CIFE

Vision 2030

Central Institute of Fisheries Education
Mumbai

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Credits

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Foreword

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सचिव एवं महानिदेशक
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SECRETARY & DIRECTOR GENERAL

सत्यमेव जयते
भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
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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.

The Central Institute of Fisheries Education (CIFE), Mumbai was established on June 6, 1961 and has completed 50 glorious years of existence and as an apex organization providing qualified and trained human resources in various disciplines of fisheries. With the upcoming state-of-the-art infrastructure and modern laboratory facilities coupled with globally competitive faculty, the institute is poised to playa more leading role as a Centre of Excellence in higher fisheries education and quality research in partnership mode with the national agricultural research system and leading international organizations.

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)

Fisheries Sector Scenario

Capture fisheries and aquaculture supplied the world with about 145 million tones of fish in 2009 (FAO, 2010) with inland fisheries contributing 45 million tonne and marine fisheries 100 million tonne. Fish Production from capture fisheries and aquaculture was 90 and 55 million tons, respectively. Global capture fisheries production comprises 80 million tonne from marine and 10 million tonne from inland which has been hovering around 90 million tonne in the recent past (FAO, 2010). The proportion of under-exploited marine fish stocks declined from 40% in mid 1970s to 15% in 2008, while the proportion of over-exploited, depleted or recovering stocks increased from 10% in 1974 to 32% in 2008. However, the proportion of fully exploited stocks has relatively remained stable around 50% since 1970s.

Globally 1.5 billion people derive Almost 15% and 20% of average per capita intake of animal protein from fish is delivered from about 3 and 1.5 billion people respectively. Aquaculture is the fastest animal food producing sector with the annual growth rate of 6.6%. It is, however, noticed that the growth rate of aquaculture production is slowing, due to wide range of factors and it varies greatly among regions. It is, therefore, expected that though aquaculture production will increase in coming decades, the rate of growth is expected to be slow.

In 2008, about 45 million people were directly engaged full-time and more frequently part-time in fisheries and aquaculture with 12% of them being women. Although capture fisheries provide a great number of jobs in the primary sector, it is noticed that share of employment in capture fisheries is stagnating or decreasing while opportunities are increasing in aquaculture. Inland capture fisheries, which is the main source of livelihood of fishers, has

shown decline due to irreparable fishing practices, habitat loss and degradation, water abstraction, dam construction and pollution.

In 2008, about 40% of the fish produced in the world was marketed fresh while 41% of fish was frozen, cured or otherwise prepared for direct human consumption. Fisheries trade is a significant source of foreign exchange earnings. Trade in fish and fish products were of the order of 20% of total agricultural exports in 2008. China, Thailand and Vietnam accounted for 50% of world export of fish and fish products in value term in 2008.

The major issues pertaining to international trade in fishery products include introduction of private standards comprising social issues and their endorsement by major retailers, certification of aquaculture and traceability requirements.

National Scenario

Marine Capture Fishery

Marine fish production in India is almost exclusively from capture fisheries and the annual production increased from 0.58 million tonne in 1950 to 2.96 million tonne in 2010-11, about 5.0 fold increase in nearly 60 years. However, the marine catch has stagnated over a decade with some fluctuations. The resources in the inshore waters are being fully exploited and scope for increasing the production from the present level is limited (FAO, 2010a,b). The Indian marine capture fisheries employ about one million people and provide about 3 million tonne of fish annually with a value of about US$3 billion at production level. According to the data provided by MPEDA (2010), during 2010-11 for the first time in the history of marine product exports, the export earnings have crossed 2.67 billion US dollars.

Inland Capture Fishery

India is blessed with huge inland capture fisheries resources (29,000 kms of rivers, 0.3 million ha of estuaries, 0.19 million ha of backwaters and lagoons, 3.15 million ha of reservoirs, 0.2 million ha of floodplain wetlands and 0.72 million ha of upland lakes). According to FAO (2010a,b) it has been estimated that about 0.53 and 0.95 million tonne of inland fish is contributed by India from different types of inland open water systems during 2004-2005 and 2008-2009 and India placed third in inland capture fish production . In India, the 14 major rivers, 44 medium rivers and other innumerable small rivers provide for one of the richest fish faunistic resources of the world. While production figures from different riverine systems are not available, estimates made for major rivers showed yield varying from 0.64 to 1.64 tons per km with an average

of 1 tonne per km. The average estimated yield in different estuaries range from 45-75 kg/ha. Indian reservoirs form the largest inland fisheries resources in terms of resource size with the average productivity of 20.15 kg /ha, having a potential of 50 to 300 kg/ha. It has been estimated that the Beels possess potential to yield as much as 1000-1500 kg/ha/year, while the present level remains at only 100-150 kg/ha (Ayyappan *et al.*, 2006).

Freshwater Aquaculture

Indian aquaculture has shown significantly higher growth rates than those of capture fisheries in the last decade, with the production increasing from 1.02 million tonne in 1990 to 1.94 million tonne in 2000 and 3.48 million tonne in 2008 (FAO, 2010a,b). Fish seed production increased from a meager 409 million fry in 1973 to 24143 million fry by year 2007-08. However, the demand for "quality", "disease-free", fry/ fingerlings is continuously increasing which needs to be addressed quickly.

