Dr. M Rosalind George: Eminent Researcher in the field of fish and shell fish disease served as former Vice Chancellor (i/c) of KUFOS. She is a pioneer in shell fish disease diagnosis and has international and domestic exposure in the field of fish and shell fish diseases and has brought out numerous publications and popular articles for the benefit of farmers and entrepreneurs.

Progress and Potential of Fisheries in Kerala

Prof. (Dr.) M. Rosalind George
Former Dean Fisheries and Vice Chancellor (i/c)
Kerala University of Fisheries and Ocean Studies
Panangad, Kochi

Fish as Super/health Food

- Fights hunger and malnutrition
- Main source of animal protein in many developing countries
- Has healthy long-chain omega-3 fatty acids
- Essential source of nutrients like vitamins such as D and B2 (riboflavin).
- Rich source of calcium and phosphorus and a great source of minerals, such as iron, zinc, iodine, magnesium, and potassium

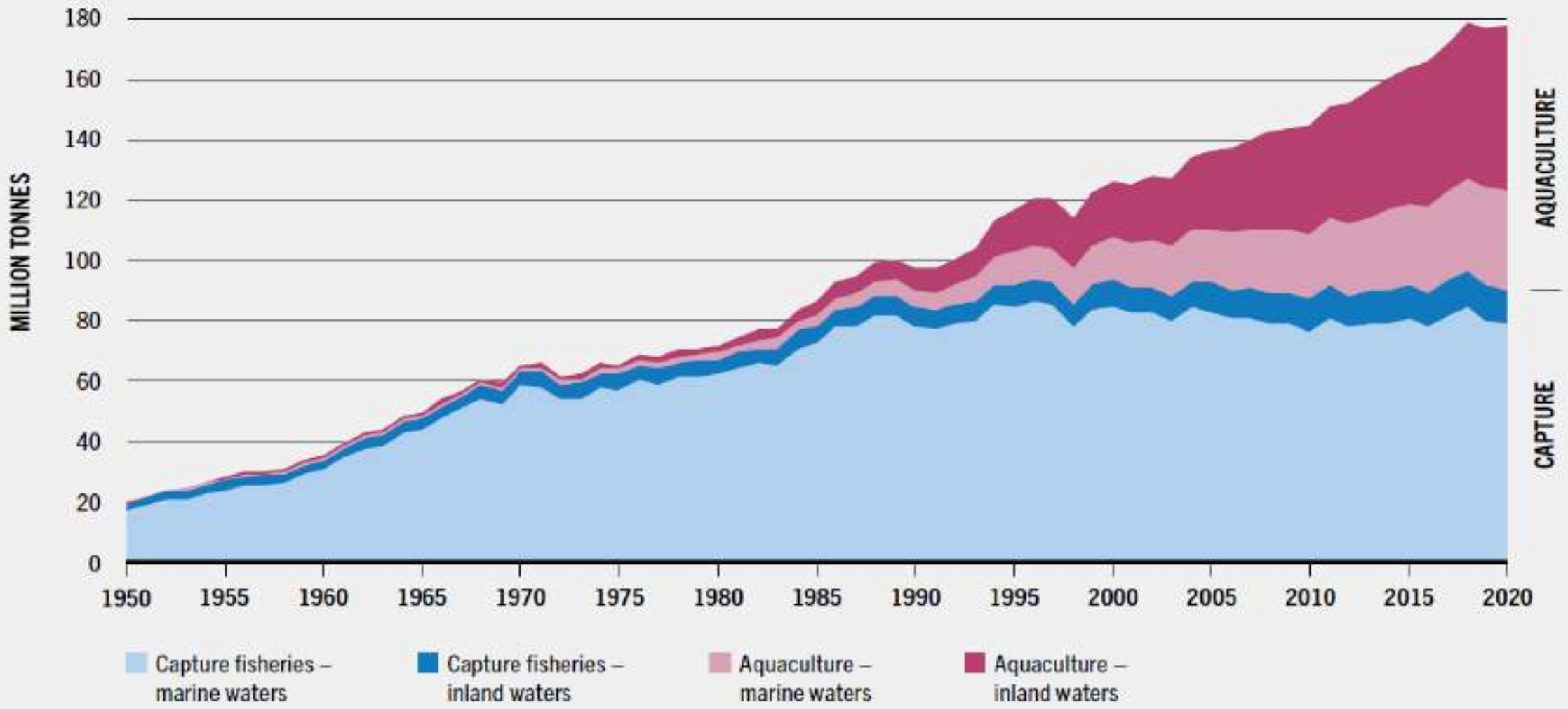
Fish Facts (FAO)

- Fish head, viscera, and back-bones make up **30-70%** of fish and are especially high in micronutrients.
- Seafood is in practice the only natural source of **iodine.** Crucial for thyroid function, essential for neurodevelopment of children.
- Small indigenous fish species (SIFS) – play an important role in alleviating malnutrition in rural poor

Fish Facts (FAO)

- **Seafood powders** made from by-products or lake sardines provide missing nutrients to the primarily grain or starch-based diets of under developed countries.
- Seafood products are among the most widely traded food commodities – totaling around US$ **145 billion** per year.
- **35%** of fish and seafood is lost or wasted – almost double the figures for losses for meat products.
- **Small pelagics are cheap, nutritious, and filled with omega-3s and other minerals can** ameliorate micronutrient deficiencies in pregnant women and adolescent girls

WORLD CAPTURE FISHERIES AND AQUACULTURE PRODUCTION



Keralayeem 3 Nov 23

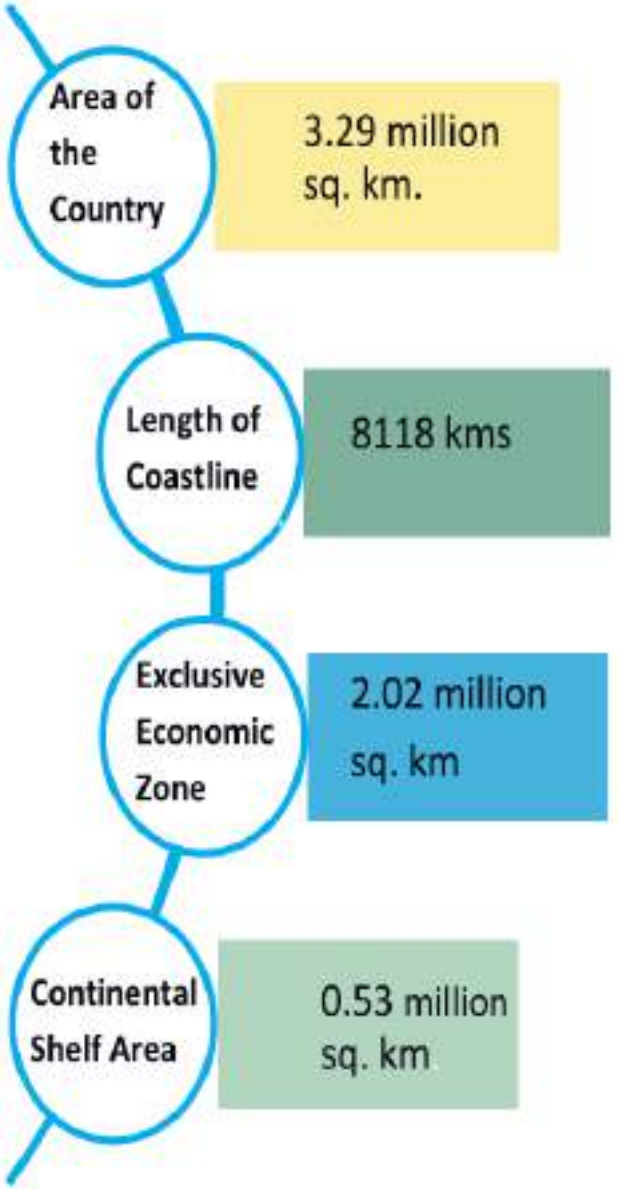
NOTES: Excluding aquatic mammals, crocodiles, alligators, caimans and algae. Data expressed in live weight equivalent.
SOURCE: FAO.

