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Vision 2030

Central Institute of Brackishwater Aquaculture
Chennai

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FOREWORD

The diverse challenges and constraints as growing population, increasing food, feed and fodder needs, natural resource degradation, climate change, new parasites, slow growth in farm income and new global trade regulations demand a paradigm shift in formulating and implementing the agricultural research programmes. The emerging scenario necessitates the institutions of ICAR to have perspective vision which could be translated through proactive, novel and innovative research approach based on cutting edge science. In this endeavour, all of the institutions of ICAR, have revised and prepared respective Vision-2030 documents highlighting the issues and strategies relevant for the next twenty years.

Brackishwater aquaculture sector has overcome several challenges in the way of its development during last three decades. The sector has amicably blended itself with the immediate social milieu, has judiciously managed viral fish diseases, and has been fast in making its own amendments in response to the raid global market changes that happened in the last decade, like imposition of tariff and non-tariff barriers and unpredictable changes in the price. Under the present context, the importance and necessity of scientific research and policy analysis support system is felt very much critical for long-term survival and sustainability of brackishwater sector in the country.

The Central Institute of Brackishwater Aquaculture (CIBA), Chennai has set of focused research programmes planned to be undertaken for resolving the immediate and pressing issues of the sector viz., system and species diversification, disease management, feed development and extension and policy support analysis.

It is expected that the analytical approach and forward looking concepts presented in the '*Vision 2030*' document will prove useful for the researchers, policymakers, and stakeholders to address the future challenges for growth and development of the agricultural sector and ensure food and income security with a human touch.

(S. Ayyappan)

Dated the 4th July, 2011
New Delhi

Preface

Central Institute of Brackishwater Aquaculture (CIBA) has established itself as an organization of international repute and has been in the forefront for development of brackishwater aquaculture sector in the country. The core research and policy support given by CIBA in the last two and half decades has brought in many laurels and wide acclaim to the institution.

Closing the breeding cycle in captivity and making year round seed production of Asian seabass possible, developing diagnostic and analytical kits and low cost feed technology are some salient achievements. Successful commercialisation of these technologies and products in a fiercely competitive market, dominated by multi-national corporate players stands as a witness to the strength of scientific acumen available in CIBA. With stakeholders as the continued focus, the research requirements of the sector will be the central point for scientific work plan of CIBA in the forthcoming years also.

The importance of visioning and long term strategic planning has been given the highest plane of consideration in Indian Council of Agricultural Research (ICAR) system as a tradition. The Vision 2020 was an eye opener and the Vision 2025 - Perspective Plan enhanced the capacity for forward looking and futuristic planning at Institute level. Now the Vision 2030 includes a complete scenario analysis and strategies to be adopted. Stakeholders were taken into confidence in the planning process to make the research agenda relevant to their needs. Flagship research projects would be designed based on strategic planning underscored in this Vision 2030 document for achieving desired goals in a shorter time.

I wish to express my gratitude to Dr.S.Ayyappan, Secretary, Department of Agricultural Research and Education (DARE) and Director General, ICAR for the invaluable guidance provided in preparing CIBA Vision 2030.

I am thankful to Dr B. Meenakumari, Deputy Director General (Fisheries), ICAR, New Delhi, Dr S.D Tripathi, Chairman, Research Advisory Committee of CIBA, Dr R.Paulraj, Member Secretary, Coastal Aquaculture Authority, Chennai and Dr.P. Krishnaiah, Chief Executive, National Fisheries Development Board, Hyderabad for the valuable inputs given.

The Head of Divisions, Scientists-in-Charge of the Units, Scientists and Technical Officers provided inputs by actively participating in the series of consultations held for synergizing the viewpoints of stakeholders and scientists for fine tuning the CIBA Vision 2030.

I believe CIBA Vision 2030 will be a guiding light for utilizing the institute's scientific output for ensuring a remunerative, inclusive and sustainable brackishwater sector in India.

04 July 2011
Chennai

(A.G.Ponniah)
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Preamble

India is the third largest producer of fish and seventh in shrimp aquaculture production. Resource endowment wise, India has been blessed with a long coast line of 8129 km distributed in nine coastal states and four Union Territories and the biodiversity of the coastal ecosystem of the country is rich with a wide spectrum of fauna and flora. The country has 3.9 million ha estuaries, 2.54 million ha salt affected coastal soils, 0.5 million ha mangroves and 8.0 million ha inland saline soils. These resources are the real biological wealth and strength that provide immense opportunities for development of brackishwater aquaculture in the country. Determined efforts put in by the Government and supporting institutions for the last 5 decades have shown the results. The fish production in the country has shown remarkable growth increasing from 0.752 million tonnes in 1950-51 to 8 million tonnes in the year 2010-11. Exports of marine products from India during the financial year 2010-11 touched the $2.67-billion mark, growing 10.96 per cent in quantity, 20.42 per cent in rupee value and 25.55 per cent in dollar realisation over the figures for 2009-10. Shrimp exports increased considerably during the year due to production of 10,000 tonnes of the white leg shrimp vannamei, in addition to the higher production of tiger shrimp monodon. Frozen shrimp continued to be a major export item, accounting for 46 per cent of the dollar earnings. Exports to the U.S. registered a tremendous growth of about 83 per cent in volume and 140 per cent in dollar terms and those to Japan showed an increase of 17 per cent in volume and 43 per cent in dollar value. The fisheries sector contributed around 29,707 crores to the country's economy, 1.04% of the national Gross Domestic Product (GDP) and 5.34% to the agriculture GDP in the last Five Year Plan period. Only 56% of the population consumes fish and the per capita consumption of fish is 9 kg/year against the global per capita consumption of 12 kg/year. The brackishwater aquaculture sector has great potentials to generate employment and attract foreign exchange. This is amply demonstrated by the rapid expansion of the sector which has grown at an average annual rate of 10% since 1984 compared to 3% for livestock meat and 1.6% for capture fisheries production. The new economic policy of the Government of India in 1991 had identified aquaculture, especially shrimp aquaculture, as a thrust area for enhancing export earnings.

