# Aquaculture and fisheries for rural livelihood:
## A climate-smart and nutrition-sensitive approach in Assam

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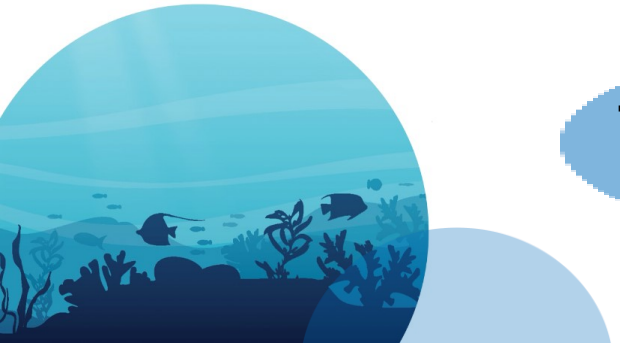
# Aquaculture and food security

"Aquaculture has been growing rapidly faster than any other food production sector over the past three decades and continuing."

"The aquaculture sector plays very momentous role in providing nutritionally rich food and livelihood support to the impecunious communities across the developing world thus contributing directly and indirectly to their food security."



Time to put "Nutrition Security" at par with "Food Security".

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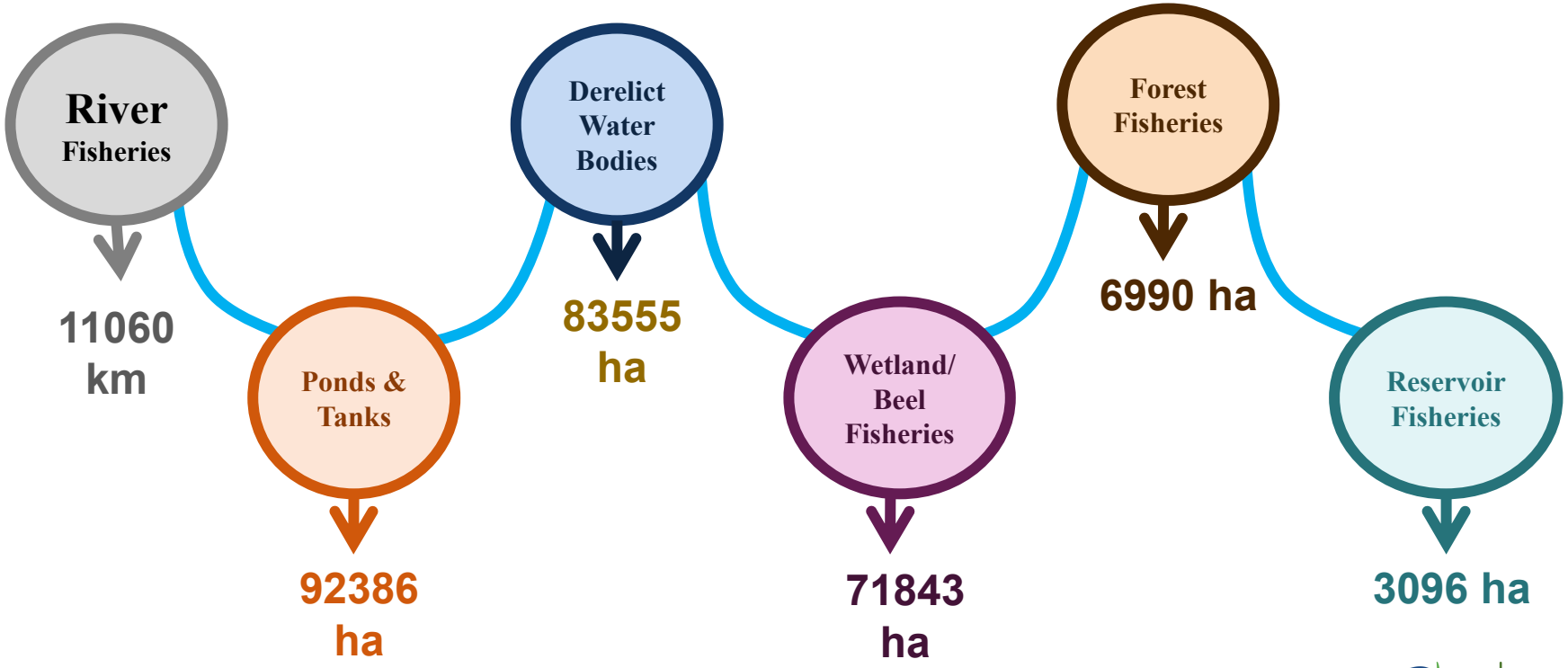
# State water resources of Assam