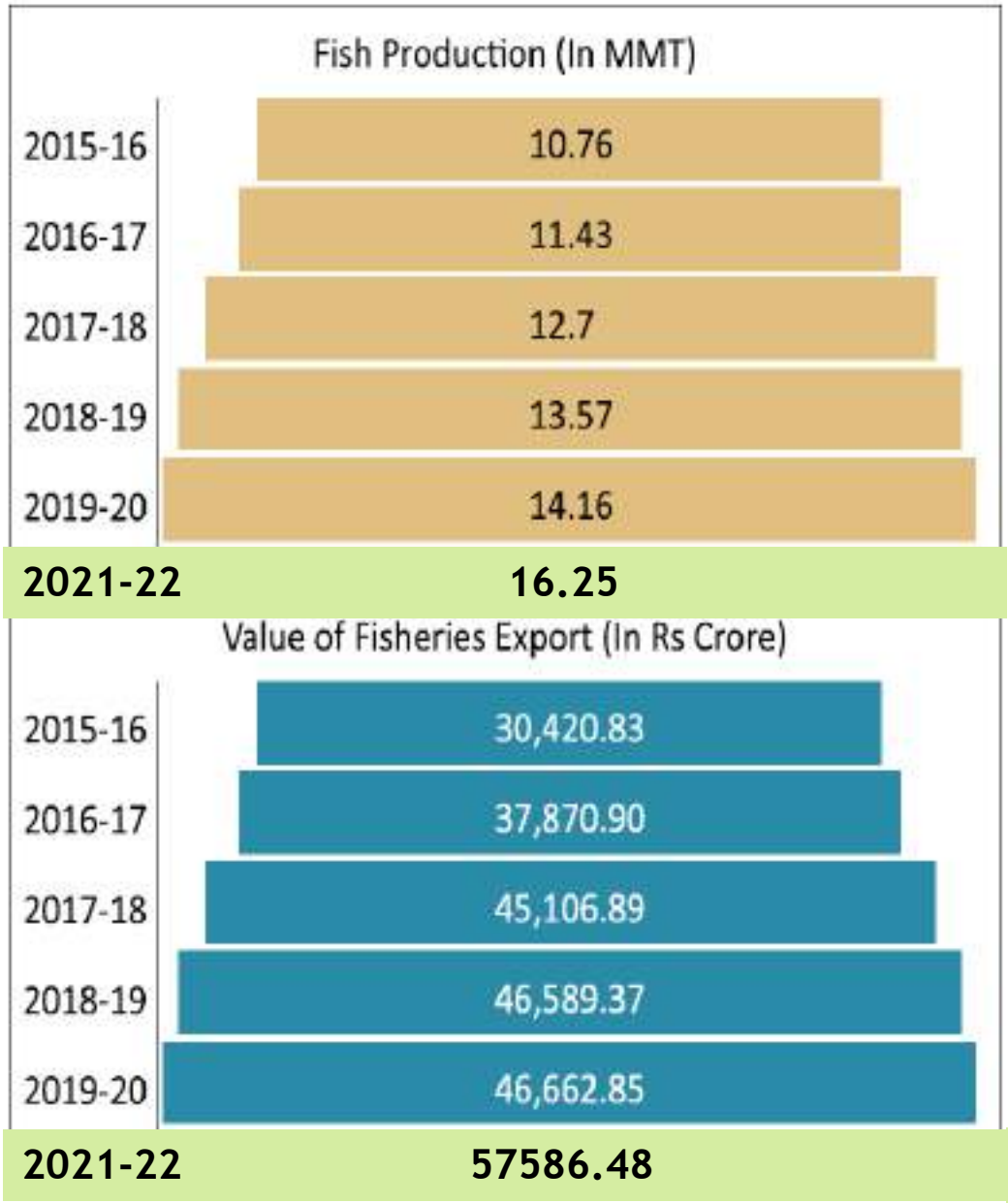
FAO 2022

Table 12.3: World Fisheries and Aquaculture Production and Utilization (In Million Tonnes)							
	1986-1995	1996-2005	2006-2015	2016	2017	2018	2020
	Average per year						
Production							
Capture							
Inland	6.4	8.3	10.6	11.4	11.9	12	
Marine	80.5	83	79.3	78.3	81.2	84.4	
Total capture	86.9	91.4	89.8	89.6	93.1	96.4	90.3
Aquaculture							
Inland	8.6	19.8	36.8	48	49.6	51.3	
marine	6.3	14.4	22.8	28.5	30	30.8	
Total Aquaculture	14.9	34.2	59.7	76.5	79.5	82.1	87.5
Total world fisheries and aquaculture	101.8	125.6	149.5	166.1	172.7	178.5	177.8
Utilization							
Human Consumption	71.8	98.5	129.2	148.2	152.9	156.4	
Non-food uses	29.9	27.1	20.3	17.9	19.7	22.2	
Population	5.4	6.2	7	7.5	7.5	7.6	
Per Capita apparent consumption(kg)	13.4	15.9	18.4	19.9	20.3	20.5	20.2

Significance of Fisheries and Aquaculture

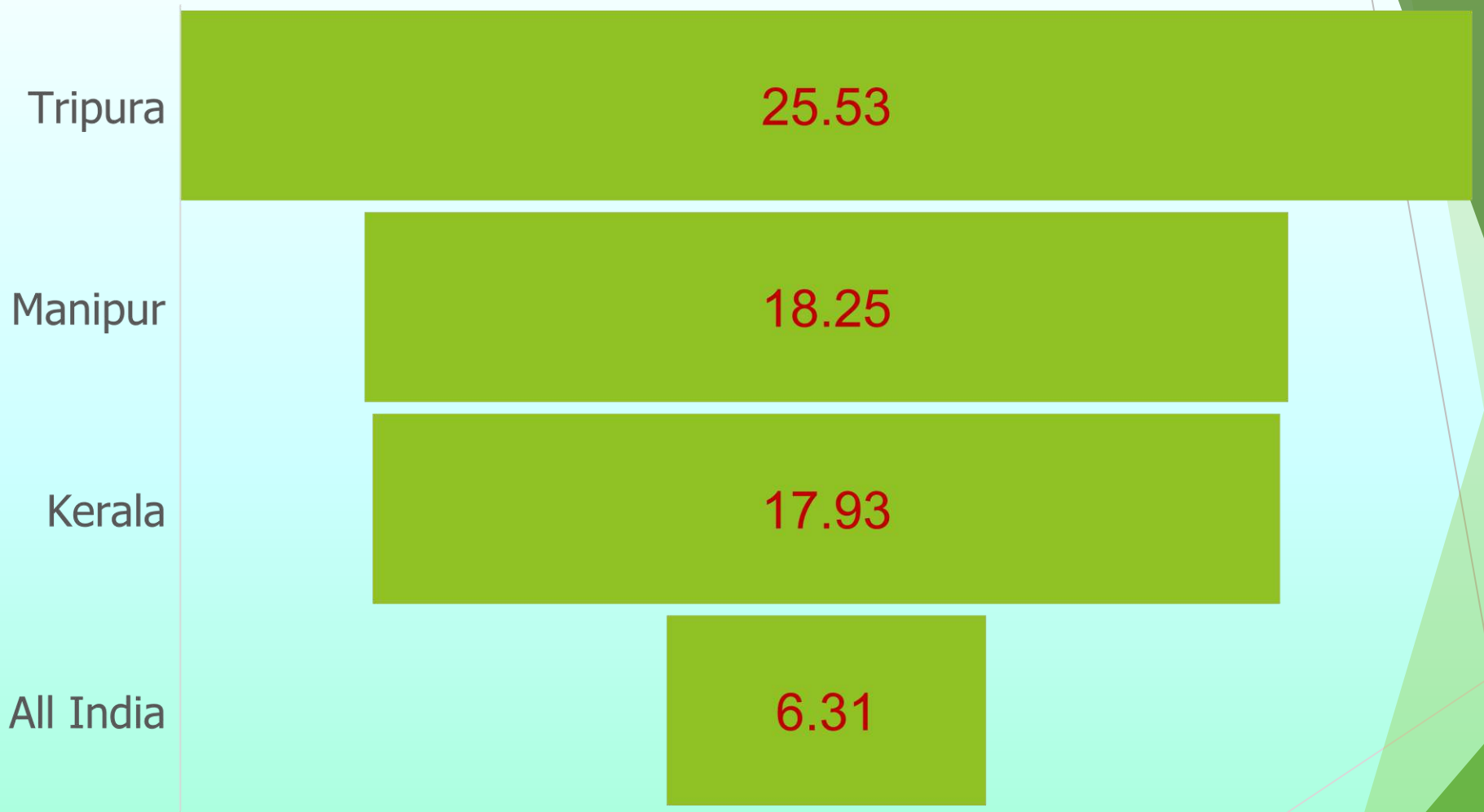
- Seafoods are the traditional food for many and staple food for coastline regions
- Capture fisheries industry is reaching plateau
- For the first time since the mid-1980s, India has become the top inland fisheries producer in 2020 at 1.8 million tonnes replacing China (1.46 mt)



