CIBA Perspective Plan

VISION-2025

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ICAR

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INDIAN COUNCIL OF AGRICULTURAL RESEARCH

VISION – 2025

CIBA
PERSPECTIVE PLAN

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FOREWORD

Indian agriculture must continuously evolve to remain ever responsive to manage the change and to meet the growing and diversified needs of different stakeholders in the entire production to consumption chain. In order to capitalize on the opportunities and to convert weaknesses into opportunities, we at the ICAR attempted to visualize an alternate agricultural scenario from present to twenty years hence. In this endeavour, an in-depth analysis of the Strengths, Weaknesses, Opportunities and Threats (SWOT) was undertaken to place our research and technology development efforts in perspective so that we succeed in our pursuit of doing better than the best. Accordingly, the researchable issues are identified, strategies drawn and programmes indicated to have commensurate projects and relevant activities coinciding with the launch of the 11th five year Plan.

India is the third largest producer of fish, second in inland fish production and forth in farmed shrimp production. The sector provides livelihood to 11 million people and contributes over 1.04% to the national Gross Domestic Product. With 1.2 million ha brackishwater resources, besides 2.54 million ha sodic soils in the coastal regions and 8 million ha inland saline soils in the hinterlands, there are immense opportunities for development of fish farming. The sector with an annual average growth rate of 10% has already made a benchmark in the developmental arena of the country.

The Central Institute of Brackishwater Aquaculture (CIBA) through its well planned R&D efforts has provided the support base for the scientific growth of this sunrise sector and has carved out a niche in the brackishwater farming enterprise by catering to the needs of the different stakeholders Among the many noted achievements of the Institute, a few are improved traditional culture of shrimp, backyard shrimp hatchery technology, diagnostic kits for shrimp viral diseases, cost-effective shrimp perspective is aimed to address the health management and environmental concerns and technology interventions required to ensure the sustained growth of brackishwater aquaculture.

It is expected that realizing the Vision embodied in the document would further ensure that the CIBA, Chennai continues to fulfill its mandate to make Indian agriculture locally, regionally and globally competitive. The efforts and valuable inputs provided by my colleagues at the ICAR headquarters and by the Director and his team at the Institute level for over an year to develop Vision 2025 deserve appreciation.

(MANGALA RAI)
Secretary, Department of Agricultural Research & Education,
and
Director General, Indian Council of Agricultural Research
Dr. Rajendra Prasad road, Krishi Bhawan, New Delhi - 110 001, India.

February, 2007

PREFACE

Brackishwater aquaculture has rapidly transformed from a traditional activity practiced largely in the states of West Bengal and Kerala, to the status of a commercial enterprise in the country and this has largely been due to the scientific and technological interventions. The brackishwater resources of the country are vast and varied, comprising 1.2 million ha in extent, besides 2.54 million ha salt affected soils in the coastal areas and 8 million ha inland saline soils. The growth of this sector has been phenomenal and mainly centered on shrimp aquaculture, focused on the culture of a single species, tiger shrimp, *Penaeus monodon*. Brackishwater aquaculture has expanded to 1,91,074 ha and resulted in the production of 1,43,170 tonnes of shrimps in 2005-06 and contributed Rs.4000 crores in the total seafood export turnover of Rs. 7245 crores.

The Indian Council of Agricultural Research (ICAR), realizing the importance and potential of this sector to the country's economy, has established the Central Institute of Brackishwater Aquaculture (CIBA) on 1st April 1987. Since then the Institute has made tremendous contributions to the growth of this sector through its research and developmental approaches oriented towards the different segments of the sector. Development of improved traditional shrimp farming, backyard shrimp hatchery, seabass seed production, shrimp feed, diagnostic kits for white spot syndrome virus (WSSV), white muscle disease (WMD) of scampi and Monodon Baculovirus (MBV), shrimp immunostimulants and bioremediation measures for shrimp farm discharge waters are some of the notable achievements of the Institute.

Although the R & D efforts of the Institute are making lasting impact on the coastal aquaculture sector, there are still many challenges to be tackled. The brackishwater aquaculture sector is threatened by major issues like viral diseases, environmental issues, *P. monodon* centric farming focused exclusively on foreign market, high cost of production, lack of coherent aquaculture policy and planning, impact of WTO and volatility of international shrimp prices.

The Perspective Plan (2007-2025) outlines how the issues preventing further growth of brackishwater farming can be addressed through development of environment friendly and cost effective culture technologies for small scale aquaculture sector, comprehensive health management, development of high-health and high-growth shrimps through biotechnological approaches, diversification of species and systems and developing sound planning tools, governance guidelines and strategies to build up value chains.

I am grateful to Dr.Mangala Rai, Secretary, DARE and Director General, ICAR, New Delhi for his guidance and suggestions for the preparation of the revised perspective plan. My thanks are also due to Dr.S.Ayyappan, Deputy Director General (Fy.), Dr.A.D.Diwan, Assistant Director General (M.Fy.) and Dr.V.R.Chitranshi, Assistant Director General (I.Fy.) and the members of the Research Advisory Committee of CIBA for their valuable inputs, suggestions and advice. I also thank all the scientists of CIBA who have contributed significantly in the preparation of the Vision 2025.

June 11, 2007

A.G.PONNIAH
DIRECTOR

EXPLANATION TO ABBREVIATIONS

AICRP	All India Coordinated Research Project
AIT	Asian Institute of Technology
BARC	Bhabha Atomic Research Centre
BOBP	Bay of Bengal Programme
BMP	Best Management Practices
CCMB	Centre for Cellular And Molecular Biology
CFTRI	Central Food Technological Research Institute
CIBA	Central Institute of Brackishwater Aquaculture
CIFA	Central Institute of Freshwater Aquaculture
CIFE	Central Institute of Fisheries Education
CIFRI	Central Inland Fisheries Research Institute
CIFT	Central Institute of Fisheries Technology
CMFRI	Central Marine Fisheries Research Institute
CSSRI	Central Soil Salinity Research Institute
DAC	Department of Agriculture and Co-operation
DARE	Department of Agricultural Research and Education
DAHD&F	Department of Animal Husbandry, Dairying and Fisheries
DNA	Deoxyribo Nucleic Acid
ERNET	Education and Research Network
FAO	Food and Agricultural Organization
FCR	Food Conversion Ratio
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GIR	Geographic Information Retrieval
GIS	Geographical Information System
GMP	Good Management Practices
HACCP	Hazard Analysis Critical Control Point
HRD	Human Resource Development
IASRI	Indian Agricultural Statistics Research Institute
ICAR	Indian Council of Agricultural Research
ICMAM	Integrated Coastal and Marine Area Management
IFPRI	International Food Policy Research Institute
IFREMER	Institut français de recherché pour l'exploitation de la mer
IISS	Indian Institute of Soil Science

INRA	Institut National de la Recherche Agronomique
IPR	Intellectual Property Rights
MANAGE	National Institute of Agricultural Extension Management
Mbps	Millions of bits per second
MBV	Monodon Baculo Virus
MPEDA	Marine Products Export Development Authority
NACA	Network of Aquaculture Centers in Asia-Pacific
NBFGR	National Bureau of Fish Genetic Resources
NBSS&LUP	National Bureau for Soil Survey and Land Use Planning
NCAP	National Centre for Agricultural Economics and Policy Research
NFBD	National Fisheries Development Board
NGO	Non Governmental Organization
NIOT	National Institute of Ocean Technology
NORAD	Norwegian Agency for Development
PCR	Polymerase Chain Reaction
RAC	Research Advisory Committee
RS	Remote sensing
R&D	Research and Development
RT-PCR	Reverse Transcriptase Polymerase Chain Reaction
SAU	State Agricultural University
SEAFDEC	South East Asian Fisheries Development Centre
Si-RNA	Small interfering Ribo Nucleic Acid
SPF	Specific Pathogen Free
SPR	Specific Pathogen Resistant
SRC	Staff Research Council
SWOT	Strength, Weakness, Opportunities and Threats
TANUVAS	Tamil Nadu Veterinary and Animal Sciences University
TISS	Tata Institute of Social Sciences
TNAU	Tamil Nadu Agricultural University
UK	United Kingdom
USA	United States of America
V-SAT	Very Small Aperture Terminal
WMD	White Muscle Disease
WSSV	White Spot Syndrome Virus
WTO	World Trade Organization

EXECUTIVE SUMMARY

Brackishwater aquaculture in the country has expanded steadily from a traditional activity to reach the present commercial scale. Out of the total potential brackishwater area of 1.2 million ha available in the country, about 1,91,074 ha have been developed for brackishwater aquaculture till 2005-06. The growth of the sector is slow and hardly 15.3% of the total available resources have been brought under farming. Brackishwater aquaculture is synonymous to shrimp aquaculture and it is centered on one species, *Penaeus monodon*. The total shrimp production from aquaculture is about 1,43,170 tonnes in 2005-06. The contribution of marine products in India's export is valued Rs.7,245 crores in 2005-06. Among the marine products exported, frozen shrimps contribute nearly 69% in value terms. In the total shrimp export, the share of cultured shrimp was 49% by volume and 76% by value. The growth of shrimp aquaculture sector was phenomenal during the 90's and this has resulted in the all round development in shrimp hatcheries, feed mills, ancillary industries like ice plants, processing plants, drugs and chemicals and other aquaculture related engineering products. The sector has generated more than three lakh jobs.

