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‘NUTRISMART FISH’ to Boost the Nutritional Security of the Rural Women

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Programme Coordination
ICAR- Central Inland Fisheries Research Institute, Barrackpore, Kolkata

Jointly Published By
ICAR-CIFRI, Barrackpore, Kolkata
&
MANAGE, Hyderabad

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Published for Dr.P.Chandra Shekara, Director General, National Institute of Agricultural Extension Management (MANAGE), Hyderabad, India by Dr. Srinivasacharyulu Attaluri, Program Officer, MANAGE and printed at MANAGE, Hyderabad as e-publication.

MESSAGE

National Institute of Agricultural Extension Management (MANAGE), Hyderabad is an autonomous organization under the Ministry of Agriculture & Farmers Welfare, Government of India. The policies of liberalization and globalization of the economy and the level of agricultural technology becoming more sophisticated and complex, calls for major initiatives towards reorientation and modernization of the agricultural extension system. Effective ways of managing the extension system needed to be evolved and extension organizations enabled to transform the existing set up through professional guidance and training of critical manpower. MANAGE is the response to this imperative need. Agricultural extension to be effective, demands sound technological knowledge to the extension functionaries and therefore MANAGE has focused on training program on technological aspect in collaboration with ICAR institutions and state agriculture/veterinary universities, having expertise and facilities to organize technical training program for extension functionaries of state department.

Nutrition and health are related to each other as good nutrition is the cornerstone of a good health. A balanced diet containing all the essential nutrients is necessary to build a good health. Fish is cheapest source of animal protein and considered as one of the complete food which contains high amount protein, good amount unsaturated fatty acid, essential amino acids and micro-and macro-minerals including essential vitamins and therefore, can meet the hidden hunger and malnutrition faced by weaker section and especially for women of our country. Consumption of fish twice in a week can not only improve the health and immunity in women, but also improve brain development, strength and mental well-being of women. Among all animal protein, the price of the fish is most stable and affordable to common man. Therefore, mass campaign/movement is required to make the people aware about health benefits of consumption of fish.

It is a pleasure to note that, ICAR- Central Inland Fisheries Research Institute, Barrackpore, Kolkata and MANAGE, Hyderabad, Telangana is organizing a collaborative training program on 'NUTRISMART FISH' to boost the Nutritional Security of the Rural Women from 10-12 August, 2021 and coming up with a joint publication as e-book on '**NUTRISMART FISH' to boost the Nutritional Security of the Rural Women** as immediate outcome of the training program.

I wish the program be very purposeful and meaningful to the participants and also the e-book will be useful for stakeholders across the country. I extend my best wishes for success of the program and also I wish ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata many more glorious years in service of Indian fisheries and allied sector ultimately benefitting the fish farmers. I would like to compliment the efforts of Dr. Shahaji Phand, Center Head-EAAS, MANAGE and Dr. Aparna Roy, Senior Scientist, ICAR-CIFRI for this valuable publication.

Dr. P. Chandra Shekara
Director General, MANAGE

Foreword

ICAR-Central Inland Fisheries Research Institute is a premier research institute in the field of inland fisheries sector in India under the Ministry of Agriculture and Farmer's Welfare, New Delhi. ICAR-CIFRI is relentlessly working towards the development of inland fisheries in India not only in terms of production enhancement and revenue generation through introduction of advance technologies but also working for the betterment of livelihood of fishers through introduction of various cost-effective technologies in a sustainable ecosystem based approach. Ensuring nutritional security is a prerequisite for a healthy society that eventually leads to the growth and development of the country. India is facing enormous challenges to tackle the 'hidden hunger' of the young, marginal, landless and underprivileged population. Despite, multiple nutritional intervention schemes at community level, malnutrition and under–nutrition remain a public health issue which needs to be addressed with utmost care and responsibility. The debilitating effects of nutritional deficiencies due to lack of essential nutritients in daily diet is more prominent in case of women and children especially from rural areas compared to that of urban population which indicaets towards the socio-economical disparity and requires immidieate intervention. Fish embodies more than a basis of protein source in human diet and endowed with essential micronutrients, minerals and vitamins which could be utilised to tackle the problems of under-nutrition and malnutrition. Hence, 'Fish for all' concept was initiated globally by World Fish to improve food and livelihood security of the rural poor of the developing countries. Incorporation of nutrient rich Small Indigenous Fish in the daily diet of undernourished and malnourished population through different Government Schemes may help our country to achieve the focus of nutritional security through accomplishing the goal of wholesome human nutrition.

In this context it is to mention that inland fisheries contribute more than 12.60 million metric tonnes of fish per year to food basket of India. ICAR-CIFRI has research experience on 'NutriSmart' fish species and also human-based dietary management study to boost the nutritional security of rural women of Sundarbans. Keeping this in view the training programme has been proposed to sensitize the extension functionaries about the importance of Nutrismart fish species for enhancing the nutritional security of the rural populace and also the the marginalized community of our country.

This e-book contains important topics on nutritional security of women *vis-à-vis* livelihood on fisheries resources. The book also covered topics to create awareness amongst the professionals on basic health care of women at different age group through better nutritional intervention. Lectures delivered by the interdisciplinary group of experts from social, medical, agriculture and allied subjects are captured in this book. Hope wide circulation of this book will help a large number of readers to enrich their knowledge on this important topic.

August, 2021.

Dr. B. K. Das
Director, ICAR-CIFRI

PREFACE

This e-book is an outcome of collaborative online training program on "NUTRISMART FISH' to boost the Nutritional Security of the Rural Women". This compendium is intended for Faculty/students of Fishery Universities, Scholars, Students and SMS (Fishery Science), ICAR Institutes, Fishery Colleges, SAUs, KVKs and State Fishery Officers., who are likely to take part in dispersal of the concept of Nutritional Fish to rural areas in future. So, there is need to update their knowledge regarding advances in technologies and its adaptation and dissemination. The content of proposed training programme has been designed in such a way, so that it can provide updated information towards capacity building in proposed area. Topics like assessment of nutritional needs of rural people, importance of nutritional intervention during pre and post-natal stage, common nutrient deficiency disorders in women and possible preventive measures have been included to sensitize the participants about the significance of nutrition on the wellbeing of people with focus on rural women. Topics like fish as health food, SIF to boost nutritional security from CIFRI's experience, 'Nutri-smart' fish to address hidden hunger is going to highlight the potential role of fish in tackling the issues of nutritional deficiency. The introduction to various 'Nutri -smart' fish species and the technological interventions required for successful production of nutria-smart fish and similar fish food products are covered in topics like orientation on 'Nutri-smart' fish species, nutritional requirement-based value addition on fish and fishery products, cost-effective nutritional sensitive innovations to address nutritional security and innovations in agricultural extension and manage initiatives and finally 'Nutri-smart' fish as potential source of livelihood is covered in the topic 'Nutri-smart' fish a potential avenue for livelihood security.

The valuable suggestions for future improvements are always welcome.

August, 2021

Editors

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ICAR-CIFRI – A National Institute of repute striding towards humankind

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The Indian Council of Agricultural Research-Central Inland Fisheries Research Institute (ICAR-CIFRI) is a premier research Institute of pre-independence era in India catering to fisheries research, training, extension and developmental activities in inland open waters with an aim of sustainable fishery, ecological, and human resource management. Recognizing the role of inland fisheries, Government of India established a Central Inland Fisheries Research Station at Calcutta on 17 March 1947, under the then Ministry of Food and Agriculture. Later, in 1959, the Central Inland Fisheries Research Station was elevated to a full-fledged Research Institute as "Central Inland Fisheries Research Institute". Later, in 1967, it came under the administration of the Indian Council of Agricultural Research, Ministry of Agriculture (currently Ministry of Agriculture and Farmers' Welfare), New Delhi. CIFRI is mandated to conduct basic, strategic and applied research for sustainable management of inland open water resources, develop protocols for productivity enhancement in reservoirs and wetlands, aquatic ecosystems management and also, human resource development. Presently, the Headquarter of the Institute is located at Barrackpore, West Bengal; and the Regional Research Centers are located at Allahabad, Guwahati, Bangalore and Vadodara, with Research Centers at Kochi and Kolkata. Since its inception, CIFRI has been instrumental in developing a number of epoch-making inventions in inland fishery sector viz,

- Induced breeding
- Air-breathing fish culture
- Composite fish culture
- Developing of small - and large-scale reservoir fisheries management
- Integrated wetland management through co-participation models
- Enclosure (Cage and pen) culture
- Riverine biodiversity conservation and ranching
- Fish for human health
- Conservation of Hilsa

- Climate smart fisheries
- Monitoring pollutants in inland waters
- Fish and aquatic health management
- E-flow in Indian rivers
- Application of GIS in inland fisheries
- Application of biotechnology & nano-technology for eco-health management
- Big Data in inland fisheries
- Reaching to outreach

ICAR-CIFRI has been pioneering in developing state of the art research facilities and expertise in inland fisheries including reservoir and wetland ecology and fisheries, riverine and estuarine fisheries, ecosystem and fish health, climate resilient inland fisheries, resource assessment, modelling and fisheries socio-economics, since its establishment. The Institute has accomplished significant scientific and technological progresses towards generating knowledge base for ensuring sustainability of inland open water ecology, aquatic biodiversity, fisheries, nutritional and livelihood securities. The Institute has been addressing the Sustainable Development Goal (SDG) # 1, 2, 5, 8, 13, 14 through different programmes towards humanity and national development. The Institute has been serving the inland open water sector includes rivers and canals (1,95,210 km), flood plain wetlands (1.2 million ha), reservoirs (3.51 million ha) and estuaries (0.029 m. ha) basically besides many derelict water bodies, and contributes 20% of inland fish production and 15% of India's fish production.

The Mandate

From a modest beginning as an aquaculture Institute reaching to a Natural Resource Management Institute (NRM) with the passage of time focussing on scope, utilization and enhancing fisheries from inland open water fishery resources with present mandate as follows:

- Basic and strategic research for sustainable management of inland open water resources
- Develop protocols for productivity enhancement in reservoirs and wetlands and aquatic ecosystems health management
- Act as repository of information on inland open water fisheries resources
- Human resource development through training, education and extension

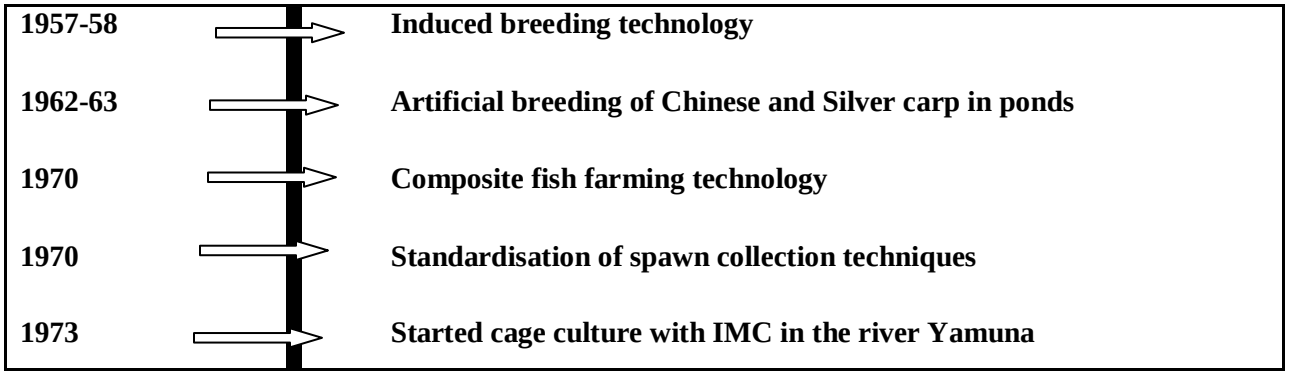
Specific objectives of the Institute activities

- Understanding the aquatic ecology, habitat quality, bio-diversity and assessment of fish stocks for sustainable fisheries in rivers and estuaries
- Formulation of ecosystem-based management plans for enhancing fish production and productivity of reservoirs and wetlands
- Assessment and monitoring environmental health fordevelopment of mitigation plans for inland open water resources
- Strengthen the support system through mapping and estimation of the aerial expanse of inland aquatic resources by GIS
- Develop prediction models based on time series information on different inland open waters
- Study the socio-institutional, livelihood and valuation issues in inland fisheries to address key interventions and measures for up-liftment of fisher community
- Address training and awareness needs in the sector
- Execute Outreach, TSP, SCSP and NEH activities towards development and propagation of technologies, especially for the tribal people and in North Eastern region

Major initiatives and achievements

The Fist Institute

Initiated, worked and reported on Induced breeding, composite fish culture, air-breathing fish culture, enclosure culture, Tilapia Lake virus, microplastics in inland waters, scientific river ranching, arsenic in inland waters & mitigation, hilsa conservation protocol and tagging, reservoir and wetland fisheries management, SIFs and mal nutrition prevention, E-flow protocol development, assessing pollutants in inland waters and so on (Fig. 1)



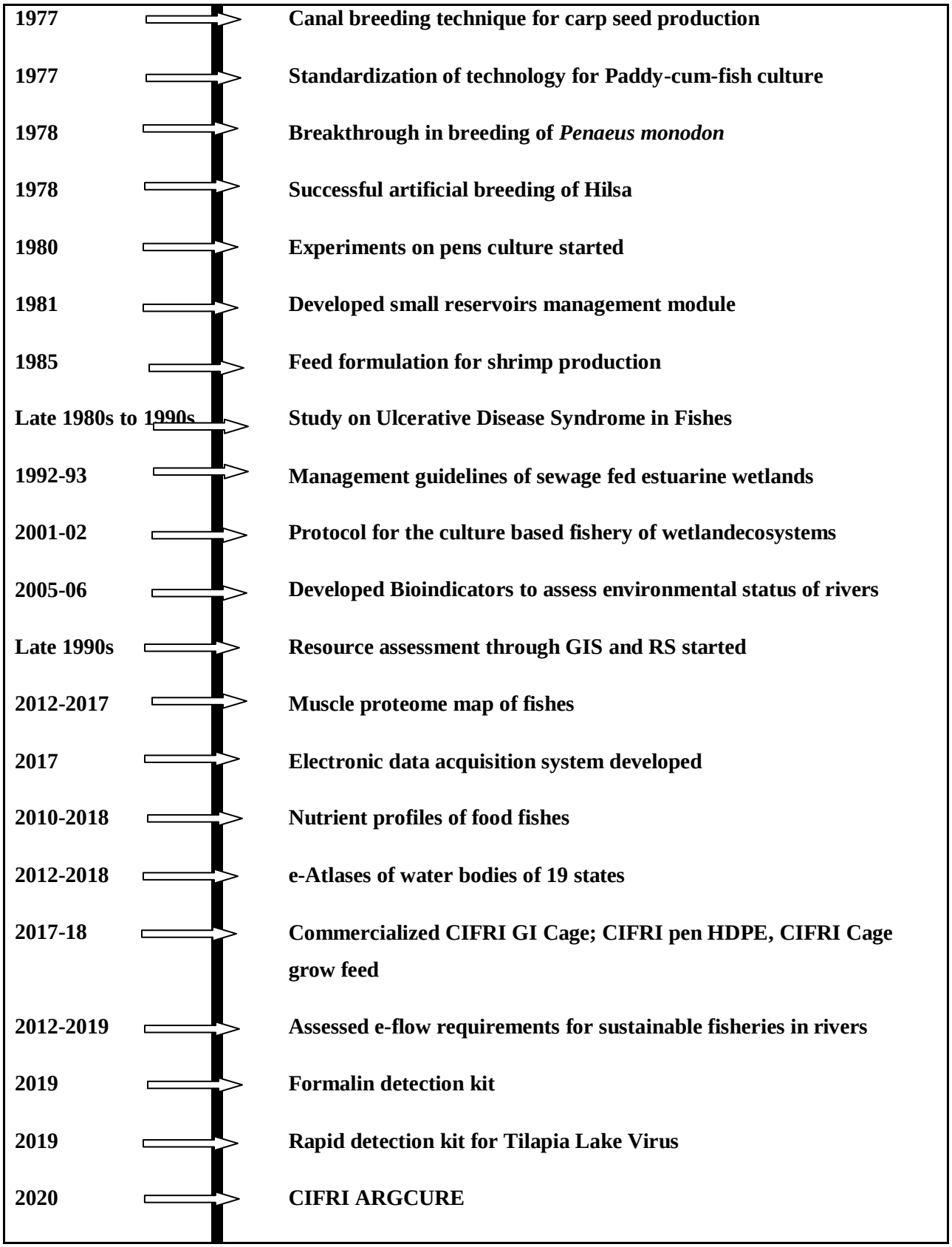


Fig 2: Major milestones of ICAR-CIFRI research

Reservoir fisheries development and livelihood security

The prime inland fisheries resource, the reservoirs, with a total water spread of 3.51 million ha, have immense untapped potentials to produce quality protein for the growing populace of India. Average productivity realized from Indian reservoirs was very low in earlier decades and through application of new technologies and innovations, tapping of the fish production potentials of the reservoirs have been progressed recently in a sustainable manner. The Institute initiated eco-friendly option of developing culture–based fisheries (CBF) based on carrying capacity in small and medium reservoirs coupled with the stock and species enhancement in large reservoirs. Successful demonstration and adoption of technologies on reservoir fisheries management has paved the way of enhancing reservoir yield substantially to 190, 98 and 34 kg/ha/year from small, medium and large reservoirs, respectively. Besides, employment generation of fishers moved upward from 30 man-days to 150 man-days/fisher household/year through adoption of CBF in reservoirs. Guidelines and best management practices for fisheries development in reservoirs have been formulated and in place. Strategic plan has been developed to achieve targeted yield of 50, 147 and 343 kg/ha/year from large medium and small reservoirs of the country under PMMSY in a more pragmatic manner.

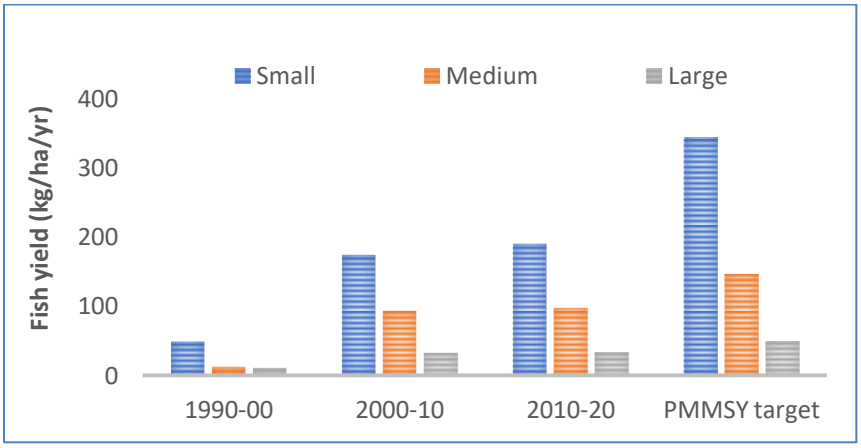


Fig 3. Increment in fish yield through technological intervention & PMMSY targets

Fisheries enhancement through CBF

Many conspicuous achievements in reservoir production across the country have been evolved. Fish yield of 58 small reservoirs of Odisha has increased by 158% through adoption of CBF.

Fish production level of 125 kg/ha/yr has been accentuated to in selected reservoirs of Chhattisgarh, Madhya Pradesh, Jharkhand, Karnataka and Tamil Nadu through CIFRI interventions. Fish yield of Indirasagar reservoir (largest reservoir), Gandhisagar reservoir (large reservoir) in MP has increased to 60 & 127 kg/ha/year respectively. The fish yield of Gobindsagar reservoir, HP, has been enhanced from 16 to149 kg/ha/yr through sound regular stocking program. Fish catch of Karapuzha reservoir, Kerala has increased from 18 to 150 kg/ha. Fish yield in 24 reservoirs of Chhattisgarh increased significantly from 80.43 to 374.46 kg/ha/year through CBF. Stock enhancement has duly reflected in fish production of large reservoir, Rihand, UP from 75.02 to 297.39 t/year.

Modelling approach and app based management

System specific mass balance models for ecosystem-based fisheries management of reservoirs have been developed by the Institute. Using Mass Balance Model, the carrying capacity of a medium size reservoir (Karapuzha) in Wayanad District, Kerala for Indian Major Carps (IMC) has been estimated Ecopath model was developed for Mettur reservoir, Tamil Nadu. Developed and successfully implemented e-Matsya, a mobile based application for fish catch estimation to resolve the issue of data deficiency in inland open waters. Management guidelines for control of Tilapia population and revival of carp fishery in Halali reservoir, MP were evolved. The strategic plan for fisheries development and management of MP and Gujarat part of Sardar Sarovar reservoir was also developed. The coming decades are to witness the harnessing the potential of reservoir fisheries of India with sustainable management with technical support.

Wetland fisheries development towards nutrition and livelihood security

India has vast floodplain wetland resources to the tune of 0.5 million ha situated in Ganga, Brahmaputra and Teesta-Torsa river basin locally known as *beel* (Assam, West Bengal, Tripura), *maun, chaur, dhal* (Bihar), *jheel* (U.P.) and *pat* (Manipur). These wetlands are among the most productive resources with a fish yield potential of 1500-2000 kg/ha/year offering multiple ecosystem goods and services benefitting millions of people in terms of livelihood and nutritional security. The Institute has been conducting research for ecological assessments and fisheries enhancement through various interventions and management models. Most promising strategies developed by the Institute for fisheries enhancement in wetlands were CBF and pen

culture. The highest fish production per ha area is achieved in West Bengal owing to good governance pattern through active fishermen cooperatives and adoption of scientific guidelines for CBF, macrophyte management and staggered stocking and harvesting and through development of skilled manpower. Adoption of CBF based fisheries protocols developed by the Institute has resulted in increase of fish yield exceeding 1500 kg/ha/yr in selected wetlands of Assam and West Bengal.

Average fish yield of 1,083 kg/ha/year was achieved in West Bengal. The mean fish yield increased from 258.5 kg/ha/yr in 2007-12 to 455.2 kg/ha/yr during 2012-17 from wetlands of Assam. Fish yield has reached upto 470 kg/ha/year in Bihar by adopting technologies with sizeable increment in man-days. CBF management in five mauns viz, Sirsa, Majharia, Rulhi and Kararia and Kothiya of Motihari district, Bihar in recent years has resulted in doubling of fish yield, from mere 75 kg/ha/yr to 470 kg/ha. This has addressed the '**ARYA**'-*Attracting Rural Youth in Agriculture* in a befitting manner minimizing the migration of the fishers from the villages as the employment generation through wetland fisheries has increased from 35 to 153 mandays/ year.

Table 1. Fish yield improvement in Bihar wetlands through CIFRI's intervention

Wetlands	Fish yield	
	Before CIFRI's intervention	After CIFRI's intervention
	kg/ha/yr	kg/ha/yr
Sirsa	190	290
Majharia	60	87
Rulhi	75	131
Kararia	180	470
Kothiya (open)	14	70

Integrated wetland management model and Pen culture

The institute has developed ecosystem based integrated wetland management model for fisheries enhancement and livelihood security, has been demonstrated in 5 oxbow lakes in Bihar which enhanced fish yield by 1.5-2.6 folds through participatory management. Refined and customized CBF management in wetlands in the States of Assam, West Bengal, Bihar, Uttar Pradesh for

fisheries enhancement and employment generation are in place. The institute has documented over 96 fish species from wetlands and taken several initiatives for biodiversity conservation. Refined and popularized pen culture technology with diversified indigenous fish species viz. *Labeo bata, Gudusia chapra, Amblypharyngodon mola, Puntius sarana, Heteropneustes fossilis, Etroplus suratensis, Villorita cyprinoides* besides IMC which has been adopted by States of West Bengal, Assam, Bihar, Meghalaya, Manipur and Kerala. Commercialised the ''CIFRI HDPE model pen'' culture technology which has been adopted by different States.

Addressing major issues and conservation of fisheries in riverine system

Area of work: Rivers: 29,000 km; 14 large (83%), 44 medium (7%) and numerous small (10%) Canals: 1.23 lakh km (both seasonal and perennial, highly underutilized for fisheries), Estuaries: 26 lakhs ha ; 56 numbers, (highly impacted and often overfished), Coastal lagoons: 1.9 lakh ha; (Highly fished) Mangroves: 4.4 lakh ha; (Biodiversity rich, vulnerable)

The major issues are: Degradation of habitat, deteriorating water quality and environmental flow. Declining fish stocks in all major rivers, estuaries and coastal lagoons. Shift in biodiversity. Decline in endemic fish species. Invasion of exotics. Loss of livelihood. Lack of database for management decision support focussing on preparation of sustainable fisheries management protocol / management guidelines of rivers, estuaries and associated mangroves

Thrust areas: Identification of critical habitat parameters for sustaining biotic integrity and fisheries, estimation of environmental flows requirement (both for species and ecosystem services), fish population dynamics and stock assessment for responsible fisheries,

Major achievements includes:

- Database on ecology, fisheries, biodiversity, flow, socio-economics, livelihoods, institutional mechanism of all major rivers and estuaries of India like Ganga, Yamuna, Brahmaputra, Narmada, Tapti, Mahanadi, Godavari, Krishna, Cauvery, Sutlej, Beas, Ken, Betwa, Gomti, Suvarnarekha, Damodar, Hooghly, Matlah, Sundarbans, Chilika, Pulikat, Vembanad, etc

- Environmental flows requirement estimated for selected stretches of rivers like Teesta, Nymazanchhu, Tangon, Dri, Cauvery, Sone, Mahanadi, etc
- Riverine health assessment through development of indices (like Index of Biotic Integrity) based on fish, plankton, macrobenthos, etc
- Participatory mangrove fisheries development, Livelihood improvement initiatives, Conservation of Small Indigenous Fishes (SIF) in Sundarbans
- Probable impact of river linking was estimated for river like Ken and Betwa
- Identified destructive role of bag nets and other zero mesh nets and prepared regulatory guidelines to conserve fisheries and biodiversity
- Monitored and estimated the impact of invasion of exotic fishes like Tilapia (*Oreochromis niloticus, Oreochromis mossambicus*), common carp (*Cyprinus carpio*), Pterygoplichthys spp., etc. on other riverine fishes
- Measured variation in biological and production characters in major carps along rivers like Ganga, Narmada, etc
- Developed methodology for collection of data and estimation of fish catch for river and estuarine ecosystems
- Collected time series data of fish catch composition at important riverine fish landing centres like Allahabad, Guwahati, etc
- Documentation of ITKs related to fisheries in rivers, estuaries, mangroves
- Helped other Governmental and Non-Governmental Organizations for preparation of management / Policy Guidelines through Consultancy services
- Identify the stretch for riverine spawn prospecting
- Discovered new species, new distributional records of fishes and other organisms from rivers, estuaries, lagoons
- Developed culture protocol of river prawns, *Macrobrachium rosenbergii*, *Paeneus monodon*, etc
- Developed aquaculture protocol for estuarine wetlands (Bheris)
- Climate change impact analysis on indigenous riverine fishes like *Glossogobius gaiuris* in river Ganga

- Study of extreme climatic events like cyclone, flood, etc on ecology of fisheries of Chilika, Pampa, Perriyar, etc
- Outreach and conservation awareness programmes among fishe
- Prepared fisheries management guidelines of important lagoons like Chilika, Pulikat, etc with documentation of their ecology and diversity
- Backwaters like Vembanad, Kayamkulam, etc were studied with intervention o enhance fishers' livelihood
- Prediction model prepared for catch of fish and shellfishes
- Partnering with National Mission for Yamuna Rejuvenation and Brahmaputra river Program for fish production enhancement and sustainable management.
- Focus on Precision farming in inland fisheries management using Drone/UAV and sensor based Technology
- Metagenomics for river pollution monitoring; Metagenomic analysis revealed bacterial and fungal diversity and their bioremediation potential from sediments of river Ganga and Yamuna.In addition to that, various beneficial microbiome and AMR have also been identitifedfrom these river sediments metagenome

River Ganga – received major attention in biodiversity conservation including ranching

- Assessment of fish and fisheries in entire river stretch – documentation of fish diversity and distribution in GIS platform
- Studied important tributaries like River Yamuna, Ghagra, Son, Gandak, Ramganga, etc to understand their impact on river Ganga
- Ranching with riverine germplasm for stock restoration of selected fishes like Mahseer, Indian Major Carps, etc
- Socio-economic status and livelihood asset mapping of fishers in river Ganga
- The Institute endeavoured with good initiatives for conservation and restoration of fishery resources of River Ganga through **National Mission for Clean Ganga** (NMCG) project. The river ranching program through this project has been attempting in re-establishing the declining fish stock of the river with ranching in identified depleted stretches of the river; during the last five years since 2015, 50 lakhs IMC fingerlings of >10 cm size of Ganga bred IMC have been ranched in to the entire riverine stretch from

Allahabad to Kolkata. Such initiatives were highly acclaimed at National level at the Ministry and future planning is in progress to adopt such methods of ranching in other vulnerable riverine systems of India including peninsular rivers.

