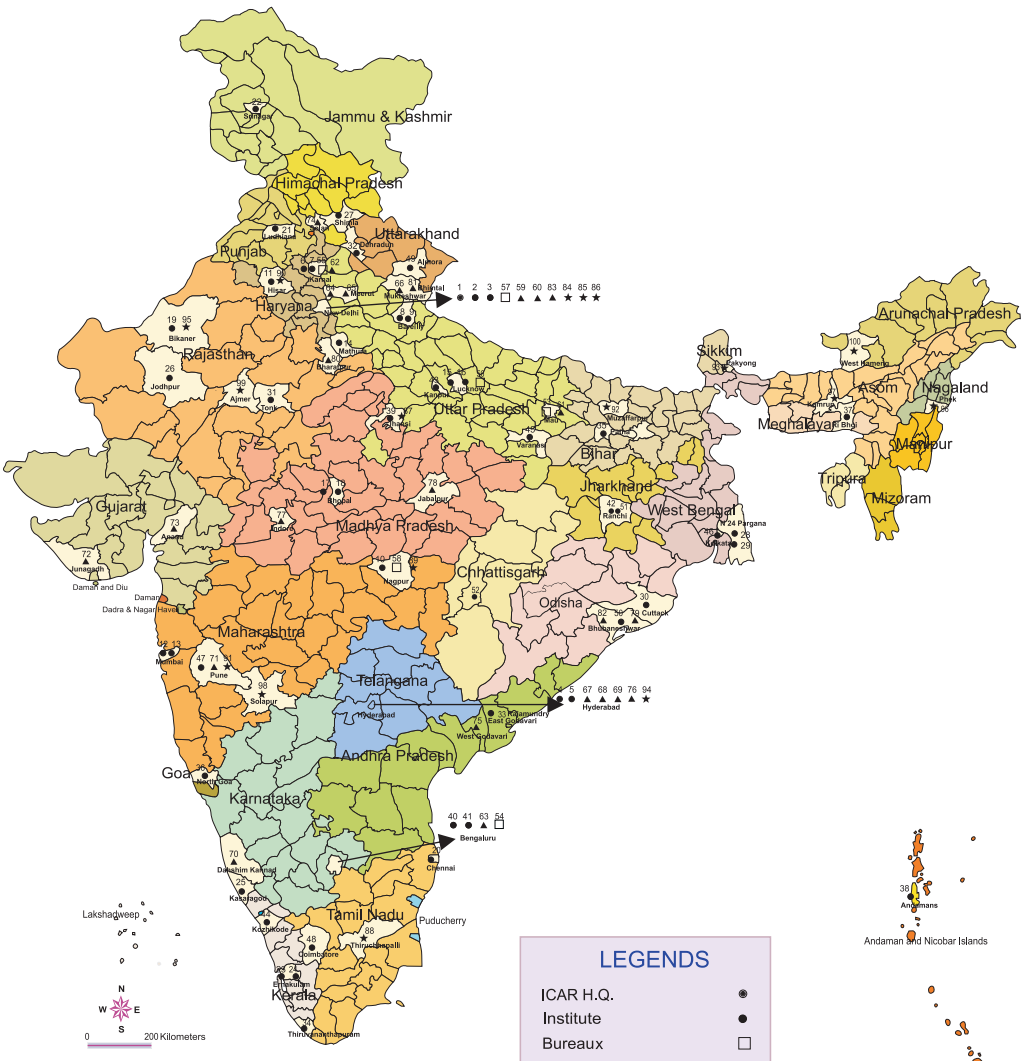
Vision 2050

Central Institute of Fisheries Technology
Indian Council of Agricultural Research

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Institutes, Bureaux, Directorates and National Research Centres



● 64 Research Institutes ● 6 Bureaux ● 15 National Research Centres ● 15 Project Directorates

Vision 2050

Central Institute of Fisheries Technology
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संदेश

भारतीय सभ्यता कृषि विकास की एक आधार रही है और आज भी हमारे देश में एक सुदृढ़ कृषि व्यवस्था मौजूद है जिसका राष्ट्रीय सकल घरेलू उत्पाद और रोजगार में प्रमुख योगदान है। ग्रामीण युवाओं का बड़े पैमाने पर, विशेष रूप से शहरी क्षेत्रों में प्रवास होने के बावजूद, देश की लगभग दो-तिहाई आबादी के लिए आजीविका के साधन के रूप में, प्रत्यक्ष या अप्रत्यक्ष, कृषि की भूमिका में कोई बदलाव होने की उम्मीद नहीं की जाती है। अतः खाद्य, पोषण, पर्यावरण, आजीविका सुरक्षा के लिए तथा समावेशी विकास हासिल करने के लिए कृषि क्षेत्र में स्थायी विकास बहुत जरूरी है।

पिछले 50 वर्षों के दौरान हमारे कृषि अनुसंधान द्वारा सृजित की गई प्रौद्योगिकियों से भारतीय कृषि में बदलाव आया है। तथापि, भौतिक रूप से (मृदा, जल, जलवायु), बायोलोजिकल रूप से (जैव विविधता, हॉस्ट-परजीवी संबंध), अनुसंधान एवं शिक्षा में बदलाव के चलते तथा सूचना, ज्ञान और नीति एवं निवेश (जो कृषि उत्पादन को प्रभावित करने वाले कारक हैं) आज भी एक चुनौती बने हुए हैं। उत्पादन के परिवेश में बदलाव हमेशा ही होते आए हैं, परन्तु जिस गति से यह हो रहे हैं, वह एक चिंता का विषय है जो उपयुक्त प्रौद्योगिकी विकल्पों के आधार पर कृषि प्रणाली को और अधिक मजबूत करने की मांग करते हैं।

पिछली प्रवृत्तियों से सबक लेते हुए हम निश्चित रूप से भावी बेहतर कृषि परिदृश्य की कल्पना कर सकते हैं, जिसके लिए हमें विभिन्न तकनीकों और आकलनों के मॉडलों का उपयोग करना होगा तथा भविष्य के लिए एक ब्लूप्रिंट तैयार करना होगा। इसमें कोई संदेह नहीं है कि विज्ञान, प्रौद्योगिकी, सूचना, ज्ञान-जानकारी, सक्षम मानव संसाधन और निवेशों का बढ़ता प्रयोग भावी वृद्धि और विकास के प्रमुख निर्धारक होंगे।

इस संदर्भ में, भारतीय कृषि अनुसंधान परिषद के संस्थानों के लिए विजन-2050 की रूपरेखा तैयार की गई है। यह आशा की जाती है कि वर्तमान और उभरते परिदृश्य का बेहतर रूप से किया गया मूल्यांकन, मौजूदा नए अवसर और कृषि क्षेत्र की स्थायी वृद्धि और विकास के लिए आगामी दशकों हेतु प्रासंगिक अनुसंधान संबंधी मुद्दे तथा कार्यनीतिक फ्रेमवर्क काफी उपयोगी साबित होंगे।

(राधा मोहन सिंह)

केन्द्रीय कृषि मंत्री, भारत सरकार

Foreword

Indian Council of Agricultural Research, since inception in the year 1929, is spearheading national programmes on agricultural research, higher education and frontline extension through a network of Research Institutes, Agricultural Universities, All India Coordinated Research Projects and Krishi Vigyan Kendras to develop and demonstrate new technologies, as also to develop competent human resource for strengthening agriculture in all its dimensions, in the country. The science and technology-led development in agriculture has resulted in manifold enhancement in productivity and production of different crops and commodities to match the pace of growth in food demand.

