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Improving Fishery Based Livelihood: Policies, Technologies and Extension Strategies

(13 - 26 February, 2020)

Training Mannual

ICAR-Central Institute of Fisheries Technology

Willingdon Island, Matsyapuri P.O., Cochin-682 029, Kerala, India.

Training Manual

on

Improving Fishery based Livelihood : Policies, Technologies and Extension strategies

(Under ITEC, Ministry of External Affairs, Govt. Of India)

Venue : ICAR-Central Institute of Fisheries Technology, Kochi, India

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FOREWORD

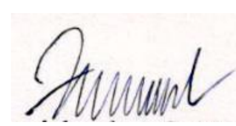
With more than 16-fold increase in national fish production in seven decades of time India has established itself as a leading nation in the world in fisheries. ICAR-Central Institute of Fisheries Technology, an institution *par excellence* in harvest and post-harvest fisheries has contributed immensely to the fisheries sector and played a key role in bringing cost effective technologies like gear and boat materials in harvesting sector; product development, packaging technologies etc. in post-harvest sector besides quality management and safety regulations, biomedical and industrial products development, developing engineering equipment, Microbial analysis and biotechnological tools and transfer of technologies. Spreading these technological knowledge and skills is inevitable for capacity building of the entire stakeholders in the fishery sector. CIFT is the pivotal in fisheries sector for sharing the research experience gained during these years to various stakeholders.

With its unchallengeable strengths in R&D sector, ICAR-CIFT has got the unique distinction of conducting such a prestigious international ITEC programme since last one decade. During current financial year 2019-20, four ITEC programmes have been conducted by ICAR-CIFT benefitting around 60 participants covering more than 24 countries in Asia, Africa, Europe, Oceania and Latin American countries.

The present ITEC programme on "Improving Fishery based Livelihood: Policies, Technologies and Extension Strategies" which was of two-week duration from 13-26 February, 2020 was attended by 11 senior level fishery extension officers and experts from nine different ITEC partner countries *viz.,* Serbia, Kenya, Eritrea, Ethiopia, Tunisia, Cambodia, Palestine, Somalia and Nigeria. The ITEC course was planned to impart theoretical and practical orientation on harvest- and post-harvest technologies in fisheries with special emphasis towards improving fishery based livelihoods through various innovative extension approaches and policy implementations. The training methodology was devised so as to make the training more interactive and effective in which we accentuate on cross learning of participants through Experiential Learning Cycle (ELC) method. The course dealt with concepts on sustainable fisheries, fish based product development and value addition, nutraceuticals from fish, fish waste utilization, engineering applications in fisheries, mitigation of harvest and post-harvest losses in fisheries, prospects in value chain in fisheries, novel extension approaches, technology dissemination in fisheries, gender empowerment, entrepreneurship development in fisheries, business planning formulation for start-ups, micro-entrepreneurship in fisheries, FPOs, KVKs and relevant topics. Besides the theory classes, field visits and industry visits were also included as a part of the course programme. of successful technology transfer in fisheries sector.

Hope this two weeks programme was fruitful and ensured better learning and effective capacity building of the ITEC Trainees during the course period. I hope the participants from various places will carry forward the knowledge gained to respective countries to fill the much needed gap of food, nutritional security and socioeconomic essentials of millions through harvest and post-harvest fisheries.

I sincerely appreciate the efforts made by the Course Director and Couse coordinators of this ITEC programme in bringing out such an informative **Compendium** which will be a reference manual for the trainees.



Dr. Ravishankar C.N.
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Content

Chapter 1

CIFT: Its contribution to Indian fishery

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Fish as a cheap source of protein, bioavailable minerals, vitamins and essential fatty acids, ensures global nutritional security. India witnessed around 14-fold increment in fish production from 0.7 million tonnes in 1950's to 10.43 million tonnes in 2014-15. With a contribution of 5.05% to world's capture production and 6.6% of total aquaculture fish production, India emerged as one among the most progressive fish producing countries in the world. Fisheries as a major agricultural sector, constitutes 0.92% of total GDP and 5.58% of total agricultural GDP of India. With the global fish export value of 148,147 million USD, India ranked seventh position among the top fish exporters of the world. The sector is crucial in securing food supply, job opportunities, nutritional needs and earning foreign exchange for the country, cataloguing it as a sunrise sector of Indian economy.

Technological developments in harvest sector

Introduction of new materials for fishing gears, mechanization of fishing crafts and modern electronic technologies for navigation and fish location, paved way for the significant increase in fish production in India over the years. ICAR-CIFT has been involved in the design and optimization of a range of crafts and gears since its inception, which gave a major fillip to the harvest sector of Indian fisheries. Considering the plateauing /decline in catches perceptible since last two decades, ICAR-CIFT has shifted its focus from increasing production to responsible harvest of resources. As a result a large number of technologies for sustainable harvest and green technologies with reduced emissions were developed.

Environmental protection and eco-friendly technologies for harvest sector

The Institute has successfully constructed few rubber wood canoes treated with a dual preservatives and combination treatment technology developed at the Institute for marine and backwater fishing. The cost of the canoe is 35-40% less than a canoe of same size built of 'Anjili' (*Artocarpushirsuta*), the usually used wood. This saves the depleting forest wealth, helps the rubber farmer to get a better prize for the under-utilized wood and gives a durable, maintenance-free boat at affordable cost to the poor (Fig.1).

Six new designs of eco-friendly and resource specific demersal trawls were developed. Trials carried out have shown that with proper rigging, none of the designs dragged bottom debris and benthos, preserving the bottom ecology of the trawling grounds.V-form otter boards designed and popularized by the Institute have also helped in eco-friendly trawling which has become popular along Gujarat, Andhra Pradesh and Kerala coasts.

Harvest technologies for responsible fishing

Square mesh codends and V form otter boards were popularized as eco-friendly and conservational fishing methods. Square mesh cod ends were seen to function better than diamond mesh in conservation by ensuring escapement juveniles. Use of optimum mesh size for target species and size class is imperative in order to prevent capture of non-target species, sub-adults and juveniles. With this in mind, a simple device for easy measurement of mesh size was developed. Selection of right size of mesh will help in popularizing responsible fishing.

Turtle Excluder device (TED) developed at the Institute was tested at Cochin, Visakhapatnam and Paradeep and found to be working satisfactorily. Turtle escape was 100% with minimum loss of valuable catch. The device is being popularized in maritime states where fishing induced turtle mortality is reported to be high. The purseine fishery of Kerala was facing hard times and as the number of vessels was reduced to 17 from 100 when ICAR-CIFT came up with suggestions for change in the mesh size. The purse seine nets and ring seines of Kerala are criticized for its very small mesh size (10-18 mm) destroying the fish wealth, as very small fish and juveniles cannot escape the net. The newly introduced purse-seine net has 45 mm mesh which has improved the catches. With increased mesh size, the target species were large sized mackerels, skipjack tunas, pomfrets, large sized carangid species etc. This net has found wide acceptance among fisherman. The new version of purse seine is a step towards conservation of fishery resources and at the same time assures good income to the fishermen, as the catches are of good marketable size.

CIFT SPTS-1 was developed as an alternative to shrimp trawling in the small-scale mechanized trawler sector, after extensive field –testing .It is capable of attaining catch rates beyond 200kg.h^{-1} in moderately productive grounds and selectively harvest fast swimming demersal and semi–pelagic finfishes and cephalopods, which are generally beyond the reach of conventional bottom trawls, currently used in commercial trawl fisheries in India.

Harvest technologies for the traditional sector

An improved design of FRP boat for backwater fishing was developed and canoes constructed for use in place of wooden canoes, which are very costly. Light weight, strength and durability are the main advantage of this material. They also have longer life when compared to traditional wooden canoes, which is a boon to the poor fisherman. The boat can be used for coastal fishing also. Fiberglass reinforced plastic (FRP) sheathed, untreated rubber wood canoes were constructed and given for experimental fishing to artisanal fishermen. Both, the preservative treated rubber wood canoe and FRP sheathed untreated rubber wood canoe, were found to be in sound condition even after 26 and 16 month field operation respectively. Fishermen have shown interest in the new technologies.

High tenacity nylon monofilament of mesh size 30 mm bar were found to be superior to nets with other mesh sizes and was found best for fabrication of gillnets for obtaining good catches.Design of twin hulled 3.6 m solar-powered boat for use in aquaculture farms, gillnetting, line fishing, transportation and aqua tourism (Fig.2). The boat with length of 3.6 m is twin hulled and is solely propelled by solar power. It can be put to use in aqua farms for aquacultural purposes and for gillnetting, line fishing, transportation and aqua tourism. Its main advantages are that it does not burn fuel, there is no atmospheric or sound pollution, has more deck space with clean FRP surface for fish handling and is suitable for shallow waters.

Harvest technologies for the mechanized sector

A prototype of a 5.22m LOA aluminum alloy boat was designed and constructed for fishing and related activates in reservoirs and rivers. This is the latest in a series of materials being evaluated by the Institute for construction of fishing vessels for the artisanal as well as mechanized sectors. Light weight, corrosion resistance, toughness and resilience make aluminum alloy a good material for construction of marine craft. This new material avoids expenditure on paints etc. and gives good re-sale value.

A sail system for use on-board medium class fishing vessels was developed for reducing fuel consumption during free running mode.Experimental fishing carried out with nylon gillnets and hand lines at Agatti islands, Lakshadweep have revealed the scope for use of these gears on the island. The islanders are now taking to such fishing methods in addition to the traditional pole and line fishing for tuna.Standardized the parameters to exploit semi-pelagic fishery resources.
Separator trawl studies confirmed the differential behavior and sorting of catch to the lower and upper cod ends. The Internationally recognized Juvenile Fish Excluder cum Shrimp Sorting Device (JFE-SSD) was the resulting invention.

Design and construction of an energy efficient, green combination fishing vessel named, ‘Sagar Haritha’. The 19.75 m multi-purpose fishing vessel, FV Sagar Harita, built under the project “Green Fishing Systems for the Tropical Seas” funded by National Agricultural Science Fund is a fuel efficient combination fishing vessel combines deep sea fishing methods like long-lining, gill netting and trawling (Fig.3). This development has turned out to be a land mark in the deep sea fishing industry of the country as no standard design of combination fishing vessel incorporating fuel efficiency features, to reduce carbon foot print is available for mechanized fishing sector of Kerala. Modifications in the hull design and changes in the operation parameters of this fishing vessel significantly reduce fuel consumption and emission of green house gases. The hull of the vessel is made of marine grade steel and the cabin and wheel house is made of FRP to reduce weight and to improve the carrying capacity and speed. The main engine power is 400 hp which is 20% lower than comparable size vessel. The fishing gear handling equipment such as split trawl winch, long line hauler, setter and gillnet hauler designed at ICAR-CIFT with hydraulic power are installed onboard. A 600 watt solar power panel is designed and installed for emergency lighting and navigational aids to promote the utilization of renewable energy resource in the sector. Acoustic trawl telemetry system with under water sensors is also installed onboard.

Harvest technologies for the inland fisheries sector

- Monoline fishing (long lining) was introduced for the first time in the reservoirs (Hirakud reservoir).
- Trammel nets of 70mm bar mesh size were found superior to other mesh sizes tried in the reservoir, contributing to 76% of the total catches
- Potential fishing zones of Thangu reservoir on Hariharjore, a tributary of Mahanadi, were demarcated based on optimum water quality parameters and depth. Survey was undertaken of some of the rivers of North Kerala with particular reference to use of bamboo in fishing. Bamboo is currently used in fabrication of traps, barriers and as gear and aquaculture accessories.
- ICAR-CIFT has designed and fabricated new collapsible fish trap and crab trap for the helping the poor fishermen operating fish traps. Crab traps were operated in Cochin backwater with fish and chicken waste as bait. The design of the collapsible trap is simple and cost-effective and any fisherman can adopt the technology. Since it is made of synthetic netting, it is light in weight. A fisherman can transport and easily operate 10-15 traps using a canoe unlike the traditional traps.

Technological developments in post harvest sector

Preservation and processing aids

Chilling is the most common and traditional method of keeping fish in fresh condition. The simplest way for chilling is icing, by which fish can be kept for 12-15 days without spoilage. However, fatty fishes like oil sardine and mackerel show visible signs of spoilage even before 10 days of storage in ice. Freezing is the major processing technique applied for long term storage of fishes for human consumption. About 12% of the fish catch is frozen for further marketing or utilization against 26% in world scenario. Fisherfolk with no/little access to modern facilities rely on the traditional methods for the preservation of fish. This includes drying, salting, pickling and smoking. All these techniques are still in practice and are preferred over a wide range of population, even though chilling and freezing gets a preference. Drying and curing also remains as of considerable importance for the utilization of seasonal bulk landings. The conventional method of curing follows sun drying the whole/gutted fish with or without prior salting. Cured fish products have good economic potential and fetch attractive prices in global market.

ICAR-CIFT has introduced a hybrid solar dryer with an alternate electrical back up heating system. Effective harnessing of solar energy using specially designed solar air heating panels and proper circulation of this hot air across the SS trays loaded with fish with the help of blowers makes the drying process faster (Fig.4). The chance of contamination and spoilage due to sand, dust, flies, insects, birds, animals and rain is completely eliminated as drying takes place inside closed chamber. The spreading of fish in S.S. perforated trays and stacking of the trays inside the drying chamber helps in reducing the space requirement of the drying process. The alternate electrical back-up heating system under controlled temperature conditions enables drying to continue even under unfavourable weather conditions like rain, cloud, non-sunny days and even in night hours, so that the bacterial spoilage due to partial drying will not occur. The eco-friendly solar drying system reduces fuel consumption and ensures significant impact in energy conservation. In India, on an average, 5% of the total fish catch is converted to cured products against 12% of the cured product proportion in world fish production.

Smoking or smoke curing is an ancient method of preservation of fish. Smoking also imparts a unique taste and flavour to the fish. It is an age old practice of preserving certain varieties of fish like tuna and little tunnies. The practice of smoke curing of fish by heating fish in an earthen pot with firewood is popular in NEH states of India, Lakshadweep islands, and remote deltas like Godavari and Krishna deltas in Andhra Pradesh. Masmin, Ngari and Colombo cured fatty fishes are some traditional cured fish products commonly prepared in these regions. However, the practice is being discouraged by many on health grounds, as wood smoke quite often contains a carcinogen, benzopyrene. Also, long term and frequent exposure to wood smoke creates respiratory and eye ailments. ICAR-CIFT has developed an eco-friendly model of a community smoking kiln (Green kiln) popularly known as COFISKI, which ensures more shelf life of over six months to the smoked fish. The smoke cured fish products of COFISKI were free from human pathogenic bacteria such as *Salmonella*, *Shigella* and *E. coli* and harbored very few number of hygiene indicator bacteria viz., fecal Coliforms, fecal *Streptococci*, Coagulase positive *Staphylococci* making it safe and fit human consumption. In traditional fish smoking kilns curing of fish are confined to individual family, whereas, COFISKI inculcated community feeling among the fisherwomen in all the villages under adoption. Thus removing socio-economic barriers and tackling the problem as one group instead of solving alone.

Smart processing and packaging technologies - A leap towards energy efficiency

Seafoods are highly perishable and usually spoil faster than other muscle foods. They are more vulnerable to post-mortem texture deterioration than other meats. Freshly caught fish undergoes quality changes as a result of autolysis and bacterial activity. Extent of these changes with time determines shelf life of the product. The novel non thermal technologies like high pressure processing, pulsed light, ultrasound, irradiation etc. find application in preservation of food and are in the line of commercialization. Microwave processing is a thermal processing aid, which has gained wide popularity owing to the rapidity of the process and applicability to a large category of products. Recent trend is to employ these techniques in newer combinations that can deliver effective preservation, without the extreme use of any single technique. These techniques aim at inactivation of microorganism rather than inhibiting them. Another interesting application in the development of ingredients and finished products is the functional modification of the food macromolecules that help the processor to have outstanding quality, with reduced cost, time and energy. The new technologies now introduce more possibilities in non-thermal or mild heat alternatives to the conventional heat processing.

High pressure processing:

High pressure processing (HPP) is a non-thermal processing technique, which uses very high pressures of more than 100Mpa to preserve food by inactivating microorganisms, spoilage enzymes and alter the food attributes, in order to achieve consumer-desired qualities. HPP was initially adopted for processing beverages and semi-liquid food items, but now this has been one of the most explored technologies and today it is a commercial reality (Fig.5). Usually the product is packed in flexible packages before processing and preferably kept in refrigeration after processing. The major attraction is that the nutritional or sensory qualities of the product are retained and thermal ill effects are avoided. This technology is used in the area of seafood safety that led seafood processors to explore high pressure technology in product development and extension of shelf life. Oysters, clams, mussels, lobsters, crabs, shrimp, cod, hake, ready to eat (RTE) seafood meals, are some examples of products that are currently being processed with HPP. A potential application of HPP is for shucking bivalves (complete separation of meat from the shell) providing high yield of product without any mechanical damage. This technology could open up the new areas of product development and product improvements in all segments of meat and fish industry. Another approach in food industry is pressure assisted freezing and thawing, which finds its unique application in product development and product quality improvement. Since HPP has minimal detrimental impact on thermally labile bioactive compounds the technology is becoming a topic of major interest for cosmetic, nutraceutical and pharmaceutical industry. Salient findings of HPP in work done at ICAR-CIFT areas follows: Indian white prawns were subjected to pressure levels of 150, 200, 250 and 300MPa with holding time at 5 min at 25 °C and subsequent stored in iced condition for shelf life evaluation. 250 MPa had a shelf life of 30 days with respect to physical and biochemical parameters. Yellow fin tuna chunks were subjected to 150, 200 and 250MPa with holding time at 5 min at 25°C and subsequent stored in iced condition for shelf life evaluation. 200 MPa had a shelf life of 30 days. Evaluation of gel strength of fish mince (unwashed) and surimi (single washed) by high pressure treatment were carried out and HPP treated had positive effect on the gelling property of sausage.

Pulse light technology:

This non thermal preservation technique uses very high-power and very short-duration pulses of light emitted by inert gas flash lamps to decontaminate and sterilize foods (Fig.6). A spectrum of white light from UV wavelength of 200nm to infrared wavelength of 1100nm is used. Exposure to PL is in the form of high intensity UV light pulses resulted in microbial inactivation through a photochemical, photothermal, and photophysical route. Hence an effective microbial inactivation is achieved, without any adverse effect on the product properties. The application of pulse light has been conducted in various foods but only few studies have been reported in fish and fishery products. The use of pulse light for the sterilization of packaging material is a growing area of food research.

Pulse electric field technology:

PEF uses high voltage short pulses to preserve the food, so as to inactivate microbes with minimal effect on quality attributes of the product. It is one of the most appealing technology due to short treatment time (typically below 1 second); hence, foods treated this way retain their fresh aroma, taste, and appearance. It is suitable for preserving liquid and semi-liquid foods. Application of PEF technology has been successfully demonstrated for the pasteurization of foods fish soups, tomato juice and liquid eggs. Application of PEF processing is restricted to food products with no air bubbles and with low electrical conductivity. PEF is a continuous processing method, which is not suitable for solid food products that cannot be pumped.

Irradiation:
Irradiation (gamma rays, X rays, and electron beams) process exposes the food to controlled levels of ionizing radiations which is detrimental to harmful bacteria, pests or parasites. The food packed is passed through the radiation chamber on a conveyor belt and exposed to radiations, without direct contact with radioactive material. Effect of irradiation on nutritional quality depends on the type of food and the dosage of radiation used. It can be used to prolong the shelf life of fruits and vegetables by inhibiting sprouting and delays ripening**.** Irradiation produces some chemical changes, which, although lethal to food-borne bacteria, do not affect the nutritional and sensory quality of the food but lead to the production of small amounts of radiolytic products.

Ultrasound Processing:
The application of ultrasound in food processing is another area in non thermal approaches, which exploits the preservative effect of the high intensity sound waves. The treatment enhances shelf life of product with greater homogeneity and energy savings. The preservative effect is by the inactivation of microbes and spoilage enzyme by mechanical actions. Ultrasonication (application of ultrasound at low temperatures), thermosonication (application of ultrasound at high temperatures), manosonication (application of ultrasound and pressure together) and manothermosonication (combined application of ultrasound, pressure and heat) are the various categories of ultrasound processing techniques. The technology finds its application in the field of extraction of proteins, lipids and their functional modifications, emulsification, viscosity improvement, homogenization and improvement of dispersion stability in liquid foods. Ultrasonics has been successfully used to inactivate *Salmonella* spp., *Escherichia coli*, *Listeria monocytogenes*, *Staphylcoccus aureus* and other pathogens. Ultrasound technology can be effectively used for freeze thawingof foods without generation of excessive heat.
Microwave processing:

Unlike non-thermal processing techniques, microwave processing involves generation of heat. Still it is attractive due to its instantaneous and rapid increase in temperature, controllable heat transmission, and easy clean-up opportunities. It is currently being used to replace or complement conventional processing technology for pasteurising or sterilising food products as well as to meet the demands of on-the-go consumers who want quick food preparation and superior taste and texture. The largest use of industrial microwave processing of food has been for tempering of meat for further processing. Conventional tempering techniques take a lot of time with considerable drip loss resulting in loss of protein and quality and economic loss. The microwave tempering can be performed in few minutes for a large amount of frozen products (5–10 min for 20–40 kg). Currently, most food industries use microwave at 915 MHz for tempering purposes. Applications of microwave drying include microwave assisted hot air drying, microwave vacuum drying and microwave freeze drying. Microwave heating is found to be an ideal system for cooking bacon and sausages, a sit greatly reduces loss of moisture through drip, fat, nutrients, and flavour. Microwaveable foods in suitable packaging materials are being developed by food processers to meet the growing demand. These convenience foods are microwaveable for use at home and away. High-density polypropylene (HDPP) is a suitable for microwave process over other materials since it can withstand the high temperature.

Modified Atmosphere Packaging:

Modified atmosphere packaging is a technologically viable method to extend the storage life of fresh seafood products. In modified atmosphere packaging air is replaced with different gas mixtures to regulate microbial activity and /or retard discolouration of the products. The composition of the gas mixture changes from its initial composition as a result of chemical, enzymatic and microbial activity of the product during storage. It is primarily the enrichment of carbon dioxide in the storage atmosphere as a means of controlling microbial growth, which results in the extension of shelf life of products. Packaging materials generally employed for this purpose are flexible films of nylon/surylyn laminates, PVC moulded trays laminated with polythene, polyester/low density polythene film etc. The use of high barrier film along with MAP that contains CO_2 effectively inhibits bacterial growth during refrigerated storage of packaged fresh fishery products. On the other hand, oxygen can inhibit the growth of strictly anaerobic bacteria like *Clostridium botulinum* although there is a very wide variation in the sensitivity of anaerobes to Oxygen. It is also seen that inclusion of only some Oxygen with Nitrogen or Carbon dioxide will not prevent botulism with absolute certainty.

Active packaging system:

The concept of active packaging started with a shift in the protection function of packaging from passive to active. It is an innovative concept that can be defined as ‘a type of packaging that changes the condition of the packaging and maintains these conditions throughout the storage period to extend shelf-life or to improve safety or sensory properties while maintaining the quality of packaged food’. They can be divided into three categories of absorber (e.g., O_2, CO_2, odour, ethylene), releasing system (e.g., N_2, CO_2, ethanol, antimicrobials, antioxidants), and other system. Other active packaging system may include the tasks of self-heating, self-cooling, microwave susceptor, anti-fogging and selective permeable film. The most important active packaging concepts forfishery products include O_2 scavenging, CO_2emitters, moisture regulators, antimicrobialpackaging, antioxidant release, release or absorption of flavours and odours. Active packaging systems with dual functionality (combination of oxygen scavengers with carbon dioxide and/or antimicrobial /antioxidant substances) is also available nowadays.

Intelligent packaging systems:

Intelligent packaging systems provide the user with information on the conditions of the food or its environment. It is a packaging system that is capable of carrying out intelligent functions (such as detecting, sensing, recording, tracing, communicating, and applying scientific logic) to facilitate decision making in order to extend shelf life, enhance safety, improve quality, provide information, and warn about possible problems. The intelligent devices such as sensors, small inexpensive labels or tags that are attached onto primary packaging (e.g., pouches, trays, and bottles), or more often onto secondary packaging (e.g., shipping containers) etc. are the integral part of intelligent packaging system, which facilitate communication throughout the supply chain so that appropriate actions may be taken to achieve desired benefits in food quality and safety enhancement. In contrary to active components, intelligent components do not have the intention to release their constituents into the food.

Smart packaging system:

Smart packaging is a broad terminology encompassing both active packing and intelligent packing concepts. Smart packaging offers a number of additional functionalities depending on the type of product, in addition to performing the four basic functions of packaging such as protection, communication, convenience and containment. They help extend shelf life, monitor freshness, display information on quality, improve safety, and improve convenience. The term smart packaging is substituted at times as diagnostic packaging, communicative packaging, functional packaging, enhancement packaging, etc.

Value addition – processor's opportunity:

Value added products are the need of the hour, since the consumers find little time for spending in preparing such products. The present day consumers, particularly urban consumers are showing more and more interest in food products which are available as ready to eat or ready to cook. The high level of expendable income and the usage of microwave ovens in households made the value added products an inevitable commodity in the super markets of the urban and even rural area. Obviously, the processors are at a side of great opportunity, as the global demand for convenient products such as marinated fillets, steaks, mince based products, extruded products etc is increasing rapidly. The major opportunities in value addition lie in the following areas:

Fish mince and mince-based products: Fish mince separated from skin, bone and fins are used for preparation of a variety of ready to eat/fry products. Battered and breaded products commonly known as 'coated products' like fish fingers, fish balls, cutlet, patties etc. are the most popular among them. Battering and breading techniques have contributed significantly to value addition of fish and fishery products. These products fetch good demand in domestic as well as export markets as theyrequire minimum financial requirement and are affordable to low time traders.

Surimi and surimi-based products: Surimi, washed mince added with cryoprotectants, also act as an intermediary in development of various products. World-wide, there is a continuous search of raw material which is suitable for surimi production. Low cost white fleshed fishes such as pink perch, croaker and perches can be conveniently used for the preparation of surimi. Even though, surimi and surimi-based products such as sausages are less popular in India, it is a much sought-after item in western markets. Moreover, shell fish analogue products from surimi fetches good demand in domestic and export markets. The Indian company 'Gadre Marine' is a leading manufacturer of surimi, exporting to 24 countries over the world.

Thermal processing and ready to serve products: Long storage life at ambient temperature without any compromise for the nutritional quality made the ready to serve thermally processed products to emerge as a highly demanded commodity. Thermal processing, which is commonly referred as heat processing or canning is a means of achieving long-term microbiological stability for non-dried foods without the use of refrigeration, by prolonged heating in hermetically sealed containers, such as cans or retortable pouches, to render the contents of the container sterile. ICAR-CIFT has standardized the processing conditions for more than 25 product styles, including the ethnic varieties such as Hyderabadi prawn biriyani, Goan mackerel curry, Malabar seer fish curry (Fig.7), Tapioka and fish curry, SeerfishMoli, mussel/oyster masala etc. This technology has a long term impact as evidenced by the adoption of fish products in retort pouch by more than a dozen companies in India. Different types of packaging materials like cans, retort pouches with different layer configurations, semi rigid containers are used for the development of these products.

Extruded snack products: Extrusion helps to improve the versatility for the development of high-nutritive, low cost and convenient food products. It is a thermodynamically efficient process and ensures the destruction of bacteria and anti-nutritional factors during extrusion process. Flavour, texture and taste are the major characteristics affecting the acceptability of these products. Usually, extruded products are prepared using cereal flour, which have less protein content and are limited in some essential amino acids. By incorporating protein-rich fish mince instead of cereal, the product is protein enriched snack food. 'Fish cure' is such a product developed by ICAR-CIFT with fish mince as base material. The flavour and taste of these products may be altered by coating with suitable spice/flavour mix. The production process involves mixing of fish mince with cereal flours, spices and salt and extrusion using a twin screw extruder (Fig.8). The dried and coated products are then packed in metalized polyester polyethylene pouches using nitrogen gas filling. The product is acceptable up to 3 months at ambient temperature.

Seaweed incorporated products:A more recent addition to the food industry from marine sector is 'processed seaweeds and seaweed extracts'. The South-East and North -West coasts of India and the Andaman- Nicobar and Laccadive archipelagoes harbour a variety of seaweeds with rich biomass and species diversity. The seaweed industry is certainly on its way marching towards socio economic development of our nation. Apart from bringing umami taste to foods, seaweeds serve as a major storehouse of polyunsaturated fatty acids, dietary fibres, minerals, vitamins and sulphated polysaccharides in good amounts, which could be used to fortify beverages and health drinks. Dietary fibre extract from seaweeds, 'Nutridrink' (grape juice fortified with seaweed extract), fish soup fortified with seaweed bioactive compound, seaweed incorporated semi-seaweed biscuits (Fig.9) and noodles are a few novel products developed in this line by ICAR-CIFT.

Fish nutritional bars: The new life styles of consumers add to the requirement of new health foods and nutritional energy supplements, in pleasing and portable way. Modern market, have gained a more attraction towards the convenient type nutritional bars/ energy bars/ protein bars in various forms and wide varieties can be made on the basis of different consumer requirement of health food, diet replacer, work out food, energy supplement, geriatric food, sugar free product and nutrient requirement for children. Globally, this trend is being driven by growing consumer awareness about better nutrition in physical performance and personal appearance. ICAR-CIFT has standardized some formulations for nutritional bars added with the best quality supplements from fish source. The protein from fish has been regarded as the high quality with well-balanced amino acid profile, that is easily digestible than any mammalian counter parts. ICAR-CIFT has developed a nutrient formulation with cereal mixes, dried fruits fortified with different biomolecules like high profile fish protein/ collagen peptide/ omega-3 oil in crunchy type granola bars with good shelf stability. Fortification of 10-15% fish protein alone and provide an average energy of 400 Kcal/100g was achieved (Fig.10).

Processed fish roe and caviar substitutes: Fish roes, which form a major component of process discards, are nutritionally valuable sources of omega-3 fatty acids and essential amino acids. Generally, the roe obtained during dressing of fish is either discarded or sold at very low price as it forms a jelly mass during cooking. However, the roe mass may be spray dried using a suitable stabiliser like gum Arabic and the powder can be added to a wide range of foods without affecting the sensory characteristics of the products. Besides the commercially available roe from sturgeon, salmon and cod, fish caviar substitute from fresh water carp roe reconstituted with suitable gelling agents such as sodium alginate will have a greater potential as fish caviar substitutes.

Miscellaneous products: A variety of products like fish sauce, fish salad, fish pickles, frozen whelk, squid fillet, shrimp skewer, stuffed squid with shrimp etc. have fairly good movement in domestic and foreign market. Canned crab, chilled pasteurised crab, crab cut, frozen 'snap and eat' legs are some of the crab based products available in the market. Identifying live crab exports as a money spinner, the Indian seafood industry is all set to rear mangrove crabs, so as to scale up the export of the crustacean that commands high price in the global market.

High value byproducts - Wealth from waste : Nearly 70-80% of the total weight of fish catch is generally discarded as bycatchor processing waste. Global fish waste generation is estimated to be in excess of 75 MMT and in the Indian scenario it is >4 MMT. It is estimated that fish processing waste after filleting accounts for approximately 75% of the total fish weight. About 30% of the total fish weight remains as waste in the form of skins and bones during preparation of fish fillets. Bio-conversion of these wastes is an environmental friendly and profitable option for the utilisation of fish waste. Some viable options for generating wealth from waste are detailed below.

Fish meal: Fish meal is highly concentrated nutritious feed supplement consisting of high quality protein, minerals, vitamins of B group and other vitamins and other unknown growth factors. Fish meal is rich in essential amino acids. It is produced by cooking, pressing, drying and grinding the fish, bycatch fish, and miscellaneous fish, filleting waste, waste from canneries and waste from various other processing operations. The composition of fish meal differs considerably due to the variations in the raw material used and the processing methods and conditions. Better quality fish meal has been a prominent item of export from the very beginning of this industry. BIS has brought out the specification for fish meal as livestock feed for facilitating proper quality control. The proximate composition of fish meal, in general, is protein, 50-60%; fat,5-10%; ash, 12-35% and moisture, 6-10% employed. Around 15% of the global fish meal demand is met from fisheries resources alone. The projected (2030) annual growth rate in fishmeal use in aquaculture is 1.7%, where the current usage is at a tune of 3.9%. The recent development in captive breeding and rearing high value species such as cobia, grouper, pompano, Nile tilapia, lobster, Asian seabass etc. implies that there is a good scope for flourishing finfish and shellfish production through aquaculture in near future. This in turn highlights the bright future of fish meal industry in coming years, as most of these species demand high protein feeds for their optimum growth.

Fish protein hydrolysate: Hydrolysates find application as milk replace and food flavouring. Enzymes like papain, ficin, trypsin, bromelein and pancreatin are used for hydrolysis. The process consists of chopping, mincing, cooking and cooling to the desired temperature, hydrolysis, sieving, pasteurizing the liquid, concentrating and drying (by vacuum or spray drying). The fish protein hydrolysate have desirable functional properties with potential applications as emulsifiers and binder agents; and can used in place of diary based and plant based protein hydrolysates as well as protein powders currently available in market place. The peptides formed by the hydrolysis of fish proteins are proven to have bioactive properties like antihypertensive, antithrombotic, immune modulatory and antioxidative properties. Also, they are good source of nutritional and functional properties. A variety of nutraceuticals from FPH are commercially produced and are available in international markets. Oyster peptide extract developed by ICAR-CIFT possessed antioxidant and anti-inflammatory activities. Similarly, hydrolysate made from squilla meat effectively reduced oil absorption in breaded and battered products, when incorporated in the batter mix.

Fish collagen/gelatin/collagen peptides: Collagen is the major structural protein in the connective tissue. Collagen extracted from fishes can be used in cosmetics, foods, biomedical applications etc. ICAR-CIFT has developed the method for the preparation of absorbable surgical sutures from fish gut. Gelatin is the hydrolysed form of collagen with applications in development of bio degradable packaging, food and pharmaceuticals. Both collagen and gelatin are high molecular weight proteins of approximately 300 kDa, hence a considerable proportion is unavailable to human body for biological functions. Consequently, in recent years, much attention has been paid to the development of small molecular weight peptides from the native collagen with improved biological activities. This can be achieved by the process of hydrolysis in which the native collagen/gelatin molecules are cleaved to small fragments of less than 5 kDa. Currently, collagen peptides are being incorporated in a wide array of food products including protein bars, cereal bars, protein drinks, smoothies, yogurts, cold desserts, soups, cured meats etc. Nowadays, collagen/gelatin peptides have gained increasing attention as these peptides exhibit various biological activities such as antioxidant, anti-hypertensive, anti-human immunodeficiency virus, anti-proliferative, anticoagulant, calcium-binding, anti-obesity, anti-diabetic activities and postponement of age-related diseases. ICAR-CIFT has standardised a protocol for the extraction of collagen peptide from fish scale and bone (Fig.11). Further a nutritional mix based on collagen peptides was developedwith a protein content of 78%. The product is mainly intended for middle aged and old people, ladies and sports-persons who needs a regular supply of collagen for healthy joints and bones. It may also be beneficial for patients suffering from osteoporosis and long-term-nursing home residents where there is a possibility of development of pressure ulcers.

Chitin: The shrimp processing industry in India churns out more than 2 lakh tones of head and shell waste per annum, which can be economically converted to chitin and its derivatives. Chitin is the most abundant polymer next to cellulose. It is a linear polymer of N acetyl-D-glucosamine. Glucosamine hydrochloride can be produced from chitin by hydrolysis. Glucosamine hydrochloride and sulphate are at present marketed as food supplement for the treatment of osteoarthritis. It also possesses other beneficial actions in wound healing and skin moisturization. The deacetylated chitin is known as chitosan. Chitin and chitosan have various applications in agriculture such as in germination of seeds and enhanced protection against pathogenic organisms in plants and suppress them in soil to induce chitinase activity and protenase inhibition, antivirus activity, in micro encapsulationfertilizersandinsecticides. The delivery of drugs and the interactions with living tissues seem to be the major topics of current research on chitosan. Other areas of interest are the antimicrobial action, nerve regeneration, cartilage and bone regeneration, skin and bone substitutes, oral delivery for wound healing etc. Carboxy methylation of chitosan imparts water-solubility to chitosan. ICAR-CIFT has recently standardised the methodology for production of chitin, glucosamine hydrochloride, chitosan and carboxymethyl chitosan. Similarly, collagen-chitosan film from fish waste, developed by the Institute has wide applications in wound dressing and dental surgery.The antioxidant chitosan derivative developed was found to be useful in micro-encapsulating vitamins and ß carotene, so as to give a novel delivery system. Similarly, a biocompatible and biodegradable wound healing formulation, composed of microencapsulated curcumin and hydrogel composite (Succinyl chitosan-fish collagen-poly ethylene glycol) developed at ICAR-CIFT, showed significantly enhanced rate of collagen deposition and hydroxyproline content in wound tissue on 14th day of post wounding as compared to control and standard. Apart from that, free radical mediated grafting of gallic acid, ferulic acid, vanillic acid and coumaric acid onto chitosan were optimised. All the derivatives showed good antioxidant and antimicrobial activities.

Fish ensilage and foliar spray: When the animal farms are very near to fish landing centres it is worthwhile to go for silage production. Fish silage is made from whole fish or parts of the fish to which no other material has been added other than an acid and in which liquefaction of the fish is brought about by enzymes already present in the fish. The product is a stable liquid with a malty odour which has very good storage characteristics and contains all the water present in the original material. It is a simple process and it requires little capital equipment particularly if non-oily fish are used. The use of oily fish usually requires oil separation. This involves expensive equipment and is suited to a fairly large-scale operation. The silage may be suitable converted to foliar spray, as foliar feeding is an effective method for correcting soil deficiencies and overcoming the soils inability to transfer nutrients to the plant. The experiments conducted at ICAR-CIFT have shown that foliar feeding can be 8 to 10 times more effective than soil feeding and up to 90 percent of foliar fed nutrients. The application of foliar spray has been advocated in spices like cardamom, black pepper, tea etc and encouraging results have been reported. The quick absorption of the nutrients and precise dosage of foliar sprays has resulted in the success of precision farming of costly vegetables and flowering plants. The controlled nutritional supply through praying is an effective method which gives predicted resulted in most of the cases. The optimized supply of required micro and macro nutrients results in the maximum productivity of the available space and minimizes the wastage of costly inputs.

Fish calcium: In marine ecosystem, there is a large amount of calcium, mainly in the form of calcium carbonate and calcium phosphate, distributed as skeletal elements of teleosts, exoskeletal elements of molluscs or as coral deposits. Every year a considerable amount of total fish catch is discarded as processing left overs and these include trimmings, fins, frames, heads, skin and viscera The bone fraction, which comprises approximately 15-20% of the total body weight of fish has high calcium content. Calcium and phosphorus comprise about 2% (20 g/kg dry weight) of the whole fish. Generally, fatty fish have lower ash levels compared to lean species. The filleting wastes of tuna and other bigger fishes are very good sources for calcium when the quantity of calcium is concerned. Also, the bone structure differs between species since a large number of teleosts have acellular bone (bone without enclosed osteocytes). Cellular bones are confined to only a few fish groups, e.g. Salmonidae. The higher surface to volume ratio in acellular fish bone is likely to increase the calcium availability compared to cellular bone. The ash content is highest in lean fish species with acellular bones. Apart from that exoskeleton of mollusks and coral deposits are excellent source of calcium. However, the calcium form these deposits are mainly in the form of calcium carbonate. Central Institute of Fisheries Technology, Cochin has optimised the process to extract from fish bone which is mainly treated as processing discards during filleting operation of larger fishes, *viz* tuna, carps etc. The calcium powder was supplemented with vitamin D which is known to enhance absorption and bioavailability of calcium in the body. *In vivo* studies conducted at ICAR-CIFT in albino rats have shown that fish calcium powder supplemented with vitamin D has improved the absorption and bioavailability.

Chondroitin Sulphate: Chondroitin sulphate obtained from shark cartilage is used for the treatment of arthritis. It is part of a large protein molecule (proteoglycan) that gives cartilage elasticity.

Squalene: Squalene is a highly unsaturated hydrocarbon present in the liver oil of certain species of deep sea sharks mainly *Centrophorus* and *Squalidae*spp. The liver oil of these species contain high percentage of squalene (90%) which can be isolated and purified and can be used as a dietary supplement. It belongs to a class of antioxidant molecules called isoprenoids. Squalene is found to be a proficient chemo preventive agent against lung metastasis in mice bearing lung carcinoma. Squalene revives damaged body cells and aids to revitalize cell generation. Its chief attribute is the protection of cells from oxidation reactions. Squalene assists to clean, purify, and detoxify the blood from toxins, facilitating systemic circulation. It purifies the gastrointestinal tract and kidneys, causes better bowel movement and urination. Squlalene helps in regulating the female menstrual cycle and also improves irregular and abnormal cycles. ICAR-CIFT has standardized the protocol for extracting squalene from shark liver oil.

Hydroxyapatite (HAp): Hydroxyapatite is the major mineral component of bone tissue and teeth, with the chemical formula of $Ca_{10}(PO4)_6(OH)_2$. The composition Hap derives from biological sources differs from that of synthetic hydroxyapatite, due to the presence of several ionic substitutions in the lattice, such as CO_3, F, Mg^{2+} and Na^+. It is a member of the calcium phosphate group with 1.67 stoichiometric of Ca/P ratio. It is one of the few materials, classified as a bioactive biomaterial that supports bone in growth and osseointegration when used in orthopedic, dental and maxillofacial applications. Fish bone and scale is a rich source of hydroxyapatite. The hydroxyapatite content of fish skeleton may vary between 40-60%. Generally, very high heat treatment is used for extraction of HAp from bone and this temperature gives a higher strength to HAp structure. The high temperature also burns away any organic molecules such as collagen protein. Hydroxyapatite, found in fish is chemically similar to mineral components of bone and hard tissues in mammals. Approximately, 65-70% of the fish bone is composed of inorganic substances. Almost all these inorganic substances are hydroxyapatite composed of calcium, phosphorous, oxygen and hydrogen.

Pigments: Astaxanthin, fucaxanthin, melanin etc. from different fish resources are found to have a variety of bioactive properties. The filleting discards of salmonids and the shell wastes of crustaceans contain significant amounts of carotenoid pigments such as astaxanthin and canthaxanthin. The protective role of carotenoids against the oxidative modification of LDL cholesterol could be explored by incorporating in health drinks. Carotenoids are also highly sought after as natural food colours. Cephalopod ink is another less tapped reservoir of a range of bioactives having therapeutic and curative values. It is an intermixture of black pigment melanin, glycosaminoglycans, proteins, lipids, and various minerals. Cephalopod ink has been reported to have anti-radiation activity, antitumor activity, immune-modulatory activity, procoagulant function and so on.The pigment melanin can be used both as a natural colorant as well as antioxidant, in addition to a number of other therapeutic and prophylactic properties including anticancer, antihypertensive, anti IDA etc.

ICAR-CIFT in quality assurance of post harvest fisheries sector of India

As fish is a food commodity that has been traded across the world, there is lot of research and development activities carried out by ICAR-CIFT on the quality and safety of fish and fishery products. For ensuring quality and safety of seafood, the Indian Council of Agricultural Research set up an independent division in 1996 for taking up research, consultancy, training and analytical services in seafood quality assurance. ICAR-CIFT has proved itsexpertise in areas such as seafood quality assurance, food safety, sanitation and hygiene in fish processing establishments, production and evaluation of process water and ice, modern quality management programmes such as HACCP, ISO 22000 and regulatory requirements *viz*., EU regulations, Codex/IS/ISO standards etc. ICAR-CIFT is involved in the Assessment Panel of Experts (APE) and Supervisory Audit Team (SAT) for establishing quality regime in fish and fish based products. Also ICAR-CIFT humbly takes the credit of implementing HACCP in India for the first time in the early 1990s. Some of the salient research activates include microbiological interventions, development of methods for chemical contaminants, different package of practices based on HACCP, withdrawal period of antibiotics, challenge studies of different food borne pathogens, quality index schemes, different chemical hazards, antimicrobial property of phytochemicals etc. ICAR-CIFT is actively involved in developing and implementing an energy efficient effluent treatment plant for the fish processing units within the state and outside.The institute is also providing consultancy in the design, development and getting accreditation as per ISO/IEC 17025:2005. ICAR-CIFT has proudly contributed to the development of standards and the recent one is development of four standards for International Standards Organizations (ISO) for the traceability of both wild and cultured Molluscs and Crustacean. CIFT has taken accreditation as per ISO/IEC 17025:2005 in 2005 and has been doing service to the industry and the needy. The institute has accredited for more than 120 parameters in chemical, microbiological and mechanical areas. The institute is also identified as the quarantine centre for fish and fishery products, for DADF, Ministry of Agriculture.

Conclusion

Fisheries is considered as a sunrise sector in India due to its recent renaissance and growth potential. The technological advancements in the harvest and post-harvestsectorcatalysed by the mechanization of fishing crafts and modern electronic technologies for navigation and fish location, along with energy efficient processing aids, offer good scope for the development of sector. Product diversification, promoting more public-private partnerships, creating more awareness on quality assurance throughout the value chain, taking initiatives for increased infrastructure facilities for market development, awareness creation on responsible and sustainable fishing practices etc. are crucial steps towards achieving ‘blue revolution’.

Fig.1. Rubber wood canoe Fig.2. Solar-powered boat useful for aquaculture etc

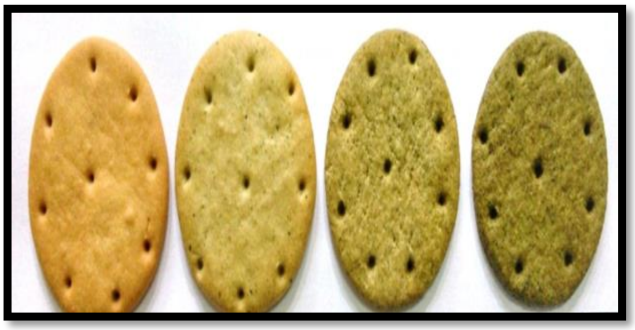
Fig.3.Sagar Haritha': Energy efficient green fishing vessel

Fig.4. Solar dyer

Fig.5. High pressure processing unit Fig.6. Pulse light processing unit

Fig.7. Fish curry in retortable pouches

Fig.8. Extruded fish snack



Nutritional bar developed by ICAR-CIFT

Seaweed enriched biscuits developed at ICAR-CIFT

Fig.11.Collagen peptide from fish scale and Nutritional mix formulated by CIFT

Chapter 2

Novel Extension Approaches for Technology Dissemination in Fisheries

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Trends in aquaculture and fisheries

Global fisheries have made rapid strides in recent years by establishing its strong hold over increasing food supply, generating job opportunities, raising nutritional level and earning foreign exchanges. These benefits become more important when placed in the context of current challenges in food production, nutritional security, social transitions and growing climate uncertainties. Fish and fishery products are the most traded food commodities in the world accounting for 1% of world merchandise trade in value terms representing more than 9% of total agricultural exports all over world (FAO, 2014). About 38% of the global fish production enters international trade in various forms and shapes, generating an export earning of nearly US$148.1billion with a record import at US$140.6 billion during 2014. Mostly the developing countries that account for over 60% of global fish catch, which has continued to expand at an average annual rate of 8.8%(FAO, 2009 & 2012)andplay a major role in the global trade of fish and fish products contributing around 50% of fishery exports in value terms and more than 60% in quantity terms supplied by them (World Bank, 2011). At the same time, demand for fish products are likely to rise as a result of rising populations that are expected to reach 9.3 billion by 2050.Developing countries have a positive trade balance due to their increasing involvement in global fisheries trade.Developing country like Indiamay have higher proportion of population growth but its impressive economic growth over the past two decades has resulted in steady increase in per capita income in real terms that in turn increases the purchasing power of people resulting in increasing demand for food to feed & ensure nutritional security of the population. As a result of which it brought inconsistency in fish consumption pattern across the coastal, marine and hill region.

It is estimated that fish production generally contributes 0.5 – 2.5 % of GDP globally (Allison 2011). In spite of that globally an estimated population of more than 1.3 billion people are in extreme poverty (2016), 795 million people (2015-16) are estimated to be in chronic hunger and an estimated one third of children in the developing world under five years of age are stunted (Conway 2012). Fish is considered as the most affordable and frequently consumed animal-source food in low income food deficit countries in sub-Saharan Africa, Latin America and Asia (World Bank,2006).It is an important source of a wide range of intrinsic micronutrients, minerals and fatty

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acids. It accounts for about 17 % of most affordable, easily digestible, high-quality animal protein and 6.7 % of all protein, all essential amino acids, essential fats (e.g. omega-3 fatty acids), vitamins and mineralsthus contributing to a great extent to food and nutrition security in many Asian and African countries where large proportion of population are still in hunger and under nourished (Kent,1987). Besides small-sized fish species are excellent source of many essential minerals such as iodine, selenium, zinc, iron, calcium, phosphorus, potassium, and vitamins such as A, D and B. About 150 g of fish provides about 50–60 % of daily protein requirements for an adult. On an average, fish provides about 20–30 kilocalories per person per day. In addition, dietary diversity of the region is mainly influenced by different quantitative and qualitative attributes viz., income, price, preference, market, type and quality of products, cultural traditions, beliefs as well as various geographical, environmental, social and economic factors that influences the fish consumption pattern. Despite the significant contributions by the sunrise sector, global debates on fisheries issues and policies appear to be dominated by concerns over environmental sustainability, overfishing and overcapacity. In this context, it is alarming to note that the sector has not received adequate attention from the social scientists to understand its various socio-economic dynamics to prove the sunrise sector as a potential driver of local and national economic development.

Major concerns in fisheries

Food security has become the prime concern with the increasing trend of population growth in a country. Over the last fifty years, the foodgrain production in India has increased considerably, but the advantage of this increase in foodgrain production has not beenreflected in the percapita availability of food grains. As per estimate, the human population and food grain production in India has grown up by 2.09% and 2.36%, respectively from 1961 to 2011, whereas the annual per capita availability of food grains has come down from 171.1 kg in 1961 to a level of 169 kg in 2011 showing a decreasing trend of 1.17 %. In case of fish, Asia accounts for almost two-thirds of global fish consumption i.e. 21.4 kg per capita per year in 2011 – a level similar to Europe (22.0 kg/cap/yr) and North America (21.7 kg/cap/yr), and close to the levels of Oceania (25.1 kg/cap/yr), whereas Africa, Latin America and Near-East have lowest per-capita consumption (10.4, 9.9 and 9.3 kg/cap/yr in 2011, respectively). Although annual per capita apparent consumption of fish products has grown steadily in developing regions (from 5.2 kg in 1961 to 17.9 kg in 2011) and in Low Income Food Deficit Countries (LIFDCs) that increases from 4.4 kg in 1961 to 8.6 kg in 2011, it is still considerably lower than in developed regions (from 17.1 kg in 1961 to 23.0 kg in 2011). It is clearly evident that rising population is nullifying the effect of growth in food grain production, keeping aside several other factors which determine the access to food grains.In this context, increasing fish production to meet the challenges of nutritional security has drawn the attention of the planners and policy makers. Hence, aquaculture is considered as a promising food production sector for high quality protein food and providing livelihood to the rural populace, which needs to be more efficient and cost-effective. However, there is multitude of challenges associated with the growth of this industry.

The fishery sector is a major foreign exchange earner for any developing countries. In India, its foreign exchange earnings were estimated to increase by 16 to 20 per cent in 2005 and 26 to 42 per cent by 2015. Nearly 85 per cent of the export benefits are projected from shrimp export alone. Because of its potential and rich source of animal protein, fish demand has been rising in both the developed and developing world at more than 2.5 percent per year (Peterson and Fronc, 2007) and demand levels were raised in proportion to increase in income in highly populated countries like China and India, (Garcia and Rosenberg, 2010).In view of higher production in fisheries, producers may lose from price fall in the domestic market; where prices were estimated to fall by 15 to 20 per cent by 2005 and 27 to 54 per cent by 2015. In spite of the phenomenal success of the sector, still there are some major issues related to the economic and nutritional conditions of fisher folk in addition to some important concerns in the context of rising environmental hazards, depressing prices world over, emerging new economic challenges following establishment of WTO, IPR & SPS issues, compliance of several multilateral agreements, etc. In the post- harvest front, the processing industriesface multifarious problems like complicated exporting procedures, high shipping costs, cut-throat competition in the industry, changing quality standards of importing countries, irregularity in supply of raw materials, hygiene problems and non-availability of quick transportation facilities from the fishing port to the processing units, etc. As a result of which trade-driven commercial fish farming is suffered that reduces the livelihood opportunities of small scale dry fish processors, petty traders within the communities of poor fishermen.

Environmental degradation poses a challenge to the phenomenal success of the fishery sector in promoting food security and adversely creates impact on nutritional rights and livelihood status of the fishermen communities for whom fish and fishery products are critical for their health benefit and wellbeing. As per directives of international conventions like Kyoto Declaration and Code of Conduct of Responsible Fisheries, this trade-driven, resource depletion sector can be sustained through by-catch reduction and juvenile fishingban. The benefit of this may be accrued through policy level intervention by institutions within the legal framework.

Small-scale fisheries are normally characterized by low capital input activities, low capital investments, lack of equipment and labor-intensive operations followed by traditional fishers. They also usually operate as semi-subsistence, family-based enterprises, where a share of the production is kept for self-consumption (Garcia *et al.*, 2008). Traditional fishers dominate the marine sector and they are socially deprived, educationally weak with very high occupational rigidity. There is inequity in the distribution of yield and effort in marine fishing in case of traditional fishing communities. They are unorganized with least social security. The informal social security system in the form of sharing of earnings among the community prevailing in the traditional fishing is hardly seen in the mechanized fishing. There are also huge regional variations in productivity among them.

Technologies are the main drivers of growth. Hence, systematic technological interventions backed by appropriate policy and institutional support are vital for making the aquaculture operations sustainable and economical. Generally, the technologies and trade interventions reinforce each other which can be characterized as skill-based, cost effective, capital intensive which can bring a change in the performance of the sector. Keeping eye upon this, following strategies have been suggested for an accelerated fishery development with focus on poverty alleviation of poor fishers:

- Commodity-centered approach
- System approach
- Prioritize technology on the basis of needs and problems at micro and macro levels
- Skill development/upgradation of the fishers
- Monitoring the technology demonstrations programs and assess the impacts.
- Innovate and strengthen institutions and policies
- Enhance investment and reorient policies to facilitate percolation of benefits to all sections of the society.
- Follow ecological principles
- Emphasize on domestic market demand and consumers' preferences
- Strengthen database and share it for a better planning and policy making inthe sector.

Extension systems for sustainable development

Unlike India, the economy of developing and underdeveloped countries in sub Saharan Africa, Latin America, Asia inclusive of 22 Low Income Food Deficit Countries (LIFDCs) is predominantly agrarian economy, where agriculture inclusive of fisheries provides employment and livelihood to majority of the rural households, but the condition of both farmers/fishers and farming is in alarming state. Hence, there is an urgent need to reform that agriculture allied sectors inholistic, scientific and systematic approach to meet the recent challenges due to climate change and global competitiveness so as to achieve sustainable production and growth under different agro-climatic conditions.

As per the report of world commission on Environment and Development (1987), sustainable development meets the needs of the present generation without compromising the ability of future generation to meet their requirements. The FAO committee on Fisheries (1991) defines sustainable development more elaborately as the management and conservation of national resource base and the orientation of technological and institutional intervention to ensure the attainment of human needs for present and future generation including fulfilment of social and economic demands and conserving the natural resource base. In response to that FAO developed a code of conduct for Responsible Fisheries (FAO,1995) that provides principles and guidelines for ensuring sustainable exploitation of marine resources.Sustainable fisheries can be possible through responsible fishery, which envisages rational fishery management that address a range of issues dealing with resource status, environmental health, post-harvest technology, trade and export, socio-economic benefits, legal and administrative support.Sustainable agricultural systems must be resource-conserving, socially supportive, commercially competitive, and environmentally sound. Hence, the agriculture research system must place emphasis on generation of resource conservation technology (RCT)along with strong forward-backward linkage between research-extension system. It involves design and management procedures that work with natural processes to conserve all resources, promote ecosystem resilience and self-regulation, minimize waste and environmental damage, while maintaining or improving farm productivity and profitability (MacRae et al., 1990).

The role of extension in fisheries cannot be ignored. Strong extension system is the key to bring the desired changes to meet the presentday challenges related to sustainable fisheries. Basically, the end product of the fisheries extension system is to work with fisheries within an agro-climate and economic environment by providing suitable technologies to enrich knowledge and upgrade skills to improve better handling of natural fish resources and applying the cutting-edge technologies to achieve desired production level. Extension system plays a pivotal role in empowering fishers and other stakeholders to make fish farming more participatory, demand-driven, knowledge intensive and skill supportive for disseminating most appropriate technical, management and marketing skill to improve profitability in fisheries that can overcome the emerging challenges and concern, thus developing a synergistic pathway for enhancing productivity along with quality produce in order to sustain production base and ensure ecological and livelihood security. The extension system needs to disseminate a broad array of information starting from farm to fork in an integrated manner for safe delivery from field to the consumer considering all the aspects of conservation and production technologies, post-harvest management, processing and value addition. Such knowledge based decision should be incorporated in reshaping of extension approaches. In present scenario, the extension system envisages a transformation from technology driven to market driven extension, where fishers would give emphasis on commercialization of fish and fish based products, maintenance of quality, fulfilling consumers' demands, etc., in the program planning process for the effectiveness of any extension programme.

Further, with the advent of global competitiveness and market liberalization, our prevailing extension system has to be strengthened with innovative extension approaches to tacklethe recent challenges in fisheries *viz.*, climate change, weather aberrations, dwindling resources and quality and safety of products; so that fishers can adjust their production portfolio keeping eye upon the emerging trends in food consumerism in domestic as well as global markets. Grooming fishers with proper information supportfor taking right decision related to fish production essentially requires a strong network of extension systems, supported with government initiatives and strong linkage among extension scientists and functionaries working for fishery sector development. This would ensure the livelihood security of millions of fisher communities by improvingthe quality production and creating better job opportunities,which intends to bring out planned changes to meet the needs of the present generation without compromising the future generation's requirements.

Innovative extension approaches for technology dissemination in fisheries

Earlier in developing countries, the extension personnel were involved in diffusion of farm technologies generated by public research organizations, mostly disseminated through appropriate mechanism, viz., On Farm Trials (OFT), frontline demonstrations (FLD), field visits, fishers' meetings, media use, etc. This process had the conceptual backup from the 'diffusion of innovation' model. But in the last two decades, the paradigm shifts in development pivots to the enhanced concern for future generations to meet their basic needs, accordingly the nature, design and integration of fisheries technologies are drawing attention of the extension professionals and practitioners across the globe. In India, different models for transfer of technology have been tested and some robust extension approaches have been validated. Furthermore, the frontline extension system of the country has been revisited and sharpened through fishersoriented approaches for technology adaptation and dissemination. The extension system in India has been designed to move beyond technology and beyond commodity through reciprocal fishers-research-extension linkages. Fish farmersstill suffer from lack of access to appropriate services like credit, inputs, market, extension, technologies etc. Keeping eye upon this, the World Development Report has focused on need to restructure and revamp agricultural extension system as a tool for realizing the growth potential of farm sector against the widening demand–supply pressures for ensuring sustainable fisheries, inclusive, pro-poor socio-economic development. Therefore,participatory technology development and participatory extension approaches emerged as a part of integration ofthe '*interdependence model*' and the '*innovation systems framework*' that offered more inclusive ways of involving the institution in technology generation, customization and diffusion. Extension approaches have to be redefined depending upon the components involved for sustainable growth and livelihood security of the farmers for which a conceptual framework has to be developed in response to recognizing and considering different livelihood assets viz., *human, social, physical, natural and financial resources*. Some of the following innovative extension approachesoriginating from multiple sources must be adopted on trial basis to make fisheries more lucrativeand sustainablewhich can be replicated in the fishery sector interwoven with numerous challengeslike increased production with sustained natural resources, growing market demand for processed products having entrepreneurial opportunities, protection and conservation of environment, and promoting international trade.

An analysis of national extension systems in the Asia and Pacific region by Qamar (2006)observes that agricultural extension is undergoing a major transformation as a result of failure of public extension systems perceived to be outdated in the context of globalization, decentralization, and information technology revolution. Extension systems in many developing countries are undergoing a paradigm shift to more fishers -oriented approaches based on rural innovation that emphasize the importance of interactive, integrated and multidisciplinary oriented mutual learning between formal and informal knowledge systems(Friederichsen, 2009).

a. Asset Based Community Development (ABCD) approach

As per the traditional approach to development, poor people see themselves as people with special needs that can only be met by outside supporting agencies. But Asset Based Community Development (ABCD) approachintends for the development of community based on the principle of identifying and mobilizing individual and community 'assets', rather than focusing on problems and needs.It is an extension approach in which a community's micro-assets are linked with its macro environment. It believes that communities can initiate and sustain the process of growth and development themselves by recognizing and harnessing the existing, but often unrecognized assets, and thereby promoting local economic potential to drive its development process (Rans & Green, 2005). The approach is optimistic in nature, because the focus is on *'what is possessed by the community, rather than the problems of the community."*

The focal point in this approach is asset and not the need of the community. Assets of individuals, associations and institutions are identified after an extensive survey and assets are then matched with the need of the people to empower communities to control their futures and create tangible resources such as services, funds and infrastructures etc.*(Foot and Hopkins, 2010.* In fishery, ABCD approach gives greater emphasis on reducing the use of external inputs and on a high degree of social mobilization in which the assets of the poor (*social, physical, financial as well as human*) can be utilized to bring sustainable livelihoods in fisheries through number of different fishery related activities.

Five Key Assets in ABCD

As per ABCD approach there are 5 categories of asset inventories such as individuals, associations, institutions, physical assets and connections

1. **Individuals**: Every individual has got certain assets, gifts and qualities; such individual is at the center of ABCD approach.
2. **Associations**: Groups of people working with a common interest are critical to community mobilization.
3. **Institutions**: The assets of institutions help the community capture valuable resources and establish a sense of civic responsibility.
4. **Physical Assets**: Physical assets such as land, buildings, space, and funds are other assets that can be used.
5. **Connections:**These are the exchange between people sharing their assets by various methods.

b. Rural advisory services (RAS)

Rural Advisory Services (RAS) refer to all the different activities that provide the information and services needed and demanded by farmers and other actors in rural settings, to assist them in providing their livelihoods by developing their technical, organizational and management skills and practices (GFRAS, 2011; FAO, 2010). RAS designers and implementers must recognize the diversity of actors in extension and advisory fields (public, private, civil society); the need for extending support to farmers' producer organizations (FPO) and rural communities (beyond technology and information sharing) including advice related to farm, organizational and business management; and explaining the role of facilitation and brokerage in rural development and value chains. In the case of aquaculture, large-, medium- and small-scale fishers need different types of RAS support. The large aquaculture farms are mostly self-reliant and need only regulatory support, while medium-sized farms need mobilization and facilitation support in addition to regulatory support. Small aquaculture farms need more education and input provision alongside facilitation (Kumaran, 2014).Timely sharing of research recommendations can address the problem of disseminating information to fishers. In this direction, innovative strategies are being formulated keeping the fishers' needs and capacities in mind to pass on appropriate technologies by combining Internet, telecommunications, video, and print technologies that may bridge the information gap and empower fishers to make better production and marketing decisions (McLaren et al. 2009).

In fishery sector, RAS helps in

- ⇨ Providing management and business development support appropriate to the scale, resources and capacities of each fisherman.
- ⇨ Better understanding markets (prices, products, seasonality, standards, value addition etc.) related to fish and fish products.
- ⇨ Linking fishers to other stakeholders involved in provision of varied support and services.
- ⇨ Creating platforms to facilitate interaction and sharing among the various stakeholders including FPOs to ensure coordinated support to fishers.
- ⇨ Exploiting information communication technologies (ICTs) to provide fishers with a range of information related to weather, prices, extension programmes and generic information regarding fisheries.
- ⇨ Facilitating the formation of FPOs and also collaborate with FPOs to strengthen the demand and supply side of RAS.
- ⇨ Promoting institutional and policy change to enable and support small-scale fishery.

RAS encourages the formation/ organisation of groups by involving individual fishers, who have little influence over the social, economic and political processes affecting them, but as a group/ organizations and networks they can deal with their specific challenges and make their voice heard. Such groupings can act as platforms to articulate concerns, exchange knowledge, influence policies and engage in collective action so that their agriculture remains sustainable and profitable. Effective formation of Rural Resource Centres (RRCs), Fishermen Cooperative Society, Farmers producers Organisations(FPOs) can be instrumental by galvanizing collective action in order to ensure better access to markets and to support innovation by their members in related activities (Sundaram, 2014).

c. Model Village System of Extension (MVSE) approach

MVSE is an integrated and holistic extension approach where *community participation*is prioritized for suitable technological interventions in the fisheries to bring all-round development in fisheries sector in terms of *socio-economic upliftment, technological empowerment, self-governance*thereby enhancing the futuristic knowledge base and skills through *participatory framework.* MVSE emphasizes oninvolvement of all stakeholders in the process to converge their activities with a stake in the food value chain *linking producer to consumer*. Nevertheless, MVSE is an action research taken up in fishers' farm based on the principle of leveraging the activities, investments and resources from outside agencies/ externally aided projects resulting higher productivity, ensuring food security and sustainable improvement in overall quality of life by promoting leadership, self-dependency of the community in food chain.Economically viable, ecologically compatible and socially acceptable suitable technologies are successfully intervened in a cluster approach through participatory mode by integrating the multi-disciplinary research. The cluster of villages is adopted as model village, the success of which is later replicated to other villages. The village is developed as a commodity village branding for a particular commodity in the market.

MVSE approach works on the following principles:

- Promotes self -governance among the fishers
- Skill improvement and leadership development among the fishing community.
- Establishing linkage through pluralistic convergence of various stakeholders associated in the sector.
- Encouraging the market opportunities through commodity based village development (CBVD).

d. Farmers Field School (FFS) approach

The FFS extension approach is an alternative to the top down extension approach which was evolved as a method to solve complex field level issues in fisheries sectors. FFSaims to build fishers' capacity to analyze their production systems, identify problems, test possible solutions, and eventually encourage the participantmember to adopt the practices most suitable to their farming systems (FAO, 2003 c). This is a learning-by-doing approach which emphasizes group observation, discussion, dissection, modification, and promotes field-based experimentation, analysis for collective decision making followed by actions. The FFS approach is an innovative, participatory and interactive learning approach that emphasizes problem solving and discovery based learning. FFS also provides an opportunity to fishers to practice and evaluate sustainable resource use technologies, and adoption of new technologies by comparing with their conventional technologies developed in congruent with their own tradition, culture and resource use pattern.The goal of FFS approach is such that, after observing and comparing the results of field level experimentation fishers will eventually "own" and adopt improved practices by themselves sidelining the conventional ones without any external compulsion. Field day is being organized at the end of the season to give visibility to the entire activities to convince the non-adopters. Exchange visits with other FFS is also encouraged to learn by association and comparison A group of 20-25 fishers can form a Farm School under the guidance of a FFS facilitator. Extension workers, NGO workers, fishermen co-op members or previously trained fishers can become Farmer Field School (FFS) facilitators. The facilitators are trained by master trainers, who have expertise in the particular subject matter. FFS is a time bound activity usually covering one production cycle or a year.

It is also significant to note that irrespective of the merits of the technology, the acceptance to technologies is influenced by the extension method. Farmer Field School (FFS) model has been accepted as a good methodology because it is exclusively participatory. A special feature of this extension approach was that it reached poor and female-headed households and lower-caste households much better than the regular extension services (Tiwari et al. 2010). FFS was also found to be effective in avoiding barriers like socio- economic constraints, infrastructure problem and incompatibility of technology for the adoption of sustainable fishery practices.The basic component of FFS is setting up of a Participatory Comparative Experiment (PCE), commonly referred to as Participatory Technology Development (PTD), whereby the fishers put the FFS concept into practice under close monitoring and supervision by the FFS members. A PCE can be developed in the field of agriculture, livestock, fishery, forestry, agro-forestry, livelihood system and others.

Principles of Farmer Field School(FFS)are as follows: -

- Field is the learning place.
- Emphasizes hands on and discovery based learning.
- Farmers become experts.
- Integrated and learner defined curriculum.
- Doing is better than learning/ seeing.
- Experiences are the start of all learning.
- Link to actual field situations and should be relevant to local needs and problems.
- Participatory monitoring and evaluation.
- Fishermen are decisionmakers.

e. Market Led Extension (MLE) approach

In order to make farming more enterprising, extension professionals need to be pro-active beyond the regular objective of maximizing the productivity of the fishers by transferring improved technologies rather fishers should be sensitized on various aspects of farming like culture, harvest, quality,processing and value addition, consumer's preference and market intelligence.This will help the fishing community to realize high returns for the produce, minimize the production costs, and improve the product value and marketability that may lead to realize the concept of doubling farmers' income(DFI).With the globalization of agriculture, emphasis on productivity and profitability to the farm enterprises has been increased and, therefore the demand- driven agriculture (and allied sectors) has led to the paradigm shift from production-led extension to market- led extension. There are many challenges in the agricultural marketing system, which can be resolved through the efforts of market- led extension models.In this approach,fishersare viewed as 'Fish-entrepreneurs'who expects high returns 'Rupee to Rupee' from his produce by adopting a diverse baskets of package of practices suitable to local situations/ farming systems with optimum cost benefit ratio (C:B ratio) ensuring maximum share of profit by exploring the market demand. Goal of market led extension is to facilitate fishers to get better price. Market led extension focuses on harnessing the ICT tools to access market intelligence including likely price trends, demand position, current prices, market practices, communication network, etc. besides production technologies.

For farmers, as the extension system is more credible source of farm technologies, the extension personnel ought to be knowledge- and skill-oriented in relation to production and marketing of agricultural goods. Thus, revamping the extension system will have a catalytic role for ushering in farmer-led and market-led extension; which can subsequently alleviate poverty and ensure livelihood security. In the light of this, the challenge remains to motivate the extension personnel to learn the new knowledge and skills of marketing before assigning them marketing extension jobs to establish their credibility and facilitate significant profits for the fishing community.SWOT analysis of the market, Organization of Farmers' Interest Groups (FIGs), capacity development, establishing linkage and synergy, harnessing ICTs, digital marketing etc are the competencies required by the extension personnel in order to effectively implement market led extension.

f. Digital Extension approach

Extension reforms brought a transformation in fishery extension system through introduction of Information and Communication Technologies (ICTs). The ICT-enabled extension systemreferred to as Digital Extension has the potential for enabling theempowerment of fishing communitiesby improving their access to information and sharing knowledgewith innovative e-agriculture initiatives (Saravanan, 2010a).With the phenomenal growth in information and communication technology, use of IT application in agriculture will bring remarkable change in the attitude and knowledge level of user. Basic requirement is to provide most appropriate information in such a capsule that can be easily understood and used by them. This approach will strengthen the extension system for better dissemination of technology. As acase study the contribution of Digital Green, a NGO that uses an innovative digital platform for community engagement to improve lives of rural communities across South Asia and Sub-Saharan Africa is remarkable. Digital Green associate with local public, private and civil society organizations to share knowledge on improved farmers practices, livelihoods, health, and nutrition, using locally produced videos and human mediated dissemination. As per the study, the Digital Green project (participatory digital video for agricultural extension) increased the adoption of certain farm practices seven times higher compared to traditional extension services and the approach was found to be 10 times more cost-effective per dollar spent.Hence, along with ICT-based advisory services, input supply and technology testing need to be integrated for greater impact and content aggregation from different sources require to be sorted in granular format and customized in local language for rapid adoption of technologies (Balaji et al., 2007&Glendenning and Ficarelli, 2011).

The effectiveness of this innovative extension approach depends on capacity building, people's participation along with government initiative to provide strong infrastructure to be worked with the cutting edge technologies. The farmer friendly technology dissemination process needs to be handled with careful planning by the incorporation of information communication technology. The use of ICT application can enhance opportunities to touch the remote farmers to live in close proximity of the scientific input. The computer based web portals namelyaAQUA, KISSAN Kerala, TNAU AGRITECH Portal, AGRISNET, DACNET, e-Krishi, ASHA, India Development Gateway (InDG) portal, Rice Knowledge Management Portal (RKMP), Agropedia, KIRAN, AGMARKNET, ITC-e-Choupal, Indiancommodities.com, Mahindra Kisan Mitra, IFFCO Agri-Portal, Agrowatch Portal, iKissan, etc.along with some mobile based Apps likemKRISHI® Fisheries, riceXpert, Pusa Krishi, Krishikosh, m4agriNEI CIFT Lab Test, CIFTrainingetc. launched in India are some of the successful digital intervention for technology dissemination.

The use of internet, mobile and video- conferencing assists the IT enabled farmers to utilize the facilities for their favors for which the most suitable permanent infrastructure is the basic requirement. Strong linkages need to be established between direct ICT interventions and it should be part of the national level program on holistic agricultural development.

g. Disruptive Extension approach:

Recently, a new extension approach christened as ‘disruptive extension’ comes into limelight which is considered as an innovative extension approach that creates a new paradigm of extension that eventually disrupts an existing approach followed by extension professionals in the field of agriculture and allied sectors.It is an entrepreneurial oriented sustainable extension system that can able to transform every link in the food chain, from farm to fork.It is a cost-recovery extension approach the fulcrum of which lies between resource exploitation on one side and resource conservation on another side that influence the livelihood security and technology sustainability for small scale farm holders. It deals with the following principles:

- Importance of good governance in agriculture (and allied fields) that considers the resource rights of the farmers.
- Emphasis on growing interest among the stakeholders by explicit analysis of field level issues for technology adoption.
- Potential to resolve the social conflicts for equal access to community resources through Memorandum of Understanding (MOU).
- Based on cost recovery mechanism.
- Ensure commitment to optimum resource management and maximum economic benefit to improve food security.
- Provision of community based social insurance.
- Maintaining the sustenance of the technology supports through custom hiring approach.
- Focus on pluralistic convergence of different partners to build a network of linkage with various entities around the farm households.
- Encouraging the farmers-scientist interaction for technology development, assessment and application through Farmers’ FIRST approach.

Global agriculture embraces diverse actors in its endeavour to feed about 10 billion people in the planet by the end of 2050. The small, marginal & landless farmers are extremely vital for food security due to shrinking of resource day by day. The contribution of women fishersalso cannot be ignored particularly in on-farm operations, harvesting, post-harvest management, processing etc.,especially in fishery and animal husbandry sector. Hence, in today’s scenario innovation in agriculture extension is the key to address the growing challenges, which need to be validated, integrated and scaled up and further recommended for large scale implementation by the policy makers. The innovative extension approach should be based on capacity building, skill development, people's participation along with government initiative to provide policy support to be worked with the cutting-edge technologies. Much effort has been initiated in going beyond the farm and the fishers and focus on beyond the technology to a wider innovation system.

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Chapter 3

Sustainable fishing practices

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India is situated north of the equator between 8°4' and 37°6' north latitude and 68°7' and 97°25' east longitude, is the largest peninsular country in the world bordered by Arabian Sea in the west, Indian Ocean in the south and the Bay of Bengal in the east. India has a coastline of 8118 km and 0.5 million sq. km continental shelf endowed with 2.02 million sq. km of Exclusive Economic Zone (EEZ). There are 3,432 marine fishing villages and 1,535 marine fish landing centres spread across nine maritime states of the country, viz., Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Odisha and West Bengal and the union territories of Puducherry and Daman & Diu. The number of fishermen in India has been estimated at around 4 million, of which more than 90% are from traditional fishermen families. The Indian fishing sector falls under three broad categories viz. the mechanised sector, using mechanised propulsion and fishing operations, motorised sector using engines for reaching fishing ground and the non - motorised sector which do not use engine power According to CMFRI (2012) there are about 1,99,141 marine fishing fleet are operated along the Indian coast. In this 72,749 were mechanised fishing vessels, 73,410 were motorised fishing vessels and remaining 52,982 were Non-motorised fishing vessels.

The ICAR - CIFT has been spear heading research in fishing and fish processing in the country for the past decades. The Fishing Technology Division of ICAR - CIFT has been involved in the development of eco - friendly and sustainable technologies for fish harvesting. The division caters to the needs of the non - motorised, motorised and mechanised sector of the fishing industry.

Rubberwood canoes

The non- motorised sector is operated by artisanal fishermen who are economically backward and investment in this sector is heavy due to increasing cost of fishing implements low cost technologies developed by ICAR - CIFT which can reduce investment cost can be taken up by entrepreneurs. Some of these technologies are described below.

A simple technology for development of traditional fishing canoe from rubber wood, which comes as a waste from rubber plantations. Though rubber wood is comparable to many structural timbers in terms of mechanical properties and working qualities, it is highly perishable under marine conditions. The study proved rubber wood as suitable for construction of canoe after upgrading by chemical preservative treatment. This technology relates to increasing the durability of the low cost and highly perishable timber like rubber wood for marine purposes. Through proper preservative treatment it is utilized for construction of small fishing canoes for inland and marine fishing. This will reduce the investment cost of the artisanal fishing craft. This is achieved through treatment of the wood with preservatives like copper chrome-arsenic (CCA) which is a water-borne preservative and creosote which is an oil-borne preservative. The preservative treatment increases the durability of wood, prevents attack of the marine borers and does not affect the strength of the treated wood. The chemical treatment process was standardized to suit the requirement of the rubber wood for using it as a boat building material. This was achieved through an initial dip treatment of freshly felled planks in 2% CCA followed by stabilization of moisture content.

The use of rubber wood, which comes as a byproduct from the rubber plantations, for marine purposes would bring in an extra income to the cultivators of rubber who are facing a crisis due to the unstable prices of latex. The technology would benefit in saving the precious forest cover. Although the stipulated forest cover of India is 33%, the actual cover is only about20% necessitating lesser deforestation. The new technology would help in maintaining the ecological stability by conserving the fast depleting forest cover. The conventional prime quality boat building timbers are very scarce and have become very costly. Traditional fishermen using wooden canoe find it extremely difficult to afford the cost. The new technology can reduce construction cost of small canoes by 35-40%. The use of rubber wood, which comes as a by- product from the rubber plantations, for marine purposes would bring in an extra income to the cultivators of rubber who are facing a crisis due to the unstable prices of latex.Approximate cost of production for 6.4 m LOATreated Rubber Wood Canoe: Rs. 17,650/- per unit.

FRP coated Rubber Wood Canoe

The technology has made possible the utilization of rubber wood and also provided additional dimensional stability through sheathing. This technology relates to the construction of a low cost, maintenance-free fishing canoe for use by traditional fishermen in the inland water and in the sea. The improvement is that FRP is used as a sheathing material on top of wood for reducing maintenance, preventing attack of marine woodborers, achieving water proofing, preventing decay and helping to provide resistance to impact and abrasion and to improve appearance.

The new technology can reduce construction cost of small canoes by 35-40%. The FRP sheathing

provides water proofing, reduces maintenance, resistance to impact and abrasion and prevents attack of marine borers and other decay causing organisms besides giving an extended service life and better appearance for the wooden canoe. Canoe made of treated rubber wood and sheathed with FRP will give a maintenance-free service life of 15-20 years. The FRP sheathing also provides environmental benefits by way of minimizing the preservatives as well as preventing leakage of chemicals into the water body. The construction is simple and can be taken up by traditional boat builders once a basic training is received. Thus FRP enables the fishermen to make efficient use of the under-utilized rubber wood for small canoe construction. Approximate cost of production for 6.05 m LOA FRP-coated rubber wood canoe: Rs. 27,100/- per unit.

Coconut Wood Canoe

ICAR-CIFT has designed and developed traditional fishing canoe from the coconut wood, which can be used for artisanal fishing like ring seining, gillnetting etc. Coconut wood is an agricultural by product with little or no value to the farmers. Though coconut wood scores higher than many structural timbers in terms of mechanical properties and working qualities, it is not used commonly for boat construction. Canoes were designed based on the dimensions commonly used for fishing boat building in Kerala. The dimensions adopted for building the prototype is 9m LOA, 1.5m breadth and 0.7 m depth. This technology relates to increasing the durability of the low cost coconut wood for marine purposes. This is achieved through treatment of the wood with a chemical preservative viz. Copper Chromium Boron is used for prolonging the life of coconut wood. The preservative treatment increases the durability of wood, prevents bio-deterioration and reduces the cost by 35-40%.The FRP sheathing provides water proofing, reduces maintenance, resistance to impact and abrasion and prevents attack of marine borers and other decay causing organisms besides giving an extended service life and better appearance for the wooden canoe. Canoe made of treated coconut wood and sheathed with FRP will give a maintenance free service life of 15-20 years. The FRP sheathing also provides environment benefits by way of minimizing the preservatives as well as preventing leakage of chemical into the water body. The construction is simple and can be taken up by traditional boat builders once a basic training is received. Thus FRP enables the fishermen to make efficient use of the under-utilized coconut wood for small canoe construction. Approximate cost of production for 9 m LOA FRP-coated Coconut wood canoe: Rs. 1,00,235/- per unit.

Catch loss in gears due to aquatic organisms

Ring seines and gillnets are important artisanal gears usually targeted to catch the shoaling pelagic fishes like sardine, mackerel and anchovies. The operational hazards faced by the artisanal fishers includes, attack of cetaceans, pufferfish bites, entanglement of small fish like ambassids and jellyfish blooms which may enter ring seines. One solution to prevent the cetacean attack in ring seine are Pingers. Pingers are devices that producesultrasound which keep the bottlenose dolphins and porpoises away from the nets. Pinger is designed to work by emitting a sound wave signal beyond70 kHz that is known to be in the best hearing range of most dolphin species. The signal acts as an alarm, and in some cases the pinger stimulates dolphins to use their echolocation which alerts them to the presence of the pingers and fishing nets.