Realizing the need for a research thrust in brackishwater aquaculture, the Indian Council of Agricultural Research (ICAR) sanctioned the Central Institute of Brackishwater Aquaculture (CIBA) on 1st April 1987.. The Institute was established at Chennai with three regional centres at Kakdwip (West Bengal), Puri (Orissa) and Narakkal (Kerala) and a field station at Muttukadu (Tamil Nadu). The Narakkal and Puri centres were subsequently closed down in July 2000 and 2006 respectively. The Institute has established state of art laboratories for research in aquatic animal health, nutrition, biotechnology, environmental biology. The X Plan budget under Plan and Non-plan is 1140 lakh and 2160 lakh respectively. The sanctioned manpower of the Institute is, scientific – 66, technical – 32, administrative – 26 and supporting – 74. Over the years the Institute has generated a wealth of information on shrimp, fish and crab production systems, nutrition and feed technology, farm environment, genetics and biotechnology, breeding and seed production of candidate species, disease diagnostics, aquaculture engineering, farm and hatchery designs, database on the various brackishwater aquaculture systems practiced in the country and the extension practices.

CIBA was mandated to develop techno-economically viable and sustainable culture system for brackishwater finfishes and shellfishes and to transfer the technologies to the benefits of the different stakeholders of the sector. It has made significant research achievements and these include development of cost effective technology packages for induced maturation of *P. monodon*, backyard hatchery technology for *Fenneropenaeus indicus*, culture and cyst production of *Artemia*, domestication of *Marsupenaeus japonicus* and production of F5 generation, improved traditional culture of *P. monodon* with 1.5-2.3 t/ha production, pond culture of *M.japonicus* with one ton production, development of shrimp feeds with FCR comparable to commercial feeds, micro particulate feed for shrimp larvae, PCR diagnostic kits for WSSV, WMD and MBV, shrimp immunostimulants, package for estimation of carrying capacity of source water body, seabass hatchery technology, captive seed production of pearlspot, polyculture of milkfish and shrimps, integrated shrimp / fish culture with poultry, breeding and seed production of mud crabs and grow-out culture of seabass. These research outputs have contributed to the growth of the sector and provided a platform for interaction with the farmers and industry for further advancements.

By 2025, the area under brackishwater farming can reach a total of 3,00,000 ha with the total production of 5,00,000 mt if major issues threatening the sustainability of the sector are addressed and technological improvements lead to increase in productivity. This would require addressing two major issues – viral diseases and environmental concerns. Shrimp aquaculture was seriously affected by viral diseases such as White Spot Syndrome Virus (WSSV) and Monodon Baculo Virus (MBV) during 1994-95 and though the situation has been controlled to a great extent through regulations, good management practices and diagnostic tools, the problem still persists and there are new emerging diseases like Loose Shell Syndrome. Production of quality disease free seed is an important requirement for the sustainability of the shrimp aquaculture. Domestication and production of specific pathogen free (SPF) and specific pathogen resistant (SPR) shrimp broodstock assumes greater importance and thrust has been given to tackle this issue on a priority basis. Diversification in to other species of shrimps, fishes, crabs etc. is yet another area of research which needs urgent attention. The emerging global scenario in the context of Post-GATT / WTO and IPR issues would need research focus. One of the main reasons for the set back witnessed in the brackishwater aquaculture was the un-planned and un-regulated development of farms in a particular area leading to over crowding which has resulted in serious environmental problems. The absence of a sound aquaculture policy and also planning and governance which has lead to such a situation needs to be addressed. Interactions and collaborations with organization both within and out side the country will help develop the scientific outputs and mechanisms to take this very important sector of food production activity to a greater level.

Based on the perspective, the following six major issues have been identified as areas needing attention through development of appropriate technology and strategies for their uptake. The major issues are: increase the area under aquaculture and the average productivity, ensure availability of disease free seed of *Penaeus monodon,* have an overall health management to control existing and emerging diseases, ensure that there is no environmental impact due to increasing area and intensification under aquaculture, mitigate against risks due to mono cropping of *P.monodon* through diversification of species and systems and ensure that brackishwater aquaculture contributes significantly to increasing the wealth status of small scale farmers and to foreign earnings.

Based on the above analysis the following thrust areas of research have been identified in brackishwater aquaculture.

- Environment friendly and cost effective brackishwater culture technologies with focus on techniques suitable for adoption by small scale farmers.
- Comprehensive health management to address the existing and emerging diseases in shrimp and fish production systems.
- High-health and high-growth shrimps through application of genetics and biotechnological tools.
- Diversification of species and systems for development of sustainable brackishwater aquaculture.
- Planning tools, governance guidelines and strategies for value chain development in brackishwater aquaculture.

1. PREAMBLE

India has a long coast line of 8129 km distributed in nine coastal states and four Union Territories. The biodiversity of the coastal ecosystem of the country is rich with a wide spectrum of fauna and flora. The country is bestowed with 3.9 million ha estuaries, 1.2 million ha brackishwater area, 2.54 million ha salt affected coastal soils and 8.0 million ha inland saline soils. The coastal mangrove area is estimated around 0.5 million ha. These resources are the real biological wealth and strength and provide immense opportunities for development of brackishwater aquaculture in the country.

India is the third largest producer of fish in the world and ranks second in world inland fish production. In shrimp aquaculture, the country occupies fourth position. The fish production in the country has shown remarkable growth with 6.3 million tonnes in the year 2004-05. The fisheries sector contributes around Rs. 29,707 crores to the country's economy, 1.04% of the national Gross Domestic Product (GDP) and 5.34% to the agriculture GDP. About 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 meet the challenges of the food security basket of the country and 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 has identified aquaculture, especially shrimp aquaculture as a thrust area for enhancing export earnings. Shrimp is the flagship commodity of Indian sea food exports. During 2005-06, the export of marine products reached all time high with actual value of Rs.7,245 crores or US $ 1500 million. Shrimp aquaculture has shown rapid growth in the last decade and expanded from 65,100 ha in 1990 to 1,91,074 ha in 2005-06. During this period the production increased from 30,000 t to 1,43,170 t. This phenomenal growth was made possible by the large investments made by the different stakeholders in this sector, ranging from small scale farmer to corporate sector.

The FAO and IFPRI-World Fish 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 disposable income of the world population. With capture fisheries at stagnation level, the demand for fish in the coming years can be met through aquaculture alone. The potentiality 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 of the economy of the country, investments in this sector is expected to grow manifold leading to several possibilities for area expansion and product multiplication. The major issues and challenges that are to be addressed are development of cost effective, environment friendly farming technologies leading to the production of high health and high value products with the application of biotechnology tools and innovations.

The Institute with its continued R & D support to the sector is poised to provide the required fillip for the all round development of the brackishwater aquaculture in the country. The Vision 2025 is presented in the perspective with a holistic approach, and with multi disciplinary team spirit and networking mode the said objectives will be achieved to take brackishwater aquaculture of the country to a high pedestal.

1.1 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.

1.2 Mission

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

2. MANDATE

Original Mandate

- To conduct research for development of techno-economically viable and sustainable culture system for finfish and shellfish in brackishwater.
- To act as a repository of information on brackishwater fishery resources with a systematic database.
- To undertake transfer of technology through training, education and extension programmes.
- To provide consultancy service.

Proposed mandate

- Conduct basic, strategic and applied research in brackishwater aquaculture.
- Provide research support for diversification of brackishwater aquaculture practices with reference to species and systems.
- Provide policy and planning support for socio-economic development through brackishwater aquaculture.
- To carry out transfer of brackishwater aquaculture technologies through creation of awareness, conducting training and providing consultancy service.

3. GROWTH

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. This institute has now one research centre, located at Kakdwip (West Bengal) However, the Narakkal (Kerala) and Puri (Orissa) centres were closed down in July 2000 and July 2006, respectively.

The Institute has been built from a modest manpower and infrastructure to meet the challenges of a fast growing brackishwater aquaculture sector which has been gaining rapid economic significance due to its export potential. The Institute has produced tangible outputs despite several constraints. Now CIBA is one of the premier Research Institution which is regarded by farmers, industry, fisheries departments of state governments, national and international organizations engaged in coastal zone development and planners and policy makers for developmental, strategic and management support.

3.1. Infrastucture

3.1.1. Laboratories

Construction of the Laboratory cum Administrative building was completed in 2000. Nutrition and Aquatic Animal Health Laboratories have been fully equipped with sophisticated equipments. A Central Instrumentation Laboratory was also created facilitating research on Biochemistry, Biotechnology and Genetics. The Pathology and Microbiology Laboratory is equipped for all types of bacteriological, mycological, histopathological and virological research.

Soil Science and Agricultural Chemistry Laboratory is equipped with analytical instruments required for soil and water quality analyses. The Computer Laboratory is equipped with 2 Mbps modem, router, Intel Xeon server, 256 kbps leased line Internet connectivity provided by ERNET India and Internet is distributed to all the Divisions and Sections with a state of art 10/100/1000 Mbps capacity Cat 6 cabling.

Kakdwip Research Centre is fully equipped for routine soil and water quality analyses. Internet Connectivity is provided with V-SAT facility through ERNET India.

3.1.2. Library

From a modest start with 52 reference books and 5 journals, the library has now over 1000 reference books and 33 International and 33 National journals. Several publications are received from NACA, SEAFDEC, BOBP and other national and international organizations.