Agricultural production environment, being a dynamic entity, has kept evolving continuously. The present phase of changes being encountered by the agricultural sector, such as reducing availability of quality water, nutrient deficiency in soils, climate change, farm energy availability, loss of biodiversity, emergence of new pest and diseases, fragmentation of farms, rural-urban migration, coupled with new IPRs and trade regulations, are some of the new challenges.

These changes impacting agriculture call for a paradigm shift in our research approach. We have to harness the potential of modern science, encourage innovations in technology generation, and provide for an enabling policy and investment support. Some of the critical areas as genomics, molecular breeding, diagnostics and vaccines, nanotechnology, secondary agriculture, farm mechanization, energy, and technology dissemination need to be given priority. Multi-disciplinary and multi-institutional research will be of paramount importance, given the fact that technology generation is increasingly getting knowledge and capital intensive. Our institutions of agricultural research and education must attain highest levels of excellence in development of technologies and competent human resource to effectively deal with the changing scenario.

Vision-2050 document of ICAR-Central Institute of Fisheries Technology (CIFT), Cochin has been prepared, based on a comprehensive assessment of past and present trends in factors that impact agriculture, to visualise scenario 35 years hence, towards science-led sustainable development of agriculture.

We are hopeful that in the years ahead, Vision-2050 would prove to be valuable in guiding our efforts in agricultural R&D and also for the young scientists who would shoulder the responsibility to generate farm technologies in future for food, nutrition, livelihood and environmental security of the billion plus population of the country, for all times to come.

(S. AYYAPPAN)
Secretary, Department of Agricultural Research & Education (DARE)
and Director-General, Indian Council of Agricultural Research (ICAR)
Krishi Bhavan, Dr Rajendra Prasad Road,
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Preface

Greetings from ICAR- Central Institute of Fisheries Technology (CIFT)!

ICAR-CIFT - the only technology Institute in India which caters to the entire spectrum of fisheries from harvest to post-harvest operations – has been in the service of the nation since 1957 under the Indian Council of Agricultural Research (ICAR), New Delhi. Today, contributions in three vital areas, viz., nutritional security, employment generation and foreign exchange earnings have made fisheries a vibrant food sector of the Indian economy.

CIFT has an increasingly vital role to play in the emerging fisheries scenario. We as the premier Fishery Technology Institute focus on maintaining a harmonious relation with the fishing and fish processing industries in order to help them in their development and contribute to the nation's economy as well as food security. We take pride in the fact that technologies developed by the Institute have played a crucial role in modernizing the harvest and post harvest fishery sectors of India and help making it a major exporter of processed fish and fish products. We are also at the service of the nation as one of the NABL accredited laboratory recognized as a Referral Lab for fish and fishery products that are exported or imported. Overall, as our contribution, we at CIFT have been focusing on basic, strategic and applied research aimed at minimizing biodiversity loss and environmental impacts, maximizing utilization of resources with stress on value addition of existing fishery products and effective waste management. In addition, the institute has also been playing a vital role in developing, recommending and implementing standards for fishing gears, fish products and waste management systems in fish processing industries.

Looking ahead, the organization has put in all its efforts to prepare a road map in the form of this Vision 2050 document. Preparation of this document has been an exhilarating experience wherein every person in the organization put in their effort directly or indirectly to create a vision that would strengthen the institute in the years to come. CIFT has the capacity to meet any challenge faced by the industry in all fields related to fisheries due to its strength of trained and experienced team of Scientists well supported by Technical and supporting staff.

The success of CIFT thus far has been because of dedication coupled with hard work by its staff and we wish to move towards 2050 with renewed vigor and spirit for continuing this tradition. We believe in networking with researchers/academia both Internationally and Nationally on any aspect of fishing or fish processing that will help to strengthen the knowledge for the benefit of our nation. As an institution, we always welcome any individual/organization (Govermental/non-Governmental – National or International) who are interested in collaborating/learning/ contributing towards development of fishing or fish processing in India.

On the human resource development front, the Institute would continue to offer its premier technical expertise and advice for entrepreneurship development in the areas of food safety, fishing and fish processing, on a continuously evolving basis. The Institute aims to offer regular and on-demand focused training programmes - on responsible fishing, fish processing, value addition, packaging and quality control systems – for the benefit of prospective entrepreneurs, industry, students alike. The institute would also continuously interact with several National/International agencies and public/private industries on the aspects of developing techniques or safety standards for fish processing, fish products or fishing, including human resource development. We at CIFT are always making every effort to empower the weaker sections of society including the fishermen, fisherwomen, the rural poor and the financially backward community, through training and technology transfer. This social responsibility aspect would also be our primary concern as we move towards 2050.

This Vision 2050 is an attempt to re-visit the broad areas of research keeping in view scenario during the period. The focus for the next four decades will also be in the core areas of the Institute's competence. The ultimate aim of our Institution would be to ensure best contributions to make the nation's fisheries sector a sustainable, profitable and healthy livelihood option apart from contributing to Nation's nutritional security.

Team CIFT would like to place on record its sincere gratitude to Dr. S. Ayyappan, Secretary, Department of Agricultural Research & Education (DARE) and Director General (DG) for the vision and direction for ICAR. Thanks to Dr. B. Meenakuamri, Deputy Director General (Fisheries), ICAR, for guidance in preparation of this document. Contributions from Dr. Madan Mohan, Assistant Director General (Marine Fisheries) and Shri. Anil Agarwal, Principal Scientist (Fisheries) are gratefully acknowledged. Colleagues at the Institute gave their valuable insights and inputs for preparing this document, and as the

Director my personal appreciations & thanks to all of them. Specifically, I appreciate the efforts of Dr. Nikita Gopal, Principal Scientist for compiling this document together, ably supported by Ms. U. Parvathy, Scientist.