**Total water spread area: 2.57 lakhs ha excluding river fishery**

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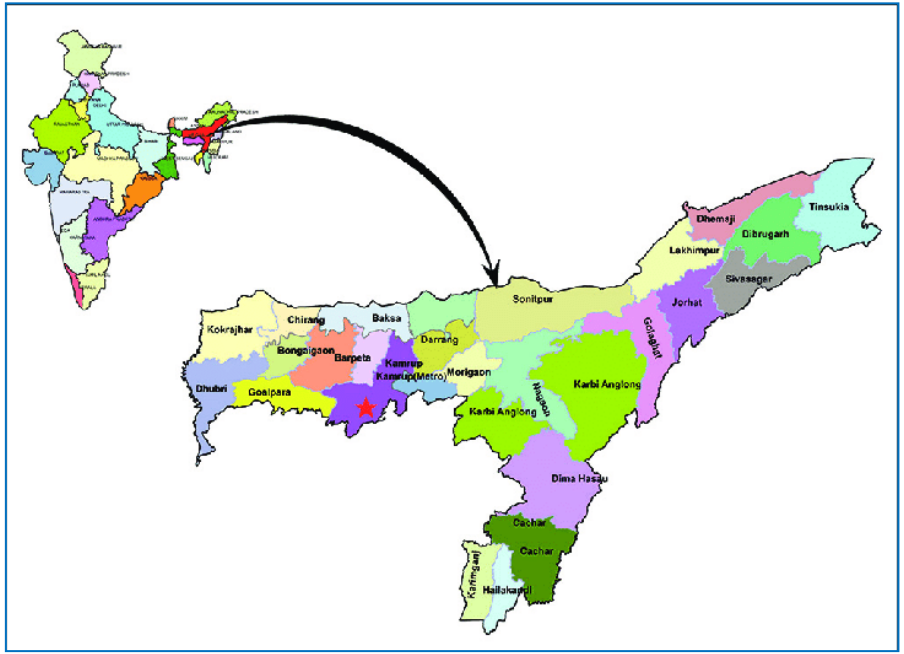
# Fish production and consumption

| YEAR | FISH (LAKH MT) |
|---|---|
| 2018-19 | 3.31 |
| 2019-20 | 3.73 |
| 2020-21 | 3.93 |
| 2021-22 | 4.17 |




Assam rank **7th position** in state wise inland fish production in the country.

Assam hold **5th position** in consumption with **11.72 kg** per capita/year.

More than **90% population** of the state consume fish as food.

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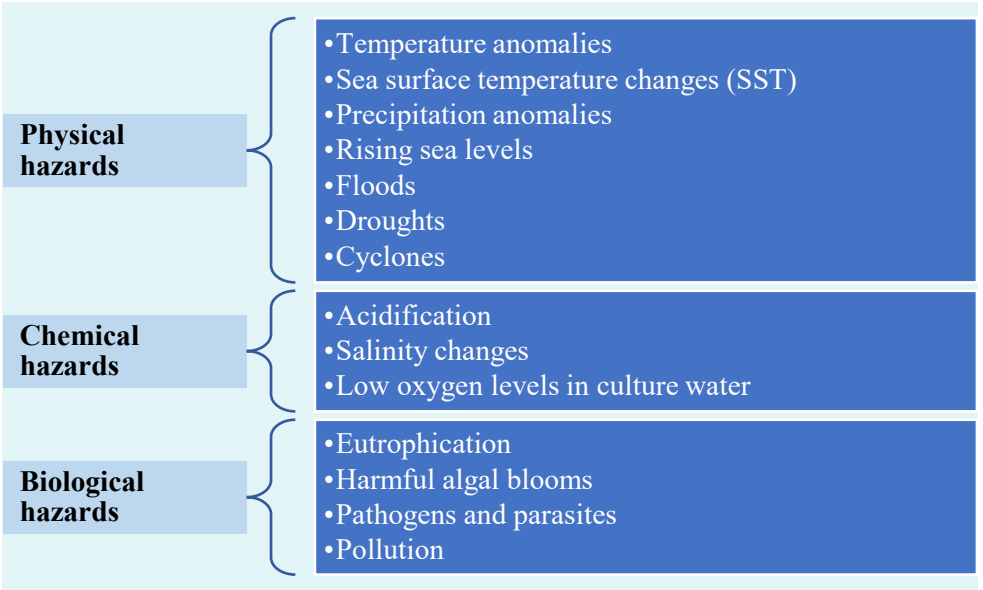
# Climate change impact on aquatic food production system of Assam

- **Rise in temperature**, **change in precipitation**, **flood, drought**, etc. are affecting the aquatic food production system (both culture and capture fisheries) of Assam the most.
- Fish being the cold-blooded animal, its metabolic rate gets strongly affected by environmental conditions, especially the **temperature**.
- **Extreme weather events** like flood, drought can have serous negative impacts like crop loss due fish escape, mortality, etc. which have adverse economic and social impacts on the dependent communities like fish farmers and fishers.