The Food and Agricultural Organisation, International Food Policy Research Institute and the WorldFish Center have predicted that there will be severe short supply of fish in the next millennium due to domestic and international demand concomitant with the higher living standards and increasing disposable income of the world population. With capture fisheries at stagnation level, the demand for fish in the coming years can be met only through aquaculture. The potentials of brackishwater / coastal aquaculture of the country are yet to be fully realized. This sector has unmatched assured return for the investment and with the opening up of the economy of the country, investment in this sector is expected to grow manifold leading to several possibilities for area expansion and product differentiation. The major challenge is implementing a vibrant research agenda that addresses present issues like White Spot Syndrome Virus (WSSV) and emerging concerns like climate change. We have to ensure that while combining the regular culture approaches with the range of tools available from biotechnology and other frontier areas, the focus should not slip from development of cost effective technologies and addressing the environmental and social concerns.

The Institute with its continued research and development support to the sector is poised to provide the required fillip for an all round development of the brackishwater aquaculture in the country. CIBA Vision 2030 is presented with a holistic approach, and its implementation in partnership with stakeholders, will sustain the growth of brackishwater aquaculture of the country.

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Brackishwater Aquaculture Scenario

Demand and prices of most of the food items are increasing across the globe. But price of fish have not increased in the last decade and in fact global average price of the shrimp has reduced due to stiff competition among the producer nations and the economic slowdown that is being experienced by consumers of USA and European Union. While the input costs are on the rise, the output prices have stagnated or even declined barring few seasonal ups and downs. This paradox of increasing input prices and decreasing output prices coupled with recurrent crop losses due to epidemic viral diseases have severely curtailed the operating margins of the farmers. Moreover, stringent food quality and safety standards that are being imposed upon by the importing nations have added to the cost of production. Under this backdrop, development of low cost production technologies and disease and weather proofing of aquaculture has become the central theme of research for sustaining the brackishwater aquaculture sector in the country. Aquaculture involves complex biological processes and many bio-eco system interactions which are also being impacted by climatic changes. Contrary to the general belief that 'shrimp aquaculture is by the rich and for the rich', brackishwater aquaculture in India is being predominantly (more than 90%) practiced by small farmers and in the lands which are mostly unfit for agriculture or any other primary production activities.

Brackishwater aquaculture and economy

Fisheries contributes 15.7 % of agriculture sector to the gross domestic product of the country in 2008-09, 5.34 % share in total exports and about a share of 18 % of national agricultural exports. Shrimp aquaculture is estimated to generate an annual income of Rs. 3,000 crores and provide employment for about 7 lakh people and directly support the livelihood security of more than 1 lakh families (FAO,2010) . Currently, only about 15 % of the potential area are under culture. The sector can easily generate an income of Rs. 6,000 crores, support employment of 14 lakh people and provide livelihood security for about two lakh families. Of the potential brackishwater farming area estimated at 1.2 million ha during 1980s, it is proposed to develop at least 20 % of potential the area i.e, 2.4 lakh ha under brackishwater aquaculture by 2030 AD. Many impediments exist for area expansion of brackishwater aquaculture. With new Coastal Zone Management regulations in place, the potential area for brackishwater aquaculture needs a re-assessment and efforts are to be put in for identification of actual potential area through micro surveys and by employing Remote Sensing (RS) and Geographical Information System (GIS) tools. Revenue classification of lands and regulatory limitations to regularisation and new area development are to be reworked. Already about 60,000 ha of shrimp farming area is estimated as abandoned due to recurrence of White Spot Syndrome Virus (WSSV) and reversal of terms of trade against producers, lean credit flow, distended input costs and condensed output prices. To make the sector vibrant, institutional mechanisms for regulation, research and development need to be revitalized, packages for rejuvenating abandoned ponds developed, production technology optimised to cut down risks and increase profitability and technology dissemination mechanisms strengthened.

Small holder aquaculture

Indian brackishwater aquaculture sector comprises of more than 90 % of the farms having less than 2 ha of land holding. Like in any other economic activity, the small brackishwater aqua farms are scale inefficient as the bargaining power for cost effective purchase of inputs as well as remunerative sale price, is severely curtailed due to miniscule volumes of operation which lead to low profitability. The profitability and sustainability of small farms are to be protected and mechanisms need to be evolved and enhanced for implementing bio-security protocols for reducing farming risks (Arthur *et al*, 2009). Group farming can take advantage of scale of operation in farming right from sourcing input, building in sound environmental management plans (Hall *et al*, 2011) and getting a better farm gate price for the produce. This would require mobilising farmers for collective compliance of guidelines and Best Management Practices (BMPs) based on a combined bio-security approach, implementing common reservoir and common wastewater treatment system and can make our brackishwater aqua farms more eco-friendly and risk resilient. Research support also needs to be extended for promotion of horizontally and vertically integrated farms and functioning of cluster and contract farms. Developing integrated operating modules of farmer groups, promoting the development of One-Stop Aqua Shop (OAS) by entrepreneurs that would help the farmers get the inputs and technology in close proximity of their farms, putting in right regulatory guidelines to ensure collective compliance by farmers, and profitable interlinking of the partners in the value chain, are needed for sustaining aquaculture as a profitable enterprise.

Technology landscape in culture operations

Brackishwater aquaculture which was started as a traditional low intensity activity a few centuries ago metamorphosed into a semi-intensive farming technology in early 1990s and due to legal intervention, changed to improved extensive farming system by the close of the last millennium. Improved extensive farms further logically got self- rationalized into sustainable low input and low output farms in the first decade of the current century, making the farmers environmentally aware to sustain shrimp farming in the long run. Revitalizing traditional systems, developing new systems (cage and pen aquaculture in open water brackishwater bodies and Recirculating Aquaculture System - RAS) are the priority areas of research and development. Increasing productivity and profitability of existing systems, smoothening of regulatory hurdles and development of environmentally sensitive packages for open water brackishwater aquaculture will be the focussed research support agenda for area development. Though possibilities exist for upgrading the traditional aquaculture farms into organic farming systems, the runoff from agriculture fields where pesticide is used finding way into traditional farming systems and the difficulties of making small traditional farmers to comply with record keeping and certification requirements, are challenges to be faced. Improving traditional systems by incorporating scientific farming principles, culture of brackishwater species in low saline aquaculture areas, developing technology packages for new aquaculture systems, conduct of regular environmental impact assessments, development of cheaper feeds and eco-friendly open water and RAS aquaculture systems hold the keys of technological enhancement process.