Due to cetacean attack in ring seines an average of 67-180kg of webbings are been replaced annually. The cost of webbing to replace the damaged area in ring seines was estimated to be Rs. 55128 - Rs. 94813. About 7.5-20 man days are lost and the mending charges per day per person are Rs. 800. Hence an average total loss of Rs.61128- Rs. 10813 is estimated. Due to puffer fish bite in ring seines an average of 25-53 kg of webbings are been replaced annually. The cost of webbing to replace the damaged area in ring seines was estimated to be Rs-19995- Rs. 43398. About 3-6 man days are lost and the mending charges per day per person are Rs.800. Hence an average total loss of Rs.22644 - Rs.48670 is estimated. Cnidarian groups entering the net along with the target fish is another menace faced by the fishers. The was during July, August, September and October. The fishermen lowers the net and allows the jellyfish to escape to prevent tearing of net. This results in loss of targeted fish shoal and fishermen move to fresh grounds. Entanglement of fishes belonging to the family Ambassidae is another problem faced by fishermen operating large meshed ring seines (LMRS) during the monsoon and post monsoon season. When Ambassis is gilled/entangled it requires lot of time and labour for removing each fish from the net. The cost of disentanglement of ambassis in ring seines ranges from Rs. 10500-14000 and the repair cost is estimated to be Rs. 331250. Thus a total cost of Rs. 343500 is estimated as loss due to ambassis entanglement. The rural fisherwomen can be trained in fabrication and mending of fishing gear under the Co - operative sector.

Mechanised Fishing Sector of India

Modern fishing is one of the most energy efficient intensive methods of food production. Motorised and mechanised fishing vessels use fossil fuel combustion as the main source of energy, generating large amount of greenhouse gases (GHG) and leading to irreversible climatic and oceanographic changes. The operation of mechanised and motorised vessels contribute significantly to the generation of GHGs. Modification of the vessel technology, fishing gear modification and adoption of energy saving operational interventions are the three main approaches which can make a visible dent in the efforts to conserve energy during fish harvesting. Some of the modifications to conserve energy in vessel technology are the optimisation of hull, propeller and machinery design. The combined synergetic effect of all the above factors will help in significant reduction in fuel consumption and thereby making fish harvesting more energy friendly, resource specific and hence more greener.

The Fishing Technology Division of ICAR-CIFT developed a 19.75 m LOAmulti-purpose fuel efficient fishing vessel is designed to achieve better fuel efficiency and carry out multiple fishing activities (trawling, gillnetting and long lining) depending on the seasonal availability of species. This vessel has an optimized hull form with a bulbous bow at forward below water line to minimize water and wave resistance at sea. The rare combination of steel for hull and fibre glass reinforced plastic for cabin and wheel house, reduces 8% of the total weight of the vessel. Solar power is utilized for cabin lighting and reduces the electrical load of the vessel. The design and construction is certified by the Indian Register of Shipping.

The unique design, combines the results of the all India survey conducted to gather information regarding the most optimum parameters for a multi-purpose deep sea fishing vessel. A most suitable design developed using the outcome of computational fluid dynamics of the hull and wave resistance at sea. The vessel can sail longer in all fishing seasons due to the multi-purpose fishing operations compared to vessels engaged in single type fishing. The carbon footprint is lower when compared to other classes of fishing vessels. Utilization of solar power for cabin lighting which cuts back the electric load of the vessel.The approximate cost of 20.0 m vessel which could be used for commercial operations will beRs. 1.25 to 1.50 crores.

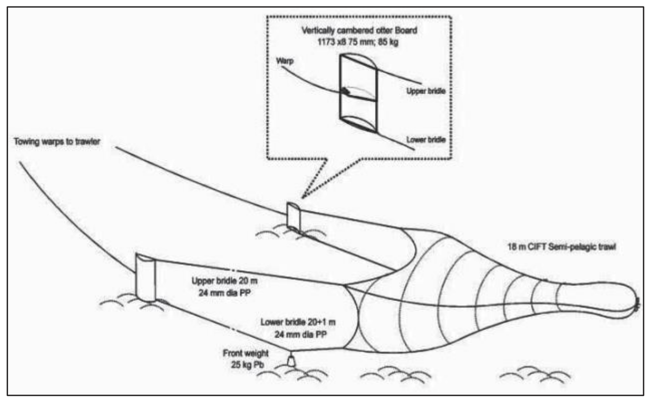
Low drag trawls

ICAR-CIFT designed andfabricated low drag trawls for fish and shrimp ofhead rope length 24.47 m and 3.00 m, respectively.The drag reduction measures included in the designare increased mesh size and new material. Thematerial used is Ultra High Molecular WeightPolyethylene (UHMWPE). As UHMWPE providessame strength at a lower diameter, the twine sizewas reduced which results in reduced twine area.An innovation to significantly reduce drag was high- strength UHMWPE materials that allow the use of thinner twine compared to traditional materials.

Low drag trawls are designed by incorporating drag reduction measures; the identified dragreduction measures are use of knotless netting, Use of thinner twine, use of large mesh, use ofcambered otter boards, optimal angle of attack of otter boards, use of slotted otter boards, use ofmulti-rig trawling and use of pair trawling. Through the study conducted by FTDivision of ICAR- CIFT UHMWPE trawl found to consume 13% less fuel than conventionalHDPE trawls. It is able to make an average increment of Rs. 7,00,000 lakhs in net profit of a 21.33 mtrawler which will be reducing the payback period from 3.04 to 2.62 years.

CIFT Off - Bottom Trawl System (CIFT-OBTS)/ Semi Pelagic Trawl System (CIFT-SPTS)

Trawler fishermen in India cannot depend on shrimp and associated species alone for viable commercial operations any more, and there is a need to adopt responsible alternate trawl systems for harvesting large demersal and semi-pelagic species. CIFT Off - Bottom Trawl System, christened as CIFT-OBTS was developed as an alternative to shrimp trawling in the small-scale mechanized trawler sector, after extensive field-testing. It is capable of attaining catch rates beyond 200 kg h^{-1} in moderately productive grounds and selectively harvest fast swimming demersal and semi-pelagic finfishes and cephalopods, which are generally beyond the reach of conventional bottom trawls, currently used in commercial trawl fisheries in India. CIFT-OBTS has been developed and perfected after extensive field trials and observations, using acoustic gear monitoring instrumentation and inference from statistical evaluation of catch, over an extended period. The system consists of an 18 m four panel semi-pelagic trawl with double bridles, front weights of 25 kg each and vertically cambered high aspect ratio otter boards (trawl doors) of 85 kg each. Its adoption and responsible use will be a boon to the Indian small-scale trawling industry, to enhance fish production and profits and minimize environmental impacts of trawling. Shrimp trawls when operated should be equipped with bycatchreduction devices (BRDs) and should target shrimp alone, in order to conserve fishery resources and minimize biodiversity loss due to trawling. CIFT-OBTS with exchangeable codends (55 mm codend for small demersals like mackerel and horse mackerel and 150 mm codendforall bodied fishes like pomfrets) is prescribed for harvesting non-shrimp trawl resources.



Major advantages of the CIFT-OBTSover the conventional shrimp/fish demersal trawl systems in vogue in Indian Fishing Industry are enumerated below:

Results of performance evaluation and biodiversity analysis have shown that CIFT-OBTS has significantly high resource specificity for off-bottom (semi-pelagic) finfishes, which are generally large in size, fast swimming and exhibit shoaling characteristics. Conventional bottom trawls have poor resource specificity and size selectivity and have greater impact on biodiversity and sustainability.Conventional bottom shrimp and fish trawls have low vertical opening, mostly limited to 1-1.5 m and hence their catches are limited to species living close to the bottom. Due to higher vertical opening up to 4.0 m realized in CIFT-OBTS, resources that are beyond the reach of conventional bottom trawls, could be efficiently harvested.

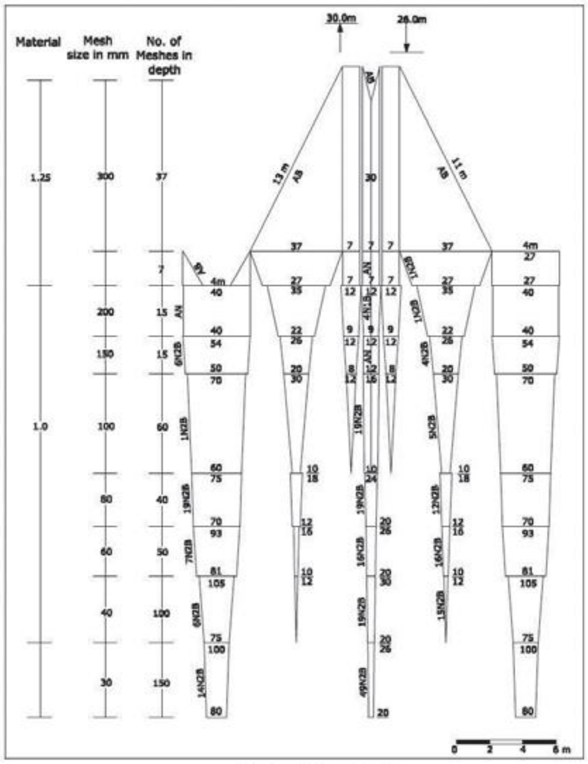
Significantly high sheer-drag ratio of vertically cambered high aspect ratio otter boards makes the system energy-efficient. The vertically cambered high aspect ratio otter boards have dual- purpose capabilities and can also be deployed for conventional bottom trawling. CIFT-OBTSis indigenously developed and is best suited to Indian fishing conditions and fishery resources. The gear system has been developed and optimized taking into consideration the biological, behavioural and distribution characteristics of tropical demersal and semi-pelagic finfish and cephalopod resources and technical capabilities of the small-scale mechanized trawler fleet, operating in Indian waters. About two million tonnes of estimated potential fishery resources in the Indian Exclusive Economic Zone would be accessible to the semi-pelagic trawl system.Approximate cost of production: Rs. 50,000/- per unit

CIFT-Multi Seam Trawl

Bottom Trawling is a very popular fishing method along the east coast of India. Ever since the shrimp catch has been considerably reduced, fishermen have diversified their fishing methods from shrimp trawling to fish trawling. Majority of the fish trawls used in the fishing industry of East coast are two seam trawls which targets bottom fishes causing damage to the sea bed. There is a need to develop diversified fishing practices and alternate responsible trawl systems which are eco-friendly. The CIFT-Multi seam trawl was developed as an alternative to the conventional bottom trawl to target off-bottom fishes and also cause less damage to the sea bottom.

Fishing experiments were undertaken to study the performance of multi seam trawl and its performance compared with a conventional two seam trawl gear in terms of the CPUE and catch composition. The experimental trawl net showed a CPUE rate of 40 kgh_{-1} against 23kgh_{-1} from 2 seam trawl. 0ff -bottom fishes namely ribbon fish, and squid catches were significantly higher in multi seam trawl.

CIFT multi seam trawl is indigenously developed and is best suited to Indian fishing conditions and fishery resources. The gear system has been developed and optimized taking into consideration the biological, behavioural and distribution characteristics of tropical demersal and off-bottom semi-pelagic finfish resources and technical capabilities of the small-scale mechanized trawler fleet, operating in Indian waters. About 4.9 million tonnes of estimated potential fishery resources in the Indian Exclusive Economic zone would be accessible to the multi seam trawl system.

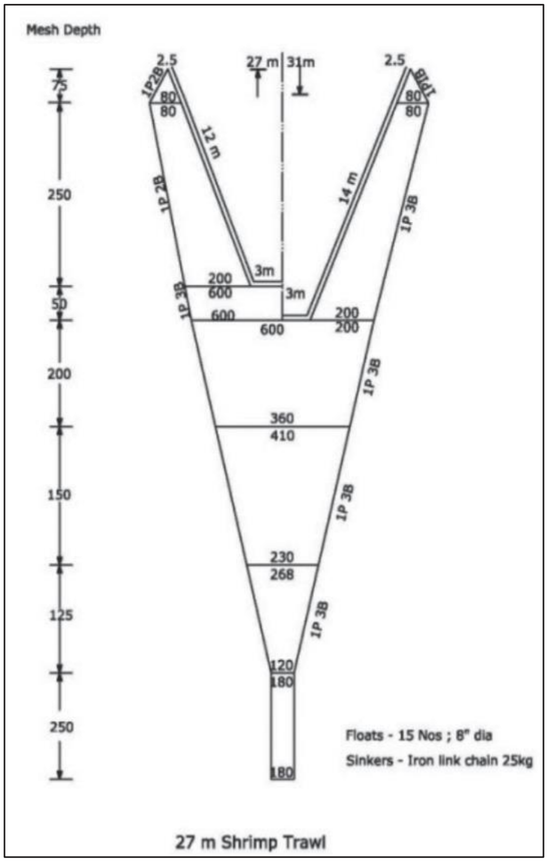


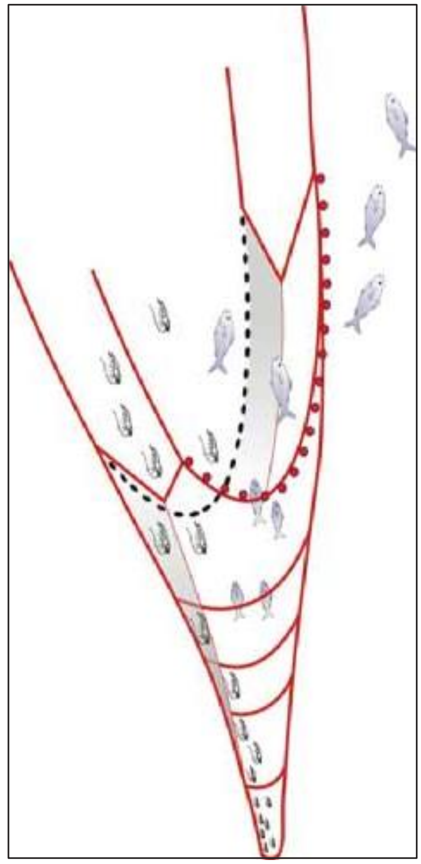
26 m Multi SeamTrawl

The 26 m multi seam trawl is fabricated with 14 seamswith seven panels. The seams are strengthened by supporting ropes. The mouth of the trawl is made with large mesh and the body netting is graduated as it narrows with decreasing mesh sizes of the lighter ranges of nylon twines. System consists of an 18 m four panel semi-pelagic trawl with double bridles, front weights of 25 kg each and vertically cambered high aspect ratio otter boards (trawl doors) of85 kg each.

The multi seam trawl had a relatively higher CPUE than the conventional two seam net and effective in targeting off-bottom fishes. The multi seam trawl can be very useful for the commercial trawlers, along the east coast of India.The net can used for exploring new grounds and also help in reducing the pressure on bottom resources, environmental damage caused due to demersal trawling and help in protecting marine biodiversity, for longer sustainability of fishery resources.Approximate cost of fabrication of Multi seam trawl is:Rs. 8000/- per unit

Short Body Shrimp Trawl

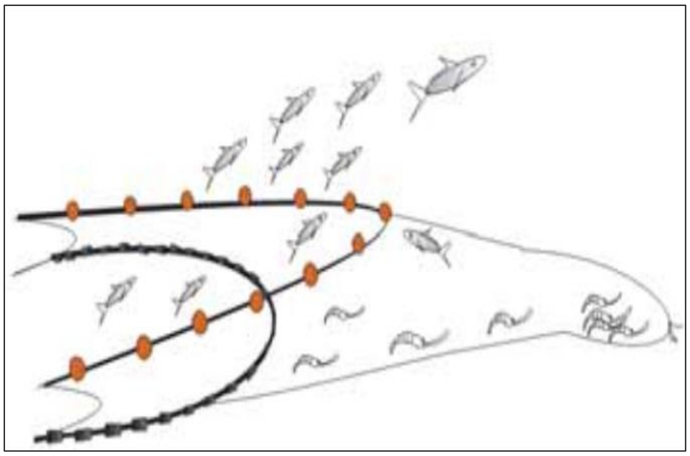




The research team at ICAR-CIFT has developed and successfully field tested a 27 m shrimp trawl with relatively short body and large horizontal spread suitable for selective retention of shrimp during trawling operations from small mechanized trawlers which are popular in India. The length of the trawl body has been considerably reduced by increasing the taper ratio and the vertical opening of the mouth has been reduced to eliminate bycatch which predominantly consists of non-targeted fishes. The relatively better swimming ability of finfishes compared to shrimps help them to counter the short and lower vertical height of trawl and swim out of the net. Because of the larger horizontal spread of the trawl mouth, the effective sweep area is more, which is an important requirement for an efficient shrimp trawl. In addition, the reduction in quantity of netting used in the trawl construction will result in operational fuel savings.

Trials carried out along the coastal waters off Cochin with a prototype of short body shrimp trawl reveals considerable reduction in the fish catch due to the difference in relative swimming speed and vertical distribution profile of shrimp and finfishes. The results indicate that there is a significant reduction in the mean catch per unit effort (CPUE kg h-1) of non-targeted bycatch which reduced from 9.75 kg $h^{-1}$to 2.75 kg.h^{-1}. No significant reduction in the shrimp catch was noticed, when compared to the catches from a commercial trawl design. Since no major investment is needed for adopting this technology, fishermen will adopt the technology as there will be increase in shrimp catch and reduction in bycatch and also reduction in cost of fabrication due to reduction in the material required. Sorting time is reduced as the catch of non-target species is less and this will also increase the productive tow time and help in fuel saving. Use of selective shrimp trawl nets should be popularized for sustainable fisheries for the long term benefit of conservation of resources and protection of biodiversity.Approximate cost of production for 27 m Short Body Shrimp Trawl: Rs. 22,000/- per unit.

Cut-away Top Belly Shrimp Trawl



A commercial shrimp trawl usually catch large quantity of finfish juveniles as a result of the vertical opening and the square, the front part of top belly. Fishes in the mouth region of the trawl are unable to escape by swimming up due to the top belly cover. ICAR-CIFT has designed and developed a 24 m shrimp trawl without top belly and relatively short body and more horizontal spread. The open belly is to facilitate the escapement of fish component from the shrimp trawl, which is dominated by juveniles and sub-adults. The new design is expected to reduce drag and reduce operating cost. In addition, the reduction in quantity of netting used in the trawl construction will result in operational fuel savings.

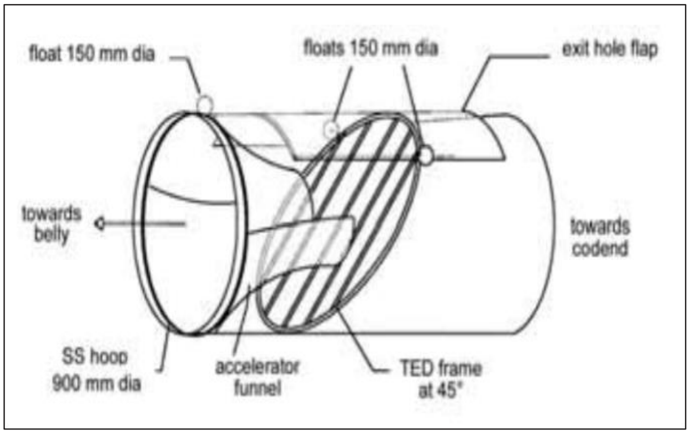
Since the top belly is removed actively swimming fishes can escape the trawl by swimming up whereas the shrimp component can be retained as usual. Increased horizontal spread will increase trawl swept area which is expected to increase shrimp catch. More area can be covered within the given time, because of better speed. Drag of the trawl is reduced since the total twine surface area is less which will lead to fuel saving and reduction in the operating cost. The long term benefits of the technology are improvements in economics of trawler operations, protection of biodiversity, resource conservation and sustainable trawl fisheries. The reduction in the quantity of netting used in the trawl construction will result in operational fuel savings.Approximatecost of production for 24 m Cut-away Top Belly Shrimp Trawl: Rs. 22,000/- per unit

Large Mesh Purse Seine

Purse seining is one of the most efficient and advanced commercial fishing methods. It is aimed mainly at catching dense, mobile school of pelagic fish and includes all elements of searching, hunting and capture. Purse seine nets use mesh sizes ranging from 10 to 22 mm in the main body of the netting and is mainly for targeting anchovies, sardines and mackerels in the coastal waters. With the objective of targeting the under exploited large pelagic fishes in deeper waters, a purse seine net was designed with large mesh size (45 mm), so as to reduce fishing pressure in the coastal waters. Introduction of large mesh purse seines facilitated by ICAR-CIFT has led to the revival of small mechanized purse seine fishery in Kerala. The changeover of mesh size in the purse seine from the conventional 20 mm to 45 mm has shown good results and the purse seiners has been able to land larger size classes of high value species. Experimental fishing operations carried out from the purse seiner MV Bharat Darshan during the period 2007-2010 in the depth range of 50 to 220 m revealed that the catch mainly comprised of large sized mackerels (62.08%), followed by tunas (16.08%), Pomfrets (1.93%), carangids (14.43%) and miscellaneous fishes (5.47%). All the purse seiners based at the Cochin Fisheries harbour, Kerala have changed over to 45 mm mesh size purse seines and started operations in the deeper waters targeting skipjack tuna, little tunnies, carangids, black pomfrets, horse mackerels, barracudas, seerfish and mackerel.

The traditional fishermen and the purse seiners were targeting small pelagics like anchovies, sardines and small mackerels in the coastal waters. The purse seiners were also targeting the same resource in the coastal waters. There was severe competition and rifts between the traditional and mechanized purse seiners. With the introduction of large mesh purse seine, the fishermen could go to deeper and farther waters targeting large pelagics like tunas, seerfish, pomfrets and large mackerels thus reducing the competition and fishing pressure in the coastal waters.Approximate cost of production: Rs. 18,00,000/- per unit

Bycatch Reduction Devices - CIFT - TED



CIFT Turtle Excluder Device (CIFT-TED)

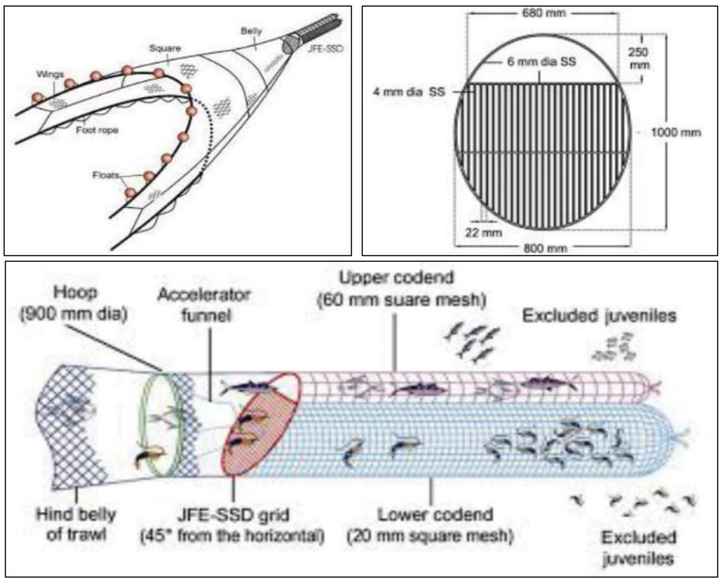
Field trials with CIFT-TED, so far, has shown a mean catch loss in the range of 0.52-0.97% for shrimp and 2.44-3.27% for non-shrimp resources, which is considerably less than the loss incurred during the operations with imported TED designs. The loss of finfish catch is expected to vary from zone to zone and from season to season, depending on the percentage representation of large finfishes and elasmobranchs in the trawl catch. However, the large species that are excluded due to installation of TED are not lost to the fishery as a whole, as they can be caught by other fishing techniques in vogue in the fishing area.Approximate cost of production: Rs. 4000/- per unit

Juvenile Fish Excluder cum Shrimp SortingDevice (JFE-SSD)

The Juvenile Fish Excluder cum Shrimp Sorting Device (JFE-SSD) is a Smart Gear (WWF) award winning design developed by ICAR-CIFT which brings down the bycatch of juveniles and small sized non-targeted species in commercial shrimp trawl and at the same time enables fishermen to harvest and retain large commercially valuable finfishes and shrimp species. In addition, the fishermen would benefit economically from higher catch values due to improved catch quality, shorter sorting time, longer tow duration, higher catch and lower fuel costs. Juvenile Fish Excluder cum Shrimp Sorting Device (JFE-SSD) replaces the conventional codend of the trawl net. The device consists of an oval grid made of stainless steel rods having bar spacing of 22 mm kept at 45° angle to the horizontal. The grid is provided with a 250 x 680 mm top opening which leads to an upper codend with large square meshes (60 mm). A funnel made of netting (20 mm mesh size) accelerates the flow of water and guides the catch components towards the lower side of the oval grid kept at 45° angle to the horizontal which separates the shrimp from the rest of the catch.

The device reduces the bycatch of juveniles of finfishes, shrimps, crabs and cephalopods, and small sized fishes of less commercial value, contributing to sustainability of the resources and protection of biodiversity. The fishermen are able to retain large fishes of higher market value, which will enhance the overall revenue realized from trawling operations. Increase in towing time can be expected due to slow filling of the codend as a result of reduction of non-target fishes and juveniles. The in situ sorting effect and separation of shrimps from finfishes and cephalopods help to reduce the sorting time and increase useful fishing time of the trawler fishermen and thus enhance the profitability.

Shrimps pass through the grid spacing and are retained in the lower codend made up of 20 mm square mesh netting. Juvenile shrimps escape through 20 mm size square meshes of the lower codend. The large fishes and cephalopods are deflected upwards to the 250x680 mm wide opening provided at the top of the grid and enter into the upper codend with large square meshes (60 mm). Juveniles of finfishes and cephalopods, and low value small sized finfishes, which have entered the upper codend escape through large square meshes in the upper codend.



JFE-SSD operations off southwest coast of India have realised bycatch reduction up to 42.9% with shrimp retention of about 95%. Out of a total retained catch (in the lower and upper codends), about 77% was retained in the lower codend and the balance in the upper codend. Of the retained catch of non-shrimp resources, about 70% was retained in the lower codend and nearly 30% in upper codend. The sorting effect was most pronounced in the shrimp species. Out of the retained shrimp catch, nearly 99% was retained in the lower codend.

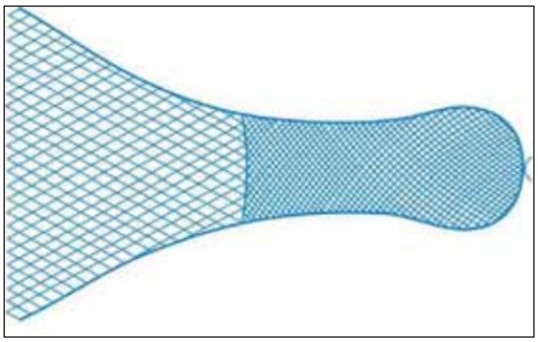
The fabrication cost of the grids: Rs. 6000/-

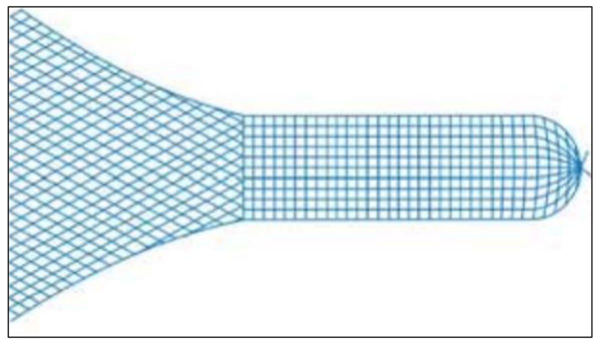
Fabrication of the double codend made of HDPE: Rs. 2000/-

Total cost: Rs. 8000/-

Square Mesh Codend

Traditionally codends are made of diamond shaped meshes, which tend to close during the fishing process and hence make the release of untargeted species in the codend very difficult. The square mesh codends, due to the virtue of its modified rigging, remain open during fishing operations unlike diamond shaped meshes. The open meshes help the juveniles of commercially important species to escape, thereby reducing the quantity of bycatch during trawling operations. Square mesh codends are prepared from diamond mesh webbing by barcuts, rejoining and then strengthening by marling to prevent the unravelling of the meshes.





Use of square mesh codends significantly reduces the bycatch often comprising of the juveniles of commercially important species. Studies carried out by ICAR-CIFT along the Indian coast have recorded an increase of 12-25% in the mean selection length of different targeted species by using square meshes in the codend. Good filtration and reduction in the drag are other benefits of the technology. No significant economic loss is incurred since the escapees are the juveniles which often fetch very less value in the market.

The traditionally used diamond meshes can be converted to square meshes and hence there is no additional cost involved. The cost of one codend can range from Rs. 1500 to Rs. 2500, depending on the design used by fishermen.

Conclusion

The technologies mentioned in the chapter and numerous other technologies can be taken up by small/ medium scale entrepreneurs for starting business in the fishing sector. The infrastructure required for these ventures will not be very high as most of the technologies mentioned can be manufactured at the village level with existing facilities like village boat yards, small workshops etc. Further women fisher folk can be trained in the cutting and fabrication of gears, bycatch reduction devices etc. which will provide an alternate livelihood for the fisher families. As there is a dearth of labour force in the gear fabrication and repair sector skilled women work force would be much in demand.

Chapter 4

Improved fish drying and packaging

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Drying

Drying is one of the age-old techniques for preservation and value addition of food products. Generally, it means removal of moisture from food products by means of evaporation. It is a simultaneous heat and mass transfer process to yield a dried product. It is aimed at lowering the water content of foodstuff, thereby arresting the growth of microbes, action of enzymes and other autolytic chemical reactions. This preservation technique is predominately used for food materials which are regarded as "highly perishable" like fruits and vegetables, milk and fish. The benefits of drying includes extended shelf-life, lower storage space, reduced packaging requirements, lower handling and transportation costs, off seasonal availability and importantly diversified product for the consumers. Dehydration is a term intermittently used for drying, however dehydration is typically used to refer a material which is dried to level of bone-dry condition *i.e* in addition to the removal of unbound moisture, part of the bound moisture is also removed in this process.

Fish drying

Use of open-air sun drying assisted by natural wind flow as a method of fish preservation by primitive societies is recorded in history. However, open sun drying of fish has few drawbacks which includes poor product quality, higher microbial contamination and dependence of weather conditions for drying. In later stages, drying developed into completely controlled process in which drying air temperature, relative humidity and air velocity is maintained at optimum level. In order to maintain the required drying conditions in the latest fish drying methods, external energy input is necessary. The fish drying process is slightly different from other food materials due to its gel like behavior until considerable reduction of water. In fish drying substantial amount of shrinkage takes place in addition to the other irreversible changes.

Generally, air drying of fish takes place in two distinct stages. First stage of drying is called as constant rate drying period in which simultaneous heat and mass transfer takes place under steady state conditions. In this stage, the moisture carrying capacity of the drying air is completed utilized. However, only the surface moisture of fish is removed in this stage and amount of moisture removal also depends on the given drying conditions i.e. drying air temperature, relative humidity of air etc. Second stage of drying is referred as falling rate drying period in which simultaneous state heat and mass transfer takes place under unsteady state conditions. That means the moisture carrying capacity of the drying air is not fully met by the product. In this stage, the rate of moisture removal is less and it depends on the fish moisture. In this stage, two different phases occur *i.e*unsaturated surface drying, and moisture movement from internal tissues to surface by diffusion process.

Preprocessing of fish for drying

Dry Curing

Dry curing is the most common method of curing. Here the fish is thoroughly washed followed by gutting, beheading and ventrally split open to remove the viscera and finally cleaned. Dorso-ventral opening is given to the larger fishes which are then cleaned well. Vertical scores are given to the body of larger fishes in order for the better salt penetration. Salt is then applied in the ratio 1:3 to 1:8 (salt to fish) depending upon the size of the fish. Proper salting is given to the fish which are placed in cement tanks or containers. Initially bottom of the tank is covered with salt and then a layer of fish is placed above that. This fashion of alternate salt and fish is followed and finally large wooden planks are placed over it. Water oozes out of the fish as salt gets penetrate into it. The fish kept undisturbed for 24-48 hours. Fishes are then removed, washed well in brine solution to remove the adhered salt and drained well. The fishes are then sundried to the accepted moisture level. The yield obtained for the product by drying by this method is 35-40% and the product shelf life is 6-10 weeks.

Drying of shrimp

The step wise procedure for shrimp drying is given below,

- Wash and clean the sample
- Weigh the sample
- Take 1:1 water and heat it to 80ºC
- Add 3% salt to it
- Give a dip in the water until the sample colour changes to pink
- Dip the sample in 0.1% citric acid
- Drain the water and keep it for drying

Design and Working Principles of CIFT Solar Hybrid Dryers

Solar dryer with electrical back up (20 kg)

The dryer assembly comprised of solar flat plate collectors with an area of 10 m^2 for harnessing solar energy to heat the air. This hot air flows in to the drying chamber for drying the product. When solar radiation is not sufficient during cloudy/rainy days to heat the air for circulation, alternative electrical back up is automatically actuated. Drying is carried out under controlled temperature and humidity conditions. The complete process parameters of fish drying can be controlled by a Programmable Logic Controller (PLC) system. The dryer can be used for drying 20 kg of fresh fish per batch.

Solar cabinet dryer with electrical back up (40 kg)

The dryer consists of four drying chambers with nine trays in each chamber. The trays are stacked one over the other with spacing of 10 cm. The perforated trays accomplish a through flow drying pattern within the dryer which enhances drying rates. Solar flat plate collectors transmit solar energy to the air flowing through the collector which is then directed to the drying chamber. Electrical back up comes into role once the desired temperature is not attained for the drying process, particularly during rainy or cloudy days.

Solar dryer with electrical back up-20 kg

Solar cabinet dryer with electrical back up-40 kg

Solar dryer with LPG back up (60 kg)

This is a hybrid solar drying system for hygienic production of dry fish by using environment friendly, abundantly and freely available renewable solar energy. Continuous drying of fish is possible in this system with the help of LPG back up, where the fish can be dried in unfavorable weather conditions without spoilage and maintaining its nutritional value. In this system, water is heated with the help of solar collectors installed on the roof and collected in a calorifier tank. The water from calorifier tank is collected through the solar collectors using a pump. Axial flow fans are provided in the drying chamber for hot air circulation across stainless steel trays loaded with fish for drying. The circulating air is heated by hot water passing through the heat exchangers. When solar radiation is not sufficient during cloudy/rainy days to heat the water for circulation, LPG back up heating system will be automatically actuated to supplement the heat requirement. The continuous drying is possible in this system without spoilage of highly perishable commodity to obtain a good quality dried product. Drying is carried out under controlled temperature and humidity conditions. The complete process parameters of fish drying can be controlled by PLC system.

Solar dryer with LPG back up-60 kg

Solar tunnel dryer

An energy efficient and low-cost solar tunnel dryer was developed for bulk drying of fish and fishery products. This dryer can be used by fishermen or small-scale fish processing units for bulk drying during seasonal higher catch/excess landing of fish. The capacity of the solar tunnel dryer is 50 kg with the floor area of 12 m^2. The materials of construction are UV stabilized transparent polythene sheet for roof cover, black absorber sheet for floor, supporting frames of CPVC and GI rod. Three ventilator fans of 0.5 hp were provided for air inlet and moisture removal. The trays with tray holder were placed inside the dryer for spreading and hooking the fishes for drying. The tunnel dryer was designed as a stand-alone system as it does not require any external power source/electricity. The fans were operated by means of a solar PV panel fitted on roof top of the dryer and associated battery setup.

Packaging of dried fish

Packaging of dried fish becomes more important in countries like India where the climate conditions vary considerably and are crucial to our modern food distribution and marketing systems.

Solar tunnel dryer

Packing protects the product from physical damage and contaminants, to delay microbial spoilage, to allow greater handling and to improve presentation. Food packaging must meet a number of conditions such as legislation, safety and many other conditions as well as functionality since it is required to be innovative, easy to use and attractive design. Proper packaging of fish is done to avoid contamination, reduce weight loss and delay spoilage and to extend the shelf life.

The special function required for a suitable dried fish/product package are inertness, leak proof, impermeability to oxygen and moisture & low transparency. Resistance to mechanical abrasion and puncture is another desired quality of a packaging material. One fifth of India's fish catch is salted and dried for internal consumption. The packaging employed till recently is highly unsatisfactory leaving much to be desired from the scientific and hygienic points of view. Baskets improvised with braided coconut or Palmirah leaves are the containers mainly used for packaging dried fish both for export and internal distribution. An overwrap with gunny fabrics is given as reinforcement in the case of products meant for export and those which have to be transported over long distances. These packages are however prone to easy entry of insects, rodents and other pests. The product being highly sensitive to changes in relative humidity, the packaging has to be sufficiently water vapour proof.

The bulk packaging materials commonly used are waxed corrugated cartons, dead wood or plywood boxes, bamboo baskets or gunny bags, dried Palmirah or coconut palm leaves and multiwall paper sap. Among different packaging material studied high density polythene woven gusseted bags are good for dried fish package. The commonly used packaging materials for consumer packs of dry fish are low-density polythene or polypropylene. These materials are cheap, readily available and have good tearing and bursting strength. Disadvantages are high water vapour and gas transmission rate, proneness to puncture or damage from sharp spines and smell coming out so that shelf life is limited. A recent development in cured fish packaging is the use of polyester polythene laminate pouches for consumer packaging.

The selection of packing materials is very important in order to develop a sustainable packaging. Different properties of packaging materials such as mechanical, barrier and migration properties determine whether packaging is suitable for the intended purpose. The level of moisture and gas permeability is vital to preserve the quality of dried fish.

Now synthetic plastics are extensively used in packaging of products like food, pharmaceuticals, cosmetics, detergents and chemicals. Approximately 30% of the plastics are used worldwide for packaging applications. This utilization is still expanding at a high rate of 12% per annum. They have replaced paper and other cellulose-based products for packaging because of their protection from chemical, physical and biological influences. The commonly used packing materials for consumer packs of dried fish are low density polythene or polypropylene. Polyester polyethylene laminated packaging materials has been used for consumer packages of dried and cured fish products which can extent shelf life and prevent spoiling by creating an enhanced layer of barriers that prevent the exposure to moisture and gases. These plastics that are synthetically derived from petroleum are not readily biodegradable and are considered as environmentally harmful waste. Most polymers are extremely durable and present a serious environmental problem, especially in urban centers. Conventional polymers are not biodegradable because of long chains of molecules that are too big and too well connected to each other to make them unable to separate the microorganisms to break down. Increasing environmental issues, awareness among the consumers and growing market, created convenience food by the development of biodegradable packaging materials from biopolymers. Biodegradable materials are those materials which can be degradable by the enzymatic action of living organisms. These biopolymers used for development of biodegradable packaging materials having great application in food industries.The packaging industry is focusing on developing environmentally friendly packaging as consumers are demanding recyclable packaging that comes from sustainably managed sources. Now the trend of packaging is towards the use of bioplastics and one of the most influential bioplastics currently marketed is polylactic acid (PLA) based materials. PLA offers packaging manufactures a cost of competitive renewable option to replace traditional petroleum based plastic materials.

Hence, the growth of fish processing industry has influenced the growth of the packaging industry which is successfully geared to meet the challenge. The achievements of the packaging industry are reflecting in the availability of a spectacular range of packaging materials and system. Newer packaging systems, change in life style, urbanization and increased consumerism, have flooded the markets with different branded packaged food products. Modern seafood packaging with the concept of hygiene and convenience has a significant role to play in the marketing of these products. Unlike many other manufactured consumer products like leather, machinery and chemicals, packaging needs of food and food products, and particularly fish, are very complex because of the intrinsic characteristics.

Chapter 5

Sustainable food value chains and opportunities for entrepreneurship development : Concepts and case of marine fisheries in India

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Introduction

It is estimated that by the year 2050, the fish production in India has to improve to the tune of 13.8 million tonnes, warranting a production improvement of 62% compared to current level. Further, fishery has been recognised as a sunrise sector, and the export demand from the sector is bound to increase. The sector has to grow sufficiently enough to absorb growing labour force in India. In order to achieve this, the major drivers of growth in the constituent components need to be identified and prioritised for investment. In that milieu, the marine sector needs to focus on sustainability and the inland sector has to focus on intensive production without hampering the environmental health. In order to turn the increased production to increased value, post-production operations needs to be enhanced focusing on value addition, improved marketing and exports. Ensuring safety, quality and traceability in the entire value chain is critical in this attempt. This indicates that the value chains in fisheries needs to be sustainable in terms of its effect in environment, economy and society.

Fisheries and value chains

The growth in the fisheries sector is much higher than that witnessed in other sectors of agriculture. The sector is also highly linked with external markets thorough trade relations. The sector provided employment and livelihood security through about 14-15 million people in India. The sector witnesses sign of economic, technological and financial duality. This is because one can visualize co-existence of highly technologically advanced fishing sector with relatively technologically underdeveloped traditional sector. Thus, the value chain in marine fisheries portrays a picture of large variation. Further, emerging recognition that fish is a health food and the consumer preference for fish products and byproducts both as a food and as a medicine has opened bright business prospects. The central and various state governments provide financial support though various schemes to establish business units and handhold such enterprises at least in the initial phase of establishment. Further, the consumer is getting increasingly concerned about the safety and quality of fish. In this context, one can visualize a fast restructuring of the value chain in fisheries, particularly marine fish.

However, the concept of the value chain has acquired the element of sustainability into to so as to evolve into sustainable food value chain, as noted by Food and Agricultural Organization. Furhter, its usage has transcended from the level of a marketing management tool to that of a policy analysis one. A value chain describes the full range of activities which are required to bring a product or a service from conception, through the different phases of production and delivery to final consumers (Porter, 1980). Often the concept of value chain is interchangeably used to notate a market chain, but there are very critical differences between them. While the market chain analysis intends to provide information on profitability for various agents along the market chain (Ferris *et al*., 2001), a value chain analysis describes the range of activities required to bring a product to the final consumer and, the extent to which intermediaries/agents gain from participating in the chain (Jacinto, 2004). In that context, a value chain describes the distribution of the benefits or value addition to different economic agents, and touches the realms of development economics. In the initial days of the development of the concept, it was used for analyzing a single company, a sector, an organization or a product; however, later it was developed to analyze single or multiple sectors and to develop policies.

Kaplinsky and Morris (2000) identify three sets of reasons for the importance of value chain analysis. With the globalisation of labour and capital, and emergence of division of labour, achieving efficiency of production has gained greater policy focus. The corporate world try to attain systematic competitiveness in the context of growing division of labour and global dispersion of production components so as to achieve efficiency in production to penetrate global markets. Value chain analysis is also done to understand the dynamic factors that plays, so as to make the best out of globalisation. This approach essentially focuses on markets, with the aim of achieving overall efficiency in terms of increasing productivity and reducing cost. However, the attainment of efficiency need to factor in the opportunity cost of the resources and optimise the benefits over a long period of time. The trade-off between efficiency attainment and equity in distribution of the benefits for the stakeholders has also attained significance. Development of a win-win situation calls for imparting efficiency in attaining targets while generating maximum benefits to the actors along the value chain. In that context, sustainability of the value chain emerges as an important consideration.

Porter's value chain concept

The concept of value chain has its origins from the commodity chain approach, which focused on the physical product flow from the producer to final consumer. Michael Porter (1985) put forwarded value chain as the value addition in competitive markets. It is the core element in the production-to-consumption chain of activities, within an organisation framework. The value added should be more than the marginal cost of that activity, for the particular intervention to be sustainable. However, the concept doesn't address the larger concern of economic development of the sector, but was limiting itself to the organisational management. Porter's VC concept in that way deals essentially with firm-level strategy and not with broader economic development.

In Porter's concept ,the activities of the firm can be broadly split into 'primary activities' and 'support activities', depending on the whole functioning (Figure 1). The primary activities include inbound logistics, which include sourcing of the raw material; operations which include conversion of the raw material into final products; outbound logistics which include system of distribution centres, wholesalers, retailers and consumers; services including trainings. The primary activities, either alone or in combination of them are essential for the firm to develop the competitive advantage for the value chain to be economically successful. On the otherhand, the support activities assist the primary activities in helping the organisation achieve its competitive advantage. They involve procurement including quality management; technology development to obtain competitive advantage with in the organisation including development of online facility; human resource management which includes recruitment, trainings, motivation, competitive advantage etc.; and, managing firm infrastructure, including managing finances, legal structure, and management structure. A co-ordination of all the activities are necessary for successful value chain development.

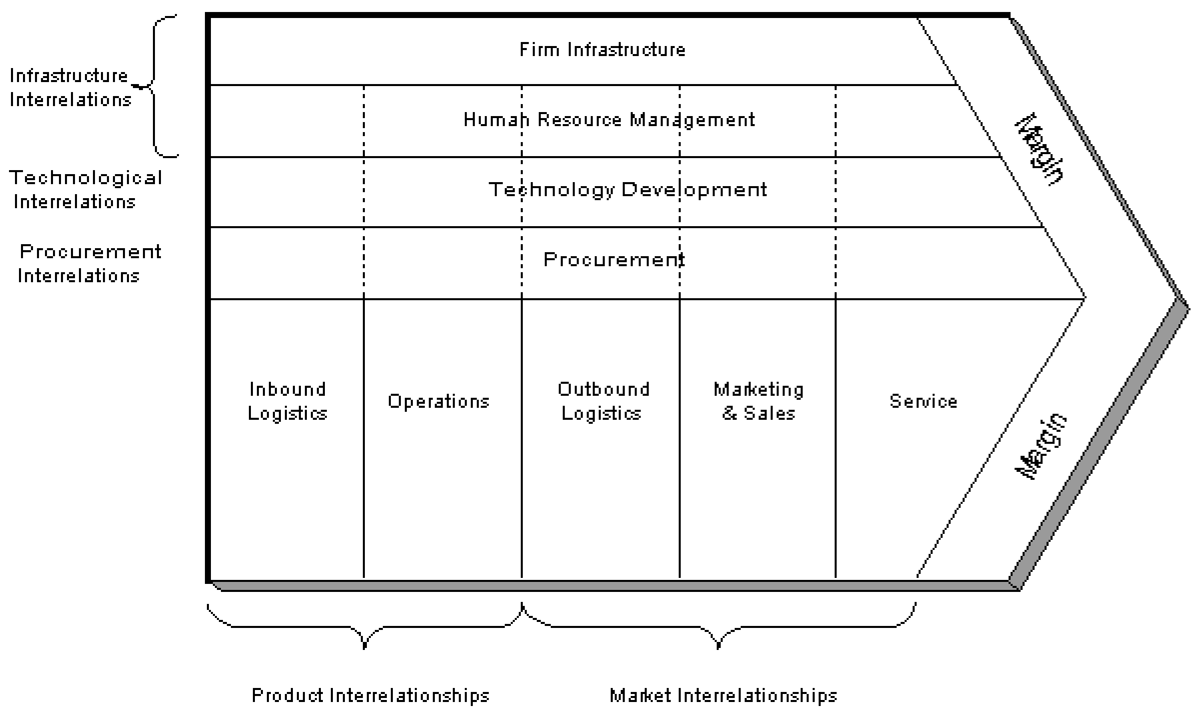

Figure 1: Michael Porter's value chain concept

Global Commodity Value Chain

On the otherhand, the global commodity value chain (GCV), as introduced by Gereffi and Korzeniewicz (1994), provides a developmental dimension, by introducing chain governance. The element of chain governance envisages how various firms across the entire chain are coordinated (or strategically linked) in order to be more competitive and add more value. Under this framework, the value chains are derived by the nature of demand from the final consumers and the process of globalisation.

The concept of global commodity value chain (GVC) shifts the focus of the analytical framework to demand side factors, compared to the supply side factors that are seen in case of Porter's value chain concept (Gereffi, 1994; Kaplinsky, 2000). This shift in the orientation of the value chain has been a result of the substantial influence that the global retailers wield over the food systems of the developing countries. The control is more forceful in those food commodities that undergo relatively low level of processing and therefore flexible. As the demand consideration varies across markets of different countries, primarily on account of different quality standards emphasised, the producing nation needs to take into account the cost of compliance. For example, the quality criteria prescribed by export markets like US is considerably different from that of Europe. This creates redefinition of markets according to quality criteria, and leads to an association which mutually reinforces quality and demand driven value chains. In such circumstances, the capability of the supplier to adhere to the quality prescriptions ceases to be a major consideration for the hegemonic retailers, and the sunk cost turns irrelevant. The cost of compliance could be prohibitively high for many firms, and the global hegemony of the retailers can be a critical factor that affects the sustenance of the value chain. One prime contribution of the global commodity value chain is the recognition of globalisation as a powerful economic phenomenon in determining food system performance and retailer hegemony as a prime factor that affect the value chain.

Sustainable food value chain

In recent times the value chain analysis has gained wide popularity, mainly to identify and prioritize the intervention points and development strategies for a sector. While the development economics has been focusing more towards the sustainability issues, value chain development literature has not addressed the issue of sustainability as the bottom line of developmental thinking (FAO, 2014). Of particular importance is how the value chain analysis addresses the issues of environment, economics and society at large. Further, the extant value chain framework is criticised for not being subjected to scientific scrutiny as well. The issues of food value chain are quite different from that of other value chain, as they have certain unique characteristics. Firstly, food is a social concern as it affects the health of all consumers, and, therefore, need to be subjected to larger public scrutiny. The factors like residential location of the consumers, habits and preferences related to food, place of origin, country of origin, form of food in terms of the extent of processing etc. have a strong impact on the nature of the VC. Second, the agricultural value chain in general and food value chain in particular affects the food and livelihood security concerns of large section of the population. This predisposes the value chain to larger political considerations. Third, the food value chain depends on the natural environment and, therefore, the costs needs to internalise the externalities out of the environmental factors (that are outside its reach). Four, the quality of food product is difficult to control, in terms of various parameters, and therefore, calls for institutional, organisational and technological interventions throughout the value chain.

The sustainable food value chain (SFVC) concept, as used by FAO, visualises an element of sustainability and applies it to specific nature of food production, value addition and distribution.

However, many services used in a single commodity approach are common to many agricultural products- for example, marketing, financing, information etc are used by many commodities, and therefore a more holistic approach would gain currency in the times to come. However, for analytical purpose, the concept of SFVC has to look into commodity chains, so as to delineate the broader trends, identify intervention points and estimate the impacts. The concept of SFVC is relatively newer one, and is largely developed by FAO. Consequently, this session largely relies on the concepts as provided by FAO (2014).

SFVC can be defined as the full range of farms and firms and their successive coordinated value-adding activities that produce particular raw agricultural materials and transform them into particular food products that are sold to final consumers and disposed-off after use, in a manner that is profitable throughout, has broad-based benefits for society and does not permanently deplete natural resources (FAO, 2014). The concept is comprehensive in term of number of actors and the activities undertaken, and takes into consideration the external environment and vertical coordination in some activities. Full range of actors include the direct actors who own each component of the business as well as those who participate in service provision, like credit, R&D, market intelligence and other support services. Further, the concept gives emphasis for ecology as well, as it visualises a non-declining natural capital stock. The core economic activity in the entire process is value addition, through various activities like processing, storing, grading, transporting etc. The major component of the value added can be captured under five head, viz. (a) Salaries for employees; (b) Net profit for asset owners; (c) Tax revenues; (d) Consumer surplus (e) Externalities . The externalities can be positive or negative, or a combination of both. The externalities are unintended effects caused by an economic agent, which are not internalised in terms of compensation, such as increased pollution, biodiversity loss etc (which are negative in nature); and increased water availability useful for the locality (which emerges as positive).

The behaviour and performance of farmers and other agri-food enterprises are determined by a complex environment. The central element of the framework is the value chain actors, who form the core value chain. They represent those who produce or procure from the upstream level, add value to the product and then sell it on to the next level (FAO, 2014). The value chain actors could either be private sector enterprises (as in most cases) or public-sector as in case of Food Corporation of India (who collects foodgrains for buffer stocking as well for distribution through PDS outlets). In a value chain several such agencies can co-exist, who bears striking difference in terms of the size, technology, goals etc., catering to a multiple market segments.

The chain distinguishes four core functions (links): production (e.g. farming or fishing), aggregation, processing and distribution (wholesale and retail). Each of these steps involves costs, which vary depending upon the participants in the value chain. In a small holder dominated agrarian economy, aggregating and storing poses challenges, and will not allow economies of scale, and therefore may be costly. Institutional intervention, in terms of farmer's collectives or producer organisation can be a good option at these levels. Many agencies, including aggregators, distributors, processors etc can be a major actor at this point of time.

In the entire core value chain activities, the major element is value chain governance structure. It refers to the nature of linkages between various actors- both vertical and horizontal. The value chain governance involves various core activities/ functions such as payment mechanisms, price determination, information exchange, market power, wholesaling etc. The value chain governance in that sense is a function of technology development, the extent of market imperfection, and rules and regulatory framework.

The support providers helps the value chain actors by providing essential roles that helps value creation by value chain actors. The SFVC visualises three kinds of support services

a. Physical input suppliers (such as seeds, irrigation, chemicals, ice, packaging materials etc.) at different levels of activity
b. Supply non-financial services (include transport, quality checking, market research, trainings, etc)
c. Financial services (Provision of capital in terms of credit, which requires growth of the banking systems).

The support system can arise from the public sector, private sector, NGOs, civil society organisations, farmer organisations etc. In some cases, all the services could be provided by a single agency, as a package. For example, many input dealers provide all the services together to the farmers, which may even to extent a buyback arrangement, not necessarily of a contract farming nature. In some cases the aggregator of the producer would be providing these services as a package along with the extension inputs.

Societal and natural environment

The external environment- like society and natural conditions- exerts significant influence on the functioning of the value chain. The societal elements can be broadly classified into four types, viz informal socio-cultural elements (like religious requirements), formal institutional elements (like regulations, laws and policies), organisational elements (like educational facilities) and infrastructural elements (like roads, ports, communication networks etc) (FAO). The value chain operates in an enabling environment shaped by the domestic and international policies. The value chain which caters to the export market is influenced by the international environment more strongly compared to the one which caters more to the domestic consumers. The food safety regulations including CODEX Alimentarius, HACCP etc prescribed by the importing countries are costly and cost of compliance is higher. The certification procedures are tedious and needs international collaboration and verifications.

Interaction of economic, social and environmental elements

The sustainability of the value chain is determined by the economic, social and environmental elements. A value chain is considered economically sustainable if the required activities at the level are economically viable and or profitable. However, the outcome of the economic activity needs to be socially and culturally acceptable to characterise it to be socially sustainable. The environmental sustainability is attained largely if the value chain activities doesn't impact the environment adversely and maintains a non-declining natural capital stock.

Principles of sustainable food value chains

Though each food value chain is unique, the sustainable food value chain is characterised by 10 interrelated principles, as noted below:

a. Economically sustainable: Commercial viability, competitiveness, growth etc. The upgraded VC should provide higher profits, income etc.
b. Socially sustainable: Inclusiveness, equitability, social norms, social institutions and organizations. Generation of greater share of value (profit and wage income) to the poor, broad-based, and equitable distribution along the VC, with no adverse effect on the poor.
c. Environmentally sustainable: Non-declining natural capital stock, for inter-and intra-generational equity. Minimise environmental footprint (water footprint, carbon footprint etc) is an issue.
d. Dynamic and system based: VC is dynamic due to changes in market demand, technology, available services, profitability, risk, barriers to entry, large-firm behaviour, input supply and policy etc. VC needs to be adapt to changes. Sub-systems are linked, and identifying root cause in the system is the solution to improve.
e. Governance centred: Needs to analyse how value chain actors of different typology transact vertically and how they collaborate horizontally. The governance needs to bring in win–win solutions, and impart element of trust among the value chain actors.
f. End-market driven: The value is ultimately determined in the end-market when consumers purchase the product/service; and therefore consumer analysis needs to be the starting point for the VC improvement.
g. Vision/strategy driven: to be successful, the actors have to carefully target development goals and stakeholders. The strategies need to revolve around a vision which is realistic, quantifiable (as far as possible) and targeting (as far as possible) selected stakeholders. The improvement of VC should focus on that area where where largest impact is possible.
h. Upgrading focused: It requires carefully assessed and innovative upgrading activities to translate a vision and strategy into an effective plan. The upgradation can be in the form of technology, organisation, institution, network etc.
i. Scalable: The VC upgrade allow replication process that is based on realistic assumptions.
j. Multilateral: It requires that the driver of the process of VC upgradation is private sector as driver and the other agencies (public sector and civil society organisations as facilitators

The fisheries sector has grown in real term at a growth rate of 6.2% per year between 2004-05 and 2015-16. The differential growth rate in inland and marine sectors has led to increased share of inland fisheries, with an element of convergence of the growth. Both public and private sector has contributed to this growth story in terms of quality inputs, technology and extension services. Further growth has to be brought through enhanced expenditure on fisheries research, education, and extension in all aspects of the value chain along with infusion of capital. Suresh et al (2018) has highlighted the need to prioritize the sectors to infuse capital, while achieving high level of efficiency. Focusing on harvest and post-harvest operations are critical in achieving higher value and income to the stakeholders. Overall, further growth in fisheries has to be achieved through careful prioritization with regard to sub-sectors, investment on research and development of infrastructure including markets.

Sustainable Marine Fishery Value Chain in India

The concept of sustainable value chain is much applicable in fisheries sector. The sector provides livelihood to about 15 million people in India either directly or indirectly. The marine capture fishery sector in India has shown a deceleration in the growth performance, mainly on account of decline in stock reported to be due to several factors including climate change and over fishing. The participants in the value chain include traditional, motorised and mechanised sectors. The fish produced caters to the domestic market mostly in fresh form and export markets in processed form. Fish export is a major foreign exchange earner in India, and therefore are affected by national and international policy and political changes. The transmission of price signals affects the fish capture and processing. The high income incentives of capture fisheries and its processing have attracted investments in the sector. This has led to over-capitalisation, and consequentially over-extraction and stock depletion.

In order to address the sustainability issues of marine capture fisheries, large scale mechanised trawl fishing is banned for certain period during the breeding season of some fishes. This would have negative impact on certain stakeholders, including the labourers who are engaged in certain associated activities, but would have beneficial effect on catch and income in a sustainability perspective.

The domestic and international regulations on fishing, processing and quality control have significant influence on fish value chain, starting from production to waste disposal. Since fish is liable to quick perishability, it is subjected to strict quality controls adhering to stringent norms. The cost of compliance with the extant and emerging quality control norms is capital intensive, and therefore warrants institutional support and handholding in human resource development in the form of acquiring necessary skills. In the whole value chain, one of the major concerns is the extent of benefits accruing to the fisherman, the labourers involved, and, their linkages with the support system.

Entrepreneurship opportunities in marine fishery sector in the sustainable value chain framework

In the context of the evolving concept of sustainable food value chain, the marine fishery sector offers wide opportunity for entrepreneurship development. They include the realms spanning across Harvest and post-harvest technologies, vessel manufacturing/ servicing units, net fabrication and maintainance units, new and improved fish culture methods, Ornamental fishery, seed production technologies, development of detection/ diagnostic kits, waste utilization technology, byproducts development, quality management and test laboratories, processed food products including ready to eat and ready-to-cook product, development of machines for descaling fishes, fish feed manufacturing units, consultancy services, quality management, food packing material manufacturing, input supply, and other support services. The business incubation centres of ICAR-CIFT handholds the establishment of these units and provide technical services. Various government schemes including start-ups, make in India programme etc. provides financial services. NABARD provides financial help though various programmes SHG-Bank linkage, micro-finance and through Farmer Producer Organisations/Companies. A dynamic business leadership can effectively utilize the favorable ecosystem for formation of successful fishery based enterprises.

Further Suggested Readings

FAO (2014) Developing Sustainable Food Value Chains- Guiding Principles, Rome

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Chapter 6

Nutraceuticals from fish and fishery waste

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Introduction

World over in the recent past, research in nutraceuticals has shown continuous growth and the progressive approach is aimed at identifying the potential nutraceutical compounds which are having health benefits in human beings. Awareness among the people is the prime reason for the growing demand for nutraceuticals. Today people are more aware about the nutrition and related health problems. Recently, researchers across the globe are exploring the possibilities to extract and isolate bio-active compounds from both terrestrial and marine sources.

Nutraceuticalis a combination of two words, “nutrition” and “pharmaceutical,” and the word nutraceutical was coined by Stephen L. DeFelice in 1989 (Wildman *et al*., 2006). Nutraceuticals are food products of natural origin from both terrestrial and marine sources having healthcare importance. The word nutraceuticals comprise of variety of products derived from terrestrial and marine sources (isolated nutrients, dietary supplements, and genetically engineered designer foods, herbal products, processed foods, and Beverages). Recent report says that nutraceuticals provides a positive healthcare approach with tremendous therapeutic impacts on human body (Das *et al*., 2012; Bagchi*et al*., 2015). The nutraceutical industry has identified a wide range of phytochemicals described as phytoestrogens, terpenoids, limonoids, glucosinolates phytosterols, polyphenols, carotenoids, flavonoids, isoflavonoids, and anthocyanidins having therapeutic effects on human health as antioxidants, anti-inflammatory, antibacterial, anti-allergic, anti-fungal, chemopreventive, immunomodulatory etc., (Gupta and Prakash, 2014; Karwande and Borade, 2015).

Classification of Nutraceuticals

Based on the bio-functional properties of bioactive compounds from terrestrial and marine sources are classified in to following –

1. Dietary Supplements
2. Functional foods
3. Medicinal food

Dietary Supplements

According to the Dietary Supplement Health and Education Act (DSHEA), 1994 in USA, dietary supplements are defined as products comprised of “dietary constituents” and orally administered to supplement the nutritional requirement of diet. The “Dietary constituents” refers to bioactive components comprising of amino acids, vitamins, minerals, fibres, important metabolites, and certain enzymes. The dietary supplements also include extracts available in tablets, capsules, powders, liquids, and in any other dosage form (Radhika *et al*., 2011).

Functional Food

Functional foods are foods derived from natural origin enriched in nutrients and are being fortified with essential nutrients (Jones, 2002). As per the Health Canada, functional food defines a regular food with an ingredient having specific therapeutic effect along with nutritional value (Wildman *et al*., 2006). Whereas in Japan, functional foods are assessed on the basis of three important standards: (1) functional foods must be derived from natural sources and consumed in their native state instead of processed in different dosage forms like tablet, capsule, or powder; (2) consumed regularly as a part of daily diet; and (3) exert a dual role in prevention and management of disease and contribute in biological processes (Arai, 1996).

Medicinal food

Medical foods are foods that are specially formulated to be consumed internally under the supervision of a physician, which is intended for the dietary management of particular disease that has distinctive nutritional needs that cannot be met by normal diet alone. Dietary supplements and functional foods do not meet these criteria and are not classified as medical food. (Radhika *et al*., 2011).

Nutraceuticals from marine sources

Chitin and chitosan

Chitin, a cationic amino polysaccharide, is a natural biopolymer composed of *N*-acetyl-d-glucosamine with β $(1 \rightarrow 4)$ glycosidic linkages. The term chitosan is used when nitrogen content of chitin is more than 7% by weight or the degree of deacetylation is more than 60% (Peter *et al*., 1986; Gagne and Simpson 1993). Chitosan is a biopolymer and it consists of d-glucosamine units obtained during the deacetylation of chitin by adopting hot alkali treatment. Chitin and chitosan can be obtained from the bio-waste generated from both terrestrial and marine sources. Chitin is abundant in the marine organisms like lobster, crab, krill, cuttlefish, shrimp, and prawn. The extraction of chitin form marine source comprises of thee-steps: deproteinization (DP), demineralization (DM), and decolorization (DC). Further, chitin has to undergo a de-acetylation process to obtain chitosan. Chitin is known for its unique properties like, biodegradability, nontoxicity, physiological inertness, antibacterial properties, hydrophilicity, gel-forming properties (Se-Kwon, 2010). In India, a few entrepreneurs are producing chitin and chitosan on a commercial scale under the technical guidance of the ICAR-Central Institute of Fisheries Technology, Cochin. In-line with chitin, chitosan also finds extensive application in multidimensional sectors, such as in food and nutrition, biotechnology, material science, drugs and pharmaceuticals, agriculture and environmental protection, dental and surgical appliances, removal of toxic heavy metals, wine clarification, industrial effluent treatment, etc. (Se-Kwon, 2010).

Glucosamine Hydrochloride

Generally, glucosamine is obtained from the crustacean waste (Xu and Wang, 2004; Tahami, 1994). Glucosamine is part of the structural polysaccharides such as chitosan and chitin, which is present in the exoskeletons of crustacean and other arthropods. Though, glucosamine was discovered long back, market for glucosamine has gained popular interest due to its health benefits. Dietary supplementation of glucosamine (glucosamine sulphate, glucosamine hydrochloride, or N-acetyl-glucosamine) is proven to promising biomolecule for the treatment of osteoarthritis, knee pain, and back pain (Houpt*et al*., 1999; Luo *et al*., 2005). It is also known for its unique properties like anti-cancer, anti-inflammatory and antibacterial effects (Nagaoka *et al*., 2011).

Chondroitin sulphate

Chondroitin sulphate (CS) consists of repeated disaccharide units of glucuronic acid (GlcA) and *N*-acetyl galactosamine (GalNAc) linked by β-(1→3) glycosidic bonds and sulfated in different carbon positions (CS no-sulfated is CS-O). Shark cartilage is found to be a good source of chondroitin sulpahte. Chondroitin sulfate plays various roles in biological processes such as the function and elasticity of the articular cartilage, hemostasis, inflammation, cell development, cell adhesion, proliferation and differentiation by being an essential element of extracellular matrix of connective tissues (Schiraldi *et al*., 2010).

Hyaluronic acid (HA)

HA can be obtained from the bio-waste like fish eyeball and it is also present in the cartilage matrix of fishes. HA finds several biomedical applications *viz.*viscosupplementation in osteoarthritis treatment, as aid in eye surgery and wound regeneration. Further, hyaluronic acid finds its applications in drug delivery, tissue engineering applications, gene delivery applications, targeted drug delivery, tumor treatment, environmental applications and sensors (Mathew *et al*., 2017).

Collagen, gelatin and collagen peptides

Fish skin and scales which constitutes about 30% and 5% of the total seafood processing discards respectively are considered as the richest source for collagen and gelatin. Collagen derived from marine sources is finding wide applications in various sectors due to its biocompatibility, biodegradability, high cell adhesion properties and weak antigenicity (Yamada *et al*., 2014). Another major application of collagen is to act as a source for extraction of collagen hydrolysates, peptides, gelatin and gelatin peptides. Collagen peptides are reported to have bioactive properties like antioxidant, antimicrobial, antihypertensive, metal chelating, tyrosinase inhibitory, immunomodulatory, neuroprotective, antifreeze, wound healing, cell-proliferation, activities (Zhuang *et al*., 2009; Chi *et al*., 2014).

Gelatin, the denatured form of collagen, by virtue of its surface active properties finds extensive applications in food, pharmaceutical and biomedical industries. Gelatin peptides are reported to have antihypertensive, antioxidant properties. The major difference between fish and mammalian gelatin lies in the iminoacid composition, viz, proline and hydroxyproline contents. (Mathew *et al*., 2017).

Fish lipids

Across the globe the researchers have well documented the health beneficial effects of long chain omega-3 polyunsaturated fatty acids (PUFA) (Connor, 2000). The major omega-3 PUFA, such as eicosapentaenoic acid (EPA C20:5) and docosahexaenoic acid (DHA C22:6) are very much essential for human beings, and hence are considered as essential fatty acids. The intake of long chain omega-3 PUFA is promoted by many health organizations owing to the health benefits associated with it. An average intake of 0.2 g and 0.65g of EPA and DHA a day is recommended by the European Academy of Nutritional Sciences (EANS) and International Society for the Study of Fatty Acids and Lipids (ISSFAL) respectively (Dedeckere, *et al*., 1998). Fish oil remains as an excellent and economical source of omega-3 PUFA. Having high contents of fat soluble vitamins and lipids, especially EPA, cod liver has been exploited as an omega-3 PUFA source for development of nutraceuticals (Mondello*et al*., 2006). Dietary consumption of fish oil (omega-3 PUFA) in adequate quantities is reported to have health benefits in the treatment of cardiovascular diseases, cancer, hypertension, Alzheimer's disease, diabetes, arthritis, autoimmune disorders and to improve overall functioning of brain and retina (Cole *et al*., 2009).

Squalene

Squalene, a naturally occurring triterpenoid compound, is an intermediate in cholesterol synthesis. It is widely present in nature, such as wheat germ, rice bran, shark liver and olive oils and among all the sources identified, shark liver oil is considered to be the richest source accounting for about 40% of its weight. Recently, the squalene has gained attention due to its diverse bioactivities such as antioxidant, anti-lipidemic, membrane stabilizing, cardioprotective, chemopreventive, anti-cancerous, antiaging properties etc (Passi*et al*., 2002; Ko *et al*., 2002). Further, it is also reported to protect human skin surface from oxidation (Kabuto *et al*., 2013). Based on its diverse bio-active properties, squalene finds applications in field of biomedical, cosmetic, drug delivery systems and even in food industries.

Minerals

Marine organisms especially fish are considered as important source of minerals such as sodium, potassium, calcium, phosphorous and magnesium. Fish bone which is often discarded after the removal of protein is an excellent source of calcium and hydroxy apatite. Being rich in minerals, fish bone powder can be fortified into several food products. However, for fortification, the fish bone should be converted into an edible form by softening its structure by pre-treatment with hot water or hot acetic acid or superheated steam. Calcium powder processed from the backbone of tuna is a potential nutraceutical. It can be used to combat calcium deficiency in children. Fortification of calcium in foods helps consumers in meeting the calcium requirements and may reduce the risk of osteoporosis. Other than fish bone calcium, certain other minerals such as selenium, potassium, iodine, zinc, magnesium are more abundant in seafood than in meat. The higher intake of seafood diet will also ensure that adequate amount of iodine is obtained.

Nutraceutical industry in India: Current scenario and future trends

During the year 2015, global nutraceutical industry, valued at US$ 182.6 billion and is one of the fastest growing industries today and expected to grow at a Compound Annual Growth Rate (CAGR) of 7.3% from 2015 to 2021. As on today, the United States, Europe and Japan account for about 93% of the total global nutraceutical market and seems to have attained maturity in all three major regions. Hence, nutraceutical industries across the world are now showing their interest to emerging markets like India and China. Nutraceuticals industry in India is one of the rapid growing markets in the Asia-Pacific region. As per the record, the nutraceuticals industry in India is worth about US$ 2.2 billion and is expected to grow at 20% to US$ 6.1 billion by 2019-2020.

Innovative work done at Central Institute of Fisheries Technology, Cochin

By adopting grafting and micro-encapsulation technology, ICAR-Central Institute of Fisheries Technology, Cochin has developed some of the nutraceuticals products, such as thiamine and pyridoxine-loaded vanillic acid-grafted chitosan microspheres; sardine oil loaded vanillic acid grafted chitosan microparticles; microencapsulated squalene powder; vanillic acid and coumaric acid grafted chitosan derivatives; thiamine and pyridoxine loaded ferulic acid-grafted chitosan. These nutraceuticals products were shown to have health beneficial and immunomodulatory response in animal models.

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Chapter 7

Assessment of harvest and post-harvest losses in fisheries and aquaculture

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Introduction

Indian fisheries and aquaculture is an important sector of food production, providing nutritional security to the food basket, contributing to the agricultural exports and engaging about fourteen million people in different activities. The total fish landing during 2018 was 34.9 lakh tons worth approximately Rs.57510 cores. India's marine product exports was 13.77 lakh tons earning 7.08 US billion dollars during 2017-18 which underlines the importance of the sector. Studies have pointed out that considerable harvest and post-harvest losses occur all along the fishery value chain through the various channels of distribution. Huge losses occur along the fish value chain, both in terms of quantity and quality due to discards at sea, improper handling, storage & icing, lack of cold chain facilities and delay in transportation. Reducing harvest and post-harvest fish loss will enable money saving for the primary producer, enable the sector to feed more and ease the pressure on water, land and climate. Ensuring proper cold storage facilities along the value chain, climate smart processing and packaging, value addition, technology interventions in transportation to avert spoilage can bring down post-harvest losses from 10 to 50% in the fisheries sector.The inland fisheries covers the brackish and freshwater systems with aquaculture practiced and managed in ponds and fields connected to natural resources. The fish landing sites are numerous and remote in interior parts of the country sometimes inaccessible. Delay in transport, non-availability of ice for proper storage brings down the price of freshwater fishes in the markets which is an economic loss for the primary producer.

The resources once harvested has to be managed and utilized judiciously to derive the maximum benefit and sustain the livelihoods of lakhs of stakeholders involved along the fishery value chain. For an assessment of the extent of harvest and post-harvest losses in marine and inland fisheries at the National level, sound statistical estimates have to be computed. The changes in fisheries sector with reference to technology advancements have led to a changed definition of 'losses' which has been accepted by researchers worldwide. Therefore, assessment of harvest and post-harvest losses gains importance when formulating effective strategies for wholesome utilization of fish and fish products.

Fish losses

Loss per se is defined as the quantity of marine fish which is not fit for human consumption due to physical loss or spoilage of some other reason. Losses at the time of harvesting and onboard the fishing craft are called harvest losses and losses occurring after harvesting *i.e.* from the landing centre up to the consumer at different stages are called post-harvest losses. Literature classifies Post-harvest losses broadly into three categories –

- ✓ Physical loss
- ✓ Quality loss

- ✓ Market forced loss

Post harvest losses occur due to improper handling and lack of infrastructure at different points starting from the landing centre to the consumer. Apart from these, there are latent losses such as realization of low value due to glut, multi-day fishing etc.

Discarding takes place because, in the course of fishing, many species other than the target species are often caught. This by-catch is usually discarded at sea unless it is worth keeping. Discarding by-catch consisting of a small proportion of mature specimens from healthy stocks causes relatively little damage, but when it consists of juveniles of commercial species it will disturb the balance of the system. Catching large numbers of juveniles is likely to reduce the future number of mature fish. This will have a direct impact on the fishery taking the by-catch, or on other fisheries if the juveniles belong to their target species.

Apart from the loss of a massive amount of potentially valuable food, the incidental capture of dolphins in tuna purse seine nets, turtles in shrimp trawls and marine mammals, birds, turtles and fish in high-seas squid driftnets has led to widespread public concern. Unfortunately, by-catches are an inevitable consequence of an industry that depends upon the capture of species that live alongside other creatures in an opaque medium and as a result can seldom be directly observed and targeted.

By-catch arises primarily because of fishing gears and adopting practices which do not selectively target the desired size and species. The reason for discarding part of the catch is generally economic. In such cases the cost of bringing fish to market is greater than its market value and it gets dumped at sea. Similarly, where a fishing vessel has limited holding capacity, low-value species are discarded in favour of the high-value ones.Introduction of improved harvesting methods, starting from mechanization, indiscriminate increase in fleet size and number, multi-day fishing, use of unregulated mesh sizes have all led to imbalance in several forms and threatening of food security. In tropical countries, high temperatures lead to fish spoilage while still in the boat, at landing, during storage or processing, on the way to market and while waiting to be sold. There is also considerable economic loss as value gets lost because of lower quality, including insect infestation and breakage.

Several studies have been conducted in the recent past for the assessment of extent of harvest and post-harvest losses in fisheries. As early as 1981 FAO recommended action to reduce post harvest losses in marine fisheries- estimated at that time to be 10 percent of the global total, and up to 40 percent in some developing countries. Studies were conducted at CIFT, Cochin on 'Assessment of harvest and post-harvest losses in fisheries' through a NATP funded project . The percentage loss due to harvest through traditional, motorized, mechanized and large trawlers has been put at 4.13, 3.61, 14.48 and 21.41 respectively within the craft/gear (Anon., 2005). The study has also assessed post-harvest losses in fisheries in different channels viz., market, pre-processing and processing and reported the percentage loss through each of these channels. Losses can be physical, economical and nutritional and can be minimized by adopting suitable post-harvest technology (Johnson and Ndimela, 2011).

Ahmed (2008) has assessed post-harvest losses of fish in Sudan with special emphasis on cultural and socioeconomic aspects including traditional food conservation; economic factors for food conservation and cost-benefit; assessment of the effect of globalization and liberalization of food markets and the fish trade in artisanal fisheries. Ward, A. (1996) developed methods to quantitatively assess post harvest fish losses and to understand and identify the causes in qualitative sense. Adams, (1995) advocates Individual Fishing Quota (IFQ) system where fishermen can be selective about factors as fishing depth, bottom substrate, or time of day, month or year. These factors are directly related to incidental halibut by catch mortality. Clucas, et. al. (1989) reported 20% post harvest losses of annual fish production of about 13.5 lakh tonnes by 16 ECOWAS countries of West Africa. Similar figures were observed in the artisanal fisheries sector that contributes about 90% of the total catch.

Estimation of losses in fisheries

A recent study completed at CIFT, Cochin attempted to estimate harvest and post-harvest losses in marine fisheries. Ernakulam and Alleppey districts were covered for the study. The estimation was carried out at the two stages harvest and post-harvest stages using stratified random sampling design. The channels of fish production namely mechanised, motorised and traditional formed the various strata at the harvest stage, In the post havest stage, losses occurring at landing centre, processing, marketing and transportation sectors were observed. The study was conducted for a full fishing season to observe loss pattern during monsoon, pre-monsoon and post-monsoon seasons. Around 1 to 3% sampling was done in the harvest stage whereas for the post-harvest study, the samping done was from 10 to 30% for the various channels.

In the processing channel, the pre-processing centres and fish processing centres in Ernakulam and Alleppey district were covered by using of a sample. The losses occurring in marketing sector was studied in the wholesale markets, retail markets, roadside markets were covered for the study. The dryfish production and marketing channel was also studied by means of a sample for recording losses occurring in the dryfish sector. The estimates were computed using methodology derived by IASRI for loss estimation (Anon., 2005).

Harvest losses in marine fisheries was estimated from Ernakulam district by stratifying fishing crafts into mechanized, motorized and traditional. Primary data on fish catch and losses was collected for 12 months from fishing crafts operating in six selected fish landing centres at Ernakulam. Loss estimates were computed analyzing the season wise data and pooled data. The sector wise harvest loss estimates are as under :

<u>Harvest losses</u>

Sector	Pre-monsoon (%)	Post-monsoon (%)	Monsoon (%)	Overall (%)
Traditional	1.93 (0.43)	0.98 (0.37)	0.83 (0.28)	1.14 (0.28)
Motorised	3.45 (0.54)	2.76 (0.13)	4.38 (0.53)	3.65 (0.17)
Mechanised (upto 7 days fishing duration)	12.74 (1.23)	11.09 (0.11)	9.11 (0.05)	14.15 (2.10)
Mechanised (more than 7 days)	13.78 (1.24)	14.98 (1.35)	13.35 (1.32)	18.73 (2.22)

Multiday fishing by the mechanized trawlers reported maximum loss due to capture of juveniles and their discards. Around 1500 to 2750 kg of fish gets discarded at sea by trawlers during fishing trips for more than 7 days duration. The no. of hauls during fishing and loss was positively correlated (0.69) at 5% level of significance. The estimate of loss due to mechanized fishing was computed by utilizing information on no. of hauls which was more precise than the traditional estimator. The losses due to motorized fishing crafts was very less in comparison with trawlers. The traditional fisheries sector reported minimal or no loss during the period.

Post-harvest losses

The post-harvest losses in marine fisheries (at the landing centre level) was estimated as below :

Sector	Loss % (SE)
Traditional	0.09 (0.0004)
Motorised	1.19 (0.07)
Mechanised	4.79 (1.09)

The loss estimates when compared with the estimates brought out by earlier studies indicate that the post-harvest losses have come down due to efficient handling of catch. The post-harvest losses in processing and marketing sector was also computed from Ernakulam-Alleppey during the period under report. For reporting loss in processing sector, 50 pre-processing units and 25 processing units were observed and data on raw material processed and loss were recorded fortnightly. Shortage of ice and spoilage were cited as the reasons for loss in pre-processing. At the processing stage, losses occurred due to discolouration, broken tentacles, black spot and at time loss during glazing. Few units reported rejections at export destination due to heavy metal detection.

Losses in the marketing sector was due to damage during transportation, spoilage when delay in transport and weather. Two wholesale markets for fresh fish and one wholesale market for dry fish were covered fortnightly for recording losses due to marketing. Similarly 4 retail markets were surveyed fortnightly of reporting loss in retailing fish. The estimates for post-harvest losses due in processing and marketing are given below :

Post-harvest losses in marine fisheries

Sector	Loss % (SE)
Pre-processing	0.38 (0.04)
Processing	1.19 (0.07)
Dry fish production	36.97 (12.88)
Wholesale market (fresh)	3.79 (1.09)
Wholesale market (Dry)	7.56 (2.12)
Retail market (fresh)	3.13 (0.02)
Retail market (Dry)	8.23 (0.13)
Roadside market (fresh)	2.54 (0.11)
Roadside market (dry)	5.43 (1.19)

The reasons for losses were also recorded along with the loss details.