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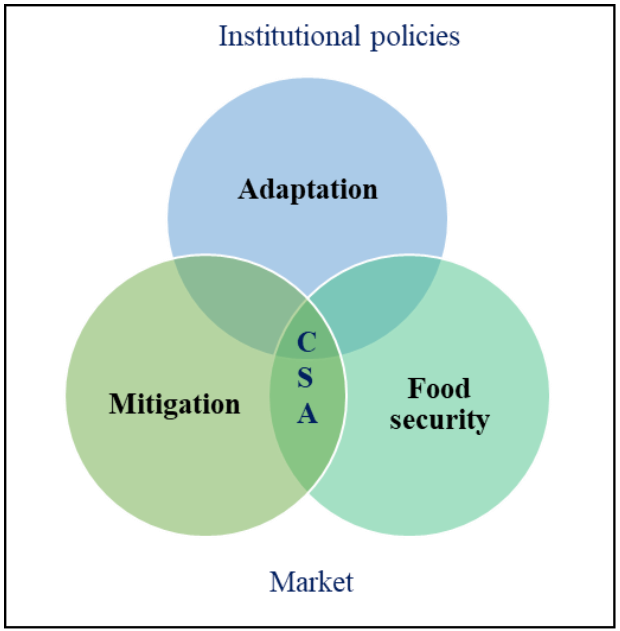
# Climate smart Aquaculture ?

**Climate Smart Aquaculture:**
Aquaculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation), and enhances the achievement of national food security and development goals.

Climate smart aquaculture allows farmers and investors to enhance adaptation and mitigate climate change in order to build resilience.




**Output**

- **Increase productivity**
- **Increase profit**
- **Improved resource use**
- **Improve input use efficiency**
- **Reduce disease related losses**
- **Reduce emissions**
- **Household nutrition**
- **Increase gender and social inclusion**
- **Increase overall resilience**

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## Our Vision

An inclusive world of healthy, well-nourished people and a sustainable blue planet, now and in the future.

## Our Mission

To end hunger and advance sustainable development by 2030 through science and innovation to transform food, land and water systems with aquatic foods for healthier people and planet.