Carp is the mainstay of culture practice in the country, which contributes 87% of the total aquaculture production. Coldwater fish such as rainbow trout, snow trout and Mahseer are cultured in the uplands of northern India. The latter, however is a small-scale activity that caters mainly for the needs of sport fishing. Freshwater fishes are produced in a variety of systems, each of which has developed in relation to the availability of inputs in the region and the investment capabilities of the farmers (Ayyappan *et al.*, 2006). The necessity of bringing more species of promise into the carp culture practice is being emphasized. Species like *Labeo calbasu, L. gonius, L. bata, Puntius pulchellus, P. sarana, P. kolus* and *Cirrhinus cirrhosa* are considered to be important candidate species due to their production potential, consumer preference and high market price, and there is a need for greater research thrust for diversification of carp culture sector. Though catfishes possess

considerable commercial importance, their culture in the country is yet to make any mark. *Clarias batrachus* (Magur) and *Heteropneustes fossilis* (Singhi) are the two air-breathing catfishes, which are well adapted to adverse ecological conditions; recently *Pangasiadon hypophthalmus* has been introduced with great hope. Research with regard to development and standardization of induced breeding and grow-out technologies of several other non-air breathing catfishes like *Mystus* seenghala, *Pangasius pangasius*, *Wallago attu*, *Ompak pabda* are also being envisaged in view of the high consumer preference for these in different parts of the country. The development of hatchery technology for *Macrobrachium rosenbergii* and later the technology of seed production of Indian riverine prawn, *M. malcolmsonii* have opened up possibilities for diversification of freshwater aquaculture.

Ornamental fish trade an important commercial component of fisheries, with world trade of over US$ 6 billion and an annual growth rate of eight percent offers a lot of scope for development. However, India's share in the ornamental fish trade is estimated to be around 0.01% of the world trade. India has about 600 fish species that have promising market as ornamental fish. The North Eastern region homes around 300 native ornamental fish. India possesses a rich diversity of ornamental fishes, with over one hundred varieties of indigenous species, in addition to similar number of exotic species that are bred in captivity. The domestic ornamental fish market is worth around Rs 500 million and the demand is increasing at 20% annually.

Brackishwater Aquaculture

Brackishwater aquaculture in India is synonymous with penaeid shrimp aquaculture. Shrimp is the single commodity that contributes almost to the total brackishwater aquaculture production. The country possesses huge brackishwater resources of

over 1.2 million hectares suitable for farming. However, the total area under cultivation is around 10% of the potential water area available. Shrimp farming which showed impressive growth during early 90s started declining during late 90s due to the outbreak of White spot syndrome virus (WSSV) disease. Recently there has been interest in the farming of Pacific white shrimp (*Litopenaeus vannamei*) due to the availability of specific pathogen-free seed and high productivity.

Asian seabass (*Lates calcarifer*), grey mullets (*Mugil* sp.), milkfish (*Chanos chanos*) and pearlspot (*Etroplus suratensis*) are the most important fin fish species cultured in brackishwater. The non-availability of seed on a commercial scale is the most limiting factor for finfish aquaculture. Breeding and larval rearing technologies have recently been developed for Asian seabass (Arasu *et al*. 2004) and this is expected to stimulate the sector. Beside this the mud crab species, *Scylla serrata* and *S. tranquebarica* are the most popular brackishwater crab species cultured in India.

Human Resource Development

Trained human resources are vital to the sustainable development of fisheries sector, one of the most important food providing sector in the country/world. To meet this demands presently there are 18 fisheries colleges and 2 universities to impart fisheries education in the country. Annual intake capacity of these colleges/institutions is around 570 undergraduates, 250 post graduates and 100 doctoral students. Beside this, need-based short term training programs are also imparted to cater to the need of the various stake holders, by the ICAR institutes and fisheries colleges. A center for advanced faculty training in fisheries is located at CIFE to update the knowledge of the faculties of fisheries colleges and scientists of various institutes.

Future Challenges

Major challenges of the sector are to ensure conservation of resources, responsible fisheries, better management practices, enhancement of productivity and eco-friendly technologies. The impact of certification and traceability requirements on exports of the country, WTO and fisheries subsidies, climate change, carbon emissions, energy price, prices and margins throughout the fisheries value chain, are the other challenging issues to be addressed. Water, because of its multiple uses, needs budgeting at micro and macro levels. The impact of climate change on aquaculture and livelihood also needs to be studied. Providing qualified and skilled trained human resource for R&D of the sector especially in emerging areas is also a challenge, which needs to be met through short-term and long-term human resource planning exercise at national and regional level.