Management of Hilsa fisheries

- Riverine fishery of the migratory (anadromous) prized fish Hilsa have been severely declined due to obstruction in its normal migration through dams, barrages, siltation, etc.
- Indiscriminate exploitation of brooders and juveniles along estuaries also played major role behind the decline
- Estimated the present stock and effort and prepared management guidelines in estuarine zone.
- Generate updated information on fisheries, migration, spawning for redefining management plan
- GIS based predictive map prepared for availability of Hilsa in Hooghly estuary
- Rational fishing / harvest strategies through modification of fishing gear for size-specific fishing
- Prepared conservation plans based on rational fishing through mesh size regulation, reduction of fishing effort, closed seasons, protected areas, etc through participatory approach
- Prepared plans to restore hilsa fisheries in barrage upstream
- Played leading role for development of aquaculture protocol of this prized fish
- Helped in State and Central Government policy preparation for sustainable Hilsa fisheries.

Re-establishing Hilsa fisheries in Ganga

Under the NMCG, ICAR-CIFRI has recently (2020-21) initialed to re-establish the Hilsa fisheries in river Ganga with salient achievements:

- First Hilsa ranching station was established on the right bank of river Ganga at upstream of Farakka barrage. The ranching station was selected after thorough investigation with

focus on hilsa transportation and availability in the downstream of Farakka barrage to acclimatize the Hilsa after transportation before ranching.

- Total numbers of 10,289 hilsa adult fish with an av. length of 322 mm and av.weight of 210 g was ranched in the upstream of the Farakka barrage. Fishers of Sahebganj, Balia, Bhagalpur and Patna reported that since last three decades, they had never caught hilsa but were surprised to catch hilsa of 150g to 250g though very less number (one or two)
- 735 adult fish were tagged with Floy T-bar anchor tags to understand hilsa migration. Tagged hilsa has been recorded at Munger and Balia, Bihar.
- More than 3200 fishers representing from the Prayagraj, Varanasi, Balia, Buxar, Patna, Bhagalpur, Rajmahal, Sultanganj and Farakka were made aware on the Hilsa life cycle, conservation and tagging of Hilsa for the migration study through locally printed pamphlets and leaflets even during the COVID19 pandemic situation.

New initiatives in riverine ecosyetem improvement

- Development of canal fisheries in Sundarbans as a means of improving livelihood of poor fishers
- Developed fish pass designs for dams and hydroelectric projects across rivers like Kameng, Mori, etc
- Prepared guidelines for barge movement to minimize loss of riverine ecology, biodiversity and fishers' livelihood.
- Distribution of nano-plastic materials in water, sediment and its impact on biotic communities
- The Institute is involved in developing aptamar based nano-biosensorusing various types of

  Nanomaterials for the detection of As, Hg, and pathogenic bacteria *Aeromonas veronii* from inland waters and diseased fishes, Developed mplecular recognition elements (MRE) for the detection of pesticides from waters

Conserving migratory fish species through effective fish passes

Fish passages are the civil structures made across the dams//barrages to facilitate easy migration of fish species. This results in sustainable fish production in the rivers. Under this background

ICAR-CIFRI has been taking up several scientific investigations suiting to the biological requirement for the migratory fish species like Hilsa, Mahseer and Trouts

a. ICAR-CIFRI has provided technical inputs to the IWAI, Ministry of Shipping towards fish passes designing for Hilsa fisheries
b. ICAR-CIFRI during 2012-20 carried out studies on the efficacy of the existing fish passes in the river Teesta and recommended for the technical improvement for the migration of Mahseer and Trouts.
c. During 2020-21, ICAR-CIFRI has provided technical support to the Sutlej Jal Vidut Nigam Limited (SJVNL) for establishing fish passes for the brown and snow trouts
d. Furthermore, ICAR-CIFRI working with Farakka Barrage Authority (FBA) towards improving the existing fish locks for effective migration of the Hilsa in river Ganga

Environmental flows for sustainable riverine fisheries

ICAR-CIFRI since last decade has been working on environmental flows for the sustainable fisheries in rivers. During this process

a. Established site specific and fish species method for the estimation of environmental flows for the river Teesta, Mahanadi, Etalin, Tamas, Sons and river Kathajodi.

b. ICAR-CIFRI in association with GIZ undr Indo-EU Water Platform has developed guidance document on"***Environmental flows assessment and implementation in India including lessons learnt from the European Union and Indian Pilot river basins****"* for river Ram Ganga, and Mahanadi delta The major focus is towards water requirement for key stone fish species for their effective migration, reproduction and survival in rivers (IEWP | India-EU Water Partnership)

c. ICAR-CIFRI has also developed national "***Guideline for maintaining longitudinal connectivity through Dams*****"** in association with Central Water Commission (CWC) with major recommendations on Fish pass, fish migration, nutrient exchange and environmental flows Guidelines for Maintaining Longitudinal Connectivity through Dams_final copy.pdf (cwc.gov.in)

d. ICAR-CIFRI as a part of scientific team, developed ***The Gazette of India on environmental flows for river Ganga*** *for sustainable habitat and fisheries REGD. NO. D. L.-33004/99 OCTOBER 10, 2018*

Environmental hazardous pollutants in inland waters

The Institute has been working at tandem in monitoring haardous pollutant for eco-health as well as human health since its inception. River pollution induced by heavy metals and pesticides in Ganga, Gomti, Mahanadi, Kathjodi, Godavari, Krishna, Cauvery were evaluated. Results indicated lower level of pollution in water phase with heavy metals (Zn, Cu, Cd, Pd, Cr, Mn) in few stretches while free from those elements in other stretches. However, a moderate level of pollutants of heavy metals in sediment was noticed in Godavari and Mahanadi. Residues of pesticides were detected in water albeit in very low concentration below critical limits of USEPA for aquatic life. In fishes of rivers, residues of few pesticides were accumulated but they were mostly within the tolerance limit of FSSI. Some new emerging contaminants like troclosan, oxytetracycline and their metabolites in the aquatic environment and their effect on biota and associated impact on human health was also assessed. Arsenic from arsenic prone area of West Bengal down the food chain has been assessed and regularly being monitored by the Institute. Field-based As residue analysis revealed *Ctenopharyngodon idella* (Grass carp) as lowest (<0.05 ppm) and *Oreochromis mossambicus* (Tilapia) the highest (1 ppm) accumulation if fishes. Low As accumulating food fishes were recommended viz, *Cirrhinus mrigala*, *C. idella*, scampi *Macrobrachium rosenbergii* as the candidate species for aquaculture in As prone areas.

Level of plastic pollution in Ganga system was first reported by the Institute revealing polyethylene, polypropylene, polyethylene-terephthalate as the most common type of plastic debris.

Major fish pathogen in inland waters

Bacteria, *viz. Aeromonas hydrophila, Citrobacterfreundii, Acinetobcterbaumanii* and *Pseudomonas aeruginosa* have been identified as major fish pathogens in West Bengal and Assam. The viral disease WSSV and parasitic disease EHP have been reported from shrimp (*P. monodon, P. vanammei*) farming systems of West Bengal. Parasitic diseases like *Argulus, Myxobolus, Dactylogyrus, Larnaea* and *Diplostomum etc.* were reported from the finfish farms of West Bengal and Assam.

Antimicrobial resistance (AMR) in Fisheries and Aquaculture

Under the ONE-HEALTH approach towards combating AMR, ICAR-CIFRI has been working towards surveillance of AMR in the open waters and in the aquaculture farms from four districts of West Bengal covering Howrah, N-24-PGS, Burdwan and S-24 PGS. The major activities:

- Created awareness to more than 1000 students, fish farmers and Govt. officials on the use and misuse of Antimicrobial substances in general and in the farms.
- AMR pattern for three bacteria viz. *A. hydrophilla, E. coli, S. aurius* in water, sediment and fishes have been analyzed through the WHONET and observed that these bacteria are resistance to certain antibiotics even up to 80%.

Carbon sequestration in wetlands

The institute has been engaged on estimating carbon (C) accumulation in wetlands with the objective of assessing their C sequestration potential which could be one of the important adaptation and mitigation strategy in inland fisheries to cope up with global warming and the climate change. In this endeavour, potential of primary C capture and ultimate C accumulation in the sediments leading to their sequestration in different types of wetlands in West Bengal and Assam has been worked out.

Fish quarantine Testing Centre

The Institute has been identified as the as Fish Quarantine Testing Centre of OIE listed pathogenic fish virus, SVCV, KHV, and TLV. The test reports are being submitted to Animal Quarantine Office of GoI for exportof ornamental fishes.

Commercialization of CIFRI Technologies

The Institute has developed, propagated, and commercialized a number of technologies for resource assessment, ecosystem health assessment and conservation, sustainable production enhancement in inland open waters, enclosure cultures, etc. Two technologies of the Institute have obtained design registrations, namely, **CIFRI GI Cage** and **Tissue Embedding Machine**, and five technologies have got trademarks, namely **CIFRI Cage Grow Feed, CIFRI GI Cage, CIFRI Pen HDPE, Argcure** - controlling Argulus in aquaculture & fisheries and **CIFLIN -** a chemical diagnostic kit tracing formalin in fish. Out of these, the first four have been commercialized by the Institute as well. CIFRI Model GI Cage and CIFRI Pen HDPE have been

widely adopted by the fishers' organizations and entrepreneurs across India. Two more technologies namely, CIFLIN, the formalin contamination detection kit in fish and One -Step PCR based TiLV Detection kit are under commercialization. The Institute is an ISO 9001: 2015 certified and provides world-class service standard. Over the years, it has worked on several aspects of not only inland fisheries enhancement but also conservation and management of natural resources, environment and eco-system based fisheries, coming out with handful of technologies and models which have contributed immensely to fisheries enhancement across the country.

Cage culture: An avenue for entrepreneurship development and enhanced income

Cage culture of commercially important diversified species is useful for realization of water productivity, entrepreneurship and employment generation paving a way for the empowerment of fisherfolk. The Institute has developed and standardized the technology for table fish production and seed raising in cages. Research, demonstration, transfer of technology and capacity building enabled the cage culture technology to be adopted in 22 states of India which has also attracted private entrepreneurs. Developed package of practices for table fish production of Pangas, *Pangasianodon hypophthalmus* in cages and achieved an average production of 3 tons/cage of 5mx5mx4m dimension. High fish production (70 kg/m^3/8 months) from cage culture of *Pangasius* sp. has been recorded in Jharkhand, Chattishgarh, Maharashtra reservoirs, etc. Experiments for diversification of fish species for cage culture in reservoirs and wetlands are being executed at various locations in different agro-climatic zones of the country using regionally important and indigenous fish species. The Institute has commercialized CIFRI GI model cage technology and at present >30,000 cages are installed in various States of India producing approximately 65,000 tons of fishes. Cage culture contributes around 15% of fish production from reservoirs, with a total employment generation of 8 lakh mandays/year. Pangas (*P. hypophthalmus*), GIFT Tilapia, Common carp (Amur), rohu etc. are major species. Technology for candidate species like Jayanti Rohu (*Labeo rohita*), *Puntius javanicus*, *Labeo bata*, *Ompok bimaculatus* are being developed. The commercialized technologies viz. CIFRI GI Cage and CIFRI Cage Grow feed have augmented the growth and spread of cage culture in the country. Growth performance of GIFT Tilapia (*Oreochromis niloticus*) and Amur carp *Cyprinus carpio* has shown promising results, when fishes fed with Black Soldier Fly, *Hermetia illucens* based fish feed being developed by CIFRI.

In addition, the technical inputs for the development of National Guidelines for cage culture in inland open waters have been rendered. Cage culture offers new avenues for entrepreneurship development due to high production, easy management and profitability.

Climate Change and Inland Fisheries

The open water ecosystem and fisheries are threatened due to climate change and anthropogenic pressures, more visible during last six decades making the resources vulnerable. In this context, the Institute has been conducting research for understanding the interaction between climatic parameters and inland fisheries which is imperative to develop mitigation and adaptation strategies. Studies showed that the mean air temperature in Ganga basin has increased to of 0.20 - 0.47 ℃ and annual rainfall decreased to 257-580 mm during the last three decades, indicating visible impacts of climatic and environmental factors on inland open water fisheries. Significant reduction in depth and area (37.20–57.68% reduction), diversity of natural indigenous fish fauna (22.85 to 54%) in wetlands was assessed.

CIFRI's initiatives towards climate smart fisheries

Several research advancements have been made including development of innovative environmental, climatological and biological thresholds associated with successful spawning of fish species (*Eutropiichthys vacha, Mystus cavasius, M. tengara, Johnius coitor, Channa punctata, Puntius sophore, Amblypharyngodon mola* and *Gudusia chapra*) in Ganges basin in the context of changing climate. Moreover, research pertaining to climate change and impact on ecology and fisheries, heat wave studies, climate resilient adaptation techniques, carbon sequestration potential of wetlands, and vulnerability assessment framework at various levels has also been attempted and published.

Sustainable Development Goals (SDG) addressed

Goal	Objective	Activity
SDG-1	End poverty	Livelihoods improvement and income generation through demonstration and capacity building of fishers
SDG-2	Zero hunger	Ensuring household nutritional security through SIFs
SDG-5	Gender equity and women empowerment	Women empowerment in Small scale Fisheries through culture of SIFs and rearing of fish seed / culture in pen

SDG-8	Economic Growth	Doubling farmers' income through cage culture and production enhancement technology of wetland
SDG-12	Sustainable Consumption and Production	Sustainable fisheries production from inland open waters
SDG-13	Climate Change	Culture of Climate resilient species
SDG- 15	Biodiversity	Conservation of bio-diversity with special focus to SIFs

Employment opportunities

The Institute research has contributed immensely towards higher employment opportunities and income generation to the fishers. Employment of the fishermen has moved upwards from 30 mandays to 150 mandays/ fisherman household/year through adoption of CBF in reservoirs and wetlands. Additional employment of 90 mandays/pen has been generated through pen culture. Pen culture in Assam has increased 50% fish production of the floodplain wetlands, enhancing the income and livelihood of the farming community. The earnings of fishers have increased significantly in Dudhwa reservoir of Chhattisgarh after the adoption of CBF and the present income of the fishers is Rs. 50,000/annum. Earnings from chaur fishers of Siwan and Gopalganj district of Bihar has increased by 20% through CBF with present average income of Rs. 55,000 per annum. A total of 100 fishers' families have earned additional Rs. 10,000 adopting Pen culture in Manipur. Canal fisheries development in resource poor Sundarbans, West Bengal has provided nutritional security and livelihood to 1200 tribal fishers. Livelihood and employment to 12.5 million fishers is being catered through Inland fisheries.

Development of farmers' friendly Mobile Apps and documentaries

- Android App for Fish Disease (Fish Disease Advisory) (https: // play. google.com /store/ apps/details?id=pathak.pratik.fishdiseaseadvisory
- Andriod App for NutriFishIn (NutriFishApp) (https: //play. google.com /store/apps /details?id=cifri.nutrifishinapp),
- Android App for Pension Database (Cifri Pension App) (https: //play. google. com/ store/apps/details?id=pathak.pratik.cifripension),
- Android Application on CRT (Catch Recording Tool) http://cifri.res.in/CRT.apk,

- 20 numbers of customized documentaries in Youtube which are farmers' friendly orienting to enhancing fishers income

Model-based decision support system was developed for better management of Assam wetlands. Fish based Index of Biotic Integrity revealed 70% sites of river Mahanadi and 85% sites of river Gomti as moderately impaired. The Tilapia Lake Virus (TiLV) was first time detected in West Bengal. One-Step PCR based Tilapia Lake Virus detection kit has been developed for quick diagnosis of the disease. ICAR-CIFRI has developed *e-Atlases* of water bodies above 0.5ha of 19 States under Central Sector Scheme (CSS). These *e-Atlases* have been provided to the policy planners of States for management of fisheries in water bodies. This would help in scientific exploitation of the resources for production enhancement and sustainability. *e-Matsya (e-DAS)* has been prepared and demonstrated for real-time and correct fish catch data collection from reservoirs, that would provide correct data for planning of reservoir fisheries development at state and national levels.

Mapping and digitization of inland water resources of the country

Proper inventorization of water resources is important to determine fish production and estimating fish production potential of these resources towards greater production. For this purpose, remotely acquired images from sensors placed on satellites were processed to extract information about these water resources. ICAR-CIFRI through years of constant and untiring effort is estimating all the inland water resources >0.5 ha in the country using GIS and Remote Sensing technologies, as well as ground truthing. Inland water bodies in 18 states have been evaluated and electronic atlases for water bodies of these states have been prepared. The aquatic resources information prepared as *e-Atlas* in CDs have been disseminated to their respective state as well as central agencies like DAH&DF.

Development of Road maps for fisheries development

The Institute has prepared, in consultation with State Department of Fisheries, and published roadmaps for inland open water fisheries development, of West Bengal, Odisha, Jharkhand, Bihar and NE States (8), Telangana and Andaman & Nocobar Islands for ushering in Second Blue Revolution. The Institute has given similar policy guidelines and recommendations to NFDB, Ministry of Agriculture & Farmers Welfare, National Waterways Authority, NGT, Chilika Development Authority, State Fisheries Departments, several hydroelectric projects/Dam

authorities, MoEF&CC, BoBLME, India-EU Water Partnerships Priority Area-II, etc. for fisheries development and ecosystem conservation in the country.

Initiatives for tribal area development

The Institute has been spearheading in developing livelihood with nutritionally security to very backward tribal folk by disseminating the inland fisheries management technologies. During last four years, since 2017, the Institute has been supporting livelihoods of 4,845 nos of tribal beneficiaries from 10 different states of India through technology provision. A total of 8,320 nos tribal populace have been sensitized through group discussion and interactions with on-field demostrations. With fast-developing India, tribal population requires specific attention not only with monetary allocation but also with handful of technical and scientific inputs for their rapid socioeconomic development. And the Institute has taken initiatives through TSP for socio-economic up-liftment of the tribal community. Inland fisheries are contributing significantly in the life of millennia: Socially, culturally, and even economically and the Institute has been endeavouring to utilize the inland fisheries resources and their management as a vehicle for social and economic changes of the tribal populace.

Initiatives for SCSP programs

Since initiation in 2018, demonstration of ornamental fish culture to 205 beneficiaries in Odisha (Kendrapara and Bhadrak) - 40 nos, WB (Kultali, Khalsi, Kaachukhali) -70 nos and Jharkhand – 35 nos by providing training, technical support, fish tank, fish seed, fish feed and other accessories. Pen culture demonstration in 2 wetlands and 2 reservoirs in Odisha, 13 Wetlands in West Bengal and 7 reservoirs in Jharkhand with providing training, Seed and feed for pen culture to >4000 beneficiaries.

Waste to wealth—a green initiative The Institute has established a Vermicompost manufacturing unit at its residential campus.

The very key aim is to convert organic waste materials, such as garden wastes, leaf litters, kitchen refuges, weed biomass, etc. into nutrient rich organic fertilizers using earthworm as composting inoculums. To cater the high demand of vermicompost, a larger unit was established. The present unit, having a composting period of 35-50 days is capable of converting more than 400 kg waste materials to approximately 100 kg manure. The converted manure has a C:N ratio of 10:1, In addition, the unit also generates a good amount of revenue for the Institute. The Institute has also filed a patent to the Indian Patent Office with Complete Specification on the entire vermicomposting procedure including the composting ingredients used in the process.

Library and Informatics Section

Knowledge bank of the Institute- the library and informatics section, symbolizing a good repository of knowledge on various facets of ecology, fisheries, & natural inland fisheries resource systems including aquaculture, possessing about 12,416 number of books, 5,030 issues of journals and a huge number of valuable documents in the field of inland fisheries and related subjects. The library also acts as repository to various reports published from ICAR-CIFRI as well as other Institutes; including annual reports, project reports, thesis of post-graduate research, bulletins, pamphlets, leaflets etc. The library catalogue is digitized and presently managed through KOHA Open-Source Library Management Software. The catalogue is available for online search through ICAR-CIFRI website and AGRICAT. The library also sends scanned copies of research papers to different NARS Institutes through Document Delivery Request (DDR).

Collaboration of CIFRI with National and International organizations/Enterpreneurs

The Institute has been jointly ventured for Project and product oriented collaborations with numbers of National and International organizations: IUCN, GIZ Germany, NFDB, FAO, Worldfish, University of Manitoba, Canada, University of Aberdeen, UK, BOBLME, WWF, NOFIMA, RMIT University, Australia, CDA, NWA, IWAI, NHPC, CWC, SSNNL, Gujarat, M/s Das &Kumars, Varanasi, Uttar Pradesh, M/s M. R. Aquatech, Bhubaneshwar, Odisha, Coal Ash Institute of India, Kolkata, PRADAN, New Delhi, Kalpasar Department, Government of Gujarat.

Policy formulation, management guidelines and recommendation

- National guidelines for cage culture
- Conservation and management action plans for Chilika
- Decision support tool using geo-spatial technology for reservoir stocking enhancement program
- National Action Plan for Hilsa&West Bengal Hilsa fishery management guidelines
- Coal transportation guidelines in National Waterways No. 1
- Development of Roadmaps for inland open water fisheries of 13 states

Resource generation

Besides Institute funded projects, the Institute conducts research through research grants from other agencies. As grant from 21 external funded projects, the Institute has received Rs 2431.68 lakhs during 2015-16 to 2019-20. It also received Rs. 1051.32 lakhs as grant of 22 consultancy projects from different sponsorers. Through sponsored training programmes, the Institute has further earned Rs. 221.98 lakhs from different States. Three technologies, viz, 'CIFRI GI CAGE', 'CIFRI PEN HDPE', 'CIFRI CAGEGROW' and 'Argcure' have been commercialized in the last three years earnings Rs. 6.5 lakhs, 7 lakhs, 6 lakhs, and 10 lakhs respectively as one time development fee, apart from royalties from sales. Two new technologies namely 'CIFLIN' and 'TiLV detection kit' are now lined up for commercialization. Department of Fisheries, Government of Odisha has signed an MOU with ICAR-CIFRI for installation of two CIFRI technologies 110 CIFRI GI Cage and 100 ha CIFRI Pen HDPE in reservoirs of Odisha with total budget of Rs. 1.13 crore and Rs. 2 Crore respectively.

Research publications

During the last five years, the Institute has published on an average 1.5 research papers publications per Scientist per year (average 1 paper per scientist in journals having NAAS rating above 6) and the average NAAS Score per Scientist per year was 7.23. Several papers have been published in top-10 journals in their relevant fields.

Honours, Awards and Recognition

The most prestigious **Sardar Patel outstanding Research Institute Award-2020** in larger category Institutes of the ICAR was bagged by ICAR-CIFRI commemorating 75^{th} years of existence in inland open water sector. Dr. B. K. Das, Director of the Institute was adjudged with the most coveted **Rafi Ahmed Kidwai Awrad** for his outstanding Research in Fisheries &

Veterinary section. ICAR-CIFRI has been awarded with ICAR **Best Annual Report Award 2018-19 in "LargeInstitute" category**. The Institute received "Cashless ICAR Institute award" in 2016. CIFRI has been awarded with the First Prize of **Ganesh Shankar Vidyarthi Hindi Krishi Patrika Purashkar 2017** for its publication ***Neelanjali*** by ICAR.

Dr. V.G. Jhingran, former Director, received the *Padma Shri* Award in 1977 becoming the only Scientist from fisheries fraternity to get the coveted award. GoI released a special postage stamp of 5 Paise denomination in 1979 as a token of recognition of the pioneering work of CIFRI. Dr. B. K. Das, Director was awarded Fellow of **The National academy of Agricultural Sciences (NAAS)** in the year 2019 in Fisheries Science.

COVID-19 Guidelines prepared by ICAR-CIFRI

The Covid-19 pandemic that spread all across the globe leading to lockdown, has significantly affected the fisheries & aquaculture sectors in a multitude of ways in the country. Besides the disruption of fishing activities from open-water, and aquaculture in freshwater system, several associated activities like seed production, supply and market chains, etc. have been greatly impacted. As a whole, the fishermen, fish workers, processors and their communities have been facing the threat of the pandemic, which is affecting the entire value chain and the livelihoods depending on it.

ICAR-CIFRI took lead in developing and issuing advisories, for safety of the workers and preventing the spread of the disease. The Institute prepared advisories for the stakeholders involved in fishing activities in rivers, estuaries, reservoirs and wetlands in 7 different regional languages, besides in English and Hindi. The Institute released advisories for fishers of Rivers, estuaries, channels and creeks in the context of COVID19 in English, Hindi and 7 regional languages. Institute also released advisories for fishers/Fisherman cooperative societies of Reservoir and wetlands in the context of COVID19 in English, Hindi and 7 regional languages.

These advisories were popularized through print & electronic media, circulated to DoF of different States, developmental agencies, NGOs and SHGs, and also through social media. Such efforts have been received very well by the sector across the country. *Recognizing the importance of these timely advisories, the* ***FAO, Rome has recommended these advisories prepared by ICAR-CIFRI by including them as Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries under the Asia-Regional initiatives for the benefit of***

fisheries sector across the globe (Webpage: http://www.fao.org/3/ca8959en/ca8959en.pdf), a huge acknowledgement of the efforts by the Institute.

Strong Leadership behind CIFRI's achievements

Need-based and timely support extended by Dr. Trilochan Mohapatra, Secretary, DARE and DG, ICAR coupled with untiring guidance in executing all the project activities including outreach by Dr. J. K. Jena, DDG (Fy. Sc), ICAR, New Delhi with relentless effort in meticulously performing all the mandated activities of the Institute by Dr. B. K. Das, Director, ICAR-CIFRI has made the Institute in its present shape with hardworking, focussed and dedicated team of Scientists, technical and administrative personnel. Fulfilling our future target of works for this vibrant fisheries sector with changed mandate of the Institute needs more endeavour towards doubling farmer's income in the days to come.

Reaching to unreached

Reaching to outreach is the key strength of the Institute for sustainable development of inland fisheries sector imparting knowledge support and capacity building to the ultimate beneficiaries demonstrating handful of technologies. The Institute has organized 405 vocational training programmes on different aspects of inland fisheries management and development imparting training to 10,500 fish farmers, officials and students (9300 male and 1200 female participants) of Bihar, West Bengal, Odisha, Assam and Tripura. During 2016-21, 900 Nehru Yuva Kendra volunteers (rural youth) were also trained on inland fisheries management. Around 1500 fish farmers trained by ICAR-CIFRI have started scientific fish culture in different districts of Bihar. These programs were further strengthened through customized Apps on Nutrifis, GIS, Fish Disease, e-DAS, and 20 numbers of documentaries in Youtube, which are farmers, students, youths & entrepreneurs friendly. The Institute took active part in number of awareness programs across India and has reached to more than 50,500 farmers under various extension programmes.

Assessment of nutritional needs of rural people with special emphasis on women

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The nutrition gap illustrates the disparity between the levels of nutrients intake by the average person, eating a normal diet, and the nutrient levels acknowledged by research is needed for optimal health in the population. The nutritional status of our bodies depend on certain factors

- Food choices or availability of food
- Food preparation methods and the nutrient contents of the food
- Activities performed by a person
- Ability of a person to absorb the nutrients from food
- Lifestyle of the person (smoking, alcohol, stress others)

Insufficient food is direct causative to under nutrition/ malnutrition. Sometimes people get sufficient food to meet their energy requirements; however, that food cannot give adequate nutrition. Hence, availability of quality food; access to food (income, purchasing power, production, distribution), utilization of safe nutritious food and stability (can be hampered by political, economical and natural factors) are the imperatives of food and nutritional security (Roy et al., 2015).