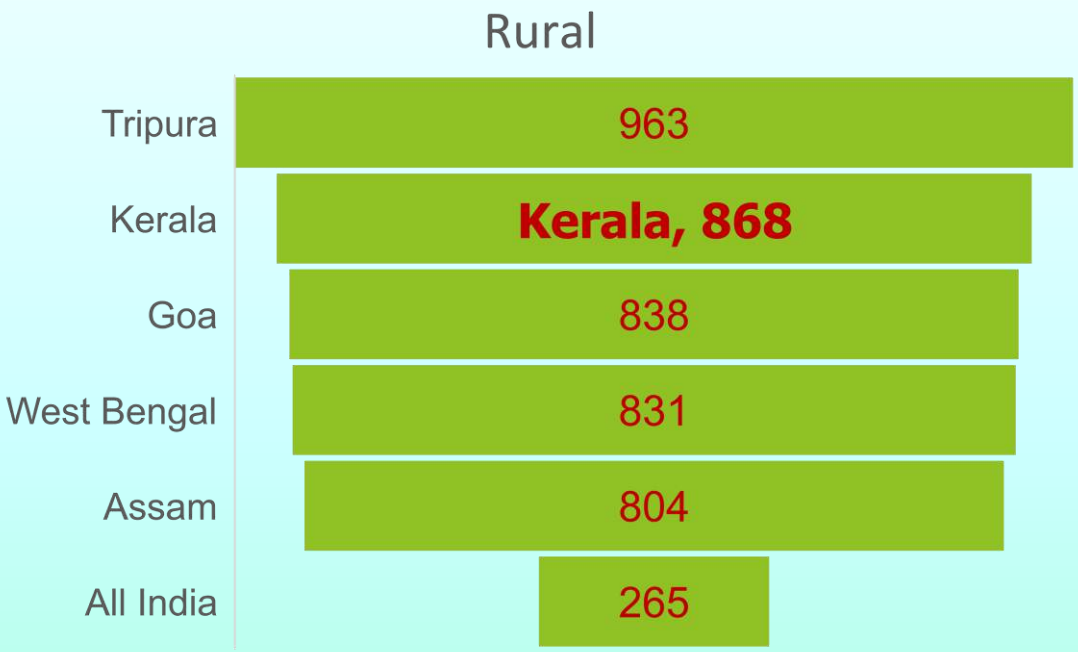


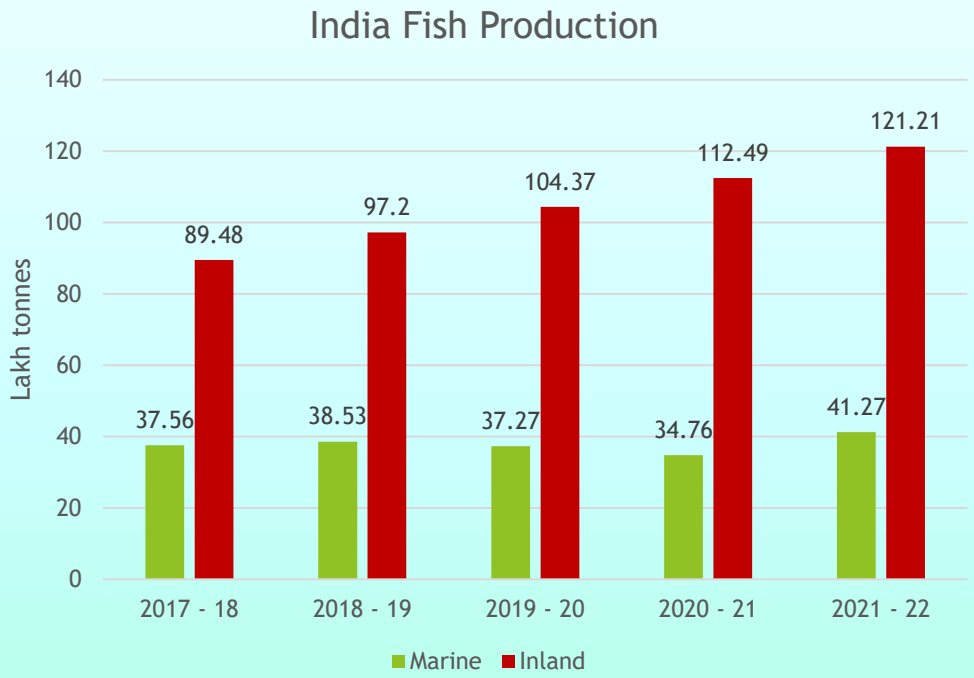
(Kerala 6,396.2)

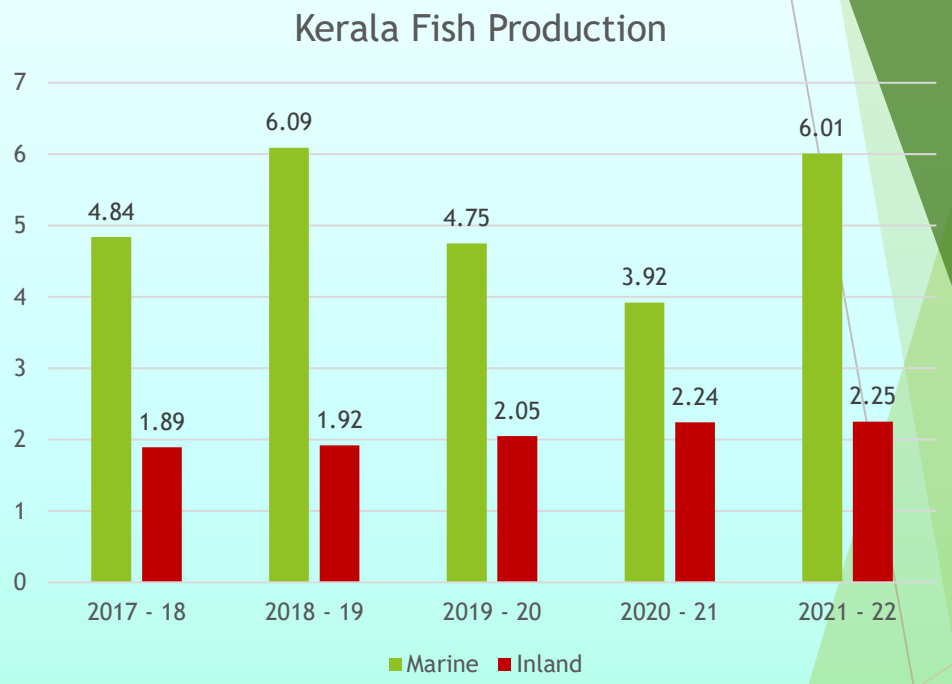
Per capita fish consumption (Kg)



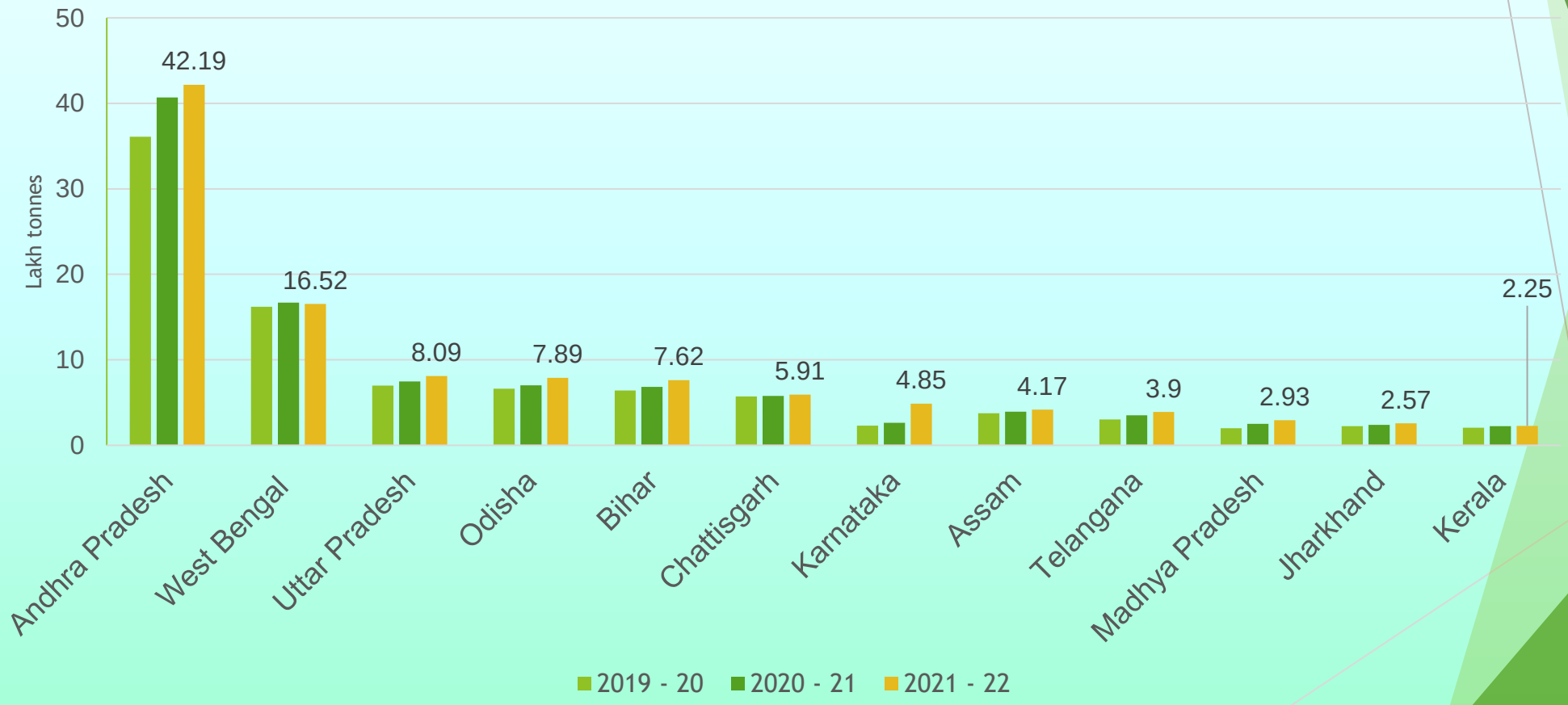
Fish consumption: Number of house holds per 1000 houses