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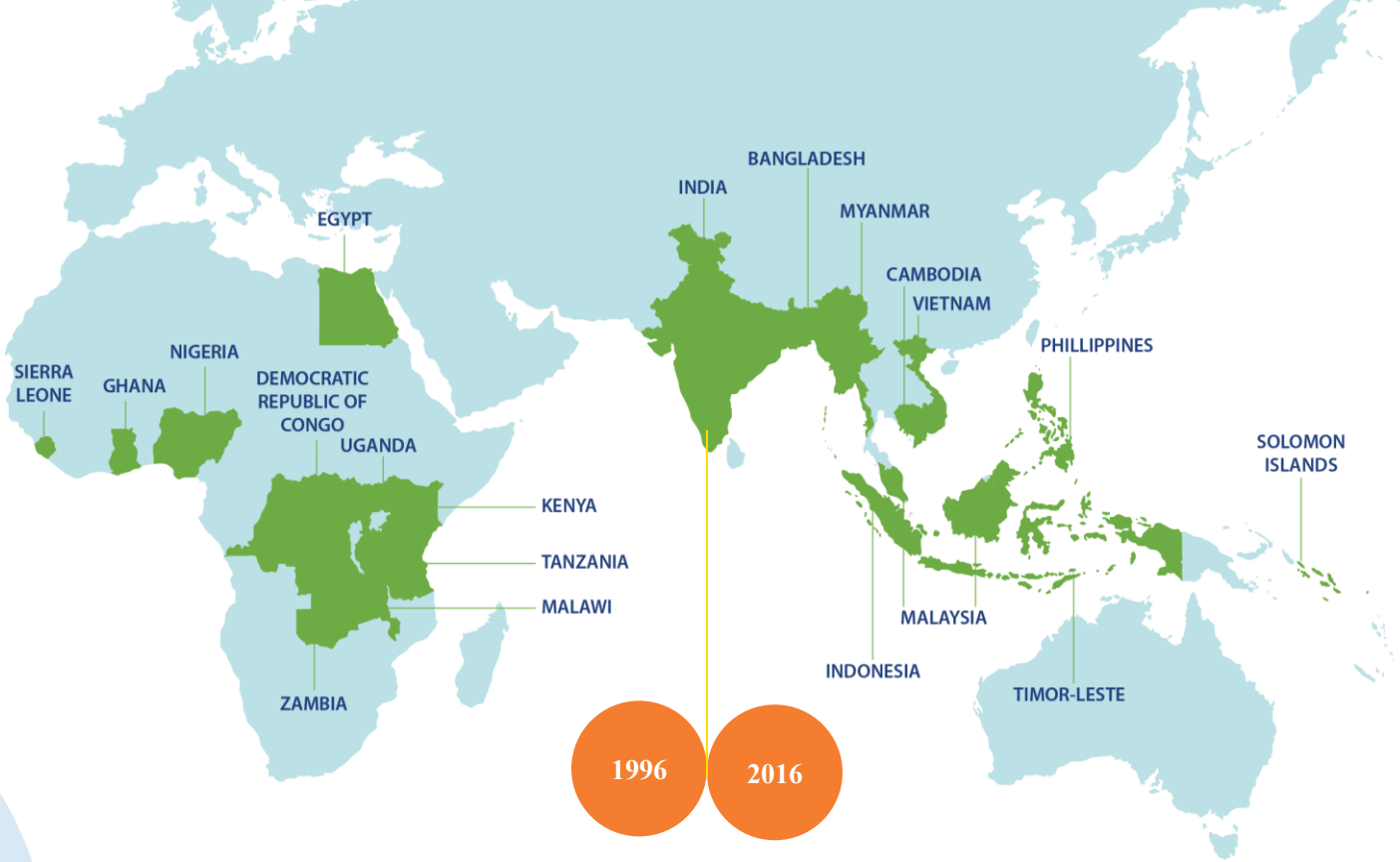
# WHERE
we are




WorldFish has a global presence in **20 countries** in **3 continents** with **446 staff** representing **30 nationalities**

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# Fish – Nutrition Power House

## Minerals

**Iron** (Fe)
essential for brain development in children and increases maternal survival rates.

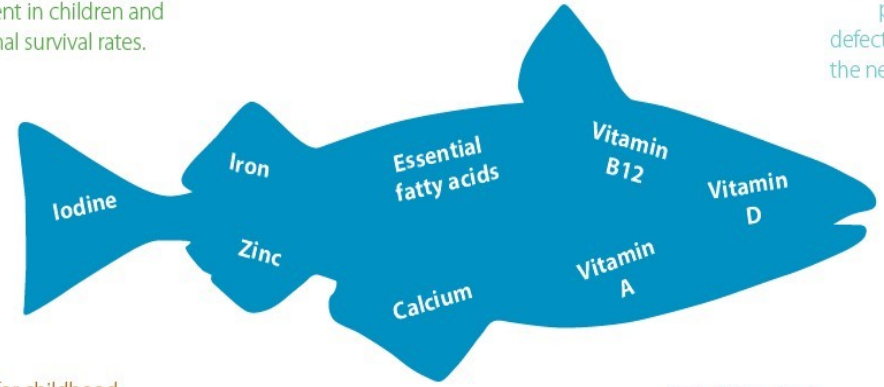
**Iodine** (I)
essential for brain development in fetus and young children and helps prevent stillbirth.

**Zinc** (Zn)
crucial for childhood survival, reduces stunting in children and fights diarrhea.

**Calcium** (Ca)
helps prevent preeclampsia and preterm delivery, and is essential for strong bones and teeth.

## Essential fatty acids

help prevent preeclampsia, preterm delivery, low birth weight, and support cognitive development and better vision in children.




## Vitamins

**Vitamin B12** (B12)
essential for a healthy pregnancy; helps prevent brain and spinal cord birth defects, and supports healthy maintenance of the nervous system and brain in children.

**Vitamin D** (D)
essential for the development of strong, healthy bones, teeth and muscles in children and helps prevent preeclampsia, preterm delivery and low birth weight.

**Vitamin A** (A)
essential for childhood survival, prevents blindness, helps fight infections and promotes healthy growth.