Assessment of nutritional status

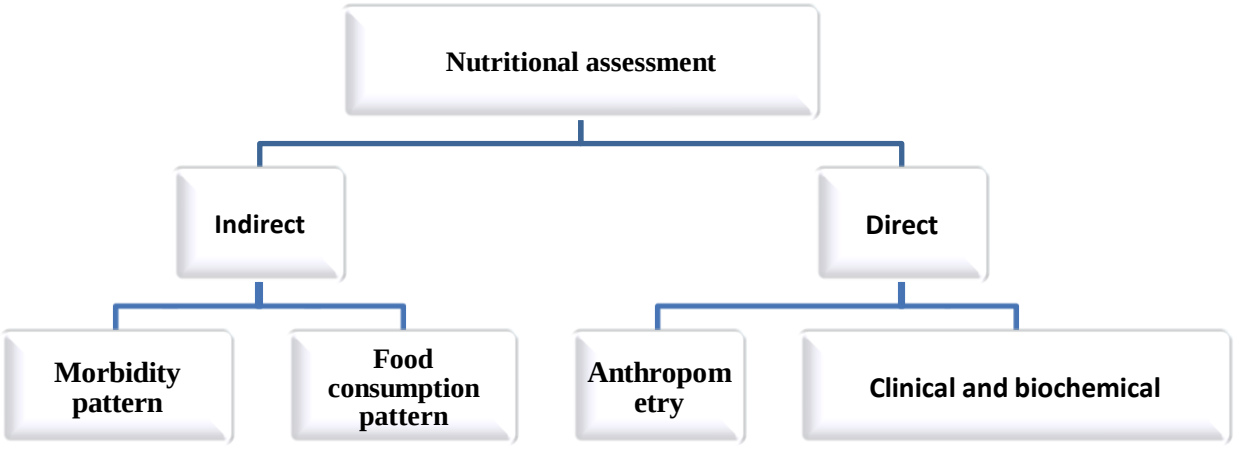
To tackle the problems of nutritional deficiencies determining the nutritional status of a population within a particular area corresponding to its socio-economical and spatial variations is crucial. The nutritional status of an individual is regulated by multiple factors which are often found to overlap with one another. Intake of adequate amount of food both in terms of quality and quantity is necessary for a healthy nutritional profile in the absence of other physical health impairments. Also pattern of consumption of food is another significant factor that eventually leads to prevalence of various non-communicable diseases including coronary heart disease, hypertension, stroke, diabetes mellitus even cancer. More severe effects include low birth

weight, malnutrition, certain inborn disabilities, mortality and an overall poor quality of life. A well documented nutritional status of the general populace helps in making government policy decisions and also helps to adopt suitable intervention strategies directed towards facilitation of nutritional issues that impairs overall growth and development and also helps to recognize particular groups or individuals who are at higher risk of facing the detrimental effects of malnutrition.

Assessment methods

Assessment of nutrition can be done either through direct or indirect method (Mahajan and Gupta, 2016). Among the direct methods there are anthropometry and clinical and biochemical methods and among the indirect there are morbidity pattern and food consumption pattern. To gain an idea about the nutritional status of the individuals in a community, the gap assessment needs to be conducted with random individuals with a large enough sample size that would sufficiently reflect the socio-economic disposition of the community, well distributed across different age groups and sexes. For proper assessment of nutritional status more than one assessment approach needs to be applied and the result needs to be assembled by combining all the data available.

Figure1. Methodology for nutritional assessment:

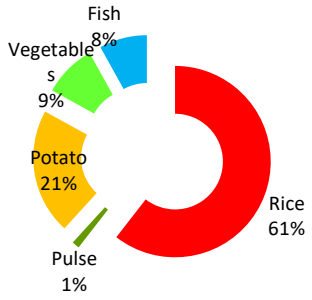


Indirect Assessment

Morbidity pattern

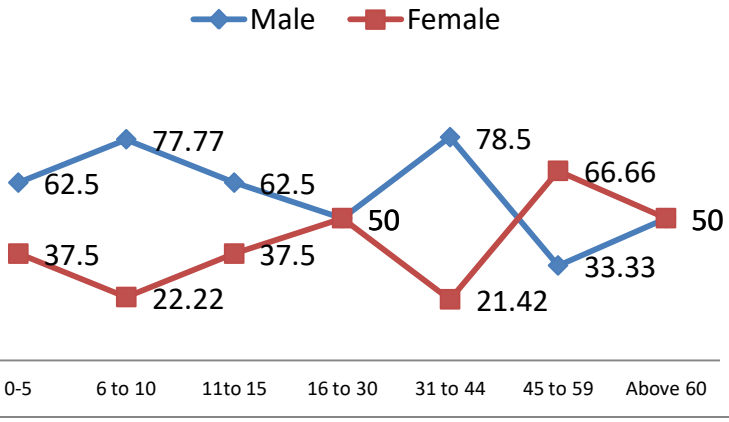
Morbidity means rate of disease in a population or condition of being diseased.The morbidity and mortality pattern observed in a community especially within different age groups helps to determine the factors that mostly cause disease in them and also helps to point out individuals at high risk from a certain factor. Recording morbidity data from hospitals, community health centers, and ground level health workers and by direct interaction through surveys helps to point out potential debilitating factors like lack of protein energy malnutrition, vitamin deficiencies, anemia due to iron deficiency etc. Observing morbidity pattern is particularly useful for children of one to four years of age group as many a time morbidity is directly interlinked with nutritional deficiencies. For newborn babies maternal health is one of the indicator. Along with morbidity pattern mortality rates can also be correlated with nutritional deficiencies in certain cases. Especially in case of infant mortality, second year mortality, low birth weight resulting in lowered life expectancy etc can be used to assess state of nutrition in a community.

Figure 3. Percentage distribution of food items in daily meal



An attempt was made to assess the pattern of morbidities amongst the populace of Namkhana GP. To conduct the survey, a pretested structured questionnaire was developed. Data was collected from the Dwariknagar rural hospital and reveals a morbidity of 78.5% for men and 21.5% for women of Namakhana GP. This staggering difference among men and women does not reflect the household survey data. Since the hospital data only shows the number of reported cases, it can be inferred that illness among the rural women of this area go unreported and untreated more often than not. (Source : Roy et al, 2020)

Figure 2 : Age specific morbidity rate in Namkhana GP Sunderbans June to December,2016



Food consumption pattern

Food consumption pattern of an individual or within a household directly corresponds to their nutritional status. Thus clinical data backed with food consumption makes the assessment more comprehensive. Food consumption pattern can be determined with either through direct survey with individuals or food consumption pattern in household. Survey of diets can be carried out through various methods like either measuring weight of raw materials used for cooking or measuring weight of cooked food or through direct questionnaire based survey. The data thus collected need to be interpreted in terms of food intake per person and can be compared with the values defined by ICMR to determine the nutritional status. Also a diet survey indicates to any lack in consumption of particular required dietary component that is essential for health and thus can be utilized for making policies or changes in crop production patterns to ensure food availability to all individuals.

Fig. 3 depicts the percentage distribution of the food items in daily meal of the rural houlseholds of Madanganj village of Namkhana Block, Sundarbans. Fish is the sole source of animal protein and contribute 8% or 38 gm on an average to the daily diet(Roy et al,2020).

Data Source: Roy et al(2020)

Direct approach

Clinical and biochemical assessment

Assessment made based on the results of clinical examination is one of the most direct and realistic method of determining the nutritional status of an individual as a number of specific and some non-specific signs have been attributed to various nutritional deficiencies. Presence of two or more of such symptoms is considered as an indicator of malnutrition. These signs that are generally used for determining state of nutrition have been classified into three categories by a WHO expert committee and they are a) signs that are known to hold value like angular stomatitis, Bitot's spots, calf tenderness, Beri-beri, endemic goiter etc. b) signs that require following investigation like malar pigmentation, corneal vascularization etc. c) signs that are considered unrelated to diet like alopecia, pyorrhea, pterygium etc. (WHO 1963). Though simple and reliable there are still limitations to this approach which is why it is better to be cautious in drawing conclusions solely based on the presence or absence of certain clinical symptoms due to

various factors. Sometimes these observed symptoms can be non-specific, certain symptoms can be overlapping, bias from the side of the observer can influence the results and bias of the observed especially due to incorrect interpretation of responses or due to lack in communication while data collection can lead to false assumptions eventually leading to a wrong assessment. In spite of these limitations recording of clinical assessments are still valuable in making nutritional assessments in a large scale community driven approach.

One way to overcome the limitations of clinical examination is to opt for laboratory and biochemical assessment which narrows the range of false assessments along with solving the problem of bias both in terms of observer and observed. Some of these tests may include estimation of haemoglobin which is not only a determining factor for anaemia but also is an indicator of overall nutritional condition, stool culture can be helpful in detecting presence of various intestinal parasites and chronic alimentary ailments and urine culture for presence of albumin, sugar or important metabolites which are also useful for determining renal performance, concentration of other nutrients like serum iron etc in body fluids or enzymes which are specific for certain vitamins and so on. In spite of being more specific in terms of results biochemical test have their own sets of drawbacks as they are time consuming, complex, expensive and most importantly can pose issues of achieving consent from the participants due to various social and cultural taboos involved. Biochemical tests are more applicable in small group among a population or in such cases where clinical examinations lead to discrepancies in terms of making assessments.

Anthropometry

Anthropometric data mainly include weight-for-height, height-for age, weight-for-age along with this three skinfold thickness and arm circumferences are also sometimes considered. This advantages of this method is that it can be easily conducted and the results are immediately available, also does not require any trained individual hence easier to practice. Along with the specific growth status of nutrition, anthropometric study can also be used to determine pattern of growth at various stages of life if data is collected for a certain amount of time also can be used to study if there is any deviation in measurements in any individual compared to the average result from the rest of the community. However it is not advisable to make assessments based anthropometric data alone as these results fail to indicate to the more detailed nutritional

deficiencies and needs to be compared with clinical examination observations for better understanding of the nutritional status of a community.

The BMI is the most widely used anthropometric index for the assessment of the nutritional status in adults. BMI is calculated from height and weight measurements (weight in kg/ height in meters^2). BMI was calculated for 300 House Holds with average family size of 4.9 in Madanganj village of Namkhana Block, Sundarbans under Nutri-smart village project. It is evident from the study that 27 percent of the women of the study area are under weight (Roy et al, 2020).

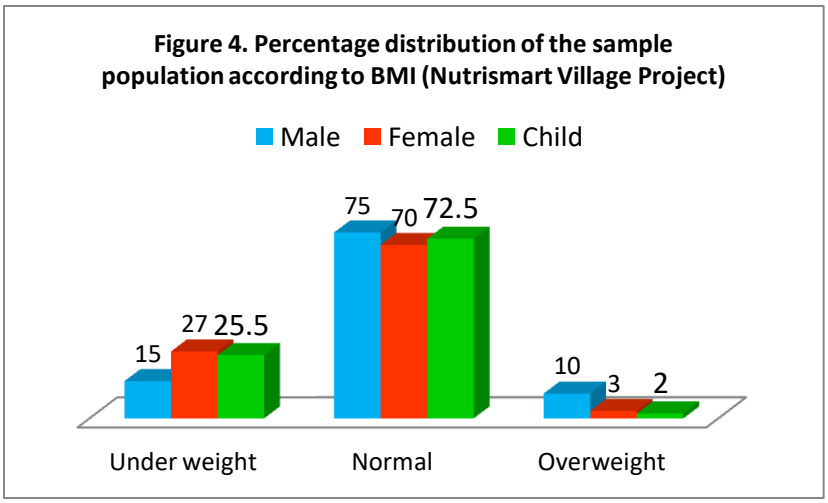


Figure 4. Percentage distribution of the sample population according to BMI (Nutrismart Village Project)

Nutritional indicators

Certain indicators can be monitored as indicators of the nutritional status especially in case of pregnant women, newborn child, infants and preschool school going children. As these indicators directly reflect the nutritional status of the concerned groups it is more practical to make assessments based on these parameters and also to ascertain the affectivity of various government schemes and programmes those are launched specifically keeping these group of people in mind. List of the indicators corresponding to particular phenomenons has been provided below:

Table1: List of indicators of nutritional status

Phenomenon	**Indicator**
Maternal Nutrition	Birth weight
Infant and preschool child nutrition	Proportion being breast fed and proportion on weaning foods, by age in months, mortality rates in children aged 1, 2, 3, 4 years, with emphasis on 2-year-olds If age known:

	height for age weight for age if age unknown: weight for height arm circumference clinical signs and syndromes
School child nutrition	Height for age, and weight for height at 7 years or school admission clinical signs

(Source: Who Techn. Rep. Ser., 1976)

Nutritional gap assessment is essential for introducing any nutritional intervention in aselected area.

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Importance of nutritional intervention during prenatal and postnatal stage (1000 days) to improve Childhood development

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Pregnancy is a physiologically and nutritionally high demanding period. First 1000 days refers to the period that begins with pregnancy planning and goes upto the time when the child reaches his/her 2nd birthday. The first 1000 days are a period of rapid physical growth and accelerated mental development and it offers a unique opportunity to build lifelong health and intelligence for the child. Each day of the journey is very special and influences on how the baby develops.

The Goals for this stage

- Plan the pregnancy
- Eat healthy food
- Stay active
- Folic acid supplement
- Avoid harmful chemical substances (quit smoking and alcohol)
- Protection from infection
- Necessary vaccination
- Consult ANM or Doctor
- Oral health
- Emotional health management

Mother's nutrition while planning the pregnancy as well as during pregnancy and breastfeeding plays an important role for baby's physical and mental development.

Essential nutrients for mother's diet

Iodine: Daily requirement 220 mcg**.** Important for brain development of child (IQ)

Iodine rich foods: Spinach, potato, iodised salt, milk, curd, boiled eggs, Fish

Folic acid: Important for baby's brain and spinal cord development. Daily requirements 400 mcg. It's good to start good source of folic acid 3 months before conceive.

Folic acid rich foods: cabbage, ladies fingers, spinach,carrot,orange,fish

Iron: Helps to prevent Anemia in mother,post partum hemorrhage and helps in baby's development. From 2nd trimester onwards it's necessary to take iron supplements.

Recommended daily allowance: 35mg/day in pregnancy and 21 mg/day during lactation

Iron rich foods: Red spinach, cabbage, radishes, Gur(jaggery), chicken,egg. Iron absorption is increased by vitamin c and decreased by tea.

Vitamin B 12*:* Mostly occurs in vegetarian mothers. Daily requirements: 1.2 mcg . It is important for baby's brain development.

Rich source: soya milk, peanuts, milk,curd,fish, boiled eggs, chicken

Vitamin D and calcium: Daily requirement for Vitamin D is 400 IU. For calcium it is 1200 mg/day. Rich source: mushroom, almond,milk, fish,curd,egg

Omega 3 fatty acids: important for the fetal brain development (DHA) .***Fish is the richest source.***

Meal plan for pregnant mother

- Choose food with low refined sugar
- Eat at least 2 katori (250ml) of cooked green leafy vegetables along with other vegetables.
- Use more than one source of oil: mustard/soya bean oil+ Rice bran/Coconut oil/ground nut oil
- Eat at least 2 fruit per day
- Daily 250 ml milk or 2 katori curd
- At least 75 gram fish twice a day or 2 full boiled eggs or 3/4 cup of cooked legume at least twice a day
- Eat at least 4 chapati made of wheat or ragi/ 2 katori Cooked rice(250 ml katori)
- Eat at least 2 katori (175 ml each) of starchy vegetables like potato/sweet potato/beet/carrot
- Stay hydrated (at least 10-12 glass water per day)

Pregnant mother should gain 9-11 kg of extra weight during her pregnancy. There is an additional requirements of 350 kcal/day during pregnancy,600 Kcal/day in first 6 months of lactation and 520 kcal/day for 6-13 months of lactation. In 1st trimester additional 0.5 gm/day,in 2nd trimester 6.9 gm/day, in 3rd trimester 22.7 gm/day protein is required for the pregnant mother. Light yoga and walking should be included in the daily routine as per doctor's advice. Heavy work should be avoided. Daily 8 hours of night time sleep and 2 hrs rest in day is required.

Importance of inclusion of fish in diet (Data from ICMR)

Iron rich fishes : hilsa(.24 gm/100gm); Mourala; Maagha fish

Calcium rich fishes: Aar (4.36 gm/ 100 gm; Maagur; Pomphret(6.57/100gm); Vela meen (6.65gm/100gm)

Protein rich sea food: crab meat, prawn, Bombay duck

Rich source of fat: bhetki,tiger prawn and lobster

Rich source of calories: parsey (320 kcal/100 gm); Dried Khoyra; Topse fish; Dried chingri.

After the delivery of the baby

The mother should be concerned about the brain development of the child. The story of brain started from the womb, the structure was made in womb but the wiring between brain cells are not completed until 2 years of child's life. Building the brain is like building a home.

Feeding the baby

- Don't give Janam ghutti,or honey or any liquid other than the mother's milk
- Exclusive breastfeeding for 6 months at least.
- Ensure good attachment during feeding and frequent feeding should be done.

Exclusive breastfeeding helps in maturing baby's immunity, gives baby the required nutrition and helps in brain development.

Complementary feeding : Annaprashan as we call it colloquially. It is the introduction of solid food in addition to breastfeeding.Signs to look for before starting complementary food .

. What to ensure during feeding

- Try only one new food at a time
- Give the baby food from same pot as of family

- Encourage baby to hold and touch food
- Never force to finish food
- Avoid whole nuts
- Honey might have bacteria that might lead to botulism
- Do not give unpasteurized milk
- Maintain proper sanitary method of cooking and feeding

Start with puree food and from 9 months onwards give foods that are finely chopped and baby can pick it up with thumbs and index finger (finger food). Increase the intake gradually.

With some simple measures and the Help of government schemes like Surakshit matritwa yojana, RSBK it's possible to have healthy mother and healthy child.

Actually, there are three critical stages in the first 1,000 days: pregnancy, infancy and toddlerhood. At each stage during the 1,000 day window, the developing child's brain is susceptible to poor nutrition. So, appropriate nutritional interventions are essential in first 1000 days for child's neurodevelopment and lifelong mental health.

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ICMR guidelines

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Common nutrient deficiency disorders in women and preventive measures using plant, animal and fish products

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Introduction:

According to the Food and Agriculture Organization (FAO) estimate 190.7 million (14.5%) people in India were undernourished during 2014-2016. Several schemes are functioning in India, namely Integrated Child Development Services (ICDS) scheme, Mid-Day Meal Programme, National Iron Plus Initiative (NIPI), National Iodine Deficiency Disorders Control Programme (NIDDCP) and National Prophylaxis Programme against Nutritional Blindness due to Vitamin A Deficiency to overcome the severe problem of malnutrition in the vast population (Gonmei and Toteja 2018).

Although required very minute quantity, micronutrients play many vital physiological and biochemical roles in the biological system. The deficiency of micronutrients (Hidden Hunger) impairs normal functioning, affects multi-systems, and manifests various ailments, including behavioral disorder and lower productivity. About 2.0 billion people in the world are deficient in single or different combinations of micronutrients. It is estimated that around two billion people in the world are deficient in one or more micronutrients. In India, around 0.5 percent of total deaths in 2016 were contributed by nutritional deficiencies (Kumar et al., 2017).

According to WHO reports, malnutrition and under-nutrition are essential contributing factors for causes of death and various disabilities globally(Nunn et al., 2019). Women of the reproductive age group predominantly suffer from micronutrient deficiencies in low- and middle-income countries (LMICs). In India, iron, vitamin A and vitamin B12 deficiencies lead to anemia in the women population, are widespread in the low-income group, and are common in pregnant women (Pathak et al., 2004). The ultimate results of these deficiencies are prepartum and postpartum complications and abnormal prenatal and postnatal health of the child. There are several reasons for deficiency, but the most crucial cause is an insufficient intake, followed by other physiological disturbances that lead to the unavailability of the particular nutrients. Food habits, geographical location, soil-vegetation type and other social reasons are also important contributing factors for malnutrition in India regarding women. Vegetarian diets diverse enough to provide adequate micronutrients may not be affordable, whereas India's large population does not accept animal products.

Here we discuss in detail the most common six micronutrient deficiencies, which include calcium (Ca), vitamin D (Vit D), iron (Fe), folate, vitamin B12 (Vit B12) and Iodine (I), with particular reference to the various age group of women.

Calcium

Calcium, the most abundant mineral in the body, is found in some foods, added to others, available as a dietary supplement. Ca plays a vital role in vascular, muscular and neurological functions. It is also involved in intracellular signaling, enzymatic, hormonal secretion and critical metabolic function. Bone tissues are considered a reservoir of calcium, and serum Ca level critically maintained with constant calcium concentrations in blood, muscle, and intercellular fluids.

Only 1% of Ca supply is available in body fluid to maintain different cellular, biochemical and enzymatic functions. The rest of 99% is stored in the bones and teeth to support their structure and function. Deposition and resorption of Ca are continuous processes due to the frequent remodeling of bones. During the early stage of life, bone formation is more significant than resorption; in middle age, there will be equilibrium, whereas, in aged persons with particular reference to postmenopausal women, bone breakdown exceeds formation with increased risk of osteoporosis.

Sources of Calcium

Rich sources of calcium are milk, yogurt, and cheese. Other natural sources are vegetables, such as cabbage, kale, and broccoli. Spinach also contains calcium with significantly fewer bioavailability.Ca preparations are primarily available in calcium carbonate and calcium citrate. Although calcium carbonate is inexpensive and convenient, citrate form is most effective due to better absorption, even in gastrointestinal absorption disorders. Other forms of calcium such as gluconate, lactate, and phosphate are used case basis.

Absorption of calcium depends upon the type of foods and concentration of Ca in the particular food. Age is one of the important factors that influence the absorption of Ca since the advancement of age inversely affects the rate. Improvement of Ca absorption is also noted in the presence of vitamin D. Food components like phytic acid and oxalic acid interfere with Ca absorption as they bind with the mineral. Oxalic acid-containing foods are spinach, sweet potatoes and beans, whereas phytic acid-containing foods are fiber-containing whole-grain products and wheat bran, beans, seeds, nuts, etc.

Calcium Deficiency

Generally, inadequate calcium intake from dietary sources for the long term causes osteopenia with clinical manifestation of osteoporosis. Osteoporotic older individual, particularly women remains under

the risk of bone fracture. Ricket is also an outcome of Ca deficiency, though vitamin D deficiency is more commonly associated.

Variation in a digestive, physiological and hormonal functioning particular group of people are most susceptible to calcium deficiency. Postmenopausal, amenorrheic and female athlete women are at high risk because of reduced estrogen production and calcium absorption. In amenorrheic women, anorexia, decreased Ca absorption and increased urinary excretion leads to Ca deficiency. The "female athlete triad" refers to the combination of disordered eating, amenorrhea, and osteoporosis. Lactose intolerance may also be a contributing factor to calcium deficiency. Chances of Ca deficiency is more in vegetarians than an omnivore, lacto-ovo vegetarian and nonvegetarians. Persons only depending on a variety of plant products are more likely to consume oxalic and phytic acids, which may interfere with Ca absorption. Previous reports suggested that vegans, who eat no animal products and ovo-vegetarians (who eat eggs but no dairy products), might not obtain sufficient calcium because they avoid dairy foods.

Vitamin D

VitD3 is an essential nutrient for women's health, also known as "sunshine Vitamin,". Recent findings revealed that Vit D is essential in innate and adaptive immune responses besides different physiological functions. Vit D is a steroid prohormone synthesized in the skin in the presence of ultra-violet light. Typically, 7-Dehydrocholesterol is present in the skin, absorbing UV light (290–300 nm) Vit D3. The intensity of sunlight and appropriate wavelength are critical factors for the synthesis of Vit D in the epidermis. This biosynthesis can be inadequate due to insufficient dietary intake, absorption, or less exposure to sunlight.

Role of Vit D

Vit D3, Cholecalceferol, and Calcitriol (1, 25(OH)2D3) play a major role in calcium metabolism. It also influences bone mineral metabolism and calcium/phosphorus homeostasis by increasing mRNA synthesis for calbindin-D, alkaline phosphatase, and other proteins—emerging roles in cell differentiation, proliferation, and immune function. The role of vitamin D in pregnancy is also taking critical dimensions. Vit D deficiency during gestation severely affects fetal bone health. Total circulating 25(OH)D concentration is the bio-markers of Vit D deficiency. Hence, serum concentration of 25-hydroxyvitamin D is the best indicator of vitamin D status as it is the primary circulating form of the vitamin in the body. A concentration below 20 ng/ml indicates immune suppression whereas a high risk of ricket is noted when it falls below 10 ng/mL (Brooks and Sempos, 2017). Serum levels of 25-OH Vit D <75 nmol/L are considered Vit D3 deficient in pregnant women. A daily intake of 200 -400 IU Vit D intake during pregnancy is recommended.

Sources of Vit D: Cholecalciferol (Vit D3) and Ergocalciferol (Vit D2) are two major forms of dietary Vit D. Cod liver oil, salmon and sardines, egg, mushrooms, and oysters are rich sources of Vit D. Nowadays, fortification of milk, yogurt, soy and cereals products is vital to approach to meet up the requirement of Vit D through diet.

People under risk of Vit D deficiency:

Vit D deficiency may occur due to malabsorption of fat, renal disorder, and obesity. This may be more common in older women, dark-skinned people, people from areas with a thick layer of ozone, women using sunscreen lotions, type of clothing, cultural practices and people from urban areas. Hence, adipose tissue acts as a repository the vitamin is not available in the circulation. Thus the obese women, including pregnant women having BMI more than 30 are at higher risk of Vit D deficiency. The problem becomes more aggravated due to less exposure to sunlight and nutrient-poor diets with adverse effects on both mother and developing fetus.

Iron

Iron (Fe) is one of the vital mineral abundantly available in the varieties of foods and food products. Fe is a major component of hemoglobin and myoglobin thus plays a vital role in oxygen transfer, muscle metabolism, and connective tissue health. Other important functions are in neurological development, cellular functioning, and synthesis of some hormonesHeme and nonheme are the main two forms of Fe. When Fe combines with protoporphyrin IX heme iron is formed. Meat, seafood, and poultry contain both heme and nonheme iron, whereas plants and Fe fortified food contain only nonheme iron(Aggett, 2012).

Source of Fe: Lean meat and seafoods are the richest sources of heme iron, whereas nuts, beans, vegetables, and fortified grain products are a source of non heme iron. Heme iron has higher bioavailability than other dietary components has less impact on its bioavailability. The bioavailability of iron is approximately 14% to 18% from mixed diets that include substantial amounts of meat, seafood, and vitamin C (Hurrell and Egli, 2010). It is to mention that ascorbic acid, meat, poultry, and seafood can increase the absorption of nonheme iron. Based on better solubility and subsequent bioavailability iron-containing salts like ferrous sulfate, ferrous gluconate, ferric citrate, and ferric sulfate are used as Fe supplements.

Iron deficiency: The World Health Organization (WHO) estimates that approximately half of the 1.62 billion cases of anemia worldwide are due to iron deficiency (WHO 2008). In developing countries, the iron deficiency often results from enteropathies and blood loss associated with gastrointestinal parasites. Depending upon the depletion of body Fe store and physiological adaptation, the deficiency progresses step-wise.

Iron depletion and deficiency progress (Powers and Buchanan, 2019; Lynch et al., 2018) is as follows:

Mild deficiency of storage iron depletion: Serum ferritin concentrations and levels of iron in bone marrow decrease.

Ø Marginal deficiency, mild functional deficiency, or iron-deficient erythropoiesis (erythrocyte production): Iron stores are depleted, iron supply to erythropoietic cells and transferrin saturation decline, but hemoglobin levels are usually within the normal range.

Ø IDA: Iron stores are exhausted; hematocrit and levels of hemoglobin decline; and the resulting microcytic, hypochromic anemia is characterized by small red blood cells with low hemoglobin concentrations.

Folate and Vit B12 deficiency along with other diseases and absorption disorders also contribute to the severity of anemia caused by Fe deficiency.

Iron deficiency in women

Menorrhagia is a condition in women at reproductive age with abnormally heavy bleeding during menstruation. It is reported that at least 10% of menstruating women are menorrhagic who are at high risk of anemia (Matthews, 2015). Loss of iron per menstrual cycle is higher in hemorrhagic women than in women with regular menstrual bleeding. High demand for iron during high red cell mass production is not physiological demand in pregnancy (Aggett, 2012). To meet the need of both fetus and placenta, the amount of iron demand increases during pregnancy. Non- availability of adequate Fe during pregnancy leads to deficiency with risk of maternal and infant mortality, premature birth, and low birthweight. Women with absorption disorder are also more at risk of Fe deficiency.

Detection of Fe deficiency: The iron status is generally evaluated from hematological indicators, which are not very specific and sensitive for the exact diagnosis of anemia. Currently, the most efficient and cost-effective test for diagnosing Fe deficiency is serum ferritin concentration that measures the body's storage. This marker is used for early diagnosis since serum ferritin depletes during the first stage of iron depletion. A serum ferritin concentration lower than 30 µg/L is suggestive ofFe deficiency, whereas the concentration less than 10 µg/L suggests Fe deficiency anemia (IDA) (Camaschella, 2015). However, combined indices of blood hemoglobin, hematocrit, MCV and serum ferritin measurement together can identify the IDA.