Harvest losses were mainly due to i) Fish fall from net ii)Bruising due to handling iii) Fish spends too long in the net and gets spoiled iv) Lack of ice / Chilling causing spoilage

The reasons for post-harvest losses -

At landing centre the post harvest losses occurred while (i) loading for transport, (ii) kept in the beach without sufficient ice. During the processing of fish when there is a low capacity in the plant fish procured for processing gets spoiled leading to losses. Also adverse weather conditions while drying and insect infestation lead to post-harvest losses

The reasons for post-harvest losses during transport, storage and marketing are listed as under :

Transport

i) Mechanical damage
ii) Delay in transport

Storage

i) Poor storage
ii) Insect infestation

Market level

i) Insect infestation
ii) Packaging
iii) Mode of transport
iv) Handling

A look at the loss estimates reveal that the fish loss in the mechanised fishing sector is more compared to the other sectors. Multi-day fishing leads to larger volume of discards at sea which has inflated the estimates. Use of stipulated mesh sizes to avoid juvenile fishing, use of by-catch reduction devices, utilisation of low value fishes for innovative product development and waste utilisation for production of fish based feed and manure will help reduction in harvest and post-harvest losses in fisheries. Training and awareness programmes on the responsible fishing methods developed by CIFT among the merchandised fishermen will check discards at sea. Under NAIP value chain project at CIFT, Cochin a number of innovative technologies for value addition from low value fishes were developed and demonstrated as viable business models for adoption by coastal fisherwomen. Popularization of these technologies along the coastal belt will enhance the income and livelihood of the fisherfolk.

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Chapter 8

Entrepreneurship development with a special focus on fisheries

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While talking about entrepreneurship, I remember the quote "Only the paranoid survive." ***By Andy Grove, former CEO of Intel.***

Entrepreneurship, according to Onuoha (2007), "is the practice of starting new organizations or revitalizing mature organizations, particularly new businesses generally in response to identified opportunities." Schumpeter (1965) defined "entrepreneurs as individuals who exploit market opportunity through technical and/or organizational innovation". But the most popular definition being "entrepreneurship is about taking risk" by Frank H. Knight (1921) and Peter Drucker (1970). *What is the risk in entrepreneurship?*

In one word it is Money..its all about losing money and the bitter consequences of it at individual, family and societal level, and at a broader sense at national level. But still entrepreneurship is the most widely discussed and topic catching attention of economists world over, because of its potential for economic growth, job creation, and regional and national competiveness.
Is there something called Entrepreneurial behaviour?
Entrepreneurial behaviour has been defined as the study of human behavior involved in identifying and exploiting opportunities through creating and developing new ventures (Bird &Schjoedt, 2009). Entrepreneurial behavior is also increasingly recognized as a proponent to social change and facilitating innovation within established organizations (Kuratko, Ireland, Covin, & Hornsby, 2005). There is a belief that it's the entrepreneurial behaviour of people in a Country which decide the initiation and growth or sustainability of entrepreneurship there.

A Special Issue on Entrepreneurial Behavior emphasizes the importance of refocusing research attention towards concrete and observable human action in venture and organizational creation and emergence (Bird, Schjoedt, & Baum, 2012).

Although entrepreneurs in different countries usually share some universal traits, they may also have other traits that are specific to their own culture. For example, entrepreneurial activity is encouraged as an avenue to stimulating economic growth and empowering marginalized segments of population in less-developed countries (Yasin, 1996).

Why to think of enterprises in food processing sector?- The case of India
According to Ministry of Food Processing:

- The **Indian** gourmet **food market** is currently valued at US$ 1.3 billion and is growing at a Compound Annual Growth Rate (CAGR) of 20 per cent. **India's** organic **food market** is expected to increase by three times by 2020. The online **food** ordering business in **India** is in its nascent stage, but witnessing exponential growth.
- Its 350 million strong urban middle class with its changing food habits poses a huge market for agricultural products and processed food.
- Food processing industry will show the annual growth of 40-60% in next five years

Need for Value addition

- Value addition of food products is expected to increase from **8 per cent to 35 per cent by 2025**
- **86% of households** prefer to have instant food due to steep rise in dual income level and standard of living, convenience, and influence of western countries.
- The Food & Grocery market in India is the sixth largest in the world. Food & Grocery retail market in India further constitutes almost 65% of the total retail market in India.
- By 2020, Indian Food and Retail market is expected to touch $ 828.92 bn
- Consumer spending rate on processed food had increased **7.6% (2008 to 2010)**

World over, the entrepreneurship development, especially based on value addition, is paid huge attention. The Global Entrepreneurship Development Index(GEDI) methodology collects data on the entrepreneurial attitudes, abilities and aspirations of the local population and then weights these against the prevailing social and economic 'infrastructure' – this includes aspects such as broadband connectivity and the transport links to external markets. The share contribution form a sector to the **State Value Added(GVA) is also taken as an important indicator rather than Gross Domestic Prodect(GDP).Gross Value Added**(**GVA**) measures the value added to the goods and service i.e it quantifies the productivity of the economy

Value addition of fish for entrepreneurship

Fisheries being an important sector contributing to the country by way of providing quality protein to the people there, employment, and export earning, the revenue generation from value addition of fish is also important.Fish is the source of best source of animal protein and any food out of fish is now considered a health food. This indicates the scope of value addition of fish and staring enterprises based on that. This will become again attractive, when the opportunities are made accessible for the primary producers, the original custodians of the resource.But a highly perishable commodity, fish require scientific approach for the value addition and building its value chain extending to ultimate consumer. The resource, the technology, the final product, the packaging , pricing etc , in nutshell the business model, should be decided according to the market opportunity and identifying the market demand.

The products range various processed ready to cook and ready to eat products to live fish. But in any entrepreneurship development process, the enterprenuer has to go through different stages which may vary according to the innovation, type of market, skill levels, state support, legal parameters an dofcourse the entrepreneurial potential of thepaerson or the group.

Accoding to Barraza Carols, Entrepreneurship has four stages

- **Innovation**

Generating the idea, innovation, identifying a market opportunity, information search, conception, screening ideas for feasibility, identifying where to extract value and the development of the product or service.

- **Triggering event,**

gestation, the motivation to start a business, the decision to proceed, the business planning, identifying the different resources required, risk assessment, resource acquisition and assembling.

- **Implementation**

infancy, incorporation, setting up and launching the new venture, business strategy, implementing the business plan, running the business, deploying of resources, building success and managing the venture.

- 4. **Growth**

adolescence, maximizing profits, harvesting the rewards and continually growing the venture to include other opportunities

Accordingly, in the fish based enterprises also, one should understand the fish value chains existing in the locality, both in inland as well as marine sectors and identify the right opportunity. The screening of market opportunity as well as identification of suitable innovation is of equal significance. The length and the type of processes involved in the fish value chain vary based on the markets involved. The vulnerabilities also should be kept in view.

The undulations in availability of resource as well as the price is the major challenge. At the same time, Technology developments in fish processing sector offer scope for innovation, increase in productivity, increase in shelf life, improve food safety and reduce waste during processing operations(Ninan,G). One has to be a dreamer, a thinker and at the same time a street smart to become an entrepreneur. The opportunities are immense, but challenges also plenty. Hence, as Jessica Herrin, founder and CEO of Stella & Dot told, "You have to see failure as the beginning and the middle, but never entertain it as an end." -

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Chapter 9

The Antimicrobial Resistance (AMR) in Fisheries: Present scenario in National Action Plan in ITEC participating countries

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A perusal of world population and other demographics indicate that: The world population as on 15th February 2020 is 7,764,565,535; Births this year are 17,540,092; Births on 15 Feb 2020 are 269,207; Deaths this year are 7,363,751; Deaths as on 15 Feb 2020 are 113,020; Net population growth this year is 10,176,341 and 156,187 is the net population growth on 15 Feb 2020.The undernourished people in the world are; 840,860,684; The overweight people in the world are 1,689,059,549; The obese people in the world; 750,227,965; People who died of hunger today (15 Feb 2020): 21,547; The money spent for obesity related diseases in the USA alone as on 15 Feb 2020 is $ 402,357,220 and the money spent on weight loss programs in the USA 15 Feb 2020 is $ 133,194,065. Water used this year (million L) is 543,110,097; Deaths caused by water related diseases this year 105,436 and people with no access to a safe drinking water source are 803, 484,809

The total world population is projected to increase up to 1500 million by 2050. This is exerting tremendous pressure on natural resources while meeting the demographic demands of food and nutritional security. In this context fish as food in meeting the animal protein requirements is playing a pivotal role in palatally of high end consumers to economically under privileged hinterland residents of different countries of the world. Fish are vulnerable spoilage for various reasons and this is leading severe economic losses. The prevention of losses is not only helpful in meeting food security needs millions across the world but takes care of primary producer’s fiscal needs in all walks of fisheries sector that includes sea food industry.

The important concern of seafoods is microbial safety. The continued occurrence of seafood and fish borne illness is not evidence of the failure of our seafood, fish and fishery products safety system. As a matter of fact, many of our prevention and control efforts have been and continue to be highly effective. In developed countries where food supply is one of the safest in the world, however, significant food borne illness continues to occur. Despite great strides in microbiological food safety, much remains to be done. The new challenges in microbial safety are antibiotic residues and the concomitant development of antimicrobial resistance (AMR) in human health hazard pathogens (HHHP) and nonpathogenic bacteria.

Use of antibiotics in both animal production and human medicine has increased in recent decades and allowing the bacteria to become resistance. The subsequent transmission and spread of resistant pathogenic bacteria sets the scene for development of drug-resistant infections (DRIs). At present, DRIs are estimated to account for 50,000 deaths each year in Europe and the USA alone, but by 2050 it is estimated that DRIs will account for 10 million deaths per year worldwide, posing and possible economic burden tuning to 20 trillion $USD and also biosecurity threat. In 2000, globally it was estimated 54billion standard units of antibiotics have been consumed, and this figure increased by 36% in the following 10 years, creating the preconditions of a public health crisis.

In the present day world, the antimicrobial resistant bacteria spread all over from farm to fork, hospitals, workplaces, animals, humans, soil, and oceans. They are near ubiquitous in nature. A consumer report published in 2013 indicated that more than more than half of ground turkey meat sold in the U.S. contained strains of drug-resistant bacteria. According to the CDC, some 2 million people in the U.S. are infected with drug-resistant bugs every year, and 23,000 of them die from these infections. Those numbers are likely to get worse in the coming decades, according to recent reports. The report on antibiotic resistance by RustavAminov in 2010 revealed the complexity of the imminent hazard "*It is not a single grand challenge; it is rather a complex problem requiring concerted efforts of microbiologists, ecologists, health care specialists, educationalists, policy makers, legislative bodies, agricultural and pharmaceutical industry workers, and the public to deal with. In fact, this should be of everyone's concern, because, in the end, there is always a probability for any of us at some stage to get infected with a pathogen that is resistant to antibiotic treatment"*.

As long as antibiotics have existed, bacterial resistance has existed alongside them- but not the magnitude of present day. "*The natural history of antibiotic resistance genes can be revealed through the phylogenetic reconstruction and the long-term presence of genes conferring resistance to several classes of antibiotics in nature well before the antibiotic era*." The threat perception of US CDC report on AMR indicates '*simply using antibiotics creates resistance'* (CDC, 2013: 14). Solutions have become problems, putting biopower out of joint. Sources of AMR included pets, supermarket meat, hospital drains, locker rooms, and lungs, guts and sores. *Antibiotic resistance is a collective ecological condition of late industrialism*. From the intended targets of therapeutic control, and increasingly off-target the AMR seeped into urban crows, plants, coastal waters, beached whales, lice, soil, aquarium fish etc.,

Drug-resistant infections have the potential to cause a level of economic damage similar to and likely worse than-that caused by the 2008 financial crisis, according to a new report by the World Bank Group entitled "*Drug Resistant Infections: A Threat to Our Economic Future*." The research shows that a high-case scenario of antimicrobial resistance (AMR)-where antibiotics and other antimicrobial dugs no longer treat infections the way they are supposed to-could cause low-income countries to lose more than 5% of their GDP and push up to 28 million people, mostly in developing countries, into poverty by 2050. And unlike the financial crisis of 2008, there would be no prospects for a cyclical recovery in the medium term, as the costly impact of AMR would persist (World Bank, 2016; AdeyiOlusoji*et al*, 2017)

The historical developments in antibiotics & antimicrobial resistance are provided in Table 1

Table 1. Historical developments in Antibiotics & Antimicrobial Resistance	
Year	**Type of development**
350-550 CE	The discovery of Tetracycline in skeletons from Sudanese Nubia (part of ancient Egypt) disapproved the commonly held belief that antibiotics didn't exist before 1928. It is believed that ancient Nubians were actually brewing tetracycline into their beers or otherwise incorporating it into their diets over a long period of time as the same was found embedded deep in their bones and the population's documented infectious diseases seem to be quite low. It's difficult to detect other ancient antibiotics, as most didn't accumulate into bones and tooth enamel the way Tetracycline do. Records show antimalarial drug presently known as artemisinin, was used in ancient Chinese medicine. Similarly in Jordan, red soils rich in antibiotic-producing bacteria were used to treat skin infections like rashes.
1928	Alexander Fleming, a Scottish biologist, took the fight against infections to a new level when he identified penicillin, making this the year that the modern antibiotic era began. Penicillin from Penicillin*rubens* became the first compound to be used officially as an antibiotic.
1943	The mass production Penicillin saved thousands of lives army men in WW II and Alexander Fleming warned of development of resistance upon over and excessive use.
1948	The works of Robert Stokstad and Thomas Jukes, at Lederle to develop an "animal protein factor" for enhancing chicken growth and boost poultry profits through vitamin B12, believed to boost animal growth contained cellular remains of *Streptomyces aureofaciens* bacteria resulted in 24 % more growth than those receiving liver extract, with high levels of B12. This becomes basis for employment of antibiotics for animal growth. During this period, Staphylococcus too started developing resistance in hospitals. According to Harvard Magazine, staphylococcal resistant infections rose from 14 % in 1946 to 59 % in 1948.
1952	Though scientists were aware of AMR, optimism prevailed on development of new drugs.
1955	The predictions of Alexander Fleming turned out to be true. The attempts to slow down the process of AMR by many countries in 1955 futile as it was too late: Many bacterial strains had already defeated the antibiotic, including staphylococci. At the same next 20 years are considered to be golden age of antibiotics in view of discovery of new antibiotics Such as streptomycin, to treat serious infections viz., endocarditis and plague; ampicillin, to treat respiratory tract infections and meningitis.
1960	In an attempt to overcome penicillin-resistant strains, 'methicillin was developed. But within a year, resistance to Methicillin was developed in the form of MRSA (Methicillin-Resistant *Staphylococcus aureus*). Now, MRSA leads multiple-drug

	resistant (MDR) bacteria.
1976	At Tufts University, Stuart Levy led from the front awareness on resistance development in bacteria due antibiotics use in animal products.
1990s	A stronger resistant strain of MRSA began sickening normal, healthy people in the 1990s. This perhaps created a greater public awareness of the danger of antimicrobial resistance. In the midst of emerging superbugs and MDR bacteria, the CDC and other public health organizations began issuing public service announcements to curb the liberal use of antibiotics.
2002	60 percent of *S. aureus* cases in hospitals were resistant to Methicillin
2005	Over 100,000 Americans were stricken with MRSA infections and some 20,000 died, more than the amount of people who were dying from HIV and tuberculosis combined, according to Harvard Magazine
2012	In a 2012 study, proposal was made to add the terms extensively drug-resistant (XDR) and pan drug-resistant (PDR) to multidrug-resistant (MDR) bacteria to better help them classify and potentially defeat these superbugs. It was the first time that scientists had a unified set of definitions for MDR bacteria to better understand them.
2013	The USFDA finally implemented a plan to phase out certain antibiotic use in animals. But the extent to which this plan is effective at reducing the massive damage already done is difficult to identify.
2014	In response to major superbug outbreaks like *Klebsiella pneumoniae* the WHO released a statement noting that "*this serious threat is no longer a prediction for the future, it is happening right now in every region of the world and has the potential to affect anyone, of any age, in any cou*ntry."
2015	McDonald's announced that it would phase out all meat sources that contained antibiotics, marking the first step of a major fast food company to heed the public health warnings and take action.

The AMR was not taken seriously in the beginning for the following reasons:

1. Altering the existing drug
2. Availability of another drug
3. Confined to non-compliant patients
4. The drug resistant mutants are rare and confined to next generation
5. Vertical genetic inheritance in nature
6. Treating it as reaction to new drugs by the same principle
7. Not treating it as fundamental challenge to the model

Antibiotics have been called a 'societal drug': when one person in a household takes an antibiotic for an extended period, for example to treat acne, density of antibiotic resistant bacteria on the skin of everyone else in the household increases. Similarly, oxytetracycline which is reported as the most widely used antibiotic for prophylactic treatment in aquaculture perhaps be called "aquaculture drug".

Antimicrobial resistance genes (ARGs) may have evolved naturally, indiscriminate use of antibiotics in human and animal sectors has led to selection and spread of resistant bacteria. **But ARGs found in aquatic systems may be derived from multiple sources.** Hospital effluents carry significant pool of ARGs. There are also evidence using metagenomics approach that the abundance of ARGs in effluents entering a river catchment area is higher than that in the receiving environment (Figure I).

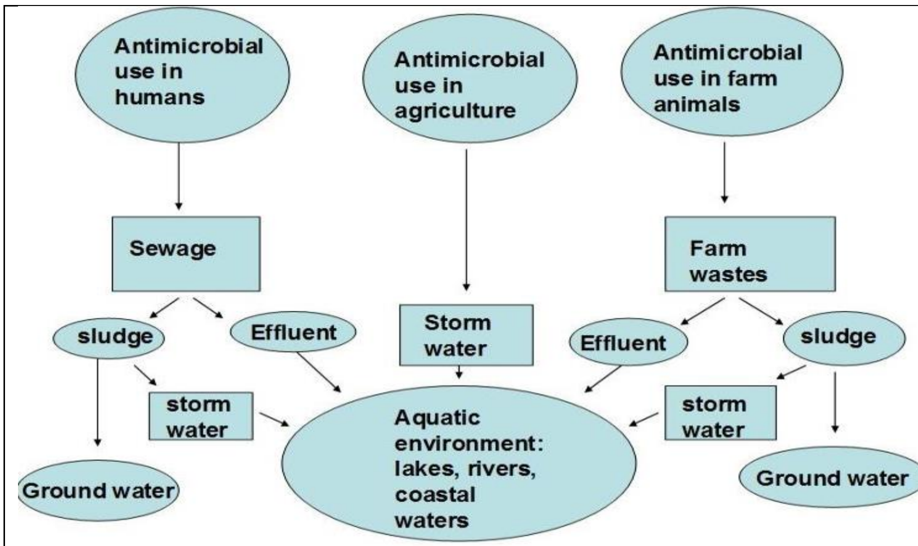

Figure I: ARG entering from different sources to aquaculture environments

Source: http://www.fao.org/cofi/aq/90408/en/ AMR Side Event, COFI/SCA 9, 25 October 2017, Rome, Italy,

FAO Action Plan on AMR: 2016-2020

Awareness

- National/regional/international fora
- Book: Responsible management of bacterial diseases in aquaculture
- CCRF Technical Guidelines on Prudent and Responsible Use of Drugs
- World Antibiotic Awareness Week (13-19 November 2017)

Evidence: Surveillance (AMU and AMR)

Practices: Best practice guidance (shrimp, tilapia and carp)

Governance: Assistance to the development of the aquaculture component (within food and agriculture) of NAP on AMR

CIFT Contributions in addressing the AMR issue

CIFT is in forefront from 1980's in Antimicrobial Resistance (AMR) related research in fish and fishery products and in aquatic systems before this became a global concern. ICAR-CIFT specially Microbiology, Fermentation and Biotechnology (MFB) Division made tremendous progress in identifying the bacteria responsible for AMR in seafood and fish curing environments viz., *Listeria monocytogenes, Salmonella, Vibrio parahaemolyticus, Vibrio cholerae, Escherichia coli, Staphylococcus aureus.* Advanced studies were also carried on Extended Spectrum Beta Lactamase (ESBL) producing *E. coli* and Methicillin Resistant *Staphylococcus aureus* (MRSA), their molecular characterization, identification of a new clone of MRSA t15669 and latest feather in cap is the whole genome sequencing (WGS) of MRSA isolated from the contaminated seafood. Aquatic products or sea-foods exported to the other developed countries increasingly tend to get rejected due to the presence of antibiotics residues which cause not only serious financial loss to the seafood industry and dent to much needed foreign exchange. In a neglected case scenario by 2050 the mortalities at global level will be 10 million and the health care expenditure is estimated to be ₹ 1300 trillion annually. In this regard CIFT has made significant contributions in source tracking of microbial contaminants and also guiding the seafood industry in production of safe foods.

Taking que from the global concern, in the last year itself CIFT has organized FAO sponsored meeting wherein the scientists from various parts of country were brought together for chalking out the research projects and possible remedial measures associated with the AMR. World AMR awareness week was also observed from 13 to 19 November 2017 at CIFT. Expert speakers were invited to deliver lectures on AMR in Indian perspective, and also taking this serious issue to school and college students and public in the forms of delivering lectures by scientist of MFB Division of CIFT. Recently an ICAR sponsored winter school on "Antimicrobial resistances in fish and aquatic environment and its impact on human health" was organized from 01 to 21 December 2017. Participants from 9states viz., Andhra Pradesh, Arunachal Pradesh, Kashmir, Kerala, Madhya Pradesh, Rajasthan, Uttar Pradesh, Uttarakhand and Tamil Nadu belonging to other ICAR institutions, State agricultural universities, Veterinary colleges, State Officers, in the profile of Scientist, Assistant professors, Associate professors, Field Officers etc.

Series of lecture cum demonstrations were delivered on very important issues of antimicrobial resistance viz., starting from history of antimicrobial resistances dating back to 350 CE to the recent additions, methods to determine antimicrobial resistance both qualitatively and quantitatively, molecular fingerprinting tools to source tracing the contamination, alternative to antibiotics and recent advances in gene editing called CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats). It is indeed a great pleasure for CIFT to play a forerunner role in frontier research areas in AMR and seafood safety and at the same time it shares that knowledge in the form of imparting training, conducting workshops to various stakeholders associated with the fisheries sectors. Further CIFT is open for the inter-institutional collaborative research to find long lasting solutions to the problems of AMR before it leads to a catastrophic proportion not only in aquatic environment but also in public health sector.

Observations specific to the country are included here for the ITEC participating countries. Countries namely Eretria, Palestine and Somalia do not have specific NAP for containing AMR which is the need of hour. One important observation is that despite the fact Eretria do not possess NAP on AMR, over the counter sale of antibiotics is prohibited which is very good sign in the direction of containing scourge called AMR.

Serbia:

4.1 Multi-sector and One Health collaboration/coordination

C - Multi-sectoral working group(s) is (are) functional, with clear terms of reference; regular meetings, and funding for working group(s). Activities and reporting/accountability arrangements are defined.

5.1 Country progress with development of a national action plan on AMR

D - National AMR action plan approved by government that reflects Global Action Plan objectives, with an operational plan and monitoring arrangements.

6.1 Raising awareness and understanding of AMR risks and response

D - Nationwide, government-supported antimicrobial resistance awareness campaign targeting all or the majority of relevant stakeholders, based on stakeholder analysis, utilizing targeted messaging accordingly within sectors.

6.2 Training and professional education on AMR in the human health sector

E - AMR is systematically and formally incorporated in pre-service training curricula for all relevant human health cadres. In-service training or other CPD on AMR is taken up by relevant groups for human health nationwide, in public and private sectors.

6.3 Training and professional education on AMR in the veterinary sector

C - AMR and appropriate use is covered in core curricula for graduating veterinarians and for veterinary paraprofessionals when relevant**.**

6.4 Training and professional education on AMR in farming sector (animal and plant), food production, food safety and the environment

B - Tailored ad hoc AMR training courses available for at least two groups of key stakeholders.

6.5 Progress with strengthening veterinary services

B - Veterinary services assessed and plans developed to improve capacity, through a structured approach such as OIE Performance of Veterinary Services (PVS) Evaluation and PVS Gap Analysis missions.

7.1 National monitoring system for consumption and rational use of antimicrobials in human health

E - On a regular basis (every year/two years) data is collected and reported on: a) Antimicrobial sales or consumption at national level for human use; and b) Antibiotic prescribing and appropriate/rational use, in a representative sample of health facilities, public and private.

7.2 National monitoring system for antimicrobials intended to be used in animals (sales/use)

C - Data collected and reported on total quantity of antimicrobials sold for/used in animals and their intended type of use (therapeutic or growth promotion).

7.3 National monitoring system for pesticide use in plant production

B - Plan agreed for monitoring quantities of pesticides used for the purpose of controlling bacteria or fungal diseases.

7.4 National surveillance system for antimicrobial resistance (AMR) in humans

D - There is a functioning national AMR surveillance system covering common bacterial infections in hospitalized and community patients+, with external quality assurance, and a national coordinating centre producing reports on AMR.

7.5 (a) National surveillance system for antimicrobial resistance (AMR) in animals (terrestrial and aquatic)

C - Some AMR data is collected locally but may not use a standardised approach and lacks national coordination and/or quality management.

8.1 Infection Prevention and Control (IPC) in human health care

D - National IPC programme available according to the WHO IPC core components guidelines+ and IPC plans and guidelines implemented nationwide. All health care facilities have a functional built environment (including water and sanitation), and necessary materials and equipment to perform IPC, per national standards.

8.2 Good health, management and hygiene practices to reduce the use of antimicrobials and minimize development and transmission of AMR in animal production (terrestrial and aquatic)

C - National plan agreed to ensure good production practices in line with international standards (e.g. OIE Terrestrial and Aquatic Codes, Codex Alimentarius). Nationally agreed guidance for good production practices developed, adapted for implementation at local farm and food production level.

9.1 Optimizing antimicrobial use in human health

D - Guidelines and other practices to enable appropriate use are implemented in most health facilities nationwide. Monitoring and surveillance results are used to inform action and to update treatment guidelines and essential medicines lists.

9.2 Optimizing antimicrobial use in animal health (terrestrial and aquatic)

C - National legislation covers all aspects of national manufacture, import, marketing authorization, control of safety, quality and efficacy and distribution of antimicrobial products.

Serbia	4.1	C	Multi-sectoral working group(s) is (are) functional, with clear terms of reference; regular meetings, and funding for working group(s). Activities and reporting/accountability arrangements are defined.	EUR	EUROPE	EUROPE	MIC (upper)
	5.1	D	National AMR action plan approved by government that reflects Global Action Plan objectives, with an operational plan and monitoring arrangements.				
	6.1	D	Nationwide, government-supported antimicrobial resistance awareness campaign targeting all or the majority of relevant stakeholders, based on stakeholder analysis, utilizing targeted messaging accordingly within sectors.				
	6.2	E	AMR is systematically and formally incorporated in pre-service training curricula for all relevant human health cadres. In-service training or other CPD on AMR is taken up by relevant groups for human health nationwide, in public and private sectors.				
	6.3	C	AMR and appropriate use is covered in core curricula for graduating veterinarians and for veterinary paraprofessionals when relevant.				
	6.4	B	Tailored ad hoc AMR training courses available for at least two groups of key stakeholders.				
	6.5	B	Veterinary services assessed and plans developed to improve capacity, through a structured approach such as OIE Performance of Veterinary Services (PVS) Evaluation and PVS Gap Analysis missions.				

7.2	C	Data collected and reported on total quantity of antimicrobials sold for/used in animals and their intended type of use (therapeutic or growth promotion).
7.3	B	Plan agreed for monitoring quantities of pesticides used for the purpose of controlling bacteria or fungal diseases.
7.4	D	There is a functioning national AMR surveillance system covering common bacterial infections in hospitalized and community patients+, with external quality assurance, and a national coordinating centre producing reports on AMR.
7.5	C	Some AMR data is collected locally but may not use a standardised approach and lacks national coordination and/or quality management.
8.1	D	National IPC programme available according to the WHO IPC core components guidelines+ and IPC plans and guidelines implemented nationwide. All health care facilities have a functional built environment (including water and sanitation), and necessary materials and equipment to perform IPC, per national standards.
8.2	C	National plan agreed to ensure good production practices in line with international standards (e.g. OIE Terrestrial and Aquatic Codes, Codex Alimentarius). Nationally agreed guidance for good production practices developed, adapted for implementation at local farm and food production level.
9.1	D	Guidelines and other practices to enable appropriate use are implemented in most health facilities nationwide. Monitoring and surveillance results are used to inform action and to update treatment guidelines and essential medicines lists.
9.2	C	National legislation covers all aspects of national manufacture, import, marketing authorization, control of safety, quality and efficacy and distribution of antimicrobial products.

Kenya:

4.1 Multi-sector and One Health collaboration/coordination

E- Integrated approaches used to implement the national AMR action plan with relevant data and lessons learned from all sectors used to adapt implementation of the action plan.

5.1 Country progress with development of a national action plan on AMR

E- National AMR action plan has funding sources identified, is being implemented and has relevant sectors involved with a defined monitoring and evaluation process in place.

6.1 Raising awareness and understanding of AMR risks and response

C-Limited or small-scale antimicrobial resistance awareness campaign targeting some but not all relevant stakeholders.

6.2 Training and professional education on AMR in the human health sector

C- AMR is covered in 1) some pre-service training and in 2) some in-service training or other continuing professional development (CPD) for human health workers.

6.3 Training and professional education on AMR in the veterinary sector

C- AMR and appropriate use is covered in core curricula for graduating veterinarians and for veterinary paraprofessionals when relevant.

6.4 Training and professional education on AMR in farming sector (animal and plant), food production, food safety and the environment

B- Tailored ad hoc AMR training courses available for at least two groups of key stakeholders.

6.5 Progress with strengthening veterinary services

D- Monitoring of Veterinary Services performance carried out regularly, e.g. through PVS Evaluation Follow Up missions.

7.1 National monitoring system for consumption and rational use of antimicrobials in human health

A- No national plan or system for monitoring use of antimicrobials.

7.2 National monitoring system for antimicrobials intended to be used in animals (sales/use)

D- On a regular basis, data is collected and reported to the OIE on the total quantity of antimicrobials sold for/used in animals nationally, by antimicrobial class, by species (aquatic or terrestrial), method of administration, and by type of use (therapeutic or growth promotion).

7.3 National monitoring system for pesticide use in plant production

A- No national plan or system for monitoring use of pesticides used for the purpose of controlling bacteria or fungal diseases.

7.4 National surveillance system for antimicrobial resistance (AMR) in humans

C- National AMR surveillance activities for common bacterial infections follow national standards, and a national reference laboratory that participates in external quality assurance.

7.5 (a) National surveillance system for antimicrobial resistance (AMR) in animals (terrestrial and aquatic)

D- Priority pathogenic/ commensal bacterial species have been identified for surveillance. Data systematically collected and reported on levels of resistance in at least 1 of those bacterial species, involving a laboratory that follows quality management processes, e.g. proficiency testing.

8.1 Infection Prevention and Control (IPC) in human health care

D- National IPC programme available according to the WHO IPC core components guidelines+ and IPC plans and guidelines implemented nationwide. All health care facilities have a functional built environment (including water and sanitation), and necessary materials and equipment to perform IPC, per national standards.

8.2 Good health, management and hygiene practices to reduce the use of antimicrobials and minimize development and transmission of AMR in animal production (terrestrial and aquatic)

C- National plan agreed to ensure good production practices in line with international standards (e.g. OIE Terrestrial and Aquatic Codes, Codex Alimentarius). Nationally agreed guidance for good production practices developed, adapted for implementation at local farm and food production level.

9.1 Optimizing antimicrobial use in human health

C- Practices to assure appropriate antimicrobial use being implemented in some healthcare facilities and guidelines for appropriate use of antimicrobials available.

9.2 Optimizing antimicrobial use in animal health (terrestrial and aquatic)

C- National legislation covers all aspects of national manufacture, import, marketing authorization, control of safety, quality and efficacy and distribution of antimicrobial products.

Kenya	4.1	E	Integrated approaches used to implement the national AMR action plan with relevant data and lessons learned from all sectors used to adapt implementation of the action plan.	AFR	AFRICA (RAF)	AFRICA	MIC (lower)
	5.1	E	National AMR action plan has funding sources identified, is being implemented and has relevant sectors involved with a defined monitoring and evaluation process in place.				
	6.1	C	Limited or small-scale antimicrobial resistance awareness campaign targeting some but not all relevant stakeholders.				
	6.2	C	AMR is covered in 1) some pre-service training and in 2) some in-service training or other continuing professional development (CPD) for human health workers.				
	6.3	C	AMR and appropriate use is covered in core curricula for graduating veterinarians and for veterinary paraprofessionals when relevant.				
	6.4	B	Tailored ad hoc AMR training courses available for at least two groups of key stakeholders.				
	6.5	D	Monitoring of Veterinary Services performance carried out regularly, e.g. through PVS Evaluation Follow Up missions.				
	7.1	A	No national plan or system for monitoring use of antimicrobials.				
	7.2	D	On a regular basis, data is collected and reported to the OIE on the total quantity of antimicrobials sold for/used in animals nationally, by antimicrobial class, by species (aquatic or terrestrial), method of administration, and by type of use (therapeutic or growth promotion).				

bacteria or fungal diseases.+

Country	Question		Answer	WHO Region	FAO Region	OIE Region	WB income group
	7.4	C	National AMR surveillance activities for common bacterial infections follow national standards, and a national reference laboratory that participates in external quality assurance.				
	7.5	D	Priority pathogenic/ commensal bacterial species have been identified for surveillance. Data systematically collected and reported on levels of resistance in at least 1 of those bacterial species, involving a laboratory that follows quality management processes, e.g. proficiency testing.				
	8.1	D	National IPC programme available according to the WHO IPC core components guidelines+ and IPC plans and guidelines implemented nationwide. All health care facilities have a functional built environment (including water and sanitation), and necessary materials and equipment to perform IPC, per national standards.				
	8.2	C	National plan agreed to ensure good production practices in line with international standards (e.g. OIE Terrestrial and Aquatic Codes, Codex Alimentarius). Nationally agreed guidance for good production practices developed, adapted for implementation at local farm and food production level.				
	9.1	C	Practices to assure appropriate antimicrobial use being implemented in some healthcare facilities and guidelines for appropriate use of antimicrobials available.				
	9.2	C	National legislation covers all aspects of national manufacture, import, marketing authorization, control of safety, quality and efficacy and distribution of antimicrobial products.				

Ethiopia:

4.1 Multi-sector and One Health collaboration/coordination

C- Multi-sectoral working group(s) is (are) functional, with clear terms of reference; regular meetings, and funding for working group(s). Activities and reporting/accountability arrangements are defined.

5.1 Country progress with development of a national action plan on AMR

E- National AMR action plan has funding sources identified, is being implemented and has relevant sectors involved with a defined monitoring and evaluation process in place.

6.1 Raising awareness and understanding of AMR risks and response

D- Nationwide, government-supported antimicrobial resistance awareness campaign targeting all or the majority of relevant stakeholders, based on stakeholder analysis, utilizing targeted messaging accordingly within sectors.

6.2 Training and professional education on AMR in the human health sector

C- AMR is covered in 1) some pre-service training and in 2) some in-service training or other continuing professional development (CPD) for human health workers.

6.3 Training and professional education on AMR in the veterinary sector

B- Ad hoc AMR training courses available for veterinary related professionals.

6.4 Training and professional education on AMR in farming sector (animal and plant), food production, food safety and the environment

B-Tailored ad hoc AMR training courses available for at least two groups of key stakeholders.

6.5 Progress with strengthening veterinary services

E- Documented evidence of strong capacity in compliance with OIE standards on the quality of Veterinary Services.

7.1 National monitoring system for consumption and rational use of antimicrobials in human health

E- On a regular basis (every year/two years) data is collected and reported on: a) Antimicrobial sales or consumption at national level for human use; and b) Antibiotic prescribing and appropriate/rational use, in a representative sample of health facilities, public and private.

7.2 National monitoring system for antimicrobials intended to be used in animals (sales/use)

D- On a regular basis, data is collected and reported to the OIE on the total quantity of antimicrobials sold for/used in animals nationally, by antimicrobial class, by species (aquatic or terrestrial), method of administration, and by type of use (therapeutic or growth promotion).

7.3 National monitoring system for pesticide use in plant production

B- Plan agreed for monitoring quantities of pesticides used for the purpose of controlling bacteria or fungal diseases.

7.4 National surveillance system for antimicrobial resistance (AMR) in humans

C- National AMR surveillance activities for common bacterial infections follow national standards, and a national reference laboratory that participates in external quality assurance.

7.5 (a) National surveillance system for antimicrobial resistance (AMR) in animals (terrestrial and aquatic)

C- Some AMR data is collected locally but may not use a standardised approach and lacks national coordination and/or quality management.

8.1 Infection Prevention and Control (IPC) in human health care

D- National IPC programme available according to the WHO IPC core components guidelines+ and IPC plans and guidelines implemented nationwide. All health care facilities have a functional built environment (including water and sanitation), and necessary materials and equipment to perform IPC, per national standards.

8.2 Good health, management and hygiene practices to reduce the use of antimicrobials and minimize development and transmission of AMR in animal production (terrestrial and aquatic)

B- Some activities in place to develop and promote good production practices.

9.1 Optimizing antimicrobial use in human health

D- Guidelines and other practices to enable appropriate use are implemented in most health facilities nationwide. Monitoring and surveillance results are used to inform action and to update treatment guidelines and essential medicines lists.

9.2 Optimizing antimicrobial use in animal health (terrestrial and aquatic)

C- National legislation covers all aspects of national manufacture, import, marketing authorization, control of safety, quality and efficacy and distribution of antimicrobial products.

Ethiopia	4.1	C	Multi-sectoral working group(s) is (are) functional, with clear terms of reference; regular meetings, and funding for working group(s). Activities and reporting/accountability arrangements are defined.	AFR	AFRICA (RAF)	AFRICA	LIC
	5.1	E	National AMR action plan has funding sources identified, is being implemented and has relevant sectors involved with a defined monitoring and evaluation process in place.				
	6.1	D	Nationwide, government-supported antimicrobial resistance awareness campaign targeting all or the majority of relevant stakeholders, based on stakeholder analysis, utilizing targeted messaging accordingly within sectors.				
	6.2	C	AMR is covered in 1) some pre-service training and in 2) some in-service training or other continuing professional development (CPD) for human health workers.				
	6.3	B	Ad hoc AMR training courses available for veterinary related professionals.				

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Country	Question		Answer	WHO Region	FAO Region	OIE Region	WB income group
	6.4	B	Tailored ad hoc AMR training courses available for at least two groups of key stakeholders.				
	6.5	E	Documented evidence of strong capacity in compliance with OIE standards on the quality of Veterinary Services.+				
	7.1	E	On a regular basis (every year/two years) data is collected and reported on: a) Antimicrobial sales or consumption at national level for human use; and b) Antibiotic prescribing and appropriate/rational use, in a representative sample of health facilities, public and private.				
	7.2	D	On a regular basis, data is collected and reported to the OIE on the total quantity of antimicrobials sold for/used in animals nationally, by antimicrobial class, by species (aquatic or terrestrial), method of administration, and by type of use (therapeutic or growth promotion).				
	7.3	B	Plan agreed for monitoring quantities of pesticides used for the purpose of controlling bacteria or fungal diseases.				
	7.4	C	National AMR surveillance activities for common bacterial infections follow national standards, and a national reference laboratory that participates in external quality assurance.				
	7.5	C	Some AMR data is collected locally but may not use a standardised approach and lacks national coordination and/or quality management.				
	8.1	D	National IPC programme available according to the WHO IPC core components guidelines+ and IPC plans and guidelines implemented nationwide. All health care facilities have a functional built environment (including water and sanitation), and necessary materials and equipment to perform IPC, per national standards.				
	8.2	B	Some activities in place to develop and promote good production practices.				
	9.1	D	Guidelines and other practices to enable appropriate use are implemented in most health facilities nationwide. Monitoring and surveillance results are used to inform action and to update treatment guidelines and essential medicines lists.				
	9.2	C	National legislation covers all aspects of national manufacture, import, marketing authorization, control of safety, quality and efficacy and distribution of antimicrobial products.				

Tunisia:

4.1 Multi-sector and One Health collaboration/coordination

C- Multi-sectoral working group(s) is (are) functional, with clear terms of reference; regular meetings, and funding for working group(s). Activities and reporting/accountability arrangements are defined.

5.1 Country progress with development of a national action plan on AMR

D- National AMR action plan approved by government that reflects Global Action Plan objectives, with an operational plan and monitoring arrangements.

6.1 Raising awareness and understanding of AMR risks and response

C- Limited or small-scale antimicrobial resistance awareness campaign targeting some but not all relevant stakeholders.

6.2 Training and professional education on AMR in the human health sector

C- AMR is covered in 1) some pre-service training and in 2) some in-service training or other continuing professional development (CPD) for human health workers.

6.3 Training and professional education on AMR in the veterinary sector

B- Ad hoc AMR training courses available for veterinary related professionals.

6.4 Training and professional education on AMR in farming sector (animal and plant), food production, food safety and the environment

B- Tailored ad hoc AMR training courses available for at least two groups of key stakeholders.

6.5 Progress with strengthening veterinary services

B- Veterinary services assessed and plans developed to improve capacity, through a structured approach such as OIE Performance of Veterinary Services (PVS) Evaluation and PVS Gap Analysis missions.

7.1 National monitoring system for consumption and rational use of antimicrobials in human health

D- Prescribing practices and appropriate antibiotic use are monitored in a national sample of healthcare settings.

7.2 National monitoring system for antimicrobials intended to be used in animals (sales/use)

A- No national plan or system for monitoring sales/use of antimicrobials in animals.

7.3 National monitoring system for pesticide use in plant production

A- No national plan or system for monitoring use of pesticides used for the purpose of controlling bacteria or fungal diseases.

7.4 National surveillance system for antimicrobial resistance (AMR) in humans

D- There is a functioning national AMR surveillance system covering common bacterial infections in hospitalized and community patients+, with external quality assurance, and a national coordinating centre producing reports on AMR.

7.5 (a) National surveillance system for antimicrobial resistance (AMR) in animals (terrestrial and aquatic)

C- Some AMR data is collected locally but may not use a standardised approach and lacks national coordination and/or quality management.

8.1 Infection Prevention and Control (IPC) in human health care

C- A national IPC programme and operational plan are available and national guidelines for health care IPC are available and disseminated. Selected health facilities are implementing the guidelines, with monitoring and feedback in place.

8.2 Good health, management and hygiene practices to reduce the use of antimicrobials and minimize development and transmission of AMR in animal production (terrestrial and aquatic)

C- National plan agreed to ensure good production practices in line with international standards (e.g. OIE Terrestrial and Aquatic Codes, Codex Alimentarius). Nationally agreed guidance for good production practices developed, adapted for implementation at local farm and food production level.

9.1 Optimizing antimicrobial use in human health

C- Practices to assure appropriate antimicrobial use being implemented in some healthcare facilities and guidelines for appropriate use of antimicrobials available.

9.2 Optimizing antimicrobial use in animal health (terrestrial and aquatic)

B- National legislation covers some aspects of national manufacture, import, marketing authorization, control of safety, quality and efficacy and distribution of antimicrobial products.

Tunisia	4.1	C	Multi-sectoral working group(s) is (are) functional, with clear terms of reference; regular meetings, and funding for working group(s). Activities and reporting/accountability arrangements are defined.	EMR	NEAR EAST and NORTH AFRICA (RNE)	AFRICA	MIC (lower)
	5.1	D	National AMR action plan approved by government that reflects Global Action Plan objectives, with an operational plan and monitoring arrangements.				
	6.1	C	Limited or small-scale antimicrobial resistance awareness campaign targeting some but not all relevant stakeholders.				
	6.2	C	AMR is covered in 1) some pre-service training and in 2) some in-service training or other continuing professional development (CPD) for human health workers.				
	6.3	B	Ad hoc AMR training courses available for veterinary related professionals.				
	6.4	B	Tailored ad hoc AMR training courses available for at least two groups of key stakeholders.				
	6.5	B	Veterinary services assessed and plans developed to improve capacity, through a structured approach such as OIE Performance of Veterinary Services (PVS) Evaluation and PVS Gap Analysis missions.				
	7.1	D	Prescribing practices and appropriate antibiotic use are monitored in a national sample of healthcare settings.				
	7.2	A	No national plan or system for monitoring sales/use of antimicrobials in animals.				
	7.3	A	No national plan or system for monitoring use of pesticides used for the purpose of controlling bacteria or fungal diseases.+				
	7.4	D	There is a functioning national AMR surveillance system covering common bacterial infections in hospitalized and community patients+, with external quality assurance, and a national coordinating centre producing reports on AMR.				
	7.5	C	Some AMR data is collected locally but may not use a standardised approach and lacks national coordination and/or quality management.				
	8.1	C	A national IPC programme and operational plan are available and national guidelines for health care				

Country	Question		Answer	WHO Region	FAO Region	OIE Region	WB income group
			IPC are available and disseminated. Selected health facilities are implementing the guidelines, with monitoring and feedback in place.				
	8.2	C	National plan agreed to ensure good production practices in line with international standards (e.g. OIE Terrestrial and Aquatic Codes, Codex Alimentarius). Nationally agreed guidance for good production practices developed, adapted for implementation at local farm and food production level.				
	9.1	C	Practices to assure appropriate antimicrobial use being implemented in some healthcare facilities and guidelines for appropriate use of antimicrobials available.				
	9.2	B	National legislation covers some aspects of national manufacture, import, marketing authorization, control of safety, quality and efficacy and distribution of antimicrobial products.				

Cambodia:

4.1 Multi-sector and One Health collaboration/coordination
C- Multi-sectoral working group(s) is (are) functional, with clear terms of reference; regular meetings, and funding for working group(s). Activities and reporting/accountability arrangements are defined.
5.1 Country progress with development of a national action plan on AMR
C- National AMR action plan developed.

6.1 Raising awareness and understanding of AMR risks and response
C- Limited or small-scale antimicrobial resistance awareness campaign targeting some but not all relevant stakeholders.

6.2 Training and professional education on AMR in the human health sector
B- Ad hoc AMR training courses in some human health related disciplines**.**

6.3 Training and professional education on AMR in the veterinary sector
C- AMR and appropriate use is covered in core curricula for graduating veterinarians and for veterinary paraprofessionals when relevant**.**

6.4 Training and professional education on AMR in farming sector (animal and plant), food production, food safety and the environment

B- Tailored ad hoc AMR training courses available for at least two groups of key stakeholders.

6.5 Progress with strengthening veterinary services

B- Veterinary services assessed and plans developed to improve capacity, through a structured approach such as OIE Performance of Veterinary Services (PVS) Evaluation and PVS Gap Analysis missions.

7.1 National monitoring system for consumption and rational use of antimicrobials in human health

A- No national plan or system for monitoring use of antimicrobials.

7.2 National monitoring system for antimicrobials intended to be used in animals (sales/use)

B- Plan agreed for monitoring quantities of antimicrobials sold for/used in animals, based on OIE standards.

7.3 National monitoring system for pesticide use in plant production

A- No national plan or system for monitoring use of pesticides used for the purpose of controlling bacteria or fungal diseases.

7.4 National surveillance system for antimicrobial resistance (AMR) in humans

C- National AMR surveillance activities for common bacterial infections follow national standards, and a national reference laboratory that participates in external quality assurance.

7.5 (a) National surveillance system for antimicrobial resistance (AMR) in animals (terrestrial and aquatic)

D- Priority pathogenic/ commensal bacterial species have been identified for surveillance. Data systematically collected and reported on levels of resistance in at least 1 of those bacterial species, involving a laboratory that follows quality management processes, e.g. proficiency testing.

8.1 Infection Prevention and Control (IPC) in human health care

C- A national IPC programme and operational plan are available and national guidelines for health care IPC are available and disseminated. Selected health facilities are implementing the guidelines, with monitoring and feedback in place.

8.2 Good health, management and hygiene practices to reduce the use of antimicrobials and minimize development and transmission of AMR in animal production (terrestrial and aquatic)

B- Some activities in place to develop and promote good production practices.

9.1 Optimizing antimicrobial use in human health

A- No/weak national policies for appropriate use.

9.2 Optimizing antimicrobial use in animal health (terrestrial and aquatic)

B- National legislation covers some aspects of national manufacture, import, marketing authorization, control of safety, quality and efficacy and distribution of antimicrobial products.

Cambodia	4.1	C	Multi-sectoral working group(s) is (are) functional, with clear terms of reference; regular meetings, and funding for working group(s). Activities and reporting/accountability arrangements are defined.	WPR	ASIA and the Pacific (RAP)	ASIA	MIC (lower)
	5.1	C	National AMR action plan developed.				
	6.1	C	Limited or small-scale antimicrobial resistance awareness campaign targeting some but not all relevant stakeholders.				
	6.2	B	Ad hoc AMR training courses in some human health related disciplines.				
	6.3	C	AMR and appropriate use is covered in core curricula for graduating veterinarians and for veterinary paraprofessionals when relevant.				
	6.4	B	Tailored ad hoc AMR training courses available for at least two groups of key stakeholders.				
	6.5	B	Veterinary services assessed and plans developed to improve capacity, through a structured approach such as OIE Performance of Veterinary Services (PVS) Evaluation and PVS Gap Analysis missions.				
	7.1	A	No national plan or system for monitoring use of antimicrobials.				
	7.2	B	Plan agreed for monitoring quantities of antimicrobials sold for/used in animals, based on OIE standards.+				

Country	Question		Answer	WHO Region	FAO Region	OIE Region	WB income group
	7.4	C	National AMR surveillance activities for common bacterial infections follow national standards, and a national reference laboratory that participates in external quality assurance.				
	7.5	D	Priority pathogenic/ commensal bacterial species have been identified for surveillance. Data systematically collected and reported on levels of resistance in at least 1 of those bacterial species, involving a laboratory that follows quality management processes, e.g. proficiency testing.				
	8.1	C	A national IPC programme and operational plan are available and national guidelines for health care IPC are available and disseminated. Selected health facilities are implementing the guidelines, with monitoring and feedback in place.				
	8.2	B	Some activities in place to develop and promote good production practices.				
	9.1	A	No/weak national policies for appropriate use.				
	9.2	B	National legislation covers some aspects of national manufacture, import, marketing authorization, control of safety, quality and efficacy and distribution of antimicrobial products.				

Chapter 10

Technology Application, Refinement and Transfer through Farm Science Centres in India

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Introduction

India has made considerable progress in improving its food security. The agricultural development strategy pursued in the country, particularly since the mid-sixties, is recognized and appreciated world over. The integration of agricultural research with quality education and a properly planned extension education system has been one of the fundamental foundations of this developmental strategy, which also led to revolutions in many other sectors of agriculture and allied enterprises. As a part of this strategy, several programmes of transfer of technology from research stations to farmers' fields were launched in the country. These included National Demonstration Project, Lab to Land Programme, Operational Research Project and Krishi Vigyan Kendras (Farm Science Centers). The programmes were continuously reviewed from time to time and reformulated for their effectiveness. Presently the Krishi Vigyan Kendras (KVKs) have been recognized as an effective link between agricultural research and extension system in the country (Venkatasubramanian*et. al.*, 2009).

Krishi Vigyan Kendras (Farm Science Centers), an innovative science-based institution, were established in India mainly to impart vocational skill training to the farmers and field-level extension workers. The concept of vocational training in agriculture through KVK grew substantially due to greater demand for improved/agricultural technology by the farmers. The farmers require not only knowledge and understanding of the intricacy of technologies, but also progressively more and more skills in various complex agricultural operations for adoption on their farms. The effectiveness of the KVK was further enhanced by adding the activities related to on-farm testing and front-line demonstrations on major agricultural technologies.

With the consolidation of other front-line extension projects of the Council during the Eighth Five Year Plan, such as National Demonstration Project (NDP), Operational Research Project (ORP), Lab to Land Programme (LLP) and All India Coordinated Project on Scheduled Caste/Tribe, the mandate was enlarged and revised to take up on-farm testing, long term vocational training, in service training for grass root extension workers and front-line demonstrations on major cereal, oilseed and pulse crops and other enterprises. The application of technology in the farmers' field is achieved through conducting of On-farm trial which include technology assessment and refinement. The proven and recommended technologies are then introduced in the system through conducting of frontline demonstrations followed by training programmes to empower the farmers, field extension personnel and rural youths for its adoption. The extension activities such as field day, exhibitions etc are conducted to disseminate the technologies across the system.

The KVKs have witnessed several changes in their functions over the years. Accordingly their functional definition also has radically got refined so as to meet the new challenges in agriculture.“KVKs are grass root level organizations meant for application of technology through assessment, refinement and demonstration of proven technologies under different ‘micro farming’ situations in a district” (Das, 2007).As of January, 2020, 716 Krishi Vigyan Kendras were operating in 732 districts of India (ICAR, 2020).

It should be clearly understood that transfer of technology is not a primary function of KVKs and the same is the responsibility of State departments. The KVKs on the other hand will assess (and if needed refine also) the newly released technologies, demonstrate the proven ones and train farmers and extension workers of the district on the same.

Role of KVKs in the context of Agricultural/Fisheries Extension in India Extension in India is largely deployed by government, implemented mainly through government institutions and to some extent through non-government agencies. Krishi Vigyan Kendras (KVKs) or Farm Science Centres as institutes of inducing behavioural change, are being managed by both government and non-government organizations. Literally, Krishi Vigyan Kendras have to serve as repository of scientific knowledge that is useful to the entire district, which is its jurisdiction. In India, agricultural/fisheries extension and extension education are interchangeably used with the same connotation as used in American tradition, meaning “Extending Information” as a means of educating people to solve their problems. As a result, agricultural/fisheries extension in India is more of “Informative Extension” than “Emancipatory Extension”.

In India, the extension efforts, particularly transfer of technology efforts, have largely been taken up by the state departments of agriculture and other disciplines as a state subject. The Indian Council of Agricultural Research (ICAR) as the apex body to provide new technologies in agriculture and allied aspects has its own transfer of technology activities too. The extension efforts of ICAR have evolved through National Demonstration Projects, Operation Research Projects, Lab to Land Programmes, and integrating of these approaches to Krishi Vigyan Kendras (KVKs) since 1974.

Technology and farm technology

Technology is any systematic knowledge and action applicable to any recurrent activity. Technology involves application of science and knowledge to practical use, which enable man to live more comfortably. The Merriam-Webster dictionary offers a definition of the term: "the practical application of knowledge especially in a particular area" and "a capability given by the practical application of knowledge”.

Technology can be most broadly defined as the entities, both material and immaterial, created by the application of mental and physical effort in order to achieve some value. In agriculture/fisheries, the term technology often confuses practitioners. This is because farm technology is a complex blend of materials, processes and knowledge. Swanson (1997) has classified farm technologies into two major categories:1) Material technology, where knowledge is embodied into a technological product; and2) Knowledge based technology, such as the technical knowledge, management skills and other processes that farmers need for better farm management and livelihood support.

KVK scientists need to have clarity over the technologies which they are assessing and refining in response to a specific problem in a specific micro-location. For example, a KVK Subject Matter Specialist may be assessing the efficacy of a particular management practice on a crop/fish's yield or growth in the KVK district. Such management practices can be broadly classified as Knowledge based technology. Alternatively, all technological products tested and demonstrated under OFT and FLD fall under material technology. Ex: Seeds/fish seeds, pesticides, fertilizer, farm machinery, irrigation systems etc.

Agricultural/ Fishery Technology Development

Technology Development (also called technology innovation) in agriculture/fisheryis a process consisting of all the decision and activities which a scientist does from recognition of a need/ problem with planning, testing, conducting research, verification, testing and dissemination for adoption. During the same time, some problems on the technology might get back to the scientist for solution thus resulting in refinement of the same. Thus, technology development is a continuous process. The KVK scientists have to equip themselves for 'technology application' - a process which includes the above mentioned processes; thus contributing their part in the overall process of agricultural/fisherytechnology development.

Agricultural/Fishery Technology Management

Technology management can be defined as the integrated planning, design, optimization, operation and control of technological products, processes and services. A better definition would be "the management of the use of any technology for farmer advantage." The KVK role under fishery technology management is very huge where-in it selects latest fisheries technologies, tests them for suitability in different micro-locations of the district and demonstrates the proven ones to farmers and extension system.

Technology fatigue in agriculture/fishery

Linkages between the laboratory and farmer fields have weakened and extension services often have little to extend by way of specific information and advice on the basis of location, time and farming system. Good quality seeds at affordable prices are in short supply and spurious pesticides and bio-fertilizers are being sold in the absence of effective quality control systems. Farmers have no way of getting proactive advice on land use, based on meteorological and marketing factors. No wonder the prevailing gap between potential and actual yields, even with technologies currently available, is very wide (National Commission on Farmers, 2007). In case of KVKs, it was found utilizing old and obsolete technologies for OFTs, FLDs and training programmes thus resulting in poor feed-forward to the extension system. A knowledge deficit as mentioned above coupled with the usage of obsolete technologies and package of practices together leads to a situation called 'technology fatigue'. Indian agriculture, particularly agriculture/fishery by resource poor farmers in rural areas is now bearing the brunt of technology fatigue. The KVK role lies in providing timely supply of proven technologies specific to various micro-locations of the district thus alleviating the technology fatigue existing in the district.

Technology Gap

Technology Gap is the gap between the level of recommendation and the extent of adoption (against recommendations). Technology gaps are a major source of concern for extension system. The successes of traditional transfer of technology (TOT) models were mainly evaluated on the basis of the extent of narrowing down in technology gaps achieved by them. KVK system being primarily focused on assessment, refinement and demonstration of new technologies, its role lies in feeding proven technologies to the main extension system. Thus, the primary focus of KVK should not be mistaken as reduction of existing technology gaps. Rather, they are meant at alleviating "technology fatigue" by providing timely supply of proven technologies specific to various micro-locations of the district. Alleviation of technology fatigue is accomplished through processes of technology and methodology backstopping.

Agricultural/Fishery Technology backstopping

Backstopping refers to any precaution taken against an emergency condition. Accordingly, agricultural technology backstopping can be defined as any technology precaution taken to combat technology fatigue in agriculture. In simple terms agricultural technology backstopping is the process of making available ready to use technologies for farm families through assessment, refinement and demonstration processes in order to combat the existing/forecasted technology fatigue.

Agricultural Methodology backstopping

This is a process almost similar to agricultural technology backstopping but differs with respect to the kind of technology solution offered. Instead of material technology, methodology backstopping aims at assessment, refinement and demonstration of knowledge based technologies often referred to as methodologies/package of practices. It provides detailed procedures to carry out the technology application functions by the extension personnel in the field. It includes methodologies for conducting OFT, which includes TAR, demonstrations, training, conducting surveys, impact assessment and evaluation etc.

Conceptual paradigm of Agricultural/Fishery Technology Development

Understanding technology development process in agriculture/fishery and its components is vital for success of KVK scientists. Farm technology development basically constitutes seven processes. They are:

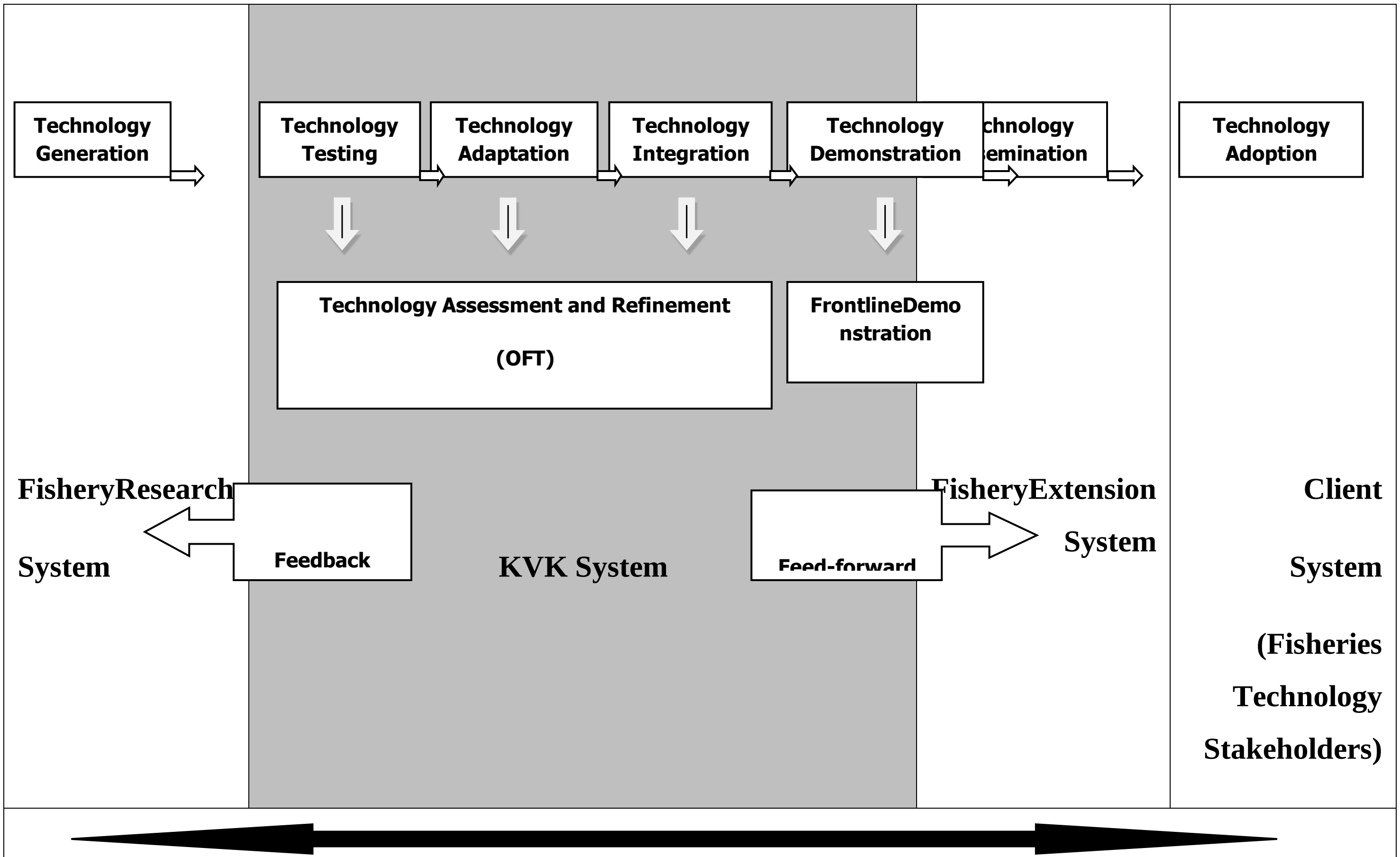
1. Technology generation
2. Technology testing
3. Technology adaptation
4. Technology integration
5. Technology demonstration
6. Technology dissemination
7. Technology adoption

Technology Assessment and Refinement (OFT)

Frontline Demonstration (FLD)

Technology generation, the starting point of technology development process is mainly a function of agricultural research system. Testing, adaptation and integration processes constitute technology assessment and refinement which KVK system executes through OFTs. The feedback is passed over to research system. KVK system also involves in technology demonstration through FLDs. Feed-forward from successful OFTs and FLDs is communicated to the extension system for mass popularization in the district. Technology adoption; the final act, occurs among the members of client system i.e. farmers.

We are presenting a new conceptual model of fishery technology development process depicting the various components and actors involved for the benefit of fisheries technology stakeholders. The role of KVK system between research system and extension system with respect to technology application is identified and highlighted here.Research system generates new technologies. In India, research system comprises of ICAR institutes, SAUs, Fishery Universities, departments like DBT, DST, other Science and Technology Institutions and Commodity boards. NGOs, Corporate and farmer innovators also contribute to technology generation.Extension system comprises of State departments of agriculture, animal husbandry and veterinary, fisheries, sericulture etc. SAUs, ICAR institutes, commodity boards, NGOs and Corporate sector also contribute to extension system.Earlier, due to the primary focus on vocational training, KVKs were categorized under extension system itself. But today, with mandates being focused on assessment, refinement and demonstration of frontier technologies, the KVK system positions itself clearly between the research and extension systems thus acting both as a feedback and feed-forward mechanism. In this paradigm, it is necessary to understand the pathways or passage of technology through KVK system.



A Conceptual model for Fisheries Technology Development Process *(Sajeev, 2020)*

Typology of technology passage through KVK system

KVK system has successfully established itself between the research and extension systems. Technology development process as explained earlier, invariably has assessment, refinement and demonstration components. Hence, there is a passage of technologies through various stages in a KVK system. We found that this passage doesn't follow a uniform pattern. For example, a technology may go through assessment stage and demonstration stage but not through refinement stage. Based on analysis of OFTs and FLDs conducted by KVKs, we identified five different typologies of technology passage through KVK system. A proper understanding of these typologies will help KVK personnel in deciding whether a particular technology has to go for OFT and FLDs or both. The typologies are:

1. **Source - Demonstration**

In this type the technology from any source/provider directly goes to demonstration by KVK. This happens when the KVK is completely sure that the technology is fully suited for the district and can go directly for FLD. Here, the technology doesn't pass through assessment and refinement stages.

2. **Source - Assessment**

In this type the technology from any source/provider goes for assessment by KVK. This happens when the KVK is not sure that the technology is fully suited for different micro-locations of the district. Here the technology fails at assessment stage itself and hence doesn't move to refinement or demonstration stages.

3. **Source - Assessment - Refinement**

This type is a variation of type 2. Here, the KVK is not sure that the technology is fully suited for different micro-locations of the district. The technology goes for and succeeds in assessment but needs refinement and hence moves to refinement stage. Here, the technology fails in refinement stage and hence doesn't move to demonstration stage.

4. **Source - Assessment - Demonstration**

This type follows type 3. This happens when the KVK becomes sure that the technology is fully suited for different micro-locations of the district. The technology fully succeeds in assessment and hence moves to demonstration stage. Here, the technology doesn't require refinement and hence move to demonstration stage.

5. **Source - Assessment - Refinement - Demonstration**

This type also follows type 3. This happens when the KVK becomes sure that the technology is fully suited for different micro-locations of the district. The technology succeeds in assessment and refinement and moves to demonstration stage. Here, the technology is successfully refined by KVK and taken to demonstration stage i.e. FLD.

FLDs are supposed to be taken up on proven technologies only. Hence, it makes obvious that once demonstrated it will go to the extension system and client system. Rarely FLDs may fail thus preventing the technology passage. But KVKs are not supposed to demonstrate such technologies which are not fully proven. The failure of FLD can be due to some extraneous factors rather than technological factors.

Client system comprises of the ultimate end-user i.e. the fish farmer/fishery technology stakeholder. Although KVK system does assessment, refinement and demonstration of new technologies as part of technology development process, some technologies get refined or rejected even in the last stage at farm/user level. Hence, client system even though being the final actor in technology development process, plays the ultimate decisive role.

Conceptual paradigm for Technology Assessment and Refinement in agriculture/fisheries

Technology Assessment and Refinement (TAR)in agriculture refers to a set of procedures whose purpose is to develop recommendations for a particular agro-climatic situation/ location through assessment and refinement of recently released technology through farmer participatory approach. It refers to the process or a set of activities before taking up new scientific information for its dissemination in a new production system. *OFTs conducted by KVKs are based on this concept and thus distinguish it from agronomic and research trials*. The process of TAR has three components. They are technology testing, technology adaptation and technology integration. TAR should be site specific, holistic, farmer participatory, providing technical solution to existing problems, inter-disciplinary and Interactive.

This process involves Scientist-Farmer linkage in terms of sufficient understanding of the farming situations, adequate perception of farmers' circumstances and their needs, the variability of conditions on the research status as compared to farmers' fields and problem orientation instead of disciplinary approach.Thus, Technology assessment in agriculture by KVKs should be understood as the study and evaluation of new technologies under different micro locations. It is based on the conviction that new discoveries by the researchers are relevant for the farming systems at large, and that technological progress can never be free of implications. Also, technology assessment recognizes the fact that scientists at research stations normally are not trained field level workers themselves and accordingly ought to be very careful while passing positive judgments on the field level implications of their own, or their organization's new findings or technologies. Considering the above factors, the ICAR has envisaged On Farm Trials (OFTs) through its vast network of KVKs covering almost the entire geographical area of the country (Anon, 1999).

On Farm Trials (OFTs)

An On-Farm Trial aims at testing a new technology or an idea in farmer's fields, under farmers' conditions and management, by using farmer's own practice as control. It should help to develop innovations consistent with farmer's circumstances, compatible with the actual farming system and corresponding to farmer's goals and preferences.On-farm-trial is not identical to a demonstration plot, which aims at showing farmers a technology of which researchers and extension agents are sure that it works in the area. *It should be noted that OFTs are strictly to be conducted in collaborating farmer fields and not in KVK land.*

Stakeholders of On-farm trials

There are various stakeholders in an on-farm trial. Understanding them and their roles can help KVKs to develop better OFTs. The stakeholders are:

1. The farmers who are the clients for the out-coming results,
2. The SMS who should help the farmers to overcome their problems and improve their economical situation. On farm trials can give them valuable information in this respect.
3. The Scientist who needs to apply promising on-station results under farmers' conditions before releasing the technology to the extension service,

4. The extension system and government itself, who is interested in seeing an efficient and participatory technology development model evolving, since most top-down approaches have failed miserably.

Typology of On Farm Trials

We can distinguish three types of OFTs in India according to the stakeholder who is going to take the lead role:

• **Type 1, Research driven:** Research system designed and managed (with the assistance of extension)

• **Type 2, Extension driven:** Extension System or KVK system designed and managed by farmers

• **Type 3, Farmer/User driven:** Farmers/user designed and managed, with the assistance of Extension system/KVK system.

Type 1. Research driven

Rationale:

Research has shown promising results in on station trials. Now the concerned researcher wants to evaluate the new technology in multi location as the on station trial does not represent the wide range of conditions (e.g. soil fertility, weed flora, altitude, rainfall, farmers' conditions).

Objective:

Assess the performance of the new technology under various conditions and test the acceptability by farmers.

Particular characteristics:

The trial is usually planned in advance and included in the annual work-plan of either research or extension. Objective and layout of the trial is thoroughly discussed by the researcher with the Institute/Division head and the respective Extension agency. Here,

a. Extension agency involved helps to locate suitable fields
b. Usually plots are of small size
c. Researchers design and manage the trials with the help of extension agencies
d. If necessary, researchers furnish inputs and may exceptionally hire labour
e. Trails are used for the purpose of field day

Outputs:

Information on the performance of new technology under various conditions; information on the acceptability by farmers and interesting positive results are published in various journals.

Type 2. Extension driven

Extension driven OFTs should not be confused as to only extension system managed. The OFTs by KVKs also fall under this type since the whole purpose of OFTs by KVKs is to give feed-forward to the extension system.

Rationale:

Type 1 trials have confirmed that the new technology will work in farmers' conditions; therefore SMS plan to implement the trial on a wider scale with active involvement of the farmers. Researchers are interested in getting the information on both biophysical and farmers assessment of the technology. KVK and SMS have developed their own ideas how to improve aspects of the new technology. They want to try it out in real farm situation.

Objectives:

a. Assess the biophysical performance of a new technology in a wide range of micro-locations within the district,
b. Obtain the farmers viewpoint about the technology,
c. Assess cost/benefit ratio.

Particular Characteristics:

a. Interest of farmer having the trial on his land must be ascertained. Objective must be very well understood by farmers,
b. SMS discuss their ideas with PC and researchers
c. SMS determines on the design and provides instruction
d. Plots are often larger than in type 1
e. Farmers' assessment of the result is essential
f. Scope for refinement after assessment
g. Feed back of the results to research and
h. Feedforward of successful technologies to extension system

Outputs:

a. Farmers' reaction on technology, on management requirement and economical sustainability of the technology.
b. Feedback for the design of new future trials and
c. Compilation of a large number of similar trials will give fairly reliable data on performance over a broad range of farm types and circumstances.

Type 3. Farmer/user driven

Toughest of all types, yet the most sought after one. It involves Participatory Technology Development thus contributing to sustainability of results. The KVKs are also expected to bring their OFTs to this level from being an extension driven one at present.

Rationale:

a. Farmers are aware of a given technology, they like what they see and would like to experiment it by themselves.
b. Farmers are aware of a problem and would try some methods to solve them and
c. Researchers want to know to which extent and how a technology is adapted by farmers

Objectives:

a. To study how farmers adapt and adopt technologies,
b. To investigate what factors affect the performance of technology,
c. Provide on station researchers with feed back on problems at farm level and provide new research issues and
d. Participatory technology development

Particular Characteristics:

a. Farmers identify problems and choose from menu of technologies.
b. Farmers decide to choose the technologies and modify them to fit their particular farming system. Control plots are not really necessary unless the farmer decides to have one
c. High level of participation and self mobilization
d. Feed back of the results to research and other interested entities
e. Feed-forward to other farmers.

Outputs:

a. SMS document the farmers' decisions, preference and the management strategies.
b. Information is collected on the uptake of the new technology by fellow farmers.
c. Feedback to researchers on technology performance and on further research needs

Points to consider:

a. It is not wise to force collection of the biophysical data (yield, climate, and soil fertility) in type 3 because of too many confusing factors.
b. Constant monitoring, recording of farmers' comments is necessary.
c. Encourage farmer to take some notes himself (inputs, yield etc.)
d. Self-diffusion of the technology needs to be monitored (e.g. seed distributed to neighbours, area expansion etc) and
e. Socio-economic data should be collected.

KVKs have to spend considerable time and efforts in planning and implementing OFTs. The basic principles of conducting successful OFTs are to be followed in this process. The principles are:

1. *Define a clear question you would like to have an answer for:*

Narrow the trial down to its simplest form; define a clear simple question to which the OFT should give an answer.

2. *Keep it simple:*

   Limit the trial to a comparison of two (or maximum three) treatments.

3. *Go step by step:*

   Farmers usually do not adopt entire new systems of production; they go step-by-step adapting components of the technology. Therefore the OFT should not include too many new steps/practices at once.

4. *Seek help:*

   When the problem is clear and the idea on how to go about the trial has evolved, the SMS should contact a competent researcher to discuss the plan of the OFT. He/Shecan also take help from other SMS and PC of the KVK.

5. *Replicate and randomize*

   Plan on enough field space (in farmers' field) to do more than one strip of each treatment being tested. Mix treatments within blocks.

6. *Stay uniform:*

   Treat all the plots exactly the same except for the differing treatments. If possible, locate the experiment in a field of uniform soil type (slope, fertility etc.).

7. *Harvest individual plots:*

   Record data from each individual plot separately. Do not lump all treatment types together or the value of replication will be lost.

8. *Remain objective:*

   The results may not turn out as expected or planned. Be prepared to accept and learn from negative results. Negative results show that the technology under testing is not suitable in the present form for the specific micro-location of the district. Such results are equally valuable for the benefit of farming systems at large.

9. *Manage time wisely:*

   Expect to devote extra time to OFT during busy seasons. Make sure to can carry out the trial even though busy, or get extra help from other SMS.

The success of an OFT should not be confused with success of the technology tested. A negative result of a technology tested shows that the technology is not suited for the specific micro-location of the district. This finding also refers to the success of the trial. Some technologies may not need refinement thus qualifying directly for frontline demonstrations. Some may successfully undergo refinement and reach the demonstration stage while some technologies fail to get refined in the farmer field. The technologies which successfully come out of On Farm Trials are then recommended for Frontline Demonstrations (FLDs).

A study conducted by National Institute of Labour Economics Research and Development during 2015 on impact of KVKs on dissemination of improved practices and technologies revealed that KVKs are having an edge over other organizations in providing technology services by virtue of their having better technical expertise and demonstration units. At national level, on an average each KVK covers 43 villages and 4,300 farmers, and it organize more field level activities than on campus activities. About 25% of the persons trained by KVKs onagri-preneurship had started self-employment venture.

Krishi Vigyan Kendra Knowledge Network Portal

Krishi Vigyan Kendra Knowledge Network Portal facilitates KVKs to update and upload all types of information so that the related information and knowledge can reach to the farming community in time. A KVK Mobile App for farmers has also been developed for Android users and is available in Google Play Store. Farmers need to register and select concerned KVK in the App for accessing information. Farmers can ask any farm related query to the experts of KVKs for solution.

Conclusion

With current reforms and policies, the public extension system would continue to play a prominent role in technology dissemination. The large scale of small and marginal farmers and landless labourers are benefited by the public extension system. The other players involved in extension/transfer of technologies such as NGOs, Farmers organisations, Private sector (both corporate and informal), para-workers etc. would actively complement/ supplement the effort of the public extension agency. Extension mechanism will have to be driven by farmer's needs, location specific and address diversified demands. There is room for both the public and private sectors in the development of a demand based and feedback driven system. Technologies required to address total farming systems are knowledge intensive. Public extension system will need to be redefined with focus on knowledge-based technologies to upgrade and improve the skills of the farmers.

Farmers' capacity building is often seen within the limited perspective of giving them the knowledge and skills required to practice crop and animal husbandry in a better way. Though, knowledge and skills are fundamental to efficiency in any enterprise, the Indian farmers need more than that because of the limitations and complexities under which they operate. The KVKs which have been mandated to work with farmers, farm workers and rural youth directly as well as through field extension functionaries have the greatest challenge to make their clients more efficient, specialized and to be economically active. The fact that the need for agricultural/fisheries and rural information and advisory services is to intensify in the immediate future exerts more pressure on KVK performance. This articlehas attempted to assist the extension practitioners in equipping themselves for the future challenges by providing a conceptual paradigm regarding technology assessment and refinement, the most important mandated activity assigned to them.

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Chapter 11

Gender in fisheries development

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Fisheries as a source of food, livelihood and income is probably as old as human civilization. Millions of men and women across the world, especially the developing world, are dependent on the sector. While fish capture in the open seas has generally been a male preserve conditioned by various social, cultural and economic factors; women also have significant contributions for sustaining household nutritional and income security. They have been engaged in fishing in inshore coastal waters, inland water bodies like rivers and ponds; and in post harvest activities like pre-processing, processing, drying, salting, and allied activities like marketing, net making and mending etc. With increasing volumes of fish coming from culture fisheries the participation of men and women in these activities are also increasing. Suffice to say that both men and women contribute to the overall growth and development of the fisheries sector. However, often women and their contributions tend to be marginalized in the fisheries development debate.

Women's roles in fisheries

In the marine fisheries sector, fishing is largely a male preserve. Women rarely venture into the sae, conditioned by cultural and social taboos rather than by skill and endurance. However, the support from women in managing the households and in taking up subsistence or other livelihood activities related to fisheries activities that may actually go into the household income security need to be acknowledged. Studies show that women comprise about 46% of the labour force in small-scale capture fisheries-related activities (FAO, World Bank, IFAD, 2008). It is as high as 73% in Nigeria to a low of 4% in Mozambique. At least 50 % of the workforce in inland fisheries and 60 % of those marketing fish are women in Asia and West Africa.

Women glean for fish, shell fish, molluscs and crustaceans. There are traditional women divers in various parts of the world who fish with primitive fishing implements. Women have been more predominant post-harvest activities like marketing; drying; smoking; salting; fermenting; and other seafood industry oriented pre-processing and processing. Women generally occupy the lowest rung of workers in seafood factories at the floor level and their work comes under the unskilled category which results in lower pay structures when compared to male workers.

The loading and unloading work at landing centres are also mostly done by men. Post landing women are actively engaged in sorting, rarely in auctioning and trading, and very active in marketing, especially in retail trade. In trading it is the access to credit and availability of resources that effect participation. It is seen that where women have access to and control over resources their interventions and participation in markets is high. It has also been observed that when women establish themselves in markets, the men from their households slowly step in and then the business goes into their hands. Fish marketing in most developing countries are poorly organised and lack of cold chain and other infrastructural facilities force vendors to transact their businesses on the same day. Women are usually relegated to the poor market spaces and have to jostle with other players in the market. Women are also engaged in sun drying of excess fish or fish procured for drying purposes. They are also the backbone of the seafood pre-processing and processing sectors all over the world with almost all of the floor level work like peeling, sorting, grading, cooking, packing being carried out by them. However, in all countries it has been observed that women are disadvantaged as far as the wages are concerned and invariably earn less than the men engaged in this industry. The working conditions also leave a lot to be desired.

While it is a fact that there are few women in sea fishing, women harvest fish from inshore coastal waters by gleaning, and fish in inland water bodies in Asia, East and West Africa, and the Pacific. Much of the catch is for household subsistence and goes for meeting the household needs. Women are active in small scale aquaculture where they perform myriad roles like helping men in pond preparation, feeding, packing etc. They are involved in pond preparation, stocking, feeding and harvesting operations along with the men. However, their labour tends to be classified as family labour and thus often goes unrecognised. Ownership of farms is still largely male dominated. Just like in agriculture a focussed shift towards empowering women by creating ownership and providing technical guidance and providing suitable inputs, the production can be further enhanced and their contributions increased considerably.

In large scale aquaculture they are paid for their jobs, which are similar to the ones they carry out in small scale aquaculture, like feeding and packing. Women's roles sometimes are restricted due to the location of aquaculture sites which may be inaccessible and employers prefer male employees as they are supposed to fend for themselves under difficult living conditions, while women need special attention. In some states of India, women's involvement in aquaculture is limited to collection of wild seed of shrimp in inter-tidal regions. A recent study by the Network of Aquaculture Centres in Asia-Pacific in Thailand, Vietnam, Cambodia and Lao PDR that focussed on small scale aquaculture systems found that, women were present in all the major nodes of the aquaculture value chains. They contribute in almost all activities right from pond preparation, stocking, feeding, water management and health care to harvesting.

A sector which is having great potential and can be exploited is the ornamental fish breeding. Thailand has seen a lot of success in generating entrepreneurship for women in this sector.Women are also involved in net making and mending which is a supplementary activity in coastal areas. Mariculture activities like cage and pen culture, seaweed culture also have potential for generating employment for women in fishing communities.

Women also manage households attending to cooking, cleaning and care giving when they are engaged in these fisheries related activities. However women in fishing communities are rarely involved in decision-making related to fishing at the household, community, regional and national levels. Women's access to resources like credit, education and health care also tends to be poor. Due to the changes taking place in fisheries across the world, there are increasing insecurities and irregularities when it comes to assuring incomes to women's work and they tend to be bigger losers and more vulnerable.