3.1.3. Farm facilities

Muttukadu Field Centre of CIBA

The Muttukadu Field Centre of CIBA has about 39.25 ha area including the lagoon. There are eight ponds having 0.7 ha area in the A series and six nursery ponds of 0.079 ha to carry out field experiments.

Kakdwip Research Centre of CIBA

The Kakdwip Research Centre has a total area of 13.57 ha and the water spread area is about 4.5 ha. The farm is divided into three sectors *viz.*, Sector A (3.85 ha), Sector B (4.86 ha) and Sector C (4.86 ha). Sector A has 20 ponds with 2.53 ha pond area. There are 8 ponds in Sector B and the total area is about 1.97 ha. The size of the pond ranges from 600 to 3750 sq.m. Sector C is proposed to be developed as a bhery to conduct experiments to improve production and productivity specific to the local situations.

3.1.4. Buildings

The following buildings were added to Muttukadu field facility:

i) Field laboratory for research on soil and water chemistry, nutrition, pollution and biology, ii) Shrimp hatchery, nursery and effluent treatment facility, iii) Wet laboratories for experimentation in nutrition, genetics and disease diagnostics, iv) Essential staff quarters (6 nos.) v) Fish brood stock holding tanks and fish hatchery with state of the art water management system.

3.1.5. Vehicles

A total of four vehicles are available at headquarters. Two jeeps, one sumo, one car and a mini bus cater to the official transport needs of the officers and staff of the Institute at headquarters. Kakdwip Research Centre has a jeep.

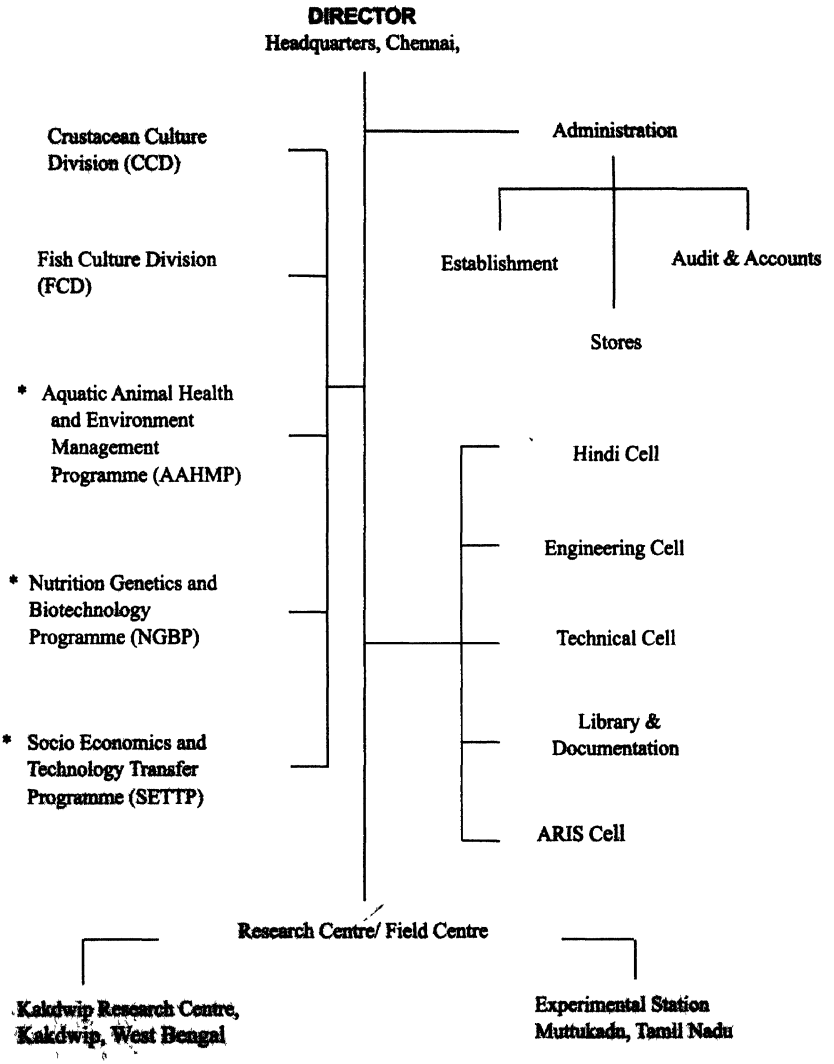
3.2. Budget (Rs. in Lakh)

Plan period	Plan	Non-plan	Total
IX Plan	947.48	1225.98	2173.46
X Plan (Outlay)	1140.00	2166.00	3306.75
XI Plan (Projection)	3500.00	4000.00	7500.00

3.3. Manpower (Sanctioned Strength)

Categories	Sanctioned	In position	Vacant
Scientific	66	45	21
Technical	32	31	1
Administrative	26	23	3
Supporting	74	64	10
Total	**198**	**163**	**35**

From two ARS disciplines in 1987, the scientific manpower availability is diversified to 20 disciplines at present, supporting multi disciplinary research capabilities.

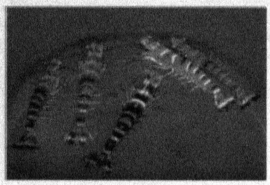


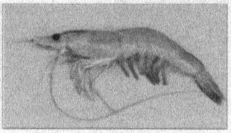
* Proposed for Division status

4. SALIENT RESEARCH ACHIEVEMENTS

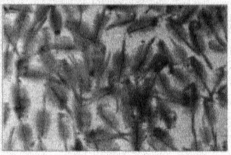
Shrimp seed production

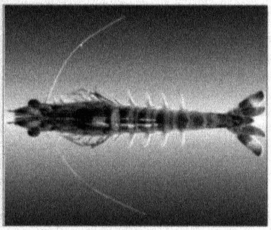
The Institute has contributed to the development of technology package for shrimps and *Artemia*.



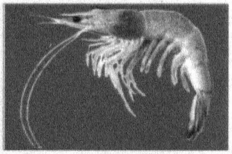


- A simplified cost-effective backyard hatchery technology package was developed for the seed production of white shrimp *F. indicus*.
- A technology package was developed for captive broodstock maturation of tiger shrimp *P. monodon*.





- A technology package was developed for the culture and cyst production of the brine shrimp *Artemia*, an important live food item for shrimp in hatcheries.
- The Institute has developed shrimp hatchery lay-out and designs for small-scale (2, 5 and 10 million capacity) and backyard shrimp hatchery.



- Domestication of *M.japonicus* has been achieved under captive conditions with the production of F5 generation.
- Captive broodstock development and natural maturation of banana shrimp *Fenneropenacus merguiensis* both in tanks and ponds were achieved.

Shrimp culture

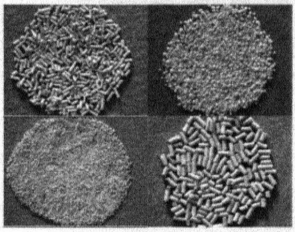
Significant contributions have been made in increasing production / productivity levels in the traditional and extensive sectors of shrimp farming through the following programmes.

- In the traditional sector, a study of shrimp farming in West Bengal, Kerala and Orissa was taken up. Monitoring of farms was carried out and technical assistance was rendered to small farmers for improving production levels.
- Under improved traditional culture, *P.monodon* production of 1.5-2.4 t/ha/crop was achieved at Kakdwip against the average production of 250-500 kg/ha/crop observed under traditional culture.

- For the first time in the country, culture of *M.japonicus* was successfully carried out in a brackishwater pond with a survival of 83% and a production of 1018 kg/ha/4 months.
- Under Institute - industry partnership programme *F. merguiensis* culture was successfully demonstrated in Gujarat.

Shrimp feed development

The Institute has carried out extensive work in shrimp feed formulation and feed processing and production technology.



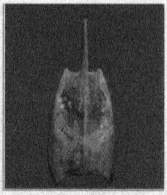
- Generated database on the nutritional requirements of candidate species of shrimp *P. monodon* and *F. indicus* which has been widely utilised for formulating shrimp feeds.

- Shrimp feeds developed in the Institute for *F. indicus* and *P. monodon* using indigenous feed ingredients were field-tested in farmers ponds and obtained a feed conversion ratio (FCR) of 1.2 – 1.7:1 which was comparable to that of imported brands of shrimp feed.
- A technology package was developed for shrimp feed processing and production on commercial scale using a nutritionally balanced feed formulation suitable for culture of *F. indicus* and *P. monodon.*

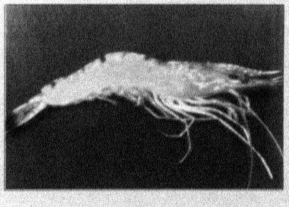
- A technology package has been developed for micro- particulate feed production, using indigenous ingredients for rearing post-larvae of *F. indicus* upto PL-20 and beyond primarily intended for medium scale hatchery operations. Micro-particulate diets using indigenous ingredients were also developed for tiger shrimp *P. monodon*
- The availability of marine protein resources in different maritime states for aquaculture feeds has been assessed and a comprehensive report was brought out on the marine protein resource availability in India as raw materials for shrimp feeds for the benefit of shrimp feed industry.

Shrimp disease investigations

The Institute has conducted extensive investigations on shrimp bacterial and viral diseases.