Folate

Folate is a water-soluble B vitamin, formerly known as "folacin" and sometimes "vitamin B9". Folate functions as a coenzyme or cosubstrate in the synthesis of nucleic acids (DNA and RNA) and metabolism of amino acids (Stover 2012). Homocysteine to methionine formation and conversion of deoxyuridylate to thymidylate are the critical biochemical pathways where folate plays an important role.

Sources of Folate

Folate-rich foods are spinach, liver, asparagus, and brussels sprouts. Other foods contain folate, including vegetables (especially dark green leafy vegetables), fruits and fruit juices, nuts, beans, peas, seafood, eggs, dairy products, meat, poultry, and grains. Folate is also synthesized by colonic microbiota and can be absorbed across the colon. Folic acid is available in multivitamins containing other B-complex vitamins and supplements containing only folic acid.

Folate Deficiency

The concentration of folate in serum is used as a diagnostic parameter in the detection of folate deficiency. A folate level of more than 3 ng/ml is considered adequate in a healthy individual. Folate deficiency mainly occurs along with other nutrient deficiencies associated with poor diet, alcoholism, digestive and malabsorption disorders. Varied ranges of general manifestations are seen in folate-deficient individuals, including weakness, fatigue, difficulty concentrating, irritability, headache, heart palpitations, and shortness of breath. Other symptoms are soreness and shallow ulcerations on the tongue and oral mucosa; changes in the skin, hair, or fingernail pigmentation; and GI disorders (Bailey and Caudill, 2012). Insufficient intake and reduced folate levels in mothers are associated with retarded fetal growth, premature birth, and low birth weight (Scholl and Johnson, 2000).

Women at their childbearing age are most likely to suffer from folate deficiency. At this stage of life, they should obtain 400 mcg/day folic acid from dietary supplements and/or fortified foods in addition regular diet with folates. The stage of pregnancy also needs a higher level of folate supply for increasing demand for nucleic acid synthesis. Therefore pregnant women are advised to take an adequate level of folic acids by the clinicians. Special care must be taken for women with absorptive disorders with a diminished gastric secretion that affects folate absorption. For pregnant women daily supplement of 600 µg DFE per day is recommended.

Vitamin B12

Vitamin B12 is a water-soluble vitamin that contains the mineral cobalt. Thus the compounds with vitamin B12 activity are collectively called "cobalamins." Methylcobalamin and 5-deoxyadenosylcobalamin are metabolically active forms of vitamin B12 (Allen, 2012). It is required for the development, myelination, and function of the central nervous system, healthy red blood cell formation, and DNA synthesis. It also acts as a cofactor of two important enzymes, methionine synthase and L-methylmalonyl-CoA mutase (Stabler, 2020).

Source and absorption of Vit B12: Protein bound Vit B12 is available in different food, mostly of animal origin, including fish, meat, poultry, eggs, and dairy products. The bioavailability of VitB12 appears to be about three times higher in dairy products than in meat, fish, and poultry.Once the protein mix with saliva, the vitamin become free and binds with haptocorrina cobalamin-binding protein in the saliva. In

addition, remaining Vit B12 is released from its food matrix by hydrochloric acid and gastric protease in the stomach, followed by binding with haptocorrin. As the complex enters the duodenum, the digestive enzymes free the vitamin B12 from haptocorrin, which further combines with an intrinsic factor, a transport and delivery binding protein secreted by the stomach's parietal cells. Finally, the products get absorbed at the distal ileum by receptor-mediated endocytosis (Stabler, 2020).

Vitamin B12 Deficiency

Megaloblastic anemia (large, abnormally nucleated red blood cells) is a prominent sign of Vit B12 deficiency. Other symptoms are glossitis of the tongue, fatigue; palpitations; pale skin; dementia; weight loss, infertility, etc. (Stabler 2020). Neurological ailments are generally manifested by numbness and tingling extremities of limbs. Neural tube defects, developmental delays, failure to thrive, and anemia in offspring are the expected consequences in Vit B12 deficient pregnant and breastfeeding women(Langan and Goodbred, 2017).Vegans and vegetarians have a higher risk of developing vitamin B12 deficiency because natural food sources of vitamin B12 are limited to animal foods. Infants of vegan women can develop a vitamin B12 deficiency, sometimes very early in life (Dror and Allen, 2018).

Detection of Vit B12 deficiency: Vitamin B12 status is evaluated by serum or plasma vitamin B12 levels. The serum or plasma level of Vit B12 below 200 pg/ml is considered a deficient individual (Carmel, 2014). Serum methylmalonic acid (MMA) and homocysteine are considered more efficient biomarkers with threshold values above 0.271 µmol/L and 15 µmol/L are suggestive of vitamin B12 deficiency (Allen et al., 2018; Langan and Goodbred, 2017); Maruvada et al., 2020).

Iodine

Iodine is an essential trace element and essential component of the thyroid hormones thyroxine (T4) and triiodothyronine (T3). Being part of the hormone the element is vital for many biochemical reactions and enzymatic activity and are critical determinants of metabolic activities (NRC, 2005). Skeletal growth and development of CNS of fetus need an optimum level of Iodine.

Iodine also plays other functions in the immune response. Thyroid-stimulating hormone (TSH) secretion increases thyroidal uptake of Iodine and stimulates the synthesis and release of T3 and T4. TSH level elevates in Iodine deficient individuals, leading to goiter, with external manifestation of the enlarged thyroid gland.

Source and absorption of Iodine:

The soil content of Iodine influences the element's availability in the crop of the particular geographical region. Iodine deficiency may occur in persons who consume foods from the region of Iodine deficient soil. The prevalence of iodine deficiency could be managed substantially by salt iodization programs in many countries (Patrick, 2008). Seaweed (such as kelp, nori, kombu, and wakame) is one of the best food

sources of Iodine. Fish and other seafood, as well as eggs, are also good sources of Iodine. Cow milk and human breast milk are rich sources of Iodine provided that the mother is supplemented with iodine-rich food. In food and various salts, Iodine is available in sodium or potassium salts and in the form of inorganic Iodine. Iodide is quickly and almost completely absorbed in the stomach and duodenum. Iodate is reduced in the gastrointestinal tract and absorbed as iodide. After entering into the circulation, iodide gets concentrated in the thyroid gland for thyroid hormone synthesis. In pregnant women, 150–249 µg/L of urine iodine and >100 µg/L in lactating women indicate the adequate level (WHO, 2007). The World Health Organization (WHO), United Nations Children's Fund (UNICEF), and the International Council for the Control of Iodine Deficiency Disorders (ICCIDD) recommend a slightly higher iodine intake for pregnant women of 250 mcg per day (WHO, 2007).

Iodine Deficiency:

Deficiency of Iodine leads to different adverse impacts on growth, development and a common condition of preventable intellectual disability. Due to a lack of sufficient Iodine, thyroid hormone production decreases. Hypothyroidism occurs in individuals whose daily intake of Iodine falls below 10–20 µg/day. The early sign of iodine deficiency is goiter. If pregnant women are deficient in Iodine, significant risks like neurodevelopmental deficits and growth retardation in the fetus and miscarriage and stillbirth may occur. Chronic form moderate in utero deficiency may cause causes cretinism, with intellectual disability, deaf-mutism, motor spasticity, stunted growth, delayed sexual maturation, and other physical and neurological abnormalities (Zimmermann, 2009).

Conclusions: Women in the underprivileged sections, both in urban and rural India, are battling inadequate resources, multiparity, less attention to the nutrient-rich diet, inadequate medical facilities for various diseases of women population combined with a surge of physiological demands cause various micronutrient deficiency. In addition, imposed customs of clothing and social vulnerability of the fairer sex coupled with the urban environmental decay will continue to pose the threat of mainly Vit D deficiency and other associated elements. Special efforts on the medical and social fronts are necessary to combat this preventable micronutrient deficiency epidemic in the women population.

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Fish as health food

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Many animal species, including humans, eat fish as a source of protein. Because water covers three-quarters of the Earth, fish has been an important part of almost every country's diet since time began. Fish is one of the least expensive sources of animal protein, and it is more readily available and affordable than other animal protein sources. Fish is a health-food for the affluent world because of the fish oils, which are high in polyunsaturated fatty acids (PUFAs), particularly w-3 PUFAs, and it is also a health-food for people at the other end of the nutrition spectrum because of its proteins, oils, vitamins, and minerals, as well as the benefits associated with the consumption of small indigenous fishes. If the principles of "enhanced function" and "reduced risk of disease" claims are correct in defining functional foods, then fish must be one of the most important functional foods. Functional foods are those that have the potential to improve health in ways other than basic nutrition. Fish contains components that can improve physical and mental health, as well as reduce the risk of diseases like heart disease, cancer, diabetes, dementia, osteoporosis, psoriasis, lupus, arthritis, retinopathy, and other chronic and inflammatory diseases. Fish and fish products are high in nutrients like proteins, lipids, vitamins, minerals, and antioxidants. The important n-3 fatty acids EPA and DHA, which have anti-inflammatory properties and play a variety of health-related roles, are an example of functional food components. As a result, fish is necessary for human nutrition for growth, development, maintenance, and optimal health. Demand and market value for health-promoting functional foods are expected to increase as consumers of all ages become more health-conscious.

Conspectus of fish as dietary component: a glance

This fish resource can be found in the vast aquatic areas of the world's seas and oceans, which account for more than 71% of the planet's surface. Inland waters, lakes, rivers, and streams in the hills and mountains are also good sources of this food, albeit of varying quality. Fish is consumed by more than half of the Indian population, and in some states, such as Tripura and other North-Eastern states, West Bengal, Odisha, Goa, and Kerala, it is consumed by more than 90%. The Lakshadweep, Andaman and Tripura are among the biggest consumers of fish in India

(The Hindu, 26 July, 2021). Fish contains a lot of proteins and other nitrogenous compounds, as well as lipids, minerals, and vitamins, and it's low in carbs. The protein content of fish ranges from 15% to 20% of its live body weight. Fish proteins contain all of the essential amino acids in the right proportions, which improves the overall protein quality of a mixed diet. Water provides many resources to humans, including a good source of high-quality protein. Fish and by-products of the fishing industry can be used as functional ingredients to improve consumer health by improving performance ability and well-being. "Let your food be your medicine, and your medicine be your food," Hippocrates taught humanity over 2500 years ago. The functional food movement revitalised the relationship between food and health in the 1980s. "Functional food" is defined as "food that provides health benefits beyond basic nutrition," according to the concept, which is gaining traction. Bringing functional foods to market with the help of the scientific and government communities will benefit billions of people suffering from chronic illness and other health problems.

Fish abound in the vast aquatic areas of the world's seas and oceans, which cover more than 71% of the planet's surface. Furthermore, inland waters, lakes, rivers, and streams in the hills and mountains are excellent sources of this food, though the quality varies. More than half of the Indian population consumes fish, and in some states, such as Assam and other North-Eastern states, West Bengal, Odisha, Goa, and Kerala, more than 90% of the population consumes fish. Fish is high in proteins and other nitrogenous compounds, as well as lipids, minerals, and vitamins, and has a low carbohydrate content. Fish have a protein content that ranges from 15 to 20% of their live weight. Fish proteins contain a high concentration of essential amino acids, which improves the protein quality of a mixed diet. As a good source of high-quality protein, water provides a wealth of resources for humans. Consumers' health, as well as their performance and well-being, can be improved by using fish and fishery by-products as functional ingredients. Hippocrates taught humanity the tenet "Let your food be your medicine, and your medicine is your food" around 2500 years ago. In the 1980s, the functional food movement revitalized the link between food and health. "Functional food," according to popular belief, is "food that provides health benefits beyond basic nutrition." With the help of the scientific and government communities, bringing functional foods to market will benefit billions of people suffering from chronic illness and other health issues. The following is a list of the components of a fish carcass (Table 1).

Table 1.Carcass composition of fish species

S.No.	Name of nutrients	Range in percentage (%)
1	Moisture	65-80
2	Protein	15-24
3	Fat	5-20
4	Ash	0.5-2

Fish as a good source of amino acids, proteins and peptides

In different species, fish proteins ranged from 15.5-23.7 % (Table 2). Fish protein has been shown to be more satiating than other animal protein sources like beef and chicken (Lonnie et al., 2018). Because there are many varieties and species of fish available, particularly in tropical countries, consumers have a wider choice of fish in terms of affordability than other sources of dietary animal proteins. Kwashiorkor (chronic protein deficiency) and marasmus (chronic calorie deficiency) are two forms of childhood malnutrition that frequently coexist. Fish, as one of the most affordable sources of high-quality animal protein, has played an important role in preventing protein-calorie malnutrition and will continue to do so (PCM). Proteins and peptides play critical roles in cell biology. The most important structural and functional component of all human cells is protein. Proteins include enzymes, membrane carriers, blood transport molecules, intracellular matrices, hair, fingernails, serum albumin, keratin, and collagen, as well as many hormones and a significant portion of membranes. The importance of fish as a source of easily digestible protein with high biological value has long been recognised. Fish has a lower unit cost of production than other animal-based sources of dietary proteins such as chicken, mutton, pork, and beef. Fish is also cheap, making it affordable to the poor. A common man can afford to meet his family's dietary requirements for animal proteins because he has the option of selecting from a fairly large number of fish species. Fish meets one-third to one-half of one's daily protein requirements. This explains why fish is so important for achieving nutritional food security, especially in the prevention of protein-calorie malnutrition. In the past, this has been used to justify the promotion of fishing and aquaculture in a number of countries. Fish contains a high protein content, approximately 18-20% fresh weight, as well as all essential amino acids, including the sulfur-containing amino acids cysteine and methionine. Small indigenous fish species, as well as saltwater and brackish water fish species, are rich in essential and non-

essential amino acids. Furthermore, the amino acids that comprise protein act as precursors to a wide range of coenzymes, hormones, nucleic acids such as RNA and DNA, and other life-sustaining molecules. An adequate supply of dietary protein is required to maintain cellular integrity and function, as well as for health and reproduction. If amino acids are not present in the proper balance in the diet, protein utilisation will suffer. Protein-energy malnutrition (PEM) is fairly common in both children and adults worldwide, and it kills approximately 6 million children each year. Protein deficiency is associated with a weakened immune system and an increased risk of infection. Protein deficiency has been linked to impaired glomerular and tubular function in the kidneys. Protein deficiency, predictably, has a negative impact on all organs. It has been shown to have negative effects on the brain in infants and young children, with the possibility of long-term effects on brain function. The nutritional value or quality of structurally different proteins is affected by amino acid composition, essential amino acid ratio, susceptibility to hydrolysis during digestion, source, and processing effects. Functional amino acids (AA) are amino acids that aid in the survival, growth, development, lactation, and reproduction of organisms by participating in and regulating key metabolic pathways. Functional amino acids are crucial in the prevention and treatment of metabolic diseases, as well as in the maintenance of health and athletic performance. Fish proteins are very easily digestible when compared to proteins from other terrestrial animals and plants. When the protein in oily and white fish is digested, polypeptides, peptides, and amino acids are formed. Many of these compounds are biologically active. The importance of fish as a source of easily digestible protein with high biological value has long been recognized. Fish has a lower unit cost of production than other animal-based sources of dietary proteins such as chicken, mutton, pork, and beef. Fish is also cheap, making it affordable to the poor. A common man can afford to meet his family's dietary requirements for animal proteins because he has the option of selecting from a fairly large number of fish species. Fish meets one-third to one-half of one's daily protein requirements. This explains why fish is so important for achieving nutritional food security, especially in the prevention of protein-calorie malnutrition. In the past, this has been used to justify the promotion of fishing and aquaculture in a number of countries. Fish contains a high protein content, approximately 18-20% fresh weight, as well as all essential amino acids, including the sulfur-containing amino acids cysteine and methionine.

Table 2. Protein content (%) of important fish species

Name of fish	Protein content (%)
Cirrhinus mrigala	15.5-17.8
Labeo catla	15.9-16.4
Amblypharyngodon mola	15.9-16.4
Anabas testudineus	16.4-16.7
Osteobrama belangeri	16.8-16.9
Labeo fimbriatus	16.7-16.9
Osteobrama cotio	19.8-20.5
Rastrelliger kanagurta	19.8-20.5
Rita rita	20.1-20.6
Sperata seenghala	18.6-19.1
Mugil cephalus	19.6-19.9
Tenualosa ilisha	21.3-21.6
Stolephorus waitei	20.1-20.7
Labeo gonius	21.2-21.5
Etroplus suratensis	21.1-21.4
Lates calcarifer	22.2-22.6
Katsuwonus pelamis	23.1-23.5
Thunnus albacares	23.3-23.7

Carbohydrates

Despite the fact that fish is a high-protein diet, it also contains significant levels of carbohydrates. As a result, it provides energy as well as structural components through the use of mono, di, and polycarbohydrates.

Vitamins

Fish contains a high concentration of vitamins A, D, and E, as well as thiamin, riboflavin, and niacin B1, B2, and B3 vitamins (Table 3). The body absorbs vitamin A from fish more quickly than vitamins (Mohanty, 2015). A from plant sources. Vitamin A levels in fatty fish are higher than those in slender fish. Children under the age of five who have a high vitamin A level, according to research, have a lower risk of dying. Vitamin A is also required for proper bone development and vision. Better processing processes are required to preserve vitamin A because sun drying destroys the majority of the available vitamin. *Amblypharyngodon mola*, a small indigenous fish, has a high content of vitamin A in compared to many other species. Because it is required for calcium absorption and metabolism, vitamin D is essential for bone development. It can be found in the liver and oil of fish. It also helps with immune function and may help prevent cancer. Oily fish has a lot of vitamin D that hasn't been supplemented. Vitamin D is not found in

many foods, and it is insufficient in many vulnerable groups, including youth and the elderly. Fish, like red meat, contains a high concentration of B vitamins and can help supplement your diet. Vitamins in the B group are involved in the conversion of food into energy in the body's cells, as well as the operation of nerve tissue. When eaten fresh, fish also contains a trace of vitamin C, which is required for wound healing, tissue health, and iron absorption in the human body. Fish consumption has several benefits for vitamins, A, E, B, and others promoting healthy vision, skin, and immune systems, as well as being necessary for the reproductive process and allowing the heart, kidneys, lungs, and other organs to work properly. Vitamin D enhances calcium absorption and promotes bone health and strength. It has an immune system, brain, and neurological system benefits. It influences the expression of genes linked to cancer formation, regulates insulin levels and improves diabetes management, promotes lung function and cardiovascular health, and regulates the expression of genes linked to cancer development. Anti-inflammatory and antioxidant properties of vitamin E. It fights disease and eliminates free radicals. The Vitamin B complex, which is made up of eight B vitamins, is essential for our bodies to function properly. These essential nutrients help convert food into fuel, allowing us to stay energised throughout the day. While several of the vitamins work together, each one has its own set of benefits, which range from promoting healthy skin and hair to avoiding memory loss and migraines.

Table 3. Fish species rich in fat soluble vitamins

S.No.	Vitamin	Fish species rich in vitamin
1.	A	*Amblypharyngodon mola*, *Epinephalus* Spp., *Sardinella longiceps, Tenualosa ilisha*
2.	D	*Amblypharyngodon mola*, *Puntius sophore*, *Epinephalus* Spp., *Sardinella longiceps*
3.	E	*Puntius sophore, Sardinella longiceps, Tenualosa ilisha, Epinephalus* Spp
4.	K	*Amblypharyngodon mola*, *Puntius sophore*, *Epinephalus* Spp., *Tenualosa ilisha*

Fish as a dietary source of mineral elements

Fish contains a high concentration of mineral components (Table 4). As a result of their consumption, women and newborns have mineral deficiencies. It is an essential meal for humans since it provides minerals, lipids containing essential fatty acids, and vitamins. A multitude of factors affects mineral content. Fish contain a diverse array of macro and microelements. Instead

of actual scarcity, a lack of accurate information about the composition of various food supplies is a major hurdle to their usage. Mineral elements play an extremely important part in human health, and their importance cannot be emphasized. Their deficiencies cause a variety of ailments and health issues in people. A discussion of biochemical activities and the role of mineral elements in human health and disease will be used to establish the value and benefits of eating fish. Minerals contained in fish include iron, calcium, zinc, iodine (from sea fish), phosphorus, selenium, and fluorine (Mahanty, 2011). These minerals are highly 'bioavailable,' which means that they are easily absorbed by the body. Iron is essential for the synthesis of haemoglobin in red blood cells, which transports oxygen throughout the body. Iron deficiency has been associated with anaemia, decreased brain function, and poor newborn learning capacity and behaviour. Due to its role in the immune system, its deficiency may be associated to an increased risk of infection. Although fish contains less iron than red meat, the iron in whitefish is easily absorbed, making it an effective iron source when compared to other animal sources. Calcium is required for the formation and mineralization of strong bones, as well as for the normal function of muscles and the nervous system. It also aids in blood clotting. Calcium, phosphorus, and fluorine consumption is higher when little fish are eaten with their bones than when the fish bones are discarded. Calcium deficiency has been related to rickets in infants and osteomalacia (bone weakness) in adults and the elderly. Fluoride is also required for the formation of strong bones and teeth. Because zinc is found in essential enzymes for metabolism together with proteins, it is required for the bulk of physiological functions. Zinc is required for regular growth and development, immune system function, and skin health. It is also essential for olfactory and gustatory senses, as well as cell division, cell growth, wound healing, and carbohydrate breakdown. Zinc deficiency, among other things, has been associated with stunted growth, skin problems, and hair loss. High-protein meals, such as meat and fish, are the best sources of zinc because they absorb quickly. Oysters have the highest zinc content of any meal. Other oily fish and seafood high in zinc include skate, anchovies, herring, sardines, crab, prawns, shrimp, mussels, and winkles. Iodine, which is found in seafood, is required for hormones that govern body metabolism and for normal growth and mental development in children. Iodine deficiency in children can induce goitre (thyroid gland enlargement) and mental retardation (cretinism). One of the few reliable sources of iodine is fish. Adults in the United Kingdom should consume 140 mcg of iodine per day, which can be obtained from a 100g plate of certain fish. Fish are high in

the mineral selenium. In the United Kingdom, men should consume 75 micrograms of selenium per day and women should consume 60 micrograms of selenium per day, and a 100g serving of baked fish may contain 34 micrograms of selenium, which is approximately half of the daily recommended minimum. Selenium is found in a variety of enzymes that aid in the protection of the body against oxidative damage (free radical damage). It's also necessary for thyroid hormone production, immune system function, and iodine utilisation. Some studies have connected selenium deficiency to an increased risk of cancer. It appears that fish provide more to people's diets than just the high-quality protein for which they are famed. Fish should be a staple in any diet since it prevents malnutrition by making these macro- and micronutrients available to the body.

Table 4. Fish species rich in important minerals

S.No.	Name of mineral	Fish species rich in minerals
1.	Calcium	*Xenentodon cancila, Gudusia chapra, Puntius sophore, Ailia coila, Neolissochilus hexagonolepis*
2.	Magnesium	*Amblypharyngodon mola, Fenneropenaeus indicus, Penaeus. monodon, Perna viridis*
3.	Potassium	*Xenentodon cancila, Gudusia chapra, Epinephalus* spp

Fish as dietary sources of lipids and essential fatty acids

Docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) are two omega-3 (n-3) fatty acids that, like other omega-3 fatty acids, are essential in human nutrition. The most important sources of DHA and EPA are fatty fish and oils derived from their tissues (Table 5). DHA is a crucial component of cell membranes throughout the body, but it is notably abundant in the neurological system, retina, and sperms. DHA is linked to cell membrane fluidity, which contributes in the facilitation of cell functions. The consumption of omega-3 fatty acids, notably DHA and EPA, acquired from fish and fish oil, is essential for human development as well as the prevention and treatment of many common human ailments.

Table 5. Fish and shellfish species rich in EPA and DHA

Name of fish	DHA content in mg/100 g of body weight of fish	Name of fish	EPA content in mg/100 g of body weight of fish
Tenualosa ilisha	980-1000	*Sardinella longiceps*	950-980
Trichiurus lepturus	490-510	*Crassostrea madrasensis*	350-380
Sardinella longiceps	460-70	*Tenualosa ilisha*	260-280
Crassostrea madrasensis	430-470	*Puntius sophore*	280-320
Gudusia chapra	380-420	*Neolissochilus hexagonolepis*	300-330
Leptolebias splendens	220-230	*Schizothorax richardsonii*	220-230
Oncorhynchus mykiss	240-270	*Leptolebias splendens*	240-270
Neolissochilus hexagonolepis	190-230	*Trichiurus lepturus*	190-230
	170-210	*Tor putitora*	170-210
Ailia coila	170-190	*Perna virdis*	170-190
Puntius sophore	150-180	*Lates calcarifer*	150-180
Perna viridis	150-170	*Etroplus suratensis*	120-140
Cyprinus carpio	140-170	*Penaeus. monodon*	110-130
Amblypharyngodon mola	130-150		

Role in the brain development and function

DHA is necessary for the healthy development of the fetus and infant's brain and retina. Tropical freshwater fish, more than any other diet, closely reflects the brain's composition. Arachidonic and docosahexaenoic acids are critical fatty acids in the brain. According to Dr. L Barbara, DHA is the primary structural fatty acid in the grey matter of the brain and retina and is an important component of nutrition for people of all ages. A deficiency of DHA has been linked to depression, memory loss, dementia, and vision problems. Although enough DHA levels are important for everyone, they are especially important for the development of the human brain, which grows rapidly in the late stages of fetal development. The content of DHA in the fetal brain reduces three to five times throughout the third trimester of pregnancy, then triples in the first 12 weeks of life. The grey matter of the brain is composed of around 14 billion cells, and adequate DHA ensures that the membranes of these nerve cells have the optimum composition possible. Docosahexaenoic acid supplementation, rather than its precursor alpha–linolenic acid,

is more likely to provide good health outcomes. The significant beneficial link between maternal docosahexaenoic acid intake during pregnancy and children's mental processing at four years demonstrates that enhancing pregnant mothers' docosahexaenoic acid status may benefit their children's long-term development. EFAs (n-3 and n-6 fatty acids) are increasingly being recognised as effective in the prevention of cognitive decline as people age. A combination of essential fatty acid formulations benefits patients with Alzheimer's disease.

Women health, pregnancy, and infants

Women have a higher DHA level than men. For women of childbearing age, a sufficient supply of n-3 fats is especially vital. Because the considerable brain and ocular development takes place in the uterus and continues for the first year after delivery, adequate DHA levels are critical for pregnant and nursing women. In breast milk, DHA is the most plentiful omega-3 fatty acid. It also aids in the expansion of a woman's breasts. Muscle cramps (dysmenorrhea, menstrual cramps) are a common gynecologic complaint and the largest cause of short-term absenteeism among schoolgirls. Fish oil contains Omega-3 fatty acids, which can help prevent muscular cramps (dysmenorrhea, menstrual cramps). The action of inflammatory prostaglandins and leukotrienes on the uterus causes menstrual pain, according to this persuasive evidence. Arachidonic acid, an omega-6 fatty acid, is responsible for inflammatory chemicals. Fish oil supplements have a positive effect on dysmenorrhea symptoms in adolescents, according to the study. As seen by the positive association between maternal PUFA consumption and neonatal PUFA level, the growing fetus's polyunsaturated fatty acid status (PUFA) is dependent on that of its mother. Pregnancy causes a drop in biochemical PUFA status, which takes a long time to return to normal following delivery. This is especially true for docosahexaenoic acid DHA, because birth spacing appears to be insufficient for maternal DHA status to fully normalise on the basis of current dietary habits. Lower PUFA status in the womb was linked to birth weight, length, and head circumference. Recent research has found that an adequate maternal intake of seafood, particularly oily fish, or fish oil supplements improves verbal communication skills at 6 and 18 months of age, lowers the risk of preterm birth (low birth weight), improves an infant's problem-solving capacity, and results in a higher intelligence quotient (IQ) in children at the age of four. Fish oil supplementation is well accepted and beneficial in lowering depression symptoms in women with PPD, according to the researchers. The frequency of postpartum

depression (PPD) is clearly connected to DHA status and seafood diet, according to Dr. Joseph Hibbeln of the US National Institutes of Health. The milk of 29 nursing women from Doromoni, Tanzania, near Lake Kitangiri, exhibited significant amounts of AA, DHA, and EPA, as well as a low AA/DHA ratio. These were linked to a lifetime of DHA and AA-rich fish eating.

Role in bone health

In young males, bone mineral formation and hence peak bone mass are both favourably connected to omega-3 fatty acids, particularly DHA. Functional meals are also helpful in maintaining peak bone mass throughout adolescence and preventing age-related osteoporosis (Doyon and Labrecque, 2008). The omega-3 fatty acids have the potential to be advantageous. Previous research has shown that consuming a diet with a low n-3 to n-6 ratio has a positive effect on bone mineral density.