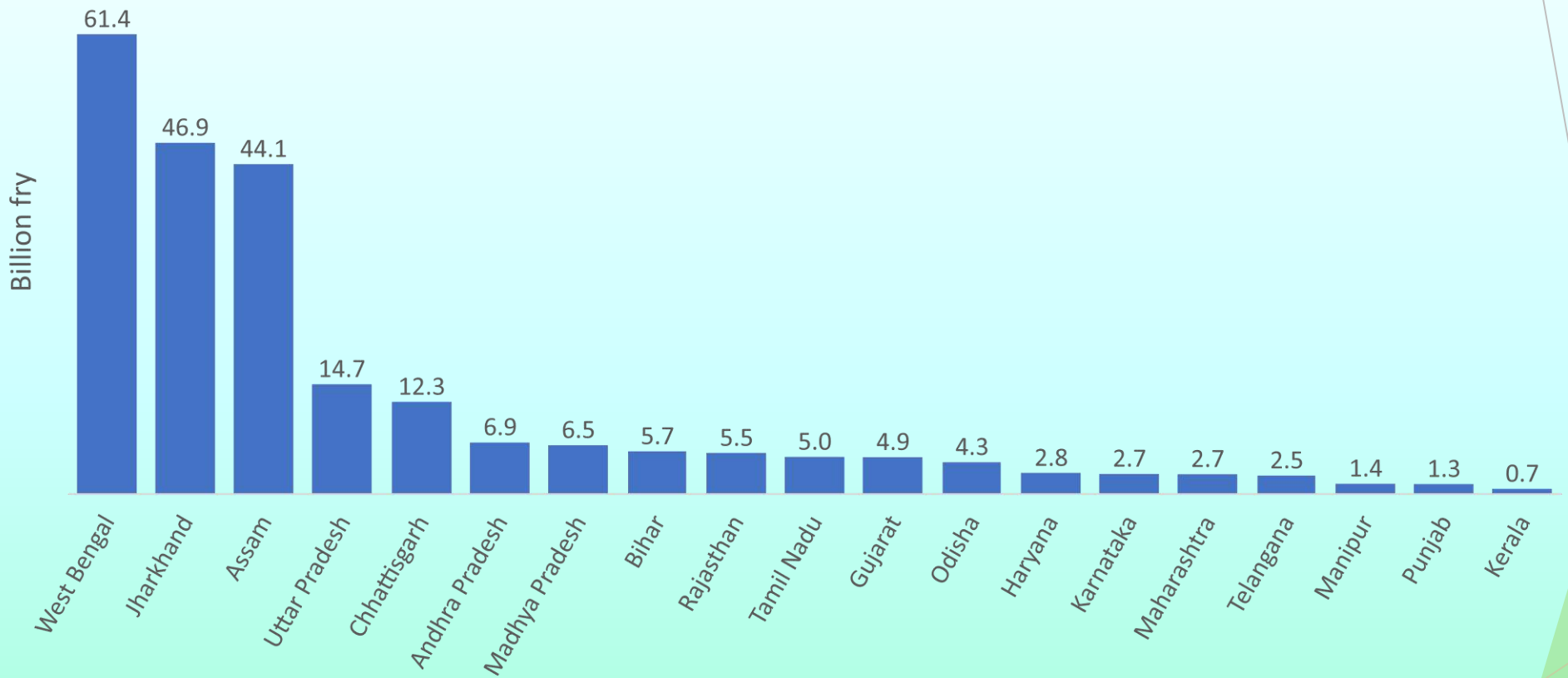

India Fish Production
Lakh tonnes
140
120
100
80
60
40
20
0
37.56
89.48
38.53
97.2
37.27
104.37
34.76
112.49
41.27
121.21
2017 - 18
2018 - 19
2019 - 20
2020 - 21
2021 - 22
Marine
Inland


Kerala Fish Production
7
6
5
4
3
2
1
0
4.84
1.89
6.09
1.92
4.75
2.05
3.92
2.24
6.01
2.25
2017 - 18
2018 - 19
2019 - 20
2020 - 21
2021 - 22
Marine
Inland

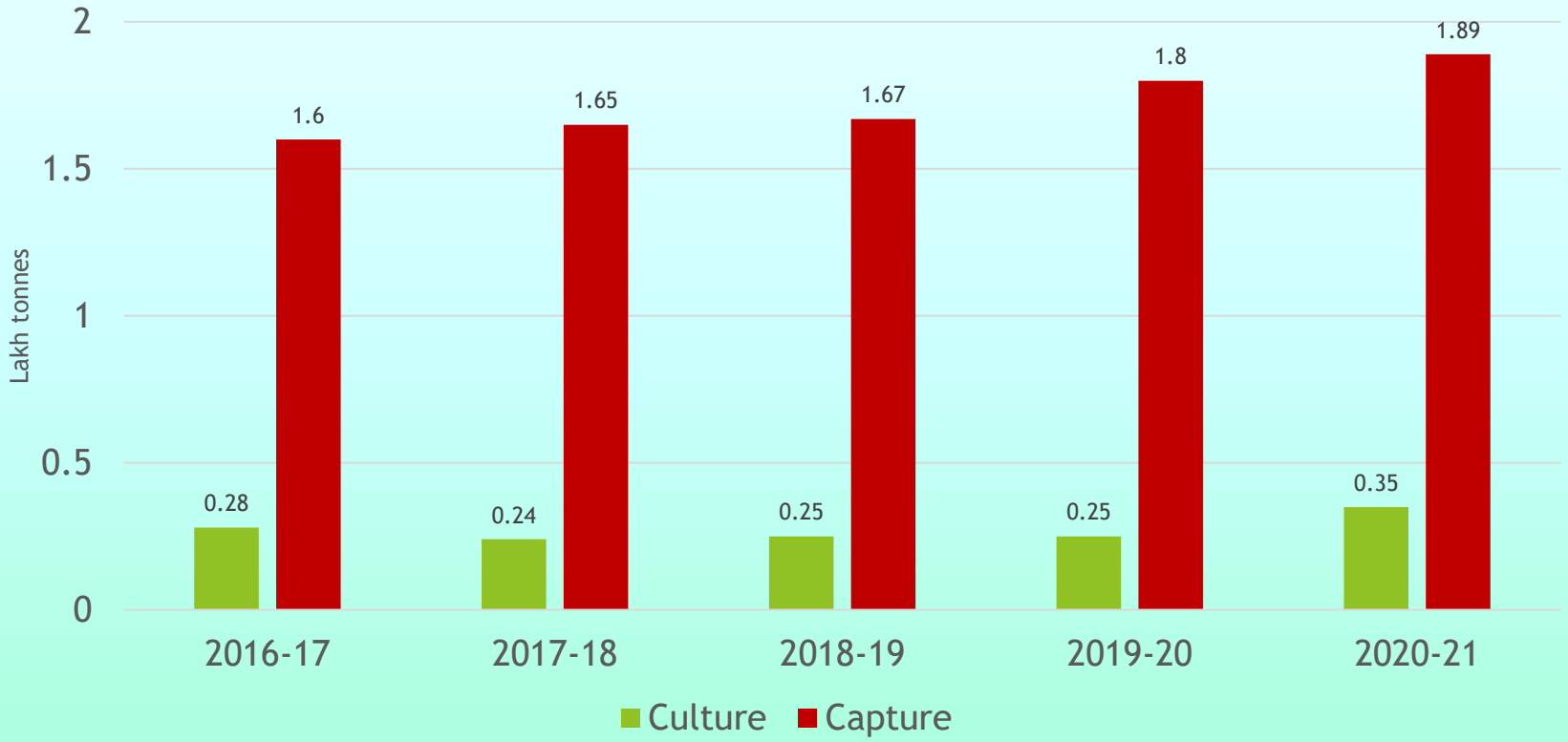
Inland fish production: States



Fish seed production (2016-17 to 2020-21)



Kerala Inland Fish Production (in lakh) (in tonnes)



Development of Aquaculture

- Increased pressure on the water resources for aquaculture
- Necessitated streamlined and refined technology of farming aquatic species with lesser quantity of water and increased productivity
- Environmental, economical and societal sustainability is at the fore now especially after the UN resolution on the sustainable development goals.