Finally, hope that this document will give the Institute the necessary direction in planning and implementing its research and extension activities for bringing out sustainable harvest and post-harvest technologies that will benefit the fishing community in particular and the fisheries sector in general, in its march towards 2050.

Needless to say that "Aquatic Foods are inevitable to the past, present and future of global nutritional security" and we can not ignore the sunrise sector like Fisheries!

Ravishankar CN PhD
Director, ICAR-CIFT

Contents

Context

The need for a Vision 2050 arises because a longer term perspective is necessary to capture an overview of the sector and the possible constraints that will be encountered, besides providing a very broad perspective of how systems and organisations should equip themselves to meet the challenges that the future is likely to present.

The ICAR- Central Institute of Fisheries Technology (CIFT) currently functions within the following mandate:

i. To conduct basic, strategic and applied research in fishing and fish processing.
ii. To develop designs for fuel efficient fishing vessels and fishing gear for responsible fishing.
iii. To develop technologies for commercial isolation of bioactive compounds and industrially important products from fish and fishery wastes.
iv. To design innovative implements and machineries for fishing and fish processing and pilot plants for facilitating commercialization of technologies developed.
v. To do advanced research in quality and safety of fish and fishery products.
vi. To provide training and consultancy services in harvest and post harvest technologies of fish.

Historically, ICAR-CIFT was established as the Central Fisheries Technological Research Station on the recommendations of a high power committee constituted by the Ministry of Food and Agriculture, Government of India. It started functioning at Cochin on 29th April 1957, under the Department of Agriculture of the then Ministry of Food and Agriculture. The Institute was given its present name in 1962. The administrative control of the Institute was brought under the Indian Council of Agricultural Research from 1st October, 1967. The Headquarters of the Institute is at Cochin with Research Centres at Veraval (Gujarat), Visakhapatnam (Andhra Pradesh) and Mumbai (Maharashtra). The research work of the Institute is orchestrated through seven Divisions viz., (i) Fishing Technology Division, (ii) Fish Processing Division, (iii) Quality Assurance & Management Division, (iv) Biochemistry and Nutrition Division, (v) Microbiology, Fermentation and Biotechnology Division, (vi) Engineering Division and (vii) Extension, Information and Statistics Division.

The Central Institute of Fisheries Technology has played a pivotal role in the technological development and modernization of both the harvest and post-harvest sectors in fisheries from its nascent stage, by actively engaging in need based technology development as well as transfer. The Institute continues to be responsive to the dynamic changes that are taking place in the fisheries sector. Within NARS, CIFT remains the only tehnology Institute catering to the Fisheries Sector and thus will continue to have a major role to play in the NARS.

The context within which NARS and the Institute will have to function in 2050 will be more dynamic and demanding requiring real time responses in terms of programmes, management and outputs. The key elements will be ecological sustainability; equitable access and utilization; cost effectiveness; and tagetted societal benefits.

The impacts of climate change will be more visible on lives and livelihoods. There will be depletion in availability of conventional resources and probable surge in unconventional resource availability. This will warrant a relook at current systems of production and processing. Stakeholder requirements at all levels will become more demanding. And hence solutions will have to be more innovative and effective. The concerns regarding safe food will take centre stage and the Institute will be asked to provide appropriate solutions for the same. There will also be avenues for research in new frontier areas which will need judicious exploitation. The increasing stress will be on 'green' technologies.

The CIFT Vision 2050 attempts to set down the key challenges and opportunities in the fisheries sector with reference to harvest and post-harvest and to provide an extensive viewpoint on the work of CIFT in tune with the overall goals of ICAR as well as the aspirations of the Fisheries sector.

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Challenges

Globally, the developments that have taken place during the past few decades has had a greater impact on human lives and natural reosurces, than have the changes that had taken place over the past few centuries. This has been fuelled chiefly by the exploring minds in science translated into the spheres of commerce and industry. While the standard and quality of human life has improved there have also been negative effects mainly due to unsustainable exploitation of natural resources leading to ecological imbalances, rapid biodiversity loss, climate change – all issues that have been compounded with growing population.

The demand for food would continue to grow in terms of both quantity and quality as the population of India is expected to grow to around 1.5 billion by 2050. Fish production in the tropics are expected to decline a further 40% by 2050. In India, current national average annual consumption of fish and fish products is 2.85 kg/capita which is also expected to increase by 2050.To satisfy the needs of 1.5 billion people in 2050, overall food production will have to increase. To achieve sufficient increases in fish production, fisheries sector has to adopt more efficient and sustainable production/harvest and post-harvest methods and at the same time strategise to adapt and mitigat climate change imapcts.

Sectoral challenges would arise from the demands and the contextual position of the fisheries sector in 2050. The likely challenges that the sector will face will be as follows:

- Climate change induced production variabilities will be a major challenge for the fisheries sector. Rising temperatures may cause changes in variables such as sea level, wind velocity and wave action, triggering ecological and biological changes in marine and freshwater ecosystems impacting the distribution and abundance of fishes. It may cause species migration and the current niches where fish thrive may alter. There will be change in species availability and species that were hitherto unexploited for various reasons may be the species abundantly available, making their exploitation and utilisation a challenge.
- There is also a possibility of regional political re-grouping for fishery resource exploitation and management with the emrgence of new target species, on the lines of the existing Tuna Commission.

There will be an increase in voluntary and mandatory guidelines by global organizations to regulate exploitation of aquatic resources. The country has to be in preparedness for the same with sufficent policy and data based scientific inputs.

- In capture fisheries the fishing pressure will continue to intensify with the addition of fishing units of greater power and capacities affecting its viability and sustainability. To make the capture fisheries sector economically viable and sustainable development of better fishing systems with stress on cost effectiveness with improved efficiency and duarbility of materials, reduction in fuel usage, and better and efficient craft and gear combinations will be required.
- Newer materials would replace existing materials for craft and gear construction. There will be demand for resilient synthetic materials for the same. It would also mean that the risk of pollution from these new synthetics will be an emerging issue and will require entirely novel mitigation and treatment strategies. Biofouling and corrosion will continue to be problems in fishing materials protection, having major economic dimensions and may require focused research, integrating developments in nano and other material technology, for finding eco-friendly solutions.
- There will be increasing demand for development and implementation of conservation technologies for minimising negative impacts of fishing on resources, biodiversity and environment.
- As long as wild capture exists, by-catch will continue to be a problem. The need for more efficient by-catch excluders will be felt, more so with time and resources becoming serious constraints. Consumers may demand safe fish for which time between the 'boat to the plate' may be a critical factor. Thus the complete exclusion of by-catch may become crucial for sustenance of wild capture fishing.
- Besides technologies for bycatch reduction/exclusion, protection of vulnerable species, minimising energy use in harvest and post-harvest operations and minimising environmental impacts will be crucial.
- Low impact and fuel efficient fishing systems are required to be further developed. Substantial amounts of energy is also wasted during the seafood processing operations which requires serious redressal.With the fast depletion of fossil and non-renewable energy resources, there will be demand for greener, cleaner, cheaper energy options, which are recyclable and reusable. This will include in its ambit bio-fuels.
- Greater regulation is expected on the size of the open waters fishing fleet. This will call for standards to be developed on fishing craft-

gear combinations to aid implementation of the regulations.