Diabetes

The development of diabetes and the growth in body fat have the strongest conceivable association. Insulin resistance is most likely induced by an increase in lipid accumulation in peripheral tissues, which is produced by increased fatty acid release from hypertrophic fat cells. In patients with poor glucose tolerance, increased physical activity and dietary adjustments have been shown to reduce the risk of Type 2 diabetes by 60%. The researchers emphasize that fish oil supplementation had no effect on glycemic control and propose that eating fish on a regular basis be seen as an essential component of a healthy diet for diabetes management (Gray and Threlkeld, 2019).

Rheumatoid arthritis

Fish oil supplements, which contain omega-3 fatty acids, can help to relieve the syntomic state of rheumatoid arthritis and should now be considered part of normal treatment for the disease. Fish oil may be an effective alternative to pharmacological treatment for many RA sufferers. Fish oil is a less expensive and safer alternative therapy for RA, and it may also be used as a disease prevention measure. Eicosapentaenoic acid (EPA), the major component of fish oil, has been proven in experimental animals to inhibit the production of these inflammatory agents.

Cardiovascular diseases

Early studies starting from the Eskimos, to Japanese, Dutch, USA, still more researches show that regular consumption of fish reduces the risk of heart diseases (Zhang et al., 2020). Fish consumption has a significant association with low mortality in population groups with a high risk for coronary heart disease (CHD), whereas, in low risk populations, this association is less impressive. Dietary n-fatty acids aid to prevent heart disease through a variety of mechanisms. Research at the University of Washington found that men and women, who consumed fatty fish just once in a week, reduced their risk of cardiac arrest by 50% (Harriset al., 2021). The American Heart Association published guidelines for patients with CHD recommending consumption of fish and fish oil, totaling 1 g/day of EPA and DHA.

Epilogue

Malnutrition, undernutrition, and low birth weight (LBW) are all major public health problems. LBW is a symptom of intrauterine growth retardation, and research in India and elsewhere have indicated that children with such difficulties have poor growth and development and are more likely to become obese as adults. According to studies, low birth weight (2500 gms) deliveries are common among India's poor, with more than half of infants under the age of three stunted (height less than WHO norms). Combating low birth weight would be a critical step toward reducing obesity and type 2 diabetes in our culture. Supplementing with n-3 fatty acid-rich foods has been shown in trials to reduce the risk of low birth weight, in addition to treating anaemia. According to Kerala studies, 90 percent of the state's population consumes fish five times each week, averaging 35 g each time. Kerala has a lower rate of low birth weight than the rest of the country, and its children have better health. The health advantages of omega-3 fatty acids present in seafood have long been known. Researchers must first assess the availability of fish, as well as the rate and patterns of fish consumption in various segments of society, particularly in fishing towns and coastal populations before they can link fish consumption to low birth weight. A survey on the impact of fish consumption on human health, such as LBW, birth weight at different ages up to three years, and blood profile, notably haemoglobin concentration in the pediatric population, is also necessary. Because low birth weight is a sign of maternal malnutrition, the expecting mother's health must also be evaluated. This information will help planners devise ways to address some of the most important child health conditions,

such as low birth weight and childhood asthma, by adopting nutritional therapies through the government's major child health programmes, such as the ICDS. The nutritional superiority of fish as a health food may be scientifically shown, allowing more people to select a fish-based diet to postpone or prevent the development of nutritionally controlled diseases in children, adults, and the elderly. Furthermore, fish and fish products play an essential role in the nutritional picture because they are a rich source of nutrients and provide an excellent mix of protein, vitamins, and minerals while being low in calories compared to other protein sources. Furthermore, these qualities are high in polyunsaturated fatty acids, which appear to reduce the risk of cardiovascular disease and are linked to better results in a range of other pathological illnesses, such as certain types of cancer and arthritis.

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Habits and habitat of 'Nutri-smart' fish Species

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Introduction

India is bestowed with plenty of water resources consisting of 29,000 km of rivers, 0.3 million hectares of estuaries, 0.19 million hectares of backwaters and lagoons, 3.15 million hectares of reservoirs, 0.2 million hectares of floodplains and 0.26 million hectares of lakes (cold water) which support enormous fish diversity. Of the 838 freshwater fish species in India (Lakra et al., 2010), 450 fish species (Sarkar and Lakra, 2010) are designated as small indigenous fish (SIF) species.Fishes which grow to a maximum size of 25 cm or 9 inches in adult life, are known as small indigenous fish (Felts et al., 1996). These native small fish are widely found in ponds, tanks, irrigation canals, abandoned waterbodies, rivers, paddy fields.They are also abundant in closed waterbodies and rivers. Small native fishes contain a large amount of macro and micro-nutrients which are essential for human health. They play a vital role in increasing the nutrition of many poor people in developing countries who mainly survived with carbohydrate-based foods.About 23% of small native fish provide food and nutrition and some native small fish have ornamental value. They help in protecting the livelihood and nutrition of the people especially in the eastern and north-eastern regions of the country.

The number of small native fish species is declining due to various environmental factors. Shrinking of habitats, overexploitation, excessive abstraction of water for agriculture, use of pesticides in agricultural fields, wanton destruction of brooders,natural calamity(Roy et al, 2015) domestic pollution, siltation, illegal fishing methods etc. are the prime concern which threatened the ecosystem stability of the aquatic environment. Nearly, 20% of freshwater fish species is now either facing endangered or extinct condition worldwide (Hanif et al., 2016) due to shrinkage of congenial habitat for them. Small Indigenous fishes are important for livelihood and nutritional security. These are rich source of vital protein, micronutrients such as calcium, zinc, iron and fatty acids for the rural poor. These SIF productions can be achieved from the natural resources (wetlands, canals, creeks, rivers etc.) through rejuvenating the breeding ground and habitats. Availability of natural food organisms plays pivotal role in achieving growth and survival of the young ones of finfish and shellfish. Live food organisms also known as 'living capsule of nutrition' improves the survivability and production of cultured fishes in modern aquaculture

techniques. It is worth to mention that excessive growth of algae may lead to 'eutrophication' which produces various algal toxins in the water body effect on fishes as well as human.

SIF- nutritional value

SIFs are vital food source for rural people. This small fish is an incomparable source of protein, vitamins and many more minerals (iron, calcium, zinc, magnesium). They help the human body to protest various diseases with physical and nutritional growth. Each part of this fish acts as a vitamin and mineral supplement. The common people of the village and the farmers are not properly aware of the nutritional value of these small fish. Studies have shown that a child needs 10 grams of protein per day and an adult needs 56 grams of protein. In general, every 100 grams of fish contains 14.2 grams of protein (Table 3). Vitamin-A rich fish helps in building the body and immunity and also helps to prevent night blindness.The calcium content strengthens teeth and bones and the essential mineral iron increases the number of red blood cells in our blood.This fish also has an important contribution in the prevention of anaemia. Overall, small indigenous fishes can easily fight malnutrition.

Table 1. Nutritional composition of some SIF

Common name	Calcium (mg/100g wet weight)	Magnesium (mg/100g wet weight)	Iron (mg/100g wet weight)	Zinc (mg/100 g wet weight)	Vitamin A (1U/100g wet weight)
Amblypharyngodon mola (Morula)	841.7±40.2	40.2±2.9	11.9±3.4	3.9±1.3	555.0±56.2
Heteropneustesfossilis (Singhi)	164.4±21.5	-	2.4±0.5	1.2±0.3	26.8± 9.8
Puntius spp. (Punti)	944.6±55.4	37.8±1.1	11.6±3.6	5.4±0.4	70.9±12.3
Xenentodoncancila (Cancila fish)	5310±23.5	220±15.3	7.51±1.9	21.3±3.6	-
Chanda nama (Chanda)	955	-	1.8	2.3	100-500
Channa punctata (Snakehead)	82.20	-	1.88	-	-
Mystusvittatus (Tengra)	190		14.5	17.0	-

Source: http://cifri.res.in/nutrifishin/view_minerals_details.php#

Congenial habitat for SIFs

Global aquatic biodiversity is on the verge of extinction andSIFs are not left behind. About 20% of freshwater fish species are endangered worldwide due to environmental degradation (Hanif et al., 2016). Although native small fish are important in terms of livelihood, nutrition protection and biodiversity, scientific research on SIFs is very limited (Plate 1).In selected areas of the Sundarbans (Anonymous, 2017) local fish species have declined drastically. For example- Pabda(*Ompakpabda*), Shingi(*Heteropneustesfossilis*), Magur(*Clariasmagur*), Bele(*Glossogobiusgiuris*), Eel (*Anguilla bengalensis*), morula (*Amblypharyngodon mola*), Tengra (*Mystusvittatus*), Snakeheads (*Channa punctata, Channagachua*), Bam (*Mastacembelasarmatus*), Pankal (*Macrognathuspancalus*), Sarpunti (*Systomussarana*), Puti (*Puntius*), Chanda (*Chanda nama*), Nandus (*Nandus nandus*) etc. have been greatly reduced since *"Aila"*. Natural and man-made disasters and the climatic abnormalities, the suitable environment for small native fish in the Sundarbans have been destroyed. Optimum physical and chemical parameters of water support to maintain congenial environment for surviving fish and other aquatic organisms. Dissolved oxygen is an essential chemical component. About 5-6 ppm DO is suitable for fish. The pH refers to the acidity of water and the level of bases. Ideally 7.5-6.5 pH is one of the criteria for a suitable aquatic environment for fish.

Feeding habitat of SIF

The natural fish food organisms play a key role for the health of an aquatic ecosystem. The food organisms include all plant (phytoplankton) and animal lives (zooplankton, nekton) graze upon by fishes in an aquatic ecosystem is commonly known as natural food organisms (Table 2). Various types of fish food organisms are found which depends on the productivity of the water body. This includes phytoplankton, zooplankton, annelids, worms, insects, molluscs etc. which provides the constituent of a complete diet for fishes. It is important that the demand of natural food varies from species to species and also between the age group of the individual for example, Catla prefers zooplankton and silver carp prefers phytoplankton. Similarly, mrigal feed on detritus and Chitala prey upon small fishes etc.

Sl. no	Name of SIF	Feeding habit	Habitat
1.	*Amblypharyngodon mola*	Planktivore	Ponds, canals, beels, slow-moving streams, nullahs and paddy fields
2.	*Anabas testudineus*	Detritivore	canals, lakes, ponds, swamps and estuaries medium to large rivers, brooks, flooded fields and stagnant water
3.	*Chanda nama*	Carnivore	Standing and running waters; clear streams, canals, beels, ponds, and inundated paddy fields
4.	*Channagachua*	Insectivore	Ponds and ditches; tolerate hypoxic conditions
5.	*Channa punctata*	Carnivore	Ponds, swamps, brackish water, ditches and beels
6.	*Chelonparsia*	Omnivore	Shallow coastal waters, estuaries, lagoons, and sometimes entering tidal rivers
7.	*Esomusdanricus*	Insectivore	Ponds, tanks, ditches and canals; found in brackish waters also
8.	*Glossogobiusgiuris*	Carnivore	Freshwater and estuaries, occur in canals, ditches and ponds
9.	*Heteropneustesfossilis*	Omnivore	Ponds, ditches, swamps and marshes, but sometimes occur in muddy rivers.
10.	*Macrognathuspancalus*	Omnivore	Inhabits slow and shallow waters of rivers of plains and estuaries;
11.	*Mystuscavasius*	Carnivore	Tidal rivers and lakes; alsobeels, canals, ditches, ponds, and inundated fields
12.	*Mystustengra*	Carnivore	Rivers and ponds in plains; flowing and standing waters
13.	*Mystusvittatus*	Carnivore	Standing and flowing waters. Usually found among marginal vegetation in lakes and swamps with a mud substrate.
14.	*Nandus nandus*	Omnivore	Ditches and inundated fields; standing or sluggish waters of lakes, reservoirs or canals
15.	*Notopterusnotopterus*	Carnivore	Clear streams and enters brackish waters; standing and sluggish waters of lakes, floodplains, canals and ponds
16.	*Parambassislala*	Carnivore	Ponds, ditches and pools. Enters brackish waters
17.	*Parambassisranga*	Carnivore	Sluggish and standing water.
18.	*Pethiaticto*	Omnivore	Found in still, shallow, marginal waters of tanks and rivers, mostly with muddy bottoms.
19.	*Puntius sophore*	Omnivore	Inhabit rivers, streams and ponds in plains and submontane regions
20.	*Salmostromabacaila*	Omnivore	Slow running streams, Adults occur in rivers, ponds, beels and inundated fields

21.	*Trichogasterfasciata*	Omnivore	Large rivers, estuaries, ditches, ponds; prefer weedy environment
22.	*Xenentodoncancila*	Carnivore	Freshwaters, primarily rivers

Table 2. Habit and habitat of SIFs

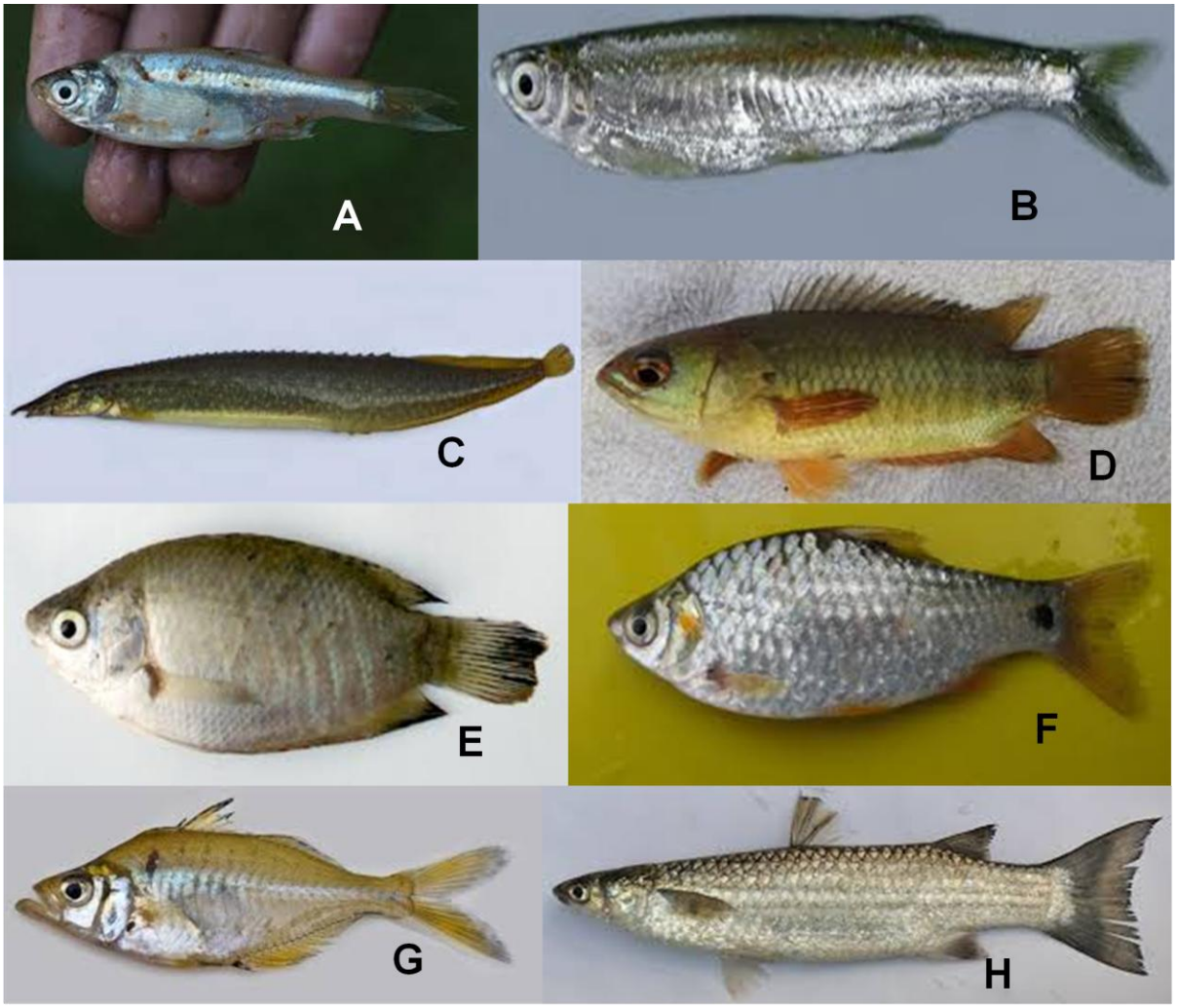

Plate 1. Few small indigenous fishes;

A)*Amblypharyngodon mola***B)***Salmostromabacaila***C)***Macrognathuspancalus*

D) *Anabas testudineus***E)***Trichogasterfasciata***F)** *Puntius sophore*

G)*Chanda nama***H)***Chelonparsia*

Importance of natural fish food organisms

A food chain is the simplest path that energy takes through an ecosystem. Each level from primary producer to top predator, energy is transferred from one trophic level to another trophic

level. Phytoplankton occupies the base of the food chain and produces the primary food materials on which other organisms in the ecosystem sustain themselves. All organisms exist in aquatic ecosystem dependent on plankton either directly or indirectly for their food and nutrition. Most of the fish and shellfish larvae in nature feed on small phytoplanktonic and zooplanktonic organisms. The abundant growth of algae in water appears greenish in colour due to chlorophyll pigment. These are generally made up of unicellular (either in solitary or in colonial form) and multicellular. Phytoplankton presents in the aquatic environment also play an important role in maintaining the carbon budget of the atmosphere. Large populations of these organisms, sustained over long periods of time, could significantly lower atmospheric carbon-di-oxide levels which in turn, lower average temperatures.

The availability of natural fish food organisms is important because they provide high protein and fat content, which promotes growth of fish. Now a days, live food organisms are commonly used in modern aquaculture system for better growth, efficient breeding and survival of cultured fishes. These live foods include both phytoplankton *(Oscillatoria, Chlorella, Spirulina, Volvox, Eudorina* etc.) and zooplankton *(Arcella, Vorticella, Brachionus, Artemia, Keretella, Moina, Daphnia, Mesocyclops, Heliodiaptomus, Tubifex* etc.). The soft bodied organism, covered by shell under the group of molluscans; polychaetes and oligochaetes are useful food for bottom dwelling fishes like catfishes, murrels etc.

***In situ* conservation**

Research on artificial insemination of native small fish is limited. Due to lack of conservation, the number of these fish is declining day by day and is on the verge of extinction. The lack of advanced technology in fish farming is largely responsible for this. An environment conducive to the reproduction of these small fish is inevitable. In this context, there are various measures to preserve the institute in harmony with the environment—Fish seed ranching in rivers or reservoirs, protected wetlands, public awareness, formation of aquatic biodiversity conservation groups, wetland rejuvenation and restoration, government regulatory measures, etc.

Cultural prospects of SIF's

Various studies have shown that channelization or irrigation canals exhibit lower fish species diversity than nearby static water bodies which is influenced by temperature and low primary producers (Daget, 1976). Fish biomass is 31% lower than in an unchannelised stream and that a 78% reduction in macro-invertebrate biomass (Anon, 1990). In Thailand, extensive

culture of bighead carp, grass carp and Nile tilapia in irrigation canals used for vegetable crops has been successful (Little and Muir, 1987). In recent study shows that physicochemical parameters in canals are strongly correlated with the phytoplankton abundance (Agnieszka, 2014). Matta, G. (2015) reported the NO_2, NO_3, SIO_3, HCO_3, PO_4, Ca and Mg are the important variables in shaping of benthic assemblage in Upper Ganga Canal and zooplankton community primarily dominated by rotifers, cladocerons and protozoans in Gang Canal (Bishnoi and Sharma, 2016).

The investigations on culture practices in Indian canals are scarce. So, adopting pisciculture practices through viable technical intervention on these resources enables to support a leading share in total fish production and livelihood support of rural people. Despite having these vast resources in India received little attention which might be boost in Inland fish production by judicious utilization of these resources.Most small native fish are hardy and adapt to the shallow water in a rapidly changing environment. They feed on algae, animal plankton, and plant plankton from the surface or in the column of the water. They do not need to supplementary food separately. Thus, farmers are less likely to incur any kind of extra cost. Fishermen can benefit in less time by cultivating small fish with big fish.

Conclusion

Indigenous small fish play an essential role in the nutrition, health protection and physical development of the human race.In this context, conservation of small fish biodiversity and restoration of their populations is imperative.If their numbers can be restored, the balance of the natural environment will be maintained, and the farmers will also prosper financially and socially.

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SIF to boost nutritional security –CIFRI's experience

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The burden of malnutrition is a global phenomenon that affects countries on a serious level. According to the Global Nutrition Report, 2020 one in every nine people in the world faces the problem of hunger whereas one in every three is found to be obese. Co-existence of undernutrition and obesity contributes to the double burden of malnutrition. Similar situation is found in India as well. India ranks 94th in the Global Hunger Index out of the 107 participating countries and has been given a GHI score of 27.2 which suggests that India is likely to meet zero target out of the total eight global nutrition targets aimed for the year 2025 which are anemia, low birth weight, exclusive breastfeeding, childhood stunting, childhood wasting, childhood overweight (including obesity), adult obesity (men, women) and adult diabetes (men, women) (Von et al, 2020). The socio-economic imbalance is quite evident from the fact that children and women are the worse sufferers of hunger and undernourishment. According to the National Family Health Survey one in every two women of reproductive age is found to be anemic and one in every three and one in every five children under the age of five is stunted and wasted respectively. These alarming numbers call for immediate attention and require strategic interventions with scientific and technological approach. The requirement of intervention is more immediate in case of the rural areas compared to that of urban areas as the prevalence of stunting is almost 10 per cent higher among the rural populace than urban dwellers. The problem of malnutrition not only affects people at an individual or domestic level but also restricts the growth of a society therefore the nation as direct association has been established between dietary practices leading to malnutrition and some known diseases, non-clinical intermediate end points and impairment of health in general, giving rise to its own focused area of research termed as the dietary epidemiology (Boeing, 2013). Human resource is the assets of any country as healthy population is precondition for sustainable growth and development of a nation(Roy et al,2020b).

Action research initiated by CIFRI

Keeping this in background a s project was undertaken to promote nutritional security through Small indigenous fish culture and conservation in Namkhana areas of Sundarbana. The comprehensive road map was also developed for Nutri-smart village through promotion of conservation, culture and consumption of SIF.A survey was conducted in Madanganj, Namkhana to study the socio-economic profile, dietary pattern, morbidity pattern to generate a proper understanding of the livelihood, current nutritional status, disease prevalence and treatment options of the fishermen community of that area.

In tandem with the survey four demonstration ponds were selected for the project in association with Madanganj fishermen cooperative society. All the selected demonstration ponds were stocked differently with SIF in various species compositions and other species to assess the productivity. A conservation site for SIFs is also developed by CIFRI through community participation in Sunderban areas. As a part of the conservation efforts six hapas have been installed in the pond and this pond will serve as seed banks which will create a seed chain for small indigenous fish culture in this area

Feeding Trial for positive effect of SIFs in health and nutrition of local population

The direct and indirect method to assess the nutritional gap of the selected population shows that nutritional deficiencies are prevalent in the area. Almost 27% women are under weight(Roy et al,2020a) and are susceptible for being morbid. Keeping this in view, a human feeding trial was organized for one month in collaboration with the ICDS centre Madanganj, by including Small Indigenous Fishes in their daily diet for a group of women. Feeding schedule comprises a total of 50 gm Mola (Amberiphaingodon mola) and Jat Puti (Puntius sophore)

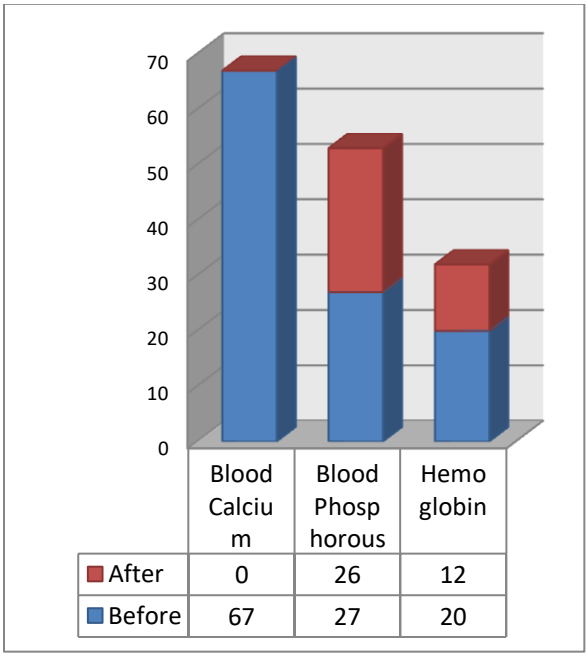

Fig: 1. Effect of SIF feeding trial among the sample population in Percentage(Roy et al,2020b)

along with their regular diet . After one month of feeding trial it was found that blood calcium was improved for almost all the tested women and occurrence of anemia has also been reduced among the women from 20% to 12% (Fig. 1)(Roy et al,2020b).

Inclusion of the selected Small Indigenous Fish (SIF) species like Mola and Puntius in regular diet have positive and significant role for increasing the blood Ca. So, the therapeutic value of SIFs was proven and it can be recommended to ensure nutritional aspects of the populace of Sunderbans.

Feeding of Sampled Population in ICDS Centre

Clinical check up

Collection of Blood Samples

Distribution of Blood Reports

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'Nutrifish' –a potential avenue for livelihood security

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The small indigenous fishes (SIFs) are considered as those species attained 25cm length at maturity stage (Nandi et al., 2013) like mola (*Amblypharyngodon mola*), chela (*Salmostoma bacaila*), puti (*Puntius* spp), darikana (*Esomus danrica*) etc. are quite abundant in freshwater ecosystem. The SIFs are often caught by local villagers from river, canal, beels, channels and any backyard or derelict water body for subsistence fishing because SIFs are integral part of rural diet as they can easily afford it with their daily meal. Thus, the small indigenous fishes are important source of micronutrients and animal protein for the rural people (Kohinoor et al., 1998; Roos et al., 2003; Roos et al., 2007a; Roy et al., 2015). The valuable native SIFs are at stake due to several issues including natural and anthropogenic causes. One of the most common practices is eradication during pond management as these species are unwanted or considered as trash fish in aqua farming (Kadir et al., 2006). Thus, sustainable culture practices need to be implemented to conserve these species. SIFs are self recruiting species and grow naturally with any fish in ecosystem. However, SIFs with polyculture could be an excellent option as source of nutrition along with prospective avenue for rural populace. Several studies reported that addition of SIFs in polyculture system can ensure daily livelihood through income generation and nutritional security (Roy et al., 2020; Bayen et al., 2020; Sinha et al., 2016).

Role of SIFs as 'Nutrifish'

Small indigenous fishes are rich source of micronutrients, vitamins and contribute high amount of animal protein in human health. The previous studies have been reported that SIFs have more health benefits compared to other commercial fishes and an important source of calcium and other micronutrients as they are consumed as whole including bone, head and eye portion, (Mahanty et al., 2014; Kongsbak et al., 2008). The trace elements like copper, zinc, iodine, selenium, iron, cobalt, magnesium and chromium are present in SIF along with macro minerals like calcium and phosphorous. Besides this, SIF are rich source of vitamins like A, D and E as

well as vitamins B complex. Vitamin A in the form of retinol have been reported in freshwater indigenous fish species like *Amblypharyngodon mola, Parambassis ranga, Osteobrama cotio, Esomus danricus* in high amount (Mohanty et al., 2013). Although SIFs are highly nutritious and available easily in any domain, their importance are often ignored. Inclusion of nutrition densed small indigenous fishes in regular diet might be a significant strategy to utilize the animal protein and nutrient. Thus combination of fish with other nutritional food ingredients represents a promising food-based approach to improve nutrition (Bogard et al., 2015).

SIFs based polyculture: An alternative option for livelihood security through income generation

Fish and fisheries are important source for food and income for maintaining daily livelihoods of the rural population (Roos et al., 2007). Floodplain ecosystems are still the main source of SIFs with other native fish species and the abundance of SIFs are quite high in homestead pond as well as other aquatic environment. Introduction of SIFs in polyculture system viz. carp along with other economically prized fish species could be practices for ensuring livelihood, providing nutritional security through income generation. The culture practices also support to restore of SIFs stock in ecosystem. Mola (*Amblypharyngodon mola*) based polyculture practices can be developed for addressing livelihood and nutritional security of rural populace (Bayen et al., 2020). SIF introduction in carp polyculture (Kadir, 2007; Sinha and Santra, 2016) not only enhanced the fish production but also secure the daily livelihood of the rural populace.