Lack of diversification

The traditional farming which is in vogue in Kerala and West Bengal provides multiple outputs in the form of a mixture of fin and shell fish. The higher production and profitability of tiger shrimp farming that was introduced in early 1990s made the sector single-commodity focused with over dependence on export. The production and price risks associated with the aquaculture of single species (tiger shrimp) were the driving forces that could detriment or benefit the sector. It is estimated that about 143 species of endemic potential cultivable brackishwater food species are available in Indian waters. It is envisioned that India should have at least six cultivable brackishwater food species accepted by farmers and markets. With concerted efforts in the last two decades, CIBA made breakthrough in making a complete package of seed, feed and market information for Asian seabass (*Lates calcarifer*). Among shrimps seed production and culture technology has been developed for diversified species like *Fenneropenaeus indicus, F. merguiensis,* and M*arsupenaeus japonicus.* CIBA also facilitated safe introduction of vannamei in the country in 2008-09. The other opportunities for diversification are development of breeding and culture technologies for herbivorous fin fishes and high value marine ornamental fishes. Technology verification and refinement, creation of broodstock and farm testing facilities and assessing profitability and marketability for endemic/new fish species assume importance. Bio-diversity issues and introduction of new pathogens with exotic species are the concerns to be cautious about. Developing of captive broodstock of cultivable fish species, facilitating disease free seed production, improving feeding and grow-out technologies, and popularising and up-scaling of new species are areas that need attention. Use of biotechnology tools to address problems of difficult to breed species, risk analysis and quarantine for introduction of exotic species, developing feed technology using plant protein sources and developing workable models of Public Private Partnership (PPP) for up- scaling fin fish farming are some promising avenues for solving the issues in diversification of fish culture.

Increasing environmental concerns

Regulations to address environmental concerns have been implemented by CAA. In view the difficulty in enforcing and higher level of investments required for forced compliance of these regulations, there is need for increasing the awareness and capacity building of farmers for maintaining environmental standards. Contrary to the perception that aquaculture is a polluting activity, public should be made aware that in India, shrimp aquaculture has not been at the expense of mangroves and properly managed aquaculture facilities have negligible level of impact on environment. Designs of effluent treatment ponds (ETP) should be based on both nutrient load and volume of water discharged. Ecosystem approach should be employed to assess the environment of shrimp farming in a holistic manner. Impact of industrial effluents and thermal power plants on coastal aquaculture are also to be evaluated. Harvesting methods need to be improved to reduce the wastewater discharge and reduce the nutrient load in the pond itself. Secondary aquaculture could be promoted in ETPs to make ETPs as revenue generating mechanisms to aid in better compliance. Development of bioremediation techniques, simplification of environmental guidelines, revalidation of ETP protocols in the scenario of changing culture practices and systems of culture and developing Environment Management Plan (EMP) and integrating them with guidelines and Best Management Practices (BMPs), are the major environmental sustainability issues that would be addressed.

Loss due to diseases

The Gross National losses due to shrimp diseases in the country during 2007-08 was estimated as i) 48,717 metric tonnes of product i.e., about 30 per cent of shrimp production, ii) national income of Rs. 1022 crores and iii) farm level employment of 21.6 lakh man days. Among the diseases, the most serious were WSSV, Loose Shell Syndrome (LSS) and combination of WSSV and LSS, White gut and Slow Growth Syndrome. These bacterial and viral diseases are to be tackled and the access to pathogen free seed for all the farmers is to be increased. Effective disease management strategies for containing existing diseases and preventing the spread of emerging diseases are to be given prime importance and support. Developing therapeutics and control mechanisms for WSSV is still a research challenge, in view of the poor immune systems in shrimp and viral mutations. Developing a surveillance mechanism for disease management has remained as a challenge unattended in spite of best efforts. Though farmers' awareness about diseases and bio-security protocols has increased, small farmers do not have sufficient wherewithal for creating bio-secure farm facilities. India has already taken steps for introduction of Specific Pathogen Free (SPF) shrimp seeds for minimizing disease incidence/risks and increasing farm production. A domesticated SPF broodstock bank if created will be of immense use to the hatchery operators and farmers. Hazard Analysis and Critical Control Point (HACCP) concept in farming practice needs to be popularized and mobile shrimp health clinics may be made operational during the crop season. Standardisation and popularisation of bio-security protocols, developing simple field level diagnostic kits and devising preventive and therapeutic measures are the other challenges to be faced. Research system needs an increased capability for tackling emerging diseases and a multi-pronged strategy for information dissemination on disease occurrence.

Climate change impact

Like in any primary production enterprise dominated by small operators, shrimp farming sector also has low level of preparedness to meet extreme climatic events. Potential for salinity and temperature increase over present levels during grow-out period are the most easily perceived climate changes. To develop climate resilient aquaculture technologies, complex interactions and uncertainties of climatic factors are to be understood and documented. For example, the impact of climate change on sea level rise may result in more areas coming under brackishwater aquaculture. CIBA should assess the impact of climate change on aquaculture and based on the likely impacts and farmers' capacity for adaptations, develop short-term and long-term remedial measures.

Export market

Major importers for Indian fish trade were USA, EU and Japan till the last decade. Now the major buyers are EU, China, Japan, USA and South East Asian countries. The product composition of exports has also changed to shrimps (20% in volume and 40% in value) and fish (40% in volume and 20% in value). Research system should aid the producer groups to meet the expected international standards. National standards are to be reworked in tandem with international consumer requirements. Novel production and marketing strategies are to be designed for extenuating negative impacts on shrimp farmers due to trade issues like levy of antidumping duty, traceability and food safety concerns and volatilities in global shrimp prices. Niche markets for organic shrimp could be explored with research and policy support from CIBA for developing organic farming standards acceptable to international consumers. To start with, popularisation of low input - low cost shrimp farming could be taken up. CIBA could assist the sector by conducting the awareness programmes for all stakeholders including consumers, capacity building of trainers and progressive farmers.