- While the conventional fishing paradigm of the 'traditional fishing-livelihood' will still continue, newer forms and systems of fishing are likely to come into practice. The focus of the traditional fisheries may shift to bring to the forefront their contribution to conservation of the resources and this type of fishing may be amenable to certification. Fishery certification, ecolabelling and traceability along with other voluntary and mandatory guidelines may also become important issues influencing international seafood trade from India, in the next few years.
- From the livelihoods point of view, climate change may cause destruction of coastal infrastructure which could enhance the vulnerabilities of the fishing communities which will require mitigation strategies.
- Inland fisheries including riverine, reservoir fisheries and aquaculture may get a boost, due to its high potential in enhancement of national fish production. Deficiencies in the legal framework and policies for leasing could be limiting factors and difficulties in cluster based integration in harvest and post-harvest operations, value addition and marketing, under value chain concept may have to be sorted out. Factors affecting riverine fish production such as pollution, destructive fishing and overfishing may aggravate in the next few decades and may need management redressal.
- For Post-harvest operations of species abundantly available (migratory species and species that were hitherto unexploited), development of techniques for seafood processing and preservation is required for which there is a need for infrastructural upgradation and remodelling, and development of business models for processing and value addition.
- Post-harvest operations and value addition generate significant quantity of waste which has to be scientifically managed for a clean and green environment in the processing sector. Fishery waste is both an issue and an opportunity, being a source of pollution on one hand and of high value products on the other. With aquaculture expected to diversify with respect to species and regions, the demand for appropriate feed will also be high for which fish wastes can be a substitute raw material.
- With majority of the population likely to reside in urban areas, consumers will become more demanding and ensuring effective utilization and value addition of fish has to be by producing convenience products. In general the demand for fish will increase

more rapidly than the supply, due to the increase in population, indicating that demand will remain strong and globally fish prices may rise. Increased awareness of consumers regarding the usefulness of fish as a source of nutrition and the changing preferences for newer and convenient products that are easy to cook or consume will call for intensified efforts in this area. The stress will be on quality, safety and prevention of wastage.

- Impact of environmental pollution, chemical abuse in processing and value addition and the emergence of new forms and variants of pathogens possibly through changes in ecosystem and introduction of new exotic fish species for value addition opens up newer challenges in seafood safety and quality issues.
- Life Cycle Assessment (LCA) of products and processes would become increasingly necessary in order to minimize ecological footprint, in terms of water and energy consumption and GHG release.
- The need for exploitation of areas like genomics for multiple uses is to be explored. Genomics is providing a unique opportunity to retrieve valuable information regarding genome structure and functional diversity which can be exploited for a variety of uses like aquatic disease control, improving nutritional quality of fish and other foods, drug development, bio-remediation etc.
- Fish is known to be an important source of PUFA and protein that mitigates lifestyle diseases. With increasing urbanization and stressed out lifestyles these disease are expected to rise. With health care expenses also rising enormously, it is important to identify and develop newer approaches for healthy nutrient intake which can also control the disease.
- Shortfall in the availability of skilled personnel, particularly in fishing, fish pre-processing and processing sectors is expected.
- The national and international policy regimes vis-à-vis trade, climate change, conservation and environment are changing rapidly and these will continue to have an impact on the fisheries sector of the country.
- The traditional systems of technology transfer will undergo changes and innovative models including public-private partnerships will evolve making the process of technology commercialization more dynamic and a truly two way process.
- Intellectual Property protection will see new challenges in the face of the need for judicious commercialization and responding to societal needs.

The Central Institute of Fisheries Technology has been sensitive to the dynamic changes that are taking place in fisheries sector and has endeavored to reframe the strategies and fine-tune the research framework in order to address emerging challenges. In meeting the above requirements of the sector, CIFT is also likely to face challenges at the Institute level in view of its current mandate, which could include the following:

- Multiplicity of institutions in the sector, funded by State governments or other agecies, resulting in duplication or redundancy of the Institute's work in fishing and fish processing technologies.
- Need to focus on cost effectiveness, especially with reference to resources as well as energy.
- Increased possibility of reduction in grants (or requirement of generating own resources) for continuing research, especially in high investment requiring frontier areas, where the results are not easily discernible in the short term.
- Increasing number of private players catering to the servicing of the fishing and fish processing industry in areas like certification, analysis, establishing guidelines and standards etc.
- Shortage of trained manpower at the Institute level to meet the challenges of the research work to be undertaken by the Institute.

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Operating Environment

The fisheries sector provides employment and livelihood opportunities to large sections of the society in India. Fish also plays a very significant role in human nutrition, being an important source of quality proteins and fats as well as vitamins and minerals. The country is also well-endowed with natural water resources which have been vital in making the sector so important from the point of view the fishing community and the nation.

The fisheries policies are laid out very broadly at the national level and the State Governments are actually responsible for developing and implementing specific rules and regulations. By 2050 there is a possibility that the policies that are as of now staggered at the state level may be integrated for better fisheries management. This is in the context of the transformations induced by climate change, need for resource conservation, sustaining fishery related livelihoods and the complexity of multiple management regimes.

The stakeholders in the renewed operating environment will continue to primarily be the fisher folk of the country, besides, players at the national and state level like the Departments of Fisheries, the Fisheries Development Board, consumers of fish, other science and technology organisations, and the private sector. The demands of each of the stakeholders will have to be looked into while conducting the activities required of the Institute so that it can continue to be relevant.

Among the most significant developments which affected the historical evolution of fishing gear and practices are (i) developments in craft technology and mechanisation of propulsion, gear and catch handling, (ii) introduction of synthetic gear materials, (iii) developments in acoustic fish detection and satellite-based remote sensing techniques, (iv) advances in electronic navigation and position fixing equipment, (v) awareness of the need for responsible fishing to ensure sustainability of the resources, protection of the biodiversity and environmental safety and energy efficiency. A wide array of fishing gears and practices ranging from small-scale artisanal to large-scale industrial systems are used for fish capture. Over the years, traditional fishing gears have been upgraded and newer more efficient fishing systems have been introduced.