A trial was conducted in Madanganj Village, Namkhana Block, Sundarbans for standardization and popularization of fish farming were conducted in four ponds (Table 1.) following the types of fish culture systems as mola based carp polyculture (T1), mola with pabda (T2), mola with prawn (T3) and only mola (T4).

Table. 1 Growth and production under different culture pond

Species name	Average weight at stocking (g)	Average weight at harvesting (g)	Survival rate (%)	Specific growth rate (% bw/d)	Production (kg in 0.1 ha)	Total production (kg/0.1 ha)
T1 (Mola + Carp culture)						
Mola	3.26±0.22	-	88.9	-	21	212.5
Rohu	5.67±0.12	281.92±19.02	56.8	2.17±0.04	40.8	
Catla	7.55±0.20	438.17±11.97	37.5	2.25±0.06	11.4	
Mrigal	6.60±0.10	312.63±18.30	97.2	2.14±0.03	54.9	
Grass carp	6.43±0.18	459.55±17.42	74	2.36±0.03	84.4	
T2 (Mola+ Pabda culture)						
Mola	3.24±0.23	-	86	-	20.8kg	38.9
Pabda	3.47±0.57	26.13±5.35	69	1.15±0.03	18.1kg	
T3 (Mola+ Fresh water prawn, galda culture)						
Mola	3.28±0.23	-	88.5	-	8.6 kg	23.27
Galda	3.71±0.11	90.68±15.34	44	1.8±0.02	14.67 kg	
T4(Mola culture)						
Mola	3.28±0.23	-	97.8	-	36.57 kg	36.57

Source: Bayen et al, 2020

Success of mola based polyculture was achieved due to selection of fast growing economically prized fish along with mola and less competition among the species for food and space (Table 2). Small indigenous species (SIS) with carp polyculture have increased production, improved economic returns, and secured nutritional well being for farmers. Culture of mola with galda (fresh water prawn) and pabda (*O. pabda*) were other options for rural people in terms of economic as well as nutritional improvement.

Table 2. Production and fish sale under different treatment

Species name	Production (kg in 0.1 ha)	Production (kg in 0.1 ha)	Selling Price (₹/kg)	Fish sale(₹)	Fish sale (₹)	Total cost/Financial returns
T1						
Mola	21	21	230	4830	4830	
Rohu	40.8	191.5	200	8160	28898	
Catla	11.4		145	1653		33727
Mrigal	54.9		137	7521.4		
Grass carp	84.4		137	11563.6		
T2						
Mola	20.8	20.8	230	4784	4784	12205
Pabda	18.1	18.1	410	7421	7421	
T3						
Mola	8.6	8.6	230	1978	1978	10063
Galda	14.7	14.7	550	8085	8085	
T4						
Mola	36.6	36.6	230	8418	8418	8418

Source: Bayen et al, 2020

Benefit –cost analysis

Financial gain in term of profit was quite high in mola based carp culture compared to other culture (Table 3.). However, the input cost was highest in mola based carp culture compared to pabda-mola, galda-mola and only mola culture which is completely opposite direction and indicates higher return can be gained by spending more input cost. Net return in terms of economic in carp-mola polyculture system is predominantly influenced by the cost of fingerlings and feed which have been reported previously Sinha et al., 2016; Karim et al., 2017; Ahmed et al., 2010. Overall the mola-carp culture is lucrative approach for the fishers due to higher return. Due to higher input cost marginal fishers or fish farmers may face problem in adopting the culture system. On the other hand, galda and pabda culture incur more input cost and have less benefit that may lead to their less adoption by poor fishers. However, mola culture alone can be

practiced by marginal and poor fisherfolk having small household ponds. Culture system like mola with carp, galda and pabda can be approached by resource-rich farmers those who can afford input cost. As mola is a self recruiting species and the fish species covers a minimum of two spawning season in a year (Gupta et al., 2013) within a few cycles of culture in an area, plenty of seed will be available that will reduce the input cost and improve the benefit. Scientific approach of mola culture integrated with carp to the level of natural uncompetitive state can be a viable option for improving household income, nutrition and the same time it will help in conserving the mola species in local condition. Ultimately culture and conservation of SIFs will lead to livelihood and nutritional security of the rural populace.

Table 3. Cost benefit analysis of fish produce from different treatments (0.1 ha.) (all the value is in Rs.)

Head	**T1**	**T2**	**T3**	**T4**
Input cost				
Renovation and maintenance of pond	1100	1100	1100	1100
Lime	150	150	150	250
Cow dung	500	500	500	500
Hired Labour	400	400	400	400
Total	2150	2150	2150	2250
Seed	8736	2078	1827	4178
Feed	3600	3040	2480	0
Total	12336	5118	4307	
Total Investment	14486	7268	6457	6428
Financial returns from fish sale				
Gross revenue from fish sale	33727	12205	10063	8418
Benefit (Net revenue)	19242	4937	3606	1852
Benefit Cost ratio	2.3	1.6	1.5	1.3

Source: Bayen et al, 2020

Conclusion

Carp polyculture with SIFs, mola is a unique culture approach and ease of management of culture operation in household ponds which improves household income for rural people in terms of providing better return as well as ensures household nutrition. Self-recruiting breeding characteristics of mola provides extra edge to rear in small household ponds both for their conservation and sustainability. The present study suggested that appropriate stocking density and suitable fish species selection can be encouraging factors for sustainable production and profit maximization. From both the economical and nutritional view of point, carp-mola polyculture is novel approach that can be adopted for improvement of nutritional and socioeconomic condition of the rural folk.

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‘NutriFish’ to address ‘Hidden Hunger’

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Introduction

Nutrition is basically the intake of food in accordance to the body’s dietary requirements and good nutrition is sufficient, well balanced diet along with regular physical activity which is a basis of good health (WHO, http://www.who.int/topics/nutrition/en/). Poor nutrition, on the other hand can occur from reduced immunity, increased susceptibility to any disease, reduced productivity, and impaired physical and mental development. Human nutrition deals with the availability of essential nutrients in the foods we eat that are necessary to maintain human life and health. It also recognizes and responds to the severe consequences occurring due to malnutrition. The ultimate aim is to encourage optimal health and thereby minimise the risk of chronic diseases like cardiovascular disease and cancer as well as to check nutritional deficiency diseases such as marasmus and kwashiorkor.

Food security is the availability of food and one's access to it. Food security exists “when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (WHO, 2019). Although there is a dramatic increase in food production in the recent years, decrease in land volume, land degradation, global water crisis and climate change, agricultural diseases and the increase in transportation charges due to depletion of the fossil fuel resources are becoming the major concerns in ensuring food security to millions of people worldwide (Bamji 1999; NAAS, 2001).

Nutrition security on the other hand is physical, economic and social access to balanced diet, and not just the calories (WHO,2019). Diet surveys in the developing countries revealed that diets are qualitatively more lacking in minerals and vitamins than calorie which is due to low intake of foods like vegetables, pulses, fruits, and foods of animal origin. About 800 million people globally, are undernourished and 925 million people suffer from chronic hunger due to acute poverty condition, and upto 2 billion people is lacking food security recurrently due to poverty (FAO 2010). Therefore, ending hunger and malnutrition is the major requirement for

sustainable development and zero hunger by 2030 is the target of the Sustainable Development Goals (SDGs) (https://sustainabledevelopment.un.org/sdgs). The major forms of hunger are protein hunger, calorie hunger and hidden hunger (micronutrient deficiency). Therefore, means for providing food and nutritional security globally is one of the biggest challenges needing policy interventions.

Hidden Hunger

Hidden hunger, the micronutrient deficiency, is a form of undernutrition that occurs when there is a lack of intake and absorption of the micronutrients i.e. vitamins and minerals e.g. iodine, zinc and iron and are too low to maintain good health and development. Factors which are behind these micronutrient deficiencies are poor diet, higher micronutrient requirement during pregnancy and lactation, and health issues due to diseases, infections, or parasites. Hidden hunger affects greater than 2 billion people, or one in three people, worldwide (FAO, 2013). Its consequences can be very severe such as poor health, mental impairment, low productivity, and even can lead to death. However, its harmful effects on child health and survival are acute, especially within the first 1,000 days from conception to the age of two, giving rise to serious physical as well as cognitive impairment. In addition to this, mild to moderate micronutrient deficiencies can also affect a person's well-being and curtail socioeconomic development, particularly in under developed countries.

Anaemia a disease caused by lack of iron, vitamin etc is a serious threat to health of people in India across all age groups especially in children and women. The percentage of pregnant women, women of reproductive age and children suffering from anaemia are 60 per cent 50 per cent 55 per cent respectively, prevalence of vitamin A deficiency in pregnant women and children are observed at 16.4 per cent and 62 per cent, and prevalence of zinc deficiency is found in 31.2 per cent people (Micronutrient deficiency, 2017). ICAR-CIFRI is working in the inland fisheries sector with the objective to mitigate 'hidden hunger' of the populace of India. In wetlands, creeks, water channels, paddy fields, reservoirs and in other natural waters small indigenous fishes (SIF) are quite prevalent. So, to fulfil the micro-nutrient deficiency SIFs that are also called as 'nutrifish' can be promoted for culture, conservation.

Nutritional databases

Safe and nutritious food which meets the dietary needs is necessary for an active and healthy life. Therefore, for developing and executing effective dietary interventions to boost nutrition at the population level, it is essential to know the nutritional situation of the target group (Elmadfa and Meyer, 2010) which needs the assessment of quality and quantity of the food items by food composition analysis. Food composition analysis data is the basis of food based dietary guidelines for healthy nutrition (Elmadfa and Meyer, 2010). The importance of such information has been recognized worldwide and huge amount of food composition data are being compiled in form of online databases. Some of the important international databases include International Network of Food Data Systems (INFOODS; http://www.fao.org/infoods/infoods/en/), European Food Information Resource (EuroFIR; http://www.eurofir.org/), Nutrient database for Standard Reference-U.S. Dept. of Agriculture (USDA) (http://ndb.nal.usda.gov/), Nutrition Coordinating Center University of Minnesota, USA(http://www.ncc.umn.edu/) etc. While INFOODS is a worldwide network of food composition experts focussing to improve the quality, availability, reliability and use of food composition data, EuroFIR AISBL extract together the best available food information around the globe from 26 compiler organisations in Europe, Australia and Canada and USA (FoodEXplorer) as well as validated data about bioactive compounds. These databases provide information on nutrient composition of food components to dieticians and clinicians for their incorporation in clinical nutrition. These databases are also be essential in creating awareness among the consumers and enhance the economic significance of food component and provide standardized calculation procedures that are required for international studies on nutrition and disease to calculate nutrient intakes across countries.

Fish is an essential component of human diet and is a rich in quality animal proteins that are easily digestible and have the dietary essential amino acids (EAA) in requisite quantities (WHO, 2007; Mohanty *et al.*, 2014). Thus, fish can play an important role in eradicating the protein deficiency diseases among 870 million people worldwide who are suffering from chronic protein malnutrition (WHO, 2007). Fish is a health food due to its richness in oil, polyunsaturated fatty acids (PUFAs) especially the omega-3 PUFAs eicosapentaenoic acid (EPA) and docoshexaenoic acid (DHA) (Calder, 2006; Mohanty *et al.*, 2016b; 2010). Besides being a rich in quality protein and oil, fish especially the small indigenous ones are micronutrient dense (Mohanty et al., 2011) and can play pivotal role in eradication of micronutrient deficiency

related diseases in the developing countries (WHO 2015; Mohanty *et al.*, 2011). In the present day world, people are more health conscious and want to know about the composition of the food they are consuming. This is particularly important for food items like fish, as there are huge varieties of fishes available from different ecological habitats which differ in their composition. Understanding the biochemical composition of food is important to know its nutritive value which in turn is required for harnessing fish to its maximum extent to provide nutritional security. Generation of this information bears more importance in developing countries like India, which harbors a rich fish biodiversity and fish is an essential component of human diet in these countries.

Complete nutritional information on different food fishes would increase their utility in clinical nutrition and help in formulating dietary guidelines and thus could contribute significantly to nutritional food security. However, dedicated nutrient databases comprising of nutrient composition of different fish species are less and such information are available for a limited number of fish species. Keeping this in the backdrop, nutrient profiles of food fishes from India, from different habitats across the country, have been extensively studied, in consortium mode, by the research institutes under the Fishery Science Division, Indian Council of Agricultural Research. The large nutritional data generated under this outreach programme has led to the development of a database, named NutriFishIn: Nutritional composition of food fishes from India' (http://www.cifri.res.in/nutrifishin/index.php) (Fig. 1.) (Mohanty et al., 2015).

Fig.1. Snapshots of Home page of database website NutriFishIn: Nutritional composition of food fishes from India (http://www.cifri.res.in/nutrifishin/)

NutriFishIn is database containing nutritional information on food fishes of India, from varieties of habitats like freshwater, coldwater, brackish water and marine systems. It has been developed under ICAR funded Outreach Activity on "Nutrient Profiling and Evaluation of Fish as a dietary Component". The main feature of the database is information on food fishes in terms of gross chemical composition, amino acid, fatty acid and micronutrients. The database has an in-built knowledgebase which provides information on the richness of different fish species in different food components which could be useful for their inclusion in dietary counselling by physicians. Besides the nutritional data, information on standard international protocols followed to generate the information and other technical aspects are also available. The objectives of this database include generation of nutrient composition data of important food fishes from India and strengthen a database on "Nutritional composition of food fishes from India". Centrally coordinated by Fisheries Science Division, Indian Council of Agricultural Research (FSD-ICAR), Ministry of Agriculture and Farmers Welfare, Government of India. Seven fisheries research institute under FSD-ICAR are part of this database, viz. CIFRI, Barrackpore (Lead centre); CIFT, Cochin; CMFRI, Cochin; CIFA, Bhubaneswar; CIFE, Mumbai; CIBA, Chennai; DCFR, Bhimtal. The huge data generated are helpful to nutritionists, dieticians, health professionals, consumers, policy planners, fish farmers and aquaculturist.

Mission of NutriFishIN

Enhancing the utility of fish in human nutrition by creating awareness on nutritional composition of food fishes

Objectives of NutriFishIN

1. Generation of nutrient composition data of important food fishes.
2. Establishing nutritional superiority of selected fishes through human feeding trials.
3. Special emphasis on micronutrient profiling of small indigenous fishes (SIFs).

NutriFishIN activities

- To generate nutrient information of Indian food fishes
- To compile and archive nutritional information on food fishes in the database
- To create mass awareness about health benefits of eating fish
- To make readily available food data for dietary recommendations for community as well as clinical nutrition
- To prepare a base for recommendation for species prioritization in aquaculture

Partners of NutriFishIN?

Centrally coordinated by Fisheries Science Division, Indian Council of Agricultural Research (FSD-ICAR), Ministry of Agriculture and Farmers Welfare, Government of India.

Seven Fisheries Research Institute under FSD-ICAR, viz. CIFRI, Barrackpore, CIFT, Cochin, CMFRI, Cochin, CIFA, Bhubaneswar, CIFE, Mumbai, CIBA, Chennai, DCFR, Bhimtal.

NutriFishIN reach?

- Nutritionists
- Dieticians
- Health professionals
- Consumers
- Policy planners
- Fish Farmers, Fishers and Aquaculturists

Different features of the database

1. Objectives

This gives information about the objectives of the project Outreach Activity #3 'Nutrient Profiling and Evaluation of Fish as a dietary component. It also contains information about the various approaches to be followed to fulfill the objectives.

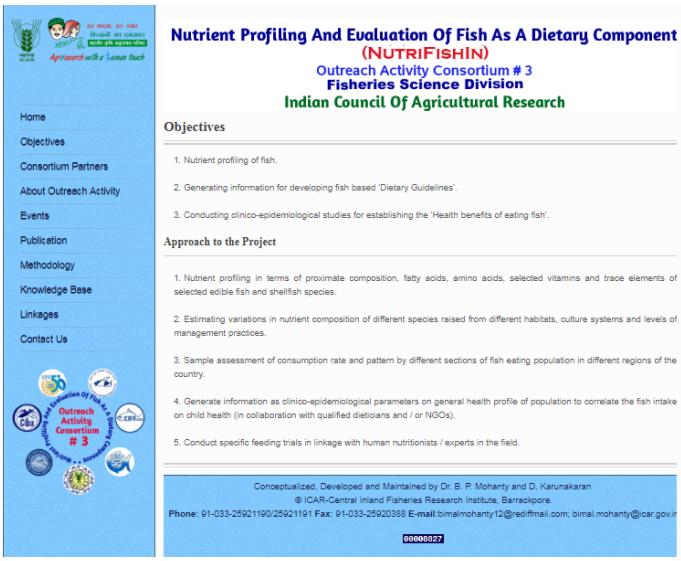


Fig. 2. Snapshots of Objective page of database website NutriFishIn: Nutritional composition of food fishes from India (http://www.cifri.res.in/nutrifishin/).

2. **Consortium Partners**

The consortium partners of the projects are detailed here.

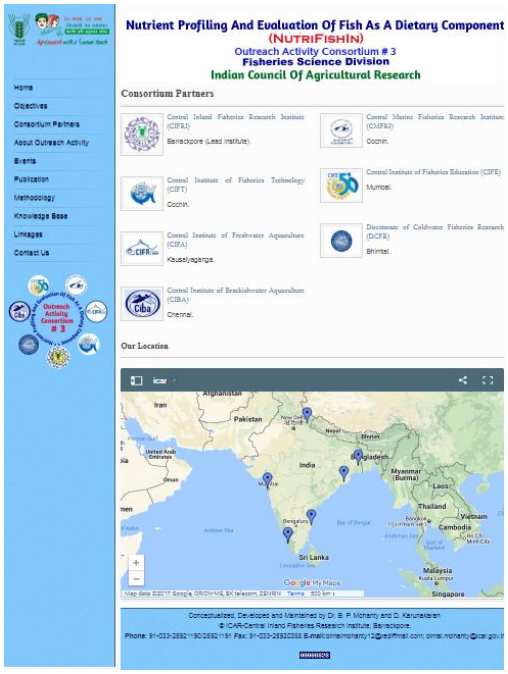


Fig. 3. Snapshots of Consortium partners page of database website NutriFishIn: Nutritional composition of food fishes from India (http://www.cifri.res.in/nutrifishin/).

3. About Outreach Activity

This page gives overview of the project and its various components.

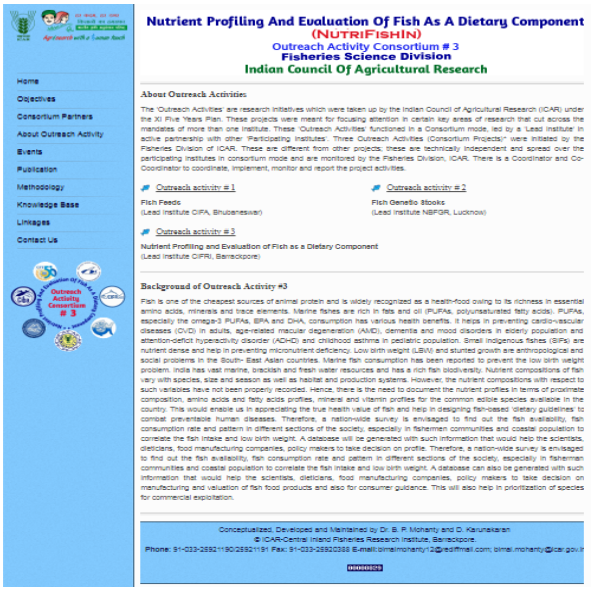


Fig.4. Snapshots of About the project page of database website NutriFishIn: Nutritional composition of food fishes from India (http://www.cifri.res.in/nutrifishin/).

4. Events and Publications

Fig.5. Snapshots of Events and Publication pages of database website NutriFishIn: Nutritional composition of food fishes from India (http://www.cifri.res.in/nutrifishin/).

5. Methodology

The 'Methodology' section contains detailed methodologies and standard protocols followed for the estimation of proximate composition, amino acid, fatty acid, mineral and vitamin analysis.

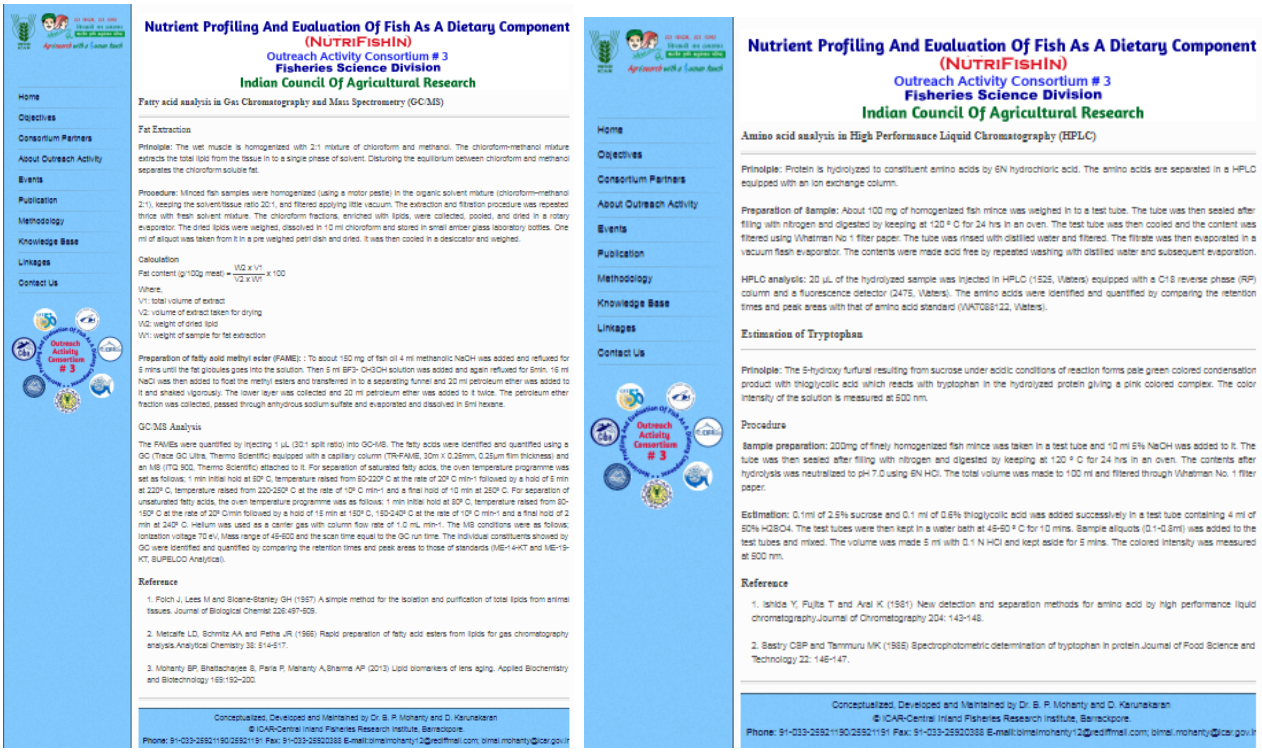


Fig.6. Snapshots of Methodology pages of database website NutriFishIn: Nutritional composition of food fishes from India (http://www.cifri.res.in/nutrifishin/index.php).

6. Knowledgebase

The Knowledgebase contain the detailed data of proximate composition, amino acid, fatty acid, mineral and vitamin analysis and also information as dietary recommendations for dieticians, physicians, nutritionists etc.

Fish species	Proximate composition (in %)	Recommendable
 *Catla catla* (Catla)	Moisture:76.2±0.3 Crude protein: 16.2±0.5 Crude fat:2.8±0.3 Ash:2.5±0.1	Proteins
 *Labeo rohita* (Rohu)	Moisture:75.6±0.5 Crude protein: 15.9±0.4 Crude fat: 2.7±0.2 Ash: 2.6±0.2	Proteins
 *Cirrhinus mrigala* (Mrigal)	Moisture:75.3±0.6 Crude protein:15.5±0.5 Crude fat:2.8±0.3 Ash:2.5±0.1	Proteins
 *Sperata seenghala* (Sykes)	Moisture: 79.4±1.2 Crude protein: 19.0±1.3 Crude fat: 0.8±0.4 Ash:0.9±0.2	Lean meat (Proteins); trace elements Fe and Zn
 *Rita rita* (Rita)	Moisture: 77.7±4.3 Crude protein: 19.5±1.2 Crude fat: 1.6±0.0 Ash:1.0±0.1	Lean meat (Proteins); trace elements Fe and Zn
 *Tenualosa ilisha* (hilsa)	Moisture: 66.9±4.2 Crude protein: 20.7±2.7 Crude fat: 10.5±4.6 Ash: 1.1±0.5	ω-3 PUFAs, vitamin E
 *Chitala chitala* (Chital)	Moisture:74.2±1.2 Crude protein:22.2±0.7 Crude fat:4.0±0.7 Ash:1.7±0.1	Proteins

Fish species	Proximate composition (in %)	Recommendable
 *Notopterus notopterus* (Folui)	Moisture:74.8±1.2 Crude protein:16.0±0.5 Crude fat:23.7±0.3 Ash:4.3±0.1	Proteins
 *Labeo gonius*	Moisture:77.3±1.2 Crude protein:20.6±0.5 Crude fat:1.0±0.3 Ash:1.0±0.1	Proteins
 *Labeo fimbriatus*	Moisture:80.3±1.2 Crude protein:17.2±0.5 Crude fat:1.3±0.3 Ash:1.2±0.1	Proteins
 *Channa striatus* (Sol)	Moisture:78.8±1.2 Crude protein:17.9±0.5 Crude fat:1.1±0.3 Ash:1.7±0.1	Proteins
 *Labeo dyocheilus*	Moisture:75.4±1.2 Crude protein:18.7±0.5 Crude fat:5.7±0.3 Ash:1.4±0.1	Proteins
 *Oncorhynchus mykiss* (Rainbow trout)	Moisture: 74.7±0.3 Crude protein:17.9±0.0 Crude fat: 3.8±0.1 Ash: 1.8±0.1	ω-3 and ω-6 PUFAs, Isoleucine, Tyrosine, Proline
 *Tor putitora* (Golden mahseer)	Moisture:74..9±0.1 Crude protein:17.9±0.2 Crude fat:4.3±0.1 Ash:1.5±0.1	ω-3 PUFAs, Tryptophan
 *Schizothorax richardsonii* (Snow trout)	Moisture: 74.8±0.0 Crude protein:16.3±0.1 Crude fat: 3.4±0.0 Ash: 2.0±0.1	ω-3 PUFAs

Fish species	Proximate composition (in %)	Recommendable
 *Neolissochilus hexagonolepis* (Chocolate mahseer)	Moisture: 75.3±0.1% Crude protein: 18.2±0.3% Crude fat: 3.3±0.0% Ash: 1.4±0.0%	ω-3 PUFAs, Calcium and Selenium
 *Cyprinus carpio* (Common carp)	Moisture:77.2±0.3 Crude protein:17.9±0.8 Crude fat:3.0±0.0% Ash: 1.3±0.1%	ω-3 and ω-6 PUFAs
 *Amblypharyngodon mola* (Mola)	Moisture: 76.2±1.1 Crude protein: 16.3±0.8 Crude fat: 4.3±0.0 Ash:4.0±0.9	Vitamin A, D and K (highest among all the species studied), Trace element Fe
 *Puntius sophore* (Puti)	Moisture: 75.7±1.9 Crude protein: 16.3±0.9 Crude fat: 4.9±0.5 Ash: 3.4±0.1	Vitamin D and K, Trace element Fe and Zinc
 *Johnius coitor* (Bhola)	Moisture:78.8±1.9 Crude protein:20.6±1.9 Crude fat:0.6±0.2 Ash:1.0±0.0	Proteins
 *Liza parsia* (Parse)	Moisture:76.4±0.4 Crude protein:22.3±0.8 Crude fat:0.9±0.0 Ash:1.6±0.0	Arginine and Leucine
 *Polynemus paradiseus* (Topse)	Moisture:75.7±1.2 Crude protein:17.6±0.5 Crude fat:4.4±0.3 Ash:2.2±0.1	Proteins
 *Osteobrama belangiri*	Moisture:73.6±1.2 Crude protein:17.0±0.5 Crude fat:7.2±0.3 Ash:2.1±0.1 (Analysis going on)	Proteins