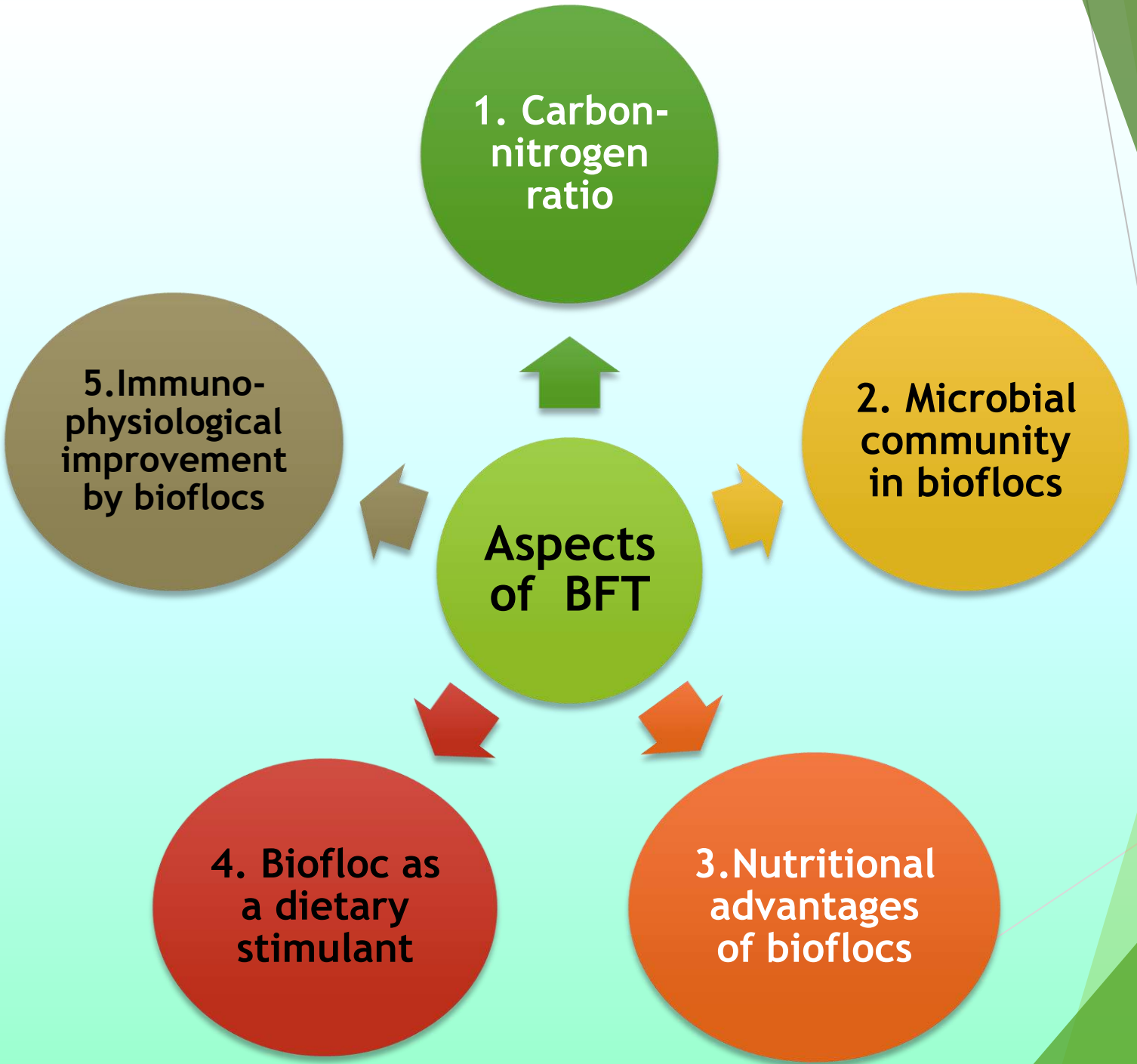
Inland potential of Kerala

- Coast length - 590 km.
- Freshwater ponds and tanks - 5295.93 ha
- Freshwater lakes - 1620 ha
- Brackish water areas - 65213 ha
- backwater stretches - 46128 ha
- Rivers: west flowing - 41 - east flowing – 3 : total length of 3092 km (suitable for pen and cage culture)

Improved techniques in Aquaculture: Overview

- New Systems:
  - Biofloc aquaculture, Recirculatory aquaculture systems, well developed Cage culture technology, Intensive and efficient in-house aquaculture production systems, IMTA, Aquaponics etc.
- Nutritionally balanced species specific diets
- Species diversification and standardised seed production technologies
- Sophisticated and rugged instrumentation
- Application of artificial intelligence in water quality and system management
- Advanced diagnostics
- Nutraceuticals

Biofloc technology


1. Carbon-nitrogen ratio
2. Microbial community in bioflocs
3.Nutritional advantages of bioflocs
4. Biofloc as a dietary stimulant
5.Immuno-physiological improvement by bioflocs
Aspects of BFT

Cage culture Bergen, Norway

Mekong river

Elevated ponds of Tamil Nadu

Guangzhou, China

Innovative systems

Recirculatory aquaculture systems (RAS)

- Innovative system management protocols like zero water exchange,
- well designed effluent treatment systems,
- computer aided underwater observation and individualised intervention measures

Closed RAS

Organic farming

- Organic agriculture : “a production system that sustains the health of soils, ecosystems and people”
- It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects
- Principles of health: Organic agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible.
  - In terms of aquaculture, the main implications of this Principle devolve to (i) the health of the species in question through proper nutrition and (ii) the nutritional quality of the product sold for human consumption
- Principle of Ecology: Organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them
  - the integration of the production system with nature and its environmental impact are of significant concern with regard to practically every main facet of activity.

- Principle of Fairness: Organic agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities
  - (i) protect the health and welfare of animals raised under aquaculture systems, including respecting their natural behaviours and (ii) how fair the production rules are with respect to the economic viability of aquaculture enterprises and the livelihoods of organic producers.
- Principle of Care: Organic agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment
  - Care in innovations in feed formulation, water management; breeding or rearing does not happen via use of hormones etc.

Achievements of Kerala

- Janakeeya Matsya Krishi and Subhiksha Keralam projects: aided innovative farming techniques - doubling of aquaculture productivity.
- Increased productivity by innovative technologies, new species, genetically improved varieties and locally preferred
- Farmer awareness - good water quality and good quality seed and feed.
- Considered natural pond based and seasonal, aquaculture has become artificial tank based and year-round activity

- The aquaculture practices in Kerala had been mainly evolved with the traditional shrimp filtration activity
- Trials on scientific shrimp farming started in 1950's and high density farming started only in 1980's after the commercialization of the penaeid seed production.
- White spot disease in 1990s caused extensive damage to shrimp farm industry

Species diversification

- Species diversification to high value species,
  - Domestication of high value, marine and freshwater species
  - genetic improvement of the cultured species,
  - constant surveillance of the aquaculture systems
  - effective scientific management approaches.
- Promoting small indigenous fish culture

Then

Now














Image credits: Google images

Aqua culture productivity of Conventional Systems

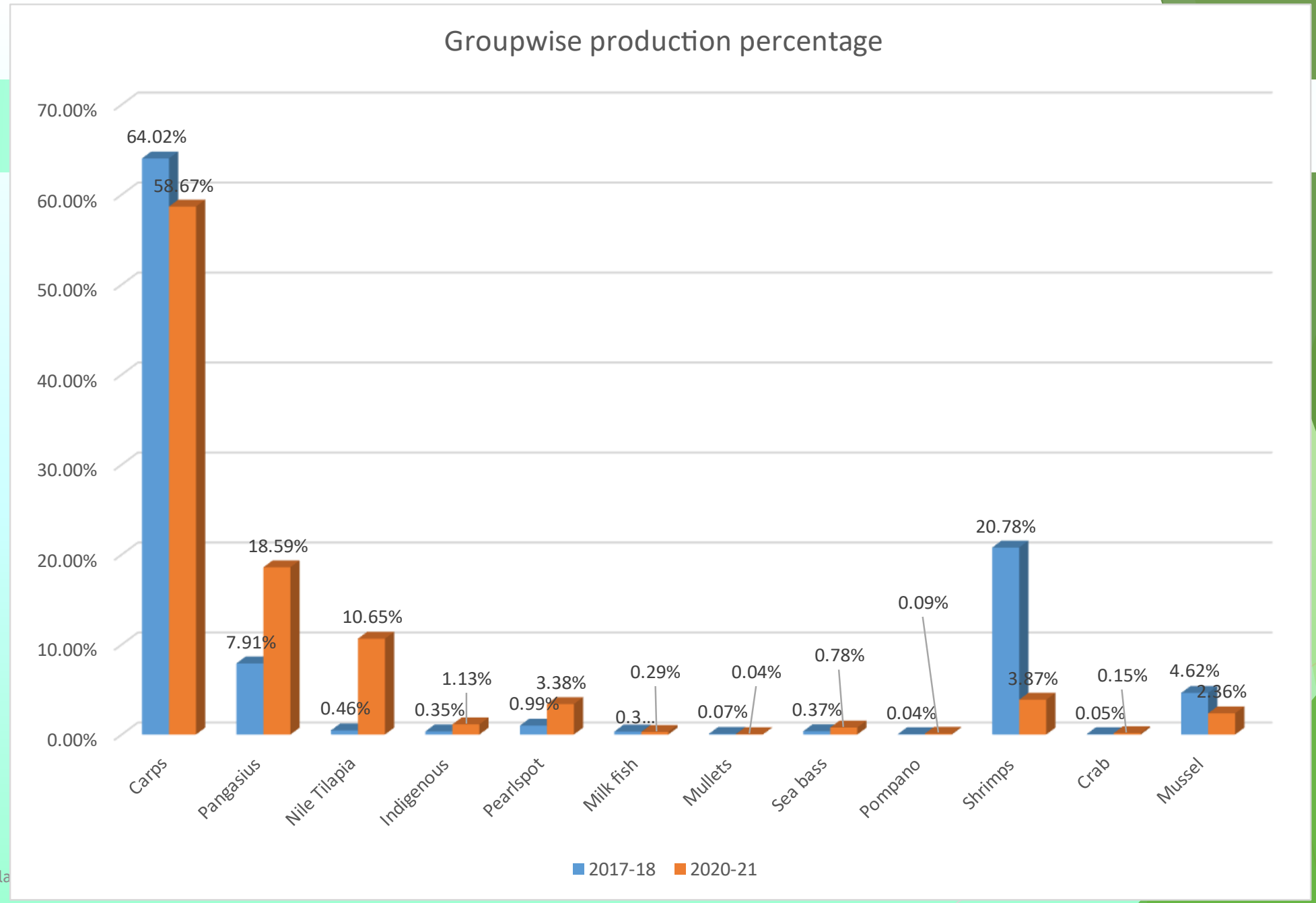
Description	Present Level (t/ha)	National Average (t/ha)
1. Fresh water ponds - Low input system	2.24	2-3
2. Fresh water ponds - Medium input system	5.02	4-8
3. Fresh water ponds - High input system	17.41	10-15
4. Fresh water paddy fields	0.46	0.5
5. Brackish water ponds - Low input system	0.76	2-3
6. Brackish water paddy fields	0.37	0.5

