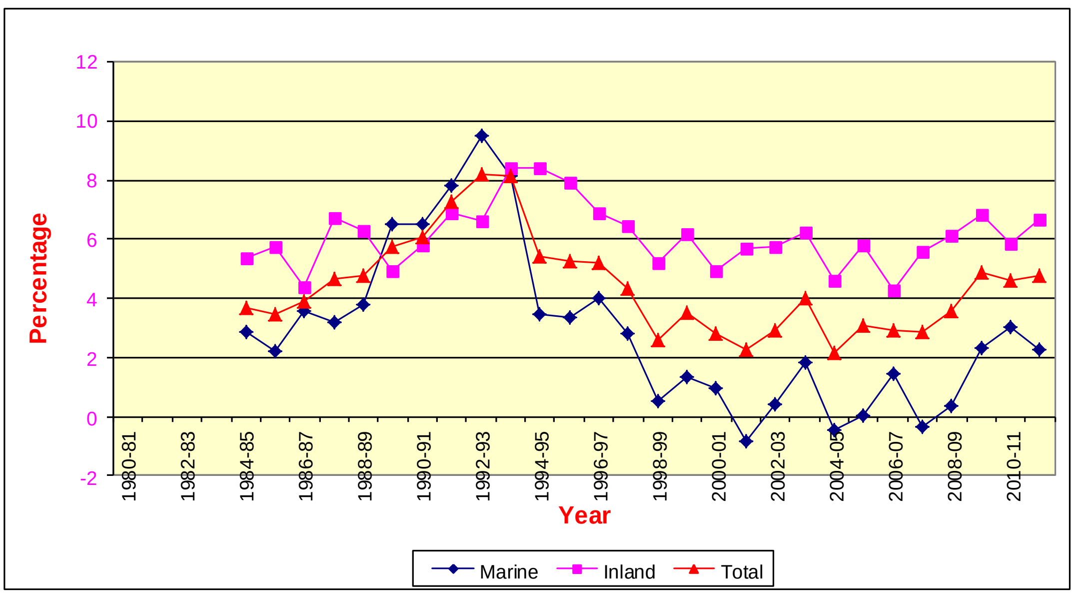


Fig. 4

Growth of Fisheries Sector in Different States of India

The growth rate analysis for various states from 1990-81 to 2005-06 showed that fish production had a significant growth in all states and Union Territories except Goa, Karnataka and Tripura in case of states and Andaman & Nicobar Islands, Dadar & Nagar Haveli, Daman & Diu and Puducherry in case of Union Territories. In some of the states like Andhra Pradesh, Maharashtra, Orissa, Tamil Nadu and West Bengal the growth of inland fisheries was found to be higher than that of marine fisheries. But in Gujarat and Tamil Nadu, marine fisheries growth was observed to be more than that of inland fisheries, though the latter is negative and non-significant (Table 6).

Table 6. Growth rate of fish production by States, 1990-81 to 2005-06*(Per cent)*

States	Inland	Marine	Total
Andhra Pradesh	13.01*	4.92*	10.03*
Arunachal Pradesh	5.11*	--	5.11*
Assam	3.36*	--	3.36*
Bihar	4.88*	--	4.88*
Goa	13.01*	1.19 NS	1.24 NS
Gujarat	-0.13 NS	1.16***	1.08***
Haryana	3.19*	--	3.19*
Himachal Pradesh	1.66*	--	1.66*
Jammu & Kashmir	2.64*	--	2.64*
Karnataka	3.52**	-0.66 NS	0.71 NS
Kerala	5.92*	1.04*	1.48*
Madhya Pradesh	10.73*	--	10.73*
Maharashtra	5.23*	1.63**	2.33*
Manipur	4.73*	--	4.73*
Meghalaya	5.15*	--	5.15**
Mizoram	1.82**	--	1.82**
Nagaland	12.01*	--	12.01*
Orissa	5.22*	1.58***	3.59*
Punjab	14.02*	--	14.02*
Rajasthan	5.22*	--	5.22*
Sikkim	2.82*	--	2.82*
Tamil Nadu	2.66*	0.90***	1.40*
Tripura	0.08 NS	--	0.08 NS
Uttar Pradesh	7.35*	--	7.35*
West Bengal	4.42*	1.96*	4.01*
A& N Islands	0.68 NS	0.67 NS	0.68 NS
Dadra & Nagar Haveli	1.15 NS	--	1.15 NS
Daman & Diu	--	2.17 NS	2.17 NS
Delhi	-6.41*	--	-6.41*
Lakshadweep	--	2.76**	2.76**
Puducherry	1.68 NS	-0.56 NS	-0.33 NS