Central Institute of Fisheries Education

The Central Institute of Fisheries Education is a premier institution in fisheries education and training in the country which, has completed 50 glorious years of its existence in the service of the nation. It was established on 6th June, 1961 with FAO/ UNDP assistance to impart training to the officers of State Department of Fisheries as a Government of India organisation. The administrative control of the institute was transferred to Indian Council of Agricultural Research (ICAR), New Delhi in 1979. The institute was accorded Deemed to be University status in 1989, by the Ministry of Human Resource Development, Government of India. It offers master and doctoral programs in 11 disciplines of fisheries and aquaculture. Main emphasis of the institute is on basic and strategic research through faculty and students' research. Need based training programs, professional development programs and entrepreneurship development programs are conducted to cater to the needs of the sector. The institute has been playing a key role in promoting excellence in higher education through revision of syllabi, state-of the art laboratories and farm facilities and innovative teaching methods.

There are six divisions at CIFE at present which, are equipped with modern laboratories and cells. Apart from the headquarters in Mumbai, the institute has four centers located in different aqua-climatic regions of the country viz., Kakinada in Andhra Pradesh, Kolkata in West Bengal, Powarkheda near Bhopal in Madhya Pradesh and Rohtak in Haryana, with farms and infrastructural facilities for imparting hands-on training to students, farmers, entrepreneurs and development personnel. The freshwater, brakishwater and inland saline water farm facilities at these centers help to conduct the field trials and to test and standardize the technologies developed in the laboratories.

The Institute has been identified as one of the top 20 'Bright Spots' in the country by Tandon Committee constituted by Human Resource Development, Govt. of India to assess the performance of the Deemed Universities of the country.

The class rooms are equipped with state-of the-art teaching gadgets, labs with sophisticated equipments and aquarium and museum to provide effective learning environment. The institute is also having modern information and communication technology cell which provides round the clock internet and intranet services along with video conferencing facility and high end statistical computing

facility. The institute's Hiralal Choudhary library, housed in 15000 sq m area is identified as the "National Library for Fisheries and Allied Sciences" and has a rich collection books, online subscription for national and international journals and CD databases etc.

CIFE has three well-furnished hostels, modest guest house and dormitory facilities for its students, farmers, visiting faculty and guests. The hostels are provided with sports and recreation facilities and Wi-Fi system which provide the access to high speed Internet connectivity 24*7. Modest accommodation facilities are available for the faculty and staff on the campus. The four centers

of CIFE are also having hostel facilities for farmers and trainees.

A total of 145 doctoral and 739 post graduate students have successfully graduated from this university since 2000. It has also successfully trained more than 5200 personnel and students including over 100 foreign students till date through two years PG Diploma in Fisheries Science and one year Diploma/Certificate courses. ClFE alumni today are either illustrious scholars or successful entrepreneurs who occupy top management positions in their respective organisations. Through its tailor-made and need-based short-term training programs more than 600 fisheries personnel, farmers, prospective aqua-entrepreneurs and the industry personnel are trained every year. CIFE as a leader in

fisheries education in India is helping to standardize and maintain uniformity in the curriculum of fisheries education in the country. The Deemed University has also published quality study materials, reference books and practical manuals useful for students, trainees and faculty members.

CIFE is engaged in the basic and applied research in frontier areas of fisheries science and has generated and disseminated several technologies for field use successfully. Important technologies in the field include Carp hatchery models D-80 to D-86, Cryopreservation of carp milt, Non-inbred seed production technology of carp, Magur (*Clarias batrachus*) and Pengba (*Osteobrama belangeri)*, Scampi seed production using inland ground saline water and artificial sea water, Raising of fish seed in cages, Tiger shrimp farming in saline affected areas, Organic aquaculture through biofertilizers, Nutrient dense micro particulate diet and Carotenoid rich feed for ornamental fish, anti-stress formulation for fish seed transport-CIFELOSTRESS, and ready to eat fish products.

CIFE was instrumental in bringing about Blue Revolution in India in general and Andhra Pradesh in particular through its extension and training programs conducted at the freshwater and brackish water demonstration farms situated at various centers, especially Kakinada Centre. Through its 'Farmers First' policy, CIFE in collaboration with various state fisheries departments is conducting a number training programs for fish farmers at various locations including its centers. The institute has conducted several training programs for women and has helped them to organize the cooperative societies for manufacturing and marketing the fish products. CIFE has been playing a significant role in developing aquaculture specially the high-value freshwater prawn culture in the North Eastern States of Tripura, Mizoram and Manipur by setting

up hatcheries using artificial seawater. The institute has initiated several programs in collaboration with departments of fisheries of different states for capacity building of extension personnel and other stakeholders in the areas of participatory and cost-effective extension services and fisheries co-management. The cage culture programs undertaken by CIFE for developing fingerlings to stock the reservoirs has tremendously improved the production of reservoirs specially the Dimbhe reservoir in Maharashtra. The innovative project on saline aquaculture taken up at Udaipur, Rajasthan, has been a successful model for productive utilisation of salt affected areas which are not suitable for agriculture and similar attempts are being made to transfer the technology in other inland salt affected areas for sustainable use of resources. CIFE maintains close linkages with various national and international organisations and agencies for ensuring quality education and research.

CIFE 2030

CIFE is striving to impart quality education that will convey core community values employing science and technology to serve the needs of present and future generations through sustainable fisheries and aquaculture. It will pass on an education, which helps to understand fish farming systems at the population, community, and ecosystem levels. A successful sustainability of higher education program must focus on the content and context of learning coupled with innovative research. The history of CIFE is one of continual change, the change for the betterment and to become the global leader in fisheries research and education.

