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Technical Report

Sustaining Circular Livelihoods: A Qualitative Analysis of the Wastewater Aquaculture Value Chain in India

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Contents

1.Introduction

Wetlands are among the most productive ecosystems on Earth, functioning as vital interfaces between terrestrial and aquatic environments. They provide an array of ecosystem services, including flood regulation, groundwater recharge, water purification, carbon sequestration, and biodiversity conservation (Ramsar Convention on Wetlands, 2018). Globally, they support millions of livelihoods through agriculture, fisheries, and tourism while acting as critical buffers against climate change impacts (Convention on Wetlands, 2025; Ramsar Convention on Wetlands, 2018). Despite their immense ecological and socio-economic value, wetlands continue to face widespread degradation. Since the 1970s, land-use change has caused the loss of millions of hectares of wetlands globally. In response to these growing threats, the Ramsar Convention on Wetlands (1971) created the first and only international treaty dedicated to the conservation and sustainable use of wetlands. The Convention emphasizes the "wise use" of wetlands—balancing ecological preservation with human well-being—and requires member countries to identify and designate sites of international importance for inclusion in the Ramsar List of Wetlands of International Importance. Currently, 172 countries are contracting parties, collectively conserving 2,546 Ramsar sites covering over 257 million hectares worldwide (Ramsar Convention on Wetlands, 2025).

In India, wetlands play a critical role in sustaining biodiversity, supporting agriculture and fisheries, and regulating hydrological cycles. They are deeply intertwined with local livelihoods and food systems, particularly in peri-urban and rural landscapes. India is home to more than 757,060 wetlands, covering approximately 15 million hectares (Ministry of Environment, Forest and Climate Change, 2025). However, wetlands in India remain among the most threatened ecosystems, facing severe stress from loss of vegetation, salinization, excessive inundation, water pollution, and rapid urbanization (Chakraborty et al., 2023; Ghosh & Das, 2020; O'Neill, 2019; P. K. Yadav et al., 2024). Recognizing these challenges, India became a contracting party to the Ramsar Convention in 1981, and as of 2025, has designated 94 Ramsar sites covering 1.3 million hectares. The country now ranks first in South Asia and third in Asia in terms of the number of designated Ramsar sites.

Against this backdrop, this study undertakes a case study of the East Kolkata Wetlands (EKW)—a Ramsar site and the world's largest functioning wastewater-fed aquaculture system. It spans approximately 12,500 hectares on the eastern periphery of Kolkata (West Bengal), and it demonstrates a unique model of circular resource management through the integration of ecological processes with rural and urban livelihood opportunities.