Kerala Fisheries Statistics at a glance 2021

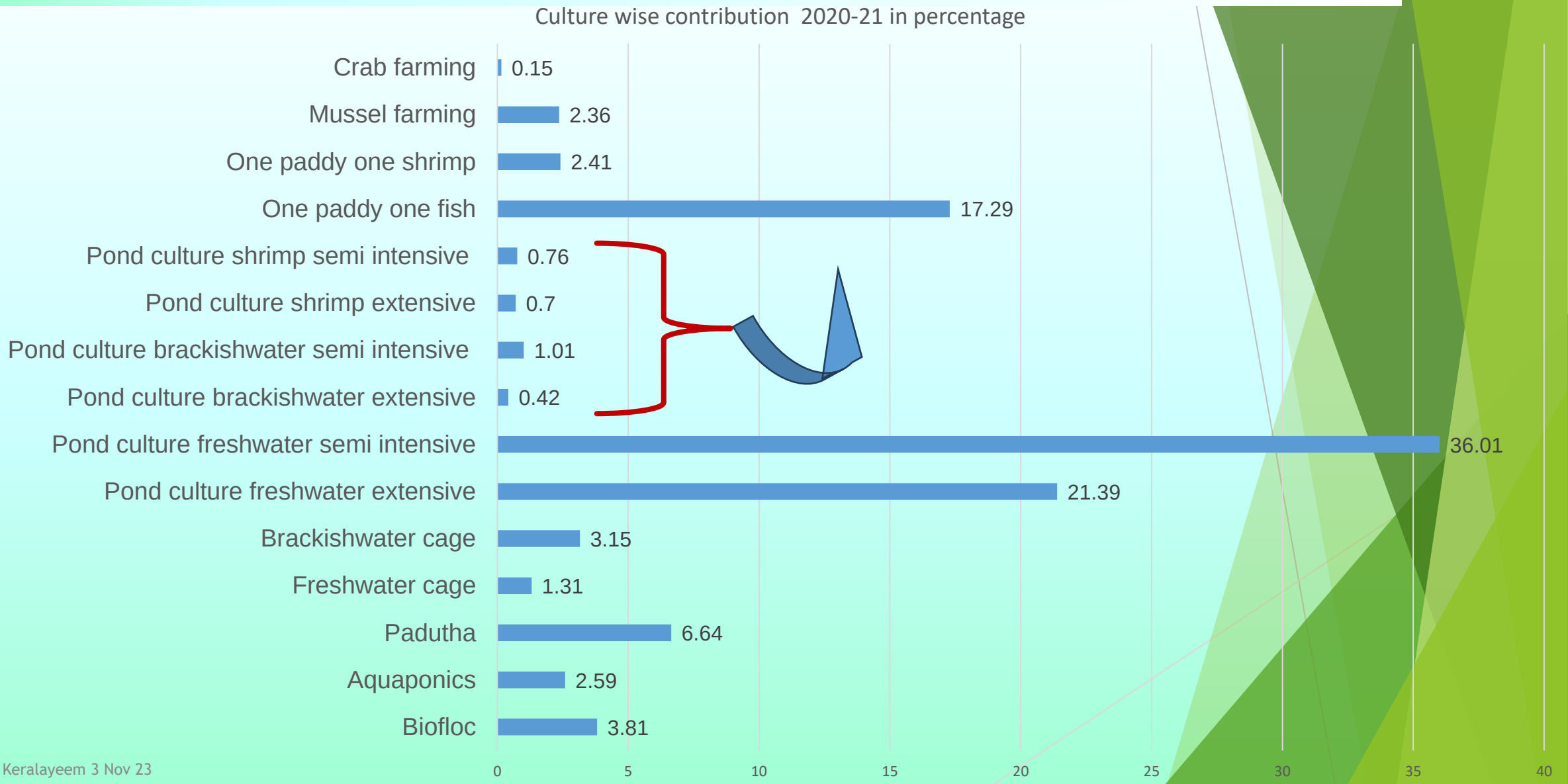
Aquaculture productivity of Innovative Practices

Description	Present Level (Kg/m^3)	National Average (Kg/m^3)
1. Cage Aqua culture System (Brackish water fishes)	11	15-20
2. Cage culture (Fresh water fishes)	16.94	30-40
3. RAS & Aquaponics	26.91	30-40
4. Padutha Ponds	6.2	8-10
5. Mussel Farming	4.43 Kg/m	8-10 Kg/m
6. Biofloc Aqua culture System (Tilapia based)	18.39	20-25

Kerala Fisheries Statistics at a glance 2021


Groupwise production percentage
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
64.02%
58.67%
7.91%
18.59%
0.46%
10.65%
0.35%
1.13%
0.99%
3.38%
0.3...
0.29%
0.07%
0.04%
0.37%
0.78%
0.04%
0.09%
20.78%
3.87%
0.05%
0.15%
4.62%
2.86%
Carps
Pangasius
Nile Tilapia
Indigenous
Pearlspot
Milk fish
Mullets
Sea bass
Pompano
Shrimps
Crab
Mussel
2017-18
2020-21

Contribution from different culture activities



- Ranching recovery was estimated at 15-26 %.
- As a remedial measure, large sized seeds need to be introduced in the wild
- KUFOS standardised seed production of indigenous species

Technology developed -KUFOS

- *Systomus serrana* (Kuruva paral)
- *Dawkinsia lepida* (Poovali paral)
- *Hypselobarbus kurali* (Koorali)

Succeeded in Breeding

- *Clarias dussumeri* (mushi)
- *Channa striata* (Varal)
- *Heteroneustes fossilis* (Kari)
- *Ompok malabaricus* (Thonnan vala)
- *Barbodus carnaticus* (Pachilavetti)
- *Labeo dussumeri* (Thooli)
- *Horobagrus brachysoma* (Manja koori)

- Small Indigenous fish species (SIFs) are vital **to prevent micronutrient (Fe, Zn, Se) deficiency** especially among rural (and marginalized) populations.

- Native carp species will **promote food security, livelihoods and economy** of local communities in inland areas of the state, especially tribal groups.