Growing domestic demand for fish

Indian domestic fish consumption is projected to increase to the tune of 0.3 kg of crustaceans and 1.2 kg of high value fin fish per capita in 2020 (Delgado *et al*, 2003). The per capita income of Indian citizen was Rs. 36,003 in 2010-11 against Rs 33,731 in 2009-10. With this kind of high growth in personal income, domestic consumption of crustaceans, mostly of high value may rise to 0.5 to 0.6 kg and consumption of high value finfish may reach 1.5 kg per annum in 2030 AD. This domestic demand requirement may help in sustaining brackishwater aquaculture sector to a major extent. Domestic market requirements of year round supply, seasonal patterns in demand and supply due to religious codes, fishing ban and natural availability of fish from seas and open waters are to be understood for a robust aquaculture production planning. Buffer storages and cold chain are to be ensured for supplying the required amount of each category of fish to inland cities having good demand for seafood. Creating awareness about fish as 'health food' among the consumers is another hurdle to ride through. Production centres should be identified and market linkages should be developed with the objectives of reduced costs of processing and transport and minimal carbon foot print. An integrated communication strategy is to be devised to promote domestic fish consumption.

Integration and value chain

Currently small farms under brackishwater aquaculture are found to have a very low horizontal and vertical integration. Coastal aqua farms should be cost effective and socially equitable for long term sustainability and for an easy fusion with immediate social milieu. A horizontal integration by different small holder farms will help in obtaining the right capital and technology required. A continuous dialogue and coordination between different stakeholders are to be encouraged. Emergence of various forms of collective farming by small scale farmer following different models of cluster and contract farming is to be encouraged and their integration with existing value chains are to be assisted with. Policy analysis and research support for customised requirements for hatchery, feed mill, grow-out and RAS are to be piloted by CIBA.

About Central Institute of Brackishwater Aquaculture

The Central Institute of Brackishwater Aquaculture (CIBA), one of the eight institutes under the Fisheries Division of the Indian Council of Agricultural Research (ICAR), was established in April 1987 to conduct research and provide technology support to the country's growing brackishwater aquaculture sector. The Headquarters of the institute is located in Chennai with field and farm facilities at Muttukadu, about 30 km south of Chennai. The institute has one Research Centre, located at Kakdwip (West Bengal). CIBA has undertaken a collaborative project on brackishwater aquaculture development in Gujarat with Navsari Agricultural University, Navsari, Gujarat to address the needs of brackishwater aquaculture development in the west coast.

The proposal by CIBA for establishment of a Krishi Vigyan Kendra (KVK) in Andhra Pradesh is also being favourably considered by ICAR and the Government of Andhra Pradesh. Research planning in CIBA has been in tandem with the priorities at the state level and national and international organizations. The Institute has also established PPP with leading private entrepreneurs for research and development of brackishwater aquaculture sector in the country.

Mandate

1. Develop economically viable and environmentally sustainable culture technologies for finfish and shellfish in brackishwater systems in different agro-ecological regions.
2. To meet emerging requirements of brackishwater aquaculture, carry out basic and strategic research.
3. Evaluate economically important brackishwater biological resources for their commercial utilization.
4. Provide policy and planning support for socio-economic development, through environmentally sustainable, brackishwater aquaculture.
5. Undertake human resource development and transfer of technology programmes through training and extension and to provide consultancy service.

Impact

Introspection on the impact of research programmes and development efforts taken by CIBA in the past two and half decades revealed considerable clout with stakeholders. In a macro level study of impact of fisheries research, it was established with state level and farm level survey data, that the new technologies have contributed to an increase in the yield of modern shrimp farms by 300 to 400% over traditional systems. But with increased yield, the production and price risks have also increased. During a disease loss assessment programme 0.49 probability of crop loss was estimated due to dreaded WSS virus. The micro level impact assessment of Institute Village Linkage Porgramme (IVLP) carried out by CIBA has proved that the livelihood of coastal poor improved with subsidiary enterprises of shrimp farming, livestock rearing and backyard gardening.

As *ex ante* assessment, a risk analysis was done for vannamei introduction. Ministry of Agriculture accepting the report, laid guidelines for vannamei seed supply and farming, which resulted in 10,000 tonnes of shrimp production from India. CIBA in collaboration with Coastal Aquaculture Authority (CAA) was directed to oversee the supply of SPF seeds of monodon from Moana Technologies. The crop performed well in Andhra Pradesh and Gujarat in 2010. Aquaculture and alternative livelihoods of shrimp feed production, crab fattening and value addition of fish were successfully transferred to women Self Help Groups (SHGs). The beneficiaries are continuing the enterprises even after the withdrawal of monetary and technical support.

CIBA 2030

CIBA has matured to an internationally recognized national research facility for brackishwater aquaculture in its existence for the last twenty five years. CIBA is regular in conducting small and focused stakeholder interaction since the last decade to get a first hand information about their problems and to showcase new technologies and CIBA has participated and facilitated many stakeholder dialogues on introduction of new species, sorting out the issues in implementing the regulatory norms and framing new guidelines solely and in collaboration with Coastal Aquaculture Authority (CAA), Marine Products Export Development Authority (MPEDA), National Bank for Agriculture and Rural Development (NABARD), ICAR's, Network of Aquaculture Centres in Asia-Pacific (NACA), Thailand and WorldFish Center, Malaysia. Strong research bondages have been developed with leading research centres in USA, Australia, UK, France, Norway, Thailand, Viet Nam and the Philippines in the last two and half decades.

CIBA has established state of art laboratory facilities and has trained most of its scientific manpower overseas with the funding support of ICAR, National Agriculture Innovation Project and Department of Biotechnology. A vibrant and responsive research setup has been created under the banner of CIBA and is in place to meet the existing and emerging challenges in brackishwater aquaculture aspects in the country.

Vision

Environmentally sustainable, economically viable and socially acceptable brackishwater aquaculture, that increases the earnings of small scale fish farmer and provides quality produce to meet the diversified requirements of consumers.

Mission

Further scientific applications to develop cost-effective technologies and facilitate growth of brackishwater aquaculture in an environmentally sustainable and socially acceptable manner.