However, the capture systems will most likely be in variance of the fishing craft and gear currently in use, in tune with the conservation

and catch regulations, exploitable species and newer materials. The area of operation will expand and more durable and precise fishing systems will be required. The capacity of the scientific manpower will have to be enhanced with suitable training in fish behavior, material science and modelling.

Greater inter-sectoral conflicts in coastal belts have highlighted the need for regulation of fishing capacity, adoption of responsible fishing practices and caution in capture fisheries development. Overfishing and fishing down effect is evident in Indian fisheries. Removal of excess fishing capacity and adoption of responsible fishing gear and practices and a conducive fisheries management regime would contribute to the long-term sustainability of the resources, minimise negative environmental impacts, protect biodiversity and facilitate rebuilding of the depleted marine fish stocks.

Other capture systems include riverine resources which have been showing a declining trend in recent years. Increased sedimentation of riverbeds, water abstraction, environmental degradation, marked alteration in the river courses and indiscriminate fishing have been detrimental to the riverine fishery resources. Reservoirs in India are considered to be a growing resource with enormous potential for yield augmentation through capture fisheries and extensive aquaculture. The overall production from Indian reservoirs could be substantially raised, with adequate management measures such as optimum fishing effort, responsible fishing, stocking support and mesh size regulation.

Fishing implements employed for inland fisheries of India are still traditional with very little scientific input. Traditional fish aggregating devices made using locally available materials and aquatic weeds are also in use in inland waters. Fishing with poison and explosives, though prohibited by law, are also common in several areas. Fishing crafts are dugout canoes, plank-built boats and rafts. Coracles using traditional and synthetic materials are prevalent in peninsular reservoirs. Wooden canoes and rafts are being replaced by tin canoes or fiberglass canoes in certain areas. A complete shift in the way inland capture fishing is looked at will be needed by 2050. This sector will become increasingly important source of fish production, in spite of competition for freshwater by other industries and demands of the burgeoning population. The legal repercussions regarding use of the water bodies will need to be clarified before major policy instruments are introduced in this regard.

Aquaculture will be the fastest growing food production sector globally, and India with its immense potential will play a major role in contributing to production. There will be diversification into new aquatic

niches, species and methods. These will result in new pathogens, diseases and call for real time responses. Traceability and species authenticity are going to be mandatory for products to enter major importing markets. Certification and ecolabelling of aquaculture products related to better management of aquaculture, if implemented in a fair and practical way, sensitive to the needs of small producers, may provide opportunities to support responsible and sustainable development of aquaculture, addressing negative environmental and social concerns over some forms of aquaculture. Principles, criteria and standards need to be developed and approaches to certification have to be harmonized, within the region. Fish will continue to be in demand globally and Indian fish exports will be an important component of the forex earnings of the country. Specialised products and markets are likely to emerge.

Fish makes a vital contribution to the survival and health of a significant section of the population. With the rise in population by 2050 and the consequent pressure on conventional land based food producing systems, the role of fish in food security will increase. Nutritional advantages of seafood and the beneficial effects they have on human health are already evident. A major portion of the protein demand in human nutrition will have to come from fish foods. The added advantage is the presence of micro-nutrients. Strategies to improve awareness and consumption will be required to mainstream fish in the food habits of the Indian population. A better understanding of the role of fish in decreasing malnutrition and improving health and creation of awareness about its significance in human nutrition will be undertaken.

The safety of food is an important health and economic issue. Fish and its safety has become a great concern in the context of free trade. The incidence of food borne diseases/emergence of new forms and variants of pathogens at all stages of the supply chain and use and abuse of chemicals in the production lines will continue to be of growing concern, which needs to be addressed.

Technology development as a process is itself not simplistic and involves many steps like proper diagnosis, pre-evaluation, planning, implementation and post-evaluation. The process may be short term or long term depending on the sector to be catered to. The fishing and fish processing sectors require technologies that stress on environment responsive harvesting and utilization of the resources. Most of the technology needs are field based and requires constant monitoring and interaction with the stakeholders. The private sector is involved in fisheries technology to the extent of utilizing technologies which are generally profitable. Technology development in core areas of fishing

and fish processing with the active participation of stakeholders will be undertaken. Conscious efforts will have to be taken to reduce societal imbalances arising out of resource access and availability, gender and other social differentiation.

In the era of increasing fish consumption for known health reasons, the per capita consumption of fish is likely to increase further. The changing life styles and excessive urbanization and furtherance of human exchange and enhanced trade, there is going to be an increased demand for fish based products probably through innovative high end technologies. Increasing pollution leading to contamination of the ecosystem and introduction of new products demands stringent quality requirements and safety standards. The possible introduction of GM fish is another possible challenge necessitating the requirement for processing and food safety protocols and standards.

Opportunities

Vision

To facilitate sustainable harvesting and total utilisation of fishery resources through innovations in harvest and post harvest technologies.

Mission

Ensure responsible harvesting of fishery resources through eco-friendly, energy efficient and economical means; ensure total utilization of the harvested fish through appropriate processing, value addition, packaging and waste utilization; ensure food safety and nutritional security to the consumer and minimising carbon and water footprint per unit volume; and to ensure equitable benefits to the stakeholders, across the value chain.

Focus

To achieve the Vision and Mission envisaged, CIFT will function with the following in focus:

- Development of climate change responsive and resilient fishing systems for capture and culture fisheries.
- Provide technology solutions for total utilization of harvested fishery resources, including unconventional resources.
- Facilitate introduction of green, renewable and recyclable energy and technologies in the fishing and fish processing sectors.
- Exploiting the opportunities of bio-prospecting and genomics of aquatic and other resources for manifold uses
- Development of quality systems using conventional and frontier technologies to ensure safe fish production, processing and consumption
- Development of appropriate biosecurity measures to tackle the issues of animal health
- Tap new technologies to develop innovative technology transfer and commercialization models.
- Enhance efforts in appropriate capacity building at all levels in the system.

Climate Change and Its Impacts

Climate change impacts are likely to become more evident causing

regime shifts of certain commercial species which may affect their regional availability and abundance, which in turn will impact the processing sector, either negatively or positively. With climate change becoming an increasingly tangible phenomenon and impacting the environment, including the aquatic ecosystems, the stress on green technologies is increasing. These are essential for reducing the carbon footprint of the sector. The technology development process in fishing and fish processing should take into account the possible long term consequences of climate change.