Multiple studies on EKW document the rich wetland biodiversity and habitat value, and they show how urban wastewater is naturally treated and reused to sustain aquaculture and agriculture (Kumar et al., 2018; Nadella & Sen, 2021; Suresh et al., 2019). The system is closely connected to local livelihoods, with fish farmers and smallholder cultivators depending on it for both income and sustenance. Research highlights how diverse wetland activities, including fishing, vegetable cultivation, and composting, collectively form integrated livelihood strategies for the communities living around the wetlands (Ditzler et al., 2018; Wavhal et al., 2025). Studies have highlighted that this system supports about 150,000 residents, including around 20,000 economically vulnerable families whose livelihoods depend directly or indirectly on its wastewater recycling system (EKWMA & WISA, 2021). Several studies have further highlighted EKWs' crucial role in delivering a range of ecosystem services, including wastewater recycling, nutrient recovery, and flood regulation, effectively functioning as a vast natural treatment system. The nutrient-enriched wastewater promotes the proliferation of algae and aquatic vegetation, which serve as feed for approximately seventeen fish species. In addition, the nutrient-laden effluents from the ponds are utilized to irrigate adjacent rice fields, supplying valuable nitrogen and phosphorus to support crop growth (EKWMA & WISA, 2021). Research indicates that each hectare of shallow pond removes approximately 237 kilograms of Biological Oxygen Demand (BOD) daily, making the EKW one of the world's most efficient natural wastewater treatment systems (Ghosh, 2018). The wetlands are estimated to capture more than 60% of the carbon from incoming wastewater, reducing about 3,500 tonnes of CO_2 emissions annually relative to standard sewage treatment, and yielding an annual cost saving of roughly ₹4,680 million (~52.33 million USD) for the city (EKWMA & WISA, 2021; Mukherjee & Bardhan, 2019). Despite its critical ecological and economic functions, research highlights that the total wetland area of the EKW has steadily declined—shrinking by roughly 15% between 1991 and 2001, 4% between 2001 and 2011, and another 3% between 2011 and 2021 (Mondal et al., 2017). Urban expansion, population growth, and land-use change have driven this loss, threatening both ecological sustainability and livelihood security (Mondal et al., 2017). Furthermore, geochemical and contaminant assessments reveal the accumulation of trace metals and industrial pollutants in sediments, water, and aquatic organisms, signaling potential ecological and human health risks that complicate the otherwise productive wetland functions (Avijit & Kamalakannan, 2023; Bera et al., 2022; Kumar et al., 2023). Although the East Kolkata Wetlands (EKW) have been widely studied, important research gaps remain in comprehending and managing this intricate socio-ecological system. Existing research has largely emphasized ecological productivity, biodiversity, wastewater-fed aquaculture, and livelihood or institutional aspects (Ditzler et al., 2018; Kumar et al., 2018; Nadella & Sen, 2021; Wavhal et al., 2025), while others have examined environmental degradation, governance challenges, biophysical processes and contamination risks (Avijit & Kamalakannan, 2023; Bera et al., 2022; Bunting et al., 2010; Roy-Basu et al., 2020; S. Yadav & Goyal, 2022). However, this extensive body of research remains largely disciplinary and fragmented, lacking systematic integration between ecological performance and the social, institutional, and economic dynamics that shape it. Consequently, the existing literature does not offer a coherent analytical framework linking ecosystem functioning

with value creation, stakeholder interactions, and governance mechanisms that sustain the EKW over time. This study seeks to address this critical gap by employing a qualitative aquaculture value chain analysis to holistically explore the interconnections among the ecological, economic, and institutional dimensions of the EKW's wastewater-fed aquaculture system. The approach is distinctive in mapping how value is created, shared, and perceived across different stakeholders such as fishers, cooperative members, transporters, intermediaries, and laborers, within the EKW network. Examining EKW is such a framework that enables us to disentangle valuable insights into how community-managed, wastewater-fed aquaculture systems can operate as sustainable and adaptive socio-ecological models amid growing urban and environmental pressures. By adopting a multi-stakeholder lens, the study contributes to a deeper understanding of how traditional wastewater-fed aquaculture systems can adapt to environmental, urban, and market pressures while maintaining ecological balance and supporting sustainable livelihoods.

This study specifically addresses the following research question: How do different stakeholders within the wastewater aquaculture value chain interact, experience challenges, and perceive opportunities for technological, institutional, and livelihood improvements? To address this question, the study adopts a qualitative research design aimed at capturing the complexity of interactions and the diversity of perspectives among value chain actors. Data was collected through Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) with fishers, cooperative members, transporters, market intermediaries, and laborers. The qualitative data were analyzed using inductive hierarchical coding, allowing key patterns, themes, and sub-themes to emerge organically from stakeholder narratives. This analytical approach provides an understanding of operational processes, institutional dynamics, and adaptive strategies across different stages of the aquaculture value chain. The study pursues the following specific objectives:

1. Map the structure of the wastewater aquaculture value chain and its key stakeholders.
2. Examine stakeholder-specific processes, constraints, and opportunities for improvement.
3. Identify cross-cutting challenges and potential areas for intervention to enhance sustainability and resilience in the wastewater aquaculture sector.

The rest of the report is organized as follows: Section 2 outlines the study area and research methodology. Section 3 presents the qualitative findings and is divided into three parts: first, a mapping of the aquaculture value chain; second, a stakeholder-specific analysis highlighting key themes and sub-themes; and third, a comparative analysis of value chain actors, emphasizing cross-cutting challenges and corresponding recommendations. Section 4 concludes the report with a summary of key insights and implications for sustainable aquaculture management in the East Kolkata Wetlands.