Vision

To be a world-class organization providing leadership in fisheries education and research

Mission

To achieve academic and research excellence by creating state-of-the-art infrastructure and globally competitive faculty

Mandate

- To conduct post graduate academic programs in core and emerging disciplines of fisheries science
- To conduct basic and strategic research in frontier areas of fisheries
- To conduct demand-driven training and educational programs for different stake holders in fisheries sector
- To provide technical support, inputs for policy development and consultancy services

Focus

- Education for Sustainable Fisheries and Aquaculture
  - Creating a participatory learning environment
  - Global curriculum and faculty
  - Innovative pedagogy

- Global outreach centres
- Customised programs
- Technology Incubation and Entrepreneurship Development
- Regional and International Hub for Fisheries Programs
- Charting New Boundaries: Basic and Strategic Research
- Centre of Excellence
- Biotechnology
- Bioinformatics
- Biodiversity and taxonomy
- Physiology
- Climate change and fisheries
- Disease surveillance and monitoring
- Policy research
- Radio ecology
- Extension and Consultancy
- Re-engineering the Systems and Procedures
- Institutional autonomy and decentralization
- Harnessing technology for effectiveness and efficiency
- Reforming Administration
- E-governance
- Integrating Value Systems
- Equity of opportunity
- Shared Values for a Great Institution
- Building State of the Art Infrastructural Facilities

Harnessing Science

As in the past, CIFE would continue its efforts to become a leading research institution for basic, strategic and upstream research in fisheries science through faculty and student research. Technology development and scientific backstopping are provided through basic and strategic research. There will be major research programs which would cut across narrow disciplinary boundaries, and will be conducted in an inter-disciplinary and collaborative mode.

Diversification in Aquaculture

The country is blessed with a diverse economically important aquatic species from freshwater, brackishwater and marine environment. Hardly, a handful of species contribute to the country's culture basket at present. Attention has not been given for the culture of medium and minor carps as well as catfishes, which are in great demand in different states. Efforts will be made to harness these resources keeping in mind the regional demand of these species. Similarly diversification of species with respect to brackishwater and sea farming also needs to be taken up. There is also immense potential for domestic marketing and export of ornamental fish. Breeding protocol and rearing techniques of ornamental fish need to be standardized.

In today's context urban aquaculture and aquaponics are gaining importance. Wastewater management, recirculation of wastewater, sewage and other liquid bio-wastes fed fisheries like dairy, beverages and distillery form part of this urban aquaculture.

Increased thrust will be given for water budgeting particularly with respect to the culture of candidate species. Even water requirement for different systems of aquaculture in different

agro-climatic zones is required to be assessed scientifically. Fish production through recirculating water system will be initiated.

Aquaculture in Inland Saline Soil and Salt Affected Areas

Refinement of existing technologies and development of new ones for inland saline and alkaline areas are the need of hour for the development and utilization of these areas for aquaculture. Hence, research needs to be strengthened for increasing the aquaculture productivity in different types of soils particularly in the states of Haryana, Maharashtra, Punjab, Rajasthan and Uttar Pradesh.

Management of Aquatic Resources

Ecosystem based approach would be initiated in the evaluation of habitat degradation and depletion of resources particularly of sensitive ecosystem like corals and mangroves. Use of GIS and remote sensing for the mapping and distribution of the resources will be intensified. An aquatic biodiversity museum with flora and fauna from the different parts of the country will be

developed.

Taxonomic identification using molecular tools and DNA Barcoding of the species at various life stages will be initiated to identify the species and devise suitable management practices for sustainable production. Further impetus will be given to bring in awareness about 'Code of Conduct for Responsible Fisheries' (CCRF) among all the stake holders to its effective adaptation and benefit.

Basic and Strategic Research for Preparedness to Climate Change in Fisheries

Climate change poses a new challenge to the sustainability of fisheries and aquaculture. The general effects of climate change on aquatic ecosystems may likely to increase water temperature, decrease dissolved oxygen levels, changes in salinity and other parameters such as, pH, alkalinity, nitrogenous wastes and the increased toxicity of pollutants. It is well known that with a narrow range of changes in temperature the basic metabolism of fish alters which may result in the distribution of the species to expand, shrink or relocate. Long-term studies on the trophic structure would be monitored to make gross estimates on the effect of climate change on the aquatic resources. Fish physiology is inextricably linked to temperature, and fish have evolved to cope up with specific hydrologic regimes and habitat niches. Therefore, their physiology and life histories will be affected by alterations induced by climate change. With the passage of time, global climate change is likely to become a more powerful stressor for fish living in natural or artificial systems. Therefore, increasing global temperatures can affect individual fish by altering the physiological functions such as thermal tolerance, growth, metabolism, food consumption, reproductive success, and the ability to maintain internal homeostasis and immunity in the face of a variable external environment. Research aimed at delineating effects of various

stressors on fish physiology in terms of growth and reproduction and basic aspect of acclimation and adaptation along with remedial measures will be taken up.