Fish species	Proximate composition (in %)	Recommendable
 *Osteobrama cotio*	Moisture: 76.1±1.1 Crude protein: 19.1±0.4 Crude fat: 1.4±0.5 Ash: 3.3±0.1 (Analysis going on)	Proteins
 *Ompok bimaculatus* (Pabda)	Moisture: 78.9±1.1 Crude protein: 16.9±0.4 Crude fat: 2.2±0.5 Ash: 1.9±0.1	Proteins
 *Pampus argentius* (Pomfret)	Moisture:76.2.±0.7 Crude protein:19.6±0.6 Crude fat:4.0±0.6 Ash:0.9±0.2	Proteins Leucine and Lysine
 *Xenentodon cancila*	Moisture:78.2±0.7 Crude protein:15.7±0.3 Crude fat:0.7±0.0 Ash:3.6±0.1	Ca and P (highest among all the species studied) and trace element Cu and Mn
 *Clarias batrachus* (Magur)	Moisture: 75.9±0.7 Crude protein: 16.4±0.3 Crude fat: 3.7±0.4 Ash: 2.3±0.0	Trace elements Zn and Se
 *Heteropneustes fossilis* (Singhi)	Moisture: 76.7±1.1 Crude protein: 16.3±0.4 Crude fat: 2.7±0.5 Ash: 2.6±0.1	Proteins
 *Gudusia chapra* (Koira)	Moisture:75.3±0.6 Crude protein:15.5±0.5 Crude fat:2.8±0.3 Ash:2.5±0.1	Ca and P, trace element Fe and Mn (highest among all the species studied)
 *Ailia coila* (Kajuli)	Moisture:82.8±0.2 Crude protein:12.9±0.5 Crude fat:1.8±0.0 Ash:2.0±0.1	Ca and P, trace element Fe and Zn

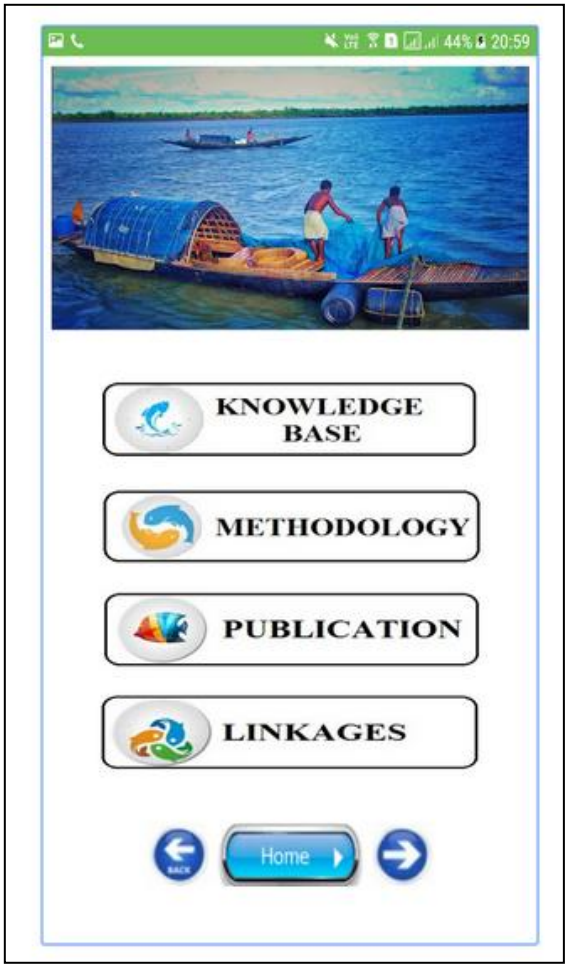
Fish species	Proximate composition (in %)	Recommendable
 *Barbonymus gonionotus*	Moisture: 74.55±0.7 Crude protein: 16.7±0.5 Crude fat: 4.3±0.6 Ash:2.6±0.6 (Analysis going on)	Proteins
 *Anabas testudineus* (Koi)	Moisture: 68.0±0.7 Crude protein: 16.9±0.5 Crude fat: 6.9±0.6 Ash: 5.3±0.2	ω-3 PUFAs, Vitamin A and Ca
 *Lates calcarifer* (Asian seabass)	Moisture: 72.05±0.4 Crude protein:21.16±0.5 Crude fat: 2.65±0.3 Ash: 1.62±0.6	Proteins
 *Mugil cephalus* (Grey mullet)	Moisture: 75.6±0.6 Crude protein:20.0±0.9 Crude fat: 1.79±0.4 Ash: 1.43±0.3	Proteins
 *Etroplus suratensis* (Pearl spot)	Moisture: 74.2±0.5 Crude protein:20.4±0.8 Crude fat: 4.7±0.8 Ash: 1.4±0.1	ω-3 PUFAs
 *Harpadon nehereus* (Bombay duck)	Moisture:87.5±2.0 Crude protein:8.2±0.9 Crude fat:2.2±0.2 Ash:1.1±0.2	ω-3 PUFAs
 *Stolephorus waitei* (White bait)	Moisture: 79.9±0.1 Crude protein: 20.3±0.1 Crude fat: 1.1±0.0 Ash: 3.3±0.3	ω-3 PUFAs , Leucine and Methionine
 *Stolephorus commersonnii* (Commerson's anchovy)	Moisture: 79.4±0.1 Crude protein: 16.4±0.1 Crude fat: 1.2±0.0 Ash: 3.2±0.2	ω-3 PUFAs , Isoleucine, Threonine

Fish species	Proximate composition (in %)	Recommendable
 *Leiognathus splendens* (Silverbelly)	Moisture: 74.7±3.7 Crude protein: 17.2±1.6 Crude fat: 3.8±3.7 Ash: 3.1±0.7	ω-3 PUFAs
 *Rastrelliger kanagurta* (Indian mackerel)	Moisture: 78.2±0.1 Crude protein: 19.2±0.1 Crude fat:1.7±0.0 Ash: 1.2±0.0	ω-3 PUFAs, Histidine
 *Thunnus albacares* (Yellowfin tuna)	Moisture: 74.1±0.1 Crude protein: 23.9±0.1 Crude fat: 0.6±0.0 Ash: 1.4±0.0	ω-3 PUFAs , Proteins
 *Ethynnus affinis* (Little tuna)	Moisture: 75.7±0.1 Crude protein: 20.9±0.1 Crude fat: 1.9±0.0 Ash: 1.5±0.0	ω-3 PUFAs, Proteins
 *Sardinella longiceps* (Sardines)	Moisture: 71.3±7.1 Crude protein: 17.1±1.4 Crude fat:9.2±5.8 Ash: 2.3±0.6	ω-3 PUFAs and vitamin E
 *Katsuwonus pelamis* (Skipjack tuna)	Moisture: 70.6±7.4 Crude protein: 22.4±2.9 Crude fat: 1.2±1.1 Ash: 1.9±0.8	ω-3 PUFAs , Proteins
 *Epinephelus diacanthus* (Spinycheek grouper)	Moisture: 78.5±1.5 Crude protein: 18.1±1.1 Crude fat: 0.9±0.5 Ash: 1.5±0.5	ω-3 PUFAs, Vitamin E
 *Nemipterus japonicus* (Threadfin bream)	Moisture: 78.5±0.1 Crude protein: 15.4±0.2 Crude fat: 5.1±0.0 Ash: 1.0±0.0	ω-3 PUFAs

Fish species	Proximate composition (in %)	Recommendable
 *Trichiurus lepturus* (Ribbon fish)	Moisture: 75.5±3.6 Crude protein: 17.9±1.5 Crude fat: 3.4±4.1 Ash: 1.6±0.4	ω-3 PUFAs, DHA
 *Macrobrachium rosenbergii* (giant river prawn)	Moisture: 73.5±0.6 Crude protein:16.8±0.5 Crude fat: 4.4±0.2 Ash: 4.9±0.2	Protein
 *Fenneropenaeus indicus* (Indian white shrimp)	Moisture: 82.2±0.9 Crude protein:16.4±0.3 Crude fat: 0.7±0.4 Ash: 1.4±0.1	Protein
 *Penaeus monodon* (Tiger shrimp)	Moisture: 76.3±0.5 Crude protein:19.4±0.2 Crude fat: 0.7±0.4 Ash: 1.4±0.1	Protein
 *Crassostrea madrasensis* (edible oyster)	Moisture: 80.1±0.7 Crude protein: 16.8±0.1 Crude fat: 2.7±0.2 Ash: 1.3±0.1	ω-3 PUFAs and Mn
 *Perna viridis* (Green mussel)	Moisture: 83.5±0.5 Crude protein: 11.0±0.1 Crude fat: 1.7±0.0 Ash: 1.4±0.0	Calcium

Nutrifish App

Nutrifish App is an Android App developed by the researchers at ICAR-CIFRI, Barrackpore. In the digital India era, where common man has an access to a mobile, Nutrifish App can provide easy access to the users on nutritional information on food fishes of India available at NutriFishIN database. The main feature of the app is that information on food fishes (gross chemical composition, amino acid, fatty acid and micronutrients) available at NutriFishIN database can be accessed anytime, anywhere. So, consumers which may be a common man, fishermen, farmer or any elite public like dieticians, physicians, planners can access the App and make use of the information. Thus, Nutrifish App empowers the public, the first target being the Indian population (17% of the global population) and the extended target is the netigens or other global citizens.



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Nutritional Requirement Based Value Addition on Fish and Fishery Products

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Introduction

Fish and fishery products are highly nutritious and play an important role in food and nutritional security around the world. Consumption of fish offers nutritional and health benefits and is considered a key element in a healthy diet. Nutritional study shows that fish protein is same as chicken protein and is superior to beef protein, milk and egg albumin. Fish is a rich source of easily digestible proteins and also provides polyunsaturated fatty acids, vitamins and minerals for human nutrition. In addition to the high percentages of animal protein, they provide several other nutrients such as vitamins A and B, E and K vitamins, and they areunique source of essential micronutrients and long chain omega-3 fatty acids. Fish provides about 3.3 billion people with almost 20 percent of their average per capita intake of animal protein (SOFIA, 2020). But the problem in fish is, it is highly susceptible to deterioration without any value addition or preservative or any processing measures. To avoid such problem & making the fish more lucrative by the consumer, value addition is one of the modern marketing concepts in the seafood sector.

What is Value Addition?

The basic concepts behind value addition as far as food is concerned include the functional and emotional benefits related to quality and nutrition, convenience in preparation and high sensory appeal at a reasonable cost. The changing market demands are generally initiating attempts to add value to basic fishery commodities and ultimately getting the nutritional benefit. “Value added fish products are usually perceived to be those that have added ingredients such as a coating or sauce, are prepared, trimmed or in some way provide more convenience to the user” (Helga Josupeit, 2006).Value addition in fish & fishery products is mostly done in the industry, particularly in fish processing industry, mainly for earning foreign exchange. Besides, value

addition is one of the possible approaches to raise the profitability of fish processing industry, which now lays greater emphasis on quality assurance.

Why we need value addition in fish & fishery products?

Fish has gained importance as a health food in both the developed and developing worlds. More than one billion people worldwide rely on fish as an important source of animal proteins, deriving at least 20% of protein from fish. Fish proteins are well-balanced with regard to most of the essential amino acids. The fish proteins are easily digestible and arerich in lysine.

In 2018, about 88 percent of the 179 million tonnes of total fish production was utilized for direct human consumption, while the remaining 12 percent was used for non-food purposes. In 2018, live, fresh or chilled fish still represented the largest share of fish utilized for direct human consumption (44 percent). A growing share of fishmeal and fish oil, estimated at 25–35 percent, is produced from the by-products of fish processing. In fisheries and aquaculture, it is estimated that 35 percent of the global harvest is either lost or wasted every year. Effective fish loss and waste reduction requires appropriate policies, regulatory frameworks, capacity building, services and infrastructure, as well as physical access to markets. Ultimately the waste utilization of fish can achieve the nutritional security.About 78 percent of the quantity exported consisted of products destined for human consumption. Recovery of flesh by mechanical deboning and development of value added products are probably the most promising approaches and this has initiated product development using mince from low or high cost fishery resources.

Value addition has opened two types of field for the profitable utilization of high valued fish as well as low valued fish catches and by-catch.

1. At higher end of the chain: Fish fillet, IQF, Block frozen, processed and ready-to-eat products.
2. At lower end of the chain: converting processing waste into food and non-food products (fish meal & fish oil, chitin & chitosan, fish bone powder, fish silage etc).

Both the products possess good product attributes and attract consumers from various sections of our society. High valued products comeunder the category of ready-to-eat or ready-to-cook value added products possessing good taste, nutritional and health benefits to the consumer. Similarly, low valued products are used as therapeutic, cosmetic, decorative agents and have nutritional health benefit to the animal.

- **Value Addition for Domestic Consumption**

The technological upgradation of the units, product diversification through value addition and compliance with safety related regulations of buyers by proper planning at higher levels and extending needed help to the fish processing units would help in increased consumption of value added items in domestic sector.

- **Better Utilization of Bulk Catches**

The marine bulk catches can be utilized by the fishermen for value addition to hygienic products such as fish mince, properly dried fish etc. Moreover, this would also prevent the wastage of by-catches from trawlers by fishermen.The other advantages are total utilization of the catch including by-catch and non-conventional species, diversification of traditional technologies, better marketability and by-product recovery.

- **Consumer Acceptability**

Value added fishery products such as fish finger, or coated fish fillet, fish portions, fish cakes, breaded shrimp, crab balls, fish balls, coated shrimp products, coated squid rings etc. are generally well accepted by the consumers throughout the world. Such products are very popular in fast food joints. This is essentially due to their appealing crispness and flavour. Consumers expect a positive assurance that the food product including seafood is safe, tasty, easy and quick to prepare, light in calories, easy to digest and nutritive. Recent trends in seafood product development technology are aiming to address these changing consumer interests.

- **Marketability**

To increase the market value of a particular product, different value additions like attractive appearances, specific see through packaging and appealing display are made in the product. Packaging requirements change with product form, target group, market area, species used and other factors.

Higher End of the Chain Value Addition & Its Nutritional Importance:

1. Thermal processed /Canned products

Canned food in which spoilage is averted by killing microorganisms present by application of heat and preservation of subsequent contamination, the product being enclosed in a hermetically sealed container.These have a shelf life of more than one year at ambient temperatures.

Fish curry in retort pouch: Ready to serve fish curry can be processed in three layer laminate flexible pouches and can be stored for more than one year at ambient temperatures.

Nutrients in canned fish: Canned fish are an important food source. Theyare rich in protein and many other essential nutrients, including many that are a good source of omega-3 fatty acids. Many different types of sea creatures are canned, including fish, molluscs, and crustaceans.Additionally, both fresh and canned tuna are good sources of several essential **vitamins** and minerals, including vitamin D, selenium, and iodine.

Health benefit of canned fish: There is an incredible number of benefits to eating tuna, including lower blood pressure and decreased risk of heart disease. By eating sardines canned in soya oil, you can give your brain and immune system a boost which can help them perform at their best. Canned mackerel is also high in omega-3 and omega-6 fatty acids, more so than just about any other common fish. It's low risk of overfishing and minimal mercury levels make it an ideal healthy food.

Fish curry in retort pouch

Canned fish products

2. Cured fishery products

Curing refers to various food preservation and flavouring processes, especially meat and fish, by the addition or combination of salt, sugar and other preservatives.

- **Dried products with its nutritional & health benefits**

Drying is a method of food preservation or a type of value addition that works by removing water/moisture from the food, which inhibits the growth of microorganisms.Dry fish have a vital factor in providing high-quality proteins, healthy fats (including long-chain omega-3 fatty acids like eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA)), and a unique source of essential nutrients such as iodine, zinc, copper, selenium, and calcium. In addition to this, it provides with fewer calories than other foodsuch as beef. 100 g of dried fish contains about 80% protein with 300 calories, while beef has more than twice the calories with far less protein. Pure dried cat fish is a completely natural product that retains the antioxidant and omega-3 benefits of fresh fish. Though dry fish is a popular delicacy across the country, its

consumption is hazardous to human health as the preservative used to keep the fish dry is highly toxic.

- **Smoked products and its nutritional importance**

Smoked fish is simply fish that has been cured through smoking as a method of imparting flavor and preserving the fish. Ultimately adding smoke to the fish, we get a pleasant flavour and aroma. The most common types of smoked fish include salmon, whitefish, trout, and mackerel. Smoked fish has the same nutritional value as fresh fish, as the nutrition facts will show. Not only is it rich in protein, but it is low in calories as well. The smoking process increased the level of protein in one fish serving even up to 18-27%. Overall, the smoking process increased the concentration of some basic nutrients and reduced the fat and mineral contents.

- **Salted Products & its nutritional value**

Addition of salt to the fish removes water making the product stable and microbial free & the process is called as salting. This is usually done as such or in combination with drying or smoking.Salted fish can be served as an appetite enhancer. Salt is an important additive in the preparation of fermented, pickled, or processed fish or fish products. Salted products are rich in micro and macro nutrients. Sometimes, high intake of salt may lead to cancer and cardio vascular problem. A best example for salt-cured fish product is fish pickle.

Preparation of Fish pickle

Ingredients

- Fish dressed and cut into small pieces : 1 kg
- Mustard : 10 g
- Green chilli (cut into pieces) : 50 g
- Garlic (peeled) : 200 g
- Ginger (peeled and chopped) : 150 g
- Chilli powder : 50 g
- Turmeric powder : 2 g
- Gingerly oil : 200 g
- Vinegar (acetic acid 1.5%) : 400 ml
- Salt : 60g
- Pepper (powdered) : 2.5g
- Sugar : 10g
- Cardamom, clove, cinnamon (powdered) : 1.5 g

Method of Preparation

Ø Mix the fish thoroughly with 3% of its weight of salt and keep for two hours. Light salted and partially dried fish also may be used.

Ø Fry the fish in minimum quantity of oil. Set apart the fried fish.

Ø Fry the ingredients (mustard, green chillies, garlic, ginger) in the remaining quantity of oil and then add chilli powder, pepper powder and turmeric powder and mix well over low flame for a few minutes.

Ø Remove from fire, add fried fish and mix well.

Ø When cooled, add vinegar, powdered cardamom, clove, cinnamon, sugar and remaining salt and mix thoroughly.

Ø Sufficient quantity of boiled and cooled water may be added to cover the ingredients well.

Ø Transfer to clean, sterile g1ass bottles and seal with acid proof caps. Take care to see that there is a layer of oil over the contents in the bottle.

Ø Flexible pouches made of 12 micron polyester laminated with l 18micron LD-HD co-extruded film can also be used for packing the pickle.

3. Fish Mince & Mince Based Products

Minced meat is the meat separated from fish in comminuted form free of bones, skin etc. In principle, meat separation process can be applied to any species of fish, but when it is applied to low-cost fishes significant value addition will accrue. Minced meat can be used as a base material for the preparation of a number of products of good demand. Meat-bone separators (meat picking machines) are generally used for the preparation of minced meat.Minced fish can be used for the preparation of a number of products like fish sausage, cakes, cutlets, patties, balls, pastes, surimi, texturised products etc. The processes for the production of most of these products are available and some of them are very much suitable for starting small scale industries.

Surimi: Surimi is a Japanese term for mechanically deboned fish flesh that has been washed with water and mixed with cryoprotectants for imparting good frozen shelf life. Washing not only removes fat and undesirable matters such as blood, pigments and odoriferous substances but

also increases the concentration of myofibrilar protein, the content of which improves the gel strength and elasticity of the product. The best example is Fish sausage.

Fish sausage: Fish sausage is made from Surimi mixed with salt, sugar, sodium glutamate, and soy protein. The above mixture is stuffed into PVC casing using automatic screw stuffer. The casing tube is closed using metal rings and heated in hot water at 85-90^{0}C for 4-6 minutes.After heating, it is slowly cooled to avoid shrinking of the tube and then dried.

Health & Nutritional Benefits of Surimi: Surimi is low in fat and calories which makes it a perfect addition to diet if one is trying to lose weight or trying to shed excess pounds. Surimi is an option for low fat foods and low calorie food to prevent chronic illness such as heart disease. It offers healthy amount of phosphorus. One percent of body weight is made from phosphorus that could be found in every body part especially bones and teeth. Phosphorous has a vital role in maintaining teeth and bone health as well as proper functioning of muscles and kidneys. It maintains healthy heart beat and supports healthy function of nerves.

Kneaded products: Several kneaded products like kamaboko, chikuwa, hampen, fish ham and sausage are processed using surimi and incorporating other ingredients. The ingredients used in most of these preparations are identical; however, the classification is principally based on the manufacturing process involved. The ingredients employed other than surimi include salt, monosodium glutamate, sugar, starch, egg white, polyphosphate and water. The method of processing all these products involves grinding together of the various ingredients to a fine paste and some sort of heat treatment at some stages.

Fiberized products: Fiberized products are the greatest in demand among the surimi based imitation shellfish products. The ingredients used in the formulation of fiberized products include, besides surimi, salt, starch, egg white, shellfish flavor, flavor enhancers and water. All the ingredients are thoroughly mixed and are ground to a paste. The paste is extruded in sheet form on the conveyor belt and is heat treated using gas and steam for partial setting. A strip cutter subdivides the cooked sheet into strings and is passed through a rope corner. The final product is formed by steam cooking of the coloured and shaped material.

4. Fermented fish products & its nutritional importance

During fermentation microorganisms convert the chemical constituents of raw substrates and enhance the nutritional value of products, improve flavor and texture, preserve the perishable foods and extend the shelf life, fortify the product with health-promoting bioactive compounds, vitamins and minerals, degrade undesirable compounds and anti-nutritive factors, produce antioxidant component and anti-microbial compounds and stimulate the probiotic function. Fermented fish products are rich in protein content &have an important role in stimulating the appetite by providing unique aromas and flavourswhich meet various consumer appetites. Many kinds of fermented fish products can be found in various parts of north eastern India. Four basic methods of fish fermentation were identified in the region: fermentation with salting; drying and fermentation without salting; drying and fermentation with salting; smoking, drying and fermentation without salting.The products are Fish sauce, Shidol, Namsing, Tungtap, Hentak and Lona ilish.

Fish sauce: Fish sauces are made from a mixture of fish and salt that has been allowed to ferment for up to two years. Traditionally, oily fish such as anchovies are placed in a barrel with salt and slowly pressed to extract the liquid. Anchovies are often used, although some fish sauces are also made from shrimp, krill, or mackerel. The basic ingredients of a good fish sauce are fish, water, and salt. Sometimes sugars such as caramel or molasses are added, or roasted rice. Fish sauce is referred to as *nampla* in Thailand, *teuktrei* in Cambodia, *nam pa* in Laos, *patis* in the Philippines, and *nganbya yay* in Burma.

Fermented product(Sheedol)

Lao Fermented fish sauce

Frozen surimi block

Fish sausage

5. Frozen fish fillets

Skinless and skin-on fillets from lean/medium fat white meat fish have enormous market potential. Many varieties of deep sea fishes such as grouper, red snapper, reef-cod, breams and jewfish are suitable for making fillets both for domestic market and for 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.

6. Chilled fish

Chilled fish is another important value added item of international trade. The most prominent among this group is sashimi grade tuna. Sashimi is a Japanese term for raw fish fillets mainly from tuna and it is a traditional delicacy in Japan. Three species, blue fin, big eye and yellow fin are mainly used for this purpose. The best quality sashimi tuna is that which is chilled at all stages from capture to final consumption. Other important products of this group are pomfret, shrimp, lobster and crabmeat.

7. Fish proteins and its nutritional value

The proteins of the fish have high digestibility, biological and growth promoting value. Hence, it plays an important role in human nutrition. The available amino acids are more evenly balanced than the other proteins of animal origin. Amino acids like lysine and methionine are rich in fish protein. 15 - 25 per cent of protein is obtained from the fish muscle which forms the chief source. The fish proteins are extracted with dilute caustic soda solution from fish fillets or waste after removing the fat. The extracted material is dried after neutralization. This powder is white in colour without any fishy dour and taste containing 80 - 90 per cent of solubilized protein.

8. Accelerated freeze dried products:

Accelerated freeze-drying is now being increasingly used for the preservation of high value food products. In this process the product in frozen condition is subjected to very high vacuum causing the ice crystals to sublime. The product has the advantages like absence of

shrinkage, quick re-hydration up to 95%, minimum heat induced damage etc. In India this technique is now applied for processing shrimp, squid rings etc. the possibilities for various ready-to-eat products based on fish and shellfish employing this technique are immense.

9. Individually quick frozen (IQF) products& its nutritional importance:

For the production of IQF products raw materials of very high quality need to be used and the processing has to be carried out under strict hygienic conditions. The products have to be packed in attractive moisture-proof containers (thermoform moulded trays have come to be accepted as containers for IQF products in western countries) and stored at around -30°C without fluctuation in storage temperature. IQF ensures that the food being frozen will freeze while producing almost no ice crystals inside of the product itself. This ultra-fast freezing of the food prevents the cells within the food from becoming damaged. Also, it preserves it, which results in a much higher quality end product. Freezing allows year round availability, and makes it easy to include as part of a healthy diet. Some of the IQF products are given below.

- **Stretched shrimp (nobashi)**: Shrimp is washed is chilled water containing 5 ppm chlorine, beheaded, deveined, using bamboo stick and peeled keeping the last segment and tail intact. The tail is then trimmed and the shrimp is then stretched using a metallic stretcher after making 2-3 parallel cuttings on the bottom side. Stretched shrimps are then packed in thermoformed trays under vacuum and frozen at -40°C.
- **Barbecue**: Shrimp is washed in chilled water containing 5 ppm chlorine, beheaded, deveined, peeled and again washed in chilled water. Bamboo stick is then pierced into the meat from head portion to tail. It is then packed in thermoformed trays under vacuum and frozen at -40°C.
- **Sushi (cooked butterfly shrimp)**: Shrimp is washed in chilled water containing 5 ppm chlorine, beheaded, deveined and again washed in chilled water. Bamboo stick is then pierced between the shell and the meat from head portion to tail and then cooked in 1% brine for 2 minutes at 100°C. The cooked shrimp is then cooled in chilled water, bamboo stick removed and then peeled completely, including the tail fans. The ventral side is then gently cut down length wise completely using a sharp scalpel. The cut surface is then gently opened up to form the butterfly shape, packed in thermoformed trays under vacuum and frozen at -40°C.

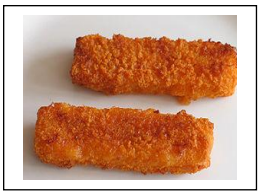
- **Skewered shrimp**: The process is similar to that of barbecue, but piercing of shrimp is carried out in such a way that 4-5 shrimps are arranged in a skewer in an inverted "U" shape. It is then packed in thermoformed trays under vacuum and frozen at -40°C.
- **Shrimp head-On (Central Peeled)**: Shrimp is washed in chilled water containing 5 ppm chlorine, peeled at the center keeping the head and the last two segments intact, deveined, and the tail is trimmed. It is again washed in chilled water, packed in thermoformed trays under vacuum and frozen at -40°C.
- **Shrimp head-on cooked (Center Peeled):** Shrimp is washed in chilled water containing 5 ppm chlorine, deveined and then cooked in 1% brine for two minutes at 100°C. It is immediately cooled in chilled water and peeled keeping the head and the last two segments intact. The tail is trimmed and again washed in chilled water. It is then packed in thermoformed trays under vacuum and frozen at -40°C.

10. Battered and breaded/Coated/Enrobed fish products

Coated product is one, which is coated with another foodstuff. Two types of coatings are in common use. They are batter and breadcrumbs. Most of these items are ready-to-cook and are processed frozen, although some may be processed fresh. Some of the products are given below.

- **Coated squid rings**: Cleaned squid tubes are cut in the form of rings, cooked in brine, cooled, battered and breaded. These are then flash fried, cooled, packed and frozen.
- **Coated fish fillets**: Skinless and bone less fillets preferably of white meat fish are cold blanched in dilute brine and drained. These are then battered, breaded flash fried and frozen in IQF form preferably in thermoformed containers.
- **Coated fish balls**: Fish balls are generally prepared from mince of low cost fish. Balls can be prepared by different ways. The simplest method is by mixing the fish mince with starch, salt and spices. This mix is then made into balls and cooked in boiling 1% brine. The cooked balls are then battered and breaded.
- **Fish cutlets**: Fish cutlets are prepared using cooked fish mince, which is mixed with cooked potato, fried onion and species etc. It is then formed into the desired shape, each weighing approx. 40 g. The formed cutlets are battered, breaded and flash fried for 20 seconds.

- **Fish Burger:** Burger is made using mince from lean white fleshed fish. Cooked mince is mixed with cooled potato and mild spices and formed into flat round pieces. These are battered, breaded and flash-fried.
- **Breaded shrimp:** These are coated with batter and breadcrumbs, flash fried and packed as IQF preferably in thermoformed trays. They can be prepared from both wild and farmed shrimp in different styles, viz. peeled and deveined, butterfly, round tail- on, cooked and peeled nobashi etc.
- **Fish fingers or fish portions:** Fish finger is a very popular product made out of fish mince. The mince is mixed with 1.0 % salt, made into rectangular slabs and frozen. The frozen mince is cut into suitable uniform sizes. These pieces are given a coating of batter followed by breading. The battered and breaded fish fingers are flash-fried in oil maintained at 180-200° C for about 20 seconds. After cooling the fingers are frozen and stored.