Increasing fish in the diet is an essential route to **reducing micronutrient deficiencies**

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# Polyculture of carps & species diversification

Double the carp production in **household ponds** sustainably from the present yield 2.5 – 3.0 ton/ha/year to **5 – 6 ton/ha/year**.

Introduction of **genetically improved strain** of **Jayanti Rahu** and **Amur common carp** in polyculture.

Stocking of **advanced fingerlings** of more than **100 mm size** in grow out ponds.

Promotion of **better management practices (BMP)** for sustainable fish production.

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# Polyculture of Carps with Freshwater Prawn

Introduction of **high value crop** along with carp polyculture system in household pond.

Freshwater prawn is recognized as an economically valued species for aquaculture due to its big market size, **fast growth rate**, wide range of foods and feeding habits.

Diversification of species with high value crop for additional income to the farmers.

Replacement of bottom dweller fish with high value compitable species.


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# Carp Mola –SIS Polyculture

Increase production of **mola** and **small indigenous fish species (SIS)** along with carps in ponds, beels and paddy cum fish integrated farming.

Promotion of mola and other SIS along with carp polyculture.

Stocking of mola brood fishes @ **50kg/ha in carp polyculture**, **25 kg/ha in paddy cum fish culture** and **5 kg/ha in beels**.

**Partial harvesting** management and use of **segregation net**.

Benefits of **additional production** and **increase income** to the farmers.

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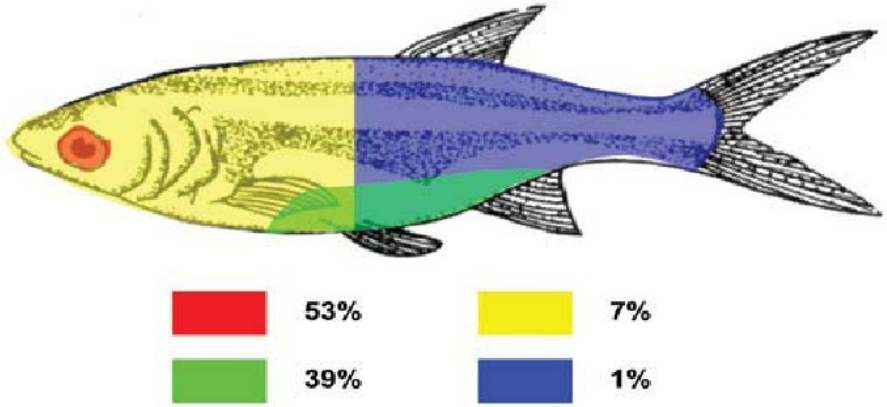
# SIS – A Micronutrients Powerhouse

Small indigenous fish species **(SIS)** are those small fishes which attains a **maximum length of 25 cm.**

SIS such as ***Amblyphayngodon mola***, ***Osteobrama cotio*** and ***Esomus danricus*** contain high amount of **vitamin A** and other **micronutrients** and **minerals.**

**FIGURE 1**
**Distribution of vitamin A in "mola". Vitamin A content: 2,680 RAE[1]/100 g raw, edible parts. Length of whole "mola": 6–8 cm; weight of raw, whole "mola": 5–9 g.[2]**




[1] RAE: retinol activity equivalent.
[2] *Source:* Roos *et al.* (2002).

# Introduction of SIS (Mola)

Introduction of Mola and other small indigenous fish species along with carps in household pond and other fish production system to support additional production, increase income and household consumption of small fishes. Improved management and periodic harvesting practices leads higher production of mola and other SIS.

Household ponds stocked with carp and **SIS** (mola). **P**

Additional production of SIS support **extra income**. **I**

Households **consuming more SIS** as a result. **C**

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# Paddy fish integration

## A climate smart approach

Paddy cum fish integrated farming is **highly profitable**, **sustainable** and most importantly is **climate-resilient** as two crops that is paddy and fish can be ensured from an unit of scarce cultivable area to secure the living of marginal and small farmers whose livelihood are under the intimidation of climate change.

It is a **multi commodity production system** with the waste recycling as the key feature.

Production of fish along with paddy crop gives the farmer an off-season occupation, which provides additional the income.