Post-harvest and Value Addition

Fish processing leads to the generation of a large biomass of fish waste (upto 40% of raw material), which is generally discarded (about 7.3 million tons/year). Thus, there is a vast scope to minimize the waste and also to utilize the waste to create useful ingredients such as collagen, gelatin, fish protein hydrolysates, fish protein concentrates, enzymes and biofuels. Hence, research in this direction will be initiated. Varieties of seafood including

cephalopods and molluscan shellfishes can be processed in different forms into different products and thus the diversification and value addition can be ensured. The Sanitary and Phytosanitary (SPS) measures and HACCP in place, new challenges need to be assessed and strategies to be worked out to address these issues.

Traceability and "Blue-eco Labelling"

In food processing, traceability (Fork to Farm concept) has important role and is done by means of barcodes/RFID tags and

other tracking media, by which all movement of product and steps within the production process is recorded. In view of seafood export potential, traceability assumes significance in the coming years and its impact needs to be assessed.

The depleting stock in the fishery resources worldwide and the increasing concern on the fishery management and biodiversity conservation needs a program that can emphasize the responsible fishing by making the consumers to prefer fishes, caught only by that way. A certification program naming, "Blue-Eco labeling" for fisheries can be started in the country to recognize and reward sustainable fishing. Initiatives in this direction are taken up by MSC (Marine Stewardship Council), England and adopted by FAO for the similar purpose. Impact of Blue-eco labeling on fish and fish product exports of the country needs to be undertaken.

Exploring Newer Aqua-feed Resources to Meet the Challenge

Feed is the major item of expenditure in aquaculture production. So, one of the major future research strategies should be to reduce feed cost. Fishmeal is now being considered as rare commodity for aqua-feed and searching for alternatives to this is the only option left for the fish nutritionists. Ever increasing cost of conventional plant feed ingredients compel the fish nutritionist to evaluate new non-conventional feed ingredients as alternative feed resources. However, presence of anti-nutritional factor is an impediment in this area. Recently use of electron beam radiation has been shown promising result for reducing the anti-nutritional factors present in the plant ingredients. Hence, research needs to be intensified in this direction.

Nutraceuticals for Boosting Immunity and Flesh Quality

Under intensive production systems, fish and crustaceans are exposed to various stressful conditions leading to growth reduction, immuno-suppression and susceptibility to infectious diseases resulting in major economic loss farmers. In this context it is a challenging situation for the aquaculture nutritionist to make a balance between fish health and growth as well. Nutritionists are exploring the nutrients or any bioactive compounds beyond the routine role of mere nutrients, which can benefit the health of fish beside growth. There is increasing recognition of the need for scientific evidence to support nutritional and medicinal claims being made within the functional food and nutraceutical industry. Recently the use of nutraceuticals in aquaculture sector is seriously felt, as disease management is increasingly perceived as health management. Besides, change of flesh quality of fish as per the demand of the consumer is the research need for the future. Though diet composition and flesh quality are closely related, specific nutraceuticals to change specific composition of flesh needs more research.

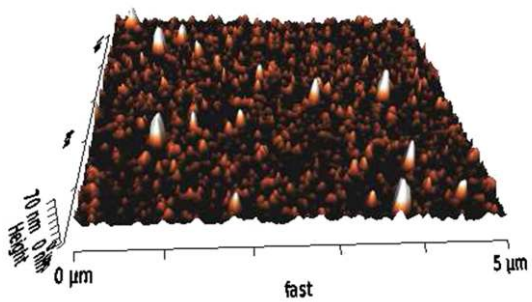
Basic Research on Gonadal Maturation and Germ-cell Transplantation

To understand the problems associated with gonadal growth and maturation and their control through environmental cues, basic research including molecular neuro-endocrinology will be taken up in certain important candidate species. In addition, basic research on germ cells in fishes will be taken up to address three main issues; embryonic origin, proliferation and migration pathway during embryonic and larval development. Germ cell transplantation has many applications in the field of fish bioengineering including investigation of complex processes of germ cell development and differentiation, producing transgenic fish by genetically modified

germ line cells, and creating brood stock systems in which target species can be produced from surrogate parents. Considering the importance of the study on germ line development and its isolation for making chimera species, visualization and isolation of germ cells, transplantation of germ cells for developing surrogate brooder fish will be taken up.

Nano-sized Delivery Systems for Novel Bioactive Compounds

Nanotechnology is being visualized as a rapidly evolving field for creative formulation of nano-sized particles through the regulated process of modulating structures and properties of matter in molecular and sub-molecular levels in order to create and use biological material structures, devices and systems with new properties and functions. Nanotechnology has already proved its importance in medical science especially in drug delivery, disease diagnostics and treatment, cosmetic industries and bioremediation of environmental pollution etc. CIFE has initiated development of efficient nano-sized delivery system for nutraceuticals, exogenous enzymes and other bioactive compounds, having pharmacological importance in fisheries science. In this context, several carriers such as chitosan, alginate, dendrines, liposomes, gold, silver, iron, zinc, PEG, PLA etc. need to be evaluated for efficient delivery of



Three-dimensional image from atomic force microscope (AFM) of chitosan nanoencapsulated yeast- RNA (CNyRNA)

bioactive molecules. The work on developing DNA nano vaccine against NODA virus in fresh water prawn and also against WSSV in *P. monodon* is going on at the institute.