Green Fuels for Harvest and Post-harvest Fisheries

Energy requirements are high in capture fisheries, aquaculture and post-harvest sectors. Green technologies, particularly depending on renewable sources viz., solar, wind, current, tidal etc. will go a long way in reducing the energy use and efficiency of the sector. Aquatic organisms based biofuels are an attractive alternative to dwindling fossil fuel resources and have significant potential to improve sustainability and reduce GHG emissions. Further research and development are necessary to establish an economically and ecologically sustainable scale of production of green fuels. Detailed assessment will have to be made on the ecological footprint, in terms of natural resources consumption and GHG release in fishing and fish processing and the benefits of using the green fuels. Energy budgeting is required to be integrated into fisheries activities.

Capture Fisheries: Fishing Systems, Materials and Conservation

Capture fisheries will continue to be important in the sector. However, there is an increasing demand for development and implementation of conservation technologies for minimizing negative impacts of fishing on resources, biodiversity and environment. The impact of climate change will also have to be mitigated considering that there will a shift in species composition and availability. The concept of wild capture fisheries must transcend from existing non-targeted or partially trageted to targeted, high precision capture techniques, integrating satellite technology, sub aquatic detection techniques combining visual and acoustic technologies; extra resilient materials (nano to sub-nano levels); and highly skilled personnel. This will make the fishing system more efficient and effective. The concept of energy self- sufficent mother vessels carrying out actual fishing operations and feeding smaller fleets will be a reality, and efforts are needed to design and develop such systems. Standards need to be developed for each fishing system that will be introduced to regulate

effort nationally. Craft-gear combinations operating on the fishery need to be optimized in terms of number of units and standardized in terms of fishing power and capacities.

Small scale traditional fishing will continue to provide livelihood options, but a paradigm shift may take place in the way this type of fisheries is looked at. This may be a model for sustainable and green fishing and will be amenable to certification with harvests from these systems fetching a premium in the market spaces. All fishery may have to be certified for trade to take place. Necessary policy framework, technology expertise and infrastructure need to be developed to address the issues at all stages of eco-certification at national and international level.

Technologies for by-catch reduction/exclusion should be developed, mainly aimed at protection of vulnerable species and to enhance eco-friendly fishing. The increase in voluntary and mandatory guidelines at a global level will need policy inputs for development of suitable instruments and frameworks, with regard to the exploitation of aquatic resources.

Reservoir fisheries may get a boost, due to its high potential in enhancement of national fish production. Deficiencies in the legal framework and policies for leasing could be limiting factors and difficulties in cluster based integration in harvest and post-harvest operations, value addition and marketing, under value chain concept may have to be sorted out.

Riverine fisheries system needs better conservation and management measures for the sustainable utilization of the resources from these waters. Factors affecting riverine fish production such as pollution, destructive fishing and overfishing may aggravate in the next few decades and may need management redressal.

Pollution of Aquatic Systems

Introduction of newer materials for craft and gear would also mean increased risk of pollution from these material, including nano and sub-nano materials, that will require new managemnt, mitigation and treatment strategies. Suitable technologies and techniques for controlling biofouling and deterioration of the newly introduced materials will be called for. This could include bio-remediation using bio-technological tools.

Pollution originating from new fishing systems is another area of concern. It could be waste is generated by by-catch discards; onboard processing; abandoned, lost or otherwise discarded fishing gear; garbage;

fuel waste; and emissions from the vessel operations. Monitoring and control of pollution needs to be improved and updated by effective policy formulation.

Plastics will continue to be extensively used in fisheries, as they have very good strength and other desirable properties, and contribute to the high efficiency and catchability of the fishing gear. Though valued for their extreme durability, plastics have been considered to be among the most non-biodegradable synthetic materials in existence. Micro-plastics are pervasive in seawater and marine sediments and are a rapidly increasing, long-term threat to the fisheries environment. The deleterious effects of plastic debris on the marine environment are well known and a large number of marine species including marine mammals is known to be harmed or killed by plastic debris. Mitigation measures to minimize plastic debris and measures aimed at the prevention and mitigation of its impacts need to be looked-for.

Risk Assessment of Aquatic Food Production Systems

More controlled fish production in the open seas and aquaculture will become vital. Introduction of new exotic species will bring with it a major risk in the types of diseases that can occur and spread, especially trans-boundary diseases. Constant monitoring and surveillance of aquaculture and mariculture systems for risk assessment, mitigation and putting in place an effective quarantine system is called for improved biosecurity thereby preventing contamination/disease outbreak. Knowledge gaps need to be filled as to the vulnerabilty of emerging species to emerging pathogens.The country will also need to undertake impact assessments and evaluation of policy options for adaptation as well as mitigation with involvement involvement of stakeholders and based on comprehensive appraisal of risks and opportunities, benefits and costs.

Total Utilization of Harvested Resources

With climate change induced alterations in species composition of harvests, unconventional resources such as oceanic cephalopods and myctophids may become significant seafood resources, in the next few decades. Unconventional fishery resources may demand appropriate technology interventions for value addition and utilisation.

Along the entire value chain there is wastage of the harvested fish, starting from the point of capture, landing centres or harbours to the markets and consumer. This is loss of precious animal protein that can be useful in ensuring the nutritional security of the country. The country

is now looking for models which will include loss minimization or zero loss along the value-chain by ensuring total utilization including that of generated waste for developing useful high value products that can have varied applications like in pharmaceutics, cosmetics, nutraceuticals, aquatic animal feeds fortified with prophylactic and nutritional ingredients etc.

Advanced techniques for seafood processing and preservation using renewable energy sources, inlcuding bio-energy, will need to be developed and applied in order to enhance food security. The introduction of unconventional fish species for processing and value addition will require infrastructural upgradtion and remodelling along with development of business models for the same. Development of processing clusters to facilitate mechanization, raw material procurement, processing and trade will take place and suitable technologies to facilitate these clusters will be called for. Technical and operational innovation that improves efficiency, while lowering operational costs, are needed.

The urban consumers are going to increase and the demand will be for customized, convenient, diversified, ready-to-heat-and-eat products catering to a variety of palates. New processing technologies will have to be developed and standardized in tune with the emerging demands. Traditional products, like dry fish, will continue to be popular but will need re-designing to suit the tastes of the discerning consumer.

The levels of awareness on safety of food products will also rise and the product will be subject to stricter and consumer friendly quality checks, needing development of standards and methods for ensuring and monitoring product quality and safety. Developing standards for processes and products will be an integral part of the food safety system. Various bio-technological and nano-technological applications can be used for rapid detection of emerging hazards of various kinds. Cost effective, rapid tools are also needed for identifying serious consumer fraud practices.

Basic and Frontier Research Applications

Better understanding of molecular mechanism of pathogenesis by functional pathway analysis of such pathogens may offer strategies for control of spread of infections. Metagenomics approach extends our comprehension of the diversity, ecology, evolution and functioning of the pathogens and provides insight about new pathogens and shrimp diseases. It will also help in identifying biosynthetic gene clusters for production of bioactive compounds. Synthetic biology may offer valuable alternatives to standard approaches for development of diagnostics and

design of molecular sensors for detection of pathogens and spoilage bacteria in seafood products.

