



## SHORT COMMUNICATION

# Restoring Ecological Harmony: The Transition From African Magur to Indigenous Fish Farming in Kheyadaha Wetland, India

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## Abstract

The Kheyadaha Wetland, located in the eastern suburbs of Kolkata, West Bengal, India, known for its rich biodiversity, has faced severe threats from invasive alien fish species (IAFS) such as *Clarias gariepinus*, disrupting the ecosystem and impacting local livelihoods. A comprehensive survey from April 2022 to September 2023 identified ten main IAFS, highlighting their detrimental effects on native species through competition and predation. This study addressed these challenges by promoting sustainable aquaculture practices, transitioning farmers from cultivating invasive species to indigenous fish like Indian major carps. The project incorporated low-cost fish feed production, value-added products, and market linkages, significantly increasing farmers' annual income. Community engagement through training, awareness programs, and capacity-building initiatives fostered a shift towards indigenous species cultivation, enhancing biodiversity conservation and economic resilience. The project's success underscores the importance of interdisciplinary collaborations and evidence-based policy formulation in invasive species management. By empowering local communities and promoting sustainable practices, the project serves as a model for effective biodiversity conservation and sustainable livelihoods in wetland ecosystems. Continued investment in such initiatives is crucial for safeguarding ecological integrity and economic sustainability, ensuring long-term resilience and environmental harmony in wetland regions.

**Keywords:** Kheyadaha Wetland, invasive alien fish species, indigenous fish conservation, sustainable aquaculture, *Clarias gariepinus*, *Heteropneustes fossilis*

## Introduction

The Kheyadaha Wetland, located in the eastern suburbs of Kolkata, West Bengal, India, celebrated for its rich biodiversity (EKWMA, 2021), has encountered significant threats from invasive alien fish species (IAFS), notably *Clarias gariepinus*, commonly known as the African magur. Native to Africa's freshwater environments, these fishes were highly adaptable, thriving in various water conditions. With its elongated body and sharp teeth, it is a formidable predator that feeds on insects, crustaceans, and smaller fish. These invasive species have disrupted the delicate ecological balance, endangering indigenous aquatic species and affecting the livelihoods of local fish farmers (Gul et al., 2020).

To facilitate aquaculture, farmers in wetlands often cultivate invasive species like African catfish, tilapia, and pacu fish due to their rapid growth, ability to survive in low oxygen conditions, and high fecundity, making them cost-effective to produce (Sandilyan et al., 2018). In the Kheyadaha Wetland ecosystem, ten primary invasive alien fish species were identified, including alligator gar, red bellied pacu, croaking gourami, Nile tilapia, and vermiculated sailfin catfish, in addition to *Clarias gariepinus*. These species were introduced either through aquaculture practices or the ornamental fish trade (Joshi et al., 2021). Detailed documentation of their breeding seasons, egg sizes, and fecundity provided insights into their reproductive dynamics and ecological impact.

Awareness-raising and training programs (Yeasmin et al., 2013) were organised, specifically targeting local fish farmers. By educating farmers about the threats posed by invasive species and the benefits of indigenous fish farming practices, the initiatives empowered them to make informed decisions regarding their aquaculture operations (Hasan et al., 2020). Additionally, value addition techniques were introduced to improve the marketability of indigenous fish species (Prakasan, 2022), encouraging farmers to move away from cultivating invasive species and effectively eradicate IAFS from the wetland (Haubrock et al., 2018). The efforts in Kheyadaha Wetland have significantly contributed to restoring ecosystem balance and promoting sustainable livelihoods (Aklakur, 2022). By fostering community resilience and ecological stewardship, the project serves as an exemplary model for managing invasive alien fish species and conserving biodiversity in wetland ecosystems. As we navigate the complexities of environmental sustainability, continued collaboration and investment in such initiatives are crucial to safeguarding our natural heritage for future generations.