- The major disease which struck shrimp farms diagnosed as the White Spot disease was the focus of studies. Other important diseases investigated were Monodon Baculovirus (MBV), Infectious Hepatopancreatic and Lymphoid Organ Necrosis, Vibriosis, luminescent bacterial disease, larval mycosis, mixed bacterial infection, black gill disease, bacterial septicemia and soft shell disease.
- Advisory services have been rendered to farmers in shrimp health management and disease prevention.
- The Institute has brought out information on shrimp diseases and shrimp health management in the form of extension pamphlet/bulletin for the use of farmers and hatchery operators.
- *Vibrio* based low cost Immunostimulant has been developed and tested in farmers' fields which resulted in higher growth and survival of the shrimps.



- Developed and commercialized a PCR based farmer friendly WSSV diagnostic kit
- An RT-PCR kit for diagnosis of white muscle disease in *M.rosenbergii* has been developed and released.
- A DNA based PCR diagnostic kit for screening Monodon Baculovirus in broodstock and postlarvae of *P.monodon* has been developed and evaluated.

- Patent has been filed for a method of fish disease diagnosis using rabbit anti-mullet (RAM) serum to detect fish antibodies in different brackishwater fish and its application thereof.

Environmental monitoring and impact assessment

The Institute has conducted extensive investigations on the impact of shrimp farming on the environment. Some of the salient studies are given below:

- Several extensive, semi-intensive and intensive shrimp farms in Tamil Nadu (Tuticorin) and Andhra Pradesh (Nellore and East Godavari districts) were surveyed and the socio-economic and environmental impacts of shrimp farming are assessed.
- With the help of the extensive database generated on impact assessment, the Institute has assisted the Union Ministry of Agriculture and the State Governments of Andhra Pradesh and Tamil Nadu in formulating guidelines for brackishwater aquaculture and standards for discharge of farm effluents from shrimp culture ponds.
- Methodology was developed and case studies were carried out for assessment of carrying capacity of source water body in relation to shrimp farming in terms of nutrient loading from shrimp culture ponds. A computer package has been developed for estimation of carrying capacity.

Patent has been filed for the following :

i) A method of fish disease diagnosis using rabbit anti-mullet (RAM) serum to detect fish antibodies in different brackishwater fish and its application thereof.

ii) Product from lignocellulosic waste for the remediation of water contaminated with heavy metals.

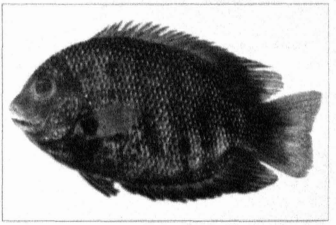
iii) Method for maximum percent recovery and detection of organochlorine and organophosphorus pesticides.

iv) Immobilising matrix from bagasse for bacterial biomass and process of preparation which has applications in development of biostimulators and bioaugmentors.

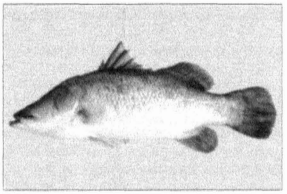
Fish broodstock development, breeding and seed production

To overcome dependence on commercial catches for breeders and to ensure production of quality fish seed for culture purpose, the Institute has undertaken broodstock development and fish breeding programme of commercially important brackishwater finfishes such as seabass *(Lates calcarifer),* grey mullet *(Mugil cephalus)* and pearlspot *(Etroplus suratensis).*

- A technology package has been evolved for the pond breeding of the pearlspot *E. suratensis* which can be easily followed by the fish farmers particularly of the Kerala region where this fish has a good market demand.

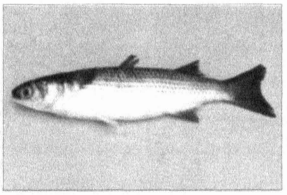


- Freeze dried micro particulate diet for weaning seabass larvae and pellet feeds in different forms for seabass grow-out culture were developed.
- Dietary requirements of protein, lipid, energy, vitamins and minerals have been determined for seabass, mullets, mud crabs and pearlspot.
- CIBA achieved a major breakthrough in the induced breeding and seed production of captive broodstock of *Lates calcarifer.*

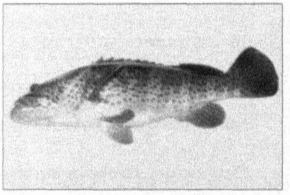


- Developed captive land based broodstock of seabass and produced F4 generation. Standardized technology package for hatchery seed production of seabass and established a model marine finfish hatchery.

- Induced breeding of grey mullets *Liza macrolepis* and *Mugil cephalus* has also been carried out. Hatchlings of *L. macrolepis* were reared successfully to fry / fingerling stage.

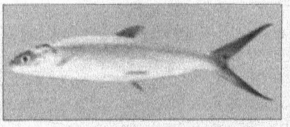


- With a view towards diversification in the fish breeding programme, captive broodstock of grouper, *Epinephelus tauvina* was built up and successfully induced matured and bred the fish in captivity.



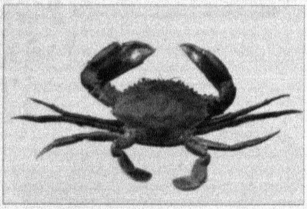
Fish culture

- The Institute has achieved success in cage/pen culture of milkfish *(Chanos chanos)* at Muttukadu,
- Polyculture of *Chanos chanos* with shrimp *F.indicus* was demonstrated in ponds.
- Seabass seed produced in the Institute were successfully cultured in a farmer's ponds and production of 1744 kg and 4030 kg/ha/11 months were obtained.
- Low-input integrated fish/shrimp cum poultry farming at Kakdwip and Narakkal has given encouraging results.

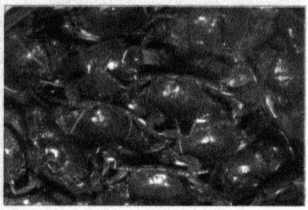


Crab broodstock development, breeding seed production and culture

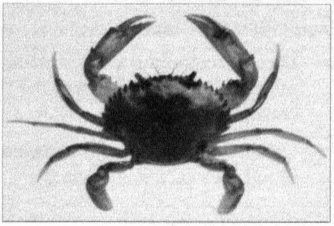
- Standardized captive broodstock development, induced maturation, production of berried females and larval rearing of *S.tranquebarica* and *S.serrata.*



- Successfully reared larvae of *S.tranquebarica* and *S.serrata* upto baby crab stage.
- Developed pellet feeds for nursery rearing and grow-out culture of mud crabs.



- Technology of mud crab fattening has been standardized and grow-out culture is in the process of development.



Database on brackishwater fishery resources

- An extensive computerized database information system was developed on brackishwater fishery resources of the country.
- The Agricultural Research Information System (ARIS) laboratory is set up.
- The Institute's web site was prepared and launched in own web server and is being updated annually.

Socio-economics and transfer of technology

- Developed economic policy notes and statistical models for fisheries exports and growth of candidate species of finfish and shellfish under culture, hatchery and laboratory conditions.
- Survey on diversification of coastal aquaculture and tsunami loss assessment in brackishwater sector were completed.
- Institute village linkage project on technology assessment and refinement in the coastal agro system of Tiruvallur district of Tamil Nadu was successfully completed.
- Participatory technology transfer model was developed for sustainable coastal aquaculture.

5. IMPACT ASSESSMENT

5.1 Growth of sector

From a homestead/ traditional type of activity, brackishwater aquaculture has grown into a bigger industry practiced by small and marginal farmers. Area under production has increased from about 50,000 ha (inclusive of traditional system) to 1,91,074 ha during 2005-06, much of the growth from about 70,000 ha to 100,000 ha took place between 1992-93 and 1994-95. The share of aquaculture production in total shrimp production showed upward trend during the 1980s. In 1988 this share already exceeded 20%, and this positive trend continued until 1992, when farmed shrimp accounted for almost 30% of the total shrimp output. Shrimp production increased from about 30,000 tonnes in 1989-90 to 1,43,170 tonnes in 2005-06. The contribution of marine food in India's exports is enormous. It has increased from Rs. 893 crores in 1990-91 to Rs.7,245 crores in 2005-06. Among the marine products exported, frozen shrimps contributed nearly 69% in value terms. Among the total shrimps exported, cultured shrimps contributed 49% on weight basis and 76% on value basis. Concomitant with the above growth in commodity, there has been all round development in hatcheries for shrimp seed production, feed mills for shrimp feed, ancillary industries in aquaculture engineering, drugs and chemicals, marketing, processing and export activities. Over 300,000 jobs have been generated in the main and supporting sectors.

5.2. Institutional growth

The above growth in brackishwater aquaculture has largely been due to Research and Development efforts of the Fisheries Research Institutes of the Indian Council of Agricultural Research and the Fisheries Division of the Department of Agriculture and Cooperation of the Union Ministry of Agriculture, which are the nodal agencies of the country for the two areas respectively. Prior to the establishment of CIBA in 1987, the Central Inland Fisheries Research Institute (CIFRI) had carried out extensive studies on the fisheries resources, biology and ecology of the major estuarine systems of the Hooghly-Matlah, Mahanadhi, Godavari and Krishna rivers and the brackishwater lakes of Chilka and Pulicat. These studies provided a wealth of information, which forms the basis to aquaculture in these ecosystems. A major programme was undertaken by CIFRI during 1972-1985 for developing brackishwater farming in different agro-ecological regions under the All India Coordinated Research project (AICRP) on Brackishwater Fish Farming. The project established the basic technology for fish and shrimp culture under tide-fed, low-input (seed, feed and management) production system. The findings made an impact on the development of extensive shrimp farming in some areas of Orissa, Andhra Pradesh and Tamil Nadu.