Focus

To meet the increasing demand of shrimp and high value fin fish like seabass, an increase in the area under culture as well as increase in average productivity are to be focused upon. On the other hand, at present the sustainability of this sector is seriously threatened by two major issues – viral diseases and environmental concerns. This has led to increased risks of crop failure and reduced profit margin. A few shrimp farms have been abandoned and in most of the cases, the small scale farmer is the most affected. Therefore development of environment friendly and cost effective brackishwater culture technologies with focus on techniques suitable for adoption by small scale farmers is an urgent requirement. This would require technological interventions to reduce the cost of feed and replacement of fish meal in feed with alternate protein sources. Greater investment into understanding the pond dynamics in relation to microbiology and nutrient flow would lead to better management of soil and water leading to improving production from traditional shrimp farming and reduced pollutant load. Bio-remedial measures and improving the existing BMPs would ensure that shrimp farming remains environment friendly. Promoting institutional mechanisms and addressing aquaculture finance issues will ensure that the small scale farmer is empowered to realise the gains from technological interventions. One of the main reasons that brackishwater farming has become high risk is due to its dependence on one species, monodon for export market. Therefore there is an urgent need to diversify into other shrimp, crab and finfish species. In crab and seabass where successful seed production has been achieved, the missing links for large scale adoption is the absence of cost effective feed that can replace the present practice of using trash fish. Therefore diversification of species and systems is vital for sustained growth of brackishwater aquaculture. Development of domestic and international markets for the produce, establishing a well knit set up for market information and intelligence for aquaculture produce with the objective of reducing information asymmetries that currently exist among different players of the supply chain should be supported by public and private investments along with implementation of HACCP, traceability, eco-labelling and quality assurance criteria for uniform and wider compliance. Therefore development of planning tools, governance guidelines and strategies to develop value chain in brackishwater aquaculture is an essential requirement.

In view of what has been said in the foregoing paragraph, the six broad thematic focus areas of research of CIBA will be:

1. Environment friendly and cost effective brackishwater culture technologies with focus on techniques suitable for adoption by small scale farmers.

2. Comprehensive health management to address the existing and emerging diseases in shrimp and fish production systems.

3. Faster growth and increased disease resistance through application of genetic and biotechnological tools.

4. Diversification of species and systems for development of sustainable brackishwater aquaculture.

5. Evaluation and utilization of economically important brackishwater resources, and

6. Socio-economic analysis and policy support for sustainable brackishwater aquaculture development

Harnessing Science

Harnessing science for development is geared towards supporting farming sector for rapidly evolving people-centered, inclusive, development oriented programmes to attain sustainable and equitable development in all the fronts. CIBA being a scientific R& D centre is committed to exploit the scientific methods and tools for the development of the sector in the six broad thematic focus areas of research identified in the earlier chapter, as detailed below.

Environment friendly and cost effective technologies

With focus on reducing feed input and increasing bio-security of pond based systems, CIBA has developed two grow out technologies of low input - low cost and improved bio-secure farming systems for tiger shrimp. For increasing the productivity and profitability of these systems, the ongoing work at yard and pond level investigations on periphyton, pond microbial and nutrient dynamics, and biofloc will be used to further reduce feed and channel natural productivity into shrimp production. This improved shrimp farming system will be popularised with farmers as Low Input and Low Cost system and with additional inputs for certification, as Organic farming.

Organic shrimp culture pond


Tiger shrimp cultured with organic inputs

The mandatory bio-secure practices for vannamei will be evaluated and improved. The ongoing disease monitoring of the traditional farming system of *bheris* in West Bengal has indicated the higher incidence of WSSV in these systems. Efforts will be made to improve the productivity and to reduce the disease risks in paddy cum fish culture, *bheris* and other traditional systems like *pokkali* in Kerala.

Scientific principles for managing the productivity of these systems, to suit the poly farming practices being adopted and development of stocking, feeding and biosecurity practices that can be implemented with minimum cost will be attempted. Developing new systems like Recirculating Aquaculture Systems (RAS) with private entrepreneurs on a pilot scale, combining their capacity for engineering design and our expertise on microbes for optimising the capacity of biological filters, will be a thrust area. Once the profitability and the environmental impact level of these systems are evaluated and found optimum, these technical details will be provided to CAA for getting such systems approved and popularised.

Paddy-cum-fish culture

Realizing feed constitutes 40 to 60 % of cost in shrimp farming (Hasan *et al*, 2007), the percentage of fishmeal and cost of shrimp feed have been brought down by substituting with cheaper alternatives while maintaining the nutritional requirements. The shrimp feed developed was evaluated in farmers' ponds under a PPP mode and the technology developed for cost effective shrimp feed has been transferred to a private entrepreneur, who has captured 20 % of shrimp feed market in Tamil Nadu. To increase the use of plant proteins in feed, pre-digesting with enzymes is being evaluated and there is scope for using fermentation and probiotics approach to further increase utilization of plant protein. 'Specific' feeds for low and high salinity conditions are being developed and feed additives which lead to increase growth and improved disease resistance will be evaluated. It is proposed to exploit the 'nutrigenomics' approach for further refinement of feeds for increasing the percentage of plant protein used, formulate specific feeds and also to increase disease resistance.

CIBA's pioneering work with a cluster of shrimp farmers in Thambikottai, Tamil Nadu, established the potential of group farming. NACA and National Center for Sustainable Aquaculture (NaCSCA) have implemented this cluster concept on large scale in different states. One of the main challenges with such group farming is ensuring cooperation between farmers. To increase the harmony among farmers within a cluster, successful clusters are being studied to identify factors responsible for cohesion or disharmony. The practices followed are also being studied and these will be fashioned into standard operating procedures for group farming by small scale farmers, which can also help in certification of their produce.

In order to develop bioremediation approaches, various agro wastes were evaluated and it was confirmed that bagasse has the potential for bioremediation and to increase shrimp production. The ongoing work on 'green water technology' of growing fish in small pens in the ponds has indicated the potential to reduce *vibrio* load and that of biofloc on reducing ammonia levels in shrimp ponds. These approaches will be further authenticated with more trials and other approaches based on pond microbial dynamics to develop *in situ* bioremediation within ponds, which assumes greater importance with the advent of semi-intensive vannamei culture.

Based on studies undertaken, the earlier ETP procedure for shrimp farms has been modified and is currently being adopted as part of CAA guidelines. Ongoing programmes on evaluation of potential organisms like seaweeds and fishes for secondary aquaculture in ETP ponds, would be further enlarged to evaluate annelid worms and molluscs. Based on the changing culture practices and system of culture, modification of ETP techniques will be taken up with additional focus on volume of water and nutrients load. With the growing adoption of vannamei culture, focus will be on improving harvesting methods and evaluation of mechanical harvesting to reduce the amount of water discharged at a point of time and its potential for reuse in addition to the quality of harvested shrimp.