* Significant at 1%, * *Significant at 5%, ***Significant at 10% and NS Non-significant

Note: 1. Madhya Pradesh, Uttar Pradesh, and Bihar include Chhattisgarh, Uttarakhand and Jharkhand, respectively.

2. Growth rates for A& N Islands and Dadra & Nagar Haveli calculated for the period 1991-92 to2005-06 and 1992-93 to 2005-06, respectively.

Current policy support in fisheries development

Allocation of funds to a particular sector is as indication of a push given for development of the sector. The outlay for fisheries sector was about 5.13 crores in the I Five Year Plan and it went to 2060.54 crores in the X plan (Table 7).

Table 7. Investment on Fisheries Development*(Rs. crores)*

Plan	Total	Agriculture	Fisheries
I	1960	294	5.13
II	4600	529	12.26
III	7500	1068	28.27
IV	15902	2728	82.68
V	39322	4302	151.24
VI	97500	6609	371.14
VII	218730	12793	546.54
VIII	434100	22467	1232.82
IX	859200	42462	2070.00
X	1525639	58933	2060.54

Its share in the total plan outlay was hovering from 0.26% in I Plan to 0.52% in IV Plan and decreasing thereafter continuously and it received only 0.14% of total outlays in X Plan, in spite of that the sector has been growing at an annual growth rate of about 5% in the last two and half decades. Similarly, its share in agricultural outlay has increased from 1.74% in I Plan to 5.62% in VI Plan and it is slowly declining sine then and is about 3.50% in X plan.

However, the status of fisheries sub-sector is better, when compared to that of agricultural sector as a whole. Because, the percent allocation to agricultural sector in the total plan outlay started decling from IV Five Year Plan onwards and is continuously decreasing further, which is a great concern for the sector's overall growth. It's share in I Plan was about 15.00% and it went upto 17.16% in IV plan and is now only 3.86% in X Plan (Figure 2.13). Considering the general importance given to agricultural sector, the preference received by the fisheries sub-sector in the plan outlays is still reasonable.

The Govt. of India operates number of centrally sponsored schemes for the development of this sector. They are listed below:

- ❑ Development of Inland Fisheries & Aquaculture
    - ❑ Development of Freshwater Aquaculture
    - ❑ Development of Brackishwater Aquaculture
    - ❑ Cage Culture
- ❑ Development of Marine Fisheries, Infrastructure & Post Harvest Operations
    - ❑ Motorization of traditional craft
    - ❑ Safety of fishermen at sea
    - ❑ Rebate on diesel oil
    - ❑ Vessel monitoring system
    - ❑ Establishment of fishing harbours
    - ❑ Establishment of fish landing centres

- Strengthening post harvest infrastructure
- Development of deep sea fishing

- National Scheme for Welfare of Fishermen
    - Development of model fishermen villages
    - Group accident insurance for active fishermen
    - Saving-cum-relief
    - Training & extension

- Strengthening of Database & Geographic Information System of Fisheries Sector
    - Sample survey for estimation of inland fishery resources and their potential and fish production
    - Census on marine fisheries
    - Catch assessment surveys for inland & marine fisheries
    - Development of Geographical Information System
    - Assessment of fish production potential in coastal areas
    - Development of Database of Fisheries Cooperatives of India
    - Mapping of smaller waterbodies and development of GIS based fishery management system

- Assistance to Fisheries Institutes
    - Central Institute of Fisheries, Nautical and Engineering Training (CIFNET), Kochi
    - National Institute of Fisheries Post Harvest, Technology & Training (NIFPHATT), Cochin
    - Fishery Survey of India (FSI)
    - Central Institute of Coastal Engineering for Fishery (CICEF), Bangalore