The Central Marine Fisheries Research Institute (CMFRI) concentrated its efforts on development of technology for shrimp breeding and successfully bred a number of species under laboratory conditions. It made significant contributions to hatchery technology for the white shrimp *Fenneropenaeus indicus*.

The new growth phase of shrimp culture for higher production, productivity and profitability commenced along with the establishment of CIBA. The technology and information needs for maintaining sustainable production levels of about 4-5 t ha/ crop (in 4 months) became very demanding. A new institute, without adequate infrastructure and trained manpower to start with, had to meet the challenges of this growth phase. Brackishwater aquaculture has been practiced on empirical basis as a state-of-the art, but the problems encountered proved the need for a deep and sound scientific basis. This needed a multidisciplinary approach.

The area of research has been expanded to include strategic research on production of seed and crop of a number of species of shrimp and finfish; nutrition and feed technology; fish and shrimp diseases, their etiology, prevention and control; pond ecology and productivity; environmental impact assessment and socio economic studies, to mention the important areas. Simultaneously basic research in digestive and reproductive physiology, metabolism, enzyme systems, microbial fermentation and immune systems has been conducted.

5.3 Input / Output Assessment

The inputs have been the research programmes in priority areas of brackishwater aquaculture with focus on technical programmes, which are immediately relevant to the production sector. These were in the broad areas of shrimp seed production technology; shrimp brood stock development; fish brood stock development in captivity; fish seed production; production technology for shrimp and fish; feed formulation and feed production technology; fish and shrimp disease diagnosis and health management; shrimp farm environmental management and impact assessment; basic research on nutrition, enzyme kinetics, bioconversion of feed ingredients and immune system to support the above areas of applied research and database on brackishwater aquaculture practices and production. These efforts were in the right direction and in consonance with the needs for technologies and information.

The outputs from the above programmes have been the technology packages wherever the results have been conclusive to a satisfactory level. Such examples are the backyard and small scale hatchery technology for *Fenneropenaeus indicus* seed production; hatchery technology for *Lates calcarifer*, formulated feeds for extensive and semi-intensive culture of *P. monodon; Artemia* cyst production; disease diagnostic techniques and water and soil quality standards. These have been transferred to the industry and farmers through technical assistance, training, publications and extension literature. At Government policy level, the Institute has played a very significant role in development of guidelines for sustainable aquaculture, in developing standards for aquaculture effluents and in furnishing scientific facts and data on coastal environmental aspects related to brackishwater aquaculture.

5.4 Short - comings

- The Institute has worked under constraints of inadequate infrastructure of laboratories and field facilities. The inordinate procedural delays in getting lands from the State Governments have been a major hurdle in physical infrastructure development.

- Human resource development in specialized areas has taken a long gestation period and opportunities in needed areas have been few. There has been imbalance in cadre strength and positions.
- There has been inadequate interaction with the industry and farmers and the requirements of the sector could not be assessed adequately.
- The State-level mechanism for extension in the Fisheries Departments has been very weak and could not absorb technologies and information available at the Institute, with some exceptions.
- Counter arguments based on scientific studies to the allegations that brackishwater culture has negatively impacted the environment were not articulated in a convincing manner.
- Network with NGOs and other organizations on specific themes has been limited.
- The shrimp culture industry itself was in a state of euphoria with liberal imports of feed, equipment etc, as also with joint ventures and franchise schemes allowing overseas consultants and technologies to establish themselves everywhere. This was short-lived as the problems cropped up due to unplanned and unregulated development and unsound technologies.
- Research on governance, policy and markets in relation to brackishwater aquaculture did not receive adequate attention.
- Research on seed production and health has received attention; however culture practice has not received the required focus.
- Field testing of products developed in the areas of health, feed and environment management has not been adequate due to lack of field testing facilities.

5.5 Lessons learnt, suggestions and options for future

- Speeding up and completion of infrastructure and increasing field testing facilities.
- Provision of balanced cadre strength and positions in all cadres.
- Creation of opportunities for human resources development in identified areas of specialization and work needs.
- Increased level of interaction with industry and farmers.
- In addition to State Fisheries Department, additional mechanism of extension needs to be explored.
- For field testing of developed products, partnership with industry and NGOs working with brackishwater farmers to be explored.
- Need to evaluate the environmental impact studies carried out and strengthen gaps and build a convincing argument in the form of scientific fact sheets and policy advice.
- Evaluate capacity of other scientific, developmental and NGO organizations and build partnerships and networking on specific themes.

6. SCENARIO

6.1 Scenario

Based on emerging trends in brackishwater aquaculture at global and national level, the broad scenario by 2025 in the country will be:

- From the present reliance of one shrimp species with the primary focus on export, brackishwater aquaculture will include a number of native species aimed at both foreign and domestic markets.
- With improved quarantine mechanisms and adoption of biosecurity protocols in designated hatcheries, exotic species will be incorporated into brackishwater aquaculture.
- The area under brackishwater aquaculture will increase to 3 lakh ha from the present area of 1.91 lakh ha with a production of 4 lakh mt by 2025 through better aquaculture planning by states and investments from private sector.
- Environmental impact of aquaculture waste water will increase unless advances in bioremediation, together with better aquaculture planning and adoption of good management practices by farmers are in place.
- By incorporating biotechnology advances into the ongoing shrimp genetic improvement programme, faster growing and disease resistant shrimp will be developed and this will contribute significantly to brackishwater aquaculture production.
- Small scale farmers will be better organized into farmer associations and would assume the scale to influence input supplies and marketing.
- Aquaculture planning will have a sound scientific basis and would incorporate the guidelines of Coastal Aquaculture and Coastal Zone Management Authorities.
- Due to increased wealth status of average Indian, domestic markets would play a significant role in shaping brackishwater aquaculture.
- There will be strong public private partnerships in specific research areas and establishment of aqua-clinics will play an important role in aquaculture extension.
- Comprehensive Indian aquaculture policy would effectively integrate brackishwater aquaculture with other sectors.

The projected target production from coastal aquaculture by National Fisheries Development Board (NFDB) is 4, 00,000 tonnes by 2020-21. Extending the similar trend of projections further, the area under coastal aquaculture is to be increased from the present 1,91,074 ha (2005-06) to at least 2,28,000ha, with an increased national average productivity to 1 ton per ha per year by 2010-11 with an aggregate national production of 2.27 lakh tons. This growth needs a compound growth rate of 3.59 %, 9.61 % and 5.92 % respectively in area expansion and production and productivity growth.

By 2025, to attain a production target of 5, 00,000 tons with an area under aquaculture of 3,00,000 ha, the per ha productivity should rise to 1670 kg/ha/year. Compound growth rates needed for this planned increases are 1.85%, 3.46% and 3.48% respectively for area, production and productivity.

Hence technological and policy support for area expansion and productivity increase in an eco-friendly manner is very much essential for augmenting the production to 5 lakh tons by 2025 AD from the present level of 1.43 lakh tons (2005-06).

6.2 SWOT Analysis

Based on the scenario projected for 2025 and the impact assessment of existing interventions, a SWOT Analysis has been carried out

6.2.1. Strengths

Sector

- Vast physical resources in the form of an estimated potential area of 1.2 million ha under a variety of ecological settings.
- Wide spectrum of species choice that can be cultured - 10 species of shrimp, 8 species of finfish and 2 species of crab in Indian waters. At present, farming of only one species of shrimp is done in India.
- The large quantum of production is another major strength, which gives the sector considerable influence in export market.

Institute

- The research programmes are well founded on a multidisciplinary approach and in some of the important areas there has been anticipatory research which has become useful in time.
- Network with number of laboratories under SAU system, international organizations and academic institutions on specific research programmes in related areas, has helped CIBA in achieving early results.

CIBA has the expertise on multiple fields to provide advice to Coastal Aquaculture and Coastal Zone Management Authorities.

6.2.2. Weaknesses

Sector

- The sector has grown based on a single commodity (shrimp) and with total export orientation and so far has neglected the large potential for diversification and domestic market.
- Unplanned, unregulated and un-scientific development of shrimp farms in the private sector and consequent social issues in certain areas and alleged environmental impacts in areas of over-concentration of farms. More than 80% of the activity is concentrated on the east coast. One single state (Andhra Pradesh) has about 50% of the total area.
- Most of the coastal areas do not have infrastructure facilities such as roads, electricity, communication and even drinking water is scarce. Farms have to function under extreme conditions.
- There has been an overplay of foreign consultants and technicians and unrestricted import of materials resulting in suppression of indigenous input supply and service sector as also skill development.
- Although an extension system (Brackishwater Fish Farmers Development Agencies) is in place, it has remained weak on technology dissemination front.

- State fisheries and local administration are not equipped to play the designated role under Coastal Aquaculture Authority Act and this delay the adoption and monitoring of guidelines for environmentally sound aquaculture.
- More than 85% of the land area under brackishwater aquaculture is stated to be with the small farmers. However the sector is projected as the domain of business sector and hence the allocation of development funds is limited.
- Overall policy guidelines to promote aquaculture development on socially and environmentally sustainable levels are lacking.
- The science of aquaculture itself is very young and has to grapple with many interacting problems unique to the aquatic organisms and ecosystems.

