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Current Status and Scope of Carp-Mola Polyculture in Odisha

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Introduction

Carp-Mola culture is an important and sustainable aquaculture system in Odisha, blending traditional practices with modern techniques to enhance food security, increase fish production, and improve the socio-economic conditions of local communities. Carp-Mola culture in Odisha refers to a mixed aquaculture practice involving the farming of carp fish (specifically, Indian major carps like Rohu, Catla, and Mrigal) alongside smaller fish species such as Mola (*Amblypharyngodon mola*). This form of fish farming is prevalent in the state of Odisha, where fish is an essential part of the diet, and aquaculture plays a key role in rural livelihoods and the local economy. Undernutrition remains a pressing issue in developing countries, particularly impacting the health of women and children. Persistent micronutrient deficiencies necessitate effective interventions. In response, initiatives promoting Small Indigenous Fish Species (SIS) from freshwater ecosystems have gained momentum. Among these, the integration of mola (*Amblypharyngodon mola*) into conventional carp polyculture systems emerges as a promising strategy to combat nutritional deficiencies (Mohanty and Sarangi, 2024). Efforts are being made to improve the techniques and productivity of carp-Mola aquaculture through research. These initiatives focus on better breeding practices, disease management, and enhancing the efficiency of mixed species farming systems. Additionally, government programs and non- governmental organizations (NGOs) support fish farmers through training, extension services, and provision of subsidies for modernizing aquaculture practices.

Historically, small indigenous fish species (SIS) such as mola have been crucial for providing micronutrients such as calcium, iron, zinc, iodine, vitamin A, B12 and D, as well as essential amino acids, omega-3 polyunsaturated fatty acids, and lipids (Mohanty et al. 2012; Bogard et al. 2015; Islam et al. 2023), which are often lacking in alternative sources (Ahern et al. 2021). Unfortunately, the diversity of SIS is declining because of various factors, including habitat degradation and overexploitation of inland capture fisheries (Nandi

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et al. 2012). The introduction of exotic species like Pangas, Pacu, Monosex Tilapia etc. have further reduced the appeal of small indigenous fish. As a consequence, they are now becoming increasingly scarce and expensive, making them less accessible to individuals with limited financial resources and depriving them of the nutritional and cultural benefits that these species provide.

With a population of 46.6 million, Odisha faces daunting challenges rooted in poverty and food insecurity (NITI Aayog and UN, 2021). The latest National Family Health Survey paints a grim picture, revealing that 31.1% of children under five in Odisha suffer from stunted growth, while 29% are underweight (IIPS and ICF, 2021), indicating widespread deficiencies in vital micronutrients due to inadequate dietary intake. These challenges compound the existing issues of food insecurity and poverty, underscoring the urgent necessity for targeted interventions aimed at uplifting the economic and social fabric of Odisha's vulnerable communities.

In this context, nutrition-sensitive aquaculture has emerged as an approach to aquaculture development that prioritizes the production and consumption of these nutrient-rich SIS alongside conventional carp polyculture (Thilsted et al. 2016). Evidence from Bangladesh suggests that this approach could play a pivotal role in providing nutritionally rich food, diversifying production, supporting livelihoods and enhancing food security for aquaculture- dependent communities (Castine et al. 2017).

Why Small Indigenous Fish Species (SIS)?

The small indigenous fish species (SIS), which have been defined as species which grow to a maximum length of about 25 cm with indigenous in origin, commonly found in freshwater wetlands/ ecosystems (Nandi et al., 2013). SIS have now great demand in the rural as well as urban markets due to their nutritional value, taste/flavor and low to moderate market price. SIS have traditionally been an integral part of rural household diet. Consumption of fish, often referred as 'Brain food' is known to play an important role in neurodevelopment in growing children. Unlike large fish, mola is consumed whole with head and bones, provide a significant source of bioavailable calcium, zinc, iron and vitamin A (Bogard et al. 2015). A 100g mola contains approximately 1,960 µg vitamin-A, 1,071 mg calcium and 7 mg iron (Roy et al. 2015). If consumed within the household, mola (*Amblypharyngodon mola*) could contribute half of the vitamin A and a quarter of the iron intake recommended for a family of four, annually (Sarah et al. 2017). In India and many other Asian countries several SIS are considered as cheap sources of proteins, minerals and

vitamins (Fiedler et al., 2016; Nandi et al., 2013; Thilsted et al., 2016) and they contribute to enrich the quality of the freshwater ecosystems (Aditya et al., 2012). The contribution to food security (Roos et al., 2007; Fiedler et al., 2016; Thilsted et al., 2016) and the livelihood (Gupta & Banerjee, 2008) are valued ecosystem services attributable to the SIS.