Squid products:

- **Squid Rings**: Cleaned squid tubes are cut in the form of rings, followed by cooking in boiling brine (3%) for 1-2 minutes. They are then cooled, breaded and battered. The battered rings are flash fried at 175-180°C for 20 seconds, cooled, frozen and packed.
- **Stuffed Squid**: Stuffed squid is prepared from small squid which are not generally processed for export. The cleaned tubes from such small squids are filled with a stuffing mixture prepared using cooked squid tentacles, potato, fried onion, spices etc. the stuffed squid are then battered, breaded and flash fried.
- **Clam and other related products**: Live clams are depurated and the meat is shucked out after boiling. The meat is blanched in boiling brine, cooled and battered, breaded, flash fried for 20 seconds, frozen and packed. Other bivalves such as oyster, mussels etc., can also be

converted into coated products by the same name.

Some other speciality products

- **Fish wafers**: Prepared from low-cost fishes. Cooked fish meat is blended with starch and salt, spread in trays and gelatinized on steam, cut into desired shape and dried. Served hot after frying in edible oil. The product has a shelf life of more than one year. Fish soup powder: An instant soup powder prepared from low cost fish with cooked fish meat, starch spices, fat milk powder etc. as the main ingredients. These ingredients are homogenized, dried & powdered and kept in air - tight containers. To be added to boiling water and served hot. The product has a shelf life of seven months.

Value Addition at Lower End of the Chain

1. Value addition in Shrimp waste& its nutritional importance

Shrimp waste consists of head shell and meat portions of shrimp that are being processing for human consumption.Approximately 70 % of the total shrimp landing becomes waste, so there is a tremendous tonnage of shrimp waste produced.Chitin, Chitosan, Glucosamine-hydrochloride, shrimp-head meal, shrimp shell powder is prepared by using shrimp shell waste. Natural polymer chitin can be used as calcium supplement. Astaxanthine and carotenoid pigment can be recovered. Shell waste is used as feed ingredient for fish cattle and poultry feed. Chitin derivatives have a lot of importance in food and nutrition, cosmetics, photography, medical & pharmaceuticals. Shrimp head meal is prepared from shell waste having high biological value with 40% protein content. Also it contains essential aminoacids particularly lysine and methionine.

Shrimp head meal

Chitin flakes

Chitosan powder

Glucosamine hydrocholoride

2. Fish Protein Concentrate (FPC)& its nutritional value

It is a stable protein concentrate which is prepared from whole fish or other aquatic animals or their parts intended for human consumption. FPC is a nutritious product having higher content of digestible & good quality protein, available lysine & mineral. It is an odourless, tasteless powder which is not

relished for consumption as such but incorporated as a protein supplement in human diet like bread, biscuits, noodle, soup & stews. Also used in Macaroni products, milk shake-drink, spaghetti sauce, infant foods, dietetic foods and breakfast cereals. The acceptable limit is 5-10% and recommended level of use is 35g/person/day.

3. Fish Meal & its nutritional importance

Fish meal is made from the bones and offal left over from fish caught by commercial fisheries. The vast majority of the fish from which fishmeal is manufactured are not used for human consumption; rather, fishmeal is generally manufactured from by-catch. It is generally used to feed farm animals in an agricultural setting. Because it is calorically dense and cheap to produce, It has played a critical role in the growth of factory farms and the number of farm animals it is possible to breed and feed. Fish meal is richest natural source of lysine and methionine (rate limiting amino acid in pig and poultry formulation). Fish meal is a source of other nutrients like B group vitamins, minerals like Ca, P, Na, Mg, Fe, Cu, Zn, Mn, I and Se.

4. Fish Oil and its role in human health

The oils from the fish are obtained by extracting from the entire body of the fish or only from the liver. The oil obtained from the entire body is known as body oils and are grouped into drying and semi drying oils. The drying oil comprises oils of sardine, salmon, herring, mackerel, anchovy, and white fish, while the oils of sprat and carp constitute semidrying oil due to the low iodine content. The body oil is edible and used for industrial purposes. Liver oil extracted from the liver, has the medicinal importance and contains vitamin A.

In view of rich concentration of vitamin A and D with digestible fat, it is found to improve nutrition and calcification in patients with rickets and tuberculosis when used. It can also be used as supplement for children and can be applied to wounds and burns. According to general recommendations on dietary fats for human consumption, the diet should supply 0.8 g EPA and DHA per day (0.27% calories). Regular intake of fish oil or EPA and DHA concentrate in the form of capsule may ensure a regular supply of omega – 3 fatty acid requirements of our system. Lack of omega-3 in pregnant mothers increases baby’s risk of impaired verbal, social and motor skill development. When pregnant mothers take omega-3 supplements, it has shown to increase the mental abilities of their babies.Poor outcomes

associated with insufficient intakes of omega-3 fatty acids during pregnancy include intrauterine growth retardation, adverse neurodevelopmental measures, residual deficits in fine motor skills, speed of information processing in infants, and irreversible deficits in serotonin and dopamine release. Omega – 3 fatty acids also control or prevent the conditionsviz.control of body weight, osteoporosis, cholesterol level and high blood pressure, mental depression, pre-term labour, glaucoma etc.

5. Fish Flour & its Nutritional importance

Fish flour is a fodder of animal origin that is produced from sea-food processing waste and inedible types of sea animals.Fish flour contains great amount of proteins and amino acids that allows enriching vegetable fodders with protein. It is rich in vitamins A, B, D, E and it contains potassium, phosphorous, iodine, and other minerals increasing growth of animals.

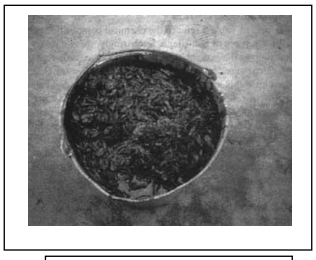
6. **Fish silage& its nutrition value**:

Fish silage can be defined as a liquid product made from whole fish or parts of fish to which no other material has been added other than an acid and in which liquefaction of the fish mass is brought about by enzymes already present in the fish. The silage concentrate is a highly digested protein hydrolysate which is convenient as a protein supply for weaning calves and pigs as well as poultry. When high amounts of fish silage protein are fed to mature ruminants or fish, the animal production and growth are reduced.This is probably due to adverse effects of highly hydrolysed protein in the metabolism of these animals. However, 5 – 10 % of the feed protein may be substituted by silage protein without negative effects.Actually, there are indications that health, fertility and general appearance are improved when some fish silage protein is included. At low levels of inclusion in diet, silage does not produce any ill effects on growth of chicken and pigs and serves as ideal substitute for fish meal.

7. Fish Collagen with its nutritional and health benefit

Fish is a natural source of collagen mainly found in connective tissue proteins making up to 30% of the total protein in the body tissue. Fish collagen is prepared from scale, fins, bone & head. Collagen is a protein responsible for healthy joints and skin elasticity, or stretchiness. Some examples of fish used for production of collagen are Japanese seabass, horse mackerel, Ayu fish (Senapati et al, Aqua international, Feb-2014 Ch-By-Products from fish bone). It is used as additive substance, also used in various foods, cosmetics & pharmaceuticals. It makes up so many critical parts of our bodies, collagen is not only beneficial but *essential* to maintaining good health. They help to maintain hydrated skin and relieve osteoarthritis pain, lowers blood pressure and blood sugar levels.

Fish meal



Fish silage

Fish oil

Fish collagen

8. Fish calcium & its importance

Calcium powder can be used to combat calcium deficiency in the diet of children. The method of production of calcium mainly involves removing the gelatin from the crushed bones and pulverizing the remaining portion. A process recommended for processing calcium powder from the backbone of skipjack tuna involves the following steps. The bone frame is crushed and washed in clean water a number of times. A 10% solution of calcium carbonate is added to the residue and is left for an hour. After draining the solution, washing and treatment with calcium carbonate is repeated a number of times. Finally, washed bone residue is further washed and dried and pulverized to the required mesh size.

9. **Utilization of Shark fins/fin rays and its importance**:

- **Shark fins**: The fins of the large sharks except caudal fin are cut near the root, washed in seawater, mixed with wood ashes and lime and dried in the sun or smoked. This product which is crisp and brittle are used in soups and regarded as delicacy. The commercial value of the fins depends on their color, size, variety and quality. Depending on the quality and quantity of rays present in the fins they are broadly classified into two varieties, generally known as black and white. The white fins usually fetch a better price compared to black fins. Fins are generally marketed in dried form. The preparation of shark fin does not require any elaborate treatment, but care is needed in cutting, trimming and drying operations. The dried fins are further processed, for the 'rays'. The price of fin rays depends mainly on color, length and thickness of the individual strands, quantity of connective tissue, cartilage present and physical appearance.
- **Shark cartilage**: Shark cartilage assumes importance because of the presence of chondriotic sulphate, which is a mucopolysaccharide. Chondriotin sulphate has therapeutic uses and is effective in reducing cancer related tumours and inflammation, and pain associated with arthritis, psoriasis and

enteritis. Oral intake of shark cartilage is reported to be effective in the above cases.

10. **Squalene:**

Squalene is an unsaturated hydrocarbon found in the unsaponifiable fraction of fish oils, especially of certain species of sharks. Liver oil containing high proportion of Squalene is distilled in a stainless steel glass lined vessel under a vacuum of 2 mm bar. Fraction distilled between 240 and 245°C is collected. All operations are to be carried out preferably in an inert atmosphere, as Squalene is easily oxidisable. Squalene is widely used in pharmaceuticals and cosmetics.

11. **Tuna eyes**:

Tuna eyes are an item of commerce. The high demand for them is attributed particularly to their content of polyunsaturated fatty acids like decosahexaenoic acid. This fatty acid is valued for its medicinal properties in combating atherosclerotic and thrombotic problems of chronic heart patients. Extraction and preservation of eyes of tuna and its marketing stand good prospects.

Conclusion

Fish is good for the health having high nutritional value. Due to the modernization of society, there is in less leisure time and increased the purchasing power of people which have made a demand for processed, convenient, ready-to-eat, or ready-to-prepare products. Thus, value added fish products are more and more preferred by consumers in recent times. The consumers' requirement for products having high quality, freshness, nutrition and health can be addressed through value addition. These changes in consumer lifestyles have resulted in diversification of the seafood processing technology as well as helps in diverting majority of by-catches to achieve the nutritional security.

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Cost Effective Nutrition Sensitive Innovations to Address Nutritional Security

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Nutritional Security

"Right for Food" is everyone's priority, even United Nation has ensured to get Food Security by 2030.In this twenty first century access of adequate, safe and nutritious food to all people is one of the big challenges. According to FAO"Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life".Food security is mounted in four dimensions such as availability of food, access to food, food use/utilization and food stability. Food security does not mean to get only food, here security also defined the term "Nutritious" i, e food should be nutritious too according to the dietary requirement.

Why it is so important?

Lack of Nutrition security, not only cost loss of human lives and well-being, as well as there is a subsidiary economic/social loss "malnourishment" too. Malnourished society are less creative, even hungry children lack of education, and eventually if hunger precede,they become less productive adults. Even acute food insecurity has a negative effect on economy. With this background, the international community are working in harmony to achieve "Zero Hunger" world. Here Zero hunger implies to the three types of hunger: "Protein Hunger", "Calorie Hunger" and "Hidden Hunger".

Hunger report of FAO says that, in 2019 nearly 690 million people or 8.9 percent of the world population are hungrydid not have regular access to safe, nutritious and sufficient food. In case of children 21.3 percent (144.0 million) of children under 5 years of age were stunted, 6.9 percent (47.0 million) wasted and 5.6 percent (38.3 million) overweight. The current COVID-19 pandemic condition might have added 83 to 132 million people to the total number of undernourished in the world in 2020 depending on the economic growth scenario (FAO, 2020). Precisely, if we framethe data in between the geographical boundary, then majority of the

under nourished /food insecurity population has found in Asia about 381.1 million (55.4%) followed by Africa with 250.3 million (36.4%), Northern America and Europe only 0.9% population and Oceania countries with 2.4 million people (0.4 %) in this category(FAO, 2020). It is well known that the vast majority are inhabiting in the developing nations. When, malnourishment persist in the developing countries, then, developing countries are facing the challenges like “overnutrition”. In these nations, the obesityand food-associated chronic diseases are increasing day by day. For the better future, it highly desirable to check the undernutrition and overnutrition from pre-pregnancy to the first 1000 days of life.

India is also facing the wrath of this situation,according to the Global Hunger Index, 2020 India was ranked 94th out of 107 countries with a score 27.2, which falls in the serious category, though trend is continuously decreasing since 2000. In India 14% of the population is undernourished, 17.2% of children below five are wasted, 34.7 % of children below five are stunted, 3.7% of children die before their fifth birthday.

Diet Quality

Diet quality refers to the first two dimensions of the food security i.e“availability of food”, “access to food”.Food insecurity can deterioratefood quality and subsequentlyintensify the perils of malnutrition such as undernutrition, overweight and obesity.Income has a significant role on quality of diet; countries with low income more depend onstaple foods than the fruits, vegetables and animal source foods than high-income nations. Generally, people of upper-middle income counties can afford sufficient fruits and vegetables as per FAO/WHO recommendation of consuming a minimum of 400 g/person/day.

Diet Cost

Healthy diets are inaccessible to poor peopleabout more than 3 billion people across the globe.Healthy diets on average, five times more priced than starchy staple giving equal quantity of dietary energy. The price of a healthy diet surpasses the international poverty line (established at USD 1.90 purchasing power parity (PPP) per person per day), making it unaffordable for the poor even average food expenditures of most countries globally (UNCTAD, 2017). The same report also states that, about 57 percent or more population of sub-Saharan Africa and Southern Asia cannot afford a healthy diet.

The food supply chain, environment, political economy, trade policy, public expenditure and investment are most of the drivers for the priced diet. Tackling these cost drivers will require large transformations in food systems including the trade-offs policies and synergies between countries.Shifting to healthy diets will helpful to reducing health and climate-change related issues.

Despite of those above challenges the world is facing nowadays, Innovations and FNS-related policies are ways of hope as the potential ways to address the hunger free society with sustainable diet.Here we are discussing about the" innovations in Food Security".

Innovations in Food Security:

Here, Innovation is referred to the technologies and the institutional policies meant for the nutritional security. For attaining food security, new technologies are considered as effective tool by the Sustainable development goals and international effort.

A collective information on technologies used for food security concerning with the four dimensions of food security (availability of food, access to food, food use/utilization and food stability) are given below**.**

Table: 1. Technologies used for food security

Food Security	Challenge	Technologies/Innovations Used
Food availability	Biotic stresses	Disease or pest resistant crops
		Pesticides, Herbicides
		Tilling machines
		Spatial repellent for on farm pests
		Improved agronomic practices
	Abiotic stresses	Salt tolerant crops
		Climate resistant /resilient varieties
	Improving crop productivity	Conventional breeding
		Tissue culture and micro propagation
		Marker -assisted breeding

		Advanced genetic engineering
		Low-cost diagnostic toolkit for extension workers
	Improving livestock /fisheries agriculture	High-nutrient, low-cost animal fodder and fish feed
		Cryo preservation or alternative for animal semen and milt preservation
		Low-cost diagnostics tool kits
		Tissue engineering for laboratory- grown animal product
		Low-cost pharmaceuticals (ideally thermostable)
	Lack of Water availability	Water storage technologies (surface water technologies, aquifers, ponds, tanks, low cost plastic water tanks, natural wet lands, reservoirs
		Canal irrigation
		Micro irrigation technologies, drip irrigation, bubbler irrigation
		Water lifting technologies
		Fungal seed and plant treatment for water related stress
		Stablilized silicic acid for drought tolerance
		Irrigation scheduling systems and decision support systems
		Planting technology for increased water efficiency
		Water pads (Water buffering technology)
		Rainwater harvesting mechanisms
		Water desalination technologies
		Wastewater reuse
		Conservation agriculture
		Portable sensors for groundwater detection
	Soil	Synthetic and organic fertilizers
		Biogas digesters

		Slurry separation systems
		Zero or Conservation tillage
		Soil microorganisms
		Natural nitrogen fixation
		Point of use kits for evaluating soil nutrient content
	Need for precise integration, scheduling of inputs for increased yield	Imaging and associated analytics
		Drones, Internet of things, Robots
		Precision farming or smart farming
		Big Data
		Farm management software and applications
	Farming in urban environments	Indoor farming
		Vertical farming
		Aquaponics
		Lowcost greenhouse
	Power and control intensive operations	Tractors
		Robotic technologies
		Animal-drawn implements
	Post-harvest loss (storage, refrigeration, transport)	Fruit preservation technologies
		Hexanal formulations
		Thermal battery-powdered milk chillers
		Nanotechnology
		Improved genetic varieties
		Seed and grain drying, aeration and storage technologies
		Innovative packaging
		Biowax coating
		Rice parboiling technology
		Efficient processing technology for pulses
		Rice drying technologies
		Cool stores

		Cleaning, grading and packing technology
		Off-grid refrigeration
		Low-cost refrigerated vehicle
		Low-cost solar dryers
		Vacuum or hermetic sealing
	Need for harvest and agro processing equipment	Crop threshers (motorized and bicycle-powered)
		Agro-processing technologies (crop, meat, dairy product)
Food use and utilization	Lack of nutritious foods, especially staple crops	High-nutrient staple crops
		Vitamin A enriched crops
		Iron and zinc fortified rice, beans, wheat and pearl millet quality protein maize
	Lack of information on healthy diets	Dissemination of nutrition information
Food stability	Inability to predict when and how to farm	Weather-forecasting technologies
		Infrared sensors for detecting crop stress
		Hyperspectral imaging, based on drones and satellites
	Lack of financial mechanisms to ensure income	Index based insurance

Source: UNCTAD, 2017**,** The Role of Science, Technology and Innovation in Ensuring Food Security by 2030, pp9-11.

According to the source of technology, Conway and Waage (2010) have categorised the technologies into four categories: conventional, traditional, intermediate and new platforms for technology.

"**Conventional technologies**" are developed by technologically advanced countries. It generally includes agricultural inputs viz. fertilizer, high yielding varieties and irrigation tools, famous as the Green Revolution tools. These technologies available as a packaged form in regional or global markets. The main focus of these innovations is dispersing knowledge to farmers for increasing production through the transmission of knowledge implanted in the products (Dockes et al. 2011).

"Traditional technologies" are the locally developed techniques passed on to the society from generation to generation through adoptability of the local communities to meet their needs.These are consequent ofthe traditional practices and generally moulded over a time to time by communities in developing countries. These are very much effective and lost cost technologies compared to conventional technologies. Numerous traditional technologies in agricultural systems have been indorsed and recognized globally. As this is invented and adopted by local people, it also referred as indigenous technical knowledge. In the farming system, a traditional technology is characterized by a low use of inputs, emphasizing the needy prospects available to smallholder farmers (Meyer 2010).

"Intermediate technologies" are a combinationof conventional and traditional technologies. The practice of such technologies is supported by an institutional change so that they can provide a full range of benefits to small farmers.

The **new platform technologies**useful in nurturing FNS contains information and communication technologies (ICT) for the agricultural sector, biotechnology and nanotechnology. ICT have been widely applied for augmenting improved market admittance, as well as allowing local farmer organizations. Many jeopardies and doubts normally faced by smallholder farmers before, during and after production are reduced via mobile phone information, subsequently increases their harvest. The mobile phone services are applied for several utilities such as delivering market and price information, knowledge sharing, protection of crop through insurance and monitoring of children's nutrition status etc. The applied technologies like bio technology and nano technology include cost effective technologies like bio fortification and fortified food.

Institutional innovations involve social and political processes in which the actors of innovation contribute to a larger action by combining inherited practices, technologies and institutions to address their interest. Institutions are defined as the rules of society or organizations that support the people or members by helping them form and deal with their expectations about each other so that they achieve common objectives. One of the classical examples of institutional innovations is Farmer's field school. IFAD (2007) outlines the importance of institutional innovations in facilitating access to natural resources and local governance, access to productive assets and markets, access to information and knowledge, and increasing political capital.

Cost effective Innovations

A) Information and Communication Technology
B) Bio fortification
C) Fortification
D) Home Garden/Nutri-garden
E) Integrated Aquaculture

A) Information and Communication Technology (ICT)

ICT include technologies used for information and communication, internet, radio, television, mobile phones, video, digital cameras, IOTs. The mushrooming of ICT applications basically through mobile phonesfacilitate opportunities to transfer knowledge in many developing countries. The greatest benefits of mobile phones are it drastically reduced communication and information costs, wide geographic area coverage and easiest way to diffuse the technology. The influencingways of ICT on nutritional security are mainly through enhanced agricultural production and approach to market-linked information, which consequentlysurges farmers' income. Many mobile based app/ applications are available on the internetplatform tohelp farmers by increasing agricultural productivities through their precise information about the inputs and the techniques to be used in farming. For farming activities, the expanding use of mobile phones supports farmers' access to information on agricultural extension services, markets, financial services and livelihood support (Donner 2009).In developing countries, most smallholder farmers are doing subsistence farming and ICT doing a novel job by offering opportunitiesto them, like providinginformation regardingmarket, weather, and extension

services.In India, the e-Choupal (internet kiosks and warehouses-basedprogram)is quite helpful for both producers and consumers by reducing the price dispersion.

B) **Biofortification**

For beneficiation of poor, who unable to afford nutritious foods, such as fruits, vegetables, fish, meat, eggs, and dairy products and depend on staple foods, so staple-related biotechnology/ biofortification are required. Biofortification is a method of incorporating nutrients into staple foods. Biofortification can be performed by plant breeding, agronomic practices like the application of fertilizers to increase zinc and selenium, or transgenetic techniques (Bouis et al. 2011). Biofortification provides a large outreach, as it is accessible to the malnourished rural population which is less exposed to the fortified food in markets and supplementation programs. By design, biofortification initially targets the more remote population in the country and is expanded later to urban populations. Biofortification has been implemented in several countries of Asia and Africa. A few crops are biofortified, including rice, wheat, maize,cassava, pearl millet, beans, and sweet potato, depending on the national context.In India among the above-mentionedcrop pearl millet is fortified with iron;rice and wheat were biofortified with zinc. For aquatic foods, biofortification is at infant state. A CambridgeUniversity based study hasexperimented biofortification of Oyster with Vitamin A and D by feeding them micro encapsulated vitamins at3% initial dosage for just 8 h; they have found the elevated quantity of vitaminsA and D in mussel tissueareenough to meet human dietary RDAs.Biofortification is cost-effective with respect to the moderate breedingcosts, while the benefit is more than the cost. It has some limitations (i) it might not be viable for application in all plants (ii)thepotential benefits of biofortified staple foods are uneven across staple food groups, asthe need of micronutrients varies along the lifecycle of the crop.

C) Fortification

Fortification is a way to advance the nutrition quality of foods by adding micronutrients after final food product but prior to its consumption.It is usually done through commercial methods, in which nutrients are added during the processing of food. Government assistance is highly recommended for this. An important success in fortification and related research is focused on the effect of iodizing salt.

D) Home Garden/Nutri-garden

Home gardens representsthe traditional agricultural practice, mainly used in rural areas. It acts as food buffer stock for small farmers. Apart from that,home gardensare more beneficial in terms of wealth generation, negotiatingpower in labour markets, post-harvest storage, non-agricultural income generatingactivities and access to credit (Hanstad et al. 2002). This traditional technology, the home garden is one of the most feasible andeffective way to progress micro-nutrient consumption. Vegetables and fruits arevital sources of micronutrients. Vegetables such as tomato (*Solanum lycopersicum*), cabbage (*Brassica oleracea*)and onions (Allium cepa), as well as traditional local vegetables, such as moringa(*Moringa oleifera*), kangkong (*Ipomoea aquatic*), perilla (*Perilla frutescens*),anemone (*Nymphoideshydrophylla*), bitter gourd (*Momordica charantia*) and jutemallow (*Corchorus olitorius*), are available in most Southeast Asian countries andare usually cultivated in home gardens. These are rich in micronutrients, tomato contains more β-carotene, vitamin E and iron but having lower antioxidant property compared to cabbage. However, in comparison with tomato, moringa have 38 times more amount of β-carotene, 24 times more vitamin C, and 17 times more vitamin E, folates, and iron.Home gardening has been used as a **sustainable strategy** that canaddress multiple micronutrient deficiencies through dietary diversification. At the same time, home gardens also serve as an integratedagro-ecosystem.Along with the dietary requirement, it will helpful for household income.In the integrated agro-ecosystem with agriculture (crop, vegetable, and horticulture) allied cultures such poultry, goat farming and pisciculture can be done. This integrated culture systems are much more beneficial and cost effective and sustainable.

Integrated aquaculture System

The term‘integrated farming’ has been used for integratedresource management which includeeither livestock or fish components or both along with the crop.Integrated aquaculture is integration of aquaculture with other farming, ie livestock or crop or both. Benefits of integration are synergistic; and in fish and livestock integrated culture, the fish and livestock componentsmay benefit to varying degrees. Fish is well known for its nutritious value Fish is more nutritious than staple foods,providing, in particular, high levels of animal protein, essential fatty acids and micronutrients, an increasing number of interventions that promote production and consumption of locally available nutritious foods as a way of tackling micronutrient

deficiencies have proposed the use of fish instead of the distribution of supplements.Simultaneously, recognizing that fish are a highly traded commodity (even at the local level), other initiatives focused on fish-related activities as potential entry points for improving household nutritional security directly through increasing fish consumption. Also, it is well establishedincome from fish (be it from aquaculture or small-scale fisheries) can be used by poor households to purchase other food commodities, including lower cost staple foods. Kumar and Dey (2006) had supported the fact that the energy intake of households that own fishponds was 10.9% higher than that of households with wage earners but without ponds, and that the undernourished population amongst the fishpond owners was 10% lower than the control population. So, the small-scale farming of livestock, poultry, or fish offers another potential strategy for ensuring food security and nutrition. Fishpond operation along with crop production and other on-farm activities easily contributed between 5 and 10% of the total household income in Bangladesh (Bouis, 2000).

Variety of Integrated aquaculture can be done, such as Fish cum poultry farming, fish cum pig farming and fish cum crop farming. Poultry- fish farming is the integration of poultry animalslike chicken, duck and geese with fish farming.Pig farming is widely practicedwith easier husbandrythan chicken farming.The pig is a highly prolific animal and itsgrouping with fish not only increase economic efficiency, but also increase its ecological efficacy as wastes,residues, and left over from kitchen, aquatic plants areoften used as pig food. Fish cum crop productionis the cultivation of agricultural crops (e.g. vegetables and arable like maize, rice etc) and aquatic plants(like water spinach, water chestnut, aquatic weeds like,Pistia, duckweed, water hyacinth, Azolla etc) with fishfarming. The vegetables, like water leaf and spinach among others can planted on the dykes, while in the case of rice; it isplanted right inside the pond. The crops get water andnutrients from the fish ponds while the crops act asfood, mainly for herbivorous fish.Also, periphytonson the crop may enhance yield of cultured fish species.

Integrated fish farming offers hope in thisdirection as it serves as food-production base with cultivation of crops, rearing of livestock and fishfarming. The scope of integrated fish farming is wide. The fish farm supplies not only enoughfertilizer to produce a large quantity of fish, but also produces meat, milk, eggs, vegetable, etc as it fully utilizesthe water body, the water surface, the land and the pondsilt to increase the food available for human

consumption.Integration is suitable for small and marginal farmers due to low expenditure pattern for food and other requirements with surplus income and dietary need. dietary requirement.The system is all encompassing asthe time is well utilized in other farming activities depending on the type of integration involved. In fish cum cropproduction, crops like the vegetables are harvested uninterruptedlyalso in dry season as water from the pond isused to water the farms sufficiently. The farmers are involved in one farming activity or the other throughout theyear thus, making them self-sufficient and productive allyear round.Similarly, in livestock, before the harvesting of the fish, farmer can use the growing period time by selling egg and other animal product to generatemore money.Besides to this, money can also begenerated from the vegetables or the crops that may becombined in the integrated fish farming.

Conclusions

Healthy diets to environmental sustainability/ Sustainable Diet: The adoption of healthy diets is necessary to increase the affordability of healthy diets with reducing the cost of nutritious foods.Innovations like Nutrigarden/Home garden and integrated aquaculture are the most beneficial way of innovation for the small scale farmers and poor. These are the low-cost technology and the easiest way to gain the nutritious organic food in very much affordable way. Besides, to this these traditional technologies are eco-friendlyand advantageous for the environment maintenance in a numerous way such as nutritional recycling, Nutrient concentration,diversity, stability, capacity, economic efficiency and evolvability.

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