FAO (2012) makes the following observations:

- In Bangladesh, women's non-governmental organizations and other entrepreneurs have encouraged women to participate in aquaculture activities.
- In Belize, most workers involved in processing are women from rural communities where unemployment levels are high and poverty is greatest.
- In Cuba, female workers constitute 27% of the aquaculture workforce (19 % are intermediate and higher education technicians; 11% have attended higher education institutions).
- In Estonia, the gender ratio of the aquaculture workforce is 1:1.
- In Israel, the workforce is a skilled one because of the highly technical nature of aquaculture in the country. In a sector where women make up about 95 % of the workforce, most workers have a high school diploma while a high percentage has a degree (Bachelor of Science or Master of Science).
- In Jamaica, about 8–11 % of fish farmers are women who own and operate fish farms; and in processing plants, women dominate the workforce.
- In Malaysia, women account for about 10 % of the total aquaculture workforce, and they are mostly involved in freshwater aquaculture and hatchery operations for marine fish, shrimp and freshwater fish.
- In Panama, 80 % of the workforce in processing plants is women, but in the production sector only 7% of workers are women.
- In Sri Lanka, women constitute 5% of the workforce in shrimp aquaculture and 30 % of those engaged in the production and breeding of ornamental fish.

Gender Mainstreaming for development

'Mainstreaming' means bringing out gender concerns in all aspects of executing policies and programmes from implementation to evaluation so that there is equality in sharing benefits.

It is now well accepted that participation of women is very important in maintaining economic growth and development. Participation does not merely mean involvement, it means ensuring equal access to all the productive resources required for production. It requires empowering women and investing in women competencies. The Food and Agriculture Organization (FAO) considers that feminisation has serious implications for the producers' economic agency and productivity and farm income. Provided the same access to productive resources as men in the world, farm yields could be raised by 20–30%, thereby increasing the overall agricultural output in developing countries by 2.5 to 4%. Besides increasing women's income, this gain in production could lessen hunger in the world by 12–17%.

In the context of fisheries, the issues are much more complex as fisherwomen are excluded from some of the activities in the sector. Even after making significant contributions to households as well as communities, they are marginalized. This is mainly because of poor access to and control over productive resources. There is also need to improve their participation in decision making and governance of fisheries as a whole. What is easily accessible to the men are often not available to women due to social, cultural, political and economic reasons. Overcoming these may not be easy but affirmative policies can ensure that changes are brought about. Most fisheries in the developing world are small scale. And in this context the community's place in the fisheries development context is important. The FAO Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication adopted in 2015 clearly states 'Gender equality and equity" as fundamental to any development and has stated it as a guiding principle.

Some gender concepts

- Gender has been defined as 'a concept that refers to the social differences, as opposed to the biological ones, between women and men that have been learned, are changeable over time and have wide variations both within and between cultures.
- Gender equity refers to the process of fair and justice treatment of women and men to reach gender equality.
- Gender equality refers to the equal enjoyment by women and men or boys and girls of rights, opportunities, services and resources.
- Gender analysis is the systematic attempt to identify key issues contributing to gender inequalities so that they can be properly addressed.
- Gender analysis provides the basis for gender mainstreaming and is described as 'the study of differences in the conditions, needs, participation rates, access to resources and development, control of assets, decision-making powers, etc., between women and men in their assigned gender roles'.

Source: http://www.rflp.org/ (Regional Fisheries Livelihoods Programme for South and Southeast

Fisheries related natural resources like seas, rivers, lakes, ponds etc, are common property resources. In effect there is no restriction on use, though traditions and conventions usually regulate access. National and regional agreements can also restrict access. Aquaculture ponds are privately owned and in most cases the owners are men. Where traditional rights are exercised, women do not figure in the decision making process. Most decisions are taken by the men in the community. Access also therefore is governed by men. This is one reason why there are very few women who actually venture into the sea for fishing. The fishing that women carry out is smaller in scale and operation and at best supportive in nature. Fisheries Development activities that focus on increasing fish production also thus are male centric. That there are women fishing in inshore waters and any development activity that is carried along the shore will have an impact on their activity is hardly ever noticed. An off-shoot has been that many activities performed by women have become excluded or banned when planning and policy making on fisheries management are formulated. Ownership and inheritance of land and of major fishing implements is also through men.

Traditionally, net making was a women centric activity. While the men went fishing, women made and mended the fishing nets, Mechanization of the netting yarn and net making process has played a part in reducing the role of women in net mending. The increasing size and type of nets has also made women leave the sector. Now fishermen themselves are engaged in making and repairing of the gear. Mechanization of craft and gear has resulted in the 'economic displacement' of many fish wives.

Credit is another important resource that determines the scale of operation of any enterprise. Rural credit has always been dominated by informal sources. In fisheries craft and gear; and marketing activities are all financed by large scale traders or auctioneers. Women find it extremely difficult to find credit support for their activities. Women usually get access to credit through their husbands or other male relatives, because of the interdependency between trade and finance. However, credit availed by women for specific activities are sometimes seen diverted for household requirements. Women fish traders usually face high costs of transportation, fluctuating prices and travel during odd hours transportation. very poor facilities also leads to health problems. Competition from male fish retailers is also high. Men generally own vehicles and transportation is easier.

One of the most important ways of improving the levels of participation of women is by improving access to the resources that were described earlier. State level policy instruments are necessary to achieve this. Community traditions are difficult to change but requirements under law need to be followed. Specific laws to include women in community decision making bodies will be a starting point. The passing of the Panchayati Raj Act in India resulted in the dramatic increase in number of women in local self-governance. Self-Help-Groups (SHGs) have improved access to credit in many countries. Through SHGs women in small units come together and get engaged in productive activities by promoting savings and providing short term loans at lower rates of interest. At a larger scale Cooperatives can perform the same role.

Equal access to skill development and technology in fisheries are also important in gender mainstreaming. Technological innovations in harvest sector have been responsible for transforming fisheries sector from a traditional subsistence to a commercial level. The use of labour saving technology is always gender specific and has differential impacts. Since women are predominant in post harvest activities related technologies can play a major role in their empowerment. Better technologies for handling, curing and drying and processing of fish have helped women improve their incomes. The technology development process is generally gender neutral. However, it must take into account the ability of the women in handling or using the technology.

The way forward

Fisheries like all other primary production sectors are undergoing changes. The impacts of mechanization, climate change, natural disasters etc. are all serious concerns in the sector. Women in fisheries contribute significantly to household incomes however their control over the same is a challenge. Conditions of work need improvement in tune with changes in all other spheres of life. Skills need to be developed to make them capable of adapting to the technological changes. Organising is another way of trying to achieve common goals and need to be encouraged by both Governments and NGOs. However, it must be ensured that in the process of 'inclusion' of women in more areas of fisheries should not result in increasing the burden of already existing roles.

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Chapter 12

Marine Fishery Regulations and Policies in India

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Introduction

India, being one of the largest marine fisheries in the world, has high stakes in managing its coastal and marine resources. The marine resources in India are highly diverse comprising of an exclusive economic zone of 2.02 million km^2 besides a continental shelf area of nearly 0.50 million square kilometers. The capture fisheries sector in India, though experienced a rapid expansion in the recent decades with the advent of mechanized fishing during 1980s, has started showing signs of over capitalization and consequent crises. Experts in the field have already highlighted the impending problems such as declining catch rate and diminishing returns, overfishing and /juvenile fishing leading to depletion of fish stock, rampant destruction of marine biota due to high-intensity trawling, and so on (Devaraj and Vivekanandan,1999; Ramachandran, 2004). The imminent crisis is increasingly getting reflected through frequent conflicts between various groups/factions of fishermen/vessel operators over their rights and shares over the resources. These circumstances echo the need for a strong regulatory and management regime for protecting and preserving the maritime resources of the sub-continent. Though India is not new to regulations in fisheries sector with a number of laws and rules in place for more than a century, the emerging scenario merits a relook into the existing regulatory framework. Against this backdrop, this chapter presents global approaches to marine fisheries regulations along with a broad overview and critical appraisal of India's marine fishery regulations and policies aimed at conservation and sustainable development.

Approaches and tools to fishery regulations

A wide variety of approaches and tools are used for regulating fisheries across the world. As the primary aim of regulating a marine fishery is to maintain a sustainable level of biomass and productivity in the wild stock, efforts in this direction are mainly directed to limit the rate of extraction. The basic scientific concept followed in this context is the 'maximum sustainable yield (MSY)' which is the maximum level at which a resource can be routinely exploited without long-term depletion. The idea was evolved in fisheries in the early 1930s, and attained popularity in the 1950s with the advent of 'surplus production models' capable of actually estimating the MSY based on oceanographic and marine data. However, subsequent assessments revealed that while establishing a sustainable level of harvest as goal with intuitive appeal, the pursuit of MSY ignores many relevant economic and social factors that are critical to the sustainability of a fishery (Larkin *et al*, 2011). A new concept namely, maximum economic yield (MEY) was introduced that defined the level of harvest or effort that maximizes the sustainable net returns from fishing (Grafton *et al*, 2006). This approach picked up momentum with developments in the area of bio-economic modeling that combines the underlying stock dynamics with the harvest function and the costs of harvest and economic value of the extracted resources. An illustration on how MSY and MEY compares with each other is presented in Figure 1. Declaration of total allowable catch (TAC) limits, especially by temperate fisheries administrations, is generally based on any of the above two concepts. MSY/MEY can be achieved through alternative strategies such as limiting access to the resources, setting caps on quantity harvested, limiting the fishing efforts, maneuvering the area and time of harvesting so as to avoid spawning and juvenile fish, and so on. These basic strategies became the guiding principles behind fishing regulations that forms essential components of all major fisheries management programs in the world. Accordingly, approaches to fisheries regulation can be broadly classified into five categories, viz., (i) Access-control based (ii) Output/catch-based (iii) Input/effort-based (iv) Temporal and (v) Spatial. However, such a classification is not water-tight and is subject to changes depending upon contexts. While the first three approaches are primarily directed to limit the rate of extraction from the stock, temporal (mainly seasonal bans) and spatial approaches generally target to minimize destruction to sensitive stocks (endangered species, spawning and juvenile fish).

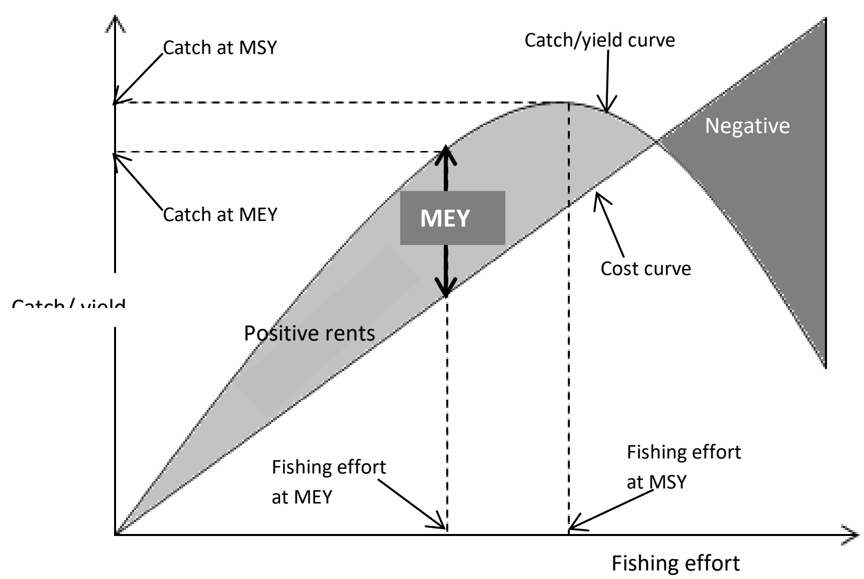

Figure 1. Maximum sustainable yield (MSY) and maximum economic yield (MEY)

Source: World Bank (2009)

A brief account of the main fishery regulatory tools that fall under the above five approaches along with a few notable examples is presented in Table 1. Among the various measures, access control is one of the most basic and easy-to-implement regulation that includes tools such as licensing and registration that limit fishing access based on a set of basic minimum requirements. It also includes options such as limited entry permits issued to impose severe access restrictions, and those like group fishing rights and territorial use rights for fishing (TURFs) that are restricted to specific communities or beneficiary groups. Output-based regulatory tools include collective/individual catch quota, vessel catch limits and minimum size limits. Catch quota are generally fixed based on TAC estimates derived based on the concepts of MSY/MEY and are subsequently rationed among beneficiaries based on certain qualifying criteria. The quotas are either transferable or non-transferable depending on the degree of regulation. Minimum size limits, another output-based regulation, are mainly set to prevent harvesting of juvenile fish thereby to hasten rebuilding of excessively exploited stocks. Nevertheless, output control measures are data intensive and requires substantial amount of resources for their implementation, thus limited only to a handful of advanced fisheries. Input-controls focus on restricting the types of inputs as well as effort involved in the stock extraction process and include gear restrictions that set limits on the type, designs and mesh-size of the gears used, engine power restrictions, as well as size restrictions on fishing vessels. Though they are relatively easier and less costly to implement as compared to output-based measures, one major demerit is the difficulty associated with assessing the extent of control on each input so as to derive desired results (FAO, 1997). Temporal controls are widely adopted across the world, wherein, the idea is to regulate resource extraction during specified seasons of the year or to fix time limits to fishing. Seasonal fishing bans, a common temporal strategy, is adopted both in temperate and tropical waters to minimize destruction of spawning population. Spatial restriction approach on the other hand, includes alternative tools such as designating marine protected areas (MPAs), temporary area closures and spatial zoning. MPAs have received considerable attention in the recent times and are increasingly employed world-wide as an ecosystem-based management strategy to conserve marine resources and to prevent the degradation of sensitive marine ecosystems through coastal protection, habitat restoration and biodiversity conservation (Halpern, 2003; Kaplan *et al*, 2015).

Fishery regulations in India

Marine capture fishery in India is governed by a number of rules and regulations which are put in place from time to time with cross cutting mandates and objectives. The pioneering attempt to regulate fishing in India was the introduction of The Indian Fisheries Act, 1897 by the then British administration. This was followed by several local regulations promulgated by various princely states in the subsequent years of British Raj. In the post-independence era, the enactment of two crucial laws, viz., The Territorial Waters, Continental Shelf, Exclusive Economic Zone and other Maritime Zones Act, 1976 and Maritime Zones of India (Regulation of Fishing by Foreign Vessels) Act, 1981 has significantly altered the way fishery in the country is regulated. These Acts which deal with demarcation of maritime zones for fishing and ocean administration were the offshoots of the UNCLOS negotiations. Other important legislations/policies passed during the 1970s and afterwards and which are relevant for marine fishing activities include, Wildlife Protection Act, 1972; The Forest Conservation Act, 1980; The Environment (Protection) Act, 1986; The Coastal Regulation Zone (CRZ) notification, 1991; New Deep Sea Fishing Policy, 1991; Biological Diversity Act, 2002; Comprehensive Marine Fisheries Policy, 2004; notifications declaring selected coastal areas as MPAs from time to time, and so on. The latest effort in this direction is the National Policy on Marine Fisheries, 2017 which was notified on 28th April, 2017 (GoI, 2017).

As per the clauses under the Act of 1971, the areas up to 200 nautical miles from the territorial sea baseline is designated as the Exclusive Economic Zone (EEZ), wherein the country has sovereign rights for the purpose of exploration, exploitation, conservation and management of the natural resources as well as for producing energy. Areas up to 12 nautical miles (nm) from the baseline are designated as territorial waters. As per the Seventh Schedule of the Constitution of India, the states have the jurisdiction to govern fishing and fisheries in the territorial waters, whereas the union government reserves its jurisdiction beyond territorial waters, i.e., between 12 nm and 200 nm. The marine fishing activities within the territorial waters of maritime states are governed by the respective Marine Fisheries Regulatory Acts (MFRAs). Kerala and Goa were the pioneering states to pass their own MFRAs in the year 1980, which was followed suit by other maritime states in the subsequent years. The MFRAs contain several provisions to regulate, restrict or prohibit unsustainable / destructive fishing practices, to define access rights, to impose spatial and temporal fishing restrictions and to make licensing and registration of fishing vessels compulsory. Clauses to penalize non-compliance and appellate provisions are also inbuilt in them so as to ensure fair governance of fishing and related activities. The specific details of the legislations and regulatory provisions contained therein with respect to the maritime states of India are presented in Table 2.

Regulatory provisions under the MFRAs: A critical appraisal

MFRAs have been found effective to a great extent in regulating fishing within the territorial waters. These legislations make use of a variety of regulatory approaches such as access control, input/effort-based restrictions, spatial as well as temporal restrictions outlined above. However, output/catch-based controls have been sparsely used by the states (except in Kerala, where MLS for fish species are notified in 2015). Provisions for compulsory registration and licensing of fishing vessels, which are the basic access control measures used world over, finds place in the MFRAs of all maritime states and UTs. Temporal restriction of mechanized fishing or seasonal fishing ban (SFB) is another tool adopted across the maritime regions of India. The basic rationale is to restrict fishing activities during the time when most marine fish species undergo peak spawning so as to ensure natural replenishment of fish stock. Gujarat, Goa, Maharashtra, Kerala and Karnataka have been diligently practicing SFB for more than 2 decades and other states have joined force during the later years. The criteria in fixing the closure periods and the type of fishing activities restricted during SFB varied across states.

Table 1. Major tools for regulating capture fisheries

Regulatory approach	Specific tool	Description	Major examples (with year of first introduction)
Access controls	License	License is the basic access requirement for a fisher to undertake fishing.	Almost all major fisheries in the world.
	Registration	Registration of fishing vessels for identification purpose is mandatory by law in most fisheries.	Almost all major fisheries in the world.
	Limited entry permits	Holders of the individual entry permits are only allowed to compete for harvests from a common pool.	Salmon fishing licenses (Alaska, 1974, British Columbia, 1968); Western Australia rock lobster (1963).
	Group fishing rights/ fishing cooperatives	Limited entry permit holders agree on a harvesting system usually by written contract.	Pacific whiting Conservation Cooperative (1998); Bering Sea Pollock Co-ops (1999).
	Territorial use rights for fishing (TURF)	Access to fishing areas limited by custom or law to members of a village, tribe or other groups.	Community-based TURFs in Oceania and Japan; Coromandel coast fisheries, Tamil Nadu, India.
Output/catch-based	Collective catch quota	Aggregate catch quotas allotted to specified beneficiary groups.	Western Alaska Community Development Quotas (1994).
	Individual catch quota	Species-specific catch quotas (in terms of weight) allocated to individuals. They are generally transferable / tradable.	Individual transferable quota (ITQ) programs in Alaskan halibut/sablefish fishery (1995); ITQs in Southern Australian shelf for bluefintuna (1983).
	Vessel catch limits/quotas	Catch quotas specific to vessels.	Individual Vessel Quota (IVQ) system for the ground fish trawl fishery in the British Columbia (1997).
	Size restrictions	Minimum legal sizes (MLS) specified to individual fish species to prevent juvenile fishing.	Minimum legal size (MLS) restrictions in Kerala fisheries, India (2015); MLS restrictions in Baltic cod trawl fishery (1994).
Input/effort-based	Gear restrictions	Restrictions on the type and designs as well as mesh-size of the fishing gear used.	Mesh-size regulations in Baltic cod trawl fishery (1994); Mesh-size limits under the marine fishery regulatory acts of India.
	Engine power restrictions	Regulations by placing an upper-limit on the engine horse power.	Common Fisheries Policy of Council of the European Union, 2009.

	Vessel size restrictions	Size restrictions on fishing vessels applicable to specific fishery fleets, especially in terms of their length/tonnage.	British Columbia Ground fish trawl fishery (1997); Nova Scotia ground fish fishery, Canada (1989).
Temporal restrictions	Seasonal fishing ban	Fishing bans imposed during specified seasons in a year, mainly to prevent fishing during spawning.	Seasonal fishing bans in eastern and western costs of India (1980 onwards); Closure of North sea beam trawl fleet to cod fishery (2001).
	Fishing duration restrictions	Limiting the duration of fishing by an individual/vessel (eg: limits on hours/day, days/season, time away from port, etc.)	Effort quotas (fishing duration) for regulating demersal fish stocks in the Faroe Islands, Denmark (1996); 'Days-at-sea' regulations for New England ground fish fleet (1995).
	Fishing time restrictions	Restrictions to fishing during particular time of the day (eg: regulation of night fishing).	Prohibition of trawl net operations between 6 pm and 6 am in Maharashtra coast, India (1981); Night fishing ban in Lamu, Kenya (2011).
Spatial restrictions	Marine protected areas (MPA)	A protected area where fishing is prohibited. MPA area divided into six categories by IUCN based on strictness of the protection regime.	MPAs in New South Wales, Australia (2002); Florida Keys National Marine Sanctuary, USA (2000); MPAs in the Indian peninsula (1978).
	Temporary area closures	Temporary area closures are practiced mainly to protect juveniles in specific areas where certain species come for spawning.	Area closures to protect octopus in Velondriake marine area in Madagascar (2004).
	Spatial zoning	Restricting access to different groups of fishers (artisanal fishers *versus* mechanized fishers) based on distance from shore/ depth of water.	State marine fisheries regulations, India (1980).

Source: Parappurathu and Ramachandran (2017)

Table 2. Capture fisheries regulatory framework in maritime states of India

Maritime State	Access controls	Temporal controls	Spatial controls	Input/effort-based	Output/catch-based	Legislation/s in force
Gujarat	Registration and licensing of fishing vessels.	Seasonal fishing ban (SFB) (Jun 1 – July 31, 61 days)	Artisanal: up to 9 km; Mechanized: beyond 9 km.	Square mesh of minimum 40 mm size at cod end need to be used for trawl net; Gillnet with mesh size less than 150 mm prohibited.	-	The Gujarat Fisheries Act, 2003.
Maharashtra	-do-	SFB (Jun 1 – July 31, 61 days); Mechanized vessels with trawl net prohibited between 6 pm and 6 am.	Mechanized (trawl net) : beyond 5-10 fathom depth in specified areas; Mechanized (any type with more than 6 cylinder engines): beyond 22 km.	Use of purse-seine gears by mechanized vessels at specified coastal zones prohibited within territorial waters.	-	Maharashtra Marine Fisheries Regulation Act, 1981 (Amended in 2015).
Goa, Daman & Diu	-do-	SFB (Jun 1 – July 31, 61 days)	Artisanal: up to 5 km; Mechanized: beyond 5 km.	Mesh-size limits of 20 mm for prawn and 24 mm for fish.	-	The Goa, Daman and Diu Marine Fishing Regulation Act, 1982 (Amended in 1989).
Karnataka	-do-	SFB (Jun 1 to July 31-61 days)	Artisanal: up to 6 km or up to 4 fathoms (whichever is farther); Deep sea vessels (up to 50 feet length): beyond 6 km	Ban of cuttle fish fishery using FADs; Ban on light fishing.	-	The Karnataka Marine Fishing Regulation Act, 1986.

			Deep sea vessels (>50 feet length): beyond 22 km.			
Kerala	-do-	SFB (Jun 15-July 31, 47 days)[4]	Artisanal: 32-40 m depth in the first zone[5] and 16-20 m depth in the second zone; Mechanized vessels (< 25 GRT): 40- 70 m depth in the first zone and 20-40 m depth in the second zone; Mechanized (> 25 GRT): beyond 70 m depth in first and beyond 40 m depth in second zone.	Mesh-size regulations: code end minimum mesh size of bottom trawl net-35 mm; ring seine and driftnet minimum mesh size – 20mm.	Minimum legal size for 58 fish and shell-fish species notified to control juvenile fishing.	The Kerala Marine Fishing Regulation Act, 1980 (Amended in 2013 and 2017).
Tamil Nadu	-do-	SFB (April 15 to June 14, 61 days)	Artisanal: up to 5 km. Mechanized: beyond 5 km; Fishing within 100 m below a river mouth is prohibited;	No fishing gear of 100 mm mesh from knot to knot in respect of net other than trawl net to be used; Pair trawling and purse seining are	-	Tamil Nadu Marine Fishing Regulation Act, 1983(Amended in 1995; 2000; 2011; 2016).

[4] While all other maritime states and UTs agreed to extending the ban to 61 days in conformity with the directive of the Union Government issued in May, 2015, Kerala continues to stick to its earlier ban period for 47 days.

[5]The 78 km area from shore up to 32 m depth in the sea along the coast from Kollencode in the south to Paravoor (Pozhikkara), is the First Zone; The 512 km area up to 16 m depth in the sea along the coast line from Paravoor in the south to Manjeswar in the north is the Second Zone.

			The number of mechanized fishing vessels permitted in any specified area subject to restrictions.	prohibited.		
Andhra Pradesh	-do-	SFB (April 15 to June 14, 61 days)	Artisanal: up to 8 km; Mechanized (< 15 m OAL): 8-23 km; Mechanized (< 15 m OAL): beyond 23 km.	A minimum 15 mm limit for mesh-size for any gear; Shrimp trawlers not allowed without turtle-exclusion device (TED).	-	The Andhra Pradesh Marine Fishing (Regulation) Act, 1995 (Amended in 2005).
Odisha	-do-	SFB (April 15 to June 14, 61 days)	Artisanal: up to 5 km; Mechanized (<15 OAL): 5-10; Mechanized (>15 OAL): beyond 10 km.		-	The Orissa Marine Fishing Regulation Act, 1981(Amended in 2006).
West Bengal	-do-	SFB (April 15 to June 14, 61 days)	Artisanal & mechanized crafts with < 30 HP engine: up to 18 km; Mechanized crafts with >30 HP engine: beyond 18 km.	Mesh size regulations for specific gears: minimum 25 mm for gillnet/shore seine/drag net; 37 mm for bag net/dol net; Standard trawl net fitted with TED to be used.	-	The West Bengal Marine Fisheries Regulation Act, 1993.
Andaman & Nicobar	-do-	SFB (April 15 – June 14, 61	Artisanal & mechanized crafts	Standard trawl nets fitted with TED;	-	The Andaman and Nicobar Islands

islands		days)	with < 30 HP engine: up to 6 nm; Mechanized crafts with >30 HP engine: beyond 6 nm.	Gillnets, shore seines and dragnets with mesh sizes above 25 mm only permitted.		Marine Fisheries Regulation Act, 2003 (Amended in 2011).
Lakshadweep	-do-	SFB (Jun 1-July 31, 61 days)		Use of purse seine, ring seine, pelagic, mid water and bottom trawl of less than 20 mm mesh size, use of drift gill net of less than 50 mm mesh size and shore seine of less than 20 mm mesh size are prohibited in specified areas.	-	Lakshadweep Marine Fishing Regulation Act, 2000.

Source:UpdatedfromParappurathu and Ramachandran (2017)

However, to avoid conflicts of fishermen from different states, the Union Government appointed a committee in May, 2013 under the Chairmanship of Director, CMFRI to suggest uniform closure period for India's EEZ. The committee, based on scientific facts on spawning periods and other relevant details as well as stakeholder consultations across states, recommended a seasonal closure for 61 days (GoI, 2014). Based on this, the government fixed the ban period during April 15 till June 14 in East Coast and during June 1 to July 31 in the West Coast, since 2015. However, within their territorial waters, the States reserve the rights to decide on the fishing ban 'period' and its applicability on 'type of boats'. Several studies have shown the positive impacts of SFB in terms of reduction in fishing effort and short-term stock replenishments of major marine fish species (Vivekandnan*et al*, 2010; Thomas and Dineshbabu, 2014). Further, SFB is proven to improve the inter-sectoral catch distribution in favour of artisanal fishermen, as the closure is more or less in alignment with the spawning and recruitment of species like sardines and mackerals which form the backbone of the traditional sector (Joe, 2008). Though conclusive evidence on the impact of SFB in improving long-term sustainability of stocks is yet to come, it continues to hold promise as one of the important fishery management measures that has stood the test of time in India.

Spatial controls have been another set of fishing regulations that are widely being used to restrict unsustainable and destructive fishing activities in the seas. Spatial zoning is one such measure used across states to designate specific zones in the coastal waters within which use of certain types of fishing vessels/gears/practices are restricted or prohibited. Zoning as a practiced in India targets two major outcomes: (i) to minimize excessive damage of marine biota through destructive fishing methods (eg: bottom trawling) in the in-shore waters and (ii) to maintain inter-sectoral distribution of fish catch by reserving in-shore areas for traditional / artisanal fishermen. The zones are specified either based on the distance from shore or in terms of depth of water. In general, in-shore areas for a distance of 5-10 km are reserved for artisanal fishermen who do not use any mechanized fishing activities or vessels beyond certain specified tonnage/engine power (Figure 2). However, such access restrictions are not revised from time to time based on the changes in fishing technology and practices, thereby losing relevance over time. For instance, the inboard motorized vessels used for ring seine operations in the Kerala dn elsewhere are often comparable with mechanized boats in terms of catch volumes thus violating the basic objectives of the policy.

Controlling the type/level of inputs/ fishing efforts are also hailed as a practical solution to regulate excessive exploitation of oceanic resources. The main tools presently being used include blanket ban of certain types of destructive fishing gears, mesh-size regulations, hook-size controls, turtle exclusion devices (TED), ban of fish aggregating devices (FADs) and so on. Gear restrictions are mainly targeted to minimize juvenile fishing to allow fishes to mature. However, these restrictions have largely been rendered insufficient due to poor enforcement mechanisms as well as the difficulty to judge maturity of fishes just based on body sizes. With this realization, the Kerala government notified the minimum legal sizes of 58 species of fishes/shellfishes in 2015 based on technical inputs from CMFRI, Kochi. This is first of its kind of output-based regulation to have introduced under the MFRA framework of any maritime state so far. However, the effectiveness of this measure also depends on the level of enforcement that the state can achieve within economically viable limits.

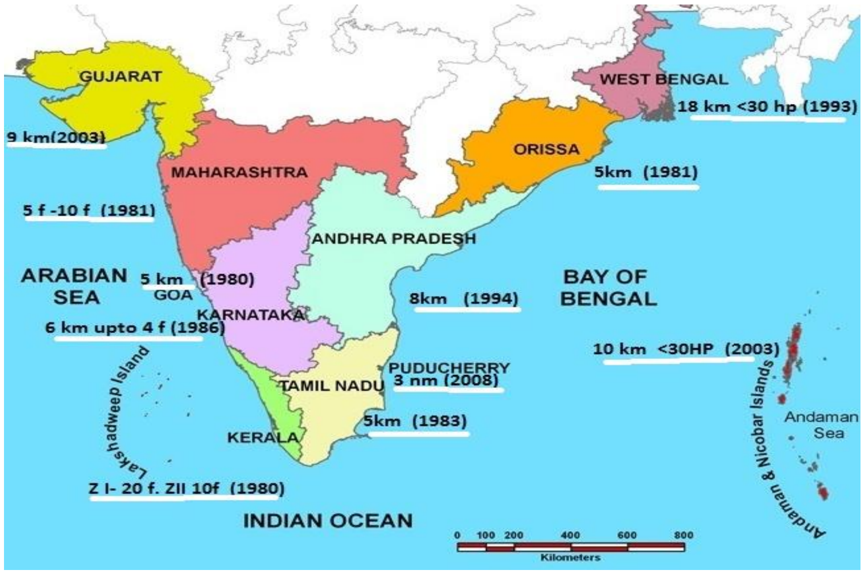

Figure 2. An illustration of spatial zoning wherein in-shore areas are reserved for artisanal fishing in India's territorial waters (Source: Parappurathu and Ramachandran, 2017)

***Sui generis*, community-based regulatory systems**

Along with formal and institutional regulatory mechanisms, a number of *sui generis* regulatory and co-management systems have co-existed in various parts of coastal India. Most of these informal, community-based governance models have evolved over time and have limited administrative jurisdictions in the concerned locales. These traditional management systems have proved to be highly dynamic by continuously adapting to changing technological paradigms and emerging challenges, retaining their relevance even now. Some such widely documented cases include the *padu* system being followed in parts of Kerala and Tamil Nadu (Lobe and Berkes, 2004); *Kadakodi* system in northern Kerala (Ramachandran and Sathiadhas, 2006); traditional *panchayat* system along the Coromandel Coast of Tamil Nadu (Bavinck, 2001) and alternate-day fishing systems in Gulf of Mannar and Palk Bay areas. The primary concerns of all these systems are resource conservation and sustainable fishery management with community control of access rights and regulations of certain kinds of harmful fishing practices. Access rights are generally determined by collective decisions based on accepted set of criteria and norms within the community. For instance, in case of *padu* system, access to designated fishing grounds is limited to members of a specific caste group in the locality based on a lottery system for harvest site allocation. The *kadakkody* system is much more elaborate with executive and legislative functions, and acts as a regulator of resources, protector of livelihoods and a mediator of social conflicts

(Baiju, 2011; Baiju et al, 2019). The *panchayat* system along the Coromandel Coast is a similar community-based governance system that regulates access and usage of fishing resources, besides discharging conflict resolution among community members. However, none of the above systems are officially recognized and continue to function as parallel systems of governance with little legal sanctity.

Conclusions

This chapter throws light on the various regulatory provisions and policies for sustainable development of India's capture fishery sector. It discusses in detail the access-based, temporal, spatial, input/effort-based and output/catch-based approaches for regulating fishing effort so that the resources are exploited at optimum level. Further, a critical appraisal of the various above provisions as enforced under the purview of MFRAs of maritime states as well as other sui-generis modes of regulations is also undertaken. The chapter underscores the fact that, though sectarian interests and lack of institutional will has held back regulatory consolidation of the sector so far, fast depletion of natural resource base in the region warrants joint action propelled by farsighted vision, common interests and shared responsibilities.

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Chapter 13

Seafood quality assurance and safety regulations

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Food Safety has been the buzz word in recent days as there are increasing consumer awareness on hazards present in food as well as the ombudsmen role played by independent media. Although regulatory regime across the world has taken proactive steps, in most of the cases it has been a knee-jerk reaction to the impending crisis. Defining the actual goal of food safety has been an arduous task as there are umpteen interrelated factors that influence the intended goals. Some of the definitions on food safety put forward by international agencies are as follows:

- Concept that food will not cause harm to the consumer when it is prepared and/or eaten according to its intended use (ISO 22000:2005)
- A suitable product which when consumed orally either by a human or an animal does not cause health risk to consumer (USDA-FSIS)
- Range of food related activities from prevention and surveillance to detection and control (ASTHO)

Food Safety also encompasses many aspects of handling, preparation and storage that introduces or controls chemical, microphysical and microbiological hazards. Quality of raw material, presence of pathogens, processing methods, climate change and cross-contamination also significantly impacts any food safety measure.

Seafood is always in news as it is proclaimed to be most nutritious and healthy food as well as being linked to increasing number of foodborne outbreaks across the globe. In the nutritional front, fish accounts for 17 percent of the global population intake of animal protein and 6.7% of all protein consumed (FAO, 2016). The world per capita consumption of fish and fishery products has increased from 9.9 Kg in 1960s to 20 Kg in 2014.

Seafood trade apart from being highly volatile accounts for 10 percent of total agricultural exports and 1 percent of world merchandise trade in value terms. In 2010, the quantum of seafood trade has crossed US$109 billion. Ninety percent of global trade in fish and fishery products consists of processed products, where 39% of the total quantity is traded as frozen. This trend indicates high mobility of the fishery products across the globe, which demands stringent traceability system in place to track the movement of the commodity from harvest to consumers. Nearly 75% of the volume of seafood in international trade is imported by developed nations and 50% of that is exported by developing nations. Hence, food safety issues concerned with seafood is no more local or restricted to a particular geographical location, but has acquired global dimension. Some of the major food safety concerns linked to seafood are:

- presence of Ciguatera toxin in reef dwelling finfish
- histamine fish poisoning
- norovirus and *Vibrio parahaemolyticus*in raw shellfish
- Salmonella in shrimp products
- *Clostridium botulinum*in processed products
- high level of environmental pollutants
  - mercury, cadmium, lead
  - polychlorinated biphenyls and pesticides
- antimicrobial residues in aquaculture products

Apart from the above mentioned concerns which are mostly global, there are regional issues like use of adulterants like formaldehyde to retard decomposition process, ammonia to mask spoilage, use of un-approved additives (preservatives), high level of pesticides in dry fish and presence of emerging pathogens in fisheries environs.

The most challenging task for the policy makers has been to link incidences of foodborne illnesses with a particular food commodity. It needs a strong surveillance and monitoring mechanism to unequivocally attribute a particular food commodity. In USA, Centre for Disease Control (CDC) does the massive work of source tracking for major foodborne pathogens through pulsenetprogrammes. The recent report by CDC (Scallan et al., 2011) indicates that 31 major pathogens reported in the United States caused 9.4 million episodes of foodborne illness, 55,961 hospitalizations and 1,351 deaths during 2. Most (58%) illnesses were caused by norovirus, followed by non-typhoidal*Salmonella* spp. (11%), *Clostridium perfringens* (10%), and *Campylobacter* spp. (9%). Leading causes of hospitalization were non-typhoidal*Salmonella* spp. (35%), norovirus (26%), Campylobacter spp. (15%), and *Toxoplasma gondii* (8%). Leading causes of death were non-typhoidal*Salmonella* spp. (28%), *T. gondii* (24%), *Listeria monocytogenes* (19%), and norovirus (11%). In India, the recently established National Centre for Disease Control (formerly, National Institute of Communicable Diseases), Ministry of Health and Family Welfare, Government of India has a similar mandate to undertake activities on outbreak investigation and provide referral diagnostic services.

In absence of etiological data linked to seafood, the export rejection figures provides an indirect account of food safety hazards associated with seafood. Import refusals and rejections from countries like USA, Japan, Russia and EU are on the rise because of presence of biological and chemical hazards in seafood, leading to heavy economic loss by seafood industries. The most common import refusal of seafood by USA is due to presence of *Salmonella*, Listeria, filth or illegal veterinary drugs. The RASFF portal of EU indicates alert notifications due to presence of veterinary drug residues, heavy metals, histamine, foreign bodies, biotoxin, defective packaging, incorrect labelling, improper health certificate, unapproved colour and additives and organoleptic aspects. In recent months most of the rejections from Japan had been due to presence of furazolidone (AOZ) and Ethoxyquin in shrimp. Seafood rejections from Russia are mostly due to presence of high load of mesophilic bacteria, coliforms, pathogens and presence of crystal violet.

Genesis of Food Safety Standards and Regulations

Food safety standards can be classified as regulatory, voluntary, Government/Statutory, private, domestic, international or benchmarked depending upon its scope and range of application. Most of these standards have evolved based upon sanitary and phyto-sanitary (SPS) requirements, economic interest, risk analysis or as precautionary approach. The precautionary approach mostly relies on perception i.e. equivalent level of protection, appropriate level of protection (ALOP) or as low as reasonably achievable (ALARA).

In international trade, sanitary and phytosanitary measures are envisioned to be based on sound scientific principles that ensure food safety and do not anyway compromise the production potential and resources of a particular country. These measures should not be linked to prevent market access based on non-scientific reasons, and are requirements but not sufficient condition of trade. As per the Annex A of WTO Agreement, Sanitary and phytosanitary measures are applied to (i) protect animal or plant life or health within the territory of the Member from risks arising from the entry, establishment or spread of pests, diseases, disease-carrying organisms or disease-causing organisms (ii) to protect human or animal life or health within the territory of the Member from risks arising from additives, contaminants, toxins or disease-causing organisms in foods, beverages or feedstuffs (iii) from risks arising from diseases carried by animals, plants or products thereof, or from the entry, establishment or spread of pests and (iv) to prevent or limit other damage within the territory of the Member from the entry, establishment or spread of pests. WTO encourages members to use accepted International standards by Codex Alimentarius Commission, OIE (World Organization for Animal Health) and IPPC (International Plant Protection Convention). Countries may introduce or maintain SPS measures that provide higher level of protection than the current international or Codex standards.

Salient features of some Export regulations related to Seafood

European Union

European Union is the biggest importer of fish and fishery products in the world. The food safety regulations set by EU is harmonised, gets periodically updated, transparent and based on principles of risk assessment. The key elements of EU requirements for import of seafood are (a) certification by a competent authority (b) compliance to hygiene and public health requirements in terms of structure of vessels, landing sites, processing establishments and on operational processes, freezing and storage (c) certified production area for bivalves (d) national control plan on heavy metals, contaminants, residues of pesticides and veterinary drugs (e) approval of establishments.

The legal acts of EU are managed through regulations, directives, decision, recommendations and opinions.

Regulation: A binding legislative act applied in entirety across EU

Directives: A "directive" is a legislative act that sets out a goal that all EU countries must achieve.

Decision: A "decision" is binding on those to whom it is addressed (e.g. an EU country or an individual company) and is directly applicable.

Recommendations: A "recommendation" is not binding act that allows the institutions to make their views known and to suggest a line of action without imposing any legal obligation on those to whom it is addressed.

Opinions: An "opinion" is an instrument that allows the institutions to make a statement in a non-binding fashion, in other words without imposing any legal obligation on those to whom it is addressed.

Some of the important EU legislations related to food safety issues of fish and fishery products are as follows:

Regulation (EC) No 178/2002: General principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety

Regulation (EC) No 852/2004: Hygiene of foodstuffs.

Regulation (EC) No 853/2004: Specific hygiene rules for food of animal origin

Regulation (EC) No 854/2004: Specific rules for the organisation of official controls on products of animal origin intended for human consumption

Regulation (EC) No 2073/2005: Microbiological criteria for foodstuffs

Regulation (EC) No 882/2004: Official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules

Regulation (EC) No 1881/2006: Maximum levels for certain contaminants in foodstuffs

Regulation (EC) No 333/2007: Methods of sampling and analysis for the official controls for the levels of lead, cadmium, mercury, inorganic tin, 3-MCPD and benzo(a)pyrene in foodstuffs

Regulation (EC) No 1883/2006: Methods of sampling and analysis for the official control of levels of dioxins and dioxin-like PCBs in certain foodstuffs

Regulation (EC) No 396/2005: Maximum residue levels of pesticides in or on food and feed of plant and animal origin

Council Directive 96/23/EC: Measures to monitor certain substances and residues thereof in live animals and animal products

Commission Decision (2005/34/EC): Harmonised standards for the testing for certain residues in products of animal origin imported from third countries

Commission Decision (2002/657/EC): Implementing Council Directive 96/23/EC concerning the performance of analytical methods and the interpretation of results

Commission Decision (98/179/EC): Official sampling for the monitoring of certain substances and residues thereof in live animals and animal products

Commission Decision (2004/432/EC): Approval of residue monitoring plans submitted by third countries in accordance with Council Directive 96/23/EC

Council Directive 96/22/EC: Prohibition on the use in stock farming of certain substances having a hormonal or thyrostatic action and of beta-agonists

Regulation (EC) No 470/2009: Community procedures for the establishment of residue limits of pharmacologically active substances in foodstuffs of animal origin

Commission Regulation (EU) No 37/2010: Pharmacologically active substances and their classification regarding maximum residue limits in foodstuffs of animal origin

Commission Regulation (EC) No 2023/2006: Good manufacturing practice for materials and articles intended to come into contact with food

Commission Regulation (EC) No 1935/2004: Materials and articles intended to come into contact with food

Commission Regulation (EU) No 1129/2011: Amendment to Annex II to Regulation (EC) No 1333/2008 of the European Parliament and of the Council by establishing a Union list of food additives

Commission Regulation (EC) No 1333/2008 : Food Additives

Commission Regulation (EC) No 1334/2008: Flavourings and certain food ingredients with flavouring properties for use in and on foods

Commission Regulation (EC) No 1331/2008: Establishing a common authorisation procedure for food additives, food enzymes and food flavourings

Directive 2000/13/EC: Labelling, presentation and advertising of foodstuffs (until 12 December 2014)

Commission Regulation (EU) No 1169/2011: Provision of food information to consumers, amending Regulations

Commission Regulation (EU) No 1379/2013: Common organisation of the markets in fishery and aquaculture products

USA

In USA both Federal and State Regulatory agencies are involved in ensuring safety and quality of seafood. Multiple federal agencies are involved in regulatory oversight of seafood for both importation and export.

United States Department of Agriculture (USDA) oversees the implementation of country of origin labelling (COOL) regulation enacted under the Farm Security and Rural Investment Act of 2002. This law requires that all retailers, such as full-line grocery stores or supermarkets must notify their customers with information regarding the source of certain foods.TheCOOL regulation for fish and shellfish (7 CFR Part 60) came into force in 2005. Apart from the country of origin, all fish and shellfish covered commodities must be labelled to indicate whether they are wild caught or farm-raised.

United States Fisheries and Wildlife Service (USFWS) is also involved in regulation of import and export of shellfish and fishery products through Convention on International Trade in Endangered Species (CITES) act (50 CFR Part 23), Endangered Species Act (50 CFR Part 17), General Permit Procedures (50 CFR Part 13), Lacey Act (injurious wildlife) (50 CFR Part 16), Marine Mammal Protection Act (50 CFR Part 18) and Wildlife (import/export/transport) act (50 CFR Part 14). Live farm-raised fish and farm-raised fish eggs are exempted from export declaration and licensing requirements. Imports or exports of any sturgeon or paddlefish product, including meat, caviar, and cosmetics made from sturgeon eggs, dead un-eviscerated salmon, trout and char and live fertilized eggs from these salmonid fish require a permit. Aquatic invertebrates and other animals that are imported or exported for human or animal consumption but that do not meet the definition of shellfish such as squid, octopus, cuttlefish, land snails, sea urchins, sea cucumbers and frogs are also covered under this provisions.

National Oceanic and Atmospheric Administration (NOAA) functioning under the United States Department of Commerce (USDC) provides voluntary seafood inspection program for fish, shellfish, and fishery products to the industry as per the 1946 Agricultural Marketing Act. The NOAA Seafood Inspection Programme often referred to as the U.S. Department of Commerce (USDC) Seafood Inspection Programme provides services such as establishment sanitation inspection, system and process audits, product inspection and grading, product lot inspection, laboratory analyses, training, consultation and export certification. NOAA Fisheries is the Competent Authority for export health certification and IUU catch documentation for US seafood products meant for export to EU and non-EU countries.

The U.S. Food and Drug Administration (USFDA) is vested with the primary Federal responsibility for the safety of seafood products in the United States. It operates a mandatory safety program for all fish and fishery products under the provisions of the Federal Food, Drug and

Cosmetic (FD&C) Act, the Public Health Service Act, and related regulations. The most important regulation enacted by USFDA was "Procedures for the Safe and Sanitary Processing and Importing of Fish and Fishery Products" published as final rule 21 CFR 123 on 18th December 1995 and came into force on 18th December 1997. It required processors to adopt the preventive system of food safety controls known as HACCP (Hazard Analysis and Critical Control Point). Seafood was the first food commodity in the U.S. to adopt HACCP in USA. For screening imports, USFDA uses a tool "Predictive Risk-based Evaluation for Dynamic Import Compliance Targeting (PREDICT)", that targets higher risk products for examination and sampling and minimizes the delay in shipments of lower risk products.

Food Safety and Modernization Act (FSMA) is the most important milestone event in the food safety scenario in USA. It was signed in to law on 4th January 2011 which sifted the focus from responding to a contamination to prevention of the actual cause. The salient features of FSMA act are as follows:

Sec. 103.Hazard analysis and risk-based preventive controls (HARPC): Requires human and animal food facilities to

- evaluate hazards that could affect food safety;
- Identify and implement preventive controls to prevent hazards;
- Monitor controls and maintain monitoring records; and
- Conduct verification activities

Sec. 106.Protection against intentional adulteration

Sec. 111. Sanitary Transportation of Food

Sec. 301. Foreign supplier verification program

- Requires importers to verify their suppliers use risk-based preventive controls that provide same level of protection as U.S. requirements.

Sec. 302. Voluntary qualified importer program

- Allows for expedited review and entry; facility certification required

Sec. 303. Certification for high-risk food imports

- FDA has discretionary authority to require assurances of compliance for high-risk foods

Sec. 304. Prior notice of imported food shipments

- Requires information on prior refusals to be added to prior notice submission
- Effective July 3, 2011

Sec. 307. Accreditation of third-party auditors

- FDA can rely on accredited third parties to certify that foreign food facilities meet U.S. requirements

Sec. 308.Foreign Offices of the Food and Drug Administration.

- Establish offices in foreign countries to provide assistance on food safety measures for food exported to the U.S.

Sec. 309. Smuggled Food

- In coordination with DHS, better identify and prevent entry of smuggled food
- Rules on anti-smuggling strategy is already framed

China - In recent years China has strengthened its SPS measures and has taken a number of precautionary steps to ensure safety to its population. Some of the important regulations enacted by Peoples Republic of China are as follows:

- GB 2763—2012: National food safety standard on Maximum residue limits for pesticides in food
- GB 2762—2012: National food safety standard on Contaminants in Food
- GB-2010: National Food Safety Standard for Pathogen Limits in Food (GAIN Report No. 12063)
- GB 2733-2005: Hygienic Standard for Fresh and Frozen Marine Products of Animal Origin
- GB 2760-2011 additives
- GB 10136-1988 Hygienic standard for salt & liquor-saturated aquatic products of animal origin

Russia has a comprehensive regulatory framework for fish and fishery products. The hygienic requirements are different from other countries as some of the microbiological parameters are expressed as absent in 0.001g or 0.01g. Also some different nomenclature like QMAFAnM is followed instead of APC. The Russian regulation currently in force pertaining to fish and fishery products is as follows:

- Hygienic requirements for safety and nutrition value of food products. Sanitary and epidemiological rules and regulations, sanpin 2.3.2.1078-01

Japan - Compared to other countries, SPS measures followed by Japan is very stringent. Many additives which are in the approved list of Codex are banned or prohibited in Japan. Japan uses a positive list system for MRL of agricultural chemicals in foods. A uniform limit of 0.01 ppm is followed for the compounds for which no risk assessment is done but which are included in the positive list (MHLW Notification No. 497, 2005). MHLW uses a toxicological threshold of 1.5 µg/day as the basis to determine the uniform limit. Substances having no potential to cause damage to human health are specified by MHLW Notification No.498. 2005. The MRL list is mentioned as compositional specification of foods (MHW Notification, No. 370, 1959, amendment No.499 2005, updated as on March 15, 2013)

The relevant food safety acts of Japan as enacted by Ministry of Health, Labour and Welfare and other agencies are as follows:

- Food Sanitation Act (Act No.233, 1947): Latest Revision on June 5, 2009, Act No. 49)
- Specifications and Standards for Food and Food Additives, Latest Revision on September 6, 2010, MHLW Notification No. 336
- Japan's Specifications and Standards for Food Additives" (Eighth Edition). Published by the Ministry of Health, Labour and Welfare in 2007
- Food Safety Basic Act (Act No. 48, 2003)
- Agricultural Chemicals Regulation Law (Law No. 82, 1948)

Codex Alimentarius Commission

The Codex Alimentarius Commission (CAC) was established in 1961-1963 by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) to implement their Joint FAO/WHO Food Standards Programme. CAC has the mandate to formulate food standards, code of practice, guidelines and recommendations to protect health of consumers, Ensure fair practices in food trade and to promote coordination of all food standards work undertaken by international governmental and non-governmental organizations. Codex operates through thee standing expert scientific bodies convened under the auspices of FAO and WHO to generate food data and provide risk-assessment type advice:

- Joint Expert Committee on Food Additives (JECFA)
- Joint Meeting on Pesticide Residues (JMPR)
- Joint Meeting on Microbiological Risk Assessment (JEMRA)

Different subject committees and commodity committees, adhoc inter-governmental task forces and regional coordinating committees function and under codex. Codex Committee on Fish and Fisheries Products (CCFFP) is entrusted with the task of formulating standards for different product categories. Although Codex standards on Fish and Fishery Products specifically do not address food safety requirements, but provide a strong framework for production, hygienic requirements and sampling.

Available Codex Standard for Fish and Fishery Products

1.	Standard for Canned Salmon	CODEX STAN 3-1981
2.	Standard for Quick Frozen Finfish, Eviscerated or Uneviscerated	CODEX STAN 36-1981
3.	Standard for Canned Shrimps or Prawns	CODEX STAN 37-1981
4.	Standard for Canned Tuna and Bonito	CODEX STAN 70-1981
5.	Standard for Canned Crab Meat	CODEX STAN 90-1981

6.	Standard for Quick Frozen Shrimps or Prawns	CODEX STAN 92-1981
7.	Standard for Sardines and Sardine-Type Products	CODEX STAN 94-1981
8.	Standard for Quick Frozen Lobsters	CODEX STAN 95-1981
9.	Standard for Canned Finfish	CODEX STAN 119-1981
10.	Standard for Quick Frozen Blocks of Fish Fillets, Minced Fish Flesh and Mixtures of Fillets and Minced Fish Flesh	CODEX STAN 165-1989
11.	Standard for Quick Frozen Fish Sticks (Fish Fingers), Fish Portions and Fish Fillets - Breaded or in Batter	CODEX STAN 166-1989
12.	Standard for Salted Fish and Dried Salted Fish of the Gadidae Family of Fishes	CODEX STAN 167-1989
13.	Standard for Dried Shark Fins	CODEX STAN 189-1993
14.	General Standard for Quick Frozen Fish Fillets	CODEX STAN 190-1995
15.	Standard for Quick Frozen Raw Squid	CODEX STAN 191-1995
16.	Standard for Crackers from Marine and Freshwater Fish, Crustaceans and Molluscan Shellfish	CODEX STAN 222-2001
17.	Standard for Boiled Dried Salted Anchovies	CODEX STAN 236-2003
18.	Standard for Salted Atlantic Herring and Salted Sprat	CODEX STAN 244-2004
19.	Standard for Sturgeon Caviar	CODEX STAN 291-2010
20.	Standard for Live and Raw Bivalve Molluscs	CODEX STAN 292-2008
21.	Standard for Fish Sauce	CODEX STAN 302-2011

Code of Practice

Code of Practice for Fish and Fishery Products	CAC/RCP 52-2003

Guidelines

Guidelines for the Sensory Evaluation of Fish and Shellfish in Laboratories	CAC/GL 31-1999
Guidelines on the Application of General Principles of Food Hygiene to the Control of Pathogenic Vibrio Species in Seafood	CAC/GL 73-2010

Guidelines on the Application of General Principles of Food Hygiene to the Control of Viruses in Food	CAC/GL 79-2012
Model Certificate for Fish and Fishery Products	CAC/GL 48-2004
Guideline Procedures for the Visual Inspection of Lots of Canned Foods for Unacceptable Defects	CAC/GL 17-1993
Guidelines on Good Laboratory Practice in Pesticide Residue Analysis	CAC/GL 40-1993
General guidelines on sampling	CAC/GL 50-2004
Guidelines on the Use of Mass Spectrometry (MS) for Identification, Confirmation and Quantitative Determination of Residues	CAC/GL 56-2005

Codex standard applicable to Fish and Fishery Products

General Standard for Contaminants and Toxins in Food and Feed	CODEX STAN 193-1995
General Standard for the Labelling of Prepackaged Foods	CODEX STAN 1-1985
Standard for Food Grade Salt	CODEX STAN 150-1985
General Standard for Food Additives	CODEX STAN 192-1995
General Methods of Analysis for Contaminants	CODEX STAN 228-2001
Recommended Methods of Analysis and Sampling	CODEX STAN 234-1999
General Methods of Analysis for Food Additives	CODEX STAN 239-2003

Bureau of Indian Standards (BIS)

Bureau of Indian Standards (BIS) functioning under the Ministry of Consumer Affairs, Food and Public Distribution, Government of India. It came into existence on 01 April 1987 through an Act of Parliament on 26 November 1986. It was functioning previously as Indian Standards Institution which was established on 06 January 1947. BIS has so far formulated 64 standards related to fish and fishery products, out of which 33 are active. All these standards are voluntary, which addresses method of production, quality and safety requirements. It also stipulates the method of testing and sampling. There is an attempt by FSSAI to re-draft all BIS standards related to fish and fishery products as most of the food safety requirements are not in sync with the current national standards.

BIS Standards on Fish and Fishery Products

IS 2168	1971	Pomfret Canned in Oil
IS 2236	1968	Prawns/Shrimp Caned in Brine
IS 2237	1997	Prawns (Shrimps) - Frozen
IS 3336	1965	Shark Liver Oil for Veterinary Use
IS 3892	1975	Frozen Lobster Tails
IS 4304	1976	Tuna Canned in Oil
IS 4780	1978	Pomfret, Fresh
IS 4793	1997	Whole Pomfret - Frozen
IS 5734	1970	Sardine Oil
IS 6121	1985	*Lactarius*sp Canned in Oil
IS 6122	1997	Seer Fish (*Scomberomorus* Sp.) - Frozen
IS 6123	1971	Seer Fish (*Scomberomorus* spp.), Fresh
IS 7143	1973	Crab Meat Canned in Brine
IS 7313	1974	Glossary of Important Fish Species of India
IS 7582	1975	Crab Meat, Solid Packed
IS 8076	2000	Frozen Cuttlefish and Squid
IS 9808	1981	Fish Protein Concentrate
IS 10059	1981	Edible Fish Powder
IS 10760	1983	Mussels Canned in Oil
IS 10762	1983	Tuna Canned in Curry
IS 10763	1983	Frozen Minced Fish Meat
IS 11427	2001	Fish and Fisheries Products - Sampling
IS 14513	1998	Beche-de-mer

IS 14514	1998	Clam Meat - Frozen
IS 14515	1998	Fish Pickles
IS 14516	1998	Cured fish and fisheries products - Processing and storage - Code of Practice
IS 14517	1998	Fish Processing Industry - Water and Ice - Technical Requirements
IS 14520	1998	Fish Industry - Operational Cleanliness and layout of market - Guidelines (Amalgamated Revision of IS 5735, 7581 and 8082)
IS 14890	2001	Sardines - Fresh, Frozen and Canned (Amalgamated revision of IS 2421, 6677,8652,8653, 9750 and 10761
4891	2001	Mackerel - Fresh, Frozen and Canned (Amalgamated Revision of IS 2420, 3849,6032, 6033 and 9312)
IS 14892	2000	Threadfin - Fresh and Frozen
IS 14949	2001	Accelerated Freeze Dried Prawns (Shrimps) (Amalgamated revision of IS 4781 and 4796
IS 14950	2001	Fish - Dried and Dry-Salted

Food Safety and Standards Authority of India (FSSAI)

The Food Safety and Standards Authority of India was established under the Food Safety and Standards Act, 2006 as a statutory body for laying down science based standards for articles of food and regulating manufacturing, processing, distribution, sale and import of food so as to ensure safe and wholesome food for human consumption. Various central acts including the erstwhile Prevention of Food Adulteration Act (1954) were merged under this act

The Food Safety and Standards Regulations (FSSR) came into force in 2011, which is divided to following sections:

- FSS (Licensing and Registration of Food businesses) regulation, 2011
- FSS (Packaging and Labelling) regulation, 2011
- FSS (Food product standards and Food Additives) regulation, 2011 (part I)
- FSS (Food product standards and food additives) regulation, 2011 (part II)
- FSS (Prohibition and Restriction on sales) regulation, 2011
- FSS (contaminants, toxins and residues) regulation, 2011
- FSS (Laboratory and sampling analysis) regulation, 2011

Recently, standards related to microbiological specifications of fish and fishery products, limit of heavy metals, PAH, PCBs and biotoxins have been incorporated in the FSSR.

HACCP CONCEPT IN SEAFOOD QUALITY ASSURANCE

Concept of HACCP was developed in the late 1950s and initiated in the early 1960s by the Pillsbury Company, in collaboration with NASA and the Natick Laboratories of the U.S. Army, and the U.S. Air Force Space Laboratory Project Group. The concepts designed were based on the principles of Failure Mode and Effect analysis (FEMA). It was first presented to regulatory community during National Conference on Food Protection in 1971 by Howard Bauman of the Pillsbury Company and first applied to low acid canned foods in 1974. In 1980s, other food processing companies embraced it voluntarily and at the same time FDA and USDA continued regulatory interest. HACCP gained regulatory approval from USFDA and USDA after it was endorsed by National Academy of Sciences and further by 9National Advisory Committee on Microbiological Specifications of Foods (NACMSF). On December 18, 1995, The Food and Drug Administration (FDA) published as a final rule 21 CFR 123, "Procedures for the Safe and Sanitary Processing and Importing of Fish and Fishery Products" that requires processors of fish and fishery products to develop and implement Hazard Analysis Critical Control Point (HACCP) systems for their operations. The regulation became effective December 18, 1997. HACCP was recommended by Codex Alimentarius Commission (CAC) in 1997 which is recognized as “Recommended International Code of Practice-General Principles of Food Hygiene” (CAC/RCP 1-1969, Rev 3, 1997). In European countries, the EU Directive 93/43/EEC mandated the implementation of HACCP in all local legislation by December 1995. Subsequently the EC hygiene regulations 852/2004 and 853/2004 mandated that all food business operators should establish and operate food safety programmes and procedure based on HACCP principles. Since then HACCP has gained acceptance by many countries in Europe, Canada, New Zealand, Australia, Central and South America and many Asian countries. In India voluntary HACCP standards are given by Bureau of Indian Standards (IS 15000:1998)

Hazard Analysis Critical Control Point (HACCP)

The HACCP system is an internationally recognized system used to manage food safety. It has been endorsed by the *Codex Alimentarius Commission* as a tool that can be used to systematically identify hazards specific to individual products and processes and describe measures for their control to ensure the safety of fish and fish products. It is a dynamic system, capable of accommodating change in the system viz., changes in equipment design, processing procedures and technological advancements.

HACCP is defined as a system which identifies, evaluates, and controls hazards which are significant for food safety

HACCP is a structured, systematic approach for the control of food safety throughout the food system, from the farm to fork. It requires a good understanding of the relationship between cause and effect in order to be more pro-active. HACCP is supported by pre-requisite programmes like Good Manufacturing Practice (GMP), Good Hygienic Practices (GHP), SSOP (Sanitation standard operating procedures), Good Agricultural Practices (GAP), and Good Storage Practices (GSP), etc.

Pre-requisite programmes

Prerequisite programs provide a foundation for an effective HACCP system. They are often facility-wide programs rather than process or product specific. They reduce the likelihood of certain hazards. Prerequisite programs set the stage for a HACCP system and provide on-going support for the establishment's food safety system. They keep potential hazards from becoming serious enough to adversely impact the safety of foods produced. Without clean working conditions free from microbiological, chemical, and physical contamination from many sources, a HACCP plan cannot be effective.

Prerequisite programmes are practices and conditions needed prior to and during the implementation of HACCP and which are essential for food safety -WHO

Some of the prerequisite programmes include GAP, GMP and GHP which must be working effectively within a commodity system before HACCP is applied. Establishments should revise their prerequisite programs, as necessary, to ensure their effectiveness, and should take appropriate corrective actions when they determine that their prerequisite programs may have failed to prevent contamination and/or adulteration of product. Good Agricultural Practices are "practices that address environmental, economic and social sustainability for on-farm processes, and result in safe and quality food and non-food agricultural products" (FAO)

The Good Manufacturing Practices commonly referred as current good manufacturing practices (cGMPs, 21 CFR 110) give details as to what specific procedures must be followed to comply with the regulation. Standard operating procedures (SOPs) are the steps your company takes to assure that the GMPs are met. They include stepwise procedures, employee training, monitoring methods, and records used by your company. Similarly, SSOP covers eight key sanitation conditions as required by USFDA.

Good hygiene practices include all practices regarding the conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain

Basic principles of HACCP

There are seven discrete activities that are necessary to establish, implement and maintain a HACCP plan, and these are referred to as the 'seven principles' in the Codex Guideline (1997).

The seven Principles of HACCP are

Principle 1: **Conduct a hazard analysis.**

Hazard: A biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect.

Hazard analysis: The process of collecting and evaluating information on hazards and conditions leading to their presence to decide which are significant for food safety and therefore should be addressed in the HACCP plan.

Principle 2: **Determine the Critical Control Points (CCPs)**

A step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level.

Principle 3: **Establish critical limits.**

A criterion which separates acceptability from unacceptability, when monitoring a critical control point.

Principle 4: **Establish a monitoring system**

The act of conducting a planned sequence of observations or measurements of control parameters to assess whether a CCP is under control.

Principle 5: **Establish a procedure for corrective action,**

Any action to be taken when the results of monitoring at the CCP indicate a loss of control.

Principle 6: **Establish procedures for verification**

The application of methods, procedures, tests and other evaluations, in addition to monitoring to determine compliance with the HACCP plan.

Principle 7: **Establish documentation concerning all procedures and records appropriate to these principles and their application**

Developing a HACCP plan (FAO guidelines)

The all-important principles form the essential requirements of a food safety system and are designed to ensure that enough precaution is taken so that any hazard which can interfere with consumer health is addressed. The first principle of HACCP is hazard analysis. But understanding the product thoroughly is extremely important to get an idea on the possible hazards which could be associated with the product so that appropriate action can be taken to control or minimize the hazard. The seven principles of HACCP are usually carried out in twelve steps, as given below.

Step 1 - Establish a HACCP team

Hazard profile is related to the commodity. Therefore in order to understand fully the commodity, to identify the hazards associated, the CCP and to work out a control measures it is pertinent to have a team which has the knowledge about the product or commodity, its production process and shelf-life. This would facilitate the proper implementation of HACCP for the production of the product. Therefore, it is important that the HACCP team is made up of people from a wide range of disciplines. The team should include:

- A team leader to lead the group and direct the team to carry out the work as per the system requirements. He should be well versed with the techniques and manage the team members to contribute to the cause.
- A person conversant with the production system who knows full details of the flow of production.
- Persons from varied field viz., biochemist, microbiologist, toxicologist, quality control manager or an engineer with an understanding of particular hazards and associated risks.
- Others who are involved in the varied activates of the system viz., packaging specialists, raw material buyers, distribution staff or production staff, farmers, brokers, who are involved with the process, and have working knowledge of it in order to provide expert opinion.
- Possibly one person to help the team with secretarial requirements.

Task 2 - Describe the product

Understanding the product is the important step as the hazard associated with depends on the product. To start a hazard analysis, a full description of the product, including customer specification, should be prepared. This should include information relevant to safety, regulation/target level, and composition, physical/chemical properties of the raw materials and the final product, the water activity of the product (a_w), the pH etc. There should information on the packaging, storage and distribution as well as information on the temperature of storage, distribution, labelling information and shelf-life of the product. This information helps the audit team to understand the possible hazards and their control measures.

Task 3 - Identify the product's intended use

Information on the intended use of the commodity or product as well as the information on the mode of consumption viz., direct consumption, cooked before hazard analysis will have bearing on the hazard analysis. The nature of the target group for the product may also be relevant, particularly if it includes susceptible groups such as infants, the elderly, and the malnourished. The likelihood of misuse of a product should also be considered, such as the use of pet food as a human food, either by accident or design.

Task 4 - Draw up the commodity flow diagram

The first function of the team is inspect the detailed commodity flow diagram (CFD) of the commodity system and the expertise of the production manager or product expert is important at this stage as far as hazard analysis is concerned.

Task 5 - On site confirmation of flow diagram

After studying the commodity flow diagram the team should visit the system where HACCP is implemented or proposed to be implemented which may include any step in the production viz., procurement of raw material, store, production area, packaging area, storage section where the product is kept before distribution, nature of distribution, conditions of distribution etc. The is known as 'walking the line ', a step by step checking to get information on whether relevant requirements of the system are considered while making the production line. The site for which the HACCP plan is being designed should be visited as many times as possible to ensure that all relevant information has been collected.

Task 6 - Identify and analyse hazard(s) - (Principle 1)

Effective hazard identification and hazard analysis are the keys to a successful HACCP Plan. All real or potential hazards that may occur in each ingredient and at each stage of the commodity system should be considered. Food safety hazards for HACCP programmes have been classified into three types of hazards:

- Biological: typically foodborne bacterial pathogens such as *Salmonella*, *Listeria* and *E. coli*, also viruses, algae, parasites and fungi.
- Chemical: There are three principle types of chemical toxins found in foods: naturally occurring chemicals, e.g. cyanides in some root crops, and allergenic compounds in peanuts; toxins produced by micro-organisms, e.g. mycotoxins, and algal toxins; and chemicals added to the commodity by man to control an identified problem, e.g fungicides or insecticides.
- Physical: contaminants such as broken glass, metal fragments, insects or stones.

The probability that a hazard will occur is called a risk. The risk may take a value from zero to one depending on the degree of certainty that the hazard will be absent or that it will be present. After hazard identification, a hazard analysis must be conducted to understand the relative health risk to man or animal posed by the hazard. It is a way of organizing and analysing the available scientific information on the nature and size of the health risk associated with the hazard. The risk may have to be assessed subjectively and simply classified as low, medium, or high. Once a food safety hazard has been identified, then appropriate control measures should be considered. These are any action or activity that can be used to control the identified hazard, such that it is prevented, eliminated, or reduced to an acceptable level. The control measure may also include training of personnel for a particular operation, covered by GAP, GMP, and GHP.

Task 7 - Determine the critical control points (CCPs) - (Principle 2).

Each step in the commodity flow diagram, within the scope of the HACCP study, should be taken in turn and the relevance of each identified hazard should be considered. The team must determine whether the hazard can occur at this step, and if so whether control measures exist. If the hazard can be controlled adequately, and is not best controlled at another step, and is essential for food safety, then this step is a CCP for the specified hazard.

If a step is identified where a food safety hazard exists, but no adequate control measures can be put in place either at this step or subsequently, then the product is unsafe for human consumption. Production should cease until control measures are available and a CCP can be introduced.

Task 8 - Establish critical limits for each CCP - (Principle 3)

Critical limits must be specified and validated for each CCP. Criteria often used include measurements of temperature, time, moisture level, pH, water activity, and sensory parameters such as visual appearance. All critical limits, and the associated permissible tolerances, must be documented in the HACCP Plan Worksheet, and included as specifications in operating procedures and work instructions.

Task 9 - Establish a monitoring procedure - (Principle 4)

Monitoring is the mechanism for confirming that critical limits at each CCP are being met. The method chosen for monitoring must be sensitive and produce a rapid result so that trained operatives are able to detect any loss of control of the step. This is imperative so that corrective action can be taken as quickly as possible so that loss of product will be avoided or minimized.

Monitoring can be carried out by observation or by measurement, on samples taken in accordance with a statistically based sampling plan. Monitoring by visual observation is basic but gives rapid results, and can therefore be acted upon quickly. The most common measurements taken are time, temperature and moisture content.

Task 10 - Establish corrective action - (Principle 5)

If monitoring indicates that critical limits are not being met, thus demonstrating that the process is out of control, corrective action must be taken immediately. The corrective action should take into account the worst case scenario, but must also be based on the assessment of hazards, risk and severity, and on the final use of the product. Operatives responsible for monitoring CCPs should be familiar with and have received comprehensive training in how to effect a corrective action.

Corrective actions must ensure that the CCP has been brought back under control. Corrective action can then be applied to pre-empt a deviation and prevent the need for any product disposition.

Task 11 - Verify the HACCP plan - (Principle 6)

Once the HACCP plan has been drawn up, and all of the CCPs have been validated, then the complete plan must be verified. Once the HACCP plan is in routine operation, it must be verified and reviewed at regular intervals. This should be a task of the person charged with the responsibility for that particular component of the commodity system. The appropriateness of CCPs and control measures can thus be determined, and the extent and effectiveness of monitoring can be verified. Microbiological and/or alternative chemical tests can be used to confirm that the plan is in control and the product is meeting customer specifications. A formal internal auditing plan of the system will also demonstrate an ongoing commitment to keep the HACCP plan up to date, as well as representing an essential verification activity.

Task 12 - Keep record - (Principle 7)

Record keeping is an essential part of the HACCP process. It demonstrates that the correct procedures have been followed from the start to the end of the process, offering product traceability. It provides a record of compliance with the critical limits set, and can be used to identify problem areas. Records that should be kept include: all processes and procedures linked to CCP monitoring, deviations, and corrective actions.

Steps involved in developing HACCP system
(Based on Codex 1997)

Step 1.	Assemble HACCP team	Preliminary Steps
Step 2.	Describe product	
Step 3.	Identify intended use	
Step 4.	Construct flow diagram	
Step 5.	On-site confirmation of flow diagram	
Step 6.	Conduct hazard analysis	HACCP Principle I
Step 7.	Determine Critical Control Points	HACCP Principle II
Step 8.	Establish critical limits for each CCP	HACCP Principle III
Step 9.	Establish a monitoring system for each CCP	HACCP Principle IV
Step 10.	Establish corrective actions	HACCP Principle V
Step 11.	Establish verification procedures	HACCP Principle VI
Step 12.	Establish Documentation and Record Keeping	HACCP Principle VII

HACCP is a core component in all national and international food safety standards such as IS 15000, ISO 22000:2005, USFDA Seafood HACCP regulation (CFR 123, Title 21), Dutch HACCP, BRC Global Standard for Food, SQF 2000, IFS, etc. Hence understanding concepts of HACCP would help in easy implementation of any food safety standard(s) deemed necessary to ensure safety of fish and fishery products.

Definitions in HACCP

Control (verb): To take all necessary actions to ensure and maintain compliance with criteria established in the HACCP plan.

Control (noun): The state wherein correct procedures are being followed and criteria are being met.
Control measure: Any action and activity that can be used to prevent or eliminate a food safety hazard or reduce it to an acceptable level.
Corrective action: Any action to be taken when the results of monitoring at the CCP indicate a loss of control.
Critical Control Point (CCP): A step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level.
Critical limit: A criterion which separates acceptability from unacceptability, when monitoring a critical control point.
Deviation: Failure to meet a critical limit.
Flow diagram: A systematic representation of the sequence of steps or operations used in the production or manufacture of a particular food item.
HACCP plan: A document prepared in accordance with the principles of HACCP to ensure control of hazards which are significant for food safety in the segment of the food chain under consideration.
Hazard: A biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect.
Hazard analysis: The process of collecting and evaluating information on hazards and conditions leading to their presence to decide which are significant for food safety and therefore should be addressed in the HACCP plan.
Monitor: The act of conducting a planned sequence of observations or measurements of control parameters to assess whether a CCP is under control.
Step: A point, procedure, operation or stage in the food chain including raw materials, from primary production to final consumption.
Validation: Obtaining evidence that the elements of the HACCP plan are effective.
Verification: The application of methods, procedures, tests and other evaluations, in addition to monitoring to determine compliance with the HACCP plan.

Chapter 14

Technology for fish-based ready-to-eat extruded snack products

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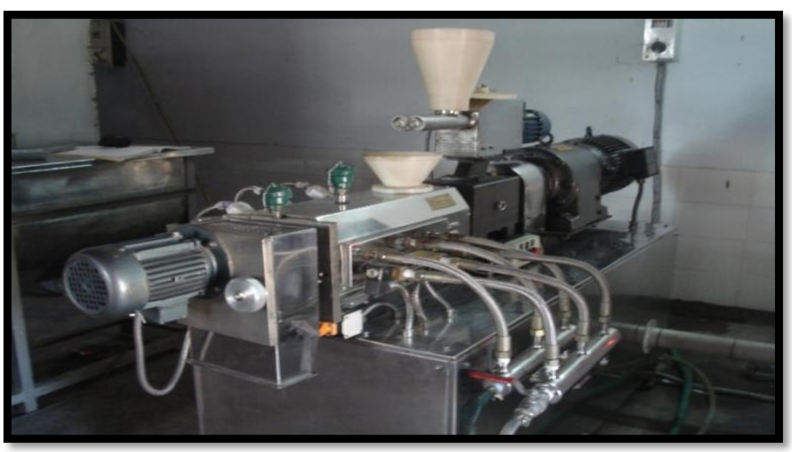
Extrusion is a size enlargement process where small granular or powdered particles are reinforced into larger sized particles with different shapes, texture, colour etc. It is used for the manufacture of food products such as ready-to-eat breakfast cereals, snack foods, soft moist pet foods and textured vegetable protein. In extrusion cooking, food material is heated either by an external heat source or through heat produced by friction and forced through dies to expand and extrude in desired shapes. Food extrusion provides a great versatility for the developmt of low-cost, high-nutritive and convenient food products such as cereal-based snack food products. Extruded snacks are gaining importance now-a-days due to their peculiar taste, texture and convenience. Food extrusionis a size enlargement process where in small granular food or powdered particles are reinforced into larger pieces with different shapes, texture, colour etc. Extruded products are rich in carbohydrates and contain low levels of protein, which makes it necessary to fortify them with protein-rich ingredients. One of the possible ways for alleviating this problem is to utilize fish and fish proteins to enrich cereal-based extruded products. Demand for fish meat and fish meat-based products is increasing and utilization of by-catch, low-cost and underutilized fish and shellfish is given greater emphasis. Utilizing fish meat and fish portions and its derivatives like fish protein hydrolysate powder, dry fish powder etc. to develop extruded products will add value to the low-cost and underutilized fish and shellfish, thus promoting their utilization.

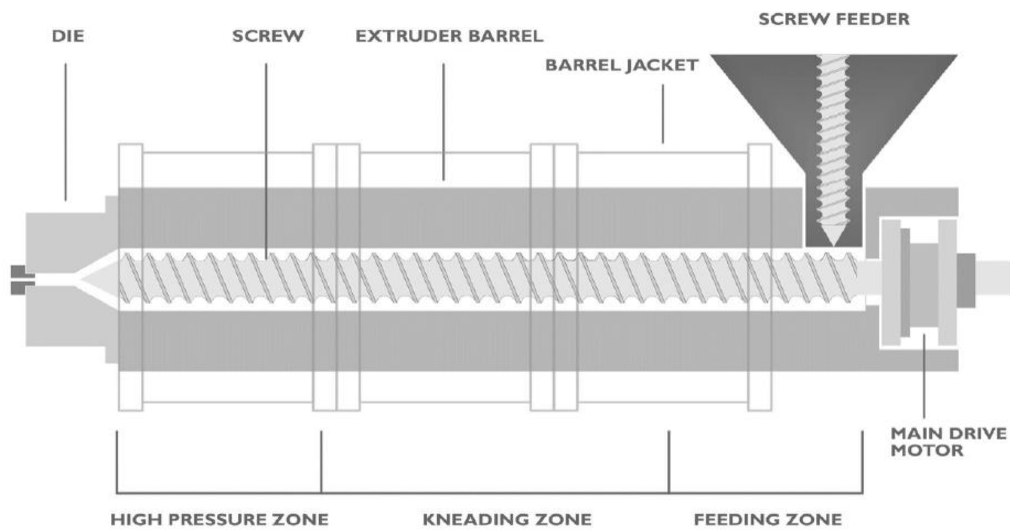
Extruders



Extruders are the tools used to introduce mechanical shear and thermal energy to food ingredients. Extruders are classified into two according to operation: Hot and cold extruders. Based on type of construction extruders are classified into: Single screw and twin screw extruder. Twin-screw extruders are used for high-moisture extrusion, products that include higher quantities of components such as fibres, fats, etc. and for the production of more sophisticated products. Twin screw extruders are again classified as co-rotating and counter-rotating types based on the direction of rotation of the screws. In the counter-rotating position the extruder screw rotates in the opposite direction, whereas in the co-rotating position the screw rotates in the same direction.

Twin screw extruders consist of five main parts:

(i) Pre-conditioning system
(ii) Screw feeder
(iii) Screw
(iv) Barrel
(v) Die and cutting mechanism



Pre-conditioning is not applied to all extrusion processes. It is applied when moisture contents around 20 to 30% and long residence times are required for of the material. Pre-conditioning favours uniform particle hydration, reduces retention times within the extruder and increases throughput and increasing the life of the equipment, due to a reduction in the wearing of barrel and screw components. It also reduces the cost of energy involved in the process.

The feeding system is normally composed of a holding bin where the material is loaded and the discharge of the material can occur through a vertical or horizontal feeding screw. It ensures a constant and non-interrupted feeding of the raw materials into the extruder for an efficient and uniform functioning of the extrusion process.

The screw of the extruder is its most important component. It determines the cooking degree, gelatinization and dextrinization of starch and protein denaturation and also ensures final product quality. Screws can be mono-piece or multi-piece. Screw elements can vary in number and shapes, each segment is designed for a specific purpose. Some elements only convey raw or pre-conditioned material into the extruder barrel, while other segments compress and degas the feed.

Others promote kneading, backflow and shear.Barrels or sleeve surrounds the screw and are often jacketed to permit circulation of steam or superheated oil for heating or water or air for cooling, thus enabling the precise adjustment of the temperature in the various zones of the extruder. Generally barrels are equipped with pressure and temperature sensing and temperature control mechanisms. The barrel is divided into feeding, kneading and high pressure zones.

The die has two main functions: to give shape to the final product and to promote resistance to the material flow within the extruder permitting an increase in internal pressure. The die can be in various designs and number of orifices. Dies are usually designed to be highly restrictive, giving increased barrel fill, residence time and energy input.The cutting mechanism is necessary for obtaining final products with uniform size. Product size is determined by the rotation speed of the cutting blades. This mechanism can be horizontal or vertical.

Principle of extrusion cooking

Raw materials (cereal flours and fish meat/fish protein hydrolysate powders) are fed into the extruder barrel through a feeder and the screws convey along it. Towards the barrel end, smaller flights restrict the volume and resistance to movement of the food is increased. As a result, it fills the barrel and the spaces between the screw flights and becomes more compressed. As it moves further along the barrel, the screw kneads the material into a semi-solid, plasticized mass. The food is heated above 100˚C and the process is known as extrusion cooking (or hot extrusion). Here, frictional heat and the additional heating that is used cause the temperature to rise rapidly. The food is then passed to the section of the barrel having the smallest flights, where pressure and shearing is further increased. Finally, it is forced through dies (restricted openings) at the end of the barrel. As the food emerges under pressure from the die to normal atmospheric pressure and temperature, it expands to the final shape, gets characteristic texture and cools rapidly as moisture is flashed off as steam.