Potential SIS for Nutrition-sensitive Freshwater Aquaculture

Nutrition-sensitive aquaculture is a food-based approach to aquaculture development that ensures nutritionally rich foods, dietary diversity, and food fortification at the heart of overcoming malnutrition and micronutrient deficiencies. This approach seeks to ensure the production of a variety of affordable, nutritious, culturally appropriate and safe food fishes in adequate quantity and quality to meet the dietary requirements of populations in a sustainable manner. If widely applied to aquaculture, this approach could create large impacts on the nutritional status and health of populations, within both resource- poor and better-off populations (Mohanty and Sarangi, 2024). There are many small fish in viz. mola (Amblypharyngodon mola), Chela. (Salmophasia bacaila), Punti (Puntius sp.), Tangra (Mystus vittatus), Pabda (Ompok pabda), Singhi (Heteropneustes fossilis), chapila (Gudusia chapra), bata (Labeo bata), dhela (Osteobramcotio cotio cotio), colisa (Colisa fasciata), kacki (Corica soborna) etc., which are potential SIS/SIFs for freshwater aquaculture (Thilsted et al. 1997). They play a crucial role in promoting nutrition-sensitive aquaculture and have the potential to significantly reduce under nutrition through food-based strategies. Combining small indigenous fish species (SIS/SIFs) with large species in homestead pond polyculture, offers opportunity to increase household dietary diversity and micronutrient intake (Bogard et al. 2015).

About 450 SIS are known in India, of which Sixty-two SIS are important for food security (Mohanty and Sarangi, 2024). Among SIS, mola (*Amblypharyngodon mola*) has a high consumer preference and has now great demand in the rural as well as urban markets due to their nutritional value, taste/flavor and moderate to high market price. Mola (*Amblypharyngodon mola*) has fast growth rates and high fecundity, reaching sexual maturity in approximately 4–5 months and reproducing two to three times per annum producing approximately 5000 eggs (Hoque and Rahman 2008; Suresh et al. 2007). Mola is mostly herbivorous and is easily sustained by the natural algal community, particularly chlorophyceae, present in ponds (Gupta and Banerjee 2013; Mamun et al. 2004). Small fish are not only cost- effective, but also nutrient-rich solution in the face of growing challenges and have the potential to play a significant role in food-based strategies to address

malnutrition within environmental boundaries.

Combining Amblypharyngodon mola with large carp species in homestead pond polyculture, offers opportunity to increase household dietary diversity and micronutrient intake (Bogard et al. 2015; Thilsted 2012). Inclusion of mola in carp polyculture systems in stand-alone ponds is currently being promoted as a means to enhance productivity, income and food and nutrition security of the rural poor. The focus on mola in carp-SIS polyculture is due to the extremely high vitamin A content and therefore the potential for mola production as a food-based approach to combat the high prevalence of vitamin A deficiency in rural India. Food insecurity and poverty can also be addressed through the harvesting and production of small fish, which form an important part of local livelihoods. WorldFish has already pioneered nutrition- sensitive aquaculture by promoting the addition of SIS/ SIFs to conventional carp farming systems (Dubey et.al., 2024). Therefore, key recommendations for large-scale adoption of nutrition-sensitive aquaculture (Fig. 1) would help in achieving many agenda of SDGs.