Extensive data on water quality parameters of discharge and receiving waters from shrimp ponds was obtained and based on this, technical advice to CAA for developing shrimp water discharge standards were provided. The methodology for estimating optimum area for shrimp farming based on the carrying capacity of receiving waters was tested in three shrimp farming areas and validated. Using these data and taking into consideration the scenario of changing culture practices and systems of culture, efforts will be made to modify the protocols for environmental impact studies and including the discharge water quality standards to be adopted, and the environmental guidelines will be simplified.

Diversification of species and systems

CIBA had developed technologies for year round production of seabass seed, nursery rearing, feed and grow-out and is carrying out demonstration in different states in farmers' ponds under NFDB funding.

Farmer with harvested seabass

Seabass harvest from farmer pond

NFDB is also funding the transfer of CIBA's seed production and seabass feed '*Bhetkiahar*' to private entrepreneurs. Two proposals for establishment of large scale integrated seabass farming involving entrepreneurs and farmers are in different stages of implementation by private entrepreneurs with technical support from CIBA. Once these facilities become operational, CIBA would concentrate on improving broodstock management. Diagnostics of nodavirus that causes mortality in seabass seed has been perfected and is available for commercialization. Development of vaccines for nodavirus and *Vibrio anguillarum* that affect the grow-out stage has been initiated with international collaboration. Steps need to be taken to augment the holding capacity for broodstock development of different species as a National Marine Finfish Program under a Public Private Partnership mode. For breeding mullet and cobia, success with captive maturation in large cement broodstock tanks has been achieved with limited spawning, and the seed production technology has to be standardized for commercial application. The ongoing efforts on nursery and grow-out rearing of mullet and pearlspot under different farming systems would be perfected for large scale demonstrations in farmers' ponds. The efforts which are already underway to develop polyculture of finfishes with shrimp would be further strengthened to channel more of natural productivity into fish production.

The seed production and capacity building in crab seed production had resulted in an entrepreneur setting up a private hatchery for mud crab seed production. Nursery, grow-out and feed technologies have been developed and large scale demonstration need to be taken for popularizing the mud crab farming and further refinement of the technology based on farmers feedback. Banana shrimp seed production and potential for domestication has been established and based on its higher rate of growth in low temperature, the species is being evaluated as a potential winter crop in Gujarat. For all the diversified species in the states where their culture is proposed to be taken up, potential for marketing along with consumer acceptance for the size of cultured fish would be taken up. Collection of data on economics of production would be taken up and based on these, support would be provided to development agencies for scaling up of area under culture and popularization of these species for culture.

Vannamei was introduced into the country based on the risk assessment carried out by CIBA and the subsequent guidelines and decisions taken have largely been based on the risks identified. For other new exotic species to be introduced, risks related to biodiversity issues, alien disease, market and society will be assessed *ex-ante*. Capacity building to carry out detailed risk assessment studies will be emphasized. The technical backstopping required for the public and private sector for introduction of improved germplasm, broodstock management and for carrying out further selective breeding would be provided so that these programmes can have a 'jump start' under a PPP mode.

Comprehensive health management

Vibrio is one of the major bacterial pathogen that causes large scale mortality, in shrimp hatcheries. Potential of bacteriophages to control vibriosis in hatcheries has been recognized. Large scale hatchery trials with these phages and the ongoing work on 'quorum sensing' will lead to new products to control *vibrio* in hatcheries. Though probiotics are extensively used in aqua farms, little is known of the mechanism involved, and the reasons for the variability in their effectiveness. Presently studies are underway to identify the underlying mechanisms so that the effectiveness of probiotics can be improved. Use of metagenomics could help in understanding the ecology and management of aquaculture systems using probiotics.

Evaluating bio-security measures adopted in farmers' ponds and correlating with WSSV disease outbreaks has clearly demonstrated that the disease risks can be reduced with farm level bio-security. Though farmers' awareness about diseases and bio-security protocols has increased, small farmers are not prepared to make the investment required for bio-secure farm facilities due to many constraints. The ongoing investigations on molecular epidemiology and horizontal transmission in shrimp ponds will increase our understanding of location specific risks and help in further standardisation and popularization of bio-security protocols. The Standard Operating Procedures to be adopted for a combined bio-security approach with common reservoirs and common wastewater treatment systems will be developed.

The ongoing molecular studies on sequential pathogenesis of WSSV and defence mechanism in monodon will increase our understanding of vertical transmission and help strengthen screening procedures of wild broodstock and improve bio-security protocols to be adopted in hatcheries. It has been possible to eliminate WSSV from adult shrimps using dsRNA techniques and this approach is being standardised for use with broodstock so that the risks of using WSSV infected wild stocks could be addressed. Different delivery mechanisms of these dsRNA will be evaluated for developing therapeutics that could be applied in the grow-out stage.

Investigations with emerging diseases such as slow growth syndrome have thrown more light on the role played by Laem-Singh virus (LSNV) in the disease. With LSS, a virus like entity has been identified and is being further characterised. Viral metagenomic approaches would be applied to understand such emerging viruses. With the advancement in understanding of these syndromes, further simple field level diagnostic kits would be developed and preventive and therapeutic measures devised. Technical support was provided for screening of exotic pathogens during quarantine of vannamei broodstock. A study on monitoring disease agents in vannamei hatcheries and farms has been initiated. For exotic pathogens like Infectious Myo Necrosis Virus (IMNV) and other viruses that are yet to be reported from India there is a need to increase our capability to tackle such exotic diseases and develop a disease reporting system with information flowing from farmer to CIBA. Policy and technical support will be provided to increase access of SPF seed to all farmers and eliminate the use of wild broodstock.

Faster growth and increased disease resistance

Efforts to genetically improve tiger shrimp using tagged and independently maintained families of tiger shrimp made it possible to demonstrate that additive genetic variation exists for growth and pond survival whereas little variation exists for WSSV resistance in tiger shrimp. Since genetic variation for WSSV resistance is low in tiger shrimp, attempts were underway to find genetic markers for WSSV resistance. In this regard, next generation sequencing technology on Illumina platform was used to acquire complete transcriptome sequence of tiger shrimp and detect single nucleotide polymorphisms in transcriptome. A DNA chip that would be useful to genotype shrimp for detected polymorphisms is under preparation. Since challenge test is required to identify WSSV tolerance, the complexities of the test were unravelled to identify tolerant shrimp. The late-dying and early-dying shrimp post-challenge would be genotyped and analyzed to find markers that would eventually be useful in genetic improvement programs. Studies to characterize morphological and genetic differences among the stocks of tiger shrimp along the Indian coast were taken up. These would help in designing proper conservation strategies and breeding programs. Studies have been initiated to attribute variations in candidate genes to body weight and disease resistance which would form basis for practicing marker assisted selection to reach desired selection goals. Contemporary approaches of suppression subtractive hybridization were being tried to find novel genes conferring salinity tolerance to tiger shrimp.