Coating of extruded products

The flavouring of extruded products follows a similar pattern to colouring. A product with fish incorporated has characteristic fishy flavour and it may develop further flavours by thermal reactions between flavour precursors in the mix or be flavoured by adding synthetic or natural flavorings. The addition of flavouring is usually carried out on the dry extrudate by spraying or dusting, because of the changes caused by the losses of volatiles during extrusion. This can be performed with simple rotating drums with electric heaters installed or with a gas operated hot air installation.

Packaging of extruded products

One of the major properties of snacks is the crispness, which is achieved during the manufacture of the product. Retention of desirable texture (crispness) is directly related to the moisture level in the product. The moisture content of snack is very low, and any increase due to the hygroscopic nature of the product may lead to loss of crispness of the product. Moisture also accelerates other biochemical changes such as oxidative rancidity. Oxygen inside the package may be replaced by an inert gas like Nitrogen. Low water vapour and gas permeability of the package is, therefore, a very critical requirement. Also the packaging material must be physically strong enough to withstand the processes of vacuumising/gas flushing. Metalized Polyester-Polyethylene laminated pouches with Nitrogen flushing are used for the packaging of extruded products.

Storage of extruded products

Extruded product can be stored at ambient temperature. Nitrogen flushed pouches can be bulk packed in carton box and stacked inside the store. Generally the shelf life of properly packed extruded products is four months.

Advantages of extrusion

- Versatility - wide variety of products are possible by changing the ingredients, varying the operating conditions & and shape of the dies
- Low operational costs
- High production yields - operate continuously and have high throughputs
- Good quality nutrient enriched products - involves high temperatures applied for a short time and the limited heat treatment therefore retains many heat sensitive components
- No effluents - is a low moisture process, eliminates water treatment costs and does not create problems of environmental pollution

Extruded products and technologies developed and commercialized by ICAR-CIFT

ICAR-CIFT has developed technologies for the preparation of extruded products fortified with fishery products and by-products such as fish meat, cooked red meat from tuna canning industries, fish protein hydrolysate powders, dried seaweed powders. Apart from these, technologies for various agri-based products such as dried jack fruit seed powder, coconut milk residue, coconut haustorium etc. were also developed in collaboration with institutes like ICAR-CPCRI, Kasargode, CARD-KVK, Pathanamthitta etc. Various products were developed in ICAR-CIFT and commercialized through the Business Incubation Unit to several entrepreneurs.

'Prawnoes'

The technology developed by ICAR-CIFT for development of extruded snacks with prawn flavour was taken up by a women entrepreneur Smt. OmanaMuraleedharan of M/s Charis Food products, Aroor, Kerala, India. She approached ICAR-CIFT with the idea to develop prawn flavored extruded snack food and registered as an incubatee at the Business Incubation Unit of ICAR-CIFT. A brand named 'Prawnoes' was created and registered for trademark protection by incubation unit. CIFT developed and standardized three varieties of extruded snack product for the incubatee, Spicy Shrimp, Shrimp n Onion and Prawn Seasoning. 'Prawnoes, is the first prawn flavored Ready-to-eat snack food. By incorporating protein rich prawn flavor, the product is an enriched snack food. This nutritious and delicious snack provides alternative to the high-fat and low-protein convenience store snacks. The rapid economic and population growth has set to fuel expansion of the snack food industry in India and the extruded food like 'Prawnoes' targeted the premium and economy market segments. 'Prawnoes' has received excellent product reviews during its marketing. CIFT gave her technical guidance in developing the product, standardization of process parameters, testing, packaging solutions, ideas for branding, assistance in trademark filing and setting up the production unit at Aroor.

KalpaKrunch'

'KalpaKrunch', a coconut based extruded snack product jointly developed by ICAR-CIFT and ICAR-CPCRI was launched by Hon'ble Union Minister of Agriculture and Farmers' Welfare, Govt. of India in 2016. 'KalpaKrunch' was prepared utilizing coconut milk residue – a byproduct obtained during extraction of virgin coconut oil. Coconut milk residue, which was previously used in animal feed production, is a rich source of dietary fiber and polyphenols. The technology of KalpaKrunch was transferred to an entrepreneur from Karnataka and Perambra Coconut Producers Company, Calicut, Kerala through the Agriculture Business Incubation Centres of ICAR-CIFT and ICAR-CPCRI.

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Chapter 15

Value Added product development

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Battering and breading enhances the consumer satisfaction by improving the nutritional value, organoleptic characteristics and appearance of the products and makes them popular among other consumer items. The soft and moist interior with porous outer crispy crust increases the palatability and makes these products an integral part of human foods.Consumers are looking for better alternative for conventional fresh food that offers time-saving preparation. Hence there exists an increased global demand for ready-to-heat frozen foods, especially breaded and battered products with high standards of quality. The most important advantage of coating is value addition as it increases the bulk of the product. Also this paves way for better utilisation of low cost or underutilised fishes. Coating is referred as the batter and/or breading adhering to a food product. Each ingredient in coating offers unique role in development of functionality and characteristics of the product. Polysaccharides, proteins, fat, seasonings and water are the commonly used ingredients. The method of product development differs with the type of product. Mostly this includes seven major steps.

1)Portioning / forming

A perfectly portioned product is the right starting point. Mechanically deboned fish meat is formed to different shapes and sizes after mixing with ingredients, if needed. The product should keep its consistency with proper weight and shape. The key factor in this production step is speed and accuracy of processing the frozen fish block at minimum costs without any compromise to the product quality.

2)Predusting

Predusting is usually done with very fine raw flour type material or dry batter itself, sprinkled on the surface of food substrate before coating. This helps to reduce the moisture on the surface of the product so that the batter can adhere uniformly. Flavourings such as salt and spices can be added in minimum amounts.

3) Battering

Batter is defined as the liquid mixture composed of water, flour, starch, and seasonings into which the fish products are dipped prior to breading. Two types of batter are there- adhesive batter and tempura batter. The adhesive batter is a fluid, consisting of flour and water. Tempura batter is the puff-type batter containing raising/leavening agents. This forms a crisp, continuous, uniform layer over the food. The predusted portions are applied with wet batter and excess batter can be blown off by a current of air. The batter mix helps in governing the amount of bread to be picked up and it contributes to flavour of the final product. Specific ingredients are used to aid viscosity, texture and adhesion.

3.1) Ingredients of batter mix

a) Flour- Wheat flour provides structure to the product through gelatinisation of starch as well as through formation of gluten protein matrix. Higher protein levels in flour increases viscosity of batter and produce darker crispy coatings. Corn flour can be added to produce yellow colour and to enhance browning during frying.

b) Water- The ratio of water to dry batter mix is 1.8:1. Formation of gelatinised starch phase, hydration of flow proteins, batter viscosity etc. depends on the purity of water used.

c) Starch- Corn starch is added mainly to control batter viscosity and thus increasing the batter pickup and breading retention.

d) Flavour and flavour enhancers- salt, sugar, spices etc. can be added to improve the organoleptic characteristics of the products.

e) Sodium tripolyphosphate- This lowers the water activity of the product and has bactericidal property. It increases the hydration of proteins and reduces protein denaturation.

4)Breading

Breading was defined as the application of a dry mixture of flour starch, seasonings having a coarse composition to battered food products prior to cooking. Normally the battered fish portions are dropped in to dried bread crumbs and are turned over to ensure complete coating with bread crumbs. A fine layer or coarse layer of bread crumps will contribute to structure and tastiness of the product. For soft products the crump depth should be fine so as to avoid the product damage on further processing.

5)Pre-frying/ flash frying

Pre-frying is the process of giving a shallow fry so as to coagulate batter over the product and lock the flavour and juices to the product. The time of frying and temperature of oil are crucial factors. This could be done at 180-200°C for 40-60 sec, thus restricting the actual heat transfer to the surface of the product. The term pre-frying is used as frying will be completed only when the consumers fry the product for 4-6 minutes depending on the product size.

6)Freezing

The fish portions are air cooled before freezing. This helps the coating temperature to drop while the batter can stabilise itself and recover from the frying shock. Freezing is done at a temperature of -10°C to -20°C in order to preserve freshness and quality of the product over longer storage periods.

7) Packaging and storage

Proper packaging and storage is essential to prevent/retard desiccation, discolouration and rancidity in coated products. Packaging in thermoformed containers and storage at -20°C are most commonly used for breaded and battered products. The developments in value added product industry demands the packaging that can withstand the higher temperatures of microwave reheating.

Advantages of coated products

- Enhanced nutritional quality
- Moisture barrier during frozen storage and reheating
- Crispy texture and appealing colour and flavour
- Structural reinforcement of the substrate
- Prevents loss of natural juices
- Increased bulk of the substrate and reduced product cost
- Improved overall acceptability of the product

Battering and breading have contributed significantly to the value addition of fishes, shell fishes and molluscs. The first commercially successful coated fish item was fish fingers. Later several other products like fish cutlets, fish balls, fish nuggets, etc. came into the market. Coated butterfly shrimp, squid rings, stuffed squid rings etc. are among the fancy items that cater to the luxury markets. Sophisticated equipments like meat bone separator, meat strainer, portioning and forming equipment, preduster, battering and breading machine, fryer, freezer and packaging machineries are in the market for preparation of a wide variety of coated products.

Battered and Breaded Fish Products

Battering and breading machine

Preparation of Fish Fingers

I. Fish Fingers from Fillet

Ingredients

Fish fillet	1 kg
Salt	3%

Procedure

Fillet the fish and cut into small pieces (about 10 cm in size) and blanch in 3% salt solution for 10-15 minutes. Drain off and pre-dust with batter powder and coat with batter and breadcrumbs and fry.

II. Fish Fingers from Mince

Ingredients

Fish fillet	1 kg
Tri-sodium polyphosphate	0.1 %
Salt	0.6 %

Procedure

Dress and fillet the fish and mince in a meat mincer. Add 0.1 % tri-sodium polyphosphate, 0.6% salt, mix, spread the mince in a tray uniformly and freeze. Cut into small pieces (about 10 cm in size) in the frozen condition itself. Pre-dust the finger with batter powder and coat with batter and breadcrumbs using a bamboo stick and fry in oil.

Preparation of Fish Balls

Ingredients

Fish mince	1 kg
Corn starch	5%
Salt	1%
Garlic	2%
Ginger	2%
Pepper	0.2%

Procedure

Dress the fish and take fillet. Mince the fillet. Make a paste of garlic and ginger. Mix with the other ingredients and make a paste. Prepare balls about 10 g and cook in 1% salt solution for 10 minutes. After cooling pre-dust with batter powder and dip in batter solution using a bamboo stick and then roll in breadcrumbs and fry in oil. (Batter ratio 1:2)

Preparation of Fish Nuggets

Ingredients

Fish mince	1 kg
Corn starch	5%

Salt	1%
Garlic	2%
Ginger	2%
Pepper	0.2%
Lemon juice	2 tbsp

Procedure

Dress the fish and take fillet. Mince the fillet. Make a paste of garlic and ginger. Mix with the other ingredients and make a paste. Spread evenly on a tray. Use heart-shaped mould to prepare bite-sized pieces (nuggets) and freeze. After freezing pre-dust with batter powder and dip in batter solution and then roll in breadcrumbs and fry in oil. (Batter ratio 1:2)

<u>Preparation of Fish Cutlets</u>

Ingredients

Cooked Fish Meat	1 kg
Cooked potato	500 g
Chopped onion	250 g
Green chilly	20 g
Ginger	25 g
Curry leaves	10 g
Mint leaves	10 g
Pepper powder	3 g
Clove powder	2 g
Cinnamon powder	2 g
Turmeric powder	2 g
Refined vegetable oil	QS
Salt	To taste

Procedure

Cook the dressed fish in 3% brine for 15 minutes and drain. Remove skin and bones and separate the meat. Add salt and turmeric to the cooked meat and mix well. Fry chopped onion in oil till brown, add curry leaves, mint leaves, green chilly and ginger in chopped form. Mix these with the cooked meat. Add mashed potato and spices and mix well. Adjust salt content to taste. Shape 25 g each of the mix in round or oval form. Coat with batter and breadcrumbs and fry in oil. Batter ratio 1:2.

<u>Preparation of Fish Cheese Balls</u>

Ingredients

Cooked Fish Meat	1 kg
Cooked potato	500 g
Chopped onion	250 g

Green chilly	20 g
Ginger	25 g
Curry leaves	10 g
Mint leaves	10 g
Pepper powder	3 g
Clove powder	2 g
Cinnamon powder	2 g
Turmeric powder	2 g
Cheese Cubes	1 pkt
Refined vegetable oil	QS
Salt	To taste

Procedure

Cook the dressed fish in 3% brine for 15 minutes and drain. Remove skin, scales, and bones and separate the meat. Add salt and turmeric to the cooked meat and mix well. Fry chopped onion in oil till brown, add curry leaves, mint leaves, green chilly and ginger in chopped form. Mix these with the cooked meat. Add mashed potato and spices and mix well. Adjust salt content to taste. Shape 25 g each of the mix in round form. Make a dip in centre of the ball with thumb. Put one cheese cube at the centre, gather the edges and pinch it into the centre to seal it properly. Shape it into ball form. Coat with batter and breadcrumbs and fry in oil. Batter ratio 1:2.

Preparation of Batter

Maida	2 kg
Corn Starch	200 g
Bengal gram	200 g
Salt	30 g
Tri-sodium polyphosphate	10 g
Turmeric powder	10 g
Guar gum	10g

Preparation of batter mix: Mix batter powder and water in the ratio 1:1

Preparation of Bread Crumbs

- Remove the outer brown layer of bread
- Grind in mixer grinder
- Spread over aluminium tray
- Keep for drying for 2 ½ hrs at 70^0C in dryer (smoker)
- Store in appropriate packages

Chapter 16

Utilization of shellfish processing discards

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The commercial aquaculture for crustaceans in India has become a huge success due to the introduction of new species, the improved hatchery production of seeds, scientific management of culture practices and the availability of good quality feed and other input. Introduction of new species like Letopenaeus vennamei has resulted in increased yield and productivity. The farming of this species has already been established in coastal Andhra Pradesh, Karnataka and Tamil Nadu and gaining momentum in Kerala and other states.

Similarly, farmers in both coastal and land locked States have gone for large scale farming of Giant Freshwater Prawn (Macrobrachium rosenbergii) popularly called "Scampi" which is having high demand in both domestic and international markets. In order to meet the raw material requirement of large number of processing units established for export and also to meet the domestic demand. The state of Andhra Pradesh accounts for more than 50 per cent of the cultured Scampi production and also in terms of area under culture. During the year 2013-14 the estimated production of L. vannamei was 406018 tons whereas the black tiger export of cultured prawn from the country was to the tune of 41947 tons and that of scampi, it was 1401 tons (MPEDA 2008).

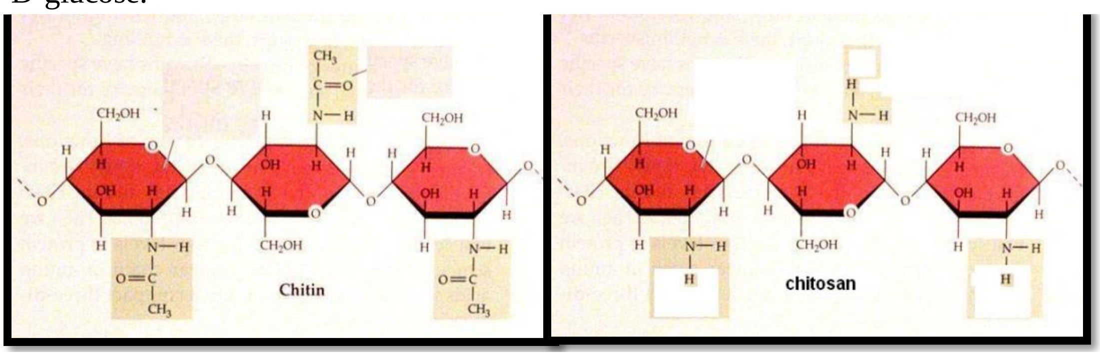
Industrial processing of prawn results in huge quantities of waste in the form of head and shell. Since the exported shrimp products are mainly of peeled items, the shell waste produced is quite high. The head and shell constitute nearly 60% by weight of the whole prawn depending on the species and size of the prawn. In India its availability is estimated to be 100,000 tonnes annually and it is the single largest fishery waste of the country. Crab shell and squilla are other important raw materials available from marine sector.

Proximate composition

Characteristic	Prawn waste	Squilla	Crab shell
Moisture %	75-80	60-70	60-65
Ash (% dry weight basis)	30-35	33-37	45-50
Protein (% dry weight basis)	35-40	40-45	30-35
Chitin (% dry weight basis)	15-20	12-16	13-15
Fat (% dry weight basis)	3-5	2-3	1-1.5

The investigations carried out at the Central Institute of Fisheries Technology, Cochin, paved the way for production of valuable food and industrial products namely protein extract, chitin and its derivatives chitosan and glucosamine hydrochloride from the head and shell waste of prawns, crab and squilla.

Chitin (anhydro- N-acetyl- D-glucosamine (N-acetyl 2- amino 2- deoxy D-glucose) is the second most ubiquitous natural polysaccharide after cellulose on earth. It is estimated that chitin is produced annually almost as much as cellulose. Chitin is a white hard, inelastic, nitrogenous polysaccharide found in the exoskeleton as well as in the internal structure of invertebrates. The monomer units are linked by β (1-4) glycosidic bonds as in cellulose. It is insoluble in water and most organic solvents. It is the most important organic constituent of the exoskeleton of arthropods. The tough and resilient property of chitin is utilized by the living organism as skeletal support and body armor against attack by other marine animals.
The waste of these natural polymers is a major source of surface pollution in coastal areas. Chitin is considered as under utlised resource which has got high potential in new functional biomaterial in various fields. The most important economical source of this material is the shrimp processing industry. Apart from shrimp, the shells of lobster, crab, squilla and squid pens also provide chitin in large quantities. Deacetylation of chitin gives chitosan, a high molecular weight linear polymer of amino-D-glucose.



Production process for chitin and chitosan

Chitin is present in the shells of shrimp or crab or squilla as chitin protein complex along with minerals mainly calcium carbonate. The process for chitin production comprises demineralisation and deproteinisation to isolate chitin. In commercial production demineralisation is done by dilute hydrochloric acid and deproteinisation by dilute aqueous sodium hydroxide. The chitin thus isolated is deacetylated using con.aqueous caustic soda for production of chitosan.

Raw materials

The wet fresh head and body peelings of prawn collected from the peeling centers, crab shell from the processing plants and squilla caught along with prawns can be used either directly immediately on arrival at the plant or can be dried and stored and can be used when required as per the production programme. Shell can be collected from distant centers in the dry form in which case transportation is comparatively easy and economical. Care should be taken to see that the shell should not contain sand and extraneous matter to any significant level.

Selection of raw material

If production of shrimp protein extract is envisaged during the production of chitosan more care has to be taken in the selection of raw material. Only fresh prawn waste can be used for the extraction of protein. It should be iced and hygienically stored and transported. Commercial dry shell gives only very dark coloured protein paste. Moreover, cleaning of the shell is not practical as it normally contains objectionable foreign matters. But, if chitin/chitosan alone is the desired end product dry commercial shell can be used as the starting material.

Production process

The process involves two important stages. (1) Isolation of chitin from shell (2) Conversion of chitin to chitosan.

Isolation of chitin

Chitin is isolated from the shell by demineralisation followed by deproteinisation. If extraction of protein is envisaged for production of shrimp extract only hygienically collected fresh prawn shell has to be taken for processing. The fresh shell has to be treated first with 0.5% dilute aqueous caustic soda and the alkaline protein solution is drained out and kept separately for neutralization, concentration and drying. The residual shell is then deproteinised followed by demineralisation.

Demineralisation

Demineralisation is the process by which the minerals are removed from the shell. If recovery of the protein is not envisaged the wet or dried shells can be directly treated with dilute commercial hydrochloric acid at concentration around 1.25 N at room temperature. The demineraliser is an open cylindrical tank of size 2 m x 1.5 m made of S.S. or M.S. or brick masonry lined inside and outside with fiber glass having perforated false bottom made of S.S wire mesh with 3 mm mesh size and with sufficient reinforcement at the lower end of the cylindrical portion. The vessel is fitted with a propeller agitator of 60 rpm and 80 cm sweep driven by a 5 HP electric motor from the top for gentle agitation of the mass to facilitate the reaction and to avoid floating of the shell. The vessel is so installed that the acidic effluent can be drained by gravity to the fiber glass lined collection tank constructed in brick masonry by the side of the demineraliser. The demineraliser is to be housed in a well-ventilated place with suitable exhaust facility to remove the acid fumes as well as the carbon dioxide coming out during demineralisation of the shell. Demineralisation is an important step in the production of chitin and chitosan. The degree of demineralisation determines to a great extent the characteristics of chitosan.

Deproteinisation

The deproteinisation is the process by which the protein is removed from the chitin protein complex. The shell after demineralisation and washing free of acid is shifted to the deproteiniser where it is treated with 5% aqueous caustic soda at 70-80$_0$C with continuous stirring at an rpm of around 100 using propeller type stirrer for about 30 minutes in a false bottomed steam jacketed open cylindrical

M.S. vessel having arrangements for heating either by steam or by thermic fluid heat exchanger. By 30 minutes the protein from the shell will dissolve in the alkali which can be drained off. The residue is washed well with water to make it free from alkali. This requires at least three washings in potable water with agitation. The product is wet chitin.

Deacetylation of chitin to chitosan

The wet chitin from the deproteiniser is transferred to the cemented collection tank and there to the centrifuge/hydraulic press/screw press for removal of water to the extent possible. The dewatered chitin cake is charged to the deacetylator where it is treated with 50% (w/w) aqueous caustic soda solution at 90-95$_0$C for 1.5 to 2 hours or longer till the deacetylation reaches the required level. After deacetylation, which is ascertained by checking the solubility in 1% acetic acid, the alkali is recovered for reuse. The residue washed twice with minimum quantity of water and collected for reuse making up the concentration. The alkaline chitosan mass is washed well either in the same vessel or after transferring to a storage tank and taking in small quantities to a S.S. washing vessel to remove residual alkali.

Dehydration

The alkali free chitin or chitosan from the washing vessel is collected in canvas bags and pressed under a screw press or hydraulic press or centrifuged to remove the adhering water as far as possible. The residue is wet chitin/chitosan with moisture content around 70%.

The wet alkali free chitin/chitosan cake is taken out, fluffed and spread in clean aluminium trays and dried in hot air drier at temperature 65-70$_0$ C. Alternatively it can also be sun dried by spreading in open cemented floor protected from dust and other contaminants to moisture content below 7%.

Pulverization

The dried chitin/chitosan is sorted manually to remove any foreign material before pulverizing. The pulverizing can be done in a swinging hammer type or a pin type pulveriser fitted with a balloon or cyclone collector to the desired particle size by suitably changing the screen. Sorting is an important step for getting high quality chitin. The foreign matter like match stick, feather, nylon pieces etc. which are normally present in the shell will be carried to the product even after demineralisation and deproteinisation. No mechanical separation is as effective as manual separation although it involves considerable labour.

Bagging and storage

The powdered chitin/chitosan can be bagged in polythene lined HDPE (high density polythene) woven sacks. Usually a bag of size 100 cm x 65 cm is used for this purpose which can hold 25 kg chitin of 1 mm size or 40 kg chitosan of 0.25 mm size produced from prawn waste or 30 kg chitin or 50 kg chitosan from crab shell. Such bags can withstand all transporting hazards.

Product quality

In commerce chitin and chitosan with the following characteristics are acceptable to the end users.

Characteristics	CHITIN	CHITOSAN
Moisture %	<10	<7
Ash %	<2	<1
Protein %	<2	nil
Colour	off white	off white
Particle size	10-20 mesh	60-80 mesh
Solubility in 1% acetic acid	nil	soluble
Insolubles in 1% acetic acid	N.A	<0.5
pH	7.0-7.5	8-9
Nitrogen %	6.5-6.8	7-7.5
Deacetylation %	N.A	>80
Viscosity (m pa s) in 1% acetic acid at 1% level at 28°C	N.A	<100

The process described above will give chitosan of medium viscosity from commercial dry prawn shell. For low, high and special grade chitosan for specified end use parameters like time, temperature, concentration of acid and alkali during demineralisation and deproteinisation and deacetylation are to be suitably modified in addition to raw material selection. Strict quality control measures are to be adopted for minimising batch to batch variation.

Glucosamine:

Hydrolysis of chitin with concentrated hydrochloric acid causes deacetylation and breakdown of the polymer releasing the monomer as glucosamine hydrochloride. Dry Chitin powder was hydrolyzed with concentrated Hydrochloric acid in a glass lined reactor equipped with reflux condenser in a thermostatically controlled digital water bath with occasional stirring. The temperature of the reaction mixture was slowly raised to the optimum level and maintained at that level for the completion of reaction until the solution no longer gives opalescence in dilution with water. During the process the liberated HCl gas was absorbed in water. The excess acid can be distilled off under vacuum after completion. The undissolved residue, was filtered after adding equal quantity of water. To this mixture 10% activated charcoal was added and the solution was warmed to 60o C for 30 minutes and filtered. If the filtrate still coloured repeat the treatment with little quantity of charcoal. This pale yellow solution was evaporated to dryness in a reduced pressure and mixture was washed with alcohol and dried under vacuum. Glucosamine hydrochloride is an approved nutraceutical product. It is prescribed as a remedy for osteo arthritis and approved by USFDA. It is found to have antiflamatory and antiulcerogenic properties.

Chitooligosaccharides (COS) applications:

Production of COS is of immense interest since these oligosaccharides are thought to have several interesting bioactivities. COS produced using endochitinase showed antibacterial activity against bacteria, that cause diarrhoeal and emetic syndromes in humans. Potential effects of COS reported were: as drugs against asthma, antibacterial agents, anti-fungal agents, ingredients in wound-dressings, reduce metastasis of tumors, increase bone-strength in osteoporosis, inhibit chitinases in *Plasmodium* parasites and thereby prevent malaria, immune modulators, and a lowering effect on serum glucose levels in diabetics.

Applications of Chitin, Chitosan and Glucosamine

Chitin and its derivatives, particularly chitosan (deacetylated chitin) find industrial application in various fields namely flocculation, paper making, textile printing and sizing, ion exchange chromatography, removal of metal ions from industrial effluents, manufacture of pharmaceuticals and cosmetics and as an additive in food industry. Several versatile applications of chitosan have been developed during the last three decades. There are about 200 current and potential applications of chitin and its derivatives in industry, biotechnology, food processing, pharmacy and medicine.

The application of chitosan for improvement of quality and shelf life of food products have been well documented. It can be directly incorporated into the food or can be used as coatings for food products or can be made as an integral part of the packaging materials. All these techniques are found to have beneficial effects on the food during processing and storage. Edible coatings can be used as a vehicle for incorporating functional ingredients such anit-oxidants, flavours and colors antimicrobial agents and nutraceutical into the food products whereby adding more value to the product. The applications of chitosan in the field of nanotechnology is being studied widely. It was observed that the antimicrobial properties of nano chitosan is far better when compared to natural chitosan. Nanochitosan in conjunction with metal ions have also been found to have applications in different fields.

Glucosamine hydrochloride and sulphate are marketed as food supplements for the treatment of osteoarthritis. Anti-ulcerative effect of glucosamine was recently reported. In the US glucosamine is one of the most common non-vitamin, non-mineral, dietary supplement used by adults. Since glucosamine is a precursor for glycosaminoglycans and glycosaminoglycans are a major component of joint cartilage, supplemental glucosamine may help to prevent cartilage degeneration and treat arthritis. Glucosamine and N-acetyl glucosamine help in building up connective tissue in joints (e.g. gycosamionoglycons (GAG), chondroitin and hyauronic acid). Glucosamine acts not only as a substrate for the synthesis of GAGs but also stimulates their synthesis and prevents degradation. Different combinations of glucosamine are now in use for treatment of arthritis and the annual global consumption of glucosamine exceeds 6000 tons.

Shrimp shell waste can be efficiently utilized by transforming it to value added by-products like chitin, chitosan, glucosamine and chitooligosaccharides that have wide and varied industrial applications.

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Chapter 17

Chitins: An overview

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Chitin is a relatively recent term used to collectively refer 'chitin and its derivatives' such as chitosan and chitosan oligomers. Chitin is a nitrogenous polysaccharide (poly N-acetyl Amino D-glucose) found in the exoskeleton of insects, shrimps, crabs, lobsters and internal structure of other invertebrates. It is the most abundant organic compound next to cellulose on the earth. Antarctic krill and squid skeleton are typically rich in chitin (~ 40%), while the dry shells of lobster, crab, cray fish, and prawns generally contain around 14-35% chitin. It is also an important structural component of the cell wall of some plant-pathogenic fungi, especially Zygomycets. The average annual global production of chitin by arthropods has been estimated to be around 13,28,000,000 MT from marine ecosystem, 28,000,000 MT from freshwater ecosystem, and 6,000,000 MT from athalassohaline ecosystem. According to Food and Agriculture Organisation (FAO), a considerable amount of crustacean shell is discarded as processing waste, which means the raw material for production of this biologically active molecule is readily available at low cost (Barrow and Shahidi, 2007).Chitin is described as a colorless, crystalline or amorphous powder, which is insoluble in water, organic solvents and diluted acid and alkali. Chitin is present as chitin-protein complex along with minerals, mainly in the form of calcium carbonate. So the process of chitin production consists of deproteinisation with dilute alkali and demineralization with dilute acids. Chitin on deacetylation gives chitosan and on hydrolysis with concentrated HCl gives glucosamine hydrochloride. Chitin and chitosan are natural, nontoxic, biodegradable compounds with a broad range of commercial applications. Chitosan is a large, polycationic polymer having degrees of acetylation ranging from 5 to 30%. Depolymerisation of chitosan by chemical and enzymatic hydrolysis yields water-soluble chitosan oligomers or chito-oligomers. Generally, chitosan with molecular weight <39 kDa and degree of polymerization <20 are known as chitosan oligomers or chito-oligomers (Mourya et al., 2011)

Chitosan

Chitosan and its derivatives have been researched extensively for biomedical applications and unique biological effects such as antioxidant, anti-allergic, anti-inflammatory, anticoagulant, anti-cancer, anti-bacterial, anti-human immuno deficiency virus, anti-hypertensive, anti-Alzheimer's, anti-diabetic, anti-obesity and matrix metalloproteinases inhibitory activities. Among these, the most extensively covered property in literature is antimicrobial property. Mainly, two different mechanisms are proposed as the cause behind the antimicrobial activity of chitosan; first one, being polycationic in nature, chitosan interferes with bacterial metabolism by electrostatic stacking at the cell surface of bacteria; the other is by way of blocking the transcription of RNA from DNA by adsorption of penetrated chitosan on DNA molecules. However, for the latter one, the molecular weight of chitosan must be small enough (∼5000 Da) to be able to permeate into cell.

Structurally, chitosan has three types of reactive functional groups, namely, an amino/acetamido group as well as both primary and secondary hydroxyl groups at the C-2, C-3 and C-6 positions, respectively. The degree of acetylation and/or deacetylation of amino functionality are the main factors which contribute to the differences in chitosan structures and physico-chemical properties. Other important characteristicsof chitosan aremolecular weight, chain length and its distribution. The molecular weight of commercial chitosan ranges from 1,00,000 to 10,00,000 Da. Mild hydrolysis of chitosan yields antibacterial oligomers; however, extensive hydrolysis of chitosan may result in reduced antimicrobial activity (Varun et al., 2017).Chitosan oligomeres with five to seven D-glucosamine units are reported to have good bioactivity. By modulating and improving these structural characteristics, chitosan and its derivatives may find potential in novel applications including the prevention or treatment of chronic diseases.

Chitin and chitosan, have attracted a great attention of researchers around the world in the past few decades due to their broad range of nutraceutical and healthcare benefits. Currently, chitosan is regarded as a potential marine nutraceutical owing to its superior biological activities, biocompatibility and non-toxic nature. It is the most popular natural food additive used as a preservative in a wide array of products, including snacks and beverages. In the food industry, the hydrolysis of chitosan is aimed to decrease its bitter and astringent-taste and to increase solubility of chitosan at neutral pH. The chitosan hydrolysates exhibiting molecular weights between 30 and 41 kDa were considered to be most suitable as a food additive or functional agent as demonstrated by sensory evaluation.

Chitosan is a popular dietary fibre often used to treat obesity and high cholesterol level (Schiller et al., 2001; Sumiyoshi et al., 2006; Trivedi et al., 2016). There are a number of *in vitro* and *in vivo* reports demonstrating the dietary lipid and bile acid binding activities of chitosan (Zhang et al., 2015).The cationic nature of chitosan enables it to bind to the negatively charged lipids, thereby reducing their gastrointestinal uptake and serum cholesterol level. Chitosan absorb many times their weight of fat and cholesterol. A very recent report on the clinical investigation of chitosan supplementation for 8 weeks indicatedlower blood lipid level, simultaneously maintaining the normal calcium, magnesium, and iron statusin elderly hyperlipidemic patients.Apart from that chitosan is reported as effective against the complications that kidney failure patients on dialysis often face, including high cholesterol, anemia, loss of strength and appetite, and disturbed sleeping (insomnia). Choi et al. (2012) have demonstrated the effect of chitosan oligomers on body weight gain, adipocyte size, adipokine level, lipid profile, and adipose tissue gene expression profile in high-fat diet-induced obese mice. Mice fed with high fat diet supplemented with 3% chitosan oligomers had gained 15% less weight but did not display any change in food and energy intake. Apart from that, chitosan supplementation markedly improved the serum and hepatic lipid profiles.Chitosan has been used as an antioxidant for protection of oils and fats against oxidation. It was reported that chitosan at concentration of 0.02%

(w/v) had antioxidant activities in lard and crude rapeseed oil. However the activity was less than ascorbic acid. Investigations by Xie et al., (2001) have demonstrated that the scavenging mechanism of chitosan is related to the fact that the free radicals can react with the hydrogen ion from the ammonium ions to form a stable molecule. Chitosan could also significantly reduce serum free fatty acid and malondialdehyde concentrations and increase antioxidant enzyme activities such as superoxide dismutase, catalase and glutathione peroxidase, indicating antioxidant enzyme regulating activities and decreased lipid peroxidation. However, the mechanism of antioxidant activity of chitosan is still disputable. Many studies have clearly shown low or no antioxidant activity of native chitosan, although the activity significantly increased with appropriate chemical modifications of the biopolymer. Studies by Je et al., (2004) have shown that chitosan may eliminate various free radicals by the action of nitrogen on the C-2 position of the chitosan. Further, the effects of dietary chitosan supplementation on lipid peroxidation and cardiac antioxidant defence system in isoprenaline-induced myocardial infarction in rats was reported (Anandan et al., 2012). Similarly, anti-aging effect of dietary chitosan supplementation on glutathione-dependent antioxidant system in young and aged rats was demonstrated (Anandan et al., 2013).

The anti-inflammatory activity of chitosan and chitosan oligomers is well documented in literature (Azuma et al., 2015). Fernandes et al. (2010) have demonstrated that the anti-inflammatory activity of chitosan oligomers in carrageenan-induced paw oedema method was not only dose-dependent but also molecular weight-dependent at higher doses. Apart from that oral administration of chitosan oligomers was found to be effective against intestinal inflammation and mortality in mouse model of acute colitis.

Chemically modified biofunctional chitosan derivatives is a new addition to the industry, and may open up new applications in functional food and nutraceutical development. Two new conjugates, namely vanillic acid and coumaric acid grafted chitosan derivatives with superior antioxidant and antimicrobial activities compared to native chitosan was developed by Chatterjee et al. (2016). Besides, chitosan has been successfully used in controlled or targeted delivery systems of nutrients and bioactive compounds. Chitosan has several advantages in encapsulation over other biopolymers, namely; ability to adhere to the gastric mucosa, lack of allergic or irritant reaction, pH dependent controlled release of the encapsulated bioactive material etc. It has been successfully used for encapsulation of cashew apple extract, olive leaf extract, tuna oil, enzymes, lactose and various antioxidants.The mounting research data published in this area every year evidently indicate the growing interest in application of chitosan and chitosan derivatives in health and nutrition.

Glucosamine

Glucosamine (2-amino-2-deoxy-D-glucose) is an amino-monosaccharide derived by the hydrolysis of chitin. Glucosmaine is primarily a component of articular cartilage, intervertebral disc and synovial fluid. Glucosamine is chemically glucose in which a hydroxyl group on the second carbon atom is substituted with an amino group. It crystalizes as glucosamine hydrochloride during purification under acidic conditions. Among the various derivatives, glucosamine hydrochloride and sulfate are the most commercialized forms worldwide. Glucosamine, is classified as a ‘safe dietary supplement’ and is widely marketed for pain relief in osteoarthritis.

With age, the body’s ability to produce glucosamine may become impaired, resulting in considerable dysfunction and pain. As a “building block” of cartilage, glucosamine appears to have the ability to treat osteoarthritis by protecting and strengthening cartilage, allowing it to retain its cushioning effects and lubricate the joints. It also plays a role in preventing further joint damage, helps to reduce inflammation and supports pain-free movement of the joints by enhancing cartilage synthesis and inhibiting cartilage break down.

There is now a large convergent documental evidence that glucosamine sulfate, given at a daily oral dose of 1,500 mg, is able to significantly reduce the symptoms of osteoarthritis (Reginster et al., 2012). It is one of the amino sugars used by biological systems for bringing modification to the functions of proteins. Although glucosamine was discovered long back, the interest in nutraceutical use received great attention since last two decades. The rationale in using glucosamine for arthritis is that in the joint and synovial fluid glucosamine will stimulate the synthesis of proteoglycans that help in repair of damaged cartilage, such as hyaluronic acid, heparin sulphate, and keratan sulphate. In the cartilage system, proteoglycans are intertwined with collagen network. Due to the net negative charge of the proteoglycans, a large amount of water is enclosed in the cartilage mass. This water content is important for the resilient and elastic properties of collagen fibrils as well as for the lubrication of the joint system. Also, as a “building block” of cartilage, glucosamine appears to have an ability to treat osteoarthritis by protecting and strengthening cartilage, allowing it to retain its cushioning effects and lubricate the joints. It also plays a role in preventing further joint damage, helps to reduce inflammation and supports pain-free movement of the joints by enhancing cartilage synthesis and inhibiting cartilage break down.

Glucosamine has been designated as an ‘over the counter’ dietary supplement by the US Food and Drug Administration. Although there are contradictory reports on the effectiveness of glucosamine in the treatment of osteoarthritis, there are more than 150 generic preparations of glucosamine alone or in combination with similar supplements in the global market. Taniguchi et al. (2012) reported that long-term oral administration of glucosamine sulfate reduced the destruction of cartilage and upregulation of MMP-3 mRNA in a model of spontaneous osteoarthritis in Harley guinea pigs. Oral administration of glucosamine sulfate for at least 12 months may prevent the need for knee arthroplasty, revealing the profound extent of the disease-modifying power of this compound. Collagen peptide is also reported to have synergistic effects with glucosamine. Inspite of all promisive results, the use of glucosamine in the management of osteoarthritis remains controversial and its specific mechanism of action in pain relief and function modification are still unclear. Animal experiments have shown that, glucosamine is having good peptic ulcer healing properties. Oral administration of glucosamine helps in the synthesis of gastric mucosa to repair the ulcer and provides pain relief. Latest research has claimed that glucosamine supplementation mimics low calorie diet in rats and increased the life span compared to control animals. Calorie restriction was proven in animals to improve the life span in laboratory studies. Gliucosamie was shown to reduce the amount of glucose metabolized through the glycolytic pathway thus mimics low calorie diet.

Glucosamine is a more recent entry to the nutracosmetic category. It can increase the skin's content of hyaluronic acid to increase moisturization, leading to enhanced skin barrier properties and reduced dryness. Glucosamine has also been reported to have potential to inhibit skin melanin production. Glucosamine has been shown to inhibit glycosylation, the addition of polysaccharide units to proteins in *in-vitro* melanocyte cell culture. Glycosylation is a required step in the conversion of certain inactive pro-enzymes to their active forms. Active tyrosinase, a key enzyme in the pathway for melanin production, is glycosylated. Thus, glucosamine inhibits the production of melanin in melanocytes.

Apart from the well-known antiarthritic and antiaging potential, recent evidences suggest a potential beneficial effect of glucosamine against cancerrisk. In these studies, the anti-cancer activity was more correlated with either one of, a decreased DNA synthesis, cell cycle arrest in G1 phase, induction of apoptosis, or inhibition of protein N-glycosylation. Based on a few other observations, glucosamine has been found to be useful for ameliorating inflammamtory bowel disease, migraine, and viral infections. In addition to that, there have been a number of studies suggesting the anti-inflammatory, antioxidant, antifibrotic, neuroprotective and cardioprotective activities of this aminosugar, enlisting it as an ideal neutrceutical supplement for meeting many of the dietary requirements.

Glucosamine is a natural component of the human body, hence, more compatible and does not impose any side effects. Glucosamine is normally synthesised in our body from its precursors however, in instants of osteoarthritis, glucosamine supplementation may be beneficial. An observed safety level (OSL) of up to 2000 mg/day reported for glucosamine, supports a confident conclusion of their long-term safety.Hence, it may be wiser option to consider the use of glucosamine as a combination therapy with other dietary supplements for better and promisive results. It is available commercially in different forms in market, including in combination with herbs, vitamins, creatine, chondroitin sulphate, ascorbic acid, manganese or dimethylsulfone. Of the various available forms of commercially available glucosamine, glucosamine sulfate is found to be more effective for treating osteoarthritis.

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Chapter 18

ENGINEERING APPLICATIONS IN FISHERIES

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Fisheries comprise a major economic activity within complex interactions between human beings and water - 'the first among equals' of the natural resources (Ahmed, 1992). Fisheries data assembled by the Food and Agriculture Organization (FAO) suggest that global marine fisheries catches increased to 86 million tonnes in 1996, then slightly declined. In the past three decades, employment in fisheries and aquaculture has grown at a higher rate than the growth of world population. The fishery engineering is evolving as an important domain in view of depleting stocks on both pre and post-harvest scenarios. It will also aid in fish processing technologies, optimizing energy and water use in seafood industries, mitigating climate change related issues and reducing carbon footprint. It is important to explore novel ways to obtain, quantify, and integrate industry responses to declining fishing stocks and increasing management regulations into fishery- and ecosystem-based management advice. The technological interventions help to reduce the wastage of fish, which is otherwise a highly perishable commodity by preservation technologies and converting it into value added products with higher shelf life. Use of appropriate technologies along the fish value chain will help in producing better quality products and fetch more markets and higher price.

Major areas of technological interventions in the field of fishery engineering cover design and development of fish processing equipment and machineries, energy efficient and eco-friendly solar fish dryers, fuel efficient fishing vessels and fiberglass canoes, indigenous electronic instruments for application in harvest and post-harvest technology of fish, quality improvement of Indian fishing fleet and energy and water optimization techniques for fish processing industries. Focused areas include development of cost effective solar dryers with LPG, biomass, Infra-Red or electrical back-up heating systems, fish descaling machines, Fish freshness sensor etc.

1. Technologies for fish processing and value addition

Post-harvesting processing of fish are important to reduce wastage, increase shelf-life, add more value to the products and ensure higher returns. The major engineering interventions for fish post-harvest operations, processing and value addition are given below:

1.1 Solar dryers

Out of total catch 30-40 % of fish is dried or processed for export and local consumption. Sun drying (open air drying) is the traditional method employed in most parts of the state to dry fishery products. It denotes the exposure of a commodity to direct solar radiation and the convective power of the natural wind. This form of energy is free, renewable and abundant in any part of the world especially in tropical countries. Also it offers a cheap method of drying but often results in inferior quality of product due to its dependence of weather conditions and vulnerability to the attack of dust, dirts, rains, insects, pests, and microorganisms. Solar drying is an alternative which offers numerous advantages over the traditional method and environmentally friendly and economically viable in the developing countries. In solar drying, a structure, often of very simple construction, is used to enhance the effect of the solar radiation. Compared to the sun drying, solar dryers can generate higher air temperatures and consequential lower relative humidity, which are conducive to improved drying rates and lower final moisture content of the final products. However, there exist some problems associated with solar drying i.e. reliability of solar radiation during rainy period or cloudy days and its unavailability during night time. To overcome this limitation, an auxiliary heat source and forced convection system are recommended for assuring reliability and better control, respectively.

In a hybrid solar drying system, drying can be continued during off-sunshine hours by utilizing backup heat source and stored heat energy of daytime sunshine. In this way, drying becomes continuous process and the product is saved from possible deterioration by microbial infestation. These types of Hybrid solar dryers find useful applications in developing countries where the conventional energy sources are either scarce or expensive and the heat generating capacity of the solar system alone is not sufficient. Further, to assist the drying process (forced convection) in a hybrid dryer, a small blower is attached in between solar collector and drying chamber or inside the drying chamber which is powered by solar PV panels installed on drying chamber. Moreover, power from PV panels can be used for street lighting purposes. In addition, if the proposed setup is not used for drying purpose (kept idle), then the same can be used to draw hot water for domestic use. Therefore, in a single set up it is envisaged to have multiple utilities i.e. drying of fish, hot water and electricity generation.

Design of solar dryer varies from simple direct dryers to more complex hybrid designs. Hybrid model solar dryers are having LPG, biogas, biomass or electricity as an alternate back up heating source for continuous hygienic drying of fish even under unfavourable weather conditions. ICAR-CIFT has developed different models and capacities of solar dryers for hygienic drying of fish. The capacity of these hybrid solar dryers varies from 6 to 110 m_2 of tray spreading area for drying of various quantities of fish varying from 10 kg to 500 kg.

The labour requirement is considerably reduced compared to open sun drying in beaches / coir mats because of the elimination of cleaning process due to sand and dust contamination. Re-handling process like spreading, sorting and storing because of non-drying or partial drying due to unfavourable weather conditions and spoilage due to rain is also not required. The drying time is reduced considerably with improved product quality. Improved shelf life and value addition of the product fetches higher income for the fisher folk. The eco-friendly solar drying system reduces fuel consumption and can have a significant impact on energy conservation.

ICAR-CIFT design includes small capacity dryers like solar tent dryers, natural convection dryers *etc*. which will be useful to dry fish hygienically during sunny days. Solar tunnel dryers, solar fish dryers with alternate electrical back up (SDE-10, SDE-20 and SDE-50) and solar fish dryers with fire wood or biomass alternate back up heating system (SDF-20, SDF-50) *etc*. can be efficiently used to dry fish using renewable solar energy which is abundantly and freely available. The details of solar dryers with different backup systems are given below:

a) **Solar Dryer with LPG back-up:** ICAR-CIFT designed and developed a novel system for drying of fish using solar energy supported by environment friendly LPG back up (Fig.1). In this dryer during sunny days fish will be dried using solar energy and when solar radiation is not sufficient during cloudy/ rainy days, LPG back up heating system will be automatically actuated to supplement the heat requirement. In the solar fish dryer with LPG back up heating system, water is heated with the help of solar vacuum tube collectors installed on the roof of the dryer and circulated through heat exchangers provided in the PUF insulated stainless steel drying chamber loaded with fish. Thus continuous drying is possible in this system without spoilage of the highly perishable commodity to obtain a good quality dried product.

   This dryer is ideal for drying of fish, fruits, vegetables, spices and agro products without changing its colour and flavour. It helps to dry the products faster than open drying in the sun, by keeping the physico-chemical qualities like colour, taste and aroma of the dried food intact and with higher conservation of nutritional value. Programmable logic Controller (PLC) system can be incorporated for automatic control of temperature, humidity and drying time. Solar drying reduces fuel consumption and can have a significant impact on energy conservation.

Fig.1. CIFT Solar-LPG Dryer

b) **Solar dryer with Electrical back-up:** Effective solar drying can be achieved by harnessing solar energy by specially designed solar air heating panels and proper circulation of the hot air across the SS trays loaded with fish (Fig.2). Food grade stainless steel is used for the fabrication of chamber and perforated trays which enable drying of fish in a hygienic manner. Since the drying chamber is closed, there is less chance of material spoilage by external factors. An alternate electrical back-up heating system under controlled temperature conditions enables the drying to continue even under unfavourable weather conditions like rain, cloud, non-sunny days and in night hours, so that the bacterial spoilage due to partial drying will not occur. Improved shelf life and value addition of the product fetches higher income for the fisher folk. The eco-friendly solar drying system reduces fuel consumption and can have a significant impact on energy conservation.

Fig.2 CIFT Solar-Electric Dryer

c) **Solar-Biomass Hybrid dryer**: A dryer working completely on renewable energy was designed and developed for eco- friendly operation. Solar Biomass Hybrid Dryer consists of well insulated and efficient solar air-heating panels, drying chamber, SS mesh trays, photo-voltaic cells, fans and biomass heating system (Fig.3). Hot air is generated by virtue of solar energy inside the heating panels and passed into the drying chamber. Continuous flow of hot air is maintained with the help of PhotoVoltaic cells and fans to enable drying process. During cloudy days when sufficient solar energy is not available to maintain required temperature within the dryer, an alternate biomass heating system is manually actuated. Thus a fully green technology for fish drying is achieved by this.

Fig.3 CIFT Solar-Biomass Dryer

d) Solar Tunnel dryer: Solar tunnel dryer utilizes solar energy as the only source of heat for drying of the products. Heat absorbing area of 8 m^2 is made of polycarbonate sheet (Fig.4). Products to be dried are placed on nylon trays of dimension 0.8X0.4 m. The dimensions of the whole drying unit is 2.21X2.10X0.60 m. The capacity of the dryer is 5 kg. Drying takes place by convection of hot air within the drying chamber. Apart from fish, this dryer is also suitable for other agricultural products like fruits, vegetables and spices.

Fig.4 CIFT Solar-Tunnel Dryer

e) Solar Cabinet dryer with electrical back-up: This offers a green technology supplemented by electrical back up in case of lacunae in solar radiation. The dryer consists of four drying chambers with nine trays in each chamber (Fig.5). The trays made of food grade stainless steel are stacked one over the other with a spacing of 10 cm. The perforated trays accomplish a through flow drying pattern within the dryer which enhances drying rates. Solar flat plate collectors with an area of 7 m^2 transmit solar energy to the air flowing through the collector which is then directed to the drying chamber. The capacity of the dryer is 40 kg. Electrical back up comes into role once the desired temperature is not attained for the drying process, particularly during rainy or cloudy days.

Fig.5. CIFT Solar-Cabinet Dryer with Electrical back-up

f) **Infrared drying** – CIFT has recently developed an Infra Red (IR) dryer heat transfer is happening by radiation between a hot element (infrared lamps) and a material (to be dried). Thermal radiation is considered to be infrared in the electromagnetic spectrum between the wavelength of 0.78 µm and 1000 µm. Infrared emitters offer efficient heat and much more advantages compared to other conventional heat technologies:

- No direct contact with the product High drying/heating rate
- Infrared radiation can be focused where it is needed in a defined time,
- Cost savings thanks to high overall efficiency and optimal infrared heaters lifetime.

1.2 Fish Descaling Machines

a) **Fish descaling machine with variable drum speed:** Fish descaling machine is designed and fabricated for removing the scales of fish easily. This equipment can remove scales from almost all types/sizes/ species of fish ranging from marine to freshwater species like Sardine, Tilapia to Rohu. The machine is made of SS 304 and has 10 kg capacity. It contains a 1.5 HP induction motor and a Variable Frequency Drive (VFD) to vary the speed of the drum depending on the variety of the fish loaded. The drum is made of perforated SS 304 sheet fitted in a strong SS Frame. Water inlet facility is provided in the drum for easy removal of the scales from the drum so that area of contact to the surface will be more for removal of scales. The water outlet is also provided to remove scales and water from the machine. An Electronic RPM meter was attached with the descaling machine which directly displays the RPM of the drum. Speed of the drum is a factor influencing the efficiency. The machine takes only 3-5 minutes to clean 10 kg fish depending on the size.

Fig.6 Fish descaling machine with variable drum speed

b) **Fish descaling machine with fixed drum speed- table top:** Fish descaling machine is designed and fabricated for removing the scales of fish easily. This equipment can remove scales from almost all types/sizes/ species of fish ranging from marine to freshwater species like Sardine, Tilapia to Rohu. This machine is made of SS 304 and has 5 kg capacity. It contains a 0.5 HP AC motor with proper belt reduction mechanism to achieve required drum speed of 20-30 rpm. Body is fabricated in dismantling type one-inch square SS tube with a suitable covering in the electrical parts. The drum is made of perforated SS sheet fitted in a strong SS Frame having suitable projections to remove the scale and provided with a leak proof door with suitable lock.

c) **Fish descaling machine hand operated:** Fish descaling machine is designed and fabricated for removing the scales of fish easily. This equipment can remove scales from almost all types/sizes/ species of fish ranging from marine to freshwater species like Sardine, Tilapia to Rohu (Fig.7). This machine is made of SS 304 and has 5 kg capacity. Body is fabricated in dismantling type 1 inch square SS tube. The drum of 255.5 mm diameter and 270 mm length is made of perforated SS sheet fitted in a strong SS Frame having suitable projections to remove the scale and provided with a leak proof door with suitable lock. A pedal is fitted in the side to rotate the drum manually.

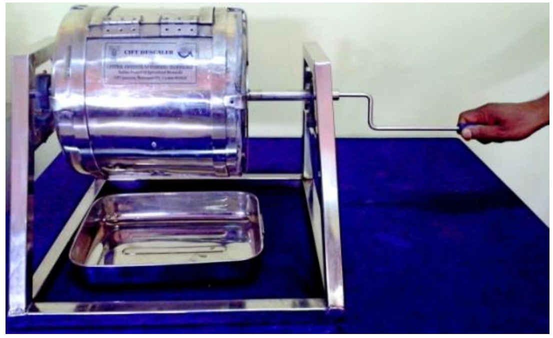

Fig.7 Fish descaling machine hand operated

1.3 Fish meat bone separator: A Fish Meat Bone Separator with variable frequency drive (VFD) to separate pin bones from freshwater fish was designed and developed. This can be used at a range of 5-100 rpm. With a unique belt tighten system developed; the new machine can be easily adapted to any species and need not be customised for specimen during the design stage. In existing imported models, only two speeds are possible which restricts the yield efficiency in a single span operation and also limits easy switching of the system for utilising specimen other than for which the yield has been originally customised. The meat yield of this machine was about 60% against 35% in imported models. Capacity of the machine is 100kg/hour.

1.4 Modern Hygienic Mobile fish vending kiosk: Most of the fisher folk across India sell fish in an open basket without any hygienic practices. The fish is kept in an open bag or container, it loses its freshness.They use ice purchased at high cost for temporary preservation and at the end of the day, if the fish is not sold, they give it at a low rate to customers with little or no profit. More over fish gets contaminated under unhygienic handling practices. The fish vending persons, especially women folk find it difficult to carry the fish as head load and subsequently sell it in the local markets or consumer doorsteps. In this context, the ICAR-CIFT have designed and developed a mobile fish vending kiosk for selling fish in the closed chilled chamber under hygienic conditions at consumer doorstep (Fig.8).

Fig.8 Refrigeration enabled Mobile Fish vending kiosk

The major advantages of the new Kiosk are as follows:

- The mobile kiosk was designed considering the maximum weight that a man pulls on rickshaw.
- The mobile unit is mounted on frame with wheels at the bottom. The kiosk can carry 100kg fish with 20kg under chilled storage display in glass chamber and remaining in insulated ice box (developed by CIFT).
- The main components of the kiosk are fish storage & display chilled glass chamber, hand operated descaling machine and fish dressing deck with wash basin, water tank, cutting tool, waste collection chamber and working space.
- The vending unit has been fabricated mainly using stainless steel (SS 304 Food Grade) and frame and supports are made with MS and GI sheets.
- The kiosk main part *i.e* chilling unit & display for fish storage which was envisaged to power by solar energy through solar PV cells,however presently powered by AC current.
- The stored fish is covered with a transparent glass cover through which consumers can see the fish and select according to their choice of purchase.
- Kiosk is attached with hand operated descaling machine for removal of scales. The fish coming out of descaler is free of scales, dirt or slime.
- It also reduces human drudgery and avoids cross contamination, consumes less time. Fish dressing deck with wash basin also designed conveniently to prepare fresh clean fish under hygienic conditions.

Chilling of fish using electricity/PV cells or by adding large quantity of ice adds to cost to the selling price. Since this technology has well insulated storage space for fish with provisions for refrigeration, it reduces the ice melting rate and its cost, thereby reducing the selling price. The unit also extends the keeping quality of fish for 4- 5 days and increases marginal benefit to fish vendors. It also helps change the practice of unhygienic handling and marketing of fish.

1.5 Electronics and Instrumentation:

ICAR-CIFT identified the vast scope of electronics and instrumentation for fisheries technological investigations and started research and development activities. This resulted in a series of instruments for systematic monitoring, analysis and assessment of the marine environment including the performance of the machinery used for harvesting the resources and post-harvest technology. Basic technologies developed in ICAR-CIFT include more than five dozens of electronic instruments with fully indigenous technology and more than 50 sensors with novel features and designs. The notable achievement is the development of indigenous sensors, which are rugged to withstand hostile marine environment and enable us to monitor field data from remote areas. The total instrumentation is built up around these sensors, with required electronics, new signal processors and other peripherals for solid-state data storing, compatibility to PC, wireless transmission to distant points *etc.*

Some of the instruments, which has got great attention and acceptance are as follows: environmental data acquisition system, freezer temperature monitor, salinity temperature depth meter, hydro meteorological data acquisition system, warp load meter, solar radiation monitor and integrator, ship borne data acquisition system, water level recorder, ocean current meter, remote operated soil moisture meter, water activity meter, rheometer and micro algae concentration monitor. Since the instruments are designed to be compatible with computers and solid-state memory module, the information can be stored for long duration and retrieved at our convenience.

By effective use of efficient and appropriate engineering technologies which are cost-effective, adaptable and environmentally friendly, the fishermen community as well as seafood industry can reduce the harvest and post-harvest expenses and losses, add more value to the products, ensure better fish value chain dynamics and thereby obtain more income. The use of green and clean technologies also ensures less carbon and water footprints.

2. Commercialization and Agri-Business Incubation

Agri-Business Incubators (ABI) open new entry points in the agricultural value chains, which in turn can use to access new markets. They afford leverage through these entry points to accelerate agricultural development and offer the unique potential to develop small and medium-sized enterprises (SME's) which can add value along these chains in ways which other development tools do not offer. There is no single "right way" to perform agribusiness incubation. Rather the work of agribusiness incubation depends on the state of development of the agribusiness ecosystem and changes over time as that ecosystem matures and develops. In its earliest phases, incubators demonstrate the viability of new business models and look to create and capture additional value from primary agricultural products. In underdeveloped agricultural economies, incubators help by strengthening and facilitating linkages between enterprises and new commercial opportunities. They open new windows on technologies appropriate to agribusiness enterprises and help agricultural enterprises discover new, potentially more competitive ways of doing business. In subsequent phases of development, incubators operate as network facilitators: they link specialized service providers to agribusinesses and link separate agribusinesses to one another. Finally, in a more advanced state of business development, incubators operate as conduits for the exchange of technology, products, inputs and management methods across national borders.

A more pragmatic system for business incubation and promoting start-up companies with respect to agricultural technologies have been evolved in recent times within the ICAR-CIFT.The Agri-Business Incubation (ABI) center along with Institute Technology Management Unit (ITMU) seeks to provide business consulting services to agriculture-related businesses and helps to develop a strategic business plan. ABIs facilities for incubation of new business ideas based on new agricultural technologies by providing cheap space, facilities and required information and research inputs. The Agribusiness Incubator Program also seeks to provide business consulting services to agriculture-related businesses and helps to develop a strategic business plan.

The Engineering Division of ICAR-CIFT has commercialized its technologies like solar fish dryers, fish descaling machines, refrigeration enabled fish vending machines etc through the ABI. On non-exclusive license mode, 10 firms have been empanelled to manufacture/fabricate machineries as per CIFT design and commercialize it to needed customers by paying royalty to the institute.In the financial year 2018-19itself, 15 entrepreneurs have taken up Solar fish drying technology and three start-ups came up by establishing CIFT designed fish vending kiosks. Five fish descaling machines were also successfully handed over to sea-food industries located both in

Andhra Pradesh and Kerala. Apart from these, 10 numbers of fish dryers of 10 kg capacity were distributed among women SHG groups located in Kerala, Manipur and Assam for demonstration purposes. Furthermore, 28incubatees(one physical and two virtual) have already registered under ABI in the current year for using engineering technologies. Apart from these, an MOU was signed between ICAR-CIFT and Society for Assistance to Fisherwomen (SAF), Directorate of Fisheries, Govt of Kerala, for fabrication and installation of 20 numbers of Refrigerated fish vending kiosk for the benefit of fisher women SHGs.

3. Energy and Water Use Optimization in Seafood Processing Industry

Energy consumption in seafood or any food processing plant depends largely upon the age and scale of the plant, level of automation, intensity and type of processing operations, plant management practices, plant layout and organization, equipment efficiency and range of products manufactured. The cooking and canning are very energy-intensive processes, whereas the filleting consumes less energy. Thermal energy, in the form of steam and hot water, is used for cleaning, heating, sterilizing and for rendering. The operation of machinery, refrigeration, ventilation, lighting and production of compressed air uses high amount of electricity (Fig. 9). Similarly, seafood industry consumes significant amounts of water in each stage of processing (Fig.10). It also produces a large quantity of waste water. The CIFT have installed energy meters in three industries within Kochi cluster for monitoring the daily energy consumption pattern.

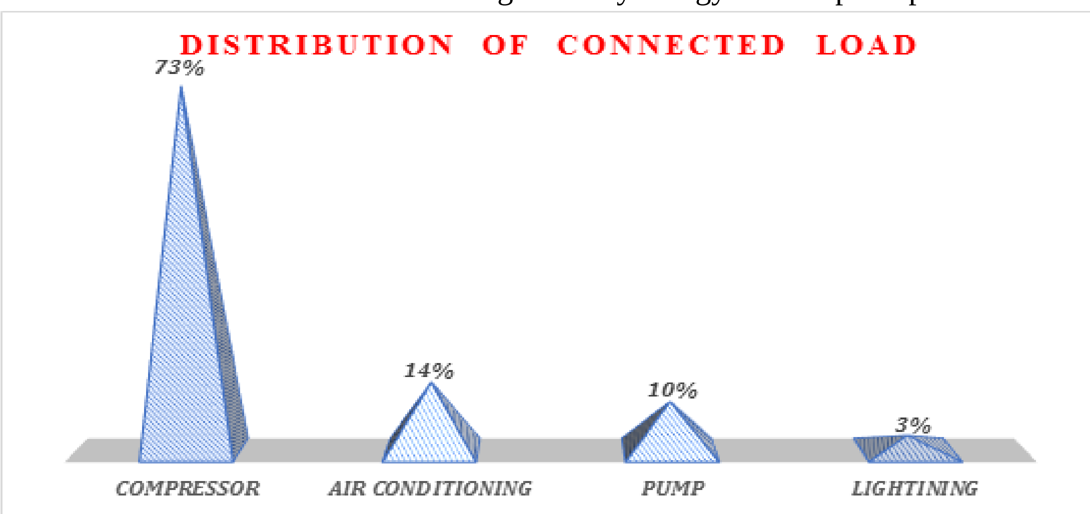

Fig. 9 Distribution of connected load in seafood processing units of the Kochi cluster (Source: BEE, 2015)

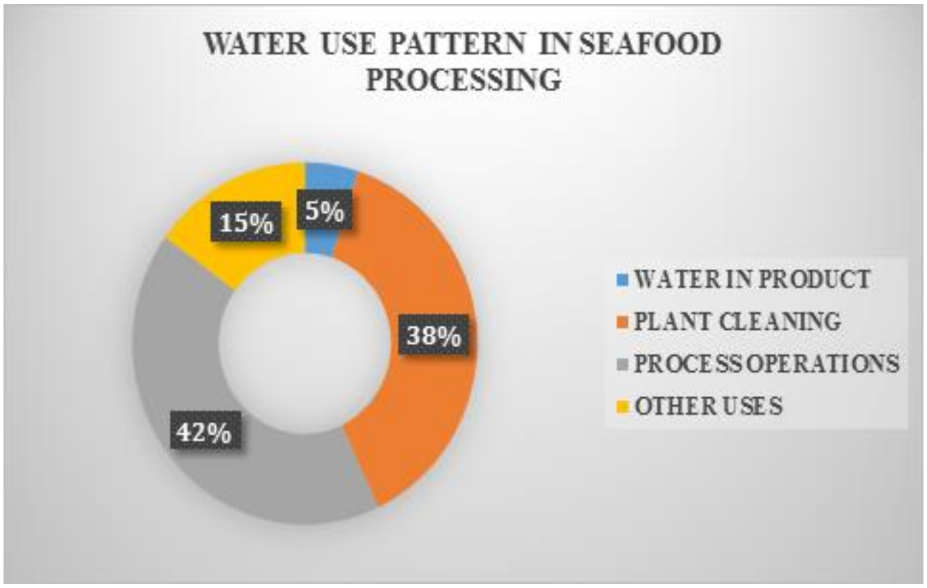

Fig. 10 Water use pattern in a typical seafood processing unit. (Source: BIM, 2017)

3.1 Energy optimization methodologies

Energy optimization methodologies can be broadly classified in the following six categories:

i ***Automation of existing process line:*** Energy wastage in the seafood industry can be greatly reduced by precisely controlling the working of all equipment in the process line. Merely by controlling the timely switching on and off equipment can save a lot of energy, which can be practically impossible in manual operation.

ii ***Sensitize the labor about energy conservation:*** The operation level labor's attitude and behavior have a major impact on the energy optimization point of view. Awareness among the labors regarding energy wastage that can occur due to mere negligence or ignorance has to be created. Instructions can be given to them regarding reducing energy wastage, for example, the chill room doors should be closed immediately after loading or unloading to prevent temperature rise inside etc.

iii ***Equipment upgrade:*** Existing equipment should be monitored for their efficient working through periodic repair and maintenance. Regular servicing and if required replacement of worn out parts should be done. This can actually improve the processing efficiency of the equipment and in turn of the whole plant. The usage of plate freezers considerably reduces the energy consumption in seafood freezing.

iv ***Replacement of out-dated equipment and technology:*** Latest technologies and sophisticated and energy saving equipment can be explored to reduce the energy consumption of plant. For example, reciprocating and centrifugal type compressors can be replaced by a screw compressor, which can give higher processing efficiency or Replacement of existing V-belt drive with synthetic energy efficient flat belt drive in the compressor motor. The direct contact water condensers can be replaced by Evapco type condensers. Installation of Variable Frequency Drive (VFD) for condenser water Pumps. These are relatively capital intensive method but high reduction in energy consumption can be obtained.

v ***Energy auditing and budgeting:*** Effective reduction in energy consumption can be achieved through proper energy auditing of the seafood industry. Energy audits can give an idea about the extent of energy utilized for various purposes in the industry and accordingly energy conservation measures can be executed. The energy auditing can be made easy through software like Energy Datamatrix which periodically check the energy consumption in seafood processing sectors.

vi ***Use of renewable energy and green industry concept:*** Switching to renewable energy sources from conventional sources are of great advantage not only to the industry but also to the environment as a whole. Nowadays, the green industry is a trending concept which emphasizes on those activities and measures which help curb environmental depletion, swapping to renewable energy.

3.2 Water Optimization Methodologies

Substantial reduction in water consumption of a seafood processing industry can be brought about by adopting some of the below-mentioned methods.

i ***Automation of equipment and process-line:***The extent of reduction in water consumption possible by automating the equipment cannot be overlooked. Conventional taps may be replaced by self-closing ones. Cut-off valves, flow diversion valves etc. are dependable accessories which may be installed in the process-line to reduce water wastage. Sensor based solenoid valves may be fitted to the water supply system which can be operated automatically or by means of an Internet of Things (IoT) system.

ii ***Monitoring water use pattern:***Close monitoring of the industry's water use pattern can give a lot of insights. Sensors may be installed in relevant points in the process-line for the same. This can be especially helpful in detecting any leaks by observing the sensor readings during the night. Even though this can incur some initial expenses to the industry, the savings both in terms of money and resources are exceptionally high. Many researchers have successfully developed system for online water monitoring based on different algorithms and tools like genetic Algorithm, Artificial neural networks, ZigBee, GPRS etc.(Liu et al, 2013; Yu et al., 2016).

iii ***Recirculation and recycling:*** Considering the safety standards a seafood industry should maintain and there are some constraints in adopting recycling of water in the process line. Nevertheless, opportunities for possible recirculation of water may be explored to reduce water consumption. Recirculated water can be used for employee wash rooms, Effluent Treatment Plant (ETP) operations and direct groundwater recharging. According to the literature, it is anticipated that a recycling unit in thawing equipment can reduce water consumption by 60 %.The different methods used for the treatment of wastewater in seafood industries are dissolved air floatation, dual media filter, activated carbon filter, sand filtration and tank stabilization, flash mixer, clariflocculator, secondary clarifiers and sludge drying beds, etc. Coarse material and settleable solids are removed during primary treatments by screening, grit removal and sedimentation.

iv *Updating or modifying conventional systems:* Minor changes may be incorporated into the existing system to utilize the available resources smartly. For example, trigger action shut off devices or nozzles can be fitted onto the hose, the addition of timers or pedals to ensure water, adjusting the flow to the minimum required to maintain performance etc. This can be relative very cheap in investment but can tremendously improve the cleaning potential of water since it is pressurized during application. Almost 40% reduction in water usage can be attained by this method.

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Chapter 19

Ornamental Fisheries in India : Scope and development

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Ornamental fish keeping is one of the most popular hobbies in present busy world, providing mental relaxation to many. Ornamental fishes are also known as “living jewel” owing to their colour, shape and behavior. Initially aquarium keeping was popular in developed countries but recently its popularity has increased in developing countries too. This is evident from the fact thatpresently developing countries are contributing two third of the total export value. Use of electrical timers assisted devises for feeding, lighting and filtration has made aquarium keeping simple enabling hobbyist to go on holidays. Most of the fresh water ornamental fishes come from tropical environment and can be easily bred in captivity and cultured in Indian conditions especially in places where the temperature does not fall down below 20°C during winter. The average annual growth rate of ornamental fish trade in the world is 14 per cent and its domestic growth rate in India is 20 %. India is still considered as a sleeping giant as its contribution to this sector globally is only 1%, despite having congenial environmental conditions to culture these fishes.Indiaranks 31st in 2016 export ranking with its share US$ 1.06 million. Singapore is the largest exporter and USA the largest importer.The world trade of ornamental fish has been estimated to be more than US$ 15billion (Karthick et al., 2019).The passion for ornamental fishes in global and domestic market gives a new hope for youth to venture to this field. This can earn them a livelihood and increase the export earnings of the country.

Realizing the immense scope of ornamental fish farming and the export opportunities many Government agencies, Non Government Organizations (NGOs), private entrepreneurs, progressive farmers and their associations have started promoting ornamental fish farming in India. This movement to enhance ornamental fish production in India is known as “Rainbow Revolution”. Government is providing assistance to farmers in terms of technology and subsidies. It is a general perception that the ornamental fish farming is a high investment venture involving sophisticated equipments and involving high level technology which can be done only by highly educated and rich farmers. In fact it can even be a low investment venture involving less expensive fishes with higher market demand and involving low investment farming technologies that can be easily adopted by marginal or poor farmers. This unique feature makes ornamental fish farming an affordable venture even to economically backward farmers.

In India indigenous fishes collected from wild mainly from north-eastern states, Himalayan streamsand Western Ghats are the main source of export earnings.Nearly 150 commercially important ornamental fish species are recorded from rivers, streams, wet lands of India. These includeloaches, eels, barbs, catfish and goby.About 90 percent of ornamental fish is traded from Kolkata port followed by 8 percent from Mumbai and 2 percent from Chennai.India possesses rich resources of marine ornamental fishes in its lagoons and coral reefs of Lakshadweep and Minicoy islands, Andaman and Nicobar Islands, Gulf of Kutch, Coast of Kerala, Gulf of Mannar and Palk Bay. Most of these fishes and invertebrates which are of high value and demand are listed under endangered category. Hence further research toward breeding them in captivity needs to be done.

Ornamental fishes can be are broadly classified into two categories as live bearers and egg layersbased on their nature ofbreeding.The livebearers are guppy (*Poecilia reticulate),* platy (*Xiphophorus sp.),* molly *(Poecilia latipinna) and* swordtail *(Xiphophorus helleri)*belonging to the family poecillidae, but majority of the fishes are egg layers these include gold fish, koi carp, barbs, tetras, gouramies, fighters, oscars, discus, loaches, etc.

The live bearer fishes give birth to young ones. The breeding and culture of these fishes is easy, requires very less space, involve simple technique which can be easily adopted by farmers. These fishes are small in size, less costly and their culture can be carried out in small pools and tubs. In live bearer fishes the eggs develop completely within the body of the female and young ones (fry) are released into water as fully formed young which accept feed from day one. Among live bearers guppy is the most sought off fish globally. The male of these fishes can be easily identified by the presence of gonopodium, which is an elongated rod shaped copulatory organ formed by the modification of anal fin. The gonopodium lies close to the pelvic fin in male when compared to female where a distinct anal fin is seen. The male is brightly coloured and small in size in comparison to female. Fertilization is internal in these fishes when compared to egg layers where it is external. Male of live bearer fishes deposit the sperm in the female fish using the rod shaped gonopodium. The interesting fact in these fishes like guppy is that the sperm can remain viable in the reproductive tract of female and can fertilize five to six batches of eggs. Hence the fishes are known to give birth to young ones even after a delivery without the presence of male fishes. The age at maturity of these fishes are less than three months and they start producing young ones by fourth month. The number of young ones varies between fishes depending on the varieties, species, size and age. In general the number of offspring's produced varies from 30 to 80 and the spawning interval varies between 3 to 4 weeks.

The breeding technique adopted for breeding these fishes is quite simple as the fish breed by themselves and produce young ones when compared to egg layers where separate techniques have to be adopted for each group of fish. The livebearer fishes produce fully developed young ones even when they are kept in groups. In general three male fishes are enough to fertilize seven female fishes. The only problem associated with seed production of these fishes is that they have a habit of eating their own young ones. Hence care should be taken to separate the parents from the offspring's. This can be easily done by keeping the adult fishes in a net cage installed in the culture tanks. The mesh size of the cage should be such that adult fishes shouldn't escape from the cage, but the offspring's should move out easily when they are delivered.

Table 1. Various groups of livebearers and their varieties

No.	Group	Varieties
1.	Guppy	Flamingo red, German red, Moscow red, Moscow blue, half black, snake skin, lemon yellow, neon, Endler's, red chili, white tuxedo, purple blue, red lace, seven colours, dumbo ear, high dorsal, crown tail, pingu, ordinary etc.
2.	Platy	mickey mouse, panda, red top, red, coral, sunset, bumble bee, neon, mango, marigold, tuxedo, pin point, ordinary etc.
3.	Molly	black, white, yellow, mosaic, high / sail fin, balloon, etc.
4.	Sword tail	red, redcap, green, painted, high fin, double sword, red eye etc.

Breeding of egg layers is bit difficult and its success depends on the maturity of fish, size of the tank used for breeding, health of fish, environmental conditions and so on. Mature fishes should be kept in separate breeding tanks before re-introducing them for breeding. These fishes are grouped in to different categories based on their breeding behaviors.

1. **Egg scatters:** In this there are two groups' barbs and tetras in first group and gold fish and carp in second.
2. **Egg guarders:** In this there are two groups first is Anabandids (fighter and gouramies) and second main group is Cichlids

A. **Barbs and tetras:** These fishes generally lay eggs in tanks and eat them. Hence the egg has to be separated from parents. Here the parents (generally one or more pairs) are put in net enclosures so that eggs move down and are protected from parents. The net should not touch the bottom of the tank. Some aquatic plants also are put in nets for fishes to breed. These fishes generally mature in 6 months; male/female identification is different for different groups, generally females are stouter and have bulging belly when ready for breeding. The fishes have to be removed after 2 days. The eggs develop into young ones in 3-4 days. Infusoria, squeezed egg yolk, E-0 shrimp larval feed can be given as early feed.

B. **Gold and carps:** Maturity in six months. In male gold fish pectoral fin ray becomes rough, few white spots develops on the operculam known as tubercles. In female fish abdomen is rounded. In male carps on slight application of pressure near anus white milt oozes out, in female greenish yellow liquid followed by eggs may come. Two male and one female are to be introduced in appropriate size tank for getting maximum fertilized eggs. Stripped polyethylene sheets or large rooted plants for egg attachment can be put. In larger carps above 0.5 kg size induced breeding will have to be done. Fish lay egg in morning within 1 or 2 days after which fishes has to be removed or they may eat eggs. The eggs are sticky in nature and get attached to polyethyne sheet. Eggs hatch out in 2 days. Fry are to be fed with squeezed egg yolk, E0 shrimp larval feed, microworms, moina, daphnia etc.

C. **Fighter and Gourami (Anababdids):** Maturity in six to eight months. Fighter male have larger fins compared to female. In female fish a white spot appears at maturity near anus/genital opening. In gourami the dorsal fin in male is elongated and pointed while in female it's rounded. Both these group of fishes are bubble nest builders. For breeding fishes should be put in plain tank without gravel. A leaf or small plastic sheet should be put on water so that it floats in water. Introduce female fish first followed by male with minimum time difference of 30 mts. The male fish will start building bubble nest below the sheet, by second day the fishes mate below the nest. The eggs are sinking in nature. The fishes pick and deposit the eggs in nest. They will mate below the nest for 10-15 times. Once breeding is completed the female has to be removed. The male will look after the nest and eggs till the eggs hatch and move out. After the fry move out of nest the male also need to be removed. Feed the fry with infusoria, artemia nauplii, egg yolk or E0.

D. Cichlids (angel, morph, oscar, discuss, flower horn etc.)
Identification of male and female is difficult. To get a pair a group of 6-8 fishes are to be put in a tank in which a tile or substrates for attaching eggs need to placed. Two fishes from group will come near the tile which is a pair. This pair has to be removed and kept in separate tank with tile. The fishes will lay egg within a week. The parents will look after the young ones if not disturbed or else they may eat the eggs. It is best to remove the parents after they lay egg and put methyline blue in water, keep a sponge filter in tank near the eggs. The eggs hatch in 4-7 days depending on type of fish. The fry has to be fed with artemia nauplii, later with micro worms and formulated feed. In case of discuss the parents should not be removed from tank as the fry feed on their mucus initially.

Fish production systems

Low investment high value culture techniques

This technique involves production of ornamental fishes in pools holding less than 1000 liter water or in used refrigerator/ fridge containers with 100-200l capacity. The pools are setup using used flex or silpaulin sheets 9 x 6 feet for pool size 1.5m length x 0.8m breadth x 0.4 m depth or 12 x 9 feet for pool size of 2.5 m x 1.5m x 0.4m. These pools need to be constructed at elevated area or at a higher terrain so as to facilitate water exchange by gravity. At weekly interval 20 % of bottom water is exchanged and this water is used for irrigating plants. This integrated farming approach uses more cops per drop of water. The pools for fish culture can also be erected on roof top of house employing wooden frames or at backyard using bricks/laterite stones.

Brick lined supported silpaulin pools

Various varieties/ strains of freshwater live bearer fishes are ideal for culturing in these small tanks. These fishes with less than 10 cm length reach marketable size within four months. They start breeding in 4 months time and subsequently each month they give birth to 30-60 young ones. Hence the farmers get an assured income from four months of culture onwards. Since the pools are of small dimension and depth they can be easily erected at backyard by farm women.

Pools setup on rooftop using wooden planks and siplaulin sheet

Used fridge boxes which are often thrown as scrape after removal of metal part can also be used for culturing and breeding ornamental fishes. The holes in the rigid foam/plastic (poly urethane/ polystyrene) can be easily sealed with adhesives like m-seal or by plastering with cement. Such fridge boxes are ideal for culturing live bearers fishes and for breeding egg laying fishes like gold fishes, small carps, oscars etc. These containers are as good as fiber tanks which can cost up to Rs.4000 for same dimension. The rigid foam facilitates stacking of boxes one above other thus enabling effective utilisation of floor area. The cost of these fridge boxes in scrape market range from Rs.75 to Rs.125. There are now specialized scrape dealers who effectively separate the metal part without damaging the inner foam in Kozhikode and sell these containers for culturing fish. On an average Rs.1000 can be earned from these boxes in a year by culturing ornamental fishes. The farmer can anytime sell back the boxes as scrape if any damage occurs, thus getting maximum benefit from it.

Fish culture in old fridge boxes

All types of fish culture tanks should be covered with net to protect the fishes from birds and other predators. Excess algal bloom can be controlled by covering the tanks with shade nets.

Culture of fishes in earthen ponds

There are many small water logged areas like space between coconut and arecanut channels where water depth is <1m and water availability is for <10 months. These areas remain unutilized as edible fish culture cannot be done profitable here. These channels can be utilized for nursery rearing of edible fishes or ornamental fish culture in a profitable manner. Bigger size ornamental fishes like gold, carp, oscar and other egg layers do not perform well

Fish culture in arecanut channels

in small silapulin pools, but these can be cultured very profitably in these channels. Since weight is not a criteria for sale of ornamental fishes these can be reared in these pools and can be marketed from 1 month of rearing onwards at regular interval. The feed cost also will be lover here due to availability of natural planktons. Care need to be taken to protect the channels with small mesh nets from all sides and top. This will prevent the entry of predators and escape of fish during flash floods.