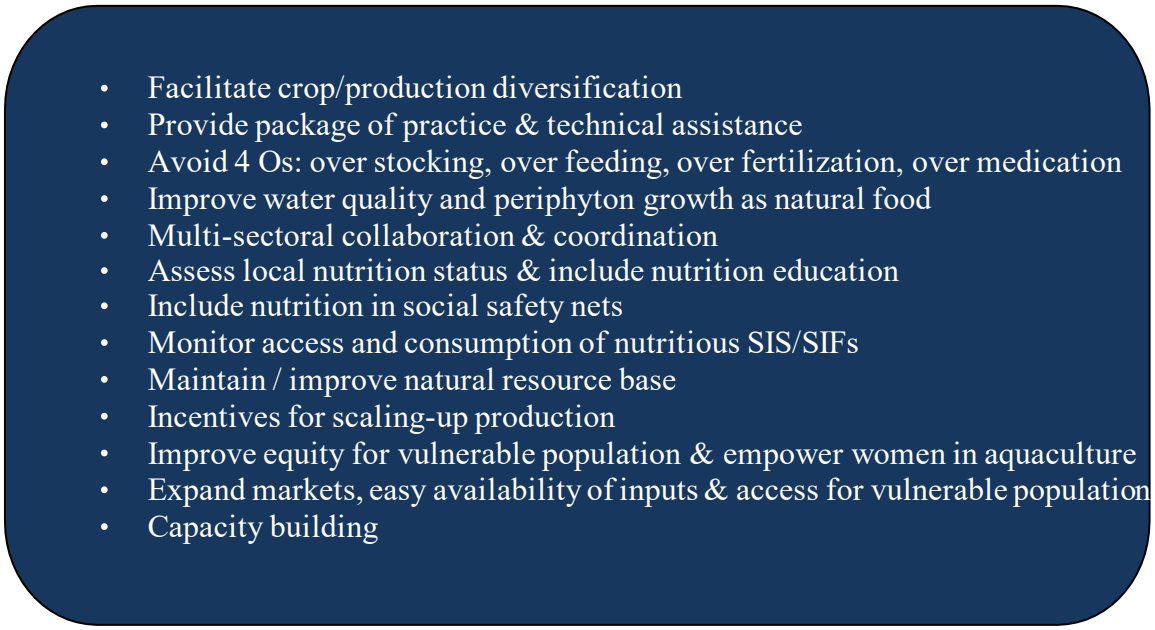

Fig1. Key recommendations for large-scale adoption of nutrition-sensitive carp-mola aquaculture

Freshwater Fishery Resources of Odisha

The freshwater fishery resources of Odisha are estimated to be 0.7 million ha comprising of tanks + ponds (0.153m ha), reservoirs (0.2 m ha), lake + swamps (0.18 m ha) and rivers + canals (0.171 m ha). From 2.60 lakh MT annually, fish production in the state over the last two decades has increased to 9.91 lakh MT in 2021-22, making it the fourth-highest fish producing state, where 90% population consume fish (Padiyar et al.,2024). The

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primary aquaculture system in Odisha cover 153,000 ha of ponds and tanks, that are extensive to semi-intensive pond-based polyculture systems. Odisha's rural landscape is marked by numerous waterbodies that are under the common property regime, governed by the Gram Panchayats, form the backbone of rural Odisha's water infrastructure. Over the past few years, numerous earthen ponds have been constructed through government initiatives and community efforts, primarily aimed at groundwater recharge and rainwater harvesting. These village community ponds or multi-utility GP tanks, can be used for community carp-mola polyculture purpose, by Women Self-Help Groups (WSHGs), Men Self-Help Groups (MSHGs), registered cooperative societies, village communities, and others.

Scaling-up Nutrition-Sensitive Carp-SIS Polyculture

To scale-up Nutrition-Sensitive Carp-SIS Polyculture Technology, WorldFish successfully developed a simple and replicable technique for mass-producing mola seeds, which has enormous promise for promoting nutrition-sensitive aquaculture in Odisha. Hatchlings were made available for sale to farmers from the project's partner hatchery, and rapid availability of mola seed is catalysing the adoption of nutrition-sensitive carp-mola polyculture in Odisha. With an average annual mola consumption of 16 kg per household and significant earnings

from sales, mola cultivation is beneficial both nutritionally and economically, underlining its importance in addressing food and nutrition security challenges and enhancing livelihoods.

In Odisha, WorldFish, with funding from the German Federal Ministry for Economic Cooperation and Development, implemented a project to upscale nutrition-sensitive carp-SIS polyculture. A pivotal breakthrough in 2022 marked the development of a first-ever protocol for hatchery-based induced breeding and mass seed production of mola. Presently, few private hatcheries in Odisha (Gogoi et al., 2023; Rajts et al., 2023) distributing mola seed to carp farmers including WSHGs, facilitating for carp-mola polyculture. Further, under the USAID-IPP project (United States Agency for International Development-Indian Partnerships Program) titled "The innovative and nutrition-sensitive fisheries technologies through partnership in Odisha", Carp-Mola polyculture is being promoted as a pilot will be carried out about 50 Anganwadi centers in Kaptipada block of Mayurbhnaj District during February – August 2021. This marked the beginning of a transformative journey towards enhancing dietary diversity and micronutrient intake among fish-dependent populations.