Biotechnological Applications for Enhancing Fisheries and Aquaculture Productivity

The institute envisions the commercial use of bacterial and zebrafish biosensors developed recently for detecting heavy metal and genotoxic pollutants in the aquatic environment. Although the use of zebrafish might be restricted to water testing labs and authorities, the bacterial biosensors could be further integrated into user friendly devices that would enable wider acceptance. Marine bacteria can also be engineered to carry these biosensor constructs, which will help in the screening of coastal waters for heavy metal pollution.

Efforts will be made to enhance the efficacy of WSSV vaccine and commercialization. In the recent years RNA interference (RNAi) technology has emerged as an effective tool for gene knockout. This technique will be used in novel ways to address various problems in aquaculture, such as captive maturation of *P. monodon* and development of effective vaccines against fish and shrimp diseases.

Genetic Conservation and Improvement of Fish Stocks

In order to protect the valuable genetic resources of the country, it envisioned to initiate *ex-situ* and *in-situ* conservation programs. Gene banks and cryo-banks for various prioritized species of the country will be developed in collaboration with NEH states/ Island states/ state government departments and universities. This will build the capacity of the participating institutes and in turn build-up the resources. The conservation strategy will also include the rehabilitation of endangered species

for their enhancement and development.

Availability of quality seed is a major constraint of fisheries sector. In addition to that, inbreeding depression in the hatcheries has brought down the performance of economic traits. The vertical expansion of the fisheries would require high yielding, disease resistant, genetically superior stock for commercial culture. Therefore, to provide quality seed of commercially important species, the institute proposes to have accredited hatcheries for the supply of genetically certified seed to the end users. For this, the selective breeding program for carps and shellfishes will be taken up.

Ecosystem Services and Economics

As everyone is aware of, our ecosystems, in general, and aquatic ecosystems in particular, are undervalued and are increasingly susceptible to development pressures and conversion. Recognizing the aquatic ecosystems as natural assets with economic and social value can help promote conservation and more responsible decision-making. The need to consider long-term ecosystem health and its role in enabling human habitation and economic activity is urgent. To help inform the decision-makers, many ecosystem services are being assigned economic values, often based on the cost of replacement with anthropogenic alternatives. As the aquatic ecosystem services in India have not been studied in terms of the value these provide, studies will be initiated in this direction.

Increased focus on Aquatic Animal Health

Rapid, sensitive and accurate diagnosis is key to any disease management strategy; the institute has been in the forefront of developing and applying high throughput molecular diagnostic tools for aquatic animal pathogens. The institute continues to play a

crucial role in developing and refining newer diagnostics to emerging diseases and to serve as an internationally accreditated referral laboratory in the field of aquatic animal diseases.

With the advanced diagnostic tools the institute will play a leading role in disease surveillance by creating a national database of fish and shellfish diseases. This database integrated with weather and agro-climatic information can help in improving disease management system and lead to a disease forecasting and forewarning system in the country.

Human-resource Development

In the recent years, the area of fisheries and aquaculture is looked upon with great expectation and this is considered as one that could contribute a great deal to the supply of inexpensive and quality protein. However, for the implementation and upgradation of research programs, development of technologies and preparedness for facing challenges and harnessing opportunities, trained and qualified human resource is a necessity. In order to meet this requirement, it has been felt necessary to prepare the students to be globally competitive with local relevance. Efforts will be made to improve the quality of education through collaboration with national and international organizations of repute. Sandwich programs with credit sharing, faculty exchange programs, introduction of additional fellowships, development of infrastructure of international standard, etc. will be initiated. Efforts will also be made to introduce subjects and specializations in emerging areas of fisheries and aquaculture with enhanced intake capacity based on the projected requirements. Centers of excellence will also be established in the emerging areas to cater to research and faculty training needs.

Bio-risks and quarantine

Cross-boundary water bodies, both seas and rivers make containment of waterborne and fish borne disease very difficult. Holding fish and other aquatic species to any territorial boundary is also practically not possible. The natural calamities like tsunami could make any management strategy insufficient. A prudent bio-risk management system in fisheries should encompass selection of multiple low risk areas for maintenance of original genetic stock, quarantine facilities, establishment of advance warning system, and development of quick action plan for disaster management. Management of biorisks of large magnitude needs studies on risk assessment that can be done taking cue from similar events around the world supported by feasibility studies.

Institutions and Policies

Increased role of fisheries sector emanating from need to ensure food and nutritional security, greater consumer awareness, investment opportunities and need to examine possibilities of higher investments through foreign investments in niche areas requires suitable policies, institutional arrangements and organizational structure and improving networking service providers in the fisheries sector. The opportunities of scaling up technologies without sacrificing the interests of the primary stakeholders will be met by coordinated efforts at increasing institutional support of production, marketing and financial institutions. Domestic marketing arrangements will be improved by concentrated efforts of institutions involved in this sub sector development involving policy support, infrastructural arrangements, minimizing supply chain inefficiencies and increased primary stakeholder involvement. Investment opportunities will be harnessed with an integrated approach to achieving maximization of returns to investment at each stage of

the marketing channel. A center of Excellence on policy research will be established to study the policy issues related to the sector.