Amblypharyngodon melettinus – SIF Vayambu

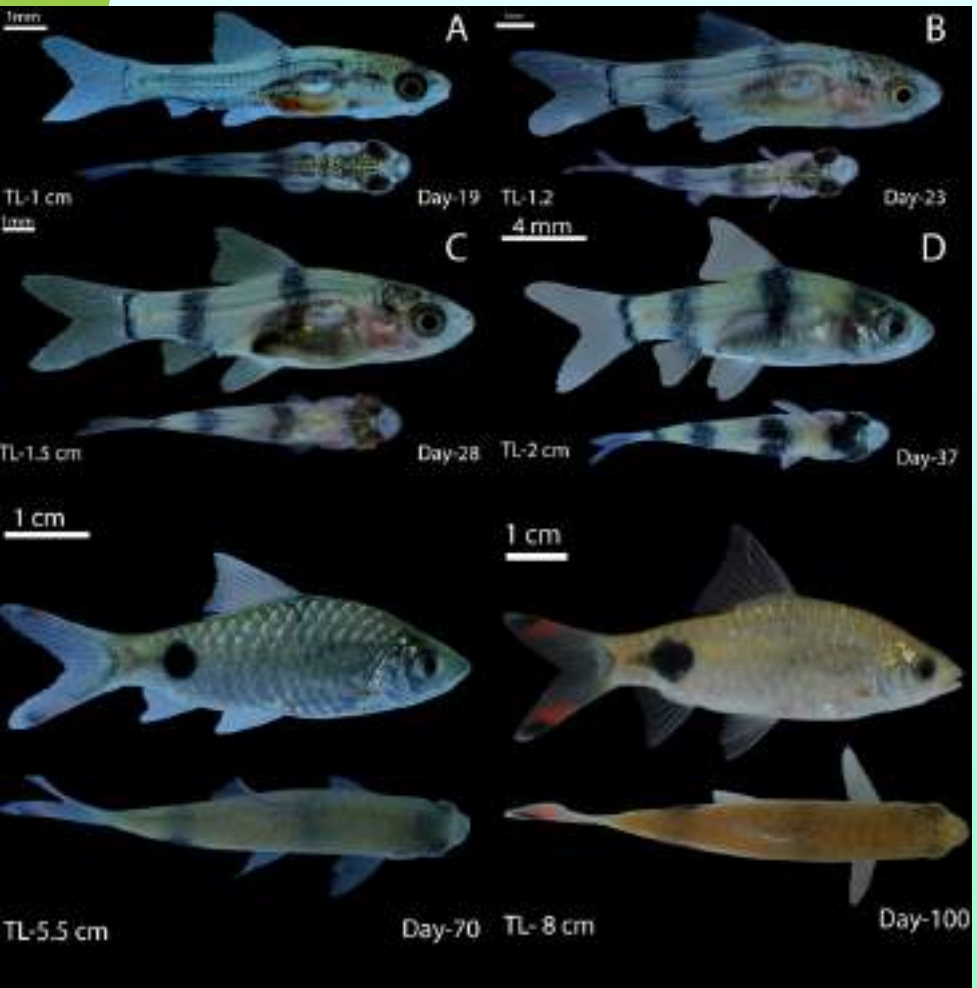
Hypselobarbus thomassi – native carp – Kooral

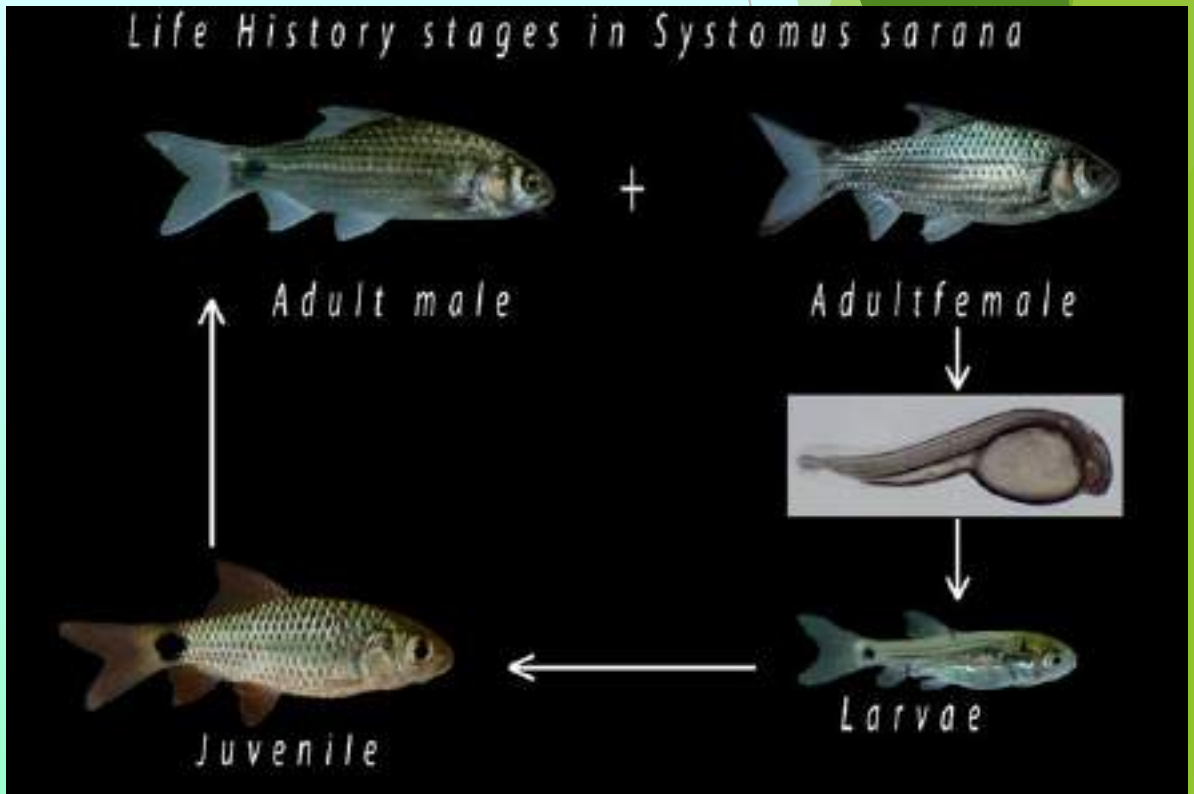
Labeo dussumieri – native carp - Pullan

Tor malabaricus – native carp - Kuyil

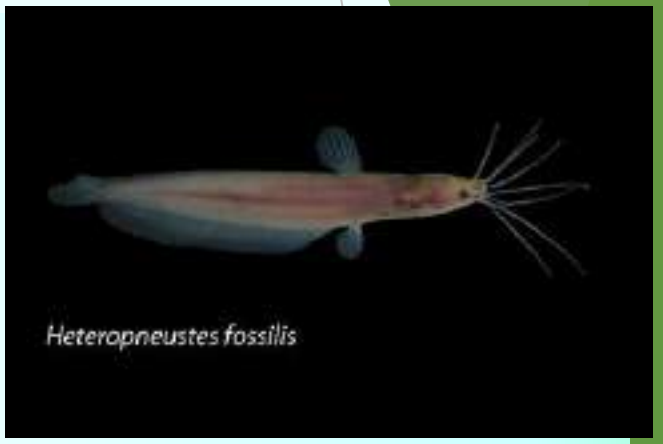
Systomus sarana – native carp Kuruvaparal

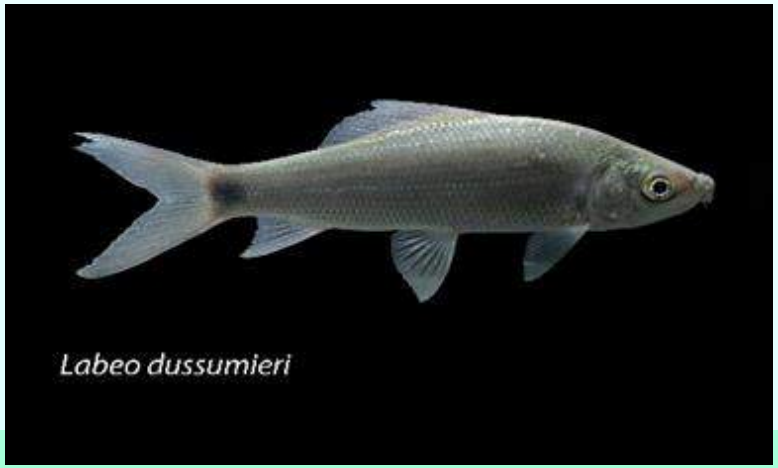
KUFOS has standardized the mass scale captive breeding protocol for the Filament barb (*Dawkinsia lepida)* and Olive barb *(Systomus sarana)*





Seed production technology is available for..