Institute

- Inadequate Scientific and Technical staff.
- Network with national and international research institutions and with development departments is yet to be strengthened.
- Lack of adequate farm facilities in different agro-climatic regions of the country for developing site specific culture technologies

6.2.3. Opportunities

Sector

India has a reputation in marine products export in the world market and has almost unlimited opportunities for improving its performance from the present US $ 1 billion to take a larger share of world market which is of the order of US $ 50 billion, through brackishwater aquaculture of shrimp, fish and other commodities.

- With the strong emphasis being paid to augmenting exports by successive Union Governments, cultured shrimp, in 2005-2006, accounted for foreign exchange earnings of about Rs 3,400 crores, in the total of Rs 7,245 crores earned from marine products exports. While export earnings will continue to rise, the contribution from cultured shrimp will increase substantially.
- Consumers' willingness to pay higher prices for seafood which is considered health food as compared to meat and poultry assures market expansion.
- The distinct coastal ecosystems and species resources provide great opportunities for diversification. Since land-based aquaculture production system works with brackishwater as well as seawater, product spectrum can be very large to include many conventional and non-conventional species to contribute to food security as well as exports.
- Possibilities that exist for area expansion, though potential area is estimated at 1.20 million ha, considering the existence of over 3 million ha of salt-affected areas in the coastal zone and 8 million ha of inland saline soils in the north western states of the country, the potential would be much larger. The current area utilization is only 0.19 million ha.

Institute

- CIBA with a multi-disciplinary research base has great opportunities and responsibility, to develop Centers of Excellence in many areas such as Fish Health Management, Nutrition and Feed, Aquaculture Biotechnology and Environment Management, to serve the growing critical needs of the industry.
- The institute has come out with many commercial products. The PCR kit released from Aquatic Animal Health and Environment Division is well received by the aquaculture sector. Another RT-PCR based diagnostic Kit for detection of White Muscle Disease in *Macrobrachium rosenbergii* was released recently. The immunostimulant based on *Vibrio anguillaram* has been extensively field tested. The hatchery management techniques for shrimps and fin fishes standardized by CIBA can be easily adopted by private hatcheries.
- The institute has four patents on disease diagnosis and bioremediation that have potentials for commercialization.

6.2.4 Threats

Sector

- Public perceptions on social and environmental issues related to brackishwater aquaculture could restrict growth of the sector.
- Eco-planning and bioremediation programmes are not given due importance.
- Without diversification and alternation of crops, the industry based on single species and export orientation could collapse due to diseases and market pressures.
- Post-GATT / WTO issues like antidumping will have negative impact on export.
- Quarantine facilities for introduction of exotic aquaculture species are not available.
- Major input supplies of quality seed and feed do not match the regional requirements and quality control mechanisms are not available.
- With increasing production of *Litopenaeus vannamei* from other shrimp producing countries and increased disease risks to grow larger size *P.monodon,* a market segment focused by Indian farmers, India's export can diminish.
- Epizootic diseases have already appeared in the shrimp farms all along the coastline affecting production and economy and other new diseases could pose threats from time to time.
- Extensive use of various drugs and chemicals for the control of diseases by the farmers without any idea about their efficiency can lead to contamination of shrimp and environment and wasteful expenditure by farmers.

Institute

- CIBA could get drawn into controversies on environmental impact of aquaculture waste water and introduction of exotics.

7. PERSPECTIVE

With the present trend of growth, by 2025, the area under shrimp farming is expected to double and reach a total of 3,00,000 ha with the total production of 5,00,000 mt. During the same period, the fish culture especially culture of Asian seabass, is expected to pick up and reach at least 12,000 ha with a production of about 50,000 mt. This would require an increase in the area under culture and average productivity. On the other hand, the sustainability of this sector is seriously threatened by two major issues – viral diseases and environmental issues. This has led to increased risks of crop failure and reduced profit margin. Shrimp farms have been abandoned in some areas and 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 entail 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 resulting in improved production from traditional shrimp farming and reduce pollutant load. Bio-remedial measures and improvement in the existing Best Management Practices (BMP) 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.

Shrimp farming in the country is seriously afflicted with viral diseases for the last few years. Though research has led to rapid diagnostic techniques for White Spot Virus and adoption of various measures like stocking only screened seed, the risk of losing a crop still remains high. Diseases like loose shell syndrome under grow out conditions and Monodon Baculo Virus are of concern in hatcheries. Development of diagnostic techniques for other exotic viruses especially Yellow Head Virus and Taura Syndrome Virus are also the need of the hour. Unless the risks due to diseases are managed, farmers especially the small scale category will be forced to abandon shrimp farming; it will not be able to attract new entrants and banks will be reluctant to finance. *Therefore the existing and emerging diseases in shrimp and fish production systems would require the adoption of a comprehensive health management approach.* Control of shrimp diseases will have to be addressed by importing or by developing SPF/SPR broodstock following GMP, cluster approach and bio-security measures. One of the issues in health management is the use of various drugs and chemicals for the control of diseases by the farmers without any idea about their efficiency. Therefore there is an urgent need for development of effective therapeutants, probiotics and vaccines. Awareness campaigns on an extensive scale are also needed to educate the large segment of small scale farmers.

The sector is dependent on wild spawners and more than 60% of the wild spawners are infected with white spot virus. On a short term, import of specific pathogen free broodstock through appropriate quarantine mechanisms and adoption of biosecurity protocols in hatcheries is one solution. On a long term basis, development of captive broodstock and domestication is a permanent solution to ensure production of disease free seed. By combining this with a genetic selection programme with biotechnology inputs, it would be possible to produce fast growing and pathogen resistant broodstock which can lead to higher production. *Therefore, development of high-health and high-growth shrimps through application of genetic and biotechnological tools is essential for increasing production in a sustainable manner.*

One of the main reasons that brackishwater farming has become high risk is due to its dependence on one species, *Penaeus monodon* catering for export market. Due to this, the farmers face higher disease risks and are subject to the price volatility in international markets and production systems. 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. Research on the development of alternate source of protein and production of low-protein and high energy "eco-friendly" feed has assumed greater importance. Successful diversification into crabs and seabass require grow-out feed which is still not commercially available. The continued practice of traditional shrimp farming with low inputs in West Bengal and Kerala offers opportunities to transform these into organic farming practices and develop a niche market. *Therefore diversification of species and systems is vital for sustained growth of brackishwater aquaculture.*

There is no coherent aquaculture policy in India to guide the development of brackish water aquaculture. This coupled with multiplicity of central and state agencies that the brackishwater farmer has to approach to get licenses, approvals and technologies is one of the greatest bottlenecks to respond to environmental concerns and rapidly changing global requirements. Coastal aquaculture planning must take into account natural calamities like storms and flooding and climate change due to global warming which will lead to an increased number of such disasters along with sea level rise. State officials and farmers need assistance and capacity building to respond proactively to environmental compliance as per the Coastal Aquaculture Authority Act. State level aquaculture planning using tools like Remote Sensing and Geographical Information Systems for sustainable growth is another priority area that is receiving less attention. Brackishwater aquaculture development depends on a number of ancillary industries for the supply of inputs, support production and post-harvest technology and marketing. All these have to be inter-linked in to a value chain with clear marketing strategies. Since brackishwater aquaculture presently caters mainly to the export market, WTO, issues like anti-dumping will continue to have a major influence on this sector. 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-labeling 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 are essential requirements.*

In view of the above facts, the five broad thematic areas of research of CIBA will be to develop:

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. High-health and high-growth shrimps through application of genetics and biotechnological tools
4. Diversification of species and systems for development of sustainable brackishwater aquaculture
5. Planning tools, governance guidelines and strategies to develop value chain in brackishwater aquaculture

8. ISSUES AND STRATEGIES

Six major issues in brackishwater aquaculture have been identified and the strategies to be adopted are given under each of the issues identified.

8.1 Increasing the area under aquaculture and increasing the average productivity

- Develop technological interventions for improving production from traditional shrimp farming systems.
- More emphasis on system approach and to increase in-house capacity to understand the pond dynamics so that overall productivity can be increased under diverse conditions through development of pond water and soil management techniques. Based on these studies the pond best management practices can be modified.
- Develop planning tools which incorporate aquaculture zonation, site selection based on species cultured and carrying capacity of the ecosystem, natural calamities and long term changes in climate and sea level due to global warming..
- Development of grow-out technologies for culture of shrimps and fishes in inland saline areas in collaboration with CIFE.
- Assist states like Gujarat, Maharashtra with aquaculture planning to bring new areas under aquaculture and Andhra Pradesh to reclaim abandoned shrimp farms and those converted to agriculture.
- Diversification intensified to increase the choice of species to cover new areas and markets
- Contribute towards development of guidelines for brackishwater aquaculture which takes care of the provisions of Coastal Aquaculture Authority Act and Coastal Zone Management Plans while ensuring that aquaculture development is not restricted.

8.2 Ensure availability of disease free seed of *Penaeus monodon*

- Domestication of *Penaeus monodon* and development of SPF and SPR broodstocks.
- Assist the government to develop quality standards for seed and guidelines for seed certification.
- Develop bio-security protocols that can be adopted in hatcheries.