Genomics can be used for identifying suitable genes having potential commercial applications in aquatic disease management for identifying mechanism of pathogenesis and drug resistance; by identifying and improving nutritional value of fish with incorporation of specific nutrients.

For mitigating lifestyle diseases, approaches like introduction of nutrient producing genes of micro-algal or fish origin into mammalian cell lines like human fibroblasts can be envisaged, especially for production of PUFA and protein. Identified aquatic resources can also be used as bio-refineries for mass production of nutrients.

Human Resources

Capacity building efforts are needed to train scientists and decision makers in the region on climate change, trade, biodiversity, environment and in developing models and new techniques and methods of research in tune with the emerging demands of the sector. Stakeholders also need to be prepared for meeting the challenges that arise out of environmental and technological changes.

Technology Transfer, Commercialization and Knowledge Management

Technologies will have to be transferred for effective uptake and innovations will have to be brought in for the same. Web and IT based technologies can be used for this purpose. Innovations will have to be integrated with conventional practices and new models will have to be demonstrated. Technology development and commercialization should merge seamlessly.

With knowledge becoming a powerful symbol, IP will be a major asset to the research system and this needs to be carefully managed to ensure maximum benefits to the nation and the fisheries sector.

Policy Environment and Framework

International and national policies impact the fisheries sector directly or indirectly depending on the areas targeted by the policies. Fishing regulations in tune with the emerging and existing voluntary and mandatory guidelines will have to be evolved and suitably addressed. Policy inputs to develop national view-points on issues such as emerging regional groupings for fish harvests in open waters and on disease control and surveillance will have to be taken up.

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Goals and Targets

The major activity of the Institute, as an integral part of NARS, will continue to be research for development of technologies for the fisheries harvest and post-harvest sectors. The major focus areas will be the following:

- Standardized, green fishing systems for sustainable exploitation of fishery resources.
- Post-harvest technologies and solutions for total utilization of harvested resources.
- Basic research in frontier areas for applications including aquatic disease management, bio-remediation.
- Quality systems for safe fish production.
- Effective and efficient technology transfer mechanisms including commercialization and capacity building among stakeholders.

The major targets that the Institute has set for itself in the next four decades are outlined in the following:

Development of Climate Change Responsive and Resilient Fishing Systems Capture and Culture Fisheries

- Development of high precision eco-system oriented fishing systems for, with standardized craft-gear combinations for emerging species compositions.
- Integration of satellite technology, sensors, cameras and other IT enabled tools to monitor the craft and gear as well catches underwater, with automated logging mechanisms.
- Development of end to end prediction models for targeted fish production through capture fisheries.
- Development of capture aiding technologies for conservation of resources by exclusion of non-targeted species and sizes.
- Back-stopping small scale non-motorised traditional fleet in attaining premium eco-certified status.
- Policy advisories for emerging fishery related standards.

Provide Technology Solutions for Total Utilization of Harvested Fishery Resources, Including Unconventional Resources

- Processing technologies for unconventional fish species
- Consumer driven process modelling in development of value added, convenience products

- Zero loss processing, by utilization of wastes for production of high value products - flavours, drugs, additives, nutritional substitutes, extracts, pigments, feeds etc.

Facilitate Introduction of Green, Renewable and Recyclable Energy and Technologies in the Fishing and Fish Processing Sectors

- Life Cycle assessment (LCA) of products and processes in harvest and post-harvest sectors, in order to bring down carbon and water footprint and minimize ecological impacts.
- Development of technologies for use of green energy sources like solar, wind, current and tidal energy for controlling fishing and fish processing activities.
- Technologies for recycling and reusing of energy in fishing and fish processing.
- Algae and other marine organisms based biofuels, as alternate for fossil fuels in fisheries sector, including marine bio refineries in the sea
- Sustainable production of energy from processing waste biomass.
- Development of technologies, methods and protocols for control and monitoring of emerging pollutants in fishing and fish processing, like nano-wastes, micro-plastics, process waste from unconventional species and GM organisms.

Exploiting the Opportunities of Bio-Prospecting and Genomics of Aquatic and Other Resources for Manifold Uses

- Identification of genes and exploring pathways for diagnostic and commercial applications in the following areas:
  - aquatic disease management
  - improving nutritional quality of fish incorporating specific nutrients
  - introduction of nutrient producing genes
  - bio-refineries for mass production of nutrients
  - bio-remediation

Development of Quality Systems Using Conventional and Frontier Technologies to Ensure Safe Fish Production, Processing and Consumption

- Development of quality systems for safe fish from production to consumption including standards, processes and protocols for ensuring and monitoring product quality and safety.
- Rapid detection methods for chemical and microbiological hazards for improved food safety

- Risk assessments of emerging chemicals and pathogens for safeguarding consumer health
- Addressing food safety issues and development of standards for GM fish.

Development of Appropriate Biosecurity Measures to Tackle the Issues of Animal Health

- Application of frontier technologies, like bio-technological, molecular and nano-technological tools, for rapid detection of emerging hazards.
- Development of improved bio-security measures and protocols through risk assessment and continued surveillance of aquaculture systems.

Tap New Technologies to Develop Innovative Technology Transfer and Commercialization Models

- Integration of emerging web and other communication based technologies for development of technology transfer models.
- New business models for fishing and fish processing through a combination of technology advice and real time data management.

Enhance Efforts in Appropriate Capacity Building at All Levels in the System

- Empowering scientists and decision makers in relevant areas related to climate change, trade, biodiversity and environment.
- Evolving model prototypes, techniques and approaches of research in tune with the emerging segment demand.
- Entrepreneurship development through incubation programmes.
- Developing capacities of fishing communities against vulnerabilities and shocks.

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Way Forward

The Central Institute of Fisheries Technology has played a vital role in the modernization of Indian fisheries and in the development of both the fishing and fish processing industries to its present stature.

While the fisheries sector is currently facing challenges in terms of excess capacity, resource depletion and changes in the fisheries environment in the coastal waters, under-utilised and unutilized resources in the deeper waters hold potential along with rapid expansion envisaged in the aquaculture sector and culture based capture fisheries from reservoirs. This calls for dual strategies of application of resource conservation technologies and appropriate management plans and diversification of fishing for under-utilised resources. Fishing has to become more precise.