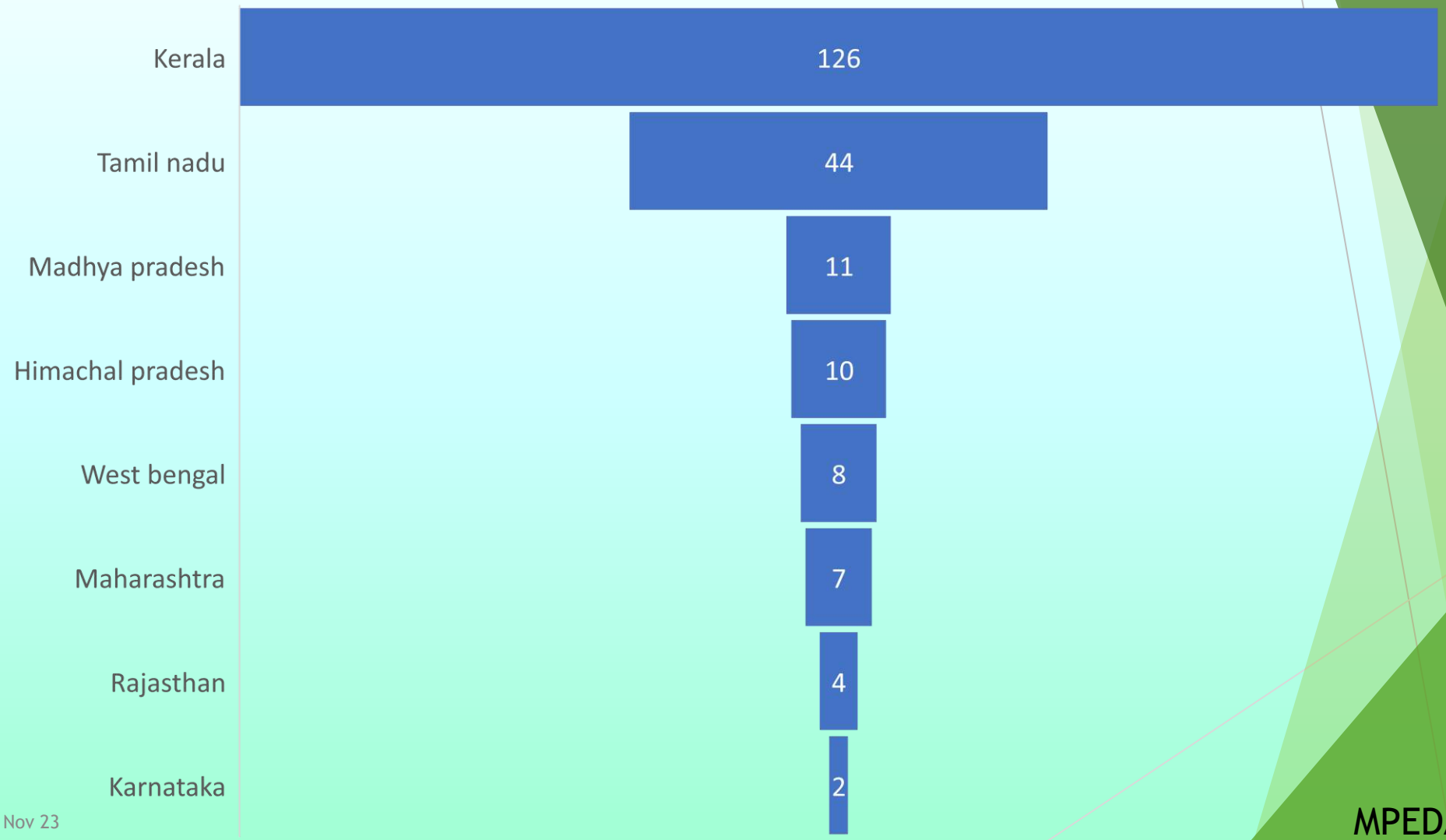




Ornamental fish culture

- Ornamental fish trade is a multibillion-dollar industry of around US$ 18 billion
- Export value of Indian ornamental fish industry is US$ 1.40 million (2017-18) with 0.4% share
- Western Ghats has about 155 species NE has 250 species
- Includes barbs, dwarf puffers, rasboras, killi fishes, glass fishes, cat fishes, catopra, hill trouts and danios
- 2020-2021 export – 221.72 tons Rs.33.3 crores
- The domestic market in India is estimated at Rs. 500 crores and the domestic trade is growing at an annual rate of about 20%.

Major breeding units



MPEDA

- Kerala Aquaventure International Limited (KAVIL), is actively engaged in the ornamental fish sector
- West Bengal 55%, , Tamil Nadu 30% and Kerala 5% are the major hubs of ornamental fish production in India
- Climatic conditions of Kerala are extremely favourable for the development of ornamental fisheries.
- With the available resource potential, 50% of the total domestic trades of fishes can be met by the State of Kerala.
- Well connected roads, rail and 4 international airports, large pool of educated manpower, continuous electricity and water availability.

Action Plan for Development of Ornamental Fisheries in India: AQUARAINBOW VISION- 2030

MISSION

- Entrepreneurship & livelihood generation through development of ornamental fisheries and improvement in quality of life through promoting the hobby aquarium keeping

VISION

- The hobby of aquarium keeping becomes a highly popular hobby both in urban and rural house-holds.
- India becomes a leading producer and exporter of both freshwater and marine ornamental fishes and allied products.

OBJECTIVE

- To **support the income of farmers** and **generate livelihood earning opportunities** in rural India through introduction of ornamental fisheries activities.
- To provide **self-employment and entrepreneurship development** opportunities to **rural and urban youth** in the field of ornamental fisheries and allied sectors.
- To **empower & encourage women, SCs, STs, other economically weaker sections** of the society to substantiate their earnings.
- To **promote private sector investment**, augment **export** of ornamental fish from country and achieve a leading position in global ornamental fish trade.
- To **promote the hobby of aquarium keeping**, help the people of country to live a stress-free healthy life and improve the quality of life.

PMMSY https://dof.gov.in/

Way Forward for the Development of Ornamental Fisheries in Kerala

- **Enhancing the Production of Ornamental Fishes**
- **Import of Ornamental Fish Brood stock**
- **Establishment of Aquatic Quarantine Centres**
- **Improve Handling and Shipping**
- **Marketing strategies**
- **Market promotion**
- **Awareness Creation and Training**
- **Address research needs (Survey, feed and nutrition, handling and transportation, broodstock and breeding, alien species, transboundary movement, diseases and management, etc)**
- **Support to employment creation**

Constraints

- Fish seed availability:
  - Hatcheries – 32 - estimated production (2019-20) - 353.55 lakh
  - Requirement of seeds – 1400 lakhs
  - Has huge potential for increasing seed production and fish production
  - The state has a deficit of 2-2.5 lakh tonnes of fish,

Remedial measures

  - Increase the number of hatcheries, ensure the quality of seeds coming to the state
  - Ensure public private partnerships for hatcheries

- Uncontrolled and unscientific expansion of aquaculture resulted in detrimental effects through:
  - habitat destruction,
  - environmental pollution through application of harmful chemicals and veterinary drugs (AMR)
  - ecosystem damage due to the impact of escapees and invasive species
  - undesirable dependence on the fish meal and fish oil for fed-aquaculture.

IMPACTS OF CLIMATE CHANGE

Short-term

- loss of production or infrastructure due to extreme events, diseases, toxic algae and parasites; and decreased productivity due to suboptimal farming conditions

Long-term

- scarcity of wild seed, limited access to freshwater for farming, limited access to feeds from marine and terrestrial sources, decreased productivity due to suboptimal farming conditions, eutrophication and other perturbations.

Risk Factors in Disease Incidence

- The expansion of aquaculture
- Movement of animals
- Farming of new species
- Lack of biosecurity and quarantine
- Lack of proper diagnostics
- Lack of awareness
- Antimicrobial resistance (AMR)
- Known and unknown stress factors
- Climate change induced vulnerability,
- invasive species and pathogens
- Stressor synergy

Advances in diagnostics

- NGS (next generation sequencing)
- Nanopore sequencing
- eDNA (environmental DNA analysis) approach
- Droplet digital PCR (ddPCR)
- Nanosystem applications (magnetic nanoparticles, metallic nanoparticles, polymeric micelles, polymeric nanospheres, functionalized fullerenes etc)
- Field level PCR kits
- CRISPR (Clustered regularly interspaced short palindromic repeats) based diagnostics

Improved control measures

- Control of microbial population through probiotics and bioremediators
- Improved biosecurity measures and personal management
- Better health management by stimulating trained immunity through vaccination and innate immunity by application of immunostimulants and herbals
- Surveillance, avoidance and eradication
- Innovative system management protocols like:
  - zero water exchange,
  - well designed effluent treatment systems,
  - AI based underwater observation and interventions
  - individualised intervention measures

Genetic selection and breeding for resistance

- Selecting resistant strains
- Calculated selective breeding programmes
- Generating progenies with heritable resistance.
- Marker-assisted selection (MAS) based on detecting the quantitative trait loci (QTL) for disease resistance

Additional interventions

- Recycling of generated wastes by integrated multi tropic aquaculture (IMTA),
- Aquaponics
- Prudent use of coastal, oceanic resources
- Social engineering of stakeholders involved in the sector (Cooperative societies) and
- Supporting background infrastructure development.

Remedies and interventions

- Utilisation of unused water logged areas for fish culture -
- Rice-fish culture - help raise the incomes of rice farmers and reduce the conversion of rice land to non-agricultural purposes. Promote Pokkali, Kaipad, and Kol regions.
- Protect water bodies from different kinds of pollution- Factory discharge, hospital discharge, direct sewage dumping, macro and microplastic disposals and farm land discharge with pesticides
- Supply electricity at lower/agriculture rates
- Declare protected areas – breeding grounds
- Cage farming in reservoirs
-

CRITICAL GAPS IN THE SECTOR and GOALS TO BE ACHIEVED

- Seed production
- Ornamental aquarium plants
- Cutting down use of chemicals/antibiotics
- Reduction of biodiversity and deteriorating aquatic environment
- Pollution of potential areas
- Protection of coastal zones of Kerala which are morphologically and socially vulnerable; and prone to extreme weather events.
- Coastal erosion and sea level rise.
- Our mangrove and marine resources are treasure troves of bioactive substances – policy inteventions

Post harvest utilisation

- Reduction of wastes
- Waste to wealth concept
- Improved value addition – product development

Shanghai, China

No waste policy

Acknowledgements

- Govt of Kerala
- Department of Fisheries
- Planning board, Gov Kerala
- KUFOS

- Thank you for your kind attention