Currently efforts are underway to identify genes responsible for maturation and spawning in tiger shrimp so that dsRNA and other molecular tools would be used for increasing the success of captive maturation. The studies would also help in the efforts to produce all female populations, since for the same culture conditions and durations, female tiger shrimp attain larger size. Increasing our capacity on molecular characterisation of reproduction would also help in developing gene-knock out technologies to produce sterile populations of salinity tolerant tilapia, one of the candidate exotic tilapia strains being considered as an alternate species for abandoned shrimp ponds. Since full genome sequence of tilapia is expected to be available soon, collaboration with such institutions would enable making faster breakthroughs.

Utilization of brackishwater resources

Brackishwater bodies are a potential important natural resource that has not been extensively utilized for aquaculture. CIBA has been able to transfer mud crab fattening in brackishwater bodies along with two other technologies mentioned earlier in the report to women SHGs as livelihood options. Since aquaculture in brackishwater bodies is not allowed under CAA, experimental work for developing cage and pen in open water brackishwater bodies could be started with CAA approval. Initially Environment Impact Assessment (EIA), carrying capacity assessments and potential for social conflicts will be evaluated, taking into consideration the multiple uses of these systems. Environmental management plans to address environmental concerns would be developed. Successful crab fattening techniques have been transferred to women SHGs and efforts will be made to customise nursery and rearing technologies of candidate species for cage and pen culture for adoption by SHGs and integration with other livelihood options that women could take up. The economic feasibility of polyculture in cages using mullets, chanos and pearlspot along with molluscs and seaweeds will be evaluated.

Marine microbes are a potential natural resource of bioactive molecules. CIBA has identified certain microbes from brackishwater environment producing agriculturally important enzymes such as isopentyl transferase, isochorismate synthase, phosphoshikimate carboxyvinyl transferase, etc, which can provide insect resistance, protection against microbial infections and herbicide resistance in plants. Such bioactive molecules require further evaluation and harnessing for improving agricultural productivity. Microalgae and halophytes will be added to the biological groups being evaluated and the focused efforts will be made to realize the economic potential of these organisms. Microalgae are the untapped resource and innovative processes and products have been applied in micro algal biotechnology to produce vitamins, proteins, cosmetics and health foods. With the development of culture and screening techniques, microalgae biotechnology can help in developing feed additives and therapeutics for use in aquaculture. Economic feasibility of growing halophytes, using brackishwater from the ponds will be evaluated.

Irrigating halophyte (Salicornia) with farm discharge water

Socio-economic analysis and support to policy and planning

The small scale nature of the shrimp farmers having land holding less than 2 ha need to be clarified since this differs for different locations and has implications for targeting subsidies and support from the state as well as for ensuring social equity when they take up group farming and get integrated with value chain. Gender studies in brackishwater aquaculture revealed the important role played by women in brackishwater aquaculture and the existing scope for promotion of entrepreneurship among them. It has been possible for capacity building and transfer of three brackishwater aquaculture and allied technologies working with women self help groups and these SHGs are able to continue using these as livelihood options even after the project period.

Women of SHGs preparing crab for fattening in pens

Preparing feed

Establishing linkage with financial institutions, government line departments, NGOs and markets has helped to stabilize their livelihoods. Based on the lessons learned and experiences gained, it is proposed to take up a similar project covering more SHGs and in partnership with Non Governmental Organizations (NGOs). Efforts are also being taken to integrate other livelihood agriculture and animal husbandry options so as to cut down risks and enlarge the basket of technology options available to them.

Based on an extensive study on the channels by which information reaches farmers in Tamil Nadu and Andhra Pradesh, the dynamics of information flow was identified and it clearly brought out that compared to freshwater aquaculture, brackishwater aquaculture farmers are greatly influenced by private consultants. Based on this study, and evaluation of other technical information dissemination modes like Aquachoupal and Village Knowledge Centres, CIBA plans to advance the uses of Information and Communication Technology (ICT) in dissemination of information to farmers and is presently evaluating the use of mobile technology.

For the purpose of aquaculture planning, using remote sensing and GIS tools, identification of potential areas that are suitable for brackishwater aquaculture development and also are within the CAA guidelines has been developed. Using these tools, CIBA has also been able to prove that shrimp farming development has not been at the expense of mangroves. With the methodology developed reclassification and reassessment of land and water resources and carrying capacity assessment will help in planning for new area aquaculture development. For effective implementation all the information generated needs to be pooled into a large scale project of combining the above approach with micro surveys to look at revenue classification of lands in the light of currently active regulations of CAA to sort out regularisation of existing pond areas and to take up new area development. This will help in increasing the area under culture in an environmentally sustainable manner. It is imperative for developing integrated operating modules of farmer groups and linking the whole value chain for profitable aquaculture in which small scale farmer is an integral part for holistic development of the sector. Awareness programmes for all the stakeholders and capacity building of trainers and progressive farmers and consumers is required to understand and address market-related issues with organic farming (FAO, 2011). For popularising fish as health food and increasing its consumption, the data that has been generated on nutrient profiling of brackishwater fishes and shrimps will be used. For making domestic fish markets as a source of sustenance of aquaculture, more market studies will be conducted. Policy analysis and support for a more equitable and efficient value chain and an integrated communication strategy to promote consumption to develop domestic markets would be worked out.

With regard to extreme climatic events whose frequency is expected to increase due to climate change, impact and adaptive responses of farmers has been assessed. Ongoing efforts are aimed at assessing the likely long term impact of climate change through modeling. Based on these, efforts will be made to modify production technologies, reduce green house gas production from aquaculture and to develop possible short-term and long-term mitigation measures with a gender perspective. Policy advice is to be provided to enhance the adoptive capacity of farmers. Based on life cycle assessment of brackishwater aquaculture value chain, what needs to done to reduce the energy requirements will be identified.