**Assam has plenty of areas under flooded paddy fields and this would definitely increase yield, income and socio-economical status of rural farmers through scientific backstopping.**

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# Paddy fish integration
## Emerging method

- Paddy fish farming varies from traditional only wild harvesting to some extend semi intensive farming system with high inputs investment including regular feeding, liming and fertilization.
- Low lying paddy land of 5 to 15 bighas area is protected through construction of earth embankment with usually higher than the local seasonal flood.
- Most these land has the motor powered bore well for water supply into the field.
- Paddy cultivation in such plot is commonly known as ***"Borokheti"*** and ***Swarna Masori*** is one of the most popular variety among the farmers.
- Paddy cultivation is done in premonsoon season (**January/February to May/June**) and subsequently later part fish farming activities is done where entire plot will act as pond for fish culture.
- Fish harvesting start after the recession of water during November-December
- The contribution of **fish** to the net income is **82.77 %**, while that of **paddy is 17. 22 %**.
- The level of profit to the **turnover is 49.61%** with **BCR 1.98**.

This integrated management of land, water and ecosystems at landscape scale can be a base for sustainable production of aquatic food and climatic resilience while reducing **greenhouse gas** emissions.

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# Beel Fisheries development

Sustainable production enhancement from the present level 0.5 – 1.0 ton/ha/year to **1.5 – 2.0 ton/ha/year**.

**Community participation** in all stages of development and post development management of beel fisheries.

Sustainable production and conservation of common property resources.

**Enhanced nutritional security** to the local communities.

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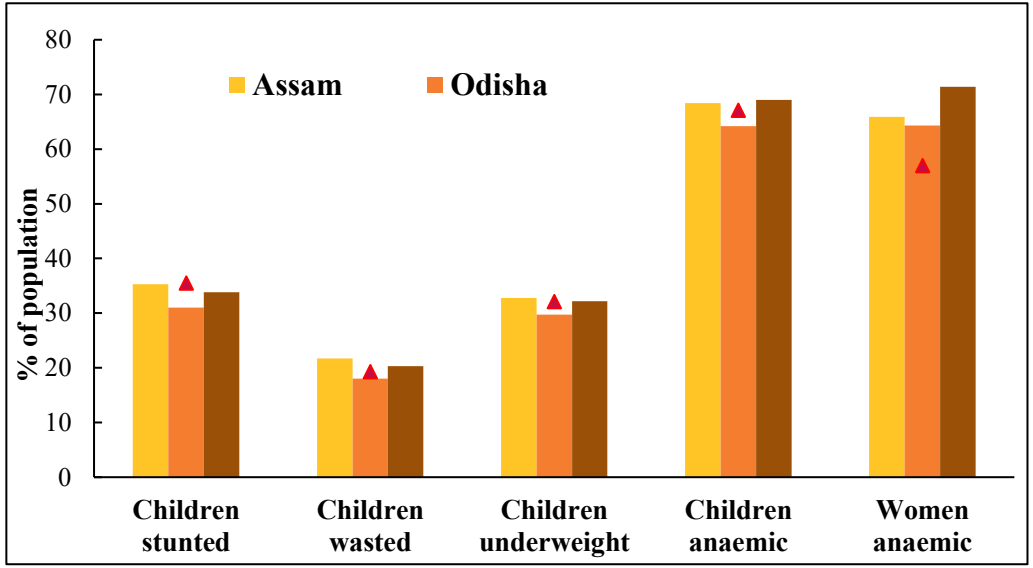
# Why nutrition-sensitive aquaculture?

- Despite advances in health services, undernutrition remains one of the major Challenges in India.
- In Assam, Odisha, and West Bengal, more than 30% of children are malnourished and more than 60% of children and women are anemic.
- Aquatic foods have a critical role in battling undernourishment in global south where fish and fish-based products are central to local cuisine.




Source: NFHS-5

**Nutrition-sensitive aquaculture:** A food-based approach to aquaculture development that prioritizes the production of nutrient-dense **Small Indigenous Fish Species (SIS)** alongside conventional carp polyculture to support beneficial nutritional outcomes.

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# Mola – Champion SIS for nutrition-sensitive aquaculture

- SIS like mola is **Superfood** – rich in essential minerals like **iron**, **zinc**, and **calcium** as well as **Vit A** and **B12**.
- SIS such as mola can be cooked and eaten whole, enabling the ingestion of vitamins and minerals found in the head, bones, and liver.
- Mola can be co-cultured in farm ponds alongside larger fish such as carp, inclusion of mola does not decrease carp production (Roos et al., 2007).
- Including SIS like mola in carp polyculture increases intakes of micronutrient-rich small fish by women and children and is a cost-effective way to reduce malnutrition (Castine et al., 2017; Feidler et al., 2016).