## Materials and Methods

### Ethical approval

Field sampling involved non-invasive morphometric measurements of fish from natural water bodies and examination of specimens already dead and purchased from local fishermen. No experimental manipulation or laboratory-based animal experimentation was performed. Therefore, formal approval from an Institutional Animal Care and Use Committee (IACUC) was not required. The socio-economic survey involved voluntary participation of adult respondents. Prior informed verbal consent was obtained from all participants, and no sensitive personal data were collected.

### Survey, sampling, and analytical methods

A survey was conducted from April 2022 to March 2023 in East Kolkata Wetland (EKW). The Kheyadaha Wetlands were visited and several fish farmers were interviewed and fish samples were collected. The collected samples were preserved in 4 % formalin for further analysis.

For this study, a comprehensive assessment of invasive alien fish species (IAFS) and their impact on the East Kolkata Wetland (EKW) ecosystem was conducted using a multi-faceted approach. Field surveys were conducted across diverse aquatic habitats within the EKW, covering fish ponds, water bodies, and sewage-fed fisheries. Systematic sampling was carried out using a combination of gill nets, cast nets, and traps to capture a representative sample of fish species. Specimens were identified on-

site, and relevant morphometric measurements including total length, standard length, body depth, body weight, head length, and mouth size were recorded. To determine the genetic identity of collected specimens and confirm their invasive status, morphological identification was performed. Abundance and distribution patterns of IAFS were assessed spatially and temporally based on the collected data. Concurrently, ecological impact assessments were conducted, focusing on potential effects on native aquatic fauna and broader ecosystem health.

The data obtained from these methodologies provide a comprehensive understanding of the invasive alien fish species in the EKW, their population dynamics, and the potential implications for the overall wetland ecosystem. The integrated approach allows for a holistic evaluation that forms the basis for informed conservation and management strategies.

## Results and Discussion

### Invasive alien fish diversity in the Kheyadaha Wetland

The comprehensive survey conducted in Kheyadaha Wetland provides valuable insights into the presence and ecological impact of Invasive Alien Fish Species (IAFS) in the region. The survey identified several invasive alien fish species (IAFS), including alligator gar (*Atractosteus spatula*), red-bellied pacu (*Piaractus brachipomus*), croaking gourami (*Trichopsis vittata*), Nile tilapia (*Oreochromis niloticus* and *O. mossambicus*), vermiculated sailfin catfish (*Pterygoplichthys disjunctivus*), and African catfish (*Clarias gariepinus*) (Table 1) which have established themselves in the wetland ecosystem.

These IAFS, often introduced inadvertently through aquaculture practices and the ornamental fish trade, pose a significant threat to the native aquatic fauna and the ecological balance of the wetland. *Trichopsis vittata* is identified as a first report from East Kolkata Wetland, emphasising the need for heightened awareness and management strategies to mitigate the spread of invasive species. The breeding seasons of these IAFS coincide with those of indigenous species in Kheyadaha Wetland, posing a risk of competition for vital resources such as food, habitat, and breeding grounds (Atique & An, 2022). Moreover, the high fecundity of these species, coupled with their similar dietary preferences, exacerbates the risk of food competition and displacement of less competitive native species. The dietary analysis reveals overlapping food preferences among the IAFS, further underscoring the potential for resource competition and ecosystem disruption.

The ecological consequences of IAFS presence extend beyond resource competition to include predation on native fish species, hybridisation, disease

Table 1. List of invasive alien fishes identified from Kheyadaha Wetland, India.

Common name	Scientific name	Family	Native region / Country	Number obtained during survey
Alligator gar	<i>Atractosteus spatula</i>	Lepisosteidae	North America	12
Red-bellied pacu	<i>Piaractus brachypomus</i>	Serrasalminidae	Amazon Basin, tropical South America	38
Croaking gourami	<i>Trichopsis vittata</i>	Osphronemidae	Java, Borneo, Sumatra, Peninsular Malaysia, Thailand, and Mekong Basin (Cambodia, Laos, Vietnam)	42
Nile tilapia	<i>Oreochromis niloticus</i>	Cichlidae	Northern Africa	58
Vermiculated sailfin catfish	<i>Pterygoplichthys disjunctivus</i>	Loricariidae	South America	30
African sharp-tooth catfish	<i>Clarias gariepinus</i>	Clariidae	Africa and Middle East	28
Silver carp	<i>Hypophthalmichthys molitrix</i>	Cyprinidae	China and eastern Siberia	10
Bighead carp	<i>Hypophthalmichthys nobilis</i>	Cyprinidae	East Asia	23
Grass carp	<i>Ctenopharyngodon idella</i>	Cyprinidae	Northern Vietnam	17
Striped catfish	<i>Pangasianodon hypophthalmus</i>	Pangasiidae	Southeast Asia; Mekong, Chao Phraya, and Maeklong rivers	30
Total	10 species	8 families		288