Strategy

The strategy or direction and scope of work of CIBA over the next twenty years would be aimed at achieving an advantage for the organisation by focused use of the available manpower and other resources to solve the core challenges faced by the sector and to enable the sector to meet the needs of markets and to fulfil stakeholder expectations. The following are envisioned as strategies for CIBA based on the SWOT analysis (Annexure I) and feedback during the stakeholder interactions.

1. Increase brackishwater aquaculture production through focused research on increasing productivity, profitability, area under culture and diversification of species and systems while addressing environment, food safety and social equity issues through more on-farm research and extension.

    a. Improving existing culture practices by incorporating science behind best management practices, harnessing natural productivity, bioremediation and better feed management

    b. Provide research input to development agencies for reclaiming abandoned farms and for culture in open brackishwater bodies and diversification of species and systems

    c. Increase awareness of farmers and aquaculture industry about environment, food safety and social equity issues and at the same time educate public about the positive aspects of aquaculture and fish as health food

2. Carry out strategic research to tackle emerging problems of brackishwater aquaculture and to strengthen the capacity of key stakeholders to address the various issues that are likely to be confronted.

    a. Preparedness on emerging diseases and advice the development and regulatory departments to address risks

    b. Assess the climate change impacts and increase the capacity of farmers to adapt to climate change and develop policy initiatives which help in adaptation and mitigation of negative impacts

   c. Evaluate risks due to intensification of culture practices and develop an action plan to be implemented by the state

3. Invest in frontier areas of research to utilize emerging opportunities and develop linkages for effective utilization of the research outputs.

   a. Carry out research on genomics of candidate species and ensure that these results are used in captive breeding, increased growth, enhanced disease resistance and better utilization of feed nutrients

   b. Enhance capacity to use biotechnology tools to address difficult to solve problems of captive maturation and disease threats like WSSV

   c. Develop linkages with universities and industry partners for promoting work on basic and strategic aspects to fill knowledge gaps

4. Partnership with other institutions, large integrated brackishwater aquaculture projects in private and public sector, entrepreneurs and innovative farmers to augment the existing capacity for broodstock and farm testing facilities, scaling up and for commercialization of products.

   a. Carry out on-farm research under a project mode with other institutions, large integrated brackishwater aquaculture projects in private and public sector, entrepreneurs and innovative farmers

   b. Commercialize products in partnership with entrepreneurs

   c. Develop a consultative mechanism with stakeholders for tracking and responding to recent developments in hatcheries and farmer ponds

5. Ensure that stakeholder needs and impact assessment set the agenda for research and awareness building.

   a. Strengthen Priority Setting Process, Evaluation and Monitoring process to undertake multi disciplinary and multi institutional research projects

   b. Increase our capacity for carrying out risk and impact assessment

   c. Increase awareness levels among stakeholders on research outputs

Epilogue

The challenges of increasing production, productivity and profitability of brackishwater aquaculture farms in the environs of increasing input costs and decreasing output prices, existing and emerging diseases, and infrastructural and policy support inadequacies are to be continually responded. CIBA is dedicated to decipher and respond to complexities and problems that may crop up in the way of development of brackishwater aquaculture sector in the country.

CIBA will develop cost effective and cutting edge technologies for solving technical problems which will ensure the competitive edge for our farmers in the global market place. CIBA will continue to educate shrimp farmers and other stakeholders on rational use of natural resources with an understanding of carrying capacity and work towards amalgamation of aquaculture productivity with protective coastal zone management regulations. CIBA will also assume the sentinel role of protecting farmers' interest and make all the efforts for ensuring an enabling value chain and policy settings, protecting the small holder aquaculture.

Sustaining small scale aquaculture and ensuring livelihood security of coastal poor with an equitable gender perspective will be guiding lights for research programmes that will be taken up. CIBA will continue to interact with stakeholders of brackishwater aquaculture sector for framing and refining its research processes in a flexible and participatory mode, with mid-course corrections as and when required. Participation of CIBA as an advocate pleading for the cause of small scale aquaculture farmers in institutional consultation processes will be sustained ceaselessly.

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Annexure 1: SWOT Analysis

SWOT analysis matrix	Strengths	Weaknesses
	1. Large potential area of 1.2 million ha brackish water of which only 10 % is being used.	1. Falling output prices and increasing input costs and limited credit flow
	2. Potential cultivable species -10 shrimp, 8 finfish and 2 crab spp.	2. Weak dissemination of technology
	3. Institutional support for research and development	3. Single commodity, focus and over dependence on export
		4. Unplanned and un-scientific farm development and inadequate policy support
Opportunities	**Strategies of S-O**	**Strategies of W-O**
1. Increasing total fish exports	1. Facilitating increase in area under shrimp farming	1. Increasing profitability/ productivity; low cost inputs-feeds; policy analysis support for credit
2. Increasing % contribution from cultured shrimp in exports	2. Diversification of brackishwater aquaculture – species & systems	2. Bioremediation techniques and carrying capacity, GIS/ RS studies for new area
3. Introduction of SPF shrimps for minimizing diseases and increasing production	3. Public-private partnership consultations, technology development delivery	3. Capacity building of line departments, consultants and progressive farmers
4. Increased incomes & purchasing power of domestic consumers' – increased willingness to pay higher prices for seafood and positive change in perception of fish as 'health food'	4. Regular monitoring and evaluation process/ impact assessments	4. Exploratory studies on new export, domestic, and niche market segments
Threats	**Strategies of S-T**	**Strategies of W-T**
1. Negative public perceptions on environmental and food safety aspects	1. Research support to initiatives on quality control mechanisms	1. Standardising and refining location specific BMPs
2. Trade issues – levy of antidumping duty and global shrimp price crashes	2. Developing a sound eco-planning, climate resilience and bioremediation programmes	2. Integrating farm production with value addition and processing
3. Absence of quality control mechanisms for seed and feed	3. Diseases watch and proactive development of preventive protocols and curative measures	3. Farmers programmes on rational chemicals and drugs usage
4. Lack of biosecurity infrastructure in farms; continuous incidence of diseases like WSSV.	4. Market studies for exploration of new export and domestic markets	4. Public and policy makers awareness meets for proper perspective on brackish water aquaculture