| Fish | Protein (g) | Fat (g) | Iron (mg) | Zinc (mg) | Calcium (mg) | Iodine (µg) | Vitamin A (µg) | Vitamin B12 (µg) |
|---|---|---|---|---|---|---|---|---|
| Mola | 17.3 | 4.5 | 5.7 | 3.2 | 853 | 17 | 2503 | 7.98 |
| Rohu | 18.2 | 3 | 0.98 | 1 | 51 | 20 | 13 | 5.05 |
| Catla | 14.9 | 0.7 | 0.83 | 1.1 | 210 | 18 | 22 | 1.3 |

**Table 1.** Nutrient content (per 100 g raw edible fish) of mola, rohu and catla (Extracted from Bogard et al., 2015).

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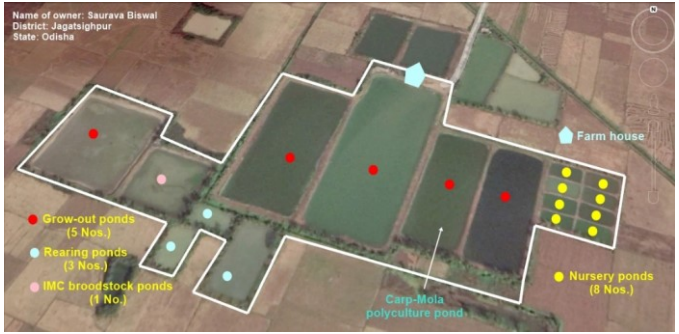
# To scale nutrition-sensitive aquaculture

- Mola broodstock were collected from multiple sources to ensure genetic diversity and reared in broodstock ponds for two months at partner hatchery (Lat 20° 12'45.84"N/Long 86° 20'3.32"E).
- Brooders were fed to satiation with 42% CP floating extruded feed twice daily.
- Selected breeders were then identified based on secondary sexual characteristics and transferred to a concrete conditioning tank (capacity: 10 $m^3$) with constant water flow for **stimulating spawning readiness**.
- After **hormone administration** fishes were returned to **double hapas** inside breeding tanks.
- The tanks were exposed to a constant shower of oxygen-rich water from an overhead tank equipped with an **aeration tower**.

# Hormone administration

- **Synthetic Gonadotropin Releasing Hormone** (e.g., WOVA-FH) was used for induced breeding.
- Dose: **0.5 ml/kg** body weight of female and **0.25 ml/kg** body weight of male.
- For 1 kg female mola breeder, at first, we diluted 0.5 ml hormone with 15 times dilution in water.
- That means 0.5 ml hormone + 7.5 ml water = 8 ml inducing solution for 1 kg of mola.
- Prepared inducing solution was injected into the peritoneal cavity of mola brood fish.
- For hormone administration, an insulin diabetic syringe of 1 ml capacity with 40 graduations was used.
- Average male-female ratio was: **2: 1**


# Breeding arrangements

# Breeding arrangements


Constant showering

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# Aeration tower: An innovation of WorldFish for improving spawn survival

## Before installation

- $CO_2$ of borehole water: 80 ppm
- $O_2$ of borehole water: 0 ppm

## After installation

- $CO_2$ of borehole water: 1**5-20 ppm**
- $O_2$ of borehole water: 100% saturation

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# Results: Mass production of mola seed

**Table 2. Breeding performance of mola of 10 production cycle (July to October 2022)**

| | |
|---|---|
| • **Avg. weight of female (g)** | 6.90 ± 0.4 |
| • **Avg. length of female (cm)** | 8.81 ± 0.38 |
| • **Avg. weight of male (g)** | 2.85 ± 0.22 |
| • **Avg. length of male (cm)** | 4.84 ± 0.17 |
| • **Female responded (%)** | 80.70 ± 4.99 |
| • **Fertilization rate (%)** | 81.20 ± 2.39 |
| • **Hatching rate (%)** | 85.05 ± 4.66 |
| • **Survival rate (%)** | 88.40 ± 2.89 |
| • **Spawning fecundity (n)** | 4217.69 ± 511.61 |
| • **Total hatchling hatched** | **7159674** |
| • **Total hatchling harvested** | **6358200** |

- **Latency period** was observed between 6–8 h (water temp.: 28-29.5˚ C).
- The released eggs were collected in 250 micron mesh outer hapa and became slightly adhesive following fertilization.
- **Incubation period** was observed after 12 h of fertilization (water temp.: 28-29.5˚ C).
- The fertilization, hatching, and survival rates were 81%, 85% and 88% respectively (Table 2).
- Total **6.35 million** hatchling harvested.
- Per kg female produced **0.425 million** hatchling
- Mola hatchlings were ready for sale after 3 days