High density farming

Biofilteration based tank

Lowering of dissolved oxygen and rise in ammonia are the two major constrains effecting fish culture. The low investment technique which does not require any electrical equipment can produce only one guppy fish utilizing two liter of water. While high density techniques can produce upto four guppies from a liter of water. For this the concrete or fiber tanks are used with separate filtration compartment. The filter compartment comprise of biosponge, recron, activated carbon, bioballs and granite stones. The water through this filter compartment is driven by air creating re-circulatory system. So a single aerator is enough to run large number of filters in separate tanks. These tanks constructed above ground level and should have depth of 0.7 to 1 m. A ball valve is also installed below so as to facilitate easy water exchange.

Farming using filtration system

Feed

The fishes need to be fed 2-3 times a day using formulated homemade feed, live feeds or good quality commercial feeds. The feed given to the fishes should be smaller than their mouth size so they consume it easily. The quantity of feed given should be in such a manner that the fish consume the feed completely within 10 minutes after feeding. In case of any infection the fishes will stop feeding in such case the uneaten feed need to be siphoned out and feeding should be stopped or cut down followed by treating them until they recover from the disease.

Disease

Ornamental fishes are very much susceptible to bacterial, fungal, protozoan, viral and parasitic diseases. Most of these are stress induced arising due to poor water quality or feed. As rule of thumb maintenance of good water quality, quarantine practice and hygiene in culture area can prevent disease outbreaks. In fish culture the good old saying “prevention is better than cure” holds good.

Conclusion

Low investment fish culture techniques using live bearer fishes can be easily adopted even by marginal and poor farmers and it involves minimum risk. Theses fishes have good demand in global and domestic markets. The low risk involved in its culture will help even a beginner to learn more about fishes, and get acquainted with fish disease, feeding behavior, water quality and other aspects and get enough confidence to expand the activity.The growing demand for freshwater ornamental fishes in Indian and International market gives an opportunity for new entrepreneur to venture in to this lucrative field utilizing the ambient environmental condition, topography and water resource for becoming successful.

References:

Karthick Raja, P Aanand, S Padmavathy and J Stephen Sampathkumar 2019.Present and future market trends of Indian ornamental fish sector,International ***Journal of Fisheries and Aquatic Studies*** **7(2):** 06-15

Chapter 20

ICT Application in Fisheries

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Introduction:

Information played an important role in all societies since the dawn of civilization. In the initial years use of ICT was limited to academic and research institutes along with costly to access. However, with the passage of time its reach has touched every strata of the society as it has become the most popular and cost effective way of sharing knowledge and information.As we thought that what do fish and fishing have to do with computers, internet and communications? On the outset, nothing... however, information technology is playing a significant role in the modernisation and growth of the fishing industry. This traditional industry is facing economic and environmental pressures, as well as ever changing regulations. Such pressures have led the fishing industry to invest in information technology to maintain sustainability and streamline its operations and be more effective and efficient. The world is undergoing an Information Communication Technology (ICT) revolution, a revolution that has enormous socio-economic implications for the developed and developing countries.ICTs play a vital role for the development of the status of fisheriessector both in marine and inland fisheries in our country. The latest ICT application will transform the fishermen lifestyle as well as their livelihood activities mainly profit motive by reduce their cost of operation and also reduce the vulnerability by timely getting of information which paving the way for social equity and ultimately uplifting fishermen to the mainstream. Nowadays clearly seen that there is fast expansion and development in the fisheries sector through ICTs such as GPS, Navigation, satellite communication and wireless connectivity etcwere significantly contribute in the field of fisheries sector globallycompare to the older technologies such as radio and television.Different initiatives in ICTs have been taken up which would also help in expanding and developing the fisheries technologies to the fisher communities.However, the rural people still have difficulties in accessing crucial information in forms they can understand in order to make timely decisions. New information and communication technologies are generating possibilities to solve problems of rural people and also to promote the aquaculture production by providing scientific information to the fishermen communities.

It is vividly believed that ICT as a basic resource for development, a number of ICT tools used in fishing such as mobile phone, television, radio, GPS, fish finder, can bring significant changes in the development and reduction in the level of poverty of different communities including the fishermen (Kularatne, 1997). ICT play an important role to linking the knowledge among all stakeholders such as researcher, fisheries officials, etc by improving the linkages between the researcher and clients. This will mainly save the cost, time and energy of the fishermen especially through mobile used by the fishermen will provide best price for their catch before brought into the landing centre. With the help these technology fishermen were moving farther into the deep sea getting better catch high value fishes. This will highly helpful for the fishermen to take decision from the various constraints such as higher operational cost, more investment, decline in the fish catch rate, less infrastructure facilities, and low profitability. All these factors are affecting the overall performance or fishing efficiency. Using ICT application in fisheries will be advantage for the fishermen to reduce their operational cost as well as increase their quantity of catch. But the rural communities in the developing countries like India still lack basic communication infrastructure were seen.

I. Basic of ICT:

a. **Information technology (IT)** is the use of any computers, storage, networking and other physical devices, infrastructure and processes to create, process, store, secure and exchange all forms of electronic data. Eg letter, Photograph, Digital sensor, GPS, satellite.

b. **Communication:** it act as a medium to transport information from one to another eg: internet, mobile network, local and wide area network.

Thereare four basic types of computers are as under:

- Supercomputer:Eg. China having world fastest super computer namely "Tianhe – 2" Super computer
- Mainframe Computer: Eg. Fujitsu's ICL VME, Hitachi's Z800
- Minicomputer: production department can use Mini-computers
- Microcomputer: Desktop computers, laptops, personal digital assistant (PDA), tablets & smartphones

c. Hardware refers to the physical parts of the computer such as monitor, keyboard, mouse, and system unit or periphereal device. Whereas the software is all programmes that the user interact with them to carry out the specific task such as Microsoft windows-MS word, internet explorer - Google chrome (search engine), E-mail, cloud storage is back up of data and syncs data that accessible on multiple devices with anytime and anywhere.

In the era of information technology we are spending more time in online using computer, smartphone and tablets and access the facilities such as speaking with people in real time, video chatting, using Google maps for directions, E-learning, e-banking, e-commerce, e government and social networking. Thefishermen's are nowadays using mobile phone for various facilities and also to access the information related to the fishing aspects.There are different tools of information and communication technologies were used in the various fields of fisheries sector such

ICT Technologies applied in fisheries sector

Various Information Communication Technologies (ICT) application tools by fishermen

There are various tools were used by the fishermen to communicate and increase the fish catch such as Whats up, Television, Radio, Mobile, Global Positioning System (GPS), GPRS, Echo sounder, Sound Navigation and Ranging (SONAR), Search and Rescue Transponder (SART), Automatic Identification system (AIS), Distress Alert Transponder (DAT), Internet enabled PC, Radio Deduction and Ranging (RADAR) , Community Radio, portal, Very High frequency wireless sets (VHF).

Radio and television

Radio and television also play important role in the development of the fishermen. Several studies have been conducted and revealed that more than half of the fishermen have their own radio set. Some of the fishermen have listened radio programmes on fishing related issues

Internet technologies: Internet refers to network of networks. In this network each computer is recognized by a globally unique address known as IP address. A special computer DNS (Domain Name Server) is used to give name to the IP Address so that user can locate a computer by a name.It is the largest network in existence on this planet.The internet hugely connects all WANs and it can have connection to LANs and Home networks. Internet uses TCP/IP protocol suite and uses IP as its addressing protocol. Present day, Internet is widely implemented using IPv4.

Data communication: Data communications refers to the transmission of this digital data between two or more computers and a computer network or data network is a telecommunications network that allows computers to exchange data. The physical connection between networked computing devices is established using either cable media or wireless media. The best-known computer network is the Internet.

Network Basic Understanding

A system of interconnected computers and computerized peripherals such as printers is called computer network. This interconnection among computers facilitates information sharing among them. Computers may connect to each other by either wired or wireless media.

Identity technologies:

Barcoding A barcode or bar code is a method of representing data in a visual, machine-readable form. Initially, barcodes represented data by varying the widths and spacings of parallel lines. These barcodes, now commonly referred to as linear or one-dimensional (1D), can be scanned by special optical scanners, called barcode readers. 2D barcodes, although they do not use bars as such. 2D barcodes can be read or deconstructed using application software on mobile devices with inbuilt cameras, such as smartphones.

Vessel tracking devices - Vessel tracking devices such as the Pelagic Data Systems (PDS) tracker can be used to establish locations in which fish are caught and landed. These data can serve as part of a digital record of seafood provenance.

Supply chain tracking software - A number of software systems are now available for tracking fish through the supply chain in order to reduce fish fraud and reliably transmit information about the seafood to buyers. First, the fish must be labeled with a unique identifier. For high value products, a QR code, barcode or NFC-enabled labels (small passive electronic disks that encode information and are activated by the magnetic fields produced by smartphones) might be required to ensure sufficient security. For other products, text messages or app input fields that include information on where the fish was caught, how it was caught, how it was handled, where it was landed and other information can be validated by trusted entities, such as local NGOs with no financial stake in the fishery

Sensors:

Environmental monitoring of aquaculture for the current means of monitoring equipment and a weak infrastructure, relatively backward status quo, using wireless sensor technology, embedded computing technology, MEMS technology (Micro-Electro-Mechanical Systems), distributing information processing technology and wireless communication technology to build the wireless network sensor network system. This system is a digital, networked, intelligent real-time dynamic for monitoring the aquaculture water quality. The system not only can deal the normal detection of the aquaculture environment indicators (temperature, PH, dissolved oxygen, turbidity, ammonia, etc.) in real-time monitoring,

Image processing:

The FishAPP mobile application software enables smartphones and tablets to capture the photo of a fish, or to select one from the local device photo library, and to connect with the FishAPP remote server. FishAPP mobile software has been developed with PhoneGap, a free and open source framework that allows to create mobile apps using a set of standardized web APIs for the desired platforms. The photo must include the full fish and it needs to respect the following guidelines: The fish must be photographed sideway; The caudal fin must be arranged in the relaxed anatomical way; Other fins should be set in a close-fitting manner. Since lifeless fishes cannot keep the fins completely visible we opted to consider only the caudal fin as an anatomical discriminative feature.

Data management:

Web-based Seafood export management software system that simplifies and helps you in a smarter way to increase your business productivity and profitability.

The inventory could operate multiple warehouse locations. It calculates the true yield and margin on everything you cut and meeting the unique challenges of weight, products where yields, collection hub, product accounting, settlement processing, catch weight, multiple freezer/warehouse and Shipment.

Server Side: Web server, Search Engines

Clients side: Browsers, Apps

Cloud : Google drive, icloud, drop box, Skydrive

Access Devices: Desktop, Laptop, tablet, smart phone..

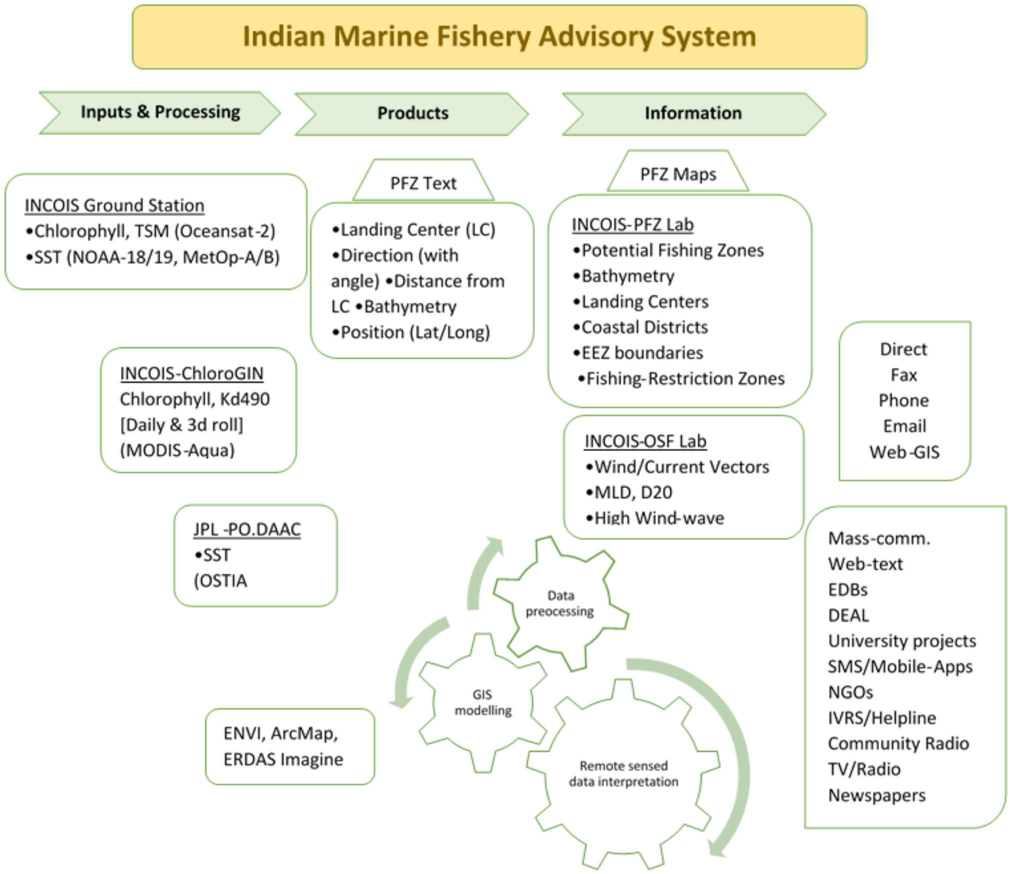
II. Application of ICT solutions in fisheries sector:

1. **Advisories:**

   Indian Marine Fishery Advisory System: Dissemination of PFZ Advisories:

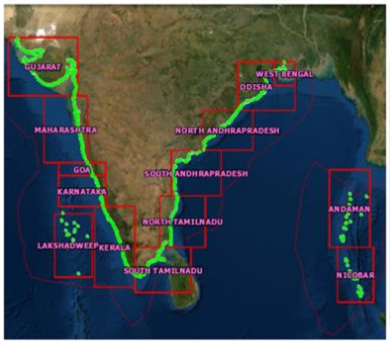
SMS, IVRS, Help lines, Voice Messages, Information Kiosks, etc. through Location Based, New Generation E.D. Boards, , Doordarshan, E.D. Boards, News Papers, E – mails, Website with Web GIS Facility, Phones & Faxes

Figure:1**Indian Marine Fishery Advisory System**



Web-based Dissemination

Unique website for multi-lingual advisories. Provides information in eight local languages (Gujarati, Marathi, Kannada, Malayalam, Tamil, Telugu, Oriya, Bengali) as well as in Hindi and English. Web GIS Facility without any commercial package installation. Retrieve PFZ information pertaining to any area in the Indian EEZ of their interest by doing simple GIS operations.

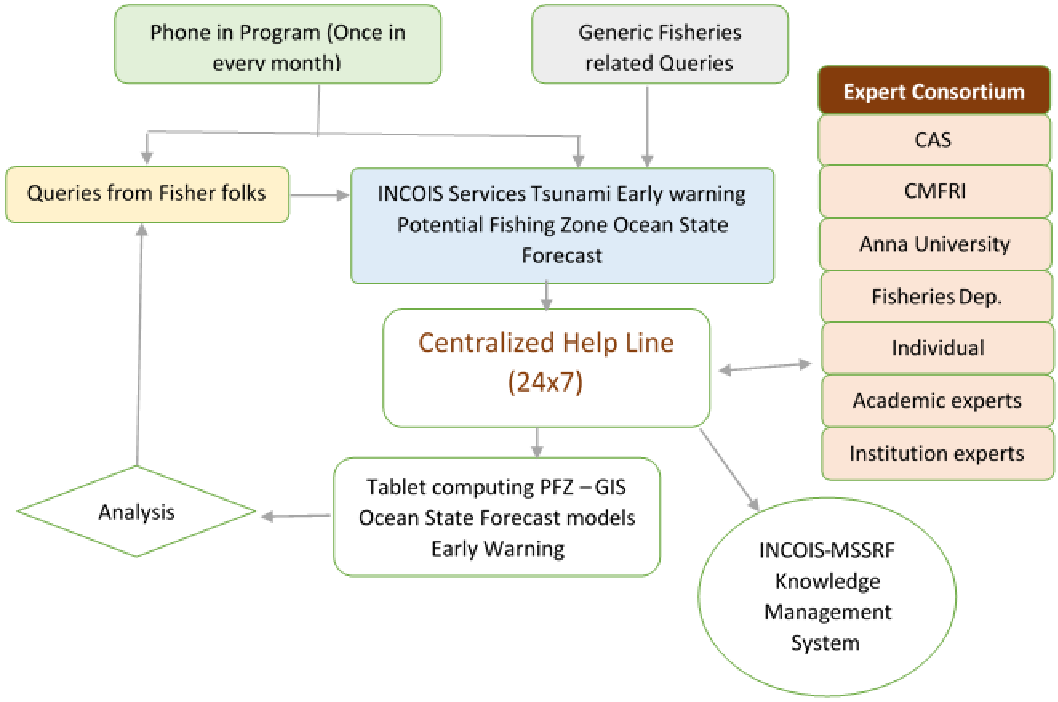


Mobile phone

Using mobile phones, fishermen are able keep themselves up to date with regard to prices and quality of fish in surrounding markets which ultimately enhance their income (Jensen, 2007). In addition, mobile phones have provided easy access to the fishermen to search the best prices for their catches in different markets (Evoh, 2009). Mobile phone penetration in rural India has revolutionized information access as also connectivity between people, the mobile phones not only have provided information with regard to market information to the fishermen but also have facilitated about weather. Mobile phones allow fishermen to avoid potential losses to boats and nets as well as risks to personal safety. Emergency and safety benefits were consistently described as the most important impacts on their life (Mittal, &Tripathi, 2009). It has been also observed that the coastal fishermen use SMS as a cheap way to get information about weather before go to sea. Fishermen also obtain information about emergencies and acting on weather forecast to return safely at sea for fishing

The use of mobile phones in the small-scale fisheries sector shows promise. In India, mobile phones are being used by fishing communities, and fisheries inspectors, respectively, to report cases of illegal, unregulated or unreported (IUU) fishing. However, the use of mobile apps for fisheries catch landings is scarce, and freely available, modifiable, fisheries apps were not available at the start of this trial. Instead only consultancies offering their services apps,Liaising with the following service providers for disseminating the PFZ, OSF and Tsunami warnings through their Mobile Networks.

Architecture of Help Line Services (INCOIS-MSSRF)



PFZ Advisory:

This app can be used for disseminating Potential Fishing Zone (PFZ) advisories to fishermen living in coastal areas of India in English language. It also provides daily advisories to fisher folk about presence of chlorophyll, sea temperature, water clarity and help them easily locate areas of abundant fish in the ocean while saving on both fuel and time used to search for the same.

mKRISHI:

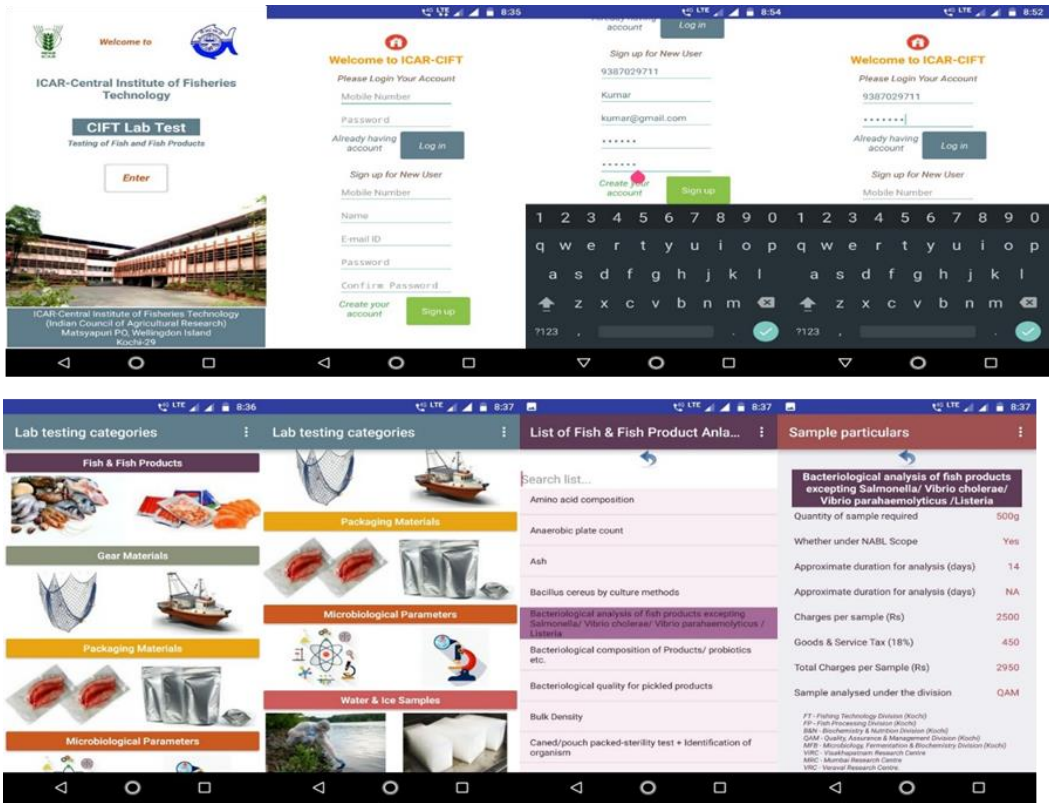
mKRISHI® Fisheries is a mobile app developed by Tata Consultancy Services (TCS) Innovation Lab – Mumbai, in collaboration with ICAR- Central Marine Fisheries Research Institute and Indian National Centre for Ocean Information Services (INCOIS) Hyderabad. This app is a result of multi-dimensional research and field work involving the best of the expertise of all the partner organisations. INCOIS generates Potential Fishing Zone (PFZ), a fish shoals prediction information based on the remote sensing data received from NOAA satellites, sea surface temperature and the presence of phytoplankton which form the food of several fish species. mKRISHI® Fisheries app consolidates these information and presents advisories in local language,

CIFT Lab Test

ICAR- Central Institute of Fisheries Technology, Cochin, an ISO 9001: 2008 certified organization has been recognized as a National Referral Laboratory for Fish and Fishery Products by Food Safety and Standards Authority of India (FSSAI) under Ministry of Health and Family Welfare, Government of India.
ICAR-CIFT has developed an innovative Mobile Application christened as "CIFT Lab Test"

intended for providing information related to different types of sample testing and analysis of various fish and fish based products, fishing gear materials, packaging materials, microbiological parameters, quality parameters of ice and water samples etc.This Mobile App may be useful for the aquaculture farmers, processing industries and other stakeholders in the sector to access the contents of different lab tests as per their interest through online and get the desired information on quantity of sample required, time required for test report and cost particulars etc. available at 24X7 times.

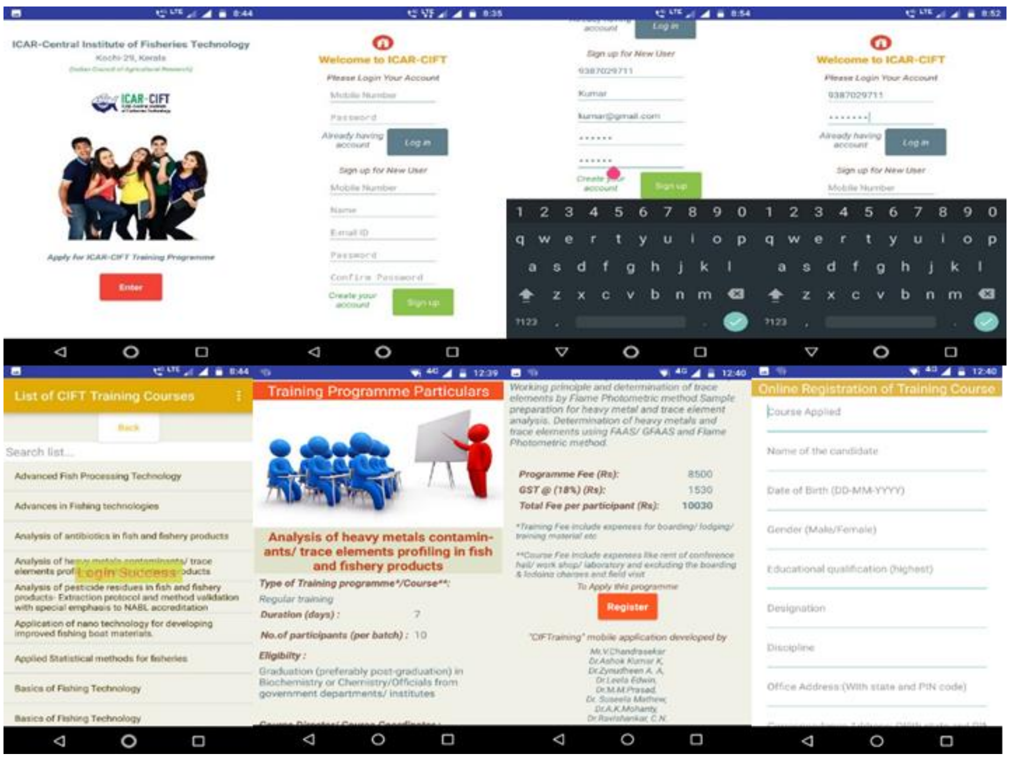
CIFT Lab Test



CIFTraining

ICAR-Central Institute of Fisheries Technology, Cochin has developed an innovative Mobile Application christened as "CIFTraining" that provides a complete package of information on ICAR-CIFT Training programmes. This App is highly useful for the fisheries students, researchers, industry personnel, state extension personnel, fisheries based entrepreneurs, fishers and other stakeholders in the sector to access the online information at 24X7 times regarding different types of training programmes in the field of Fishing Technology, Fish Processing, Biochemistry & Nutrition, Microbiology, Quality control, Engineering and Extension & Economics.

The "CIFTraining" Mobile App has embedded with a total list of 68 types of clientele based trainings programmes available in ICAR-CIFT, which contain 60 regular training courses along with 2 comprehensives, 3 specialized and 3 certified courses covering the themes of seven divisions. The “CIFTraining” mobile app will help the stakeholders to search the training of their interest and see the training programme details like course contents, course fee, duration, eligibility and other facilities at fingertips, so that the right stakeholder can opt for right training programme for improving the technical knowledge and skill in the concerned field. Finally applying the training programme through online registration mode.



Fisher Friend Mobile Application

Developed on Android mobile platform which supports English, Tamil , Telugu, odiya and Malayalam languages

FFMA provides following facilities to fisher folks:

- Potential Fishing Zone
- GPS facility
- International Border Line Alert
- Ocean State Forecast
- Disaster Alert
- Weather Forecast
- Government Schemes
- Market Information
- News
- Important Contacts

E-Commerce in fishery

www.marinefishsales.com is developed under the NICRA project of ICAR-CMFRI as an innovative multi-vendor e-commerce. The platform is made available as an android application for mobile phones to facilitate direct sales between fisherfolk and the customers. The app envisions reasonable prices as direct sale between fishermen / farmer to consumer is facilitated.

Daily fish: The voyage of your 'Daily Fish' from 'catch' to 'kitchen' has never been so world class. Daily Fish, the online seafood store serves you ready to cook seafood which is 'As good as Live' with all the goodness of nutrients stored in it. This is in step with the vision of Baby Marine; promoters of Daily Fish and one of the leading exporters of marine products from India to Europe, US, South America, Japan, South East Asia, Gulf, South Africa and Australia for over four decades.

Decision support system:

A decision support system (DSS) is a computer-based application that collects, organizes and analyzes business data to facilitate quality business decision-making for management, operations and planning. A well-designed DSS aids decision makers in compiling a variety of data from many sources: raw data, documents, personal knowledge from employees, management, executives and business models. DSS analysis helps companies to identify and solve problems, and make decisions.

Types of Decision Support Systems (DSS)

These can be categorized into five types: Communication-driven, data-driven DSS, document-driven DSS,knowledge-driven DSS and model-driven DSS

Example: Aqua manageris a comprehensive, integrated software solution for improved efficiency in aquaculture industries. It is a complete fish farming software that supports all stages of fish production, from hatchery to harvest.

Supply chain:

Integrating technology into a supply chain can be a challenge, and the seafood industry is no exception with the advent of traceability technology that monitors the catch from water to plate.

As more consumers demand to know where the fish they eat comes from, companies have started developing high-tech solutions to capture, receive and transmit data across every component of the seafood supply chain, from fishermen to processors, transporters, distributors, and retailers.

Traceability:

Traceability is linked to the validity of seafood labels that boast about a product's sustainability, authenticity, location and other factors important to consumers. Providing a socially responsible product can translate to higher profit margins, enhanced customer loyalty, and improved brand reputation.Suppliers are under increased pressure from consumers and retailers to provide traceability for their products.Traceability is seen as a way to soothe such worries.Traceability technology can mitigate risks and limit the impact of public health incidents.

A unique ID code for fisheries and its application in traceability and data-sharing The unique codes for fisheries maintained as part of the Global Record for Stocks and Fisheries (GRSF) will save time and money for the seafood supply chain, traceability/technology companies, governments, and non-governmental organizations (NGOs).

The GRSF, the Global Record of Stocks and Fisheries, integrates data from three authoritative sources: FIRMS (Fisheries and Resources Monitoring System), RAM (RAM Legacy Stock Assessment Database) and FishSource (Program of the Sustainable Fisheries Partnership).

Microfinance: Still it is not developed specifically for fisheries so microfinance application in fisheries sector will may try to reduce accounting work of self help groups. The app contains centre, region, unit, SHG and member logins. Each members and their heads can use this app with their account. Network connection is needed for this app. Simple UI and easy to use.

Aquaculture farm management:

Fisheries plays an important role for livelihood and food security of millions. Diseases form a major setback/hindrance to the fish production including both wild capture and culture system. As in natural open waters diseases spread very quickly than the culture system, therefore documentation of disease outbreaks, timely diagnosis and cataloguing of pathogens combinely could help in developing remedial measures or chemotherapy to combat against the disease outbreaks.

Various ICT tools used for fisheries sector:

1. **Fisheries repository management:**
    a. **Fish Base**

Fish Base is a global biodiversity information system on finfishes. Its initial goal to provide key facts on population dynamics for 200 major commercial species has now grown to having a wide range of information on all species currently known in the world: taxonomy, biology, trophic ecology, life history, and uses, as well as historical data reaching back to 250 years.

At present, FishBase covers >33,000 fish species compiled from >52,000 references in partnership with >2,000 collaborators: >300,000 common names and >55,000 pictures. https://www.fishbase.de/home.htm

2. **Identity management:**

AIS (Automatic Identification System)

The Ship borne Automatic Identification System (AIS) is a vessel tracking system capable of communicating navigation information automatically between AIS equipped vessels and coastal authorities. It is a collision avoidance system that gives information all the ships in your area, their speed and courses and how to contact them (name, callsign, MMSI). This information is publically broadcast on VHF radio which can be picked up either by other ships or by shore-based receivers. Main purpose to improve the safety of navigation by assisting in the efficient navigation of ship, protection of the environment, and operation of Vessel Traffic Services (VTS), by satisfying the following functional requirements In a ship-to-ship mode for collision avoidance, As a means for littoral States to obtain information about a ship and its cargo and As a VTS tool, i.e. ship-to-shore (traffic management).

Location recognition:

a. **GPS (Global Positioning System)**

A network of satellites that continuously transmit coded information, which makes it possible to precisely identify locations on earth by measuring the distance from the satellites. As stated in the definition above, The satellites transmit very low power radio signals allowing anyone with a GPS receiver to determine their location on Earth

The advantage is that the global positioning system (GPS) enables the fishermen to plot a course to the potential fishing area. A fisherman can plot his course from any location by using stand-alone GPS, which can work without a mobile network

b. Fish Finder:

It provides valuable information to help you locate rich fishing grounds and boost your catch the Bottom Discrimination Function - Analyze bottom structure Configurable Alarm function (depth, fish echoes, etc.) Post-processing Gain Control applied to all echoes displayed on the screen Share and display information on a chart plotter

Very High frequency wireless sets (VHF)

VHF has been retained for short distance communications but the range is limited under normal circumstances to less than 20 nm. VHF channels at sea especially the distress, safety and calling Channels 16 (156.8 MHz) and 70 (156.525 MHz)

age of social media, especially among the youth is increasing day by day. In this context, a study was conducted to identify the internet and social media usage by students as well as their mode of accessing professional (fisheries) information through social media.social media has been classified into two types, namely social networking sites, and Instant messaging applications based on both form and content of the media

Social Networking Sites	**Instant Messaging Applications**
Instagram	WhatsApp
Twitter	FB Messenger
Pinterest	Yahoo Messenger
Google plus	Skype

Google groups	Google Hangouts
ResearchGate	IMO
Google Scholar	Snap Chat
Wikipedia	Viber
Facebook	Hike
YouTube	Telegram
LinkedIn	We Chat
BharatStudent	

Server Side: Web server, Search Engines
Clients side: Browsers, Apps
Cloud: Google drive, icloud, drop box etc
Access Devices: Desktop, Laptop, tablet, smart phone..

The Department of Fisheries through the following agencies serves this sector.
Information source exposure: Seminar, workshop, Training programme, scientific books/ Literature, Fisheries related magazine and other publications, radio programme, Television programme, Exhibition, Newsletter, Mobile help line communication, News paper, NGOs and others,
Fisheries related government organisation:

a. Fisheries Department
   - Kerala State Cooperative Federation for Fisheries development Ltd (Matsyafed), http://www.matsyafed.in/
   - Agency for Development of Aquaculture, Kerala (ADAK),
   - Kerala Fishermen's Welfare Fund (KFWEB),
   - State Fisheries Resource Management Society (FIRMA),
   - Fish Farmers Development Agency (FFDA),
   - Kerala State Coastal Area Development Corporation(KSCADC),
   - National Institute of Fisheries Administration and Management (NIFAM),
   - Society for Assistance to fisherwomen (SAF)
   - Kerala Aquaventures international limited (KAVIL)

b. MPEDA, Fisheries College, Research institute, CMFRI,

c. KVK, ATIC, AFCA, CIFNET, CIFT, NGO,

Mass media:
Newspaper, Magazine, Newsletter, Farm Journals, Periodicals, Exhibitions, TV, Radio, Internet, Video lessons.

Social organization:

Village panchayat, Co-operative credit, Co-operative group, Fisheries co-operative society, Fishermen association, Community organization, Harbour mechanised boat association,

Initiatives in Fisheries Sector and aquaculture in India (CIBA 2012)

Aquaculture is technology driven farming enterprise and the aqua farmers are looking for quality information in time at an affordable cost. ICT aided tools like e-learning courses, epublications, compact discs, short films, mobile telephony, Phone in programme, information kiosks, expert systems and decision support systems have developed and implemented in a limited scale as projects or programmes. Some of the initiatives are detailed below.

1. E-learning courses on aquaculture: With the financial support of National Agricultural Innovation Project (NAIP), of Indian Council of Agricultural Research (ICAR), the College of Fisheries, Mangalore and Fisheries College and Research Institute, Thoothookudi have developed the e-learning courses for undergraduate fisheries programme to enable the students throughout the country to acquire more effective learning systems. The e-learning courses would enable the students to interact with the teachers more effectively to enhance their knowledge and skills apart from providing them an anytime and anywhere learning opportunity (ICAR 2012).

2. The 'Phone- in' Programme (PiP): PiP is an e-initiative and service facility where farmers/ fishermen can telephone and record their queries on a given telephone number. They would be called back and provided the required information. At the time of live interaction, they can ask questions to the experts at the station and get replies to their queries immediately.

3. Technology dissemination through mobile phones: Mobile phones are the most important medium through which short messages on farming and related aspects can be communicated to the farming community as well as extension workers. Based on a detailed information need assessment the subject matter is made as short technical messages and were disseminated via SMS for the officials of Department of Fisheries of states and farmers in vernacular languages.

4. Village/ Rural knowledge Centre: The Village/ Rural knowledge Centre is the initiative of M.S. Swaminathan Research Foundation (MSSRF) to help ensure food security. The centre provide the rural communities access to a variety of information in fostering agricultural and allied sectors through a hybrid wireless network comprising computers, telephones, VHF duplex radio devices and facilitating both voice and data transfer. It also provides information regarding fish density in the ocean to the fishers. Its primary aim is to set up multipurpose resource centres at the villages of the country. Each Knowledge centre is run by local self help groups, and cater to knowledge based livelihoods and create income avenues for rural people, farming communities and disadvantaged people

5. **Kisan Call Centre:** The Department of Agriculture & Cooperation, Ministry of Agriculture, Govt. of India launched Kisan Call Centres across the country to deliver extension services to the farming community. A Kisan Call Centre consists of a complex of telecommunication infrastructure, computer support and human resources organized to respond to queries raised by farmers in their local language. The subject matter specialist using telephone and computer, interact with farmers and answers the queries at the call centre.

6. e-Sagu Aqua: e-Sagu Aqua is an ICT based tool for personalized aqua-advisory system. It aims to improve farm productivity by delivering high quality personalized (farm-specific) aqua expert advise in a timely manner to each farm at the farmer's doorstep. The aquaculture extension services are extended through ICT tools like database, internet and digital photographs.

7.Aqua-Choupal: The Aqua-Choupal model in Godavari districts of Andhra Pradesh, a web supported initiative of the Indian Tobacco Company (ITC) was designed to provide market and farming related information to enhance farmers' productivity and their farm-gate price realization. the unique web based initiative of ITC Ltd. offers the farmers of the state of Andhra Pradesh all the information, products and services they need to enhance productivity, improve farm gate prize realization and cut transaction cost. Farmers can access information on weather, scientific farming practices and market prices through a web portal. Aqua choupal also facilitate the supply of high quality farm inputs as well as purchase of shrimps at their doorstep

8.e-TSA: The extension module on Tiger Shrimp Aquaculture (e-TSA), a PC based application was developed for knowledge management and dissemination of Better Management Practices (BMP) of tiger shrimp (Penaeus monodon). Information on BMPs has been covered under ten headings, viz., site selection, pond design and construction, pond preparation, seed selection and stocking, feed management, water quality management, health management, waster water management, harvest and post-harvest management, and shrimp farm bio-security. The e-TSA also assists the user in identifying a shrimp disease and its management through selection of symptom(s) provided in the system, apart from assisting in calculation of lime, fertilizer, chlorine and daily feed requirement for shrimp farming activity.

9.Decision Support Systems: The Decision Support Systems (DSS) like carrying capacity based aquaculture planning in a given creek, multi-criteria based site selection tools for brackishwater aquaculture site selection have been developed by CIBA.

10.Farmer-friendly touch screen information kiosk on BMPs in shrimp culture: A vernacular based information kiosk with touch screen facility on BMPs of shrimp culture was developed and dedicated to the small scale farmers.

11.one stop aqua shop : One of the major recommendations of DFID funded project "Investigating improved policy on aquaculture service provision to poor people" was to establish one stop aqua shop (OAS). It is intended that OAS would provide better access to farmers regarding appropriate aquaculture technology as well as information on government schemes and rural banking and micro finance.

Apart from these, farm advisories, success stories and important information which are to be informed to the end users immediately are being uploaded as e-publications in the websites of the institutions concerned, and short duration video-film on different aspects of aquaculture are being produced especially in local languages.

12. Helpline: Leveraging on the IT revolution in India and the increasing penetration of telephones in villages, many State Agricultural Universities and ICAR institutes have started helpline services. The helplines address queries related at specific hours. The helpline number is advertised through mass media viz., radio and press

APPLICATION OF ICT FOR AQUACULTURE

Globally, ICT has been widely used for the study and improvement in various aspects of fisheries including, research and education. As in any farming enterprises, health management is the key subject in aquaculture too, and aptly, ICT aided tools have been most widely applied in the field of fish disease diagnosis and health management, apart from its application in other areas viz., aquaculture site selection, aquaculture farm management and aquaculture produce marketing.

Expert Systems

The expert systems are the computer applications developed to solve complex problems in a particular domain, at the level of extra-ordinary human intelligence and expertise.Development of Expert System for Shrimp Aquaculture (ESSHA) involved five steps viz., problem selection, knowledge acquisition, knowledge representation, system design and development as well as system validation (Zetian et al., 2005).

Expert Systems in Fisheries Sector:

Expert systems are rapidly becoming an integral part of applications in a number of domains ranging from traditional manufacturing processes to applications in outer space. Expert systems have been shown to improve traditional approaches by as much as an order of magnitude. There are number of areas, including fisheries and aquaculture, in which the return on investment in an expert system can be tremendous.

Categories of Expert Systems developed in Fisheries

1 Fish identification
2 Fisheries management
3 Aquaculture management
4 Fish Disease diagnosis and health management
5 Fisheries information management
6 Fish product marketing

Social media in fisheries science

• Blogs. • YouTube. • Facebook. • Flickr. • LinkedIn. • Ning. • Vimeo. • Twitter • Webinars • Skype • Instagram • Pinterest • Videos • Discussion Forum

https://twitter.com/FisheriesBlog

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Chapter 21

Technological Forecasting

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Technological forecasting is the probabilistic assessment of the feasibility of future technology transfer (Vogel, 1970). It is the forecast with reasonable level of confidence regarding the the expected technological advancement in a specified time period provided a level of support in the form of expert knowledge or data regarding the concerned domain. It need not predict precise form of technology in future application, rather itdescribes scientific knowledge, technical skills, and examples of systems and components which science and technology can be expected to produce over a specified time if supported by orderly programs of research and development (Cetron et al,1966).

Technological forecast is concerned with the investigation of new developments, disruptive technologies, and new dynamisms which could arise from the interaction of factors such as new policies, innovations, expectations and apprehensions of general public. Technological forecasting is considered as an instrument to visualise the probable direction, pace, and outcome of technological change (Kang et al,2013). Researchers make technology forecasts based on past experience and current technological developments.

There are four elements in a technological forecast (Martino, 1983):

1. A time period.
2. A specific technology.
3. Functional characteristicsofthe technology.
4. Statement of probability of the outcome.

Like other forecasts, technology forecasting can be helpful for both public and private organizations to make smart decisions. It is a crucial input for planning the future development

Some applications of technology forecasting

• Collecting information on the environment and other determinants of technological change,

• Identifying limits of future applications of technologies in terms of threats and opportunities

• Understanding how future scenarios might be shaped or affected by today's long-term technology investments, and

• Understanding consequences of technology change and development in the context of economic and social implications.

Limitations of Technological Forecasting

- Reliance on the quality of the data and the assumptions.
- Difficulty in predicting the probability
- Problems in giving weightage to the factors.

- Biasness of the researcher may creep into the quality of the forecast.
- Technological forecasts do not provide conclusive results.

The techniques, both qualitative and quantitative methods, used in technology forecasting can be classified into two broad categories(Ramarao,undated), viz. Exploratory forecasting and normative forecasting. Short brief of some of the technology forecasting techniques are given below followed by an overview of Delphi method.

A. Exploratory methods:

Exploratory technological forecasts are largely based either on aggregates of 'genius' forecasts or on the use of leading indicators and other simple trend line approaches (Roberts, 1969).Cetron (1966) has defined It as a prediction with a level of confidence of a technical achievement in a given timeframe with a specified level of support. It starts with given situation and tries to predict the innovations.

1. Intuitive methods depend on the experts having vast knowledge and experience in the field who are able to envision the future scenario. Some commonly used intuitive methods are:

i) Individual forecasting: Experts in particular domains often make predictions about probable scenarios. But it lacks rigour of collective interaction and biasness is more. Probability of failures is high.

ii) Opinion polls: Opinions of selected experts are collected and analysed. At least twenty Ambiguous questions may lead to wrong responses .Also the danger of majority opinion masking the minority opinion also exist..

iii) Panels: It involves interaction among a group of experts. Though it has the merit of being multi- disciplinary and knowledge pooling, it suffers the weakness of being overpowered by a dominant persons.

iv)Brainstorming: Brain storming is another approach to make out from pooled ideas. Even the wildest of ideas are encouraged, resulting in a large pool of ideas. This could act as the input for further forcasting.

v) Delphi: Itinvolves iterative process of data collection and analysis until consensus is reached among anonymous experts in relation to complex situation.Here the assumption is that collective wisdom is better than the individual 'guesstimate'. Delphi technique is discussed detailed manner in later part of this chapter.

Input-output method: The input/output method systematically relates technological change and final demand to industry growth rates (Ranard,1972). Input-out tables are mainly used by firms to understand market penetration.

Growth curves: Growth curves are used to predict the advance of some technologies. Sigmoid growth curve with initial slow pace of growth followed by speedy advancement before declining to a steady state is most commonly used .young (1993) has used nine types of technological growth curves to study the characteristics and assumptions behind this genre of models

Scenario Planning offers an opportunity to visualise the future and help to plan accordingly. It is used to specify a future technology with possible environment. It is a narrative method which outline potential course of events. There can be multiple scenarios on a given time horizon since future is uncertain.

Trend extrapolation:In this method historical data series is used make a trend which is further extrapolated using appropriate statistical methods linear or logarithmic extrapolation techniques.

Substitution: When competitive substitutions are available,substitutions models can be used provided the time period for initial few substitutions. , Extrapolation of the substitution curve can be used to predict the extent of substitution in the future.

Technology monitoring: It involve scanning the environment for getting information related to the Technology followed by evaluation and utilisation of information for forecasting. In some cases predictionis possible by monitoring the early signals of the innovation. This is mainly achieved by a literature review, intellectual property search etc for ideation of technologies

Multivariate analysis:multivariate analysis of relation between dependent variable and two or more explanatory variables will help in forecasting based on the estimated value of the coefficients

B.Normative methods

Normative methodsstart with future needs then work backward to identify the technologies, environment and actionsneeded to meet them in best possible manner. This is need-based approach where required skills and capabilities are identified for the realisation of the goals. It depends on Bayasian statistics, and other operational research tool (Roberts, 1969).It includes rational allocation of resources for creating futuristic technologies.

Some of the available normative techniques for TF are:

Network techniques: This involve formulation of elements of forecasting network for converting description of technology system into network These techniques are mainlyused for missionoriented planning exercises mainly to analyse the road blocks to achieve the final target of objective.

System for Event Evaluation and Review (SEER): This is a modified variance of Delphi ideal for corporate exercises not necessarily the ones aimed at consensus. This consists of a single round of event evaluation (Ramarao,n.d).

Cross-impact analysis: Different events in present and past interact with each other and impact each other. Forecasts are made based on these interactions. It can be considered as an extension of Delphi technique. The purpose here is to study the mutual influence of the interacting events and utilise it to forecast technical capabilities

Morphological Analysis It involves systematic assessment of the morphology of technology for identifying the potential for performance improvements (Yoon and Park,n.d). This involve organising the information to provide a framework for searching possible solutions for a problem

Relevance trees: Here a broad topic is divided into smaller subtopics and shows different ways to achieve the goals. These ways are different in terms of probability of success and cost.

Evaluation of these alternatives helps to forecast associated costs, durations and probabilities for each element.

Dynamic modelling: These are computer aided structural modeling techniques in which time varying effects can be explicitly considered. It involves construction of a model based on perceived idea about system performance and tested against past performance of the system. Sensitivity analysis will be done to identify the controlling variables and to calibrate it further. This model will be used for prediction of future performance of the system (Blackman,1971).

C. Delphi technique: An Overview

The Delphi technique is used for problems that do not lend themselves to p r ecise analytical techniques , but can benefit from subjective judgments on a collective basis . Morgenstern (2) considers the Delphi technique to be the single most noteworthy contribution to the fi e ld of technological forecasting.

The Delphi exercise involves number of steps to elicit the response of group of experts or members of intended audience andfurther to modify it. (Rothwell and Kazanas, 1997). The process starts with selection of experts. It is followed by development of questionnaire which can be structured (Rothwell and Kazanas, 1997), and comprehensive of the area of study or unstructured which mainly involves the open ended questions related to area of investigation (Lang, 1998). Thequestionnaire issent to the respondents through online or offline modes. The responses collected are analysed and used develop questionnaire for next round. The procedure is repeated until there is consensus.

The information generated is processed and used by the investigating team to develop a subsequent more focused questionnaire, which is distributed together with the results of the previous round to participants in the third step of the procedure. This process of synthesizing data and refining the questionnaire continues until there is agreement of opinion among participants (Lang, 1998).

Delbecq et al., (1975) described the Delphi technique with the following steps:

1. Formulation questionnaires: The questionnaire may be open ended or require response on a rating scale. They are revised for each round based on the responses from previous round
2. Selection of experts: Experts are selected using snow ball technique, where key informants identify and recommend the experts in the particular area.
3. Sample size: The sample usually varies between 10-30. Anecdotal evidence points out that a sample between ten to twenty is sufficient.
4. Distribute the questionnaire:Sent the questionnaires to selected respondents and collect the responses in prescribed time.
5. Data analysis.: Collected responses are analysed using appropriate statistical techniques to see whether sufficient degree of consensus exist among respondents.
6. Formulation of questionnaire for second round, distribution and collection of feedback: The questionnaire for second round has to be developed based on the feedback from first round. The respondents should be requested to review their responses in this round

7. Data analysis: The responses from send round also analysed for possibility of consensus among experts. If sufficient consensus is reached, the iteration can be stopped. Otherwise the process will continue to next round.

8. Formulation of questionnaire for third round, distribution and collection of responses:Provide the summary of second round to respondents and ask them to review their responses in light of the collective feedback. The collect the responses

9. Data analysis:Consensus is examined using different measures.

10. Develop the conclusion and prepare final report.

Measuring Degree of Consensus

It was observed that, most of the researchers used quantitative and statistical measures such as mean, median, mode, standard deviation, skewness index, interquartile range, and rank for assessing the degree of consensus (Trexler et al., 2006). Some researchers have opined that criteria of consensus need to be identified based on the topic of the research (Kantz, 2005). The method is lacking a universally accepted measure of consensus. It is one of the major drawbacks of Delphi method. (Hung et al., 2008; Murry and Hammons, 1995). Single measure of consensus was followed earlier, but to add more rigour to the method 2-3 criteria are used in recent researches.This could help overcome the problems associated with single measure of consensus.

Some of the measures of consensus are listed below (Birko, Dove and Özdemir,2015;Rayens and Hahn,2000; English and Kernan, 1976).

1. De Moivre index (DM): It takes a value of 0 or 1 only depending on whether all respondents have agreement in their opinion.

2. Interquartile Range:It is a measure of variability in data, which can be calculated by taking the difference between largest and smallest values in the middle half of observations.

3. Coefficient of variation (CV): It is the measure of relative variability calculated as the ratio of standard deviation to mean in a set of observations.

4.Pairwise Agreement: Pairwise Agreement is the corresponding average measure of pairwise agreement over all possible pairs of experts

5. Clustered Pairwise Agreement: Based on the pairs of agreement in each consensus cluster.

6. Extremities Version of the Clustered Pairwise Agreement: It is modifiedClustered Pairwise Agreement, it takes only the agreements falling in upper or lower bound of the scale (e.g., 1-2-3 and 8-9-10 respectively in our simulation).

English and Kernan (1976) reported that if the value of the coefficient of variation (CV) more than 0.5 and less than or equal to 0.8, it means less than satisfactory degree of consensus and there is possible need for additional round. If CV is less than or equal to 0.5, there is no need for additional round. Elwyn*et al*., (2006) opined that consensus will not be there if 30 per cent or more of the ratings fall simultaneously in the lower third and in the upper third of the scale. Hackett *et al*., (2006) considered Fifty-one per cent of experts responding to the highest category as the criteria of consensus, while Beattie and Mackway-Jones(2004) and Roberts-Davis and Read(2001) argues for agreement by more than 75 per cent of experts.The concept ofapplying more than one consensus criteria is based on the premises of methodological triangulation wherein the methods will substantiate one another (Creswell, 2007; Mason, 2002; Silverman, 2005).

Number of Rounds

The number of rounds in the process of iteration varies depending on the nature and purpose of the exercise. Normally, consensus is reached in two or three rounds (Delbecq et al.,1975). In case of heterogeneous audience, more rounds will be required. In case of homogenous groups, one or two rounds are sufficient. As the number of rounds increases there is a threat of reduction in response rate (Alexander, 2004; Rosenbaum, 1985; Thomson, 1985).

Panel Size

There exists no clear cut rule regarding the size of the panel. It depends on the nature of the study, degree of complexity, required precision and expertise. It can be large or small, geographically dispersed or confined, homogenous or heterogeneous etc. But the rule of thumb is15-30 people for a homogeneous population i.e., experts coming from the same discipline (e.g. nuclear physicists) and 5-10 people for a heterogeneous population, people with expertise on a particular topic but coming from different social/professional stratifications such as teachers, university academics and school principals (Delbecq et al., 1975; Uhl, 1983; Moore, 1987). According to Adams (2001), by increasing the size beyond 30, reliability and validity hardly improves. It has been pointed out that more than 13 respondents are suffient to achieve satisfactory level of reliability (Dalkey,1969). Hasson, Keeney,and McKenna (2000) points out that achieving impartiality in recruiting panel members is often difficult. There will be selection bias very often make a case for seeking impartiality in recruiting panel members, but this

Survey Instrument

Delphi questionnaires can be open ended or requiring response on 5-point likert type scale. In some cases, open ended questionnaires are used in first round to have sufficient information base. In the repeated round likert type scales are used based on the first round.

Confidentiality

Responses to the Delphi questionnaires need to be treated with complete confidentiality, and the anonymity of experts in panel was thoroughly maintained throughout the data collection.

Mode of Communication

The mode of communication may be on line or through mailed questionnaires. With the advent of Information and communication technologies there are many possibilities to fasten the process. The applications like ‘Google form and Survey monkey’ can be effective used for the purpose

Statistical analysis used

Descriptive statistical analysis such as mean, median, mode, percentage, interquartile deviation (IQD), standard deviation and coefficient of variation were used for analysing the data.

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Chapter 22
Establishing Fish Based Enterprises for Livelihood Security: Scopes and Opportunities

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The basic reason for poverty is not nothingness...... It is the tendency of unwillingness of human mind for sharing the available, inability to make use of opportunities effectively and lack of willpower.........Technology for a micro-enterprise is a 'game' for the rich, a 'dream' for the poor and a 'key' for the wise…………………………….....(Kudumbashree, Kerala State Poverty Eradication Mission)

It is an unequivocal proposition that, fisheries sector occupies a paramount position in the socioeconomic development of our country. Fisheries, aquaculture and fish based enterprises are considered the sunrise sectors in India, providing nutritional security, contributing to the nation's GDP and offering employment to over 14 million people directly and indirectly. Constituting about 6.3% of global fish production, the sector contributes to 1.1% of the GDP and 5.15% of the agricultural GDP (NFDB, 2016). The extent of inland water resources of India prevailed hovering potential considering aquaculture-entrepreneurship development. In fisheries sector the input production and the input-delivery-systems like fish production, marketing and exports, processing and product developments needs emerging entrepreneurs.The professionals in the government sector cannot take up all the responsibilities in order to bring quantum change in the system. There exists a variety of initiatives around the globe by the individuals and institutions, involving in missions of philanthropic nature, which try to create viable and sustainable changes in person's lives. Social entrepreneurship will be demanded to replace the existing aquaculture practices of India with more sustainable resilient practices and management strategy. This is one of the major lacunae of entrepreneurship development in fisheries sector. But according to Kahan (2012), farmers see their farms as a business and as a means of earning profit and thereby ultimately to bring about development. It would be pertinent to have a look into the scope and opportunities of fish based enterprises for livelihood security of fisherfolk in the chain of development.

The word development means the upliftment in the standard of living of the poorest of the poor in the society. Development of Indian fisheries sector in a broader visualization will be materialised with poverty eradication programmes though the transparent media namely Self Help Groups. Self Help Groups can play a vital role for the fisheries sector development. The utmost important requisite for this is ensuring participation of fisherfolk especially women in the planning and implementation of various coastal sector development progammes.Alternative livelihood options through appropriate and economically viable micro enterprises are the only solution for meeting the ever-increasing demand of population in coastal belt in the context of diminishing per capita fish catch. The means of livelihood of coastal fisherfolk in different maritime states vary from one another. Since the livelihood conditions and technological requirements of the fishing population have not been studied in depth, it is difficult for any technological intervention and implementing other management options for improving the livelihood status of the fisherfolk. An attempt is made for developing a theoretical framework based on the review of past research studies related to livelihood analysis both at national and international level.

A couple of reviews in the National Level:

Livelihood analysis indicates the way in which the farmers belonging different category of wealth make their livelihood including the crisis management. (Sabarathnam 2000) Viswanathan*et al* (2002) informed that fisheries in developing countries are under intense pressure from increasing coastal populations, over exploitation of resources and conflicts over access to degraded livelihood resources.This is one of the techniques of Participatory Rural Appraisal (Bhat,2003) for an expeditious analysis of the rural situation to plan and act. Livelihood analysis of coastal fisherfolk in any region is inevitable for the appropriate micro enterprise selection for the location for empowerment. (Kurien, 2003). Similarly several micro and macro level socioeconomic studies had been conducted by various agencies and research workers in different regions of our country on the livelihood problems of fisherfolk. (Srinath 1987; Sathiadhas and Panikkar,1988; Aujimangkul*et al*, 2000). The generalized objectives of such socio-economic studies stress on the assessment of human resources of identified geographical location, features of the target groups of specific developmental programmes, poverty, hunger, mal-nutrition and health status of fisher households, impact of introduction of new technologies and practices on income and employment, alternate fishing strategies and mariculture practices, infrastructure facilities and potential for development, rural indebtedness and supply of credit by various agencies, inter and intra structural conflicts in harvesting and post harvesting activities of marine fisheries, role of women in small scale fisheries sector, feedback information from the field to revise the strategy or devise to follow up action etc. Gender based studies and impact microfinance and SHGs also gained significance to a great extent in the present topic of discussion. (Vipinkumar et al, 2013)

A short glimpse of reviews in the International Level :

Livelihoods are attracting increasing attention in the context of Community Based Coastal Resource Management (CBCRM). The livelihood analysis encompasses all the strategies and assets that individuals and households use to earn a living (DFID, 2001; CBCRM Resource Center, 2003; Graham and Tanyang, 2001; Arciaga*et a*l, 2002; Ashby, 2003). This definition is extremely broad, and its implications and local understanding of the term can only be understood through context specific participatory research and dialogue. There are three specific areas where livelihoods connect directly with CBCRM initiatives and all have relevance. First of all, from a livelihoods perspective, natural resource use by an individual or a group of people is part of their livelihood strategy. “A reversal of environmental degradation require new livelihood options that change people's incentives, in particular the benefits and costs of resource use" (Ashby, 2003; p2). Many livelihoods in coastal communities are based on the sea, therefore resource management activities, such as those commonly carried out through CBCRM initiatives, are livelihoods activities that reduce local vulnerability and enhance natural capital (Graham and Tanyang, 2001; Arciaga*et a*l, 2002, Vipinkumar*et al,*2015, 2017).

Some general observations in Fisheries sector

Generally in fisheries sector, because of the lack of saving tendency, whatever the fisherfolk earn are being spent. Nothing is generally left for tomorrow. Entire family may starve unless he goes for fishing. While becoming sick, they may depend on private moneylenders for sustenance, food and medicine. If he falls in the trap of huge interest, the major potion of his earnings will be for paying interests. If the repayment is obstructed, the interest amount will grow bigger than the amount borrowed. The debt may transfer to the subsequent generations also. The formal financial organsiations and banks are even at present unapproachable to these poor fisherfolk.It is not due to lack of interest that the fisherfolk don't save anything, but it is the lack of opportunity to save, which becomes the major obstacle preventing them from saving something. Even if they are interested in savings, there are a lot of obstacles to deposit in banks. For opening an account, another person possessing account in the bank has to introduce. Photographs and identity documents are required. Similarly, he has to remit a fixed amount to open an account. In addition to this, he has to forgo / sacrifice one day's labour for this purpose. Here comes the relevance of Self Help Groups.

Relevance of Community Cohesion and Self Help Groups

There are a couple of differences between savings and thrift. Savings is the balance amount from expenses out of total earnings. But for the poor income groups, expenses are more than earnings. Therefore, savings will be meager. Thrift is just like an item of expenditure compulsorily kept aside for future use and is not the balance from earnings. This is strictly kept apart. In olden era, a handful of rice kept apart every day when gets accumulated was being used during off seasons for sustenance. Thrift is just like that. A few women fisherfolk when mobilized as a group, members can contribute the fixed nominal amount as thrift in every week in the group meetings. This collective amount can be deposited in banks as joint account the very next day. Slowly this thrift amount gets grown to a considerably big amount Say for example, 25 members in an SHG when collect Rs 20/- each every week as thrift, it becomes Rs 500/- in the first week. It will be Rs 2,000/- in the first month and Rs 12,000/- within 6 months. As the thrift collection regulates the judicious spending habit among members, economic discipline in the SHG will be easily feasible. After 6 months of initiating the thrift collection, the members for the Self Help Groups can be given loan for their emergency expenditure at a nominal interest rate. The members themselves can decide the norms for the credit. Since the SHG members are known to each other, the needs can be prioritized as per their importance / significance and it meets the essential requirements of the members throughout 24 hours just like an informal bank in front of their house. The members will decide the duration of loans and interest particulars. By solving the problems of the SHG members on group basis the skills and ability of the members in handling financial matters get enhanced and the group slowly gets led to Self Helping Stage.

For undertaking some income generation activities for the members, a suitable micro enterprise is to be found out for the Self Help Group and then SHG can be linked to other financial organizations like NABARD, *Rashtriya MahilaGhosh*, other banks etc for availing better credit facilities. The savings of the SHG when gets deposited in formal banks, there commences the relationship with the financial organizations. Since the welfare of the SHG naturally becomes the responsibility of the banks also, they actively involve in further activities, growth and progress of the SHG. Banks give loan assistance without supporting documents to SHG and in turn the SHG gives it to the members.

An SHG which functions as thrift-credit group for a minimum period of 6 months, can avail double of the thrift amount as loan from well- established financial institutions, The increase in thrift amount and punctuality in repaying the loans make these SHGs' deserve multiple times of thrift amount as loan further based on the norms of the institution. There are a lot of other financial organizations giving loans to SHGs'.Experiences and observations indicate that, for a group to be developed as a Self Help Group, normally a period of 36 months (3 years) will be required. Within this gestation period when the group passes through three distinct phases, up to 4 months as the Formation Phase, up to 15 months as Stabilisation Phase, and up to 36 months as the Self Helping Phase, the group gets led to the stage of a flourishing Self Help Group as per the indications given by social research results on Self Help Groups.The fisheries Self Help Groups have to focus attention on joint efforts co-operatively for finding out suitable micro enterprises, which can assure a constant income for the fisherfolk, based on locally available resources for poverty eradication.

What is a micro enterprise ?

A micro enterprise is an activity which requires less capital, less manpower, local raw materials and local market. It is an individual enterprise whether known or unknown. (Vedachalam,1998).In fisheries sector, for the upliftment of fisherfolk below the poverty line, some successful micro enterprises developed based on the location specific resource availability and experience and some alternate avocations and subsidiary entrepreneurial ventures successfully being undertaken by Self Help Groups in coastal sectors and allied areas as follows :

Value added fish producing units, Dry fish unit, Fish Processing unit, Ready to eat fish products, ready to cook fish products, Ornamental fish culture, Mussel culture, Edible oyster culture, Clam collection etc. are very important.In agricultural sector, Vegetable cultivation, Ornamental gardening, Floriculture, Kitchen Garden, Orchards, Fruit products, Fruit processing, Sericulture, Mushroom cultivation, Medicinal Plants, Vermi compost, Snacks units, Catering Units, Bakery Units, Cereal Pulverizing units are some micro enterprises undertaken by Self Help Groups.

Based on the resource availability and circumstances the micro enterprises those the SHGs' can generally bring to practical utility in allied sectors are Wood work units, Stone work units, Soap units, Garment units, Computer centre, Poultry centre, Cattle rearing, Piggery unit, Bee Units, Stitching units, Hand Weaving Units, Candles, Chalks, Umbrella units, Foam Bed Units, Bamboo based handicrafts, Paper cover, Scrape selling, Vegetable seeds, Marriage bureau, Medicine collection, Patients service, Real estate, Medicine processing, Direct marketing, Coir Brush, Plastic weaving, Second sails, Meat *masala*, *Rasam* powder, Curry powder, Pickle powder, *Sambar*powder, Consumer service centres, Home delivery package, Repacking business, Cleaning powder, Phenol lotion, Liquid soap, Washing soap, Toilet soap, Kids' garments, Toffee & Sweets, Photostat, Washing powder of best quality and medium type, Emery powder, Domestic animals, Nursery plants, Note book, Book binding, Rubber slipper production, Pillow cushion, Incense stick production, Cloth whiteners, Eucalyptus oil, Dolls, Hand shampoo, Soap shampoo, detergent shampoo, Jackfruit jam, Chips, Hotel, Catering service, Grape wine, Pineapple wine, Soft drinks, Chicken farming, Dried mango wafer, Dried chilli, Gooseberry wine, Ginger wine, *Pappads*, Tomato sauce, Day care centre, Coconut water vinegar, Syrups, Artificial vinegar, Mixed fruit jam, Milk chocolate, Tomato squash, Gum production, Cleaning lotion, Soft drink shop, Reading room, Private tuition, Counseling-guidance, Rent sales, Paying Guest service, Repairing centre and handicrafts are some of the employment opportunities that the SHGs' can venture throughout Kerala depending on the suitability of situations and availability of resources.

The suitability of the enterprise varies from situation to situation. The essential features for the success of a viable micro enterprise are :

1. The availability of sufficient quantity of raw materials locally.
2. The identified enterprise is known or easy to learn and practice.
3. The cost of production must be low.
4. The products must be of very good quality.
5. The availability of market for the products.

The important financial organizations giving financial assistance to SHGs' are Khadi Village Industries Board, Department of Commerce & Industry, *JawaharRosgar Yojana*, Women Industrial Cooperative Societies, Kerala State Social Welfare Advisory Board, Kerala Financial Corporation, National bank of Agriculture and Rural Development, District Rural Development Agency, Other Non Government Organizations, *Kudumbasreeayalkoottam*groups etc.

A case study undertaken on preference of fisherfolk by ranking of priorities forsome selected viable micro enterprises in fisheries, agricultural and allied sectors in Milkatkar and Navgav locations of Alibag district in Maharashtraare presented Table 1. Technology status and technology needs were prioritized and ranking of priorities based on the Rank Based Quotient (RBQ) on fishery based micro enterprises was in the order as Preparation of value added products, fish processing, dry fish products, mussel culture, ready to eat & ready to cook fish products, ornamental fish culture, and edible oyster culture. With regard to Agriculture based micro enterprises the ranking was in the order of Kitchen garden, Vegetable Cultivation, Planting mangroves and acacia trees, Catering units, Cereal Pulverizing units, Ornamental Gardening enterprise etc. With regard to allied sector micro enterprises, the ranking was in the order of Cattle unit, Poultry unit, Bamboo based handicrafts, Wood – Stone carpentry, Computer centre, Candle unit, Chalk Unit, Umbrella Unit etc.

Table 1 : Ranking for priorities of women fisherfolk for the technology needs/ micro enterprises in fisheries sector based on the suitability of location

No	Fishery based micro enterprise	Rank
1.	Preparation of Value Added products in Fisheries	I
2.	Preparation of Dry Fish products	III
3.	Fish Processing Unit	II
4.	Ready to eat fish products	V
5.	Ready to cook fish products	VI
6.	Ornamental Fish culture enterprise	VII
7.	Mussel culture	IV
8.	Clam collection	IX
9.	Edible oyster culture	VIII
10.	Pearl culture	XII
11.	Mud Crab culture	XI
12.	Any other	-
	Agriculture based micro enterprise	
1.	Vegetable cultivation	II
2.	Ornamental Gardening enterprise	VI
3.	Floriculture	VII
4.	Kitchen garden	I
5.	Orchards	XII
6.	Fruit products	VIII
7.	Fruit Processing	X
8.	Snacks bar	IX
9.	Catering Unit	IV
10.	Bakery Unit	XI
11.	Cereal Pulverizing Unit	V
12.	Sericulture Unit	XIII
13.	Any other : Planting mangroves & acacia trees	III
	Allied sector micro enterprises	
1.	Soap unit	X
2.	Clothes unit	XI

3.	Garments	XII
4.	Wood – Stone carpentry	IV
5.	Computer centre	V
6.	Cattle unit	I
7.	Poultry unit	II
8.	Hand weaving	XIII
9.	Candle unit	VI
10.	Chalk Unit	VII
11.	Umbrella Unit	VIII
12.	Foam Bed Unit	IX
13.	Bamboo based handicrafts	III
14.	Firewood	XIV

Certain important facts will be revealed as the consequences of Coastal Zone Development when gets practically materialized through SHGs'.

- Since the empowered SHGs' assist the members by undertaking thrift-credit activities through own savings and loans from banks though suitable micro enterprises, they adequately earn and make the members capable to stand in their own legs.
- Since the problems faced by the members are being presented and resolved on consensus every week, in the SHG meetings, they become able to exist with extreme protection feeling and mental health built by wholeheartedness developed through this coordination.
- Women's savings have a profound influence on the family safety and set up. The self-confidence that they can also work for the welfare of their family can be built up through these Self Help Groups.
- Since the SHGs' meet every week, all the members get a very good grasp about the beneficiaries in the respective locality and thereby making the election process of beneficiaries very transparent.
- The beneficiaries can be persuaded to utilize the eligible benefits for the purposes for which those were intended.
- Self Help Groups created a remarkable change in the social responsibility feelings for the fisherfolk. The incidents in which certain women SHGs' significantly contributed to the disaster relief funds are the clear-cut examples of the transformations created by economic empowerment.
- Irrespective of the political / religious restrictions, the ways by which Self Help Groups started taking lead role in cultural activities like celebrating special days, organizing common action programmes with involvement of cultural leaders, conducting arts and games competitions and literacy classes etc. are the examples of social responsibilities of Self Help Groups.
- These SHGs' as the symbol of 'collective cooperation' can function as an informal bank in front of home, a genuine friend in emergencies, a protector from exorbitant interest for loans etc.

- Based on the thrift deposits generated by an SHG, constituted with exact norms and standards, clear cut rules and regulations, the fisherfolk can come forward to identify suitable income deriving micro enterprises with the effective utilization of loans available from banks and other financial institutions and thereby escape from the 'permanent debt trap' for ever.

From the light of experiences, it can be stated undoubtedly that, by solving common problems of coastal sector such as literacy, drinking water, lack of health and sanitation, housing/ shelter with extreme cooperation and commitment, the fisherfolk can improve the 'local economy' of the SHG and progress towards prosperity through empowerment of SHGs' based on participation.

Impact on Gender & SHG based fishery enterprises for livelihood security in Coastal India

Similarly in another research study on Gender mainstreaming and impact of SHGs emphasized on selected 750 'Self Help Groups' in Gender mainstreaming in marine fisheries sector, an assessment of the level of performance and extent of empowerment through appropriate indices of measurement from 25 nos. of fishery based micro enterprises from Kerala, Karnataka, Tamil Nadu, Andhra Pradesh and Odisha was undertaken. In this study, identified the relevant fishery based and allied sector micro enterprises catering to the location specific needs of the SHG members and imparted 45 Entrepreneurial Capacity Building (ECB)Training programmes on the identified micro enterprises by appropriate HRD intervention programmes and organized 120 fisherfolk interaction meets. Data were gathered with standardized protocols, scales and indices developed in Mararikkulam, Thannermukkam, Kumarakom, Vadakkekkara, Vallikkunnu and Kasaba in Kerala, Bengare, Surathkal and Ullala villages of Dakshina Kannada district in Karnataka and Pampan, Rameswaram, Thankachimadam and Mandapam locations in Tamil Nadu and Arakuda and Astaranga villages in Puri district of Odisha for standardization.In Andhra Pradesh, farmer interaction meets and video documentation were conducted for women SHGs of Bandarvanipetta of Sreekakulam district, Chinthappaly of Vijayanagaram district and Pudimadakka, Lawson's bay and Jalaripetta of Visakhapatnam district assessed the impact of SHGs.Documented 200 success cases on ECB of SHGs with special reference to gender perspective. Brought out 20 movies as Gender Mainstreaming series on Impact of SHGs, (Table 2) one book on, Gender Mainstreaming and Impact of SHGs in Marine Fisheries Sector and one Interactive Multimedia on Gender Mainstreaming and SHGs: A cyber extension package.

Table 2: Fishery based Enterprises and details of SHGs covered

Sl. No	Enterprise	Number of SHGs	Avg. Level of Performance	Avg. Empowerment Index
1	Fertifish unit	15	72.75	0.82

2	Chinese dip net	10	79.16	0.89
3	Aqua-tourism	8	78.92	0.88
4	Fish Aggregating Devices	10	79.95	0.89
5	Hand picking fishing unit	15	50.11	0.65
6	Clam processing	75	56.33	0.67
7	Pickling unit	75	72.26	0.83
8	Fish drying	60	69.95	0.78
9	Dry fish & fresh fish procuring	45	79.53	0.87
10	Fish vending /selling	70	69.16	0.78
11	Mussel culture	50	75.95	0.84
12	Prawn culture	30	59.61	0.69
13	Quarry fish culture	16	78.75	0.89
14	Cage farming	27	72.23	0.82
15	Ornamental fish culture	49	63.5	0.74
16	Fish culture	30	65.5	0.76
17	Paddy cum fish culture	30	74.91	0.83
18	Seaweed farming	30	77.63	0.86
19	Fish Amino units	10	75.35	0.84
20	Ready to Eat Fish Products	15	74.36	0.83
21	Ready to Cook Fish Products	20	71.35	0.81
22	Crab Processing	15	68.34	0.77
23	Aquaponics	5	70.21	0.61
24	Bivalve collection	30	69.16	0.77
25	Fish feed production	10	59.25	0.61

Whatever the enterprise may be, the selection or identification of the fishery based micro enterprise is the crucial and major deciding factor according the technical viability and economic feasibility. It varies from time to time, from place to place, from situation to situation and from occasion to occasion. The economic feasibility analysis of these enterprises representing the indicative economics such as profitability, B:C ratio, Market Potential, Break Even Point, Pay Back Period etc. have been worked out through Business Plans developed under the project and these business plans can be used as a practical manual for implementing the appropriate fishery microenterprise based on the scope and opportunities. (Vipinkumar*et al*, 2017) This paper is a pertinent effort to make an overview of some viable micro enterprises through community participation and Self Help Group mobilization for rural livelihood enhancement, particularly in the fisheries sector and an analysis of livelihood options of fisherfolk. Paper also focuses on rural mobilisation through Self Help Groups as an inevitable requisite for poverty eradication in a developing country like India. How a meticulously mobilized SHG with an appropriate micro enterprise in fisheries, agricultural or allied sectors can progress towards prosperity within a short span of time is also depicted. A study undertaken on livelihood analysis showed the priorities on fishery based, agri-based and allied sector based micro enterprises based on the preferential ranking as per suitability. These prioritized micro-enterprises identified based on the suitability of the SHG through livelihood analysis in turn can bring about a desirable impact on technological empowerment in the coastal fisheries sector to a great extent.

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Chapter 23

Co -Governance for Responsible Fisheries

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"An unexamined fishery is not worth fishing"
-Ramachandran,et al 2020

This lecture shares our thoughts, some still evolving,on the Why and How of Co-governance as a means towards achieving Responsible Fisheries.We have depended on the findings fromvarious studiesconducted in Tamil Nadu and Kerala, two major maritime states in India.Experiences and learnings from elsewhere also are used in forming our insights. After introducing the concept of Responsible fisheries,we discuss the role of the state and non-state actors in its praxis which we call Co-Governance. We acknowledge the global community of fisheries scholars for the innumerable publications made freely available through Google. And of course our fisher "professor" friends, with whom we have been interacting for the last two decades.

Responsible Fisheries (RF)

The concept of Responsible Fisheries can be considered as a set of guidelines for ensuring sustainable utilization of fisheries resources of the world. In that sense, it is synonymous with the FAO Code of Conduct for Responsible Fisheries (CCRF). The Code is often referred to as the Holy Book of Global Fisheries Management.

The CCRF as an international policy instrument for fisheries management was developed and released by Food and Agriculture Organisation (FAO), functioning under the United Nations, on 31stOCTOBER 1995. The code was developed after a series of international deliberations that began in 1992. More than 160 countries, including India, are signatories to this international instrument. The Code is considered as a landmark document symbolizing the international consensus achieved on the necessity for providing guidelines to ensureensure sustainable and responsible fisheries governance and management**.**

The most salient feature of this global instrument is that it is **voluntary**in nature.

Foundations of the Code

That the sustainability of marine capture fisheries at the current level of harvesting is at stake is no longer a moot point. It is being realized that **fisheries, especially marine,**anywhere in the world is more a socioeconomic process with biological constraints than anything else. The **Open access /Common property nature of the resource** coupled with unregulated penetration of advanced, but not necessarily eco-friendly, harvesting technologies (a phenomenon called *technological creep*) has enacted a virtual "tragedy of the commons" in our seas. Making the issue still more complex, especially in the context of the Millennium Development Goals (MDG), is the rampant poverty existing among our fisher folk despite the fact that the capture fisheries makes significant foreign exchange contribution in many parts of the world. The plateauing of the resource as revealed by recent trends in landings doesn't augur well for the ecologic and economic sustainability of the marine fisheries sector.

The philosophy behind RF

If there are no technological magical bullets for the current impasse what is the way out? This is precisely the question the FAO code is trying to answer. "*The right to fish carries along with it anobligation to do it responsibly"* is the cardinal principle of the code. This principle is built on the foundation of what is known as a **Precautionary Approach.**

Precautionary approach, which originally was proposed as Principle 15 of Agenda 21 the Rio Earth Summit meeting in 1992, enunciates that
"*where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation*".

While in simple terms the precautionary approach means "**better safe than sorry**", it clearly recognizes that changes in fisheries systems are only slowly reversible, difficult to control, not well understood, and subject to changing environment and human values.

It involves the application of prudent foresight. It is about applying judicious and responsible fisheries management practices, based on sound scientific research and analysis done proactively rather than reactively to ensure the sustainability of fishery resources and associated ecosystems for the benefit of future as well as current generations.

Taking account of the uncertainties in fisheries systems and the need to take action on incomplete knowledge, it requires, *interalia:*

a. consideration of the needs of future generations and avoidance of changes that are not potentially reversible;

b. prior identification of undesirable outcomes and of measures that will avoid them or correct them promptly;

c. that any necessary corrective measures are initiated without delay, and that they should achieve their purpose promptly, on a timescale not exceeding two or three decades;

d. that where the likely impact of resource use is uncertain, priority should be given to conserving the productive capacity of the resource;

e. that harvesting and processing capacity should be commensurate with estimated sustainable levels of resource, and that increases in capacity should be further contained when resource productivity is highly uncertain;

f. all fishing activities must have prior management authorization and be subject to periodic review;
g. an established legal and institutional framework for fishery management, within which management plans that implement the above points are instituted for each fishery, and
h. appropriate placement of the burden of proof by adhering to the requirements above.

The **reversal of burden of proof** means that those hoping to exploit our marine resources must demonstrate that no ecologically significant long-term damage will result due to their action. Or in other words human actions are assumed to be harmful unless proven otherwise.

Contents of the Code

The code provides a necessary framework for national and international efforts to ensure sustainable exploitation of aquatic living resources in harmony with the environment. It is achieved through **12 articles** covering areas like

a) Nature and scope of the code (article 1)
b) Objectives of the code (article 2),
c) Relationship with other international instruments (article 3),
d) Implementation, monitoring and updating (article 4),
e) Special requirements of developing countries (article 5),
f) General principles (article 6),
g) Fisheries management (article 7),
h) Fishing operations (article 8),
i) Aquaculture development (article 9),
j) Integration of fisheries into coastal area management (article 10),
k) Post-harvest practices and trade (article 11), and
l) Fisheries research (article 12).

(The full text of the FAO CCRF (hereafter referred to as the Code) translated into Malayalam was published by CMFRI in 2002 under an agreement with the FAO (Ramachandran,2002). Thus, Malayalam became the second language, after Tamil, to have a translated version of the most important international fisheries management instrument. You can access it at www.cmfri.org.in. The pdf of the English full text, along with other major world languages, is freely available.)

Characteristics of the Code

As we have seen, the most salient feature of the code is that it is *voluntary* in nature. Unlike other international agreements like UNCLOS, or UN Agreement to Promote Compliance with International Conservation and Management Measures by Fishing vessels on the High Seas or the Straddling Stock Agreement,1995, it is not legally binding. That is, violation of the code cannot be challenged in a court of law.

A **fundamental objective** of the Code is "*to serve as an instrument of reference to help **states** to establish or to improve the legal and institutional framework required for the exercise of responsible fisheries and in the formulation and implementation of appropriate measures*." The policies of the state for managing the fisheries resources should be based on the provisions of the code.

Implementation of the code is primarily the responsibility of states. The code will require regional and sectoral implementation in order to address the particular needs of fisheries in different regions or sub-sectors.

Relevance of the Code

The most important problem a fishery faces is what is known as over fishing. It takes place over time as the fishing is intensified. It is the stage where a stock of fish loses its natural capacity to keep on providing the Maximum Sustainable Yield (MSY). It is at this stage that the fishery is at the verge of an almost irredeemable loss, economically and biologically. MSY is like a *Rubicon* or *LaxmanRekha*. The most frightening aspect about this *LaxmanRekha* is that we need to cross it to realize that we have trespassed it. Hence we can build our defence against the spectre of overfishing only on the basis of a stronger understanding and contextual analysis of its symptoms. Will Indian waters also witness collapses like that of the Canadian Cod? That such a tragedy has not happened so far is not a guarantee that it will not happen here. But we have a better sense of optimism thanks to the resilience of our marine ecosystem which is mainly due to the rich biodiversity. However, we need to be concerned if recent events like pelagic fatigue in Kerala are of any indication. The decline experienced by our fishers vouch for a serious rethinking on our laid back attitude. Our fishers also share the veracity of different ways in which symptoms of overfishing are being manifested. They are:

a) severe decline or total absence in those fish which used to be abundant,

b) decline in the size range of major species ,

c) excessive catch of juveniles,

d) increase in fishing time and distance,

e) frequent fluctuations in the total catch, and

f) changes in species composition.