transmission, and habitat disruption. Predatory behaviour, especially targeting native fish eggs and young, can lead to declines in native fish populations and loss of biodiversity. Moreover, hybridisation with invasive species poses a threat to the genetic diversity and adaptation of native fish populations, potentially compromising their long-term survival and resilience. Effective management strategies are imperative to mitigate the adverse effects of IAFS and safeguard native fish populations and their habitats.

### DST-SEED project activities in Kheyadaha Wetland

The DST-SEED project in Kheyadaha Wetland exemplifies a holistic approach to invasive fish species management, integrating scientific research, community engagement, and sustainable aquaculture practices. The multifaceted initiatives undertaken by the project in Kheyadaha Wetland reflect a concerted effort to address various challenges and opportunities in aquaculture and environmental conservation. Through the implementation of low-cost fish feed production programs, the project has empowered local fish farmers with the knowledge and skills necessary to reduce dependency on commercial feed suppliers (Gabriel et al., 2007).

By utilising locally available resources and adopting simple production methods, farmers can minimise production expenses while ensuring the nutritional adequacy of fish feeds. The production of value-added fish products, such as African catfish pickles, represents a significant opportunity for income generation and economic diversification among local communities in Kheyadaha Wetland. Species such as African catfish (*Clarias gariepinus*), inadvertently

introduced through aquaculture and trade, threaten native fauna and ecosystem balance for many years. Through the project's interventions and awareness programs, local fish farmers transitioned from cultivating IAFS to indigenous species like Indian major carps (Cyprinidae) and ornamental fish like singhi (*Heteropneustes fossilis*) and indigenous magur (*Clarias magur*). This shift not only promotes biodiversity conservation but also enhances profitability for farmers, emphasising the success of community engagement and sustainable aquaculture practices. Through comprehensive training programs and capacity-building initiatives, the project has equipped fish farmers with the necessary skills to capitalise on market opportunities and enhance the value of their aquaculture products.

By promoting value addition and efficient resource utilisation, the project not only commands higher pricing for fish products but also contributes to waste reduction and environmental sustainability. Furthermore, the establishment of cluster rearing units and the facilitation of market linkages by the project have created conducive environments for knowledge sharing, collaboration, and economic empowerment among fish farmers in Kheyadaha Wetland. By fostering a supportive ecosystem where farmers can exchange resources, ideas, and best practices, the project enhances the overall efficiency and resilience of aquaculture enterprises. Moreover, by assisting farmers in marketing their products to diverse consumer segments, including those interested in ornamental fish and indigenous catfish, the project promotes market diversification and economic resilience.

The community engagement efforts of the project,

particularly in water quality assessment and scientific fish farming techniques, underscore the importance of grassroots involvement in environmental conservation and sustainable development. Through participatory workshops, training sessions, and knowledge exchange platforms, the project fosters a culture of environmental awareness and civic responsibility among villagers, empowering them to actively contribute to the preservation of wetland habitats and ecosystem integrity. By leveraging interdisciplinary collaborations and technological innovations, the project sets a precedent for evidence-based policy formulation and informed decision-making in aquaculture management and environmental stewardship.