Climate change will have a serious impact on the fisheries sector and will affect lives and livelihoods of the fishing community. Suitable policy and management inputs are required to mitigate the impacts. Greater focus is required for development of appropriate post-harvest technologies for the new and under-utilised resources and for handling the probable production enhancements from aquaculture and culture based capture fisheries. Seafood safety systems and standards for the domestic market require focused attention while continuous attention is required to deal with emerging challenges in terms of stricter quality standards, compliance requirements and policy changes by the importing nations. Expanding aquaculture and culture based capture fisheries would bring in its own challenges in terms of the need for development of region specific harvesting systems, market specific processing, value addition, product development, and quality assurance systems. Minimization of resource loss and conservation of energy in the entire gamut of operations would be important policy objectives and technology challenges for the future.

The Institute has presented the scenario with reference to its being part of NARS. The increased stress on public-private partnership for better delivery of benefits has been recognized nationally with the private sector joining hands in public utility delivery systems as well. This may well be the case in research activities that CIFT has to undertake. In such a scenario the service delivery to the sector can be channelized through the private sector with the core research activities remaining with the Institute.

CIFT, however, continues to hold a pivotal position with its unique blend of technological capabilities that will continue to be useful to facilitate and support the technological transformation that is projected to take place during the period leading to 2050 in Indian fisheries and making it a viable economic activity, facilitating sustainable production enhancements for economic development, employment, food security and livelihood of millions of people in India.

The strategy for achieving the Vision of the Institute will be as follows and is further elaborated in Annexure 1.

Annexure I: Strategic Framework

Goal	Approach	Performance measure
Improved climate change responsive and resilient fishing systems	• Development of standardized craft-gear combinations for high precision eco-system oriented, species and sizes specific fishing systems and prediction models for capture fish production. • Development of automated tools to monitor the craft and gear as well catches underwater. • Development of end to end prediction models for targeted fish production. • Policy advisories for emerging fishery related standards and eco-certification.	▪ Optimized, resource specific, conservation oriented fishing systems ▪ Scientific end-to-end policy inputs
Absolute utilization of harvested fishery resources using appropriate technology	▪ Consumer oriented process modelling and technologies for value added, convenience product development including unconventional fish species ▪ Complete exploitation of wastes for high value product development viz., flavours, drugs, additives, nutritional substitutes, extracts, pigments, feeds etc.	▪ Value added convenience products ▪ High value products from fishery waste ▪ Innovative processes and protocols for new products ▪ Small scale cost effective, energy efficient fish processing and packaging machinery
Employing green energy and technologies in the fish harvest and post harvest sectors	• Minimization of carbon and water footprint in harvest and post-harvest sectors by Life Cycle assessment (LCA) of products and processes. • Utilizing green energy sources like solar, wind, current and tidal energy for controlling fishing and fish processing activities. • Use of Algae based biofuels, as alternate for fossil fuels in fisheries sector. • Development of know-hows and protocols for control and monitoring of evolving pollutants in fishing and fish processing.	▪ Green fishing vessel' designs ▪ Adoption of fuel efficient practices in fishing and fish processing ▪ Use of recyclable and reusable fuels ▪ Reduction in carbon footprint in fish production and fish processing. ▪ Algae based biofuels for fisheries sector.
Bio-prospecting of aquatic and other resources.	• Identification of genes and genetic pathways for commercial applications in areas like aquatic disease management, bio-remediation, improving nutritional quality of fish incorporating specific nutrients, introduction of nutrient producing genes, bio-refineries for mass production of nutrients, bio-remediation	Commercially viable bio and genetic based technologies for producing nutrition enhanced cultured fish; nutritional components; drugs; feeds

Molecular diagnostics for food-borne and cultured species pathogens.	▪ Surveillance of seafood for bacterial and viral pathogens ▪ Rapid methods for detection of bacterial and viral pathogens. ▪ Strategies for control of transboundary diseases of cultured species. ▪ Surveillance of aquaculture systems for pathogens/ exotic pathogens	▪ Database on the prevalence of seafood borne and cultured species pathogens. ▪ Improved detection methods for seafood borne pathogens and shrimp viruses. ▪ Protection of indigenous fish species from exotic diseases. ▪ Development of improved biosecurity measures in aquaculture farms.
Genomics, proteomics and molecular diversity studies of marine bacteria.	▪ Whole genome sequencing and annotation of pathogenic organisms. ▪ Identification of novel genes responsible for pathogenicity ▪ Identification of biosynthetic gene clusters for novel biomolecules.	▪ Understanding the mechanism of pathogenesis, drug resistance and host-parasite relationship and immune response. ▪ Database on marine bacteria with novel industrial applications. ▪ Novel bioactive molecules for food and industrial applications.
Development of quality systems using conventional and frontier technologies to ensure safe fish production, processing and consumption	▪ Development of quality systems for safe fish from production to consumption including standards, processes and protocols for ensuring and monitoring product quality and safety. ▪ Rapid detection methods for chemical and microbiological hazards for improved food safety ▪ Risk assessments of emerging chemicals and pathogens for safeguarding consumer health ▪ Addressing food safety issues and development of standards for GM fish.	▪ Low cost indigenous diagnostic kits for fish/shrimp pathogen ▪ Optimized Farm-to-Fork Food Safety Management System (FSMS) designs specific for seafood processing. ▪ Standards for domestically marketed fish for adoption by food legislating authorities. ▪ Trends of biological hazards; spatial and temporal variation of hazards in fishery environments. ▪ Risk assessment and standards for GM fish ▪ Development of biological (DNA) tags for traceability/ authentication of fish/fish products
Development of appropriate biosecurity measures to tackle the issues of animal health	▪ Application of frontier technologies, like bio-technological, molecular and nano-technological tools, for rapid detection of emerging hazards. ▪ Development of improved bio-security measures and protocols through risk assessment and continued surveillance of aquaculture systems.	▪ Rapid techniques for identification of hazards for surveillance of aquatic systems ▪ Improved biosecurity measures through surveillance of aquaculture systems for pathogens/exotic pathogens

Innovative technology development for effective technology transfer and commerciali-zation	• Utilising effective web based technologies for development of technology transfer models. • Integration of innovative technology with conventional ones.	▪ Novel real time responsive TOT models
Human Resource Development at all system levels	• Empowering researchers in relevant areas related to climate change, trade, biodiversity and environment and entrepreneurs through incubation programmes. • Developing models and new techniques and methods of research as per the emerging demands of the sector.	▪ Capacities developed for meeting the challenges in the fisheries sector

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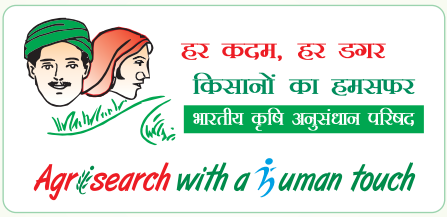
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