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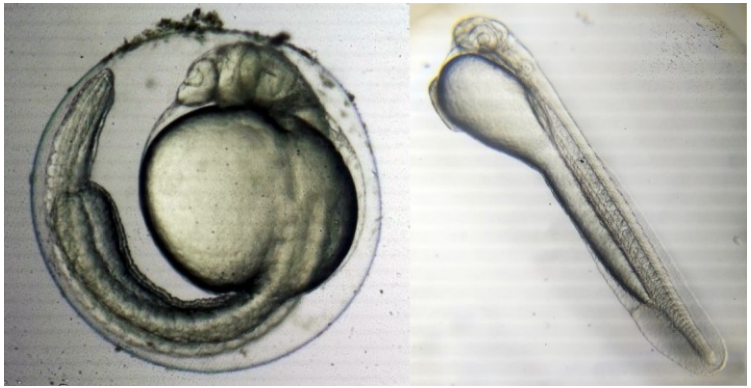
# Results: Mass production of mola seed

Mola eggs attached to outer hapa (left), and one day old hatchlings (right).



Microscopic view of developed mola embryo (left) and a freshly born mola hatchling (right).

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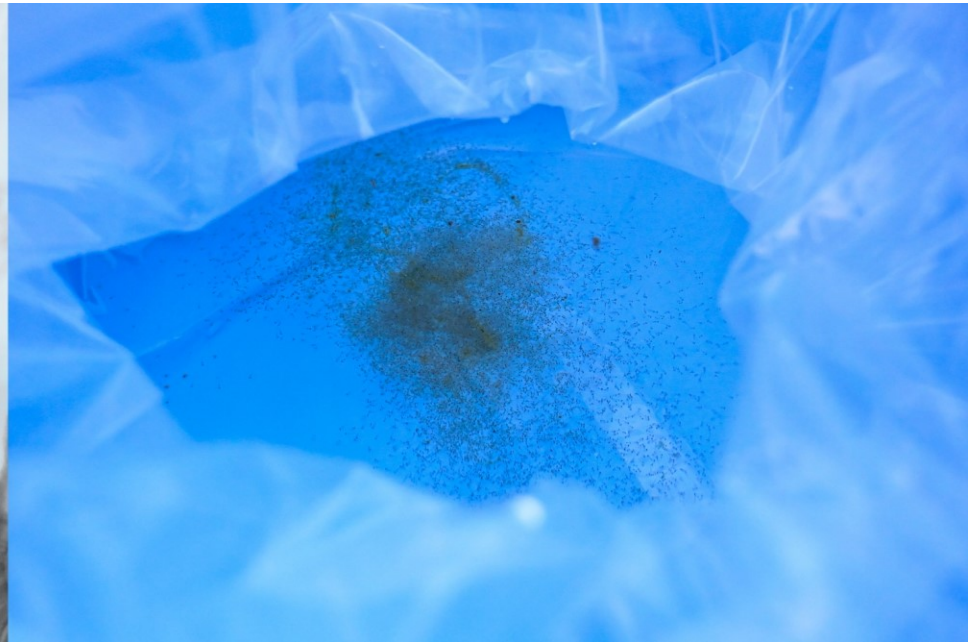
# Results: Mass production of mola seed



**Mola hatchlings ready for sale after 3 days**

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# Sale of mola hatchling – for the 1st time in India


On 17th July 2022, for the 1st time in India, mola hatchling is sold from Odisha

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# Multiple advantages of stocking hatchery-produced SIS seed

| Wild broodstock | Hatchery produced seed |
| --- | --- |
| • For seasonal pond, stocking wild breeder is challenging. | • Uniformed sized SIS seeds and same age and can be stocked at the optimum time and density to maximize survival and growth. |
| • SIS populations comprised of a mix of age groups, resulting in the production of SIS of variable sizes. | • Less pathogen infestation due to strict biosecurity |
| • Risk of contaminating the farmer's pond with pathogens. | • Transportation with well oxygenated clean water – high chance of survival. |
| • Seed produced by spontaneous natural spawning in the pond also faces multiple hardships such as competition for food, cannibalism, and predation. | • Guarantee a consistent size at harvest, improving their marketability and bringing in higher prices. |
| • Arrangement cost is high | • Enables farmers to benefit from early breeding in hatcheries to ensure a steady supply of SIS seed. |

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# Thank You

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