### Economics of invasive alien fish culture

In past years, a considerable number of fish farmers in Kheyadaha Wetland were engaged in the culture of African magur, also known as *Clarias gariepinus*. This practice yielded them an annual profit of INR2,10,000 (USD2,520) per farmer on average. However, with the intervention of the Project, these farmers transitioned to indigenous fish farming methods, which resulted in a noteworthy increase in their annual income. A number of 250 fish farmers who were previously cultivating exotic fishes, after transitioning to indigenous fish farming, their annual income doubled to INR5,20,000 (USD6,240) per farmer on average. This transformation not only improved the economic status of the farmers but also enhanced the sustainability of aquaculture practices in the Kheyadaha Wetland. To delve deeper into the impact of this transition, it is essential to consider the gender dynamics within the fish farming community. In Kheyadaha Wetland, both men (200) and women (70) actively participate in aquaculture activities. The Project has been instrumental in empowering both genders to adopt sustainable indigenous fish farming practices, thereby contributing to gender equality and economic empowerment (Table 2).

Table 2. The income enhancement recorded after the transition reflects the financial sustainability and inclusiveness of indigenous fish farming systems.

Gender	Annual income before INR lakh year <sup>-1</sup>	Annual income after INR lakh year <sup>-1</sup>
Male	2.1 ± 0.23	5.2 ± 0.14
Female	1.1 ± 0.22	3.1 ± 0.13

USD1.0 = INR83.33

Both male and female fish farmers experienced a two-to-three-fold increase in their annual income following the transition to indigenous fish farming (Table 2). This increase not only reflects the economic benefits of sustainable aquaculture practices but also highlights the inclusive nature of the Project.

### Invasive alien fish species awareness program in the Kheyadaha Wetland

The invasive alien fish species (IAFS) challenge in Kheyadaha Wetland prompted the project to launch a targeted awareness program. Initial surveys and farmer interviews highlighted a heavy reliance on IAFS for aquaculture, posing threats to native biodiversity. Through extensive outreach and training, the project successfully encouraged a shift towards indigenous and ornamental fish species cultivation. This strategic transition not only mitigates ecological risks but also enhances biodiversity and aligns with Ramsar site conservation goals. The intervention instigated a paradigm shift in aquaculture management, diversifying species cultured and reducing ecological footprints. Farmers, now cultivating indigenous *Clarias batrachus* and *Heteropneustes fossilis* alongside ornamental species, tap into new market opportunities, boosting economic resilience. Furthermore, the cultivation of indigenous fish contributes to biodiversity preservation and ecosystem integrity. The Project's success underscores the significance of community engagement, scientific research, and collaborative conservation efforts. By empowering local communities with knowledge and resources, the project fosters stewardship and ownership over wetland resources, ensuring long-term sustainability and resilience. Continued monitoring, capacity-building, and stakeholder partnerships are vital for effective invasive species management and biodiversity conservation in Kheyadaha Wetland and beyond.

### Strategies applied to regulate the IAFS farming in Kheyadaha Wetland

Farmers were encouraged to transition from African magur farming to indigenous fish species through the provision of incentives and technical support for breeding and cultivation, including the supply of indigenous fish seed tanks and essential aquaculture equipment. Educational workshops and training programs were conducted to raise awareness about the ecological impacts of African magur farming and to highlight the ecological and economic benefits of indigenous fish culture. Demonstration farms were established to showcase successful indigenous fish farming practices, offering farmers practical exposure and confidence to adopt alternative culture systems. In addition, monthly farm visits were carried out using a mobile unit to assess water quality and fish health, providing continuous technical assistance, guidance on feeding, breeding, and disease management, and ensuring sustained support throughout the transition process.

Regulatory measures and guidelines were implemented to restrict the farming of African magur in Kheyadaha Wetland, encouraging farmers to adopt alternative indigenous fish species with support from government officials and non-governmental

organisations. Market linkages were strengthened and local consumption of indigenous fish species was promoted to create stable demand and economic incentives for farmers to shift away from African magur farming. Concurrently, investments were made in research to develop improved breeding techniques, cost-effective feed formulations, and efficient farming methods for indigenous species, enhancing their productivity and profitability. Capacity-building programs and public awareness campaigns were also conducted to improve farmers' technical skills and knowledge, thereby empowering them to successfully transition to sustainable indigenous fish farming practices.