8.3 Need for overall health management to control existing and emerging diseases

- Develop disease control mechanisms based on epidemiological studies and evaluating economic consequence of diseases.
- Improve in-house capacity and network with other institution for development of prophylactics, therapeutants, diagnostics and vaccines.
- Integrate the work on fish health with that of environment management and develop guidelines that can be incorporated into the Best Management Practices adopted by farmers.
- Develop quarantine mechanisms and protocols for introduction of exotic species and assist the DAHD & F to establish quarantine facilities.
- Facilitate the establishment of a net work of laboratories for monitoring and surveillance of diseases under DAHD & F.
- Establishment of Centre of Excellence in Aquatic Animal Health Management and carry out anticipatory research to tackle new emerging diseases.

8.4 Ensure that there is no environmental impact due to increasing area and intensification under aquaculture

- Develop bio-remediation products from agro waste and microbe mining that can be used safely in ponds to bring down levels of organic carbon, nitrogen and phosphorus levels.
- Based on the field and modeling work on the carrying capacity of creeks, develop brackishwater culture guidelines that can be applied in different geographic areas.
- Environmental impact due to aquaculture development is prevented through sound planning by application of GIS and addressing choice of sites , zonation and carrying capacity of ecosystem
- Improve the existing effluent treatment plants to be adopted by individual and cluster of farmers.

8.5 Mitigate against risks due to mono cropping of *P.monodon* through diversification of species and systems

- Development and standardization of seed production, nursery and grow-out culture technologies for prioritized species of shrimp, crabs and finfish identified for diversification.
- Investments on basic research on digestive physiology to optimize feed development and on reproductive physiology to address problems in maturation and seed production of diversified species.
- Transfer and commercializing the technologies of seed and feed production and promotion of culture of diversified shellfish/finfishes.
- Socio-economic evaluation for development of income and employment opportunities and addressing risk and uncertainty in relation to species diversification.

8.6 Ensure that brackishwater aquaculture contributes significantly to increasing the wealth status of small scale farmers and to foreign earnings

- Technology development for reducing the costs of feed through replacement of fish meal with alternate plant protein sources.
- Regulation of drugs and chemicals of unproven efficiency being marketed to avoid wasteful expenditure by farmers.
- Empowering farmers and women self help groups to ensure that aquaculture development is socially acceptable.
- Promotion of value chain for each of the diversified species with development of market strategies for domestic and export market.
- Modeling changes in terms of trade and gains from value chain analysis, market intelligence and development of support policies.
- Promote public private partnership in brackishwater aquaculture and develop policy guidelines to promote the partnership.
- Promote institutional and informal arrangements including aqua clubs and gender dimensions to promote greater equity and increased wealth creation by the small scale farmer.
- Increase in the share of international market through adoption of HACCP in hatcheries and farms , improved traceability, eco-labeling and product quality assurance
- Establishment of domestic market for high value species taking advantage of raising standards of Indian people and the awareness that seafood is a health food compared to meat products.

9. PROGRAMMES AND PROJECTS ON TIME SCALE FOR FUND REQUIREMENTS

Research programmes under the various thrust areas are listed with the time frame

Type of Research	ACTIVITY	2007 - 2012	2012- 2017	2017- 2025
Programme 1. Environment friendly and cost effective brackishwater culture technologies with focus on techniques suitable for adoption by small scale farmers.				
Basic	Understanding basic pond dynamics in relation to microbiology and nutrient flow.			
	Developing database for delineating the aquaculture pond soil profile under different agro climate and to develop a system of pond bottom soil taxonomy.			
	Fractionation of organic matter and determination of carbon and nitrogen mineralization rates for each fraction and sorption and desorption studies of phosphorus to understand the dynamics in pond soils.			
	Nitrogen budgeting in shrimp aquaculture for improvement of fertilizer and feed management.			
Applied	Optimising varying organic carbon inputs to aquaculture ponds and its effect on sediment nitrogen retention, and on shrimp/fish and crop productivity.			
	Pond bottom soil management techniques and pond fertilization procedures to improve productivity of pond systems.			
	Evaluating the scientific basis of Best Management Practices (BMP) being adopted to improve them			
	Technological interventions for improving production from traditional shrimp farming systems.			
	Development of low-cost and low fish meal feeds for shrimp aquaculture			
Applied	Low cost technology for the culture of shell fishes and finfishes in inland saline areas.			
Basic	Determination of pathway of detoxification of aquatic toxicants and detection of detoxifying genes through nucleic acid based techniques.			
	Removal mechanism of aquatic pollutants using plants and agro-wastes			
Applied	Isolation and characterization of indigenous bacteria for development of probiotics, biostimulators and bioaugmentors.			
	Development and evaluation of environmental friendly products (phytochelators/ biosorbents/ natural ion exchangers/immobilizing matrices) from plants and agro-wastes for bioremediation of aquaculture water.			

Type of Research	ACTIVITY	2007 - 2012	2012- 2017	2017- 2025
	Bioremedial measures for pond based water recirculation system and green water technology.			
Basic	Establishing input-output relationship for aquaculture commodities			
	Development of bioeconomic and prediction models for enhancing fish production and sustainable livelihood options.			
Applied	Evaluating aquaculture finance issues related to credit and insurance and repaying capacity of small farmers			
	Evaluate gender participation in brackishwater aquaculture and measures to explore possibilities of gender equity to empower women in coastal aquaculture			
	Institutional and informal arrangements including aqua clubs and gender dimensions in aquaculture extension			
	Socio-economic evaluation of need based technology identification and capacity building			
Strategic	Replacement of fish meal in feed with alternate protein sources.			
Programme 2. Comprehensive health management to address the existing and emerging diseases in shrimp and fish production systems.				
Basic	Cataloguing of pathogens in brackishwater aquaculture systems			
	Development of shrimp and fin fish cell lines for pathogenicity studies and evaluation of drugs			
	Studies on pathogenesis and epidemiology of major pathogens and parasites causing epizootics and economic consequences of diseases.			
	Surveillance of shrimp and fish health in coastal aquaculture systems.			
	Microbial diversity and microbe mining for bioactive compounds for application in aquatic animal health.			
	Genomics and proteomics of selected viral and bacterial pathogens			
Applied	Development of prophylactics and therapeutants for disease control in aquaculture using conventional and molecular approaches such as siRNA, DNA vaccines and tissue culture.			
	Development of microarray diagnostics for viral and bacterial diseases of shrimp, fish and crab.			
	Epidemiology of diseases for developing disease control programme			

Type of Research	ACTIVITY	2007 - 2012	2012- 2017	2017- 2025
Strategic	Establishment of Centre of Excellence in Aquatic Animal Health Management.			
	Conventional selection programme for improved growth and disease resistance			
	Marker-assisted selection programmes for genetic improvement of brackishwater shellfish			
Programme 3.	**High-health and high-growth shrimps through application of genetics and biotechnological tools**			
Basic	Development of DNA markers and genome mapping for identification of candidate genes for economically important traits in brackishwater shellfish.			
Applied	Development of HACCP guidelines for adoption in hatcheries and grow-out systems.			
	Development of quarantine protocol in support of regulated introduction of exotic germplasm.			
	Cloning and expression of structural protein genes of WSSV for development of immunodiagnostic assay.			
	Development of biosecurity protocols for hatchery and grow-out systems			
Programme 4.	**Diversification of species and systems for development of sustainable brackishwater aquaculture**			
Basic	Production dynamics, nutritive value for diversified live food organisms			
	Hormonal control of oocyte development and maturation in species identified for diversification			
Applied	Development of technology for controlled breeding and seed production of species identified for diversification			
	Development of cost-effective culture techniques for species identified for diversification			
Basic	Digestive physiology, energy metabolism and nutrient utilization in species identified for diversification			
Applied	Development of larval, nursery and grow out diets for species identified for diversification			
	Development of organic shrimp and fish farming protocols and organic feeds.			
	Controlled breeding technologies for brackishwater ornamental fishes.			

Type of Research	ACTIVITY	2007 - 2012	2012- 2017	2017- 2025
Basic	Modeling aquaculture production under different scenarios of diversification.			
Applied	Development of support policies based on modeling changes and gains in trade and impact on small scale farmer using value chain analysis and market intelligence.			
	Development of support policies to promote income and employment opportunities and addressing risk and uncertainty for small scale farmer.			
	Demonstration of culture technologies of diversified species for livelihood options.			

Programme 5. Planning tools, governance guidelines and strategic value chain management options for developing brackishwater aquaculture

Basic	Development of sample survey methodology in coastal aquaculture			
	Assessment of brackishwater land resources using remote sensing data and GIS and delineation of potential aquaculture areas.			
Applied	Developing models for public private partnership in brackishwater aquaculture and identifying government interventions to promote the partnership			
	Development of policies for sustainable brackishwater aquaculture in accordance with coastal zone management.			
	Development of aquaculture planning tools using GIR and RS.			
	Development of state level plan integrating costal aquaculture in to coastal zone management and mitigation plans for natural calamities and long term changes in climate and sea level due to global warming.			
	Development of strategic value chain management options			
Applied	Value chain mapping for major commodities produced in brackishwater aquaculture ecosystems, identification of misalignments and imbalances and development of policy options.			
	Assessment of carrying capacity of environment/ ecosystem/ zones/ sites and optimization of brackishwater aquaculture development for incorporation into aquaculture planning			

10. LINKAGE, CO-ORDINATION AND EXECUTION ARRANGEMENTS

The Institute has established good linkages with other research institutions for carrying out the projects envisaged. Apart from these the Institute is an active member in various networking projects.