2. Study area and methodology

2.1 Study area

The East Kolkata Wetlands (EKW), located on the eastern periphery of Kolkata, cover an area of approximately 12,500 hectares. EKW comprises a mosaic of shallow fishponds, paddy fields, vegetable farms, and human settlements. Historically, it forms a part of a brackish water continuum that connects the Gangetic Delta with the Bay of Bengal and the Sundarbans (EKWMA & WISA, 2021). It is often described as the "Kidney of Kolkata" for its natural ability to treat the city's wastewater. EKW encompasses 37 mouzas (revenue villages) spread within the districts of Kolkata, North and South 24 Parganas. Unlike most wetlands, EKW lacks a natural catchment area, relying entirely on wastewater inflows for its hydrological functioning. An intricate network of manually dug canals reuses around 900 million litres of pre-settled sewage from Kolkata every day for aquaculture and irrigation, directing it into the wetlands (EKWMA & WISA, 2021).

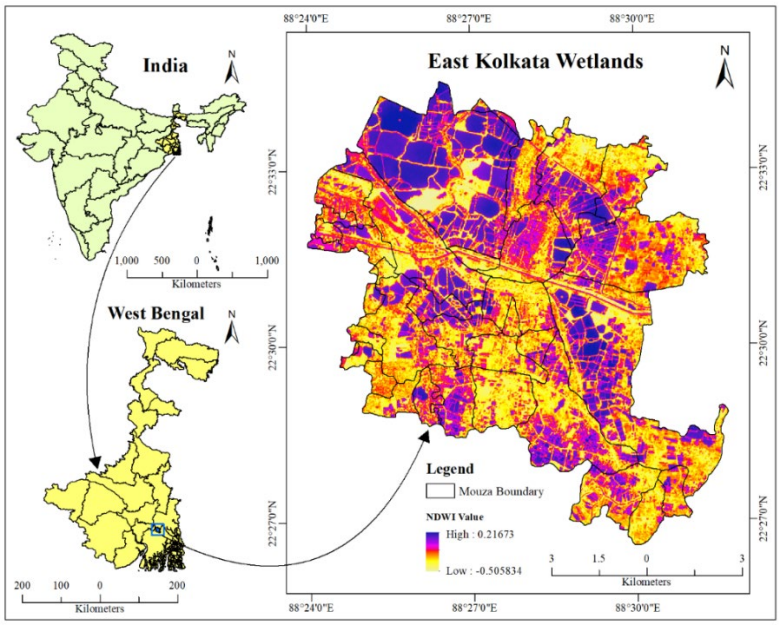


Figure 1**:** Study area of the East Kolkata Wetlands highlighting the fish ponds.. Note: Water bodies are shown based on the Normalized Difference Water Index (NDWI). Source: Authors