The present results clearly demonstrate that the Kheyadaha Wetland is experiencing a high level of invasion by alien fish species originating from multiple geographic regions. The dominance of species such as *Oreochromis niloticus*, *Trichopsis vittata*, *Piaractus brachypomus* and *Clarias gariepinus* reflects the strong influence of aquaculture practices and the ornamental fish trade in shaping the fish community structure of the wetland. Similar patterns of invasive alien fish establishment have been reported from other tropical wetlands, where favourable environmental conditions and weak regulatory enforcement allow non-native species to spread rapidly (Olagoke & Oyeboade, 2023). The first record of *Trichopsis vittata* from the East Kolkata Wetlands is of particular concern, as it indicates an ongoing and possibly underestimated invasion process. Ornamental fish releases are recognised as one of the major pathways for freshwater fish invasions worldwide (Sandilyan, 2016). Once established, such species are difficult to eradicate and may permanently alter local biodiversity.

The overlap in breeding seasons between invasive and indigenous fish species observed in the present study increases the risk of competition for spawning grounds and nursery habitats, which can negatively affect the recruitment success of native fishes (Azzurro et al., 2024). High fecundity, rapid growth, and broad feeding habits provide invasive alien fish species with a competitive advantage over indigenous species. The observed dietary overlap among IAFS suggests intense competition for food resources, which can lead to reduced growth, survival, and population decline of native fish species. Similar ecological impacts, including reduced native fish abundance and altered trophic structure, have been documented in other invaded freshwater ecosystems (Garcia & Vendel, 2016). Beyond competition, predation by invasive species such as *Clarias gariepinus* and *Atractosteus spatula* poses a serious threat to native fish eggs, larvae, and juveniles. Such predatory pressure can result in long-term declines in indigenous fish populations and overall biodiversity loss (Nõomaa et al., 2022). Additionally, the risk of disease transmission and genetic erosion through hybridisation further compromises the resilience of native fish communities.

The results also highlight the effectiveness of community-based interventions implemented through the DST-SEED project. The transition from invasive alien fish culture to indigenous fish farming not only reduced ecological pressure on the wetland but also improved farmers' incomes and livelihood security. Similar studies have shown that promoting native species-based aquaculture can simultaneously support conservation goals and rural development (Kim et al, 2022). Overall, the findings emphasise that controlling invasive alien fish species in the Kheyadaha Wetland requires an integrated approach combining scientific monitoring, farmer awareness, regulatory support, and economic incentives. Continued stakeholder participation and long-term monitoring are essential to prevent new introductions and ensure the sustainability of both wetland biodiversity and local livelihoods.

## Conclusion

The DST-SEED project has emerged as a pivotal intervention in addressing the proliferation of invasive alien fish species within Kheyadaha Wetland. The transition from African magur *Clarias gariepinus* to indigenous fish farming marks a significant stride towards sustainable development in the region. Through concerted collaborative efforts and targeted interventions, the Project has empowered fish farmers to adopt innovative practices, thereby enhancing both their livelihoods and the conservation of aquatic ecosystems. Ongoing support for initiatives promoting sustainable aquaculture is imperative for fostering community resilience and environmental harmony. By equipping local communities with knowledge and resources, the project has not only contributed to the preservation of indigenous ecosystems but also bolstered the resilience of fish farming enterprises against environmental challenges. Continued investment in similar initiatives is crucial for safeguarding the ecological integrity and economic sustainability of wetland ecosystems. The success of the project underscores the pivotal role of scientific interventions in enhancing livelihoods and promoting environmental sustainability. Through capacity-building efforts and resource provision, the project has catalysed a positive transformation in the aquaculture sector, leading to improved economic outcomes and ecosystem resilience. These findings emphasise the importance of community-centred approaches and interdisciplinary collaborations in achieving long-term ecological and socioeconomic sustainability in wetland ecosystems.

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**Author contributions:** Swagat Ghosh: Conceptualisation, methodology, investigation, data curation, formal analysis, writing – original draft, supervision. Anju P.: Investigation, data curation, validation, writing – review and editing, fieldwork and sample collection. Rajib Pattanayak: Methodology, resources, project administration, writing – review and editing.

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