Major area of Collaboration	Major Programmes	Organization
NATIONAL		
Resources	Shrimp and finfish broodstock assessment	CMFRI, Kochi
	GIS mapping and water bodies	CIFRI, Barrackpore
Aquaculture environment	Hydro dynamics of water bodies	NIOT & ICMAM, Chennai
	Soil & water quality and GIS	CSSRI, Karnal, NBSS&LUP, Nagpur
	Improvement of soil and water quality	IISS, Bhopal
	Isotope studies	BARC, Mumbai
	Studies on environmental impact	TNAU, Coimbatore
Culture systems	Integrated aquaculture	TANUVAS, Chennai CIFA, Bhubaneswar
	Culture technology development	State Fisheries Colleges NFDB, Hyderabad
	Aquaculture development	MPEDA, Kochi NFDB, Hyderabad
Broodstock management	Selective breeding	CIFE, Mumbai
	Genetic Resources	NBFGR, Lucknow
Nutrition	Bio-enzyme research	CFTRI, Mysore
	Cellular metabolism	CCMB, Hyderabad
Aquatic animal health	HACCP and food safety	CIFT, Kochi
	Surveillance of diseases and culture technology development	State Fisheries Colleges
Social sciences	Extension programmes	MANAGE, Hyderabad NFDB, Hyderabad
	Social Science Research	TISS, Mumbai
	Agricultural Economics & Policy Research	NCAP, New Delhi
	Statistical modeling	NFDB, Hyderabad IASRI, New Delhi
Human resource development	HRD	CIFE, Mumbai

INTERNATIONAL		
Resources	Resource assessment	BOBP, Chennai
	Fish resource conservation & Aquaculture extension	WorldFish Centre, Malaysia
Aquaculture environment	Research on aquaculture environment	Auburn University, USA
Culture systems	Aquaculture farm management	AIT, Bangkok
Broodstock management	Shrimp broodstock selective breeding	NORAD, Norway
	Breeding and culture of finfishes	IFREMER, France
Nutrition	Fin fish, Shell fish nutrition and metabolism and exogenous bioenzyme research	INRA, France
Aquatic animal health	Research in fish diseases	University of Sterling, UK
	Fish diseases	NACA, Thailand
Social Sciences	Policy research	IFPRI, Washington
	Aquaculture guidelines	FAO, Rome
Human resource development	HRD	IFPRI, Washington

11. CRITICAL INPUTS

- Field testing infrastructure facilities
- Staffing in all cadres as per ICAR Norms
- HRD through rigorous and periodic training of scientists and technicians
- External support in training of scientists in highly specialized areas such as genetics, biotechnology, immunology and vaccine development.
- Policies for sustainable brackishwater aquaculture at the Central and State levels and essential regulations
- Industry – Institution linkages in R&D areas.
- Networking of R&D in aquatic animal health management, shrimp domestication, feed development, organic farming, extension and economic evaluations.

12. RISK ANALYSIS

Shrimp farming in India has experienced a quantum jump and at the same time has faced many pitfalls. The country possesses number of significant advantages for successful brackishwater aquaculture. It has suitable temperatures all through the year and have a wide spectrum of aquaculture species. It has offshore broodstocks of the most sought-after aquaculture species, *Penaeus monodon*. However the sector faces many risks which are listed below:

12.1. Production Risks

Diseases are the most restricting production risk faced by the shrimp farming sector in the country. Explosion in virus disease problems was experienced not only in India but also in many Asian countries. However while other countries have shifted a greater share of their production to *L.vannamei* for which SPF stocks are readily available, India is continuing to relay only on *P. monodon*. With more than 60% of *P. monodon* wild broodstocks infected with WSSV and the increasing appearance of lose shell syndrome after 60 days of culture, the probability of losing the crop is higher.

Non availability of quality, reliable inputs is another production risk that is to be tackled.

Most of the small scale farmers do not have spare ponds which can be used as reservoirs. Therefore water cannot be chlorinated before use and these farmers run the risks of diseases as well as reduced production.

12.2. Environmental Risks

Effluent water treatment has attracted considerable attention and many bigger shrimp farms have effluent treatment ponds where sediments are allowed to settle at the bottom before the water is released. As such these improvements are not adopted by the small scale farmer due to higher costs and the concentration of such farms in creek based farming systems lead to environmental risks for the ecosystem. Natural calamities and long term changes in climate and sea level due to global warming can cause unfavorable conditions and lead to large areas currently under culture to be abandoned.

The non adoption of the environmental norms as stipulated in the Coastal Aquaculture Authority Act can lead to cancellation of license to operate the farms.

12.3. Biodiversity Risks

There is a clamour for introduction of exotics and there is risk of introduction of exotic diseases or ecological risks due to establishment of invasive exotic species.

12.4. Market risks

Non compliance with the standards like the use of antibiotics set by importing countries and trade restrictive measures like anti dumping also can lead to rejection of consignments. The cost of inputs is raising while the price received by farmers is reducing and coupled with the loss due to diseases, the farmer faces the risk of making a net loss. Strengthening of rupee against the currencies of our seafood export countries can lead to reduced profit margin since most of the shrimp produced is exported.

13. PROJECT REVIEW, REPORTING AND EVALUATION ARRANGEMENTS

The present system provides for such reporting and reviews through organization of projects and Divisions at the Institute level. The supervisory, evaluating and advisory structure has been organized into Staff Research Council (SRC) and Research Advisory Committee (RAC).

The projects proposed by the Divisions are critically examined by the SRC and scrutinized by the RAC in the light of the Institute's mandate and immediate and long-term goals assigned to the Institute. For all the projects, technical programme-wise, quantifiable and monitorable targets are set and closely monitored for deliverables by the Project Monitoring and Evaluation Committee

The institute also has an Institute Management Committee, to advice and assist in the management of the Institute with delegated administrative and financial powers.

The Director as Chairman or Member of the committees draws suggestions, advice, recommendations and decisions from these committees as per the terms of reference in managing the research programmes and administration.

The research and administration of the Institute is reviewed once in five years by Quinquennial Review Team constituted by the Council and submits their recommendations for consideration and implementation by the Council.

A new concept of Interface among the three departments of Agriculture Ministry – DAC, DAHD&F and DARE has been put into practice for added co-operation among the different groups under R&D.

14. RESOURCE GENERATION

The Institute's resource generation is mainly from farm produce consultancies, royalties, testing fees and training charges. Funds were also generated through external funded projects.

Amount in Lakhs

Head	IX Plan	X Plan	XI Plan (Projection)
Revenue Generation	14.74	91.80	125.00
External funded Projects	113.43	555.96	1000.00

The resource generation could be further improved by strengthening farm facilities, hatcheries and animal health testing facilities of the Institute. Consultancies, contract research and external funded projects are other sources to garner more revenue for the Institute.

15. OUTPUT OF THE R& D PROGRAMMES UNDERTAKEN

The execution of the identified programme would lead to the following outputs:

- Culture technologies for improving production from traditional shrimp farming systems of West Bengal and Kerala.
- Low cost feed through replacement of fish meal with alternate plant protein sources.
- Improved good management practices based on scientific input which is extensively adopted by farmers.
- Extension technical material that could be disseminated through the Village Knowledge Centers and innovative extension approaches integrating public and private sector agencies.
- Identified enabling environment and linkages required for successful institutional and informal arrangements for operating farmers associations
- Effluent treatment systems which can be adopted by individual and by cluster of farmers.
- Coastal Aquaculture Authority guidelines based on carrying capacities of individual creeks and geographic areas.

- Improved pond water and soil management techniques and bioremediation products based on natural plant products which would address both water and soil quality as well as environmental impact.
- Health management products (diagnostics, prophylactics and therapeutants) developed based on molecular approaches which would help tackle risks due to disease.
- HACCP guidelines to be adopted in hatcheries and farms for health management and product quality assurance
- Domesticated broodstocks and fast growing and specific pathogen resistant stocks developed through the application of genetic and biotechnological tools.
- To bring about diversification - seed, feed and culture technologies for a number of shrimps, crabs and finfishes.
- Organic farming technologies which help farmers to access a niche market.
- Planning tools, policy guidelines and value chain development strategies which meet the demands of both domestic and export markets.
- Support policies to promote income and employment opportunities and addressing risk and uncertainty for small scale farmers.

16. OUTCOME OF THE R& D PROGRAMMES UNDERTAKEN

The outputs and the strategies identified will ensure the following outcomes.

- Increased productivity levels in the traditional, extensive and intensive sectors of shrimp farming without any adverse environmental impact.
- Area under brackishwater aquaculture increased due to diversifications of species and science based aquaculture planning.
- No adverse environmental impact due to increased productivity and area under brackishwater aquaculture.
- Brackishwater aquaculture exonerated from allegations of environmental pollution due to application of bioremediation technologies and implementation of Coastal Aquaculture Authority guidelines.
- Quality produce which meets the diversified needs of both domestic and foreign consumers.
- Brackishwater aquaculture contributes significantly to increased wealth status of small scale farmers and foreign earnings.
- Brackishwater aquaculture becomes socially equitable, participatory and acceptable.

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