Technology Transfer Systems

New and improved technologies will have greater visibility and acceptance with the adoption of suitable technology transfer systems. The impact of selection of appropriate technology transfer mechanism will be measured in terms of minimization of gaps between potential and realized. An appropriate mix of extension methodologies including both electronic and print media will be used to achieve the optimum blend of media for networking research output with target stakeholders. A combination of mix of transfer of technology mechanisms will be suitably modified to address the level of end users.

Pathogen recognition receptors (PRRs) and innate immune mechanism in cultured finfish and shellfish

In response to challenges against pathogens, all multi-cellular organisms possess several immune recognition systems. Innate immune response functions by recognizing a set of molecular structures which are highly conserved and specific to microbes known as Pathogen-Associated Molecular Patterns (PAMPs) through a set of receptors called Pathogen Recognition Receptors (PRRs) These PRRs are significant as they respond to specific molecules derived from bacteria and viruses and play an essential role in host defense. Recognition of PAMPs by PRRs results in the activation of different intracellular signaling cascades leading to the activation of innate host defense.

During recent years, research on PRRs of aquatic organisms such as farmed fish has been a focal theme in many laboratories in the world. This is mainly due to the economic significance of

aquaculture and the negative impact of infectious diseases. Research on PRRs has been providing significant cue in understanding the immune defense mechanisms of fish that can contribute to the development of management strategies for disease control. However, the frontier area of molecular immunology of fish has not been a subject of intense research in India. Now, as the country is looking for diversification and intensification of aquaculture through a variety of species, there is an urgent need to understand the immune defense mechanism of fish to combat emerging diseases, and elucidating the role of various PRRs would be the key in this context. Therefore, this area will be a focal theme of the research programmes of the Institute in the coming years.

Strategy and Framework

The following strategies would be adopted to accomplish the vision and goals of Central Institute of Fisheries Education (see Annexure-1).

From Local to Global: The Challenge of Becoming the Global Leader for Fisheries and Aquaculture Education

- Human resource planning in fisheries sector to assess the future requirements of academics, research, extension and development
- Devising the international standard curricula, through adequate resource allocation, providing access to modern technology and collaboration with all stake holders
- Giving greater emphasis on learning rather than teaching through innovative pedagogy
- To harness the strength and power of national and international collaborations and partnerships that allow complementary solution finding
- Put in place more flexible structures to allow faster response to the public agenda
- Bringing changes in the faculty reward and incentive systems that allow both effectiveness and efficiency in responding to the set agenda
- Move to "outreach" as a parallel organizing framework to research for the future
- Greater use of information systems and distance education technologies to expand both impact and access
- Attaching high priority for the development of intellectual

and academic leaders with the capacities to develop visions and scenarios of future worlds as the basis for strategic development of their own institutions

Innovative and Collaborative Research

- Developing multidiscipline multi-institutional focused mission mode mega-research and technology development programs
- Collaborative research programs/consultancies with emphasis on public-public, public-private linkages
- Bridging the gap between basic and applied research for translating science into practice
- Taking a leadership role on behalf of the fisheries and aquaculture industry in addressing the 'market need' in R&D, with the objective of establishing a fully functional and integrated R&D chain
- Transforming smallholder aquaculture into a modern, competitive, productive and sustainable enterprise
- Refining existing technologies and developing new technologies for utilization of degraded and waste lands for aquaculture
- Managing the environment to the benefit of people without compromising the productive capacity of the earth and its biodiversity in the future
- Addressing IPR issues for the benefit of all stake holders

Technology Dissemination

- Identification of transferable technologies having relative advantage in terms of economic, technical and environmental friendliness and their dissemination

- Maintain and enhance a consultative framework which provides for a supportive relationship between governments, public, private and the fishing community, and encourages a healthy and respectful dialogue with other users through inclusive and meaningful processes
- Harness the potential of ICT tools for education, training and dissemination of technology

Epilogue

Despite the metamorphosis of Indian fisheries sector into a thriving industry, there are still vast resources that are under utilised, throwing open many uncommon opportunities and challenges for the educational and research institutions. CIFE responds to these challenges by becoming an innovative and proactive institute to lead the knowledge-based revolution. In accordance with such challenges, the mandate of CIFE has been revised from time to time. Through Vision 2030 CIFE envisages on the demand-driven and need-based educational and training programs to conduct basic and strategic research, to establish centres of excellence in emerging areas, and to provide support for policy development and enhancing the quality of extension services. The major components of this vision are: focusing CIFE across the globe through its outreach centres, developing world class curriculum and faculty, introducing student and faculty exchange program, sandwich degree courses. CIFE has contributed immensely for capacity building of various state fisheries departments and personnel, who have been managing State Government Departments at various levels across the country and the respective departments of other countries, and have contributed immensely to the aquaculture and fisheries development in the country. Realising the premier role of CIFE in the field of fisheries education, research and development, and the lessons learnt in the past, CIFE would reinvent itself to achieve its vision of *becoming a global player.*