Our Tool Box

There are five types of remedies for the disease called “over fishing”.

1. Based on the total catch of the fish (yield or Output)
2. Based on fishing effort or input
3. Based on time or season (temporal)
4. Based on space or depth (spatial)
5. Based on technical things

A typical example of the first type of remedies is the Quota system of fisheries management which is common in countries like EU, USA and Australia. This demands the assistance from a very precise stock assessment science. These measures which are similar to rationing of the catch, can be considered as the last ditch effort feasible in areas of lower species diversity that makes determination of MSY much less cumbersome. The second type of measures aims rationalizing the fleet size. Licensing based on an optimum fleet size is an example here. The next type of measures based on time and space is well known to us through the Monsoon Trawl Ban or seasonal ban. Other examples are Marine sanctuaries, and no- fishing zones. Technical measures include Mesh size regulations and Minimum legal size.

(For an overview of the status of the tool box (interpreted in a slightly different mode) in our context see, Shinoj and Ramachandran, 2017).

As long as a fishery remains a common property resource, a regulated fishery is more profitable than an unregulated fishery in the long run. Our fishers have started accepting this truism. But they are helpless to avoid competitive fishing due to two main reasons. One is the increase in fuel cost. And the other is the high demand for fish which has led to a situation where you are economically rewarded whatever meagre be the catch. So fishers tend to do indiscriminate fishing. This has resulted in an illusion of super abundance, which again drives more and more fishing effort. This is leading to a very dangerous situation. There are fishers (like Mr JossyPalliparambil,Munambam Kerala) who characterize this ugly scenario as a phase of "*Foolish Fishing*" (*Mandan fishing* in Malayalam language). It is high time each fisher take more care in analyzing the fluctuations observed in the economics of their operations.

The marine fisheries sector in India is currently going through a phase of socio-economic cum ecological turbulence. The rate of growth in marine fisheries production, as evidenced by recent studies, is plateauing, if not, declining. It is evident that the natural processes of rejuvenation have been imperilled. A major factor that endangers its sustainable utilization is the open access nature of marine resources and the veritable lack of an enforceable property rights regime or unanimously agreeable regulatory mechanisms

To engender an ethos of Responsible fisheries among the varied stakeholders concerted extension attempts are essential. According to the Article 6.16 of the FAO Code of Conduct for Responsible Fisheries promote *"States, recognising the paramount importance to fishers and fish-farmers of understanding the conservation and management of the fishery resources on which they depend, should* ***promote awareness of responsible fisheries through education and training.***It is obvious that communication is the key in this endeavour. Communication will be effective a) if the stakeholders themselves are involved in the designing of the tools and b) if the message is decided based on the information needs felt by the stakeholders. The best way to enhance the capacity for practicing responsible fisheries is by building upon the nascent /indigenous initiatives of the stakeholders themselves.

Capacity here denotes knowledge and skill needed to undertake the responsibilities of resource management by the community and other stakeholders. It is essential for the stakeholders (officials and the fishers) to become aware that their relationship is not a one-way-road, with one party being at the receiving end and the other being at the giving end, but rather an alliance of partners pursuing the same goal of strengthened local livelihoods through improved management of fisheries and other aquatic resources. The normal TOT paradigm of extension is perceived to be insufficient in this context and emphasis is being given to dialogues rather than dissemination of information.

It is also in this context that the actions and initiatives being taken by the Extension Scientists of CMFRI, become relevant. A Responsible Fisheries Extension Module (RFEM), which consists of 22 tools including a Malayalam translation of the code, animation films in all maritime languages etc. developed have been widely used to create awareness among the fisherfolk. A state-wide campaign on Responsible Fisheries was launched and the RFEM was released for further scaling up by the respective State Fisheries Departments. These mass communication tools have the potential to reach almost 85 % of the fisher folk and other stakeholders in the country. It is reasonable to conclude that CMFRI has made a pioneering initiative in the cause of popularization of the concept of Responsible Fisheries in India. Though the communication tools and strategies already developed by the institute have been useful in creating awareness on the need for sustainable /responsible fisheries there is a need to develop and scale up specific communication interventions to sensitize the stakeholders in making a transition towards ecosystem based approaches that ensure responsible management of our waters. Fisheries management is fisher management and participatory approaches informed/initiated by a proactive research system taking place in a democratic and decentralized civil society space is globally accepted as the key to Ecosystem Based Fisheries Management (EBFM). The future is decided by the capacity we build today amongst the different stakeholders responsible for sustainably utilizing the marine fisheries resources of our country.

Fisheries Management –different shades

As in many tropical developing countries, the fisheries management in India is often intertwined between formal and informal agreements (traditional systems), which are not easily observed.The ongoing development in fisheries has been accompanied by an almost equal increase in attempts to develop management strategies that help control fishing efforts (e.g. gear restrictions, catch limitations by setting quotas, closed seasons, etc.). These are aimed at the optimisation of yields and ensuring sustainable exploitation. However, in most cases the emphasis has been mainly on the single-species fisheries of northern temperate waters - as these have been impacted by industrial fishing firstly and most seriously. The situation in the tropics is however very different. Tropical coastal fisheries resources consist of highly diverse multispecies complexes, which are characterised by high levels of growth, natural mortality and turnover rates. A common feature of these resources is that they frequently exhibit maximum abundance in near-shore shallow waters (i.e. less than 50 m depth). This is very different from the situation prevailing in the northern temperate waters, where commercially viable fish abundance occurs down to a depth of one kilometre or more. Nevertheless, regardless of the variation existing in the nature of different fisheries around the world, management strategies developed for the northern temperate regions have been copied and transplanted to the tropical regions.

The fisheries scientists believe that fishing techniques using active gears such as bottom trawling scrape the sea floor, damaging bottom structure and the coral reefs. It destroys habitats, shelter and suitable breeding areas for the fish and disturbing the larvae and eggs.

Ostorm (1999) reported that common resource pools, like fisheries, managed by the community, which holds the right over decisions regarding the resource exploitation, is a much better option than open access, government and private ownership of the resource.

Co-management is the mechanism by which the state and user groups share responsibility for the formulation and implementation of management strategies. The idea is built on the assumption that when fishermen or their organizations are given a pro-active role in fisheries management i.e., when they get involved directly and formally in the management decision-making process, they develop more responsible attitudes towards resource use, and rule compliance. Resource users, as an informed community, are expected to take collective authority in this approach. But the trouble with this approach is that it is easier said than done. The success of this approach depends on a number of factors that function at different levels like supra-community, community and individual/ household level (Pomeroy *et al.,* 2001). The missing link often is community itself – a community in its fullest sociological sense (Jentoft, 2000).

In spite of the growth of India's fisheries sector, recent years have witnessed a drawback in fish production, with either levelling or declining catches, and the present state of fisheries in India is considered to be unsustainable. As is now commonly acknowledged, bottom trawling seriously damages the benthic environment and the species depending on it. Accordingly, fishing and fishery related activities have had, and are having, an enormous impact on the marine environment and its resources, and have presently reached a level at which we can speak of the serious depletion of global fish stocks.

In India, the third Five-Year plan shifted the focus from the **development of fisheries** to help the poor to increasing production for export. From 1980-92 an increase in mechanised boats of nearly 50 percent has been reported in Tamil Nadu. This attracted investments from areas other than the fishermen community. The investment was initially in export trade and processing, but later direct investments in boats and hiring of fishermen as the crew and for maintenance transformed it into a modern, export-oriented industry.

Pauly*et al.,* (2002) reported that throughout the 1950s and 60s, the enormous expansion of global fishing effort led to an increase in catches, initially well exceeding human population growth. For a while, it seemed that the marine resource was inexhaustible, and that launching new boats would automatically lead to higher catches.

The modernisation of Indian fisheries has contributed to the standardisation of fishing gear throughout the subcontinent, and the historical differences in gear and fishing techniques have given way to the recent division between artisanal and trawler fishermen . Entering into the prawn export trade was the turning point in the annals of fishing history in India, and is often referred to as the 'pink gold rush'. The tantalizing returns from exportable varieties encouraged the introduction of mechanised boats on a large scale. But this didn't stay long. According to many studies, the finfish and shrimp resources are in the stage of over exploitation. The reason for this can be attributed to increased fishing pressure, damaging effects of bottom trawling, disposal of industrial wastes and thermal pollution, pollution by heavy metals, discharge of untreated sewage, over fishing and port related activities; coral and sand mining can also be quoted.

The ensuing conflicts between traditional or artisanal non trawl operators and the mechanised or trawl operators snowballed into a serious law and order problem. Responding to the long struggles of the fishers the maritime states in India, especially Kerala, exercised their constitutional provisions in promulgating Marine Fisheries Regulation Acts in the early 1980s for their respective territorial waters. A major intervention,where Kerala took the lead, was the implementation of zonation and banning of the operation of trawlers during the monsoon season. The increasing clashes between the Andhra and Tamil Nadu fishermen along with CMFRI report pressured Tamil Nadu to enforce a uniform ban. Eventually Tamil Nadu implemented ban between 15 April- 29 May19 of every year and it was the last state to do so. The socio economic motives, rather than the scientific research regarding sustainability formed the basis for the choice of the length of the ban (45 days), as the fishermen cannot sustain their livelihood for any period longer than that.

The MTB or seasonal ban is the most diligently followed management measure in India. Apart from the strong support of the State machinery, the willingness of the fishers to accept the measure also played a significant role here. Along with the role played by scientifically informed civil society activism (that was in the forefront of fisher struggles) the existence of a community based ethos of conservation oriented concerns, built by indigenous non-state institutions might have augured well for this renewed commitment.

Non State Institutions

Non-State management institutions like traditional sea tenure systems, have received much attention and traction in recent times, thanks to the FisheriesDevelopment thinkers and social scientists who have made serious efforts to examine the management problems of small-scale fisheries. Social scientists argued that livelihood vulnerabilities and poverty of coastal communities resulted in management failures in small-scale fisheries.Another concern that repressed effective enforcement of management strategies in developing countries refers to the nature of fishery conflicts.They argue that the ecological and socio-economic issues of fisheries management have been the product of their integration into growing international markets. Hence modern management strategies should seriously weigh the influence of such external drivers seriously. Experts have explored in depth the nature of conflicts in the use of marine fisheries resources in both industrial and small-scale fisheries The role of traditional sea tenure systems for the management of artisanal fisheries in Sri Lanka has been detailed by Alexander (1977), Papua New Guinea by Adjaya (2000), Solomon island by Aswani (1999) and in Asia Pacific regions of Papua New Guinea and North Sulawesi, Indonesia by Cinner (2005). Adding to this, vast literature on community-based fisheries management, discussed the relevance of community-based co-management for the sustainable governance of coastal fisheries in Southeast Asia and Pacific Island Region .

The **FAO SSF guidelines** have provided a new impetus too in this direction. These institutions existing in many small-scale fisheries contexts of the world coordinate various actors and provide norms to resolve conflicting interests among contesting users to sustain livelihoods, economic returns and resource health.

Governance to Co-Governance initiatives

Our fisheries have undergone tremendous changes during the past six decades. Before the advent of modernization, (motorization, mechanization, refrigeration, export orientation and transportation) the access to sea was limited to a few skilful and adventurous community of people who were by birth fishers. The community could afford to have self -regulations oriented towards resource conservation which were arrived through the ecological experience of the community over generations. These concerns were institutionalized too. An example of such an institution still, surprisingly, surviving in Kerala is the *Kadakkody* of the Malabar coast (Ramachandran, 2006). The self regulations and community regulations which were rooted in the traditional wisdom have given way to technological skills. These skills, unleashed by what we generally refer to as an era modernization, most often take a dehumanized manifestation thus weakening the hold of the community. This is where the crucial role of the State comes into play in the management as well as development of the fishery. This is better known as fisheries governance. Fisheries governance is dependent on the particular stage of economic development and local ecological status of the fishery resources. This varies with each country. It is because of this contextual nature that the Code has been made as a voluntary tool. Each government is free to make its own rules, regulations and strategies based on the guidelines and principles elaborated in the Code. Thus article 4.3 says "FAO through its competent bodies, may revise the code, taking into account developments in fisheries as well as reports to COFI on the implementation of the Code. (But in recent times an argument against this position has also emerged).

There is now widespread scientific consensus on the ecological impacts of continued over-fishing and the threats to seafood security and broad agreement on policy issues such as curtailing illegal catches and minimizing the impacts of fishing on marine ecosystems. The basic requirement for adoption of Ecosystem Approach is a dynamic knowledge base on stock assessment. The stock assessment knowledge base generated and continuously maintained by CMFRI is a unique achievement among the developing tropical context countries.

There are many traditional institutions which directly or indirectly influence/address the resource management questions within the fisher folk community. The strength of these institutions is its embeddedness. They can be called as *sui generis* forms of co-management and can be used as very effective platforms for co-management interventions. (Ramchandran, 2004).There is an increasing realisation today that the inherent effectiveness of non state institutions can be better harvested if they act in a complimentary mode along with the active support and mutual recognition with the State institutions. This is Co-governance.

Engendering a scientifically informed fisheries management governance system is the need of the hour. As recent events like the Kochi Initiative (Ramachandran and Mohamed 2015) is of any indication, formation of multi stakeholder platforms of responsible fisheries co-governance is not an impossible task in our context. The response of the State in facilitating this transition is essential. With the landmark promulgation of insisting Minimum Legal Size for 55 species of fish by the Government of Kerala (GoK,2017) done based on the recommendation of CMFRI (Mohamed *et al*., 2014), the State of Kerala has shown an instance of proactive engagement with responsible fisheries governance which is worthy of emulation by other maritime states. It is,however, worth remembering that regulatory measures like MLS would become impotent in the absence of strong arm efforts to eliminate (or at least rationalize) external drivers like demand for the juveniles either for reduction or consumption. As scholars of regulatory politics argue, legislative coercion though necessary cannot be open to tendencies for inefficient rent seeking in a public good.

For a nice review of the functional institutions please see the paper BaijuKK *et al.*, 2019. The paper shows how local communities, with active support of non-governmental organizations (NGOs), shoulder responsibilities of management through mutual consultations and negotiations, ensure rational sharing of fisheries among various users, and resolve fishery conflicts and sustained local livelihoods.

Similarly there are a number of functional Non state institutions in Tamil Nadu. The local agreements or heterogeneous local management systems or voluntary responsible fisheries management which is followed in Tamil Nadu coast, for example, are: *Vembar*fishing village(time restriction, daily and yearly), *Tharuvaikulam*fishing village– (no trawling only passive gears), *Veerapandianpatnam* (mechanised boats do not operate for 5-6 months and time restriction, daily and yearly and spatial separation), *Tuticorin*fishing village (time restriction, daily and yearly), Palk Bay and Gulf of Mannar (GoM) region of Ramanathapuram District (three-four day rule)and Gulf of Mannar (GoM) region of Ramanathapuram District(self-regulation in seaweed collection). The most notable among them is the Three-Four Day rule.

Three-Four Day Rule

In the view of the major conflicts took place between mechanized fishing vessels, specifically those using trawlers, and the small-scalefishing vessels, the three-four day rule was implemented in the Palk Bay and Gulf of Mannar (GoM) region of Ramanathapuram District from 1993, based on the decision taken at a District Collectors' meeting. It allows mechanizedfishing vessels tofish for three days a week, while small-scale fishers couldfish on the remaining four days. The 'three-four day rule' system was initiated as part of district administrative orders to maintain law and order in the district, is one of the importantfishing regulations being implemented by district-level officers. Similar kind of rule was implemented during 1977 in the Pudukkottai and Thanjavur Districts. The decision was to implement different regulations for the northern and southern parts of the districts, and also in different seasons. The regulations for the northern part of the district, that is, Palk Bay, are strictly implemented by the District Directorate of fisheries officials, whereas in the case of theGoM, the regulations have been formulated by fishermen's organizations and boat owners' associations themselves, to avoid conflicts in thefishing grounds.

In addition, the Assistant Directors at the district levels are responsible for issuing tokens to mechanizedfishing vessels on a daily basis, before they venture into the sea. These tokens are also used to distribute subsidized fuel, to maintain law and order, and implement the three-four day rule. Mechanized fishing vessels are not allowed to venture into the sea without a token.

The noticed local agreements strive to provide solutions for the three characteristic problems arising in areas where mechanised and traditional fishing vessels exploit the same resource:

1. Mechanised boats often damage the fishing gear of traditional fishermen, causing financial loss to them;
2. Mechanised boats pose danger to the safety of the traditional fishermen: due to collisions between mechanised boats and country boats, traditional fishermen get injured; and
3. The expanded reach and undiscriminating nature of trawling downgrade the marine resources, lowering catch and income of the traditional fishermen and endangering sustainability of the resource.

In India, however, asBaiju*et al*(2020) observes,there exists a certain cynicism about the effectiveness of community-based organizations and institutions to manage small-scale marine fisheries. The predominant concern is that, relying on Indigenous institutions for resource management is not socially desirable due to the close affiliation of these informal institutions to traditional caste/religious networks. It is also believed that non-state institutions would become weak and even dissolve under the influence of globalization and growing international trade and market influences. (Nevertheless, a critique of the Co-Governance is expected as a moot point for the participants).

Concluding thoughts,,,,,,

Much has been said about rights-based fisheries, fisheries co-management and ecosystem-based fisheries management with fisheries managers, policy-makers, scientist and researchers racking their brains about the meaning of each of these fisheries management approaches. In trying to find definitions and formulating "how-to" guidelines and handbooks on such fisheries management approaches, their essential ingredient often is overlooked, namely dialogue. Creation of such democratic platforms need to be one of the area where the state should show its stewardship responsibility. The Kerala has recently shown the way in legislating a three tier Fisheries Management Council as per the reformed Kerala Marine Fisheries Management Act. With the formation of a separate Fisheries ministry at the centre it is expected that country wide governance systems will be in place soon.

Whether talking of co-management (or co-governance) and partnerships between fisheries stakeholders or of the adaptive nature of ecosystem-based fisheries management, the fundamental nature of any fisheries management effort is the communication process among its various protagonists.Neither a partnership between fishing communities, fisheries managers, researchers and other stakeholders, nor the merging of the development goals of human well-being with that of ecological well-being through an ecosystem-based fisheries management approach would be possible without free-flowing information among the various partners in the management/governance process. If the marine fish resource is to be sustained, livelihood-driven over capacity can no longer be taken as an alibi against taking precautionary approaches in fisheries governance. A strong State is a prerequisite here. Let there be governance first especially to quell the free-rider as well as free-choice problems, and co-governance would follow to bolster it as the stakeholder community will gradually learn to own the management responsibility.

In the wake of un-tameable external drivers like climate change, the role of the state is to bolster consensus-based, gender enabled, and conservation oriented fishing practices. To paraphrase Aristotle, "*an unexamined fishery (by the State) is not worth fishing*". And an informed community, ably supported by the State, is the best immunity against the "Tragedy of the Commons".

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Chapter 24

Enhancing Farm Income through Entrepreneurship Development in Fisheries Post harvest sector

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Introduction

Value addition means "any additional activity that in one way or another changes the nature of a product, adding to its value at the time of sale". It is the most talked about word in food processing industry, particularly in export oriented fish processing industry, because of the increased realisation of valuable foreign exchange. Of the fish destined for direct human consumption, the most important product form is live, fresh or chilled fish, with a share of 46.9 % in 2010, followed by frozen fish (29.3 %), prepared or preserved fish (14.0 %) and cured fish (9.8 %) (Anon.2012).Value can be added to fish and fishery products according to the requirements of different markets. These products range from live fish and shellfish to ready to serve convenience products. There is a great demand for seafood/seafood based products in ready to eat "convenience" forms. A number of such diverse products have already been available in the western markets. One of the factors responsible for such a situation is more and more women getting educated and taking up employment and not having much time for traditional cooking. Reasonably good expendable income, education, awareness and consciousness towards hygiene and health, increased emphasis on leisure pursuits, etc. are some of the other reasons.

Marketing of value added products is completely different from the traditional seafood trade. It is dynamic, sensitive, complex and very expensive. Market surveys, packaging and advertising are a few of the very important areas, which ultimately determine the successful marketing of a new product. Most of the market channels currently used are not suitable to trade value added products. A new appropriate channel would be the super market chains which procure directly from the source of supply of the products and control most of the components of production and supply chain like packaging, advertising and retail marketing. Appearance, packaging and display are all important factors leading to successful marketing of any new value added product. The retail pack must be clean, crisp and clear and make the contents appear attractive to the consumer. The consumer must be given confidence to experiment with a new product launched in the market. Packaging requirements change with product form, target group, market area, species used and so on. The packaging technology needs to be evolved which should be attractive, convenient and adding to the shelf life of the processed products (Gopal et al, 2015).

The Agri-Business Incubation (ABI) Centre and Zonal Technology Management Centre (ZTMC) established at ICAR-CIFT, Cochin supports operations on business projects as a measure of enhancing the foundation for new technology based industries and establishing a knowledge-based economy. It focuses on finding new ways of doing business in fisheries by finding doors to unexplored markets. ABI Centre helps prospective entrepreneurs, by providing pro-active and value-added business support in terms of technical consultancy, infrastructure facility, experts' guidance and training to develop technology based business ideas and establish sustainable enterprises. It acts as a platform for the speedy commercialization of the ICAR technologies, through an interfacing and networking mechanism between research institutions, industries and financial institutions. The Incubator at CIFT differs from traditional Business Incubators as it is tailored specifically for technology based industries and is operational at an area with a high concentration of fish production. This industry-specific incubator also allows new firms to tap into local knowledge and business networks that are already in place. ABI offers its services to industries not only in Cochin, but also all over India through virtual incubation. Beyond promoting business growth, the Centre aims to bring its benefits to all the fisheries communities in India.

Major Technologies in fisheries post-harvest sector are outlined below:
Processing Methods

The methods used for freshwater fish includes chilling, modified atmosphere packaging, active packaging, freezing, drying, thermal processing, drying and smoking. Major freshwater fish species which can be used for the production of coated products are Rainbow trout (*Oncorhynchus mykiss*), European eel (*Anguilla anguilla)*, Japanese eel (*Anguilla Japonica*), Milk fish (*Chanos chanos*), Channel catfish (*Ictalurus punctatus*), Nile tilapia (*Oreochromis niloticus*), Rohu (*Labeo rohita*), Catla (*Catla catla*), Mrigal (*Cirrhinus mrigala*), Common carp (*Cyprinus carpio*), Roach (*Rutilus rutilus*), etc. Prominent fresh water shellfish are scampi (*Macrobrachium rosenbergii*) and crayfish.

Live fish: Many fishes if sold in live condition fetch a much higher price than in the frozen or chilled forms especially in overseas markets. Hence, it is becoming a general practice to transport those varieties of fish and shellfish to the prospective markets in the live condition. They are also sold in the live condition in the super markets. Murrels are being transported in live condition in India to distant overseas markets. Fishes like channa,catfish etc. are preferred in live condition. In North Eastern States, carps are also fetching better price in live condition. Although fish are transported in live condition, it is essential to evolve much better technology to transport them to distant places and with full freshness to fetch better price.

Chilled fish: Chilled fish is another important value added item of international trade. Immediate chilling of fish ensures high quality products (Connel, 1995: Huss, 1995).Chilled fish fetches more price than frozen fish. . Indian major carps like, catla, mrigal and rohu packed in boxes in iced condition and exported. From Andhra Pradesh different species of fish is packed in boxes, transported to Calcutta and other major cities in trucks or by rail in chilled condition. Chilled storage life of fish depends on several factors such as composition, microbial contamination and the type of microflora present in the fish (Venugopal, 2006). Up to 35% yield of high value products can be expected from fish processed within 5 days of storage in ice, after which a progressive decrease in the utility was observed with increase in storage days and beyond 9 days of ice storage no high value products could be processed (Venugopal and Shahidi, 1998).

Vacuum packaging**:** In vacuum packaging, air inside the pack is removed completely and sealed immediately. This helps in reducing the oxidation in fatty foods and also reduces the growth of aerobic microorganisms thereby extending the shelf life considerably.

Modified atmospheric packaging (MAP): Modified atmospheric packaging is a process by which the shelf life of fish is increased by enclosing it in an atmosphere so modified that it slows down the degradation by microorganisms and development of oxidative rancidity. In practice fish/fish products are packed in an atmosphere of carbon dioxide and other gases like oxygen and nitrogen. MAP chilled fish has an extended shelf life of 10 days or more depending on the species. Different combinations of gases have been studied for extension of shelf life of fish in a modified atmosphere. Elevated carbon dioxide levels in MAP have been shown to inhibit the normal spoilage flora of seafood and double or triple the shelf life. Studies conducted at CIFT proved that a mixture of 80% carbon dioxide and 20% oxygen was more effective in extending the shelf life of *Catlacatla* fillets when stored at 0-4_0C. The shelf life was limited to 28 days using 80% carbon dioxide and 20% oxygen, 20 days in a mixture of 50% carbon dioxide and 50% oxygen compared to 12 days in air. Dressed and gutted pearl spot packed in 60% carbon dioxide and 40% oxygen had a shelf life of 11 days in air compared to 22 days in modified atmosphere packaging. Rohu fish fillets packed in 40% carbon dioxide, 30% oxygen and 30% nitrogen had a shelf life of 28 days in MAP compared to 18 days in air (Gopal,2009). MAP can be effective if used in conjunction with packaging materials of correct O_2/CO_2 permeability characteristics. Properties required may not be found in one polymer, hence laminated films or multilayer films are used.

Active packaging: Active packaging is defined as 'a type of packaging that changes the condition of the packaging and maintains these conditions throughout the storage period to extend shelf-life or to improve safety or sensory properties while maintaining the quality of packaged food' (Vermeiren et al. 1999). These systems can be classified into active scavenging systems (absorbers) and active releasing systems (emitters). Scavenging systems remove undesirable compounds such as oxygen, excessive water, ethylene, carbon dioxide, taints and other specific food compounds. Releasing systems actively add compounds to the packaged food such as carbon dioxide, water, antioxidants or preservatives. Most important active packaging components includes: O_2 and ethylene scavenging, CO_2 scavengers and emitters, moisture regulators, anti-microbial packaging, antioxidant release, release or adsorption of flavours and odours.

Oxygen scavengers is mainly used to prevent oxidative reactions, discolouration and mould growth. Different Oxygen scavengers are chosen depend on the amount of Oxygen to scavenge (pack size and material) and product water activity. Oxygen scavengers for high water activity foods react faster compared to scavengers for dry foods but in general the absorption is slow and exothermic. Work carried out at CIFT using O_2 scavenger, an extension of shelf life for about 10 days was achieved for catfish (*Pangasius sutchi*) steaks packed in EVOH pouches in chilled conditions.

In some cases, like meat and fish products, high CO_2 levels (10-80%) are desirable to extend the shelf-life. CO_2 has a inhibitory effect on bacterial growth. It is particularly effective against gram-negative, aerobic and psychrotrophic spoilage bacteria, such as pseudomonas sp. The commercial CO_2 emitters are based on either ferrous carbonate or a mixture of ascorbic acid and sodium bicarbonate. Studies conducted using salmon fillets with soluble gas stabilization technique with combined oxygen absorber and carbon dioxide emitter (Ageless G-100) indicate fast microbial growth stored in air without absorbers and slower growth rate using absorbers and emitter.

Frozen fish fillets**:** Many varieties of fresh water fishes like rainbow trout, shell fishes, catla, rohu, tilapia fillets can be frozen for domestic market and export to developed countries in block frozen and IQF forms. In the importing countries these fillets are mainly used for conversion into coated products. Fish fillets can also be used for the production of ready to serve value added products such as fish in sauce and fish salads.

Individually quick frozen products: IQF products fetch better price than conventional block frozen products. However, for the production of IQF products raw materials of very high quality needs to be used, as also the processing has to be carried out under strict hygienic conditions. The products have to be packed in attractive moisture-proof containers and stored at -30°C or below without fluctuation in storage temperature. Thermoform moulded trays have become accepted containers for IQF products in western countries. Utmost care is needed during the transportation of IQF products, as rise in temperature may cause surface melting of the individual pieces causing them to stick together forming lumps. Desiccation leading to weight loss and surface dehydration are other serious problems met with during storage of IQF products.*Some of the IQF products in demand are the following:* Prawn – Whole, peeled and deveined, cooked, headless shell-on, butterfly fan tail round. Fish fillets – Fillets of rohu, tilapia, catla, trout & catfish.

Battered and breaded products: Coated products viz., fish fingers, squid rings, cuttlefish balls, fish balls and prawn burgers form one of the major fish and shellfish based items of trade by the ASEAN countries (Chang et al., 1996).Battered and breaded seafood offers a convenience food valued widely by the consumer. Battered and breaded items are included in the value added products because the process of coating with batter and bread crumbs increases the bulk of the product thereby reducing the cost element. The pick-up of coating on any product can be increased either by adjusting the viscosity of batter or by repeating the process of battering and breading. As a convention 50% fish portion is expected in any coated product.

Ready to serve fish products in retortable pouch: Ready to serve fish products viz. curry products, in retortable pouches are a recent innovation in ready to serve fish products for local market. The most common retortable pouch consists of a 3 ply laminated material. Generally it is polyester/aluminium/cast polypropylene. Some of the products are rohu curry, prawn curry, mahaseer fish curry, prawn kurma and prawn Manchurian. These products have a shelf life of more than one year at room temperature. As there is increasing demand in the national and international markets for ready to serve products the retort pouch technology will have a good future. The technology for retort pouch processing of several varieties of ready to serve fish and fish products has been standardised at CIFT and this technology has been transferred successfully to few entrepreneurs in the country. The demand for these products is very good. Work carried out in Central Institute of Fisheries Technology has shown that different commercially important species viz., oil sardine, mackerel, seer fish prepared in curry medium and packed in retort pouches having composition polyester / aluminium foil / cast polypropylene remained in excellent condition for a period ranging from 18 to 36 months at ambient storage conditions (Ansar Ali et al., 2005; Ravishankar et al. 2002; Gopal et al., 2001).

Ready to eat combination meal in polypropylene trays: Ready to eat combination meal consisting of rohu fish curry and parboiled rice were developed using indigenous thermoformed polypropylene trays. In this, rohu and parboiled rice/tapioca were packed in separate trays and thermal processed to an F0 value of 8.0 min at 121^{0}C. The developed product had a shelf life of 15 months at ambient temperature.

Ready-to-eat fish-kure: CIFT has worked on the production of extruded products by incorporating fish mince with cereal flours. One such popular combination is the combination of Japanese threadfin bream (*Nemipterus japonicus*) mince with rice flour and Bengal gram flour. The product obtained is finally coated with Chaat masala to provide a mouth-watering snack that has been christened as “Fish Kure”.Similarly extruded fish products can be prepared from fresh water fish fillets frames and other low value fresh water fishes.

Fish Soup Powder: Soup powder prepared from different materials like vegetables, meat, egg, chicken etc. are very popular and widely consumed in different parts of the world. These are rich in constituents like protein, vitamins, fat and minerals. However, soup processed out of fish is not so common. Fish soup powder contains partially hydrolysed protein, carbohydrates, fat and several seasoning compounds including salt and is hygroscopic in nature. Fishes of low economic value can be used to prepare this product which will have good export as well as domestic markets.

Pickled products: Fish pickle makes use of the non-fatty variety of low cost fish having good meat content. Major ingredients are: fish, garlic, green chilly, ginger, chilly powder, turmeric powder, gingelly oil, salt, vinegar and sugar. The method of preparation of pickle is simple, the preservative being oil, salt and vinegar. The traditional packing is in glass bottles. Modern packing materials suitable for packing fish pickles have also been identified. Pouches and stand packs made of 12 micron polyester laminated with 118 micron LD/HD co-extruded film can be used for packing pickles.

Zonal Technology Management Centres of ICAR

The IP and technology management drive of ICAR has entrusted the Zonal Technology Management Centres (ZTMC) to establish a mechanism that accedes to the conditions of international standards and also to find ways for stimulating research, enabling access to technology and promoting enterprise growth, all for the ultimate benefit of the Indian farming community.

The main activities of ZTMC is targeted at the development and use of a Database System for management of intellectual assets, IPR protection, sensitization and capacity building, development of technology evaluation tools, formulation of model Business Plans/Project Reports and technology transfer/commercialization through business incubation. The Centre aims at protecting and translating the research results arising from the field of fisheries and other agricultural sectors into successful business ventures. It identifies new opportunities of business formation and helps the prospective entrepreneurs, by providing pro-active and value-added support in terms of technical consultancy, IP protection, infrastructure facility, business support services and training to develop technology based business enterprises.

ZTMC guides the member institutes under the zone to secure IPR protection of the research results, as per the Indian law and in conformity with the international agreements to which India is a signatory. It promotes transfer of these IPR enabled technologies, including finished processes, products, creations / works and other know-how, through commercial and public routes to farmers. The systematic management of IP assets have promoted commercial ethos in public sector research helping to transform agriculture from a predominantly subsistence mode to a globally competitive one. The Unit has the powers and flexibility to outsource for efficient execution of IP and commercialization matters.

The ZTMC established at ICAR - CIFT is one of the hubs for R&D information management in ICAR for South India. The Centre caters to the needs of following ICAR research institutions that are specialized in Fisheries sector.

- Central Institute of Fisheries Technology (CIFT), Cochin
- Central Institute of Brackishwater Aquaculture (CIBA), Chennai
- Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar
- Central Marine Fisheries Research Institute (CMFRI), Cochin
- Central Inland Fisheries Research Institute (CIFRI), Barrackpore

- Central Institute of Fisheries Education (CIFE), Mumbai
- National Bureau of Fish Genetic Resources (NBFGR), Lucknow
- Directorate on Coldwater Fisheries Research (DCFR), Bhimtal

Business Incubation Centre at CIFT

Fisheries sector with its important role played in the socio-economic development of the country has become a powerful income and employment generator, and stimulates the growth of a number of subsidiary small, medium and large scale industries. In order to translate the research results arising from the field of fisheries and other agricultural sectors, and to establish fisheries enterprises through IPR enabled technologies, ICAR set up an innovation based Agri-Business Incubation (ABI) Centre at ICAR - CIFT, Cochin. ABI supports operations on business projects as a measure of enhancing the foundation for new technology based industries and establishing a knowledge-based economy. It focuses on finding new ways of doing business in fisheries and allied agricultural fields by finding doors to unexplored markets. The Centre helps prospective entrepreneurs, by providing pro-active and value-added business support in terms of technical consultancy, infrastructure facility, experts' guidance and training to develop technology based business ideas and establish sustainable enterprises. It acts as a platform for the speedy commercialization of the ICAR technologies, through an interfacing and networking mechanism between research institutions, industries and financial institutions. The Incubator at CIFT differs from traditional Business Incubators as it is tailored specifically for technology based industries and is operational at an area with a high concentration of fish production. This industry-specific incubator also allows new firms to tap into local knowledge and business networks that are already in place. ABI offers their services to industries not only in Cochin, but also all over India through virtual incubation. Beyond promoting business growth, the Centre is also trying to bring its benefits to all the fisheries communities in India.

With the aim of transforming the incubator into a symbol of entrepreneurship and innovation, the ABI has created an environment for providing timely scientific and technical assistance and support required for establishment of technology based business ventures. The activities of the ABI focuses on finding creative and innovative ways for linking public sector resources and private sector initiatives within and across regional and national boundaries for promoting economic growth. The Centre uses the right expertise in relevant fields to identify and analyze the constraints and barriers hindering the growth of a business and devise appropriate strategies. It explores various structures and strategies to help small enterprises to grow and ensure a promising future in the global market. It fosters corporate and community collaborative efforts, while nurturing positive government-research-business relationships.

Process of Business Incubation

The Agri-Business Incubation (ABI) Centre targets entrepreneurs, from fledgling start-ups in need of basic small scale processing capacity to sophisticated businesses in need of R&D back up, office infrastructure and pilot / test market processing facility for the development of new products. It possesses good infrastructure facilities suitable for providing direct incubation to 9 entrepreneurs in a corporate environment within the premises of CIFT at a time. The purpose of direct incubation is to support emerging companies through their infancy. ABIapart from being a multi-tenant facility with on-site management that delivers an array of entrepreneurial services to clients operating with the facility, it also serves clients that are not located in the facility through virtual incubation or incubation without walls.

The Centre regularly conducts industry interface and technology promotional programmes for sensitization of entrepreneurs and to identify interested potential candidates for physical and virtual incubation. The Clients at ABIgets the privilege of meeting ICAR-CIFT officials directly, to discuss and finalise the strategies to be adopted to take the business forward. It is also the peer-to-peer relationships that develop within the incubator, that ensures the delivery of basic services such as how to actually incorporate a business; what are the legal issues; how to take intellectual property protection; how to do basic accounting and cash flow; how to do business presentations etc. Those kinds of skills are what are transmitted as part of the incubation process.

Client Selection

The process of client selection starts with the review of applications submitted by the Entrepreneur for becoming Business Incubator Client. The application must address the requirements described a prescribed format which includes executive summary, vision and focus, financial plan and economic impact of the proposed business. The application and the proposal will be first reviewed by the Principal Investigator of the Business Incubation Centre against the set criteria. During the second stage of the selection process, applications will be evaluated by a Joint Evaluation Committee. The committee reserves the right to request additional information from an applicant, or reject / accept an application. During the committee’s review, applicants will be required to make presentations of their proposals. Once selection procedures are completed, the Client can sign Memorandum of Understanding with CIFT, for availing the facilities and services of ABIfor a limited period of time on a payment basis.

The residency period for direct incubatees is normally for one year, extendable by another year in special cases, depending on the progress of business development. As the business venture becomes mature enough, the concessions and the facilities provided to the incubatee companies will be gradually withdrawn. Incubatee mentoring will continue in virtual mode after graduation on a case to case basis.

Services and facilities offered

The Incubation Centre provides shared physical workspace, management and technical assistance, access to financing and other supporting services to the incubating entrepreneurial firms. Incubation facilities under one roof are:

- Furnished office suites within the premises of CIFT, with shared facilities like secretarial assistance, computing, copying, conferencing, video conferencing, broadband internet and communication services.
- Pilot level production lines
- Culinary facility
- Modern laboratory facilities for product testing and quality control
- Physical and digital libraries

Pilot Level Production Lines

A state-of-the-art generic semi-commercial production facility is made available to incubating entrepreneurs for developing value added products from fish. ABIprovides access to these facilities along with support of manpower, and assists the entrepreneurs in production and testing of new product formulations. For the tenants, the pilot plant is an ideal testing arena to determine the commercial viability of new products. The plant also serves as a process lab, a place to see how processing equipment impacts food products under varying conditions.

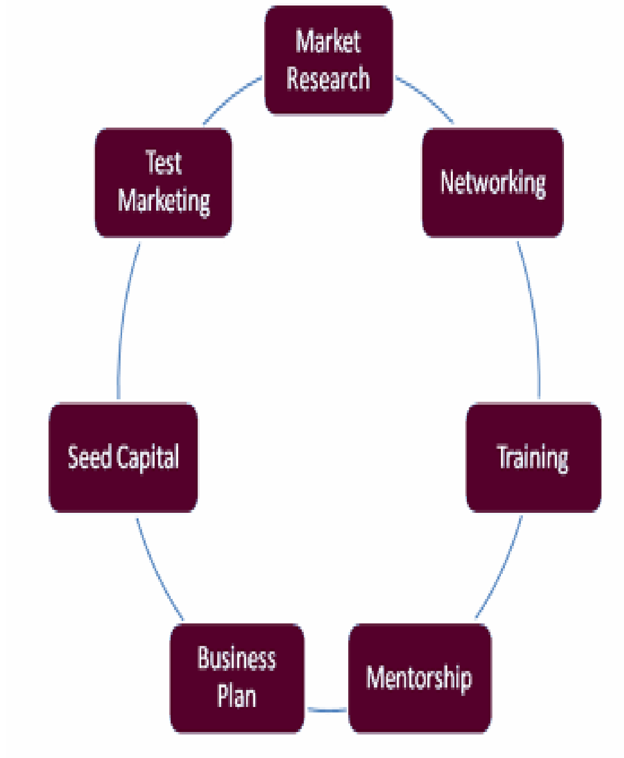
Various lines available with ABIfor entrepreneurs are listed below:

- Fish Pre-Processing line
- Retort Pouch Processing unit
- Fish Canning line
- Fish Sausage production line
- Fish extruded product line
- Fish Curing and Drying line
- Fish battering and breading line
- Fish product packing system line
- Chitin & Chitosan Production line

By providing access to these resources, the Centre greatly reduces one of the major barriers to the commercialization of institute technologies by smaller firms - the high capital cost of intermediate or large scale process equipment.

Business Services

The business oriented services offered by ABIinclude assistance in complying with business regulations, licensing procedures, financing, information services, marketing and tailor-made services designed for the various tenant enterprises. Incubator clients can also gain special advantage in terms of tax savings through special regulations for Business Incubators. ABIalso offers a wide variety of services, with the help of strong associations throughout the Business Incubation Network. Currently the services being offered as part of business development assistance are as follows:



Facilitation for financial assistance

The Zonal Technology Management Centre at CIFT facilitates the availability of loans with the aid of State Bank of India (SBI), Agri-Commercial Wing and provides direct access to financial schemes offered by Micro Small and Medium Enterprises (MSME) for gathering capital investment, company expansion and new product development. It also helps entrepreneurs in developing linkages with various venture funding agencies. ABIbeing a registered member of Indian STEP and Business Incubators Association (ISBA), the privileged tenants of incubator are entitled for getting tax exemption benefits as well as opportunity to attend the ISBA Annual conference, workshops, training programs etc.

Promotion of ICAR Technologies

The ZTMC, since its establishment at CIFT, has been responsive to the rapid transformation of innovation processes and business needs, and has been continuously trying to enhance the visibility of ICAR technologies through Business/ Industry Meets, Exhibitions, Industry Interface Programmes etc. This has helped in strengthening the public private partnerships and to bring together innovators involved in research and development, and entrepreneurs from the field of fisheries on to the same platform. Technology exhibitions are regularly organized, and entrepreneur-ready innovations and technologies developed by the ICAR Institutes specialized in fisheries and aquaculture are exhibited to the Industry. The areas addressed are seed production technologies of fish and shrimp, cost-effective and nutritious fish feed formulations, diagnostic and test kits, new and improved aquaculture methods, harvest and post harvest technologies, ready-to-cook / ready-to-serve products from fish, pharmaceutical and biotechnological products, and techniques for fisheries waste management.

Human Resource Development

Human resource development for the fisheries industry has been in the mandate of CIFT since its inception. Fish processing industry is a fast growing industry in our country as well as abroad, where there are immense opportunities for rightly trained professionals. CIFT has the right expertise and facilities to provide hands-on, application-based training courses such as HACCP concepts, HACCP Audit, Seafood Quality Assurance, Basic Food Hygiene, Food Processing and Preservation, Energy Efficient Harvesting Techniques, Boat Construction etc. Successful trainees have high potential for employment in India and various foreign countries including Middle East and South Africa. The ZTMC organises several awareness workshops, seminars, training programmes etc. for human resource development in the fisheries sector. The Unit also conducts capacity building programmes to help the incubatees build their competence in the areas of business practices, technology up scaling, networking and financing strategies.

Outcomes

- Transmitting benefits of developed technologies to the nation fast and effectively
- Distributed regional economic growth and national wealth creation through SMEs
- Creation of gender equity and economic independence to women through SHG clustering
- Reduced chances of failure for first generation entrepreneurs and consequent saving of national wealth
- Import reduction and enhanced national life style through introduction of innovative products and services
- Increased national savings through efficiency enhancement of industries
- Employment generation
- Enhanced build-up of human resources and national IPRs
- Encourage thrust towards solution driven research to benefit target groups
- Increased revenue to host Institute

Lessons Learned in Business Incubation and Way Forward

From the experience gained from the interaction with budding entrepreneurs, three primary reasons which create difficulty to the small and medium start-up businesses to remain competent have been identified. They are, lack of access to capital, lack of managerial skills, and the lack of knowledge about how to estimate their markets, gauge growth and potential business basics. Incubators are proved tools that can specifically address these three issues. High risk start-ups are instrumental in creating jobs, and business incubators play a role in making and leveraging the investments these entrepreneurs make. In a country like India, entrepreneurship is ubiquitous and is reflected in all the major dimensions of civilization *viz*. social, political and economic. With the initiation of economic reforms in early 1990s, India's business environment has witnessed considerable improvement. Domestic and foreign investors are finding it easier to do business after the reforms, which are aimed at reorientation of the centrally controlled economy to a market-oriented one in order to foster greater efficiency and growth. In spite of the global meltdown, Indian economy offers ample opportunities for business, both to the domestic and foreign entrepreneurs.

Conclusion

Amidst the changing paradigms and demanding global structure, India, in order to remain a frontrunner among developing nations, has primarily focused on the agriculture sector. The scope and level of protection of intellectual property rights (IPRs) has been increasing in the past few decades. The three tier IP management system is introduced in ICAR as an incentive for investing in research and development, creative activities, and for extending markets for technology and products. Among the various strategies to promote planned growth in this sector, focus was also given on promoting viable small and medium scale enterprises. However the Indian agricultural sector, despite its importance in industrialization strategy and immense potential for employment generation, confronts several problems in business development and management. In this context, business incubators which can help entrepreneurs turn their ideas into viable businesses and promote innovation, by providing business support services and resources have great scope and significance.

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Chapter 25

Cage culture – a livelihood opportunity for coastal women

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Like any other women, the coastal women also play a major role in household management. Management of food, childcare, education, health and even finance are mostly done by women. While these factors add pressure in the family chores, coastal women have realized that active fishing or related activities by men alone cannot support the family needs due to highly fluctuating earnings due to various reasons leading to uncertainty in capture fisheries. This realization has, necessitated mainstreaming of women to adopt profitable and sustainable alternative livelihood options. Even though micro-enterprises are a viable option for women, they often fail due to poor management and lack of skills. Involvement of coastal women in productive activities is an important strategy for poverty alleviation among the community and for overall empowerment. It is a known factor that any initiative involving women, designed with a right frame and implemented using a right approach can prove to be an important tool for social and political empowerment along with economic empowerment. With this hypothesis open water cage culture has been introduced in the coastal waters of Kerala and Karnataka for finding an alternative livelihood, additional income or as a mode of women empowerment through entrepreneurship. Empowerment of women is a multifaceted concept aimed at improving the living status as well as social status of women. Empowering women to become more financially autonomous has proven to be one of the most effective poverty alleviation tools. Coastal women, often restricted to childcare and household works, can greatly benefit from cage farming activities through income generation, protein availability and roles in economic decision-making.

In Countries of Africa and Asia, fish accounts for more than 50% of the total animal protein intake. Fish is highly nutritious by providing quality protein, essential fatty acids and micronutrients without of any type of anti-nutritional components in it. Marine fish supply vitamins, essential fatty acids, and micronutrients and minerals, including phosphorus, magnesium, selenium, and iodine. Even in small quantities, fish has a positive impact in improving the quality of dietary protein by complementing the essential amino acids that are often absent in vegetable-based diets. About 75% of the world fish catch is used for human consumption and about 80% of the coastal rural households catch fish for food or to sell, and people receive about 63% of their animal protein from fish. The demand for fish for food is expected to continue to grow in future.

In traditional fisheries women are not directly involved in fishing activities, either on account of the physical strain and the long hours away from home and family, or because of social taboos, customs, and beliefs which prohibit them from fishing; whereas, the role of women in fish farming, especially in small fish farms, has been proven successful in many countries. Involving women in fish farming can benefit with improved income, protein availability and with roles in economic decision-making. Owing to lower physical demands and proximity of the household to the water body, small-scale cage farming involving women has been gaining momentum in India.

Cage culture is an advanced technology that offers better opportunity for women to involve in fish farming. People living closer to any open water can do cage culture, provided the site is suitable for the same. Cage culture in coastal waters has been developed into an advanced and user-friendly technology that opened the door of opportunity for women to easily involve in fish culture. Open water cage farming is a good opportunity for coastal women in India. When male members of the family are away for jobs, women can look after small scale cage farms with 5-10 units of 4 m x 4 m cages. In cage farms, role of women ismainly to manage the feeding of fish, cage supervision, harvesting and marketing. Further in cage farming women can take part in various stages of farm development (planning, construction and actual operation), seed production to grow-out/rearing, harvesting, marketing or in post- harvest handling.

Increase in the participation rate and the skill of women in aquaculture/ cage culture, government institutionsand NGOs provide different types of training and financial facilities. In India involvement of womenin fish culture is quite satisfactory, Government organizations and NGO’s initiations havehelped a lot to increase women’s participation in fish culture and other fisheries activities.

Table 1: Average Economics of coastal cage farms in Kerala based on the data collected from 60 farmers (320 cage units): Average farm area115 m^3

Particulars	115 m^3	m^3
Fixed costs		
Cost of cage structure	191416.7	1659.0
Freezer & accessories	16133.3	139.8
Depreciation	49968.7	433.1
Interest on Fixed capital	24906.0	215.9
Annual Fixed cost	74875	649
Operational costs		
Seed	91168.8	790.2
Feed	233978.3	2027.9
Labour	64533.3	559.3
Other expenses	25916.7	224.6
Gross Revenue	990429.0	8584.1
Total operational cost	415597.1	3602.0
Total cost	490471.8	4250.9
Net profit	499957.2	4333.1

Table 2: Economics of cage farming: Composite culture Asian Sea bass with Pearlspot(CageDimension 4x4x3 m^3)

	Particulars	
I	**Capital Cost**	**(in Rs.lakhs)**
1	Cage frame (1.25 inch B glass pipe with ISI)	0.25
2	Mooring and Floats(8nos for each cage)	0.15
3	Nets	0.25
4	Freezer and accessories	0.2
	Total	**0.85**
5	Depreciation (20%)	0.17
6	Int. on FC(12%)	0.102
7	**Annual Fixed cost**	**0.27**
II	**Recurring expenses**	
8	1400 seabass seeds @ Rs. 30/seed	0.42
9	Pearlspot seed @500nos@Rs.15/seed	0.08

10	Nursery rearing (Hapa)	0.02
11	Feed(Trash fish/ floating feed)	1.0
12	Labour 2 hrs/day@Rs.100 for 8months	0.48
13	Harvesting and miscellaneous expenses	0.2
	Total cost	2.46
14	Production/ cage(kg)	2000
15	Gross revenue(@ Rs.300/ kg fish)	6.0
16	Net profit	3.54
17	NPV	6.57
18	BCR	1.62
19	IRR	72%

Note: Depreciation on cage frame and accessories were calculated using straight line method with an expected life of 5 years. The financial indicators such as NPV, BCR and IRR were calculated for a project period of 5 years at 15% discount rate.

Now there are so many aids for the self-employment programmes as well as agricultural programmes for the financial assistance along with a very good viable cage culture technology is available and many women groups as well as families are coming forward for fish culture in cages. Kerala is a state where traditional fish farming activity is a common practice and many women are involved in cage farming one way or other. As the cage culture technology has demonstrated as a new technology in many parts of the country coastal cage culture has attracted many women into it in the past few years.

The economics of cage farming has been worked out and is given in the tables 1& 2. Assessment of economic viability of cage farm units indicated that feed cost accounted 57.56% of the total cost followed by cost of seeds (16.53%). The gross revenue realised was 8306 USD with a net profit of 4397 USD. The investment generates an IRR of 68% with benefit -cost ratio of 1.38. Aswathy and Joseph (2019) reported an average production of 18 kg/m^3 with a stocking density of 32 fishes per m^3 with net benefit earnings ratio of 0.5 based on the data from fish farmers undertaking cages of various dimensions and diverse varieties of fishes in Kerala. Based on the economic viability indicators, small scale cage farming can be suggested for up-scaling in the coastal areas in Kerala for augmenting fish production and as a livelihood measure for women also.

It has been concluded that by following the successful models of cage farming adoption in Kerala, it can be implemented for livelihood enhancement in other developing countries also.

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Chapter 26

Streamlining Community Based Organizations for Climate –smart Agriculture

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Introduction

India being a tropical country with increasing dependence on natural resources, the chances of experiencing impact of climate change will be more. The Food and Agriculture Organization (FAO) expects that considerable efforts would be required to prepare developing countries to deal with climate-related impacts, particularly in agriculture (FAO 2007). At the country level, climate change refers to observable changes and permutations of temperature, rainfall and extreme climate events and their single or collective impacts on various agricultural production and harvesting activities (Concepcion, 2008). Compared to increase in temperature, climate disruption in terms of changes in variability in rainfall will be more difficult to react to and adapt (FAO, 2012). Ray *et al.* (2014) reported that most of the coastal areas suffer from excess water in monsoon season with attendant problem of prolonged deep water submergence having adverse effect on crop growth. In coastal states like Kerala having long coastal line, the problems of water logging and salinity are critical factors affecting agricultural productivity.

According to IPCC (2007), reduction of crop yields due to crop damage and crop failure, water logging of soils due to increased rainfall and flooding, increased livestock disease and mortality, and salinization of irrigation water can all be expected to affect the activities and productivity of smallholder farms. To reduce vulnerabilities due to climate change, Climate Smart Agriculture (CSA) involving identification of barriers to adoption and providing appropriate solutions (FAO, 2013) has to be adopted. Increasing diversity of production at farm and landscape level is an important way to improve the resilience of agricultural systems (FAO, 2010). For effectively streamlining such activities at grass root level, initial efforts can better be made for assessment and refinement of the technologies in a small scale, where local adaptations can be identified and standardized through farmer participation. Once the practices are standardized for their suitability to a particular location and also for the adaptability to climatic vagaries, it can be replicated at a regional level.

An attempt at a smaller scale was attempted with farmer participation by ICAR-Central Plantation Crops Research Institute, Kayamkulam in two FLD gardens in the southern coastal tracts of Kerala at Arattupuzha (Alappuzha district) and Alappad (Kollam District), where poor fertility status of the soil due to poor physical and chemical constraints of soil, water logging due to precipitation variation and salt water inundation were observed as major impediments to successful cultivation of coconut and year-round cultivation of many of the intercrops.

Methodology for technology assessment and refinement for standardization of *climate-smart* adaptations

Technology demonstration was undertaken in 1 Ha. each in both the places in a participatory mode with timely assessment of the practices and suitable refinements for climate resilience. The steps followed include:

- Introducing recommended technology package to the farmers.
- Selection of Technology options from the recommended technology package with farmer participation.
- Implementation of the selected technology options.
- Monitoring and evaluation of technologies coupled with analysis of vulnerability of small farmers to climate risks
- Farmer participatory identification of strategies and measures to enhance resilience of CBFS.
- Assessment of strengths and weaknesses of adaptation options.
- Identification of ways to further improve adaptive capacity based on experience, field testing for refinement and standardization of adaptation measures.

Successful experience of Participatory assessment and refinement for farm level climate Resilience

The rich experience of farmers under the demonstration programme paved a way in successfully refining the technologies to suit to the requirements of coastal farmers of South Kerala. To overcome the problems of water logging and salt water inundation, different intercrops like banana (4 varieties), pine apple, vegetables including cool season vegetables, tuber crops, fodder grass, ginger and turmeric were tested for their adaptability. Various intercrops were planted with and without husk burial in the planting pits/ application of coir pith compost under coastal sandy conditions and their performance were evaluated. Pine apple was found to be the most ideal crop to withstand water logging, yielding fruits on an average 1.0-1.75 kg . Banana varieties also performed well and bunches weighed on an average of 7 kg for *Nendran*, 13.5 kg for *Njalipoovan* and 22.5 kg for Robusta. All the tuber crops (except colocasia) were found to be affected by water logging. Among the vegetables, amaranthus, bitter gourd, cow pea, tomato, cauliflower and cabbage performed well. Cauliflower weighing up to two kg and cabbage up to 2.50 kg could be harvested. The farmers could get single plant yield up to 18 kg from bitter gourd and four kg from cow pea.

The yield of coconut also showed improvement up to 59% at Arattupuzha and 55% at Alappad. The net income from the coconut based cropping system varied from Rs.1.35 lakh to Rs.1.89 lakh.depending on the intensity of intercrops cultivated. Several farm level *climate smart* practices were adopted by the farmers to increase productivity and build resilience in the coastal tracts with climatic vagaries. A modified method of sideways placement of husk around the plant for pine apple showed better performance when compared to normal recommendation under water logged conditions. This has resulted in better growth, early bearing and higher fruit weight for pine apple (average 1.75 kg) compared to normal planted ones (average 1.00 kg). Other climate resilient measures adopted by farmers including shifting of planting time of tuber crops and banana and standardizing the age of banana suckers for planting were proved to be successful. Planting 4-5 months old suckers of Njalipoovan variety of banana during November-December was found to help tide over the water logging experienced during the early stages of bunch development. Earthing up with silt (150 kg/plant) along with application of 100g of Muriate of Potash/plant at the time of bunch emergence improved growth of plants. By this refinement, the farmers could save 100% of the plants from lodging and poor finger formation due to water logging.

Because of the coincidence of rainy season with growth period of most of the tuber crops, it was difficult for the farmers to raise them under normal planting time. By planting short duration varieties of tapioca like Vellayani Hraswa (5-6 months), Sree Jaya (7 months), and Sree Vijaya (6-7 months) and through advancement of planting time to October-November, the farmers could get a reasonable yield (average 3.2 kg/plant). In case of elephant foot yam and dioscorea, the farmers retained the previous year‟s crop in the field and obtained average yields of 6.3 kg from Dioscorea, 5.2 kg from Gajendra variety and 13.5 kg from Peerumedu Local variety of elephant foot yam.

Productivity improvements and climate resilient adaptations were found crucial for saving agriculture in such tracts and the reactive adaptation measures *viz*., modified method of husk burial for pine apple and banana, advancement of planting time, planting of 4-5 months old suckers and earthing up with silt, green manure, coir pith compost and husk for banana, planting of short duration varieties and advancement of planting time for tuber crops undertaken by few farmers were proved to be successful and sustainable to suit to the requirements of small farmers of the Southern coastal areas of Kerala.

How can farmers develop an adaptation strategy for wider level replication?

The adaptation practices identified under this work can further be modified to reduce the vulnerabilities and can be replicated at a wider level by scaling up the adaptation strategies and technologies through community based organizations, which can bridge the adaptation deficit at a regional level. To assist development workers in helping smallholder farmers, the Integrated Climate Risk Assessment Framework for Small Farmers (ICRAF) developed by Lasco et al. (2011) can be used.

ICRAF is a rapid appraisal tool best implemented by a team of interdisciplinary and inter-sectoral researchers, development workers and farmers. Several approaches can be used to generate and analyze information depending on available resources: focus group discussions, surveys, multi - sectoral workshops, review of literature, GIS mapping, and computer simulation.

Steps in Implementi ng ICRAF

The key steps to ICRAF are: adaptation deficit analysis, identification and prioritization of existing adaptive strategies, building capacity for adoption of identified strategies, planning and implementation of on-farm research along with monitoring. Details of the steps to be followed are:

Step 1: Trend analysis of climatic variables in the study areas.

Weather variables, mainly variability in rainfall events, maximum and minimum temperature will be analysed.

Step 2: Adaptation deficit analysis.

- Assess current risks and vulnerabilities of small farmers to climate risks related to variability in rainfall events, temperature and humidity on crops in terms of soil, land and water management practices, time line documentation of pest build up and disease incidence and agro-biodiversity in coconut based cropping systems in the study locations.
- Document local adaptation strategies / agro-ecological practices for enhancing resilience of small holder farming systems.
- Assess the strengths and weaknesses of current adaptation strategies.
- Determine if an adaptation deficit exists.

Step 3: Building adaptive capacity through CBOs.

Approach: Multi –stakeholder approach – Identify/develop sustainable agriculture strategies for enhancing resilience of the coconut based farming systems in coastal areas involving CBOs.

Key activities:

- Collection of current and historical weather data of the project areas from KAU Research Stations, ICAR institutes and IMD
- Agro-biodiversity conservation and utilization: (a) Identification, conservation and collective multiplication of seed varieties which can tolerate droughts, floods, salinity and pests and diseases so as to establish community seed banks for ensuring farmers' access to quality seeds at the right time. (b) Identification, conservation and utilization of the diverse microbial wealth.
- Identify / develop improved land, water and soil management practices such as (a) Improving soil organic matter, soil structure, soil nutrient replenishment, efficiency of nutrient uptake, water infiltration and water use efficiency (b) reducing soil erosion (c) on-farm water and soil conservation and (d) low-cost irrigation systems.
- Identification / development of climate smart management practices like altering planting time, ideal crops and crop varieties, modified planting techniques along with conservation agriculture (CA) including combination of reduced tillage, retention of crop residues / mulching or maintenance of cover crops, crop rotation and intercropping / crop diversification.
- To identify / develop agro-ecological practices like ecological engineering, trap cropping, management techniques utilizing low external inputs and chemicals, biological control measures etc. to manage shifting pest pressures and pathogens due to climate change.

- Diversification of farm and livelihood activities through mixed cropping or polycultures to mitigate risks from extreme weather-related events and other shocks.
- Prioritization of adaptation options by judges rating through multi-sectoral workshops
- Assess strengths and weaknesses (and costs and benefits) of the identified adaptation options.
- Assess future climate risks and what adaptation can be done now.

Step 4: On-farm research, monitoring and refinement of potential adaptation strategies.
This step involves validation of promising adaptation strategies and refinements.
Key activities:

- Developing Climate Resilient Model Farms (CRMFs) through on-farm research and experimentation on potential agro-ecological practices and adaptation strategies identified or developed at field level.
- Monitor and evaluate the strengths and weaknesses (and costs and benefits) of potential adaptation options.
- Assess future climate risks and plan adaptations for future.

Step 5. Knowledge management on climate smart agriculture
Key activities:

- Creating massive climate awareness through multi-sectoral workshops, campaigns, and exhibitions.
- Enhancing extension services on localized climate and weather information systems coupled with climate risk management through capacity building of extension personnel, farmers and local organizations, 'Climate Field Schools' and 'Climate Information Hubs'.
- Strengthening communication and outreach through mass media and ICTs.
- Strengthening CBOs and local institutions for promoting use of natural resources along with protection and management of natural vegetation and sacred groves.

All the above steps require the continued participation of the stakeholders involved along with other concerned community members. The adaptation strategies identified through Step 2 activities can be prepared and implemented, placing emphasis on the need to regularly monitor and evaluate the progress of implementation. Documentation of the individual experiences of farmers can help development and local government agencies to pick up on best practices which can in turn be recommended to other farmers. The final adaptations developed through on-farm research should be taken up at policy level so as to replicate at the state level as refined technological options in the changing climatic scenario. Extension efforts if focused in this line can build up confidence in the farmers of the coastal tract that there are viable adaptation options that can be implemented at low cost and/or with high benefit - cost ratios.

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Chapter 27

Improving Data Quality for effective Knowledge Management in Fisheries

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Background

Fisheries in general, marine fisheries in particular revolve around a resource which is natural mostly self propagating and self sustaining, which re eminently prone to vagaries of various anthropogenic and climatic factors. Though this the template of dynamics for other natural resources too, the challenge as regards fisheries lies in the proper adjudication of factors and their extent of influence. These efforts can be mind boggling mostly and are ever resilient due to the reason that the level of predictability is low even in medium term. Fisheries like other resources are depicted by an array of numbers, data, under standard frameworks. They can be easily juxtaposed with climatic, oceanographic and anthropogenic factors with similar granularity. But the challenge starts only then. To conceive the paradigms of influence of climatic factors on fisheries is totally different from the set of models which one would be toying with to link oceanographic causes. The cause-effect relation between anthropogenic effects, mainly the fishing efforts, are totally distinct from the other two to zero in on a link function. Known modelling templates give way to lot of opportunity and challenges with respect to tweaking when it comes to explaining the phenomena exhibited by marine fisheries. The growth of the animals has two levels of enhancement, one at individual level and the second at a stock or group or niche level. These two enhancements involve intricate biologically unique set of processes like addition in biomass by increase in size, by recruitment and loss in biomass owing to various kinds of mortality and lack of food availability. Such processes are different at different stages of the animals, starting from egg, larval to juvenile before recruitment into the fishery and then as adult and then as gravid animals. All these stages are affected by various factors of biotic and abiotic in nature and also get overwhelmingly impacted by single dominant threshold factors too. To complete the complexity of the intricate dynamics a shrouding pall of thick sheet of water envelops the whole set of dynamics, which makes palpable information near impossible. Analysing the second stage, treating the geo-spatial area stock as the limiting factor and treating similar animals (same species) as a bunch of self sustaining yet competing individuals, the factors like intrinsic rate of growth in numbers of the species in the stock and the spatial limitation of the defining habitat are used as the deciding factors of getting a palpable assessment of the strength of the resource's presence. As one can easily understand this type of postulation is never complete as many extraneous factors that either limit the spatial/ food availability by means of vying for the same base and those that define the primary productivity or the plankton availability of the zone under focus are possible additions to these models. To summarize the fisheries information dynamics gives less while taxing more as regards evolving into knowledge which is consistent and generic. So needless to say, knowledge management in such situations are a challenge of higher order and on the flip side are quite handy if successfully performed. In this discussion the focus would be on possibilities and issues of knowledge management (KM) in fisheries, mostly marine fisheries.

What is KM?

KM as its linguistic ramification leads to is about putting the organized information on any subject or resource to more proper utilization than mere summarization in such a way as to hidden paradigms emerge. Data mining too falls under this purview. Uncovering hidden patterns and relisting causes with the addition of latent ones form the basic tenets of this facet of knowledge management. But to understand this better the basic requirement would be a huge data pool of organized or unorganized in nature pertaining to any given subject or resource. Thus a collated platform of different types of measurable and processable data is the starting point for knowledge management. To cite Bruce Mathew et al (2014) KM represents a deliberate and systematic approach to ensure the full utilization of the organization‘s knowledge base, coupled with the potential of individual skills, competencies, thoughts, innovations, and ideas to create a more efficient and effective organization. Knowledge, simply put, is a collection of personalized view points pertaining to any subject. It is a sort of opinionated data base on any facet of the product or subject under review. Hence such knowledge can be tacit, which is intrinsic and demands more effort to be located, and explicit, which is a sort of ready to use type.Tacit knowledge if strong in its adaptability orientation while explicit knowledge is quite useful in its training and exhibiting orientation. Each has its own inherent strength and weakness, which when properly treated would lead to better utilization of the hybrid vigor. KM is managing the corporation's knowledge through a systematically and organizationally specified process for acquiring, organizing, sustaining, applying, sharing and renewing both the tacit and explicit knowledge of employeesto enhance organizational performance and create value (Davenport and Prusak, 2000).Knowledge management is about applying the collective knowledge of the entire workforce to achieve specific organizational goals. The aim of knowledge management is not necessarily to manage all knowledge, just the knowledge that is most important to the organization. It is about confirming that people have the knowledge they need, where they need it, when they need it – the right knowledge, in the right place, at the right time.

With this as background fishery managers and researchers can treat the accumulated wealth of information available as a starting point for KM. There are quite a few established tools in the realms of KM, which can be put to good use for zeroing in on the right and correct knowledge at the right occasion. The following case study elaborates the application of Rough Set Theory in predicting or assessing the factual dynamics of one of the most important marine fishery resources of South West India, Indian Oil Sardine, Sardinellalongiceps (Val.). It was carried out while mining four years of catch/ catch rates recorded at the landing centres of Kerala state of South Western Indian peninsula and factoring them alongside six climatic variants viz. Sea Surface Temperature, Relative Humidity, Atmospheric Temperature, Meridional wind, Sea Level Pressure and Total cloudiness. Using the local covering, rule mining and reducts, which are the analytical arms of Rough Set Theory, a significant subset of combination of attributes with discretised ranges was carved out from the plethora of combinations. The pre-processing of datasets was performed by using R and the analysis by ROSE2 (Rough Sets Data Explorer). In all 33 rules were churned out, which when explained turned out to be as simple as stating “if SST falls in the range 28.75956 to 28.92879, and SLP falls in the range 1007.252 -1008.006, then total catch will be in the range 2968.5 to 6763.9 tons”. Such “what if” scenarios can lead to better quality of knowledge and thus can aid inbetter management of fisheries.

Other tools to fish out tangible inference

Apart from these nonconventional means using argumentative alternatives by treating the datasets as totally unorganised array, there are tools to treat them as organised or semi organised array of smoothly behaving realisations of well defined populations. These are collectively referred to as data mining tools. The most prominent amongst them are Artificial Neural Networking (ANN), Decision trees (Chi Squared Automatic Interaction Depetector (CHAID)) etc. There are instances in fisheries domain where prediction of resource abundance has been attempted by popular engineering tools like wavelet theory and fuzzy regression. All these indicate the sufficiency of data wealth, however unorganised, they are which is why these many tools which are formal and quasi-formal are being applied for forecasting and decision making at various degrees of success. Another major branch of inferential analysis is the Bayesian mode of inference. With most of the sub processes in the life cycle of fish well identified the undercurrents can be modelled and those prior defined models can be incorporated to analyse the realised datasets with added efficiency. With the explosion in the computational prowess of an average researcher leapfrogging to astronomical proportions, the application of any sort of deductive tool gets too easy in terms of operationalisation.

Quality of data

Riding upon the wave of computational rigours and tools, the most unexpected challenge faced by a researcher is strangely bringing him back to basics. How good is the data? For once the data is available in a portable and scalable digital format a myriad of opportunities are listed in literature to treat them as formal numeric data, ordinal data or even nominal information with parametric and nonparametric treatments with the souls aim of arriving at an inference. But as it can be easily proven information is data deep. It can say more than what has been realised in numbers. But inference can be woven based on intrinsic and extraneous measures related to the information. But in the steady phase even that need proper updating to match the progress of time and its impact on systemic processes. Thus it becomes equally or rather more important to assure quality of data. This may sound odd in these days Internet of Things (IoT), but true it is. The groundswell is important but the aquifers are more important. In fisheries it is all the more sacrosanct. It can be seen by simple review of literature, that fishery inferences, especially on the population inference like biological reference points (BRP), which are managers’ gospel, keep fluctuating from time to time with impunity. One of the most famous BRP, Maximum Sustainable Yield (MSY) is the test case. Its variability is so unique and permanent that with stock, location and year it is destined to change. That which is supposed to help managers in taking a call on the future interventions to conserve and make the fishery sustainable, itself keep changing the goalposts. Probably less known in other fields.So precise and that too consistently precise data collection is the bedrock of such vital parameter computations. So any method which is immediately lapped up for being listed as a "data deficient situation tool" is wrought with lots of risks in fisheries. We may come across works publicizing themselves as simply catch based with no support of effort to have been measured parallelly with catch, need to be opted as last resort. For catch rates that too from unbiased cruises are the basic building blocks of any inference on the status of marine fishery resources. The only possible exemption permitted could be to consider commercial catches and landings instead of random cruises. Dilution of these any further will make the inference circumspect and management highly inefficient. So on a macro scale there is a minimum requirement of getting a correct measure of catch rate or quantity of a resource caught per unit effort or per boat is mandatory.

Sampling methods to improve data quality

After underlining the quality of basic data be it catch or effort or anything down the granularity as size spectrum of the resources etc., it is the prerogative of any planner to suggest ways and means of collecting such information. In marine fisheries by far the most efficient and successful method to estimate catch rate is to go for sampling of the fisheries process at various stages and collating the unbiased collection of datasets for further analysis and inference. As a classic situation we may consider the catch and effort estimation procedure being followed by Indian Council of Agricultural Research- Central Marine Fisheries Research Institute (ICAR-CMFRI) as detailed in Srinath et al.(2005) Here the fishing operation is treated as an incessant process occurring throughout the day for all the days in a year carried out by multiple types of crafts and gears, targeting a few commercial resources. Usually and sample survey plan would have properly defined populations and the attributes that are required to be estimated termed as parameters. They are estimated by statistics, which are realisations from the appropriate samples. As per statistical ethics, the sample must have the impartiality enshrined by means of application of randomness at some level. The other aspect of a proper sample is in its being the most representative of the population under consideration. So naturally when we attempt to measure catch/ landings and efforts in a fishery during a period the following define the population.

1. Geographic area/ zone
2. Duration/ period
3. Gear/ craft or a combination

And

4. the species/ resource under focus

As per ICAR-CMFRI methodology, which has won plaudits from FAO and other peer organisations, the population is defined as a zonal month for a particular gear and species. For example it could be the total landings/ effort expended for zone-1 (district equivalent) of Kerala state for the month of October, 2017 pertaining to Oil sardine using Ring net gear. Now once the population is defined the sampling frame needs to be listed unambiguously. As per the structure of fish landing centres/ harbours in India, a list of identified distinct and exhaustive list of such places are collated zone/ districtwise. The centres are then grouped into two to three homogenous classes based on the intensity and variety of fishing prevalent there called as strata. The calendar month is then divided into three sequences of ten days interregnum each to ensure that the lunar and sub-seasonal variations in fish availability get offset. Then as a basic first stage unit of a typical sample the landing centre- day is identified. It signifies a 24 hours period at a selected landing point of a given stratum. Thus depending upon the workforce and the strata, invariably at least two landing centre days are selected for each stratum in a zone- month. The 24 hours are selected in such a way as to maximise the possibility of first hand observation of fish landings by the enumerator. Traditionally these happen mostly during day time either early morning or near twilight, and hence an enumerator is instructed to cover a landing centre from 12 noon of the first day to 12 noon of the subsequent day with 12 hours of direct observation in two spells viz. 1200-1800 hrs and 0600 hrs- 1200 noon. The details of interceding night's landing are then recorded by enquiring those present in the centre the next day. Thus the statistical one landing centre day gets covered. These three spells, called sessions in a landing centre day are followed up by second level of sampling which involves random selection of at least two crafts of a particular gear-type totalling to around 10- 15 per session. The randomness of selection of the landing centre days equally spread over the three ten day interregnums and the 10-15 boats selected in a session follow a random start followed by systematic picking suiting the size of landings subsequently. Technically it can be seen here that sampling occurs at two levels, first at landing centre day level and the second at the craft selection level and this happens within each stratum of each zone (district) for every month. Hence this falls under the generic category of stratified multistage (two stage) random sampling whereby using appropriate scaling or raising factors the catch/ landings for each population unit viz, zone- month is estimated. Parallelly estimated is the corresponding dosage of effort expended too. Combining these two with suitable standardization usually results in catch rate, which is the starting point in any study of resource abundance as traditionally biomass availability or otherwise are strategically equated to the catch per unit effort of an average fishing craft on an average day. Thus ICAR-CMFRI has a long time series of such scientifically planned and systematically executed time series of catch and effort right from its inception in late 1940s.

Advanced methods enhanced precision

With the advent of new fishing methods and the direct impact that markets exert, these kinds of sample survey methodologies need constant review and update. As it can be seen from the basic method described in previous section, gear is one of the deciding features of a population. But as it is well known, the gears are no more unique with different shades of the generic type reflecting the innovative evolutions of the fishermen in a semi-controlled environment like that of Indian waters. Also unattributed is the days out on sea. With fishing spans topping over a month the units samples no more represent the traditional single day unit. Hence these may have to be inculcated into the survey procedure or at least in the estimation. Hence the options like two phase sampling, hybrid estimation and post-stratification approach are quite relevant in this fast-changing multi-gear multi- species scenario.

The two-phase sampling has an approach of double sampling, the first one to estimate a parameter hitherto assumed to be precisely known, like total number of gears of a kind in a stratum and their frequency during the ten-day interval, while the second one aims at selection of landing centre days suitable to measure the dynamics associated with the gear. The fishery, as is now being practiced in India, is quite dynamic in terms of targeted resources and the collateral by-catch turning out to be regular fishery. That too this remaining in a state of constant flux, with by catch fishery being interchanged with core fishery, is quite a challenge to design a sample survey. Thus, in such situations the two phase sampling/ two time sampling can come in handy. The second option is to have samples post-stratified for resource groups post selection, as in many cases the resource specific targeting does not exist and the collateral catches are too voluminous and significant to ignore. But this needs a very careful planning as these strata are supposed to be flexible but at times overlapping, resulting in over or under estimation of catch and effort. Hybrid estimators are one of the most practical alternatives to improve quality of estimators without enhancing the sample coverage or adopting complex designs. This involves collation estimates of standard peer establishments and arriving at a validation-based penalty to combine all of them into ones. In other words, this could be termed as a survey of surveys.

To conclude

While knowledge management has ways and means to exhaustively revise the traditional expertise available in fisheries, the success of any such tool depends on the precision of their roots, data collected. Hence the best foot forward for a sound fisheries management is to buttress its data collection mechanism, right from enumerator selection to sampling design and estimation and adoption of suitable KM tools or mining analytics for better guided exploration and inference of the population under study.

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Chapter 28

Farmers' First Approach in fisheries- Concepts and methodologies

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Farmer FIRST (Farmers Farm, Innovation, resources, Science and Technology) is an ICAR initiative to move beyond production and productivity focus of research and incline towards needs and objectives of the complex, diverse and risk prone realities of small and marginal land holdings. This needs enhanced and redefined farmers- scientist contact. The two pillars of this programme is the ' enriching knowledge' and 'integrating technology'. Enriching knowledge is not only for the farmers as commonly envisaged but more importantly to research system also to learn mutually with the subsystems also. Technology integration is of utmost importanceto small and marginal land holding farming, as the scientific outputs coming from research institutions need alterations and adaptations at field level for its acceptance, adoption and successful impact realizations.

Experimentation in technology applications

ICAR has made several experimentations to transfer technologies generated from research institutes to farming community to raise the production and productivity of commodities and enterprises. The major initiatives were as follows:

1. **National demonstrations**: this was launched in 1964 on major food crops, which was anation wide program with uniform design and pattern. The major objectives was to demonstrate the advantages of technologies convincingly to the farmers and extension personnel regarding the potential outputs per unit area of land and per unit time. The results were utilised for further upskilling through training programme in improved cultivation practices. The outcomes provided opportunities for researchers to get feedback on the problems of farmers on HYV and recommended package of practices.The impacts envisaged were generation of income and employment and bridging up of yield gaps and bringing out operational constraints. The efforts finally revealed the wide gap in yield realization, higher cost of production and higher returns also.
2. **The Operational research project (ORP)**: This was started in 1974-75 to disseminate newer technologies in a subject matter on water shed basis, covering whole village or cluster of villages, concurrently studying constraints (technological, extension, administrative barriers). The specific objectives of ORP were to test, adopt and demonstratenew agricultural technologies in farmers fields in a whole village /water shed area and to determine the profitability of the new technologies and pace of spread among farmers. It also attempted identification of constraints and barriers and demonstrated group action for popularizing faster adoption of technologies.
3. **Lab to Land**: was launched in the country on June 1, 1979 as part of the ICAR golden jubilee celebration. In this programme 50,000 farm families comprising small and marginal farmers and landless agricultural labourers were adopted by ICAR institutes. The two major dimensions of the

programme were to study the family profile for evolving and executing farm plans and to provide both technical and financial support for effecting changes in the economic conditions of the poorest sections of the rural community. The programme successfully increased production and income of farmers and was continued with 75000 farm families in second phase and subsequently with 50000 small and marginal farm families in the third phase. This programme brought farmers and scientists closer and supplementary sources of farm income also included like animal husbandry, fisheries, rural crfts, api/seri cultures etc.

4. **The institute village linkage programme (IVLP):** started in 1995 by ICAR with special emphasisi in generating appropriate technologies by refining and assessing innovations generated in different farm production systems like commercial, green revolution and complex, diverse and risk prone. This was implemented through ICAr institutes, SAUs, KVKs and ZRSs following basket approach in cluster of villages. The specific objectives included introction of technological interventions, integrating appropriate technologies to increase agricultural productivity and marketable surplus, facilitate adoption of appropriate post harvest technologies, and to monitor socio economic impact at meso and mega levels.
5. **The National Agricultural Innovation Project (NAIP):** started in 2006 with objective of facilitating and accelerating sustainable transformation of Indian Agriculturein support of poverty alleviation and income generation, through application of technological innovations.this was emphasised with the collaborative development of innovations by the public organizations in partnership with farmer groups, private sector and other stakeholders.The broader interventions were on building critical capacity of ICAr as catalyzing agent in NARS, promote production to consumption systems research in priority areas to enhance production, nutrition, profitability, income and employment, improve livelihood security of rural people and to build capacity and undertake basic and strategic research to meet challenges and predictable future.