Experimental Field Trials in Odisha

Experimental farmers' field trials were conducted in ponds with average pond size of 0.32 ha, with approximately 50% ranging between 0.1 to 0.5 ha. 24% of seed buyers purchased mola spawns, and 76% opted for mola fry. Seed prices varied, with an average of 1176 INR per 1 lakh for mola spawn and 300 INR per thousand for mola fry. Farmers stocked mola spawn averaged at 2,83,583 numbers/ha, while mola fry were stocked at 22,190 numbers/ha. The average culture duration was 9 months which allowed breeding of stocks in the pond with several strategic partial harvests. Mola production commenced within 3-5 months of hatchery- produced seed stocking with carps. Harvesting practices varied, with 31% of farmers opting for partial harvesting and the remaining 69% performing complete harvesting, primarily utilizing cast nets and drag nets. Mola production averaged 194 kg/ha, with 34% of farmers obtaining 151-200 kg/ha and 28% achieving 101-150 kg/ha. Mola production contributing 9% to total pond fish production, reaching a maximum contribution of up to 26%. Each household consumed an average of 14 kg of mola, with a per capita consumption of 3.04 kg/year. Total fish production from carp-mola polyculture ponds averaged 2831 kg/ha, with 24% of farmers reaching 2501-3000 kg/ha (Dubey et al., 2024). Mola was sold at an average price of 145 INR/kg, with the majority of farmers selling at prices ranging from 140-150 INR/kg. On average, farmers earned an additional 19,700 INR/ha from mola sales.

Notably, mola production through hatchery-produced seed surpassed that from GP tanks in Odisha using wild brood stock (Padiyar et al. 2021), indicating the potential for sustained household consumption and income. Optimizing the carp-mola production system requires strategic partial harvesting. Pond size demonstrated a significant positive correlation with mola production, income, and consumption, suggesting that an increase in pond size beyond existing levels is associated with higher outcomes. Increased stock density positively influenced sales

and production per hectare, emphasizing the importance of stocking practices. Culture duration exhibited a significant positive effect on household-level consumption, attributed to the prolonged presence of mola in the pond through auto-breeding, allowing for more frequent harvesting (Dubey et al., 2024).

Several experimental studies have been conducted on the polyculture of mola and other SIS with carps and yielded varying degrees of success (Wahab et al., 2003; Alim et al., 2005; Gupta and Rai 2011). Importantly, the integration of SIS in polyculture has proven to

be a viable and profitable concept, avoiding reductions in cash crops like carp production. This system showcases no dietary overlapping or species competition, emphasizing resource sharing and niche utilization among different species. These benefits highlight the potential of polyculture with SIS as an effective and sustainable approach to maximize productivity without compromising other farming aspects.

Components of Carp-Mola Polyculture:

1. **Species Selection**:
    - **Indian Major Carps** (IMC): These include Rohu (Labeo rohita), Catla (Catla catla), and Mrigal (Cirrhinus mrigala), which are high-value species known for their fast growth and high market demand. and SIS is Mola (Amblypharyngodon mola) is high nutritional value and ecological balance in the aquaculture system.
2. **Polyculture Practices**:
    - **Stocking**: Farmers usually stock both carps and Mola fish in the same pond. The IMCs are stocked at a higher density compared to Mola, which thrives in the same environment but prefers a smaller size.
    - **Feeding management**: The feeding regime involves the provision of supplementary feed for the carp species while Mola fish primarily feed on plankton and natural food present in the water body. Mola helps control the plankton population and keeps the pond ecosystem balanced.
    - **Water management**: Proper water quality management, including maintaining oxygen levels and controlling algae growth, is vital for the success of mixed aquaculture.
3. **Advantages**:
    - Yield enhancement:
    - Higher returns:
    - Sustainability:
4. **Challenges**:
    - Water Quality Maintenance:
    - Seed availability:
    - Disease Management:
5. **Socio-Economic Impact**:
    - The practice of Carp-Mola culture supports the rural livelihoods of fish

farmers in Odisha. It has provided a sustainable source of income and nutrition, especially in economically disadvantaged areas where fish farming is a primary activity.

Conclusion

Carp-mola nutrition-sensitive aquaculture has emerged as an approach to aquaculture development that prioritizes the production and consumption of these nutrient-rich SIS alongside conventional carp polyculture. Including nutrient-rich small indigenous fish, such as mola, into carp polyculture systems offers a promising solution to the challenges of undernutrition and limited income faced by small-scale aquaculture communities in Odisha. By combining the nutritional benefits of mola with conventional carp farming, nutrition sensitive aquaculture could play a pivotal role in providing nutritionally rich food, diversifying production, supporting livelihoods and enhancing food security for aquaculture-dependent communities. This integrated method not only boosts overall fish production but also significantly improves the nutritional security. A major challenge in scaling carp–mola polyculture technology is the reliance on wild broodstock or the lack of sufficient hatchery-reared mola seeds – needs upscaling. Besides the successful development of hatchery-based protocols for the production of mola seed, there is enough scope for new hatchery setup and initiating carp-mola poly culture in Odisha taking advantage of PMKSY, Macha Chasa Pain Nua Pokhari Yojana or Matsya Pokhari Yojana (MPY) by creating new tanks and renovating old ponds.

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