- National Fisheries Development Board
    - Intensive Aquaculture in Tanks and Ponds
    - Fisheries Development in Reservoirs
    - Coastal Aquaculture
    - Mariculture
    - Seaweed Cultivation
    - Infrastructure: Fishing Harbours and Landing Centres
    - Fish Dressing Centres and Solar Drying of Fish
    - Domestic Marketing
    - Technology Upgradation
    - Deep Sea Fishing and Tuna Processing
    - Other activities

- Coastal Aquaculture Authority
    - To regulate the coastal aquaculture activities without affecting the environement
    - To grant permission for import of SPF shrimp brooders

- Issuance of Biometric ID cards to Fishermen
    - To prevent recurrence of terrorist attacks through sea route
    - Capturing of biometric details of individual fisher, production and issuance of cards

The sector is faced with many constraints which need to be addressed in order to harness the full potential of this sector. Some of the major problems are listed below:

- Development of sustainable technologies for fin and shell fish culture
- Fish Seed Certification
- Yield optimization
- Infrastructure for harvest and post-harvest operations
- Landing and berthing facilities for fishing vessels
- Uniform registration of fishing vessels
- Lack of reliable database on fish resources
- FishNon-availability of suitable fish yield models for multi-species fisheries
- Weak inter-disciplinary approach in fisheries & aquaculture
- Inadequate HRD & specialized manpower in different disciplines
- Weak linkage between R & D machinery
- Weak marketing & extension network
- Poor technology transfer
- Decline in fish catch
- Loss of biodiversity
- Depletion of natural resources
- Over-exploitation of coastal fisheries
- Pollution of water bodies with effluents
- Clandestine introduction and spread of exotic species
- Contamination of indigenous fish germplasm

Drivers for future growth

To sustain this growth of the sector in general, technology, infrastructure and market would play a major role apart from enhanced investment in research and development. Proven technology had been the main factors responsible for the phenomenal growth of the aquaculture, particularly after the advent of carp polyculture and composite fish culture in the late 70s. Similarly, major investments on infrastructure such as construction of mini harbours, jetties, landing centres, introduction of trawlers and mechanized vessels, supply of nets, etc. led to increased catch and contribution from capture fisheries sector. However, market has not been able to play a major driver for the growth of the sector so far. To untap the potential of the sector, this would take the lead in furthering the growth, especially in the emergence of aquaculture sector. Some of the illustrative aspects under each major driving force are given below for future attention.

(i) Technology

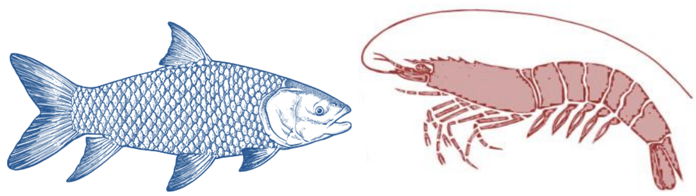
i. Quality seed production
ii. Selective breeding of carps
iii. Formulation of low cost feed materials using locally available ingredients
iv. Fabrication of nets for targeted fishing

(ii) Infrastructure

i. Construction of landing centres in second tier potential costal towns
ii. Creation of cold storage near landing centres
iii. Upgradation of manually operated boats into outboard motorized ones
iv. Supply of ice box

(iii) Market

i. Creation of domestic markets
ii. Creation of institutional structures like marketing societies with fishermen / fish farmers as members
iii. Creation of cold storage facilities
iv. Transportation of fish and fishery products by refrigerated containers from point of landing / production to consumption centres
v. Documentation of innovative market models already existing in the sector and replicating in similar areas with support from both Govt. and non-governmental agencies
vi. Grading, Standardization and Branding of fish an fishery products
vii. Creation of Market Information System with the application of ICT tools.



Annexure 1

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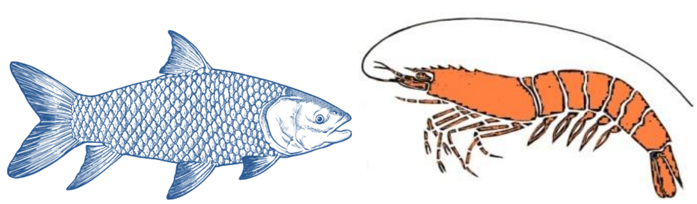

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