Farmer FIRST Programme (FFP)

This is an opportunity for the researchers, extension officials and farmer to work togetherand find appropriate ways to help farmers problems through assessing solutions. Farmer FIRST is not only applied at household level but also at village and community level as community experimentations. This concept includes farmers to participate in the research process with scientists. The specific aims of FFP are

- To enhance farmer scientist interface, enrich knowledge and facilitate continued feedback
- Identify and integrate economically viable and socially combatible technological options as adoptable models
- Develop modules for farm women to address drudgery reduction, income enhancement and livelihood security
- To study performance of technologies and perception of farmers about agriculture as a profession in rural settings
- To build networks of linkages of organizations around farm households for improving access to information, technology , input and market

Components of FFP

The major components of the Farmer FIRST programme are

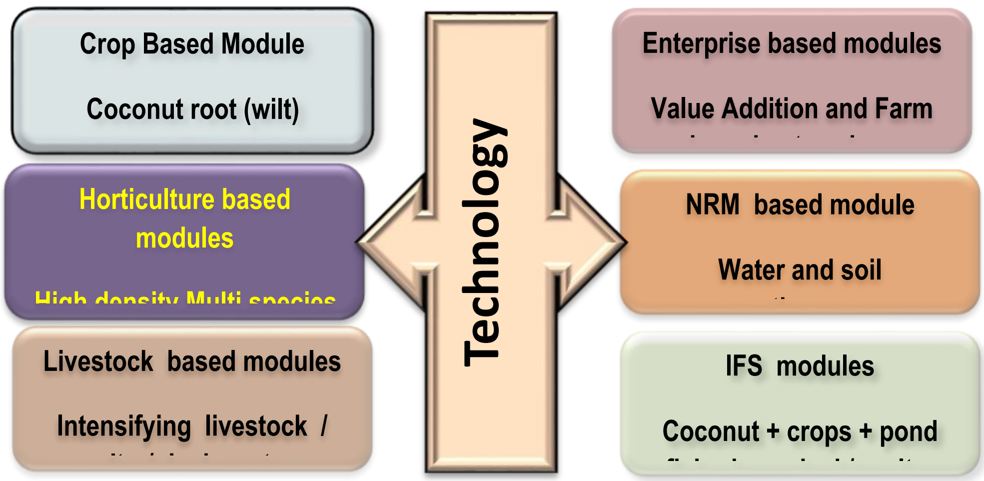
i) Enhancing farmer scientist interface

ii) Technology assemblage, application and feedback

iii) Partnership and institution building

iv) Content mobilization

The technology assemblage, application is being done in six technology modules for its assessment, application and generating feedback.



ICAR- Central Plantation Crops Research Institute (CPCRI) is implementing the Farmer FIRST Programme "Technology integration to empower and ensure livelihood security of farmers in Alappuzha district" in Pathiyoor panchayath, Alappuzha district, which is the only programme of its kind in Kerala state, since 2016.

Participatory problem analysis and prioritization done among the farmer clusters, through PRA, Survey, focus group discussions and field visits. The prioritized problems identified were as follows:

- Low income from unit area of farming
- Limited access to farming resources (land, capital, labour, technology etc) to women farmers
- Absence of convergence programs with existing schemes in agricultural development for supporting farming community
- Lack of value addition or processing units in coconut, sesamum and other major crops
- Low level of integrated management of root (wilt) disease and adoption of Plant Protection operations
- Mastitis disease of livestock, low adoption of cow mat, low availability of green fodder, high feed cost, unscientific back yard poultry only lacked commercial units
- Very low adoption of scientific fish farming, abandoned or discontinued homestead pond fisheries
- Absence of market led extension, and active farmer organizations
- Very low availability and adoption of HYV of tubers, intercrops and their scientific cultivation

Technology assemblage & integration strategies for DFI

The technology interventions towards improving farmers income requires multi pronged strategies involving multiple actors. The level or type of interventions in the Farmer FIRST Programmes under the six modules for improving and doubling farmers income were mainly were as follows:

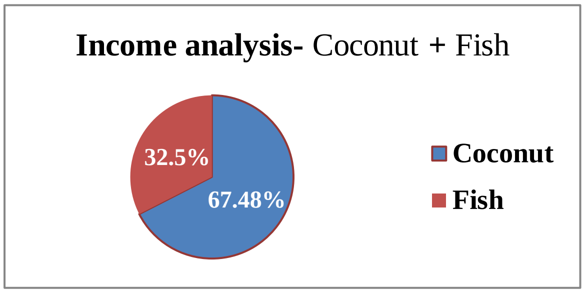
Technology interventions	Integrated management of root (wilt) diseased coconut palms, Area wide pilot participatory demonstration of CPCRI nutrient mixers- Kalpa Poshak for seedlings and Kalpa Vardhini for bearing palms, soil test based nutrient management, Coconut based cropping/ farming systems, hybrids and HYV of sesamum, turmeric, ginger, tubers, vegetables, finger millets, fodder, maize, cowpea, horsegram, paddy, Bio inputs, Mechanization, Mastitis prevention campaign using kits, Cow mat as GAP for livestock, egg incubators, hydroponics, azolla, Good breeds of poultry birds, Value addition machineries, products
Social interventions	Science based Bio input production at village level - Kera probio, vermicompost and Trichoderma, quality chick and duckling production , homestead and public pond revival and rejuvenation, technology awareness build up and farming cluster formations of crops, desi cows, planting material production clusters, women farmers Self Help groups (SHG), Community and group interventions, formation of 'Odanad Farmer Producer Company Ltd.' facilitated by NABARD and ICAR CPCRI as POPI for FFP farmers
Extension interventions	Capacity building activities/programs for women, youth and farmers, peoples representatives, individual farm and community level farming plans, responsible extension approach (REA) for area spread of HYV thru responsible farmer to farmer critical input exchange, area wide customized soil test based nutrient management in FFP panchayath, Mutual benefits for women farmers with low access to farm land and farmers – Fodder for livestock farmers, fresh farm products for consumers, land consolidation for farming, new crops introduced, traditional crops revived. Model evolved for MGNREGS and community food and income security farming, Linking student and teacher community of FFP area (4500 students) with coconut farming, decentralized participatory workshops on feedback on FFP interventions, extension literature and social media usage
Value chain interventions	Value chain strengthening of coconut, sesamum, turmeric processing, branding products, establishment of Farmer producer Company for organized marketing,
Linkages and convergence interventions	Purposeful Linkages with local self government bodies, convergence project with MGNREGS, linkages with 32 organizations/agencies for technology assemblage and integration, Swatch Bharat for clean Pathiyoor in convergence with MGNREGS

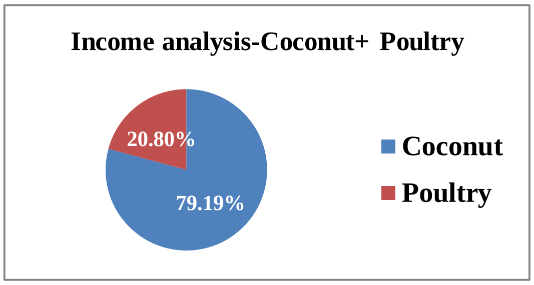
Social Model of doubling farmers' income- A case study

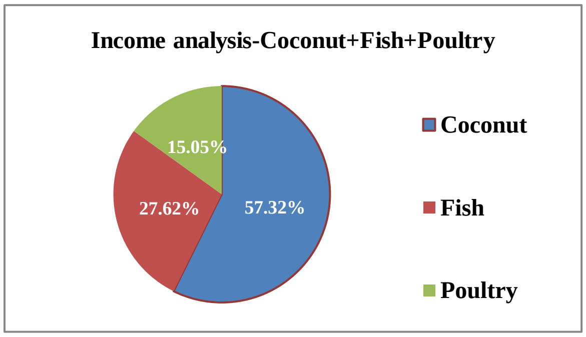
The farming community in general is the embodiment of diversity of resources, attitude, aptitude, motivation, perceptions, knowledge, skills, and ideas. The challenges of doubling income of farmers could be attained only through individual, group and society level mutual integration, converges and linkages. One of the ideas of income challenge put forward in the focus group discussions (FGD) with farming communities was to attain Rs. 10000 per 10 cents of land through choices of scientific combinations preferred by the farm family. The successful model thus evolved was mainly poultry of 100 birds, improving yield of the existing 5 to 8 coconut palms combined with vegetables,banana and tubers in interspaces, and artificial pond for fish culture.

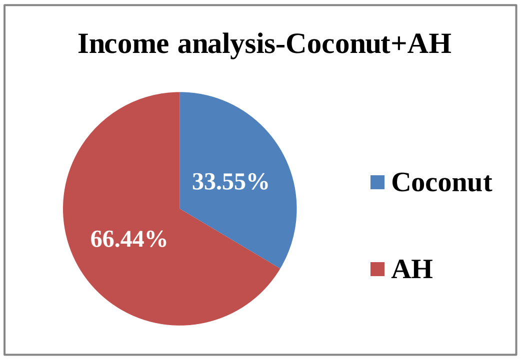
The size of land holdings demands combinations of crops and farm components for improving income from unit area over a period of time, at regular frequency and to produce marketable surplus. Coconut is the perennial base crop in every plot irrespective of the size of holdings and in the farmer FIRST program several combinations with common intervention for Coconut root (wilt) disease management (soil test based nutrient management, micro nutrient mixtures for seedlings and adult palms) and other combination options of Coconut management + intercropping, Coconut + inter/mixed cropping, Coconut +livestock + Intercropping, Coconut +livestock + Intercropping + poultry, Coconut +livestock + Intercropping + poultry + fish/duck, and Coconut +goat + Intercropping + poultry + fish/duck.

The income contribution of various intervention components at household level is furnished in the following graphs.

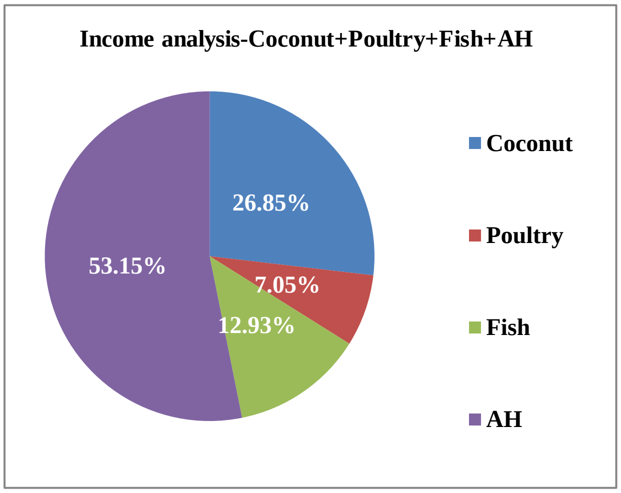


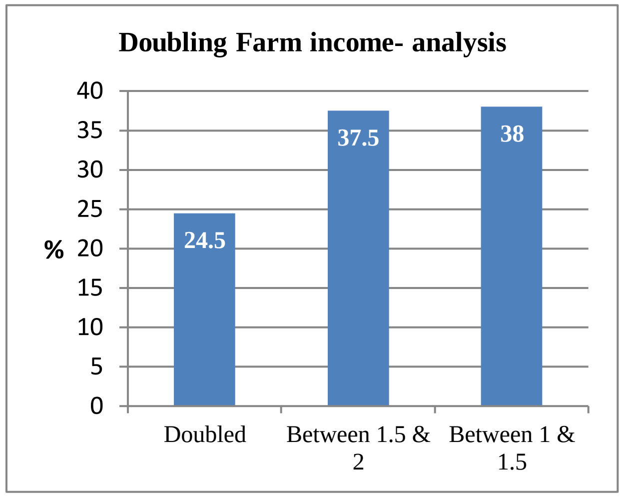






The above graphs clearly indicated the importance of integration of income sources through participatory farm planning and scientific technological intervention in multiple modules. Coconut based homestead systems requires and offers tremendous potentials in choice and inclusion of other enterprises towards income doubling. Components in Fisheries and Animal Husbandry contributed 25 to 60 percent income in IFS modules per household. Maximum utilization of farm resources through social empowerment and social capital generation evolved as the key factors towards doubling of farmers' income.





The income realized per household on an average from revival and rejuvenation of ponds and fish culture was Rs. 70193.50 which was almost absent before the FFP interventions and through poultry interventions of scientific housing, breeds such as gramasree, gramapriya nd BV 380 especially in marginal land holdings was Rs. 20435.80 after the FFP. The average income improvement from coconut alone, of IFS households with combinations of coconut + poultry + fish + animal husbandry was from Rs. 36506.40 before FFP interventions and Rs.50618.40 after FFP with an improvement of Rs. 14112.00 and income improvement of coconut in non IFS households was Rs. 5775.00, which also strongly indicated the incremental benefit in increasing coconut income adopting IFS components in coconut gardens.

The propensity of small, marginal and sub marginal land holding sizes and social structure with less dependency on farm income by majority of the population spread out scenario of wider variation of the farming systems adopted, unit area productivity, purpose of farming and income. A pilot study conducted among 120 FFP participants of the panchayath confirmed the above observations. The general results of the study were as follows:

- The improvement income or doubling the income was mostly observed in land holding sizes up to 60 cents. This may be due to the efficiency of resources and family labour under direct supervision and involvement. The annual gross income from one cent of coconut based system was Rs. 905.00 in marginal and sub marginal sized coconut gardens with coconut, intercrops mostly for home purposes and pond fish culture and in small holding sizes holding with coconut as base crop integrated with livestock, fodder and intercrops, it was recorded as Rs. 1100.00. The income will be Rs. 2, 23535.00 and 2, 71700.00 which is 21.51 percent more in small land holding sizes.
- The income from coconut cultivation alone before the FFP interventions was Rs. 60900 per annum and improved to Rs, 69000.00 after one year of scientific management in farmers' gardens which comes to Rs.5775.00 per month on an average. Since coconut is a perennial palm crop and due to the physiology the observable increase in yield takes minimum three years. Thus the data showed 13.50 percent of improvement in income which will be in progression as the case of coconut.

- In sub marginal plots of 10-20 cents area (400- 800 sq m) the major intervention to double income was poultry component which required very less area, which was not scientifically prevalent before FFP. This component was seen to provide gross additional income of Rs. 20435.00 to Rs. 69600.00 depending on the number of birds per unit. A total of 68 poultry units is successfully continuing mostly by women farmers in the FFP area with Gramasree, Gramapriya and BV 380 breeds.
- The most successful and result oriented FFP intervention serving social cause of water collection and conservation and fish culture was the revival and rejuvenation of 72 homestead ponds with participation and involvement of farming community. This single intervention provided additional income of Rs. 11120 to Rs. 110870.00 depending upon the pond size. Based on the farmers preference 75000 Nile thilapia and Koi Anabas was cultivated scientifically. The range of increase in income was found to be 1.01 to 3.56 folds after the FFP based on land holding size, combination and integration of farm components and FFP interventions. The combination which was prominent in contribution to farm income was coconut, fish culture and livestock. The most impressive learning case was with the coconut based entrepreneurs which could improve their total income by 34 folds compared to pre FFP income level indicating the critical role of value addition units in doubling income directly and indirectly of other farmers.

  Farmer FIRST Programme of ICAR CPCRI is uniquely implemented as participatory and partnership programme venturing to farm entrepreneurship, farmer organizations, wider participation of women self-help groups (SHG), convergence with MGNREGS and Swatch Bharath Mission and ensuring sustainability through youth and student participation and evolving and mentoring local leadership in farming as model social empowerment for doubling farmers income by 2022.

Chapter 29

Behavioral change interventions for sustainable fishing

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Implementing the principles and practices of sustainable fishery has been a great challenge in Indian fishery. As signatory in the international instrument for responsible fishery by FAO, the Code of Conduct for Responsible Fisheries (CCRF), the country has been struggling hard for the sustainable utilization of its fisheries resources. Human behaviour is governed by many psychological factors. Theories of social psychology state that these psychological determinants can be manipulated to change the behaviour of human being. Behaviour change interventions use such methods to alter human behaviour for a better social cause**.** Dialogues with policy stakeholders, and educational efforts directed at fishers were found to be one of the most common actions for sustainability of fisheries (Crona et al 2019).

Modifying social norms can create conditions that incentivize a company, country, or individual to fish sustainably, curb illegal fishing, or create large marine reserves as steps to enhance reputation or self-image (*Lubchenco, et al 2016),* evaluating conservation tools by their ability to align incentives of actors with broader goals of sustainability is an underused approach that can provide a pathway toward scaling sustainability successes.
Behavioral interventions should target social norms instead of increasing enforcement for the focal regulations (Thomas et al, 2016). These interventions could include articles in local newspapers and fishing magazines highlighting the extent of regulation compliance as well as using respected local fishers to emphasize the benefits of compliance through public meetings or letters to the editor.

Rewarding the positive behaviour or punishment of negative behaviour is the most common method used for fishery management in the areas where there is sufficient resources to do so. Whereas Fisheries with limited resources to support efficient monitoring, inspection and penalizing depend upon behavioural change interventions for better fishery resource management. Social determinants such as existing norms in the society, trust among people, and the perceived legitimacy of regulations by the fishermen are the psychological traits which are used for human behaviuor alterations (Battista *et al* 2018).

Behavioral change interventions for sustainable fishing in India

Fisheries generate significantly more value when they are sustainably managed, and also provide biological and social benefits. Furthermore, the economics of the global seafood market suggests that

prices and demand for sustainable products will increase. Therefore, investing in sustainable fisheries can be seen as both a necessary and potentially profitable investment (Sinha et al, 2017)
Marine fisheries need management and conservation measures to maintain sustainable use of marine biodiversity in future. Stock enhancement program must be integrated along with a fishery management that involves habitat protection and release of juveniles with appropriate control of fishing effort (Serajuddin, et al 2018)

"Perceived crisis or the felt need" by the community is another behavioural determinant which led to an initiative for sustainable fishing in Kerala. A very serious decline in pelagic resources like sardine and mackerel, experienced along the Kerala coast acted as the immediate trigger for a collective rethinking on fishing practices in the area by both traditional fishers and mechanized fishing sector (Ramachandran, 2015). The case study point towards the fact that only when the resource supply is so threatened that the livelihood options are severely hampered, do fish workers appreciate the need for scientific management.

In small-scale fisheries, Village councils (or *ur panchayats*) and civil society organizations can play significant role for sustainable management of resources (FAO. 2019).

Religious principles and faith in God is another behavioural determinant which led to an initiative for sustainable fishing in Kerala. A system locally called as *Kadakkodi* (Sea Court) literally means "sea court" among the fishermen community in some of the fishing villages especially northern Kerala is an age-old community institution. It is a very old practice or custom that has prevailed throughout the marine villages of northern Kerala and still active in some of the coastal villages

Fisher's attitude towards responsible fishing is another behavioural determinant which led to an initiative for sustainable fishing. The degree of positive or negative affect which they associate with scientifically informed and regulated fishing practices which contributes towards conserving fishery resources for the future generation while earning a livelihood out of it. Literature review and thematic analysis of stakeholder discussions implied that Fishers attitude towards responsible fishing, is influenced by both personal and external factors. Willingness to participate in co-governance, compliance to rules and regulations, conservation orientation, willingness to adopt resource saving technologies /responsible fishing practices, experience with regard to negative impact of fishing, willingness to participate in training and awareness campaign are the important personal factors which influence responsible fishing behaviour.
The external factors related to responsible fishing behaviour are institutional factors/ capture fisheries regulatory framework in terms of access control, temporal control, spatial control, input/ effort based output/ catch based and legislation/s in force.

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Chapter 30

Self-sufficient Sustainable Seed System for Rice (4S4R) Model

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What is a FPO?

A Farmer Producer Organization (FPO) is typically a **society/company** consisting of only practicing farmers who are also **actual producers of a specified commodity/ commodities**, and is formed under the **Cooperative Societies Act, 1962** or as a Farmers Producer Company (FPC) under Section 581 (C) of the **Indian Companies Act, 1956**, as amended in 2013. These organizations are created at the **cluster, block, district or State level** depending upon the needs of the producers considering the demand potential to adopt value chain approach to enhance farmers'/producers' economic and social benefits.

Main objectives of a FPO

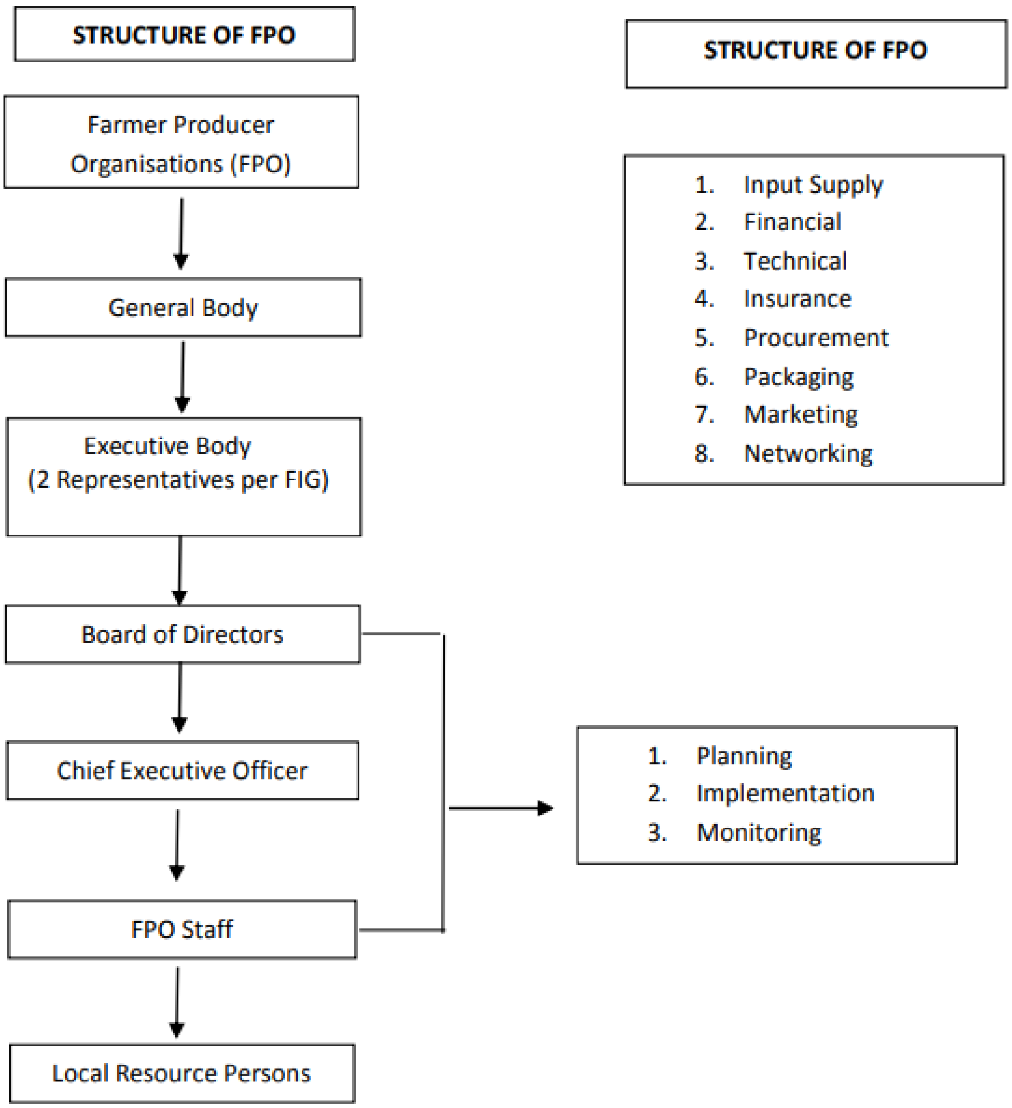
The FPOs will successfully deal with challenges and constraints that confront farmers by leveraging **collective strength and bargaining power** to access financial and non-financial inputs, services and appropriate technologies, **reduce transaction costs**, **tap high value markets and enter into partnerships with private entities** on more equitable terms.

The FPOs will offer forms of **aggregation and investments** in irrigation, storage, processing etc. leaving land titles with individual producers and will use the **strength of collective planning and bargaining for production, procurement and marketing**, so that considerable value is added to the members' produce.

This will ensure **improvement of production, productivity, direct linkages, and higher unit value** realisation for the farmers and easy and cost effective access to specific quantum and quality of raw material required by the industry.

It aims at maximizing direct and indirect **employment generation** through establishment of marketing outlets, creating necessary supply chain like **sorting and grading yards, transportation, warehouses and cold storages.**

Structure of FPO:



Background of forming 4S4R FPCs (IT enabled Self-Sufficient Sustainable Seed System for Rice):

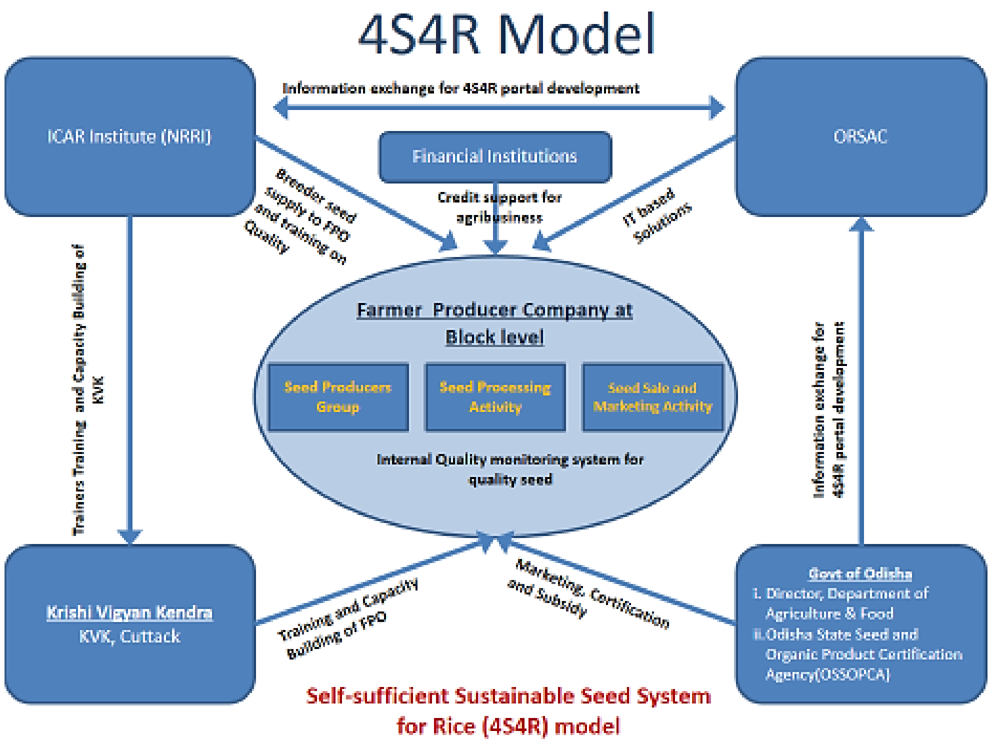
India has nearly 43 million hectare land under paddy cultivation for which it requires roughly **2.0 million tones of quality paddy seed** as per varied seed rate required for different varieties. According to Department of Agriculture and Cooperation (DAC), **0.69 million tons of certified seed was available** for *Kharif* 2013, which is only ⅓ **of total seed requirement** of the country. It may be noted that the use of **quality seed** alone can **increase productivity of rice by 15–20%** (D. Behura, OUAT). But the **seed replacement rate** (SRR) for paddy in India is only **40.42%** (2011). In case of Odisha the scenario is even worse; it is only **21.65%** as per Seednet Report 2011.Ideally, the SRR should be 100% to exploit the benefits of quality seed.

Problems that had to be addressed due to the formal seed supply system:

- Limited range of varieties and specified quality standards, not able to meet the diverse needs of farmers.
- Not all farmers have access to formal seed sector.
- The quantity and quality of seed delivered may not be appropriate.
- The seed production costs and prices are high.
- The timeliness of supply is major concern.
- The formal system cannot guarantee small-farmer seed security at the community and household levels (More than 80% of the food crops in India are sown from seed stocks selected and saved by farmers).
- It is likely that the seed supplied is a mix of different varieties and not pure types.
- The logistics are expensive and difficult to organize the seed supply by the government agencies due to high costs and other overheads.

Features of 4S4R

- Established and working in 5 blocks of Cuttack district of Odisha, named as Cuttack 4S4R Seed Farmer Producer Company Ltd., Athagarh 4S4R Farmer Producer Company Ltd., Niali 4S4R Farmer Producer Company Ltd., Badamba 4S4R Farmer Producer Company Ltd., Bankadurg 4S4R Farmer Producer Company Ltd.
- 4S4R as a Local seed system produces seed according to local farmers' need (right variety), in right quantity, with lower cost of production (right price)& supply (right place) and with timely delivery (right time) of seed to farmers.
- Paddy Seed Production Portal (4S4R portal) having Paddy Seed Production Expert System for Odisha.
- GIS based solutions for planning paddy seed production at block level using land and resources maps.
- MIS for seed demand, availability, price and supply for local marketing.
- Mobile based solutions (App) for farm advisory service for seed production by farmers group.
- Impart trainers training on i) paddy seed production and ii) FPO formation to KVK staff and block level agriculture officers.
- Develop FPO consisting of producers group, processing unit and marketing unit at block level.
- Develop Business Plan for Seed Production by FPO at Block level.
- Developing internal monitoring for quality paddy seed production & processing.
- Developing Rural Entrepreneurship to promote 4S4R seed marketing.



How we convinced to register FPC?

- FPC should be formed by a group of farmers certified by district or block officials.
- It should be a registered body in the eye of law where the organization gets status of individual entity in the name of organization.
- Only Farmers can be the members in the organization with no limitation on memberships.
- It deals with business activities related to the aggregation, Value addition and Agri inputs for farmers.
- It works for the benefit of the member producers in their education, training, skill development, welfare activity.
- A part of the profit is shared amongst the farmers as per the percentage of investment.
- Rest of the surplus is added to its owned funds.
- This legal entity has enabled transparency through mandatory internal and statutory audit.
- Committees can be formed as per law and all the reports can be uploaded to central govt. as per Ministry of Corporate affairs provision to enable a corporate culture and governance.
- Directors and Managing directors cannot take over the control from shareholders; shareholders can organize themselves in majority to take decision through Extra-Ordinary General Meeting.

- Neither government nor Private party can buy stake in the company, nor can be transformed to such format of legal entity.

What we did in 4S4R:

Selected leaders for their skills

Sl.No.	**Name of block**	**Total number of initial leaders**	**Members during registration**	**Current membership**
1	Mahanga	7	15	900
2	Athagarh	5	10	900
3	Niali	5	10	700
4	Badamba	7	10	1000
5	Banki-Dompara	5	10	200

Seed Production & sales status 2018-19

Sl.No.	**Name of FPC**	**Total area under seed production (acre)**	**Total quantity of seed production (quintal)**	**Total sales in Rupees**
1	Cuttack 4S4R Seed Farmer Producer Company Ltd.	22	390	7,71,370
2	Athagarh 4S4R Farmer Producer Company Ltd.	25	20	62,240
3	Niali 4S4R Farmer Producer Company Ltd.	22	350	6,71,440
4	Badamba 4S4R Farmer Producer Company Ltd.	10	80	1,06,200
5	Bankadurg 4S4R Farmer Producer Company Ltd.	0.8	4	10,000

Forecasted Seed Production & sales status 2019-20

Sl.No.	**Name of FPC**	**Total area under seed production (acre)**	**Total quantity of forecasted seed production**	**Total forecasted sales in lakhs**

			(quintal)	
1	Cuttack 4S4R Seed Farmer Producer Company Ltd.	20	360	15 lakhs
2	Athagarh 4S4R Farmer Producer Company Ltd.	18	240	9.6 lakhs
3	Niali 4S4R Farmer Producer Company Ltd.	25	450	18 lakhs
4	Badamba 4S4R Farmer Producer Company Ltd.	16	280	11 lakhs
5	Bankadurg 4S4R Farmer Producer Company Ltd.	8	140	5.6 lakhs

FIG development status

Sl.No.	**Name of company**	**FIG leaders assembled during registration**	**FIG members organised& membership till date**
1	Cuttack 4S4R Seed Farmer Producer Company Ltd.	7	900
2	Athagarh 4S4R Farmer Producer Company Ltd.	5	900
3	Niali 4S4R Farmer Producer Company Ltd.	5	700
4	Badamba 4S4R Farmer Producer Company Ltd.	7	1000
5	Bankadurg 4S4R Farmer Producer Company Ltd.	5	200

Land purchased by each FPC on which storage godown and processing plant is to be established:

Sl.No.	**Name of company**	**Expected value of assets at end of 2020**
1	Cuttack 4S4R Seed Farmer Producer Company Ltd.	52 lakhs
2	Athagarh 4S4R Farmer Producer Company Ltd.	56 lakhs

3	Niali 4S4R Farmer Producer Company Ltd.	53 lakhs
4	Badamba 4S4R Farmer Producer Company Ltd.	50 lakhs
5	Bankadurg 4S4R Farmer Producer Company Ltd.	55 lakhs

Background for forming a Fisheries FPO

110.5 million tonnes of fish destined for human consumption, making an average annual global per capita consumption of 16.7 kg. In 2030, world population is expected to reach 8.32 billion, whereas India's population will be 1.25 billion. If per capita consumption to be maintained, we will require 40% more fish for food.Most producers have had to produce and market their products without access to reliable or affordable inputs, financial, technical or transport services. Small-scale producers are forced to compete with large commercial producers from all around the world and to meet increasingly stringent quality and safety requirements demanded by buyers and consumers &find themselves disadvantaged owing to their weak bargaining position.

Elements of success:

Participatory development and promotion of simple on farm "Better Management Practices" - "BMPs"

- Pond preparation.
- Seed quality.
- Water quality.
- Feed management.
- Health monitoring/Biosecurity.
- Disease management.
- Better Harvest and post-harvest Practices.
- Record maintenance/Traceability.
- Environmental awareness.

Role of FPO in Fisheries

- Enhance participation and consultation of all stakeholders in the planning, development and management of aquaculture, including the promotion of codes of practice and BMPs.
- Facilitate mechanisms for voluntary self-regulation for attaining best practices such as the cluster management concept.
- Promote the appropriate and efficient use of resources, including water, sites, seed, stock and other inputs.
- Develop human resource capacity by facilitating the provision of training, technology transfer and access to information.
- Increase market access through enhanced ability to meet market requirements, increased negotiation and bargaining power and economies of scale.
- Facilitate the provision of extension services, credit and market information.

- Develop government communication and consultation processes and promote comprehensive policies and a supportive legal and institutional framework that support sustainable aquaculture development.
- Build partnerships with government to progress and implement policies and programmes, making government efforts and the use of scarce resources more cost-effective. (Hough and Bueno, 2002)

Services that can be provided through FPO for fisheries

- ✓ **Marketing** services (input supply, output marketing and market information)
- ✓ **Financial** services (working capital, investments, loans and other forms of credit)
- ✓ **Technology** services (quality control, processing and extension)
- ✓ **Educational**services (business skill, training, technical knowhow)

Benefits of a Fisheries FPO

- Highlighting farmer problems.
- Mobilizing public and institutional support for farmers.
- Protecting the interests of the FPO.
- Providing technical services to members.
- Becoming organized to resist exploitation by intermediaries and local pressure groups.
- Mobilizing credit.
- Influencing policy decisions.

International market and trade can be an opportunity for FPO

- Production costs can be managed.
- Business structures of export-oriented aquaculture.
- Risk management strategies of larger traders and buyers driving against small-scale farmers.
- Easier for big buyers to deal with big farms with large product volumes. (Small quantities of product – inconvenient to larger buyers)
- Market access requirements and standards for certification, traceability and quality assurance.

Pre-requisites to initiating FPO Model

- Aware the objective of model.
- Complete the 5 Years business plan for production, processing & marketing.
- Developing affinity with Dept. Of Agriculture, Fisheries & allied agencies.
- Developing Activity calendar for each year.
- Seed sales data of the intervening market area.
- Aware the FPO concept & benefits as per Producer Company Act.
- Discuss Production, processing and marketing Plan.
- Making group of leaders through Farmer Interest Group (FIGs).
- Collecting equity money contribution from potential leaders or Farmer Interest Groups.
- Economic Benefits of farmers.

- Manpower team with legal knowledge, managerial skills, production know how, social skills are essential to start this project.

Implementation process

Potential Assessment of Block/Area:

- Varieties.
- Demand.
- Supply.

Area Selection for the FPO:

- Technical feasibility.
- Social feasibility.
- Sales feasibility.
- Logistics feasibility of the village.

Farmer Group Selection:

- Selecting key leader farmer.
- Common village meetings.
- Workshops.
- Exposure visits.
- Paid membership Groups.

Production aspect:

- Training on production.
- Production planning and business plan preparation.
- Providing inputs required.
- Production area preparation and further activities.

FPO registration:

- Identification of Stakeholders.
- Organizing Focus Group Discussions.
- Draft Preparation for legal entity.
- Producer Company Name Approval.
- Documentation to be prepared for online filing.
- Digital Signature Certificate. (DSC)
- Online Application at MCA Site.
- Approval of online Application & PAN number Generation.
- GSTIN Application.
- Business Commencement e-filing at MCA Site.
- Issuance of Share certificate.

Other legal activities:

- Bank account opening.
- Auditor appointment.
- Regular AGM meeting.
- Income Tax Filing.

- Taking DIC registration.
- Taking other legal permissions for processing and marketing.

Organisational setup activities:

Making various dept. like

- Administrative Dept.
- Accounts Dept.
- Production Dept.
- Procurement Dept.
- Processing & Packaging Dept.
- Marketing & Sales Dept.

Conclusion

At present, the best solution for meeting farmers / fish farmers' problems lies in institutionalising farmers into legal framework. Farmer Producer Organisation provides all necessary structures including administrative, legal, technical, economical and social structures with permanency. FPO is future of Extension. We need to equip ourselves to meet this challenge.

Chapter 31
Farmer producer organization platform for rural agripreneurship

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About Farmer Producer Organization
Defining Farmer Producer Organization

"Any **legal entity** or **registered body** having farmers as members who are supplying agricultural produce to fulfill the need of aggregation of produce& producers in order to benefit from economies of scale in production, farm mechanization and optimizing sourcing of farm inputs where a part of profit out of business is being shared among the farmer members as **dividend and utilizing for benefit of farmer members for** their education, social security, welfare measures."

Features of Farmer Producer Organization

- -It should be formed by a group of farmers certified by district or block officials.
- -It should be a registered body in the eye of law where the organization gets status of individual entity in the name of organization.
- -Only Farmers can be the members in the organization.
- -It deals with business activities related to the aggregation, Value addition and Agriinputs for farmers.
- -It works for the benefit of the member producers in their education, training, skill development, welfare activity.
- -A part of the profit is shared amongst the farmers
- -Rest of the surplus is added to its owned funds.

Aspects of Failure in Co-operative Form

-Co-operative structure has been failure in most of the cases such as chicory, tobacco, cotton, vegetables, grains and canal irrigation co-operatives to serve its purpose.
-Co-operative has been ruled by elite capture, promoting differentiation instead of equity in rural communities like in case of sugar co-operatives in Gujarat. In India, the only exceptions to the failure have been sugar and milk co-operatives in some states especially in Maharashtra and Gujarat.
-Co-operative are subject to state government regulation so involving beaurocracy to an extent of high decreasing professional management aspect and increasing corruption practice.
-Co-operative society is being habituated only for collection of produce and lacked the post-production aspects.

-Compliance structure in co-operative was not strengthened to scrutinize various operational and financial transactions.
-Investment options to farmer based organizations was limited and Co-operatives could not able to be in race of getting investment options by changing economic condition globally.
-Lack of credibility and legitimacy in the current business environment.

All above aspects was the reason for which there was felt of other alternatives to restructure the legal aspect to govern farmer based organization. For this cause The Government of India. In the Ministry of Law, Justice and Company Affairs (Department of Company Affairs), by its Order No. 11112/99-CL-V dated 1st November, 1999, constituted a High Powered Committee to reexamine the co-operative structure and framing legislation which would enable incorporation of cooperatives as companies and conversion of existing cooperatives to increase the efficiency through regulated framework of company.

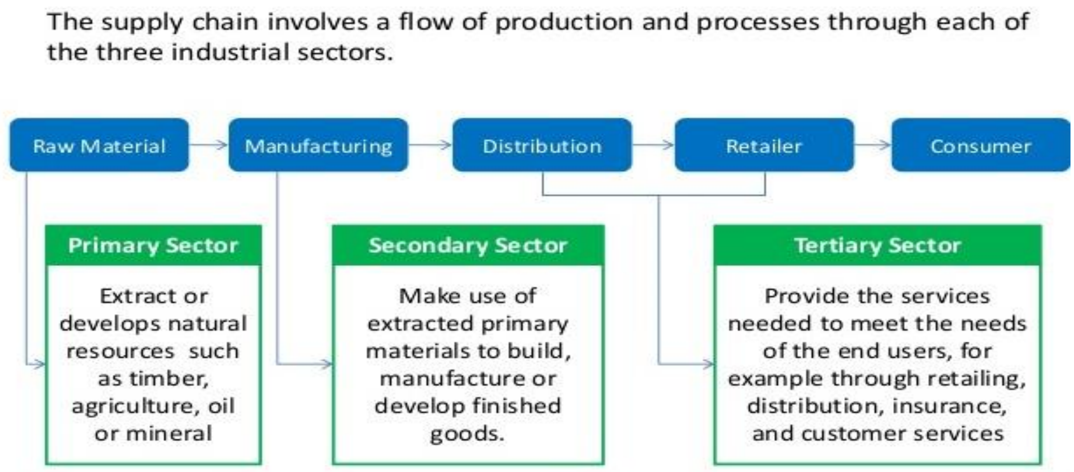
Y.K. Alagh Committee Work

The committee had been constituted under the leadership of Dr.Y. K. Alagh, Economist with other eminent from various departments. The committee reviewed all aspects and presented the legislation during the year 2000, The Bill, entitled "Companies (Amendment Bill) 2000, seeks to amend the Companies Act,(Act I of 1956), so as to insert an additional Part, "Part IXA", concerning the formation of Producer Companies. So the word **"Producer Company"** was used in the **Alagh Committee report** for **the first time** in the framed legislation to constitute company under features of co-operative.

2.About Farmer Producer Company

What is Producer Company, Primary Producer & Primary Produce

Then there are other stakeholders who process and involved in the value addition process. So if we consider the place of the farmer in the value chain, it comes at Primary Position. The farmer being at the Primary position produces raw produce which we can name as Primary Produce which move to the secondary as well as tertiary stakeholders in the process of value addition& finally reach to consumer.
So by considering the supply chain, the farmer can be called as **Primary producer** who produce various natural products where the raw produce can be referred as **Primary Produce.**



In Hindi language, we can call the Primary Producer as "**PrathamikUtpdadak ".** The Primary Produce can be calledas **"PrathamikUtpad".**

What is Primary Produce (*PrathamikaUtpad*) as per Act?

Production based

1. The raw produce of farmer arising from agricultural activity such as animal husbandry, horticulture, floriculture, pisciculture, viticulture, sericulture and any other agricultural activity.
2. The raw product from forestry, forest products, re-vegetation, and farming plantation products collected comes under Primary Produce.
3. Any persons producing any product of handloom, handicraft and other cottage industries by utilizing natural resources can be termed as Primary Produce.
4. Any by-product resulting from any of the above activities can be called as primary produce.

Service/Activity Based

Apart from this production aspect, there is another service aspect to be defined as Primary Produce too. If a group of **Producer** is involved service delivery to those involved in the production part, the service can be defined as Primary Produce in the eye of law.

1. Any activity or service which promotes the interest of the farmers in producing their primary produce.
2. Any an ancillary activity that would assist or promote to increase the Quantity production or Quality of anything referred to in the point number 1 to 4.

Who is a Primary Producer or Producer (PrathamikaUtpadak) as per Act?

Any person engaged in any production based or service based activity as defined in the primary produce section, can be referred as Primary Producer or Producer (PrathamikUtpadak).So from above discussions its Concluded that, not only farmers can form Farmer Producer

Organization(FPO), but also artisans, handicraft makers, handloom weavers, forest produce collectors can form Producer Organization under Section 465 of Producer Company Act 2013.

New-Generation Co-operative Act-Producer Company Act

Producer company act is also referred as new generation co-operative act. This act has been designed with base rules & guidelines of Co-operative society along with strong compliance rules as per Companies Act. Goodness of both the acts, have been merged to make a new act where, regulatory authorities can monitor the efficiency & operation of farmer based organizations. This act has same principle of general body making as it is in the co-operative act, same social principles of co-operative act like **"Principles of Mutual Assistance".** The basic principles are as follows.

1. Voluntary & Open membership to producer members
2. Democratic Member Control'
3. Members Economic Participation
4. Autonomy & Independence
5. Education, training & Information
6. Co-operation within members/Institutions
7. Addressing problems of community.

Producer company act has all above principles in its every part of management principles, to strengthen the rural India's small & marginal farmer's community.

Advantage of Producer Company over Co-operative

Feature	**PC**	**Co-operative**
Registration under	Companies Act	Co-op societies Act
Membership	Only to producer members and their agencies	Open to any individual or co-operative
Professionals on Board	Can be co-opted	Not provided
Area of operation	Throughout India	Restricted
Relation with other entities	Can form joint ventures and alliances	Only transaction based
Shares	Tradable within membership only	Not tradable
Member stakes	Articles of association can provide for linking shares and delivery rights	No linkage with no. of shares held
Voting rights	Only one member one vote and non-producer can't vote	One person one vote but RoC and government have veto power

Reserves	Mandatory to create reserves	Can be created if made profit
Profit sharing	Based on patronage but reserves must and limit on dividend	Limited dividend on capital
Role of government	Minimal	Significant
Disclosure and audit requirements	Very strict as per the Companies Act	Annual report to regulator
Administrative control	None	Excessive
External equity	No provision	No provision
Borrowing power	Many options	Restricted
Dispute settlement	Through arbitration	Through co-op system

3. Process of FPC Formation

Registration Process of Producer Company is an important process. This process involves co-ordination of various stakeholders such as Local Government Administration, Producer members, Producer Group Leaders, Legal Professionals, Consultant on producer Company.

1st Step- Identification of Stakeholders

The registration involves documentary work, Certification Work, objective setting, roles & responsibility allotment, Legal drafting. All this are executed by separate stakeholders. So identification of particular stakeholder is important to initiate the process of Registration.

2nd Step- Identification of Efficient existing leaders

Minimum 15 to 20 leaders should come forward with following documentary process.

- **a)** Proven record of leadership selection by majority.
- **b)** with proven record of their group equity collection,
- **c)** Proven record of equity collection and are agreed to constitute company and agreed to receive Equity grant in the company account in future.

Need of Finding Effective Leadership

- Already existing group leaders will have public relation to raise equity efficiently.
- Proven records of bank account will tell the equity capacity of group.
- The process will ensure elimination of individualistic approach leaders.
- The process will give boost for scale up of existing producers.

3rd Step- Constitution of General Body

- All the 15-20 leaders should seat in between themselves to decide the directors, accounts person and other company management principles to be framed.

Benefit of Constitution of 15 to 20 leaders General Body Prior Company Registration of representing minimum 300 farmer base

- Allow group discussion and resolution among them.
- Allow responsibility allotment in between them.
- To collect equity money by Accounts responsibility persons prior company formation so that at later stage equity deposit at bank will not be an issue.
- Enable public decision making from its formation stage,
- Only Group activity oriented leaders will get opportunity to take leadership.
- From the date of registration, the company membership can be filed of 300 to 400 within one month.
- This Process also makes conducive to get matching equity grant as per the equity contribution of members.

Decision of General Body on following aspects needed in resolution forms

- Objective on which the producer company are working and are intended to work in future.
- The total amount of Paid up Capital that should be contributed by all members subject to not minimum of One lakh of Rupees in total where contribution from all members are equal.
- Criteria for Membership generation, Qualification and Cancellation.
- Directorial board selection & Retirement Process.
- Eligibility & Duties of Directors.
- Power & Function of Board.
- Criteria for Active Member in producer Company.
- Voting Criteria in the producer company format.
- Duties of Member in a producer Company.
- Dividend distribution principle.
- Distribution of surplus in the producer Company.
- Shareholding and share Transfer Process.
- About Annual General Meeting and process.
- About Board Meeting and its directorial board appointment process.
- Statutory compulsions involved.
- Records and documentary works needed to be Keep Transparency among member governed process

4th Step-Document Collection& Equity contribution

There is need of documentation which is most crucial steps of producer company registration. Those are ready to contribute for registration of Producer Company; equity money should be collected & aggregated with a responsible person. There is required equal equity money to be collected of minimum of Rs. 1 lakh for registration process as per Registrar of Companies guidelines.

1. Self attested photocopy of Pan Card for verifying date of birth, Aadhar Card to serve as Identity Proof, Voter Id Card to serve as citizenship
2. Self attested photocopy Bank Passbook front page to serve as Address Proof

3. Self attested photocopy Updated Bank Statement page to serve as bank account is active.
4. DIR-2form signed for declaration by proposed directors.
5. INC-9 signed affidavit form from directors cum promoters and subscriber-cum-promoters.(Needed to be Notarized)
6. Signature of all applicants along with their name, fathers name, occupation, equity contribution & declaration in the Memorandum & Article for registration of Producer Company.
7. Producer Certificate from local Government.
8. Self attested photocopy Utility bill not less than two months older of the owner.
9. House Rent agreement with No objection certificate from house owner for registered office.
10. Two passport sized recent colour photos.

5th Step- Draft Preparation By Consultant

- After all the above parameter is discussed and suggestions received from the members, Memorandum of Association (MOA) which depicts the objective of the producer company through which set limitation to its activities.The second drafted material is Articles of Association (AOA) Which depicts the governance parameters through which it operates by its Members.

6th Step- Company Name Approval

- There is process in Registration where consultant has to approve name that the producer company wants to keep. For this more than name is choose as name is subject to cancellation as per norms of Companies Act or Name gets Resembled with other approved names. Name rejection also happens if sufficient explanation does not provided while applying for name. The name should be apply such that it ends "………..Producer Company Limited"

7th Step- Digital Signature Certificate (DSC) Issuance

- The Information Technology Act, 2000 states use of Digital Signatures on the documents submitted in electronic form. This process has been designed in order to ensure the security and authenticity of the documents filed electronically. DSC physically look like Pendrive which has unique code in coded form provided by certified agencies like EMudhra, TCS etc. While application of company and future compliance requirement, DSC attached in the computer and the all applications are electronically uploaded.

8th Step- Online Application by consultant

- This step is very sensitive and variable process due to continuous change in the Ministry of Co-prorate Affairs updates on incorporation process.. Generally,CompanySecretary/CharteredAccountants/ Advocates are authorisedpersonnels to carry out such online filing by their certification about the truthfullness of the documents given.

9th Step- Incorporation certificate & Business Commencement filing

- After online submission of all required documents by authorized consultants(CA/CS), incorporation certificate will be granted by Registrar of Companies. Incorporation certificate also comes with e-PAN & e-TAN.
- Post incorporation activity, all equity money shown in the respective names of promoters-cum-subscribers in the registration document, to be deposited in the bank. Then the proof of deposit(Bank statement), has to be filed in the RoC site which is called as filing of business commencement.

4. Cost of Farmer Producer Company Registration by Consultants/Agencies

- There is varying cost as per the authorized capital of the company to be approved from Registrar of Companies. But, there is very minimal fees(within 800) to register a company of authorized capital of Rs.10 lakhs. The authorized capital is the permissible limit of a company to raise equity from its shareholders.

Sl. No.	**Particulars**	**Quantity**	**Amount**	**CGST**	**SGST**	**Amount**
A.	**Govt. Fees**					
1	Name Approval	1	1000	0	0	1000
2	Company Registration	1	800	0	0	800
3	DIN filing	3	400	0	0	400
4	Auditor Appointment	1	1000	0	0	1000
B.	Subtotal (Govt. Fees)		3200	0	0	3200
C.	**Professional Fees**					
1.	Bylaw Drafting fees(MOA & AOA)	2	5000	450	450	5900
2.	Certification of MOA & AOA	1	5000	450	450	5900
3.	Digital Signature Approval	5 Nos.	5000	450	450	5900
4.	GST Registration	1	2000	180	180	2360
5.	GST filing	12 months	6000	540	540	7080
6.	Business Commencement filing	1	2000	180	180	1180
7.	Share certificate preparation for 1000 members	1	3000	270	270	3540
8.	Statutory book updation for one year	1	3000	270	270	3540
D.	**Sub Total (Professional Fees)**		**27000**	**2790**	**2790**	**28320**
E.	**Grand Total**		**34200**	**2790**	**2790**	**39780**

5. Statutory Compliance Structure of Producer Companies

Sl.No.	**Compliance**	**About**	**Nature of**

			Compliance
1.	Business Commencement E-filing	After Incorporation certificate is generated, all the promoters contribution should be deposited in bank. The bank statement has to be certified and efiling to be made to initiate business	Once
2.	GST Registration	GST Certificate is needed to efile taxes collected during sales and services.	Once
3.	GST Monthly & Quarterly filing	Even if nil tax collection, Monthly and Quarterly GST e-filing has to be made as per GST Mandate	Monthly & Quarterly
4.	Statutory Auditor Appointment	FPC board should first appoint a Chartered Accountant by proper board resolution followed by filing of auditor appointment within 15 days of incorporation. If not, then filing is accompanied with fine amount.	Applicable from 1 to 5 years, but can be removed any time as per Companies Act.
5.	Organizing First Annual General Meeting (AGM)	As Per Producer Company act, first AGM should be organized within 90 days from incorporation of company.	Once
6.	Annual General Meeting	Consecutive Annual General Body Meeting has to be held within 15 months from the first General body meeting for each financial year.	Once in 15 Months
7.	Audited Statement Preparation & filing	Before each annual general body meeting, audited statement with Profit –Loss statement &Balancesheetshould be prepared by the board and to be sent with notice of annual general body meeting prior of 25 days of AGM.	For each financial year
8.	Annual Return filing	Annual return is filed to show the shareholding by various shareholders and percentage of share hold. Apart from this e-form of registers can be filed.	For each financial year
9.	Income Tax Filing	All those companies registered within march are bound to file income tax within September last week. For this, the company Pan card has to be registered with Income tax filing website. Then all the details extracted from audited statement are filled at Income tax filing website	For each financial year
10.	Fresh Equity Filing	Farmer members registering through FIGs provided shareholder certificates and the equity contributed is also intimated to Registrar of Companies through Fresh Equity allotment e-filing	Any time, as per need to increase the farmer member shareholding

11.	Record keeping	Various registers are maintained like Register of Members, Register of Directors and Key Managerial Personnel and Their Shareholding, AGM meeting Minutes, Board Meeting minutes, Register of Shares.	Maintained as per activity with monthly monitoring

Background for forming a Fisheries FPO

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Role of FPO in Fisheries

- Enhance participation and consultation of all stakeholders in the planning, development and management of aquaculture, including the promotion of codes of practice and BMPs.
- Facilitate mechanisms for voluntary self-regulation for attaining best practices such as the cluster management concept.
- Promote the appropriate and efficient use of resources, including water, sites, seed, stock and other inputs.
- Develop human resource capacity by facilitating the provision of training, technology transfer and access to information.
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Benefits of a Fisheries FPO

- Highlighting farmer problems.
- Mobilizing public and institutional support for farmers.
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Conclusion

- At present, the best solution for meeting farmers / fish farmers’ problems lies in institutionalizing farmers into legal framework. Farmer Producer Organization provides all necessary structures including administrative, legal, technical, economical and social structures with permanency. FPO is future of Extension. We need to equip ourselves to meet this challenge.

Chapter 32

Value Chain in Fisheries: Global Issues and Opportunities

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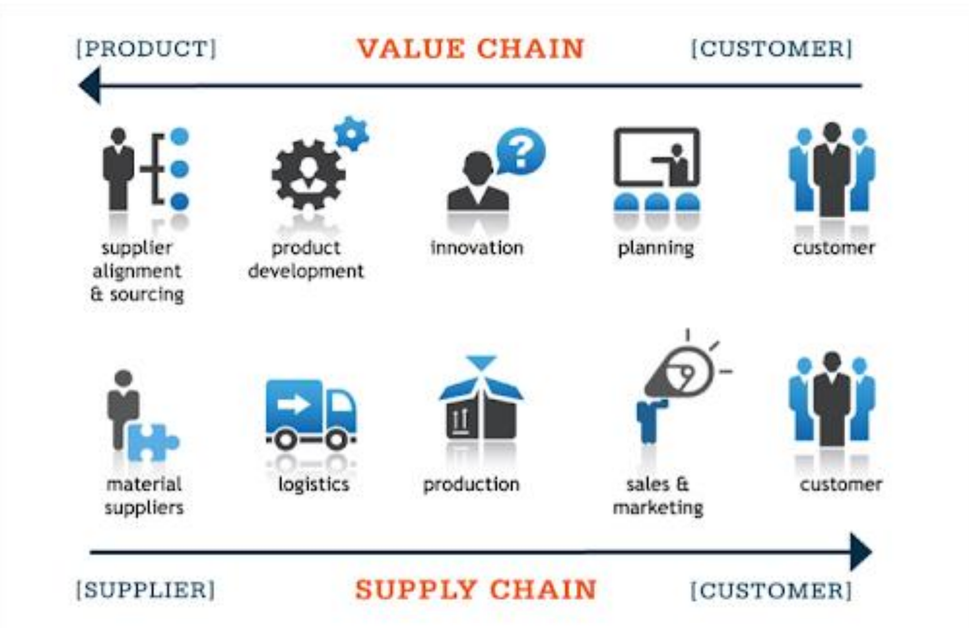
Value chain analysis and its management is a strategic planning tool used in analyzing the value chain of a company or sector or a product. 'value chain' was first introduced by Michael porter in his book 'Comparative Advantage' during 1985. It is defined as "*the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final customers, and final disposal after use*".

The word 'supply chain' and 'value chain' differed in terms of the flow of activities. Supply chain covers the activities of the downstream flow of activities from source (supplier) to consumer. The starting point of supply chain is producer (fishermen). This is also called as producer driver chain. But, value chain flows reverse i.e., from consumer to supplier. This is also referred as 'demand chain' and consumer driven chain (Fig. 1).



Source: http://www.mepsupplychain.org

Fig. 1. Supply chain Vs Value chain

Each value chain consists of different actors and activities which ultimately determines the length and scope of the chain. A value chain has mainly two components viz., actors and activities.

i. Actors: Actors are the drivers of the value chain who are the major driving force in operating the value chain. Ex: Suppliers, producers, wholesalers, retailers.

ii. Activities: A typical value chain consists of activities such as design, production, marketing, distribution and support to the final consumer.

Actors are the players who are the part of the value chain viz., suppliers, producers, wholesalers, retailers and consumers. The activities of value chain comprised of both primary and supporting activities. Primary activities can be classified into production and marketing activities that encompass inbound logistics, operations, outbound logistics, marketing & sales and services. The supporting activities comprised of procurement, technology development, human resource management and infrastructure. These activities are linked together through inter relationship. Porter has explained the value chain using framework approach and derived a value chain framework (Fig. 2).

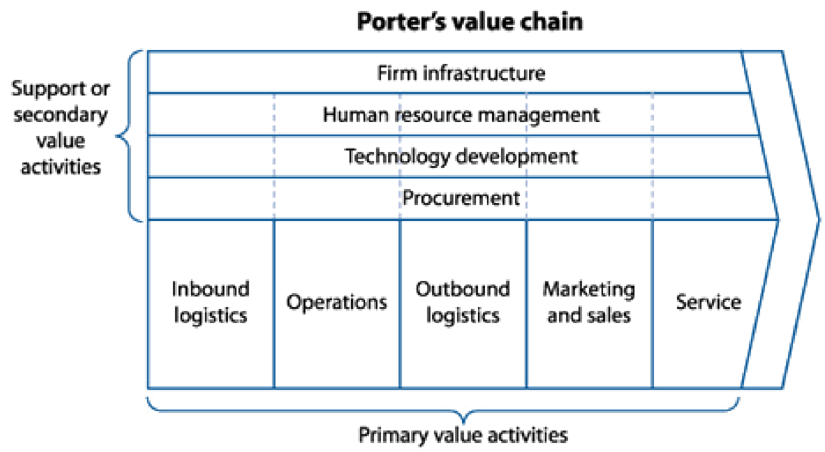
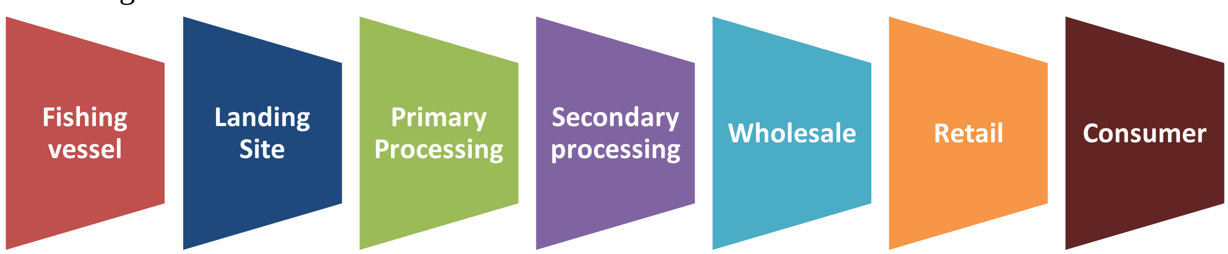


Fig. 2 Porter's Value chain framework

Value chain in fisheries

Like all products, the value chain in fisheries has included the all the common actors and activities with modifications of time and space. The common value chain in fisheries included the primary actors as given below.



Fig,3,Fish value chain in India

In every value chain, the concern is towards increase the producers' share, minimum cost of the processes, increase the efficiency and effectiveness of the actors, eliminate the unwanted processes i.e., non-value addition, quality assurance in product development and ensure consumer satisfaction.

Value chain analysis process

Value chain process comprises of various steps towards improve the value chain improvement analysis. It starts with the selection and prioritization followed by value chain mapping and analysis. After the value chain analysis, the formulation, up gradation and monitoring was carried out. The final step is for assessing the impact of the value chain. In the global value chain scenario, the dimension of value chain has been expanded by incorporating the concepts of Integration (Integrated value chain) and Sustainability (sustainable value chain). The value chain has been expanded by incorporating value creation, value capture and value networks. This resulted in establishing a new chain by lining supply chain, value added chain and transport (distribution) chain.

Methodology for undertaking value chain research

The methodology for assessing the value chain was formulated by using the steps involved in value chain analysis (Fig. 4).

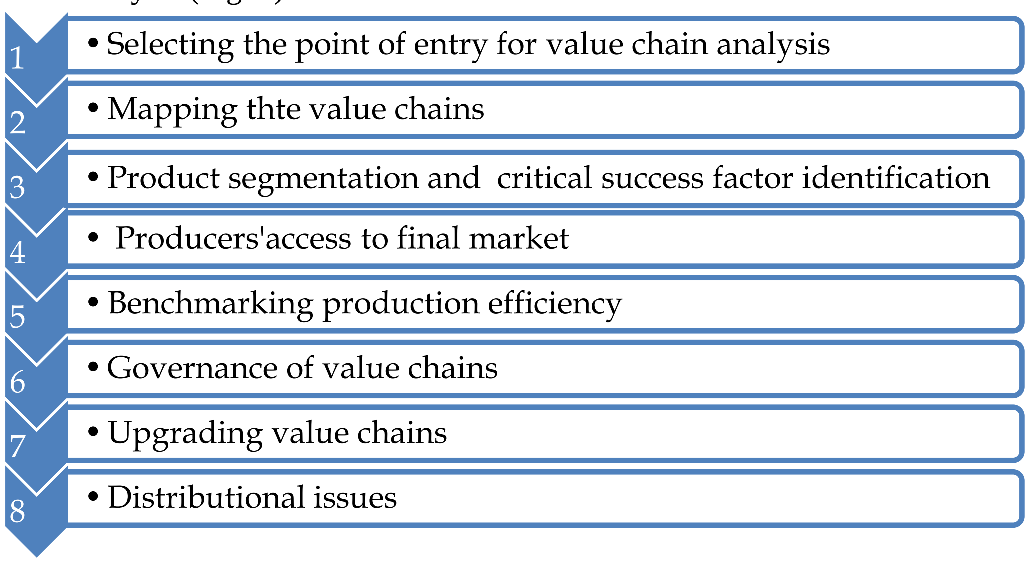


Fig. 4. Methodology used for value chain analysis

The methods for carrying out the value chain research include selection of point of entry, mapping and analysis. The bench marking, governance, upgradation of value chain should also be assessed. The identification of distribution and impact issues are also part of the methodology. The steps in implementing the value chain approach in fisheries include a value chain mapping, stakeholder mapping and detailed strategies for addressing the challenges and constraints.

Global Value chain (GVCs)

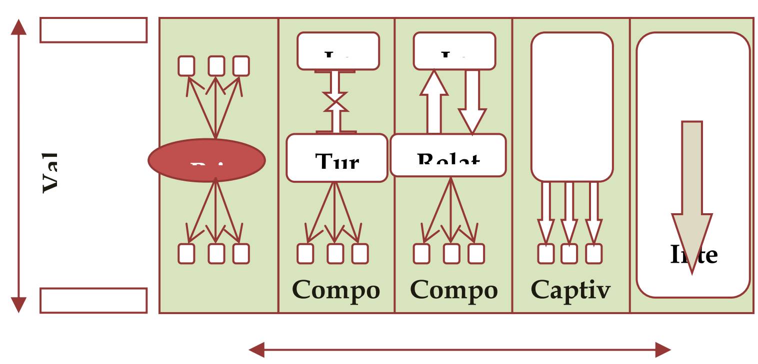
The concept of 'Global Value Chain' played a significant role in the globalisation era with incorporation of international production, trade and investments. This means that the different stages of production process which are specific to countries were linked across countries through value chain processes. This necessitates the restructuring of operations to international standards and regulating trade barriers in the particular sector. In general, GVC incorporates the local production to the global markets. The governance of GVC depends on various dimensions. The input-output structure, geographical consideration, governance structure, institutional context and upgrading are the various dimensions through which the local production can be improved towards linking with the global value chain (Table. 1)

Table 1 . Dimensions of Global Value Chain

Dimensions	Description
Input – output structure	Process of transforming raw materials into final products
Geographical consideration	Identification of lead firm/ country in the global scale
Governance structure	How the VC are controlled (way of controlling and co-ordinating actors)
Institutional context	Institutional set up in which VC is embedded
Upgrading	dynamic movement within the value chain by examining how producers shift between different stages of the chain

Value chain governance

Governance of value chain is linking the various actors and activities of value chain by utilising power asymmetry and co-ordination based on different situations, time and regions. The common value chain governance types are given in Fig.5.



Source: Gary Gereffi (2013)

Fig. 5. Types of value chain governance

The governance of GVC depends on the degree of co-ordination and power asymmetry. There are five types of value chain governance viz., market, modular, relational, captive and hierarchy.

Determinants of global value chain governance

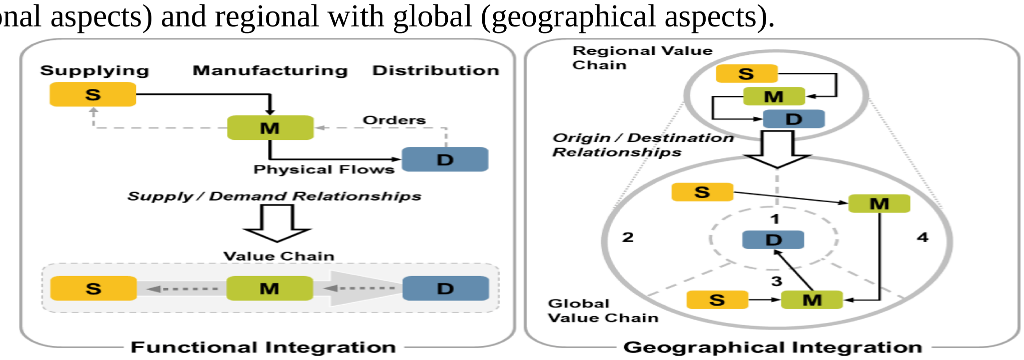
Value chain patterns are not static, it changes over time, region and product. Even in particular industry, there is possibility of intra variation in governance pattern among various stages. The variations in value chain are mainly attributed by three variables extensively. In all the governance types, the degree of power symmetry and explicit co-ordination will act from low to high. These determinants will form various combinations and scenarios for execution. The key determinants which affect the dynamics in the value chain are presented below in Table 2.

Table. 2 Determinants of global value chain governance

Type of governance	Transactions complexity	Transactions ability	Supply base capability
Market	Low	High	High
Modular	High	High	High
Relational	High	Low	High
Captive	High	High	Low
Hierarchy	High	Low	Low

Transparency in value chains

Transparency in value chain can be achieved through confession of information between or among the actors. The information includes production and supplier sources, prices, timing of harvest and resources availability. This is the primary mechanism to ensure sustainability in the value chains. This transparency in value chain can be ensured through functional and geographical integration. In many times, the operational and regional differences influence the GVC in larger way. This can be carried out through integration of activities viz., supply, manufacturing and distribution (Functional aspects) and regional with global (geographical aspects).



Source: *Rodrigue, J-P (2006)*

Tools used in value chain analysis

The data required for the analysis can be collected using either quantitative or qualitative or both. The questionnaire or interview schedule is used for collecting the quantitative data. The qualitative data can be collected through semi-structured questionnaire and focus group discussion. The data collected were analysed using various econometric tools viz., means, proportions, ranks, factor analysis, cronbach's alpha and regression analysis. These analyses are used to find out the dominant actor and activities in terms of cost and value. The tools used for data collection and data analysis in value chain analysis are presented in Table. 3.

Table. 3. Tools used in value chain analysis

Data collection tools	Data analysis tools
I. Quantitative tools	I. Means, proportions and ranks
i. Questionnaire / interview schedule	II. Factor analysis Eigen values Chi-square values Kaiser-Meyer-Olkin (KMO) Barlett's Test of sphericity
II. Qualitative tools	III. Cronbach's Alpha
i. Semi-structured interview ii. Focus group discussion	IV. Regression analysis

Issues related to Value Chain Analysis

The issues related to value chain analysis are classified under broad categories viz., macroeconomic issues (covers capital flows and their volatility), political issues (covers the factors determining the investment productivity) and social capital determinants. Value chain analysis provides important insights into these four issues. Of course it does not tell the whole story, which to be complete would also have to address macroeconomic issues (particularly capital flows and their volatility), political issues (particularly the factors determining the rate and productivity of investment) and the determinants of social capital. But value chain analysis, which focuses on the dynamics of inter-linkages within the productive sector, especially the way in which firms and countries are globally integrated, takes us a great deal further than traditional modes of economic and social analysis.

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ITEC Programme on
"Improving fishery based livelihood: Policies, Technologies and Extension Strategies"

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ITEC Training Programme on

IMPROVING FISHERY BASED LIVELIHOOD: POLICIES, TECHNOLOGIES AND EXTENSION STRATEGIES

(Under ITEC, Ministry of External Affairs, Govt. of India)

(13 – 26 February, 2020)

Organised by

ICAR- Central Institute of Fisheries Technology

Cochin-682029, Kerala

Date (Day)	Session Time	Topic	Resource person
13 Feb., 2020 (Thursday)	**09.30 am- 10.30 am**	**REGISTRATION followed by Pre-Training Evaluation**	
	10:30 am- 11.45 am	**INAGURATION**	
	11.45 am - 12.00 pm	**TEA**	
	12.00 pm- 1.15 pm		
	1:15 pm - 2:30 pm	**LUNCH**	
	2:30 pm – 3:30 pm	Visit to ATIC, CIFT Labs, Workshops and Processing plants	**Dr. M. Baiju, EIS**
	3:30 pm- 3:45 pm	**TEA**	
	3.45 pm- 4.45 pm	Visit to ATIC, CIFT Labs, Workshops and Processing plants	**Dr. M. Baiju, EIS**
14 Feb., 2020 (Friday)	**09.30 am- 10.00 am**	Reflections on previous day class (WILY Session)	**Course Coordinators**
	10:00 am- 11.00 am	CIFT: Its contribution to Indian fishery	**Dr. Ravishankar C.N. Director, ICAR-CIFT**
	11.00 am - 11:15 am	**TEA**	
	11:15 am- 12:15 pm	Novel extension approaches for technology dissemination in fisheries	**Dr AK. Mohanty HOD (EIS)**
	12:15 pm – 1:15 pm	Sustainable Fishing Practices	**Dr Leela Edwin HOD (FT)**
	1:15 pm - 2:30 pm	**LUNCH**	
	2:30 pm – 3:30 pm	Improved fish drying and packaging *(Practical)*	**Dr. S Murali Dr. Aniesrani Delfiya**

			Dr Sarika
	3:30 pm- 3:45 pm	TEA	
	3:30 pm- 3:45 pm	Improved fish drying and packaging *(Practical)*	Dr. S Murali Dr. Aniesrani Delfiya Dr. Sarika
15 Feb,, 2020 (Saturday)	09.30 am- 10.00 am	Reflections on previous day class (WILY Session)	Course Coordinators
	10:00 am- 11.00 am	Improving value of fisheries sector: Policies and promotion	Dr A Suresh Principal Scientist
	11.00 am - 11:15 am	TEA	
	11:15 am- 12:15 pm	Developing Nutraceuticals from Fish	Dr Suseela Mathew, HOD (B & N)
	12:15 pm – 1:15 pm	Value chain in fisheries : Global issues and opportunities	Dr Pe Jeyya Jeyanthi Scientist (EIS)
	1:15 pm - 2:30 pm	LUNCH	
	2:30 pm – 3:30 pm	Visit to Sea food processing and export firms **Baby marine**	Mr. K. D. Jos/
	3:30 pm- 3:45 pm	TEA	
	3.45 pm- 4.45 pm	Visit to Sea food processing and export firms **Baby marine**	Mr. K. D. Jos
16 Feb., 2020 (Sunday)	Full day	Visit to Munnar Hill Station	Mr. V. Chandrasekar/ baiju
17 Feb., 2020 (Monday)	09.30 am- 10.00 am	Reflections on previous day class (WILY Session)	Course Coordinators
	10:00 am- 11.00 am	Assessment of harvest and post-harvest losses in fish value chain	Dr V. Geethalakshmi Principal Scientist(EIS)
	11.00 am - 11:15 am	TEA	
	11:15 am- 12:15 pm	Entrepreneurship Development in fisheries	Dr S Ashaletha Principal Scientist
	12:15 pm – 1:15 pm	Importance of AMR in fisheries	Dr M.M. Prasad HOD (MFB)
	1:15 pm - 2:30 pm	LUNCH	
	2:30 pm – 3:30 pm	Extruded product development (Theory & ***Practical)***	Mr. Sreejith S, Scientist (FP)
	3:30 pm- 3:45 pm	TEA	
	3.45 pm- 4.45 pm	Extruded product development (Theory & ***Practical)***	Mr. Sreejith S, Sreejith (FP)
18 Feb., 2020	09.30 am-	Reflections on previous day class (WILY	Course

(Tuesday)	**10.00 am**	Session)	**Coordinators**
	10:00 am-11.00 am	Gender empowerment in fisheries through SHGs	**Dr Nikita Gopal Principal Scientist (EIS)**
		TEA	
	11.00 am - 11:15 am	Technology Assessment and refinement (TAR): A tool for effective technology dissemination	**Dr. M.V. Sajeev Senior Scientist (EIS)**
	11:15 am-12:15 pm	Development of standards for ensuring seafood safety	**Dr S.K. Panda Principal Scientist,(QAM)**
	1:15 pm - 2:30 pm	**LUNCH**	
	2:30 pm – 3:30 pm	Value Added product development- (***Practical)***	**Dr. Sreelakshmi Dr. Sarika**
	3:30 pm- 3:45 pm	**TEA**	
	3.45 pm- 4.45 pm	Value Added product development- (***Practical)***	**Dr. Sreelakshmi Dr. Sarika**
19 Feb., 2020 (Wednesday)	**09.30 am- 10.00 am**	Reflections on previous day class (WILY Session)	**Course Coordinators**
	10.00 am- 11.00 am	Marine fisheries regulatory regime in India	**Dr P Shinoj, Senior Scientist, ICAR-CMFRI**
	11.00 am - 11:15 am	**TEA**	
	11:15 am- 12:15 pm	KVK initiatives in fishery sector development: Successful experiences	**Dr Shinoj Subramanian Sr Scientist &Head, KVK, Ernakulam ICAR-CMFRI**
	12:15 pm – 1:15 pm	Developing high value secondary products from fish waste	**Dr A.A. Zynudheen I/c HOD (QAM)**
	1:15 pm - 2:30 pm	**LUNCH**	
	2:30 pm – 3:30 pm	Fish Waste management- (***Practical)***	**Dr. Binsi P.K., Dr. Mandakini Devi**
	3:30 pm- 3:45 pm	**TEA**	
	3.45 pm- 4.45 pm	Fish Waste management- (***Practical)***	**Dr. Binsi P.K., Dr. Mandakini Devi**
20 Feb. 2020 (Thursday)	**09.30 am- 10.00 am**	Reflections on previous day class (WILY Session)	**Course Coordinators**
	10:00 am- 11.00 am	Engineering applications in Fisheries	**Dr.Manoj P Samuel HOD (Engg.)**

	11.00 am - 11:15 am	TEA	
	11:15 am- 12:15 pm	Ornamental Fisheries in India : Scope and development	Dr Pradeep Kumar, KVK, IISR, Calicut
	12:15 pm – 1:15 pm	ICT Applications in Fisheries	Chandrasekar Scientist
	1:15 pm - 2:30 pm	LUNCH	
	2:30 pm – 3:30 pm	Technology forecasting in fisheries	Dr V.K. Sajesh Scientist (EIS)
	3:30 pm- 3:45 pm	TEA	
	3.45 pm- 4.45 pm	Recent developments in fish processing technology	Dr K. Ashok Kumar, HOD (FP)
21 Feb., 2020 (Friday)	**Full day (Holiday)**	**Visit** to **Puthotta Farm**	**Dr. M. Baiju, EIS Division)**
22Feb., 2020 (Saturday)	**09.30 am- 10.00 am**	Reflections on previous day class (WILY Session)	**Course Coordinators**
	10:00 am- 11.00 am	Establishing fish based micro-enterprises for livelihood security- Scope and opportunities	**Dr. Vipin Kumar, Principal Scientist, ICAR-CMFRI**
	11.00 am - 11:15 am	**TEA**	
	11:15 am- 12:15 pm	Farmers Producer Organizations for sustaining fisheries : Ways and means	**Dr. G. A. K. Kumar Head, Social Science, NRRI, Cuttack**
	12:15 pm – 1:15 pm	Co-Governance of responsible fisheries	**Dr C. Ramachandran, Principal Scientist, CMFRI, Cochin**
	1:15 pm - 2:30 pm	**LUNCH**	
	2:30 pm – 3:30 pm	Boosting Start-ups through Agri-business incubation (Interactive lecturette)	**Dr. G. A.K. Kumar Head, Social Science, NRRI, Cuttack**
	3:30 pm- 3:45 pm	TEA	
	3.45 pm- 4.45 pm	Boosting Start-ups through Agri-business incubation (Interactive lecturette)	**Dr. G. A. K. Kumar Head, Social Science, NRRI, Cuttack**
23 Feb., 2020 (Sunday)	**Full day**	**Local sightseeing**	**Mr. K. D. Jos and Mr. Rakesh M Raghvan, EIS Division**
24 Feb., 2020 (Monday)	**09.30 am- 10.00 am**	Reflections on previous day class (WILY Session)	**Course Coordinators**
	10:00 am- 11.00 am	Technology commercialisation: CIFT Experience	Dr George Ninan Principal Scientist (FP)

	11.00 am - 11:15 am	TEA	
	11:15 am- 12:15 pm	Export promotion for fish and fishery products	**Dr. Shine Kumar, MPEDA**
	12:15 pm – 1:15 pm	Open Cage culture – a livelihood opportunity for coastal women	**Dr Imelda Joseph I/c HOD, Mariculture ICAR-CMFRI**
	1:15 pm - 2:30 pm	LUNCH	
	2:30 pm – 3:30 pm	Visit to fisheries institutes in Cochin (CMFRI, MATSYAFED, NIPHATT, CIFNET, MPEDA)	**Mr. Santosh K.D., EIS**
	3:30 pm- 3:45 pm	TEA	
	3.45 pm- 4.45 pm	Visit to fisheries institutes in Cochin (CMFRI, MATSYAFED, NIPHATT, CIFNET, MPEDA)	**Mr. Santosh K.D., EIS**
25 Feb. 2020 (Tuesday)	**09.30 am- 10.00 am**	Reflections on previous day class (WILY Session)	**Course Coordinators**
	10:00 am- 11.00 am	Community based organisations for climate smart agriculture	**Dr. Kalavathy, S Principal Scientist, CPCRI**
	11.00 am - 11:15 am	**TEA**	
	11:15 am- 12:15 pm	Improving data quality for effective knowledge management in fisheries	**Dr J. Jayasankar, Principal Scientist ICAR-CMFRI**
	12:15 pm – 1:15 pm	Farmers' First Approach in fisheries- Concepts and methodologies	**Dr. Anitha Kumari, P Principal Scientist, CPCRI**
	1:15 pm - 2:30 pm	LUNCH	
	2:30 pm – 3:30 pm	Preparation for Country Presentation	
	3:30 pm- 3:45 pm	TEA	
	3.45 pm- 4.45 pm	Preparation for Country Presentation	
26Feb. 2020 (Wednesday)	**09.30 am- 10.00 am**	Reflections on previous day class (WILY Session)	**Course Coordinators**
	10:00 am- 11.00 am	Behavioral interventions for sustainable fishing in India	**Dr. K. Rejula Scientist (EIS)**
	11.00 am - 11:15 am	TEA	
	11:15 am- 12:15 pm	**COUNTRY PRESENTATION**	**ITEC Participants**
	12:15 pm – 1:15 pm	**COUNTRY PRESENTATION**	**ITEC Participants**
	1:15 pm - 2:30 pm	LUNCH	

	2:30 pm – 4.00 pm	**VALEDICTORY SESSION**	

Programme Director : Dr. Ravishankar C.N., Director, ICAR-CIFT

Course Director

Dr. A.K.Mohanty, HOD,EIS

Course Coordinators

1. Dr. S.Ashaletha,Principal Scientist
2. Dr. A.Suresh, Principal Scientist
3. Dr. M.V.Sajeev, Senior Scientist
4. Dr. Pe.Jeyya Jeyanthi, Scientist

Training Coordinators

1. Shri. K. D. Jos ,ACTO
2. Shri. K. D. Santosh.STA
3. Smt.Sruthi.P,TA
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