CIFE will reorient its research programs to cater the needs of the country for accelerating the aquaculture production by charting new boundaries in basic and strategic research to handle the future challenges like global warming and climate change, sensitization

towards conservation of fisheries biodiversity and fisheries policy formulation and reforms, building state-of-the-art infrastructural facilities and setting new centers of excellence. Different strategies to achieve goal by 2030 include diversification of aquaculture including breeding and culture of new species compatible to adverse conditions in future, nano-biotechnological approaches to explore novel genes to highlight the specific trait as transgenic fish, conservation and documentation of aquatic biodiversity, post-harvest and value-addition and nutraceuticals for enhancing qualitative and quantitative enhancement of fish production, gonadal maturation and germ cell transplantation, aquatic animal health management. The CIFE, which has completed glorious fifty years in the service of the nation, has a wonderful amalgamation of both education and research programs to address future human resource needs of the sector.

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ANNEXURE-1: Strategic Frame Work

Goal	Approach	Performance
Create adequate human resources to address the challenges in fisheries sector	* Modernizing the fisheries education system * Introducing sandwich degree programs * Student and faculty exchange programs * Introducing new degree programs in highly specific areas to address the emerging need * Introduction of e-courses * Initiation of Postdoctoral fellowships * Capacity building through training * Opening outreach centres in Afro-Asian countries	Excellence in fisheries education and quality human resources in highly specific areas
Innovative and Collaborative Research	**Diversification of aquaculture** * Appropriate corrective measures for the sodic and acidic soils * Selection of the candidate species for breeding * Knowing physiological changes and adaptive mechanism in adverse conditions * Optimizing culture practice and health management * Development of brood stock and standardization of breeding protocol * Hatchery Development * Optimization of culture in pond condition with feed * Appropriate health management	* Large scale seed production for new candidate species * Culture of new candidate species * Aquaculture in ground saline and degraded soil
	Bio-prospecting of novel genes for qualitative and quantitative enhancement of fish production * Identification and characterization of novel genes like salt tolerance, disease resistance, ; Hypoxia Inducing Factor (HIF), Heat Shock Protein (HSP); * Pollution monitoring through fish and bacterial biosensor; * De-saturase gene for enhancing n-3 fatty acids in flesh; * RNAi technology for gene silencing or captive maturation and production of DAN vaccines for disease control * Transfer of desired gene to target species	* Enhancement of flesh quality of fish * Development of stock compatible to climate change and global warming * Development of trait specific transgenic fish
	Conservation of aquatic biodiversity and taxonomy * Selection of areas traditionally rich in aquatic biodiversity * Recording of depletion of species * Conduct awareness programs for the conservation of resources * Reduction of bycatch and juveniles by regulating crafts and gear * Employing molecular tools for classification of aquatic resources	* Improvement in quantity and quality of resources over a period of time * Reduction in percentage of juveniles and spawners * Increase in abundance and distribution pattern of resources * Developing National Aquatic Biodiversity Repository

Goal	Approach	Performance
	WTO and fisheries policy	
	* Implementation of HACCP guidelines for improved export performance	* Improved export performance
	* Policy framework for avoidance of anti-dumping duties	* Higher levels of acceptance of Indian seafood exports
	* Information dissemination on traceability	
	* Enabling fisheries and aquaculture policy	* Sustainable development of the sector
	Nutraceuticals for production and reproduction of healthy fish	
	* Identification and extraction of bioactive compound from natural resources	* Nutraceutical based feed for enhancing growth and immunity and reproductive performance of fish
	* Nutraceuticals for stress mitigation for enhancing immunity	
	* Nano size delivery of bioactive compounds for efficient utilization	
	* Utilization of unconventional feed ingredient s supplementing with bioactive compounds	
	* Optimizing the reproductive performance of fish by dietary nutraceuticals	
	Aquatic animal health management	
	* Development of molecular and immunodiagnostic kits for the detection of finfish and shellfish pathogens	* Better health management protocals
	* Training of regional laboratories for the diagnosis of finfish and shellfish diseases	* Reduced incidence of disease outbreaks
	* Improved diagnostics for aquatic animal pathogens	* Better framework to deal with emerging and newly introduced pathogens
	* Scientific database on aquatic animal diseases	
	* Improved understanding of fish immune system	
	To ensure seafood quality and safety through research outputs and field-applicable technologies	
	* Quality management through molecular approach	* Development of cost-effective seafood pathogen detection kits
	* Shelf-life extension of fish and fishery products	* Development of field-usable Bionsensor kits for fish freshness detection
		* Predictive modeling studies for shelf-life of the products
		* Identification of natural compounds for fish preservation

Goal	Approach	Performance
Technology Dissemination	* Training to fisherfolk, farmers, processors development personnel and field staff for skill up gradation * Training to academicians and fisheries professionals * Conducting location specific techno-economic feasibility studies and up-scaling the improving the improved technologies in the target domain * Use of conventional and ICT methods of extension for effective transfer of technology * Local networking of development agencies and local communities for capacity building, effective transfer of technology * Documentation and validation of ITKs	Faster and effective technologies and improved socio economic conditions

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