2.2 Methodology

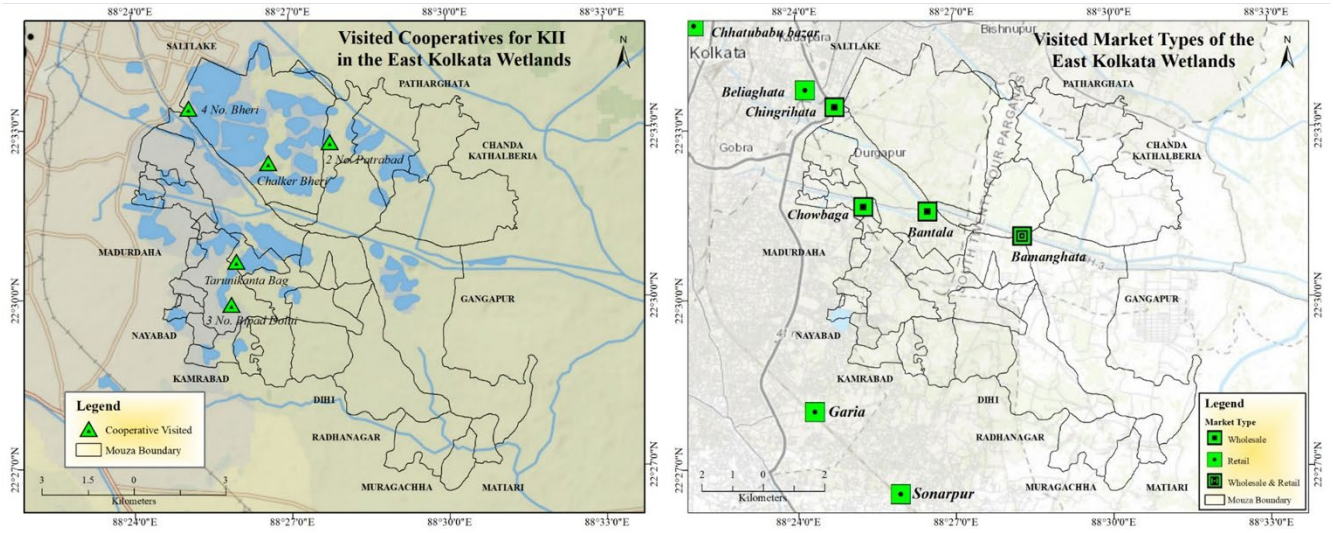
The qualitative study was designed to gain an in-depth understanding of existing aquaculture practices, identify key challenges encountered by stakeholders, assess their awareness and adoption of technological and managerial innovations, examine the barriers that constrain such adoption, and document stakeholder-driven recommendations for strengthening and improving the overall efficiency and sustainability of the fish value chain.

3.2.1 Key Informant Interviews (KIIs) and Focus Group Discussion (FGDs)

We conducted a qualitative analysis by using data from KIIs and FGDs with various stakeholders in the aquaculture value chain of EKW. A total of 38 KIIs were conducted with stakeholders representing various segments of the fish value chain. Participants included fishers (both owners and leaseholders), office bearers of fish cooperatives, transporters who moved fish from production sites to markets, as well as aggregators, wholesalers, and retailers. To capture diverse governance and management perspectives from functioning cooperatives, KIIs were conducted with cooperative managers and secretaries across both the northern and southern zones, covering sites such as *4 No. Bheri, Chalker Bheri, 2 No. Patrabad, 3 No. Bipad Dolui, and Tarunikanta Bag* (Figure 2, Panel A). Further, to map the market and distribution landscape and examine market outcomes, KIIs were also conducted with fish intermediaries across key trading hubs, including *Chhatu Babur Bazar, Bamanghata, Bantala, Chingrihata, Beliaghata, Chowbaga, Sonarpur,* and *Garia* (Figure 2, Panel B). These prominent fish markets were visited to capture the spatial spread of aquaculture trade within the wetlands and adjacent urban centers. Additionally, FGDs were held with *Jeoni* fish laborers to explore their roles, working conditions, and challenges within the aquaculture system. Participants in all interviews and discussions were carefully selected based on their experience and engagement in the aquaculture sector, ensuring informed and context-rich insights. The KIIs and FGD were conducted using semi-structured guides, allowing for flexibility to probe emerging themes while maintaining consistency across key areas of inquiry.

Table 1. Number of Key Informant Interviews and Focus Group Discussions conducted across different stakeholders of the wastewater aquaculture value chain in East Kolkata Wetlands.

Discussion Type	Stakeholder	No. of KIIs and FGDs
Key Informant Interviews (KIIs)	Fishers (Owner/Leaseholder)	4
	Cooperative Office bearers	5
	Transporter (Aquaculture)	3
	Aggregators	8
	Wholesaler (Fish)	9
	Retailer (Fish)	9
Focus Group Discussion (FGDs)	Fish laborers (*Jeoni*)	1 (with 7 participants)



Note:

Figure 2. Location for where Key informant interviews were held. Left: The locations of cooperatives visited. Right: The locations of markets visited for KIIs with market intermediaries. Source: Authors

3.2.2 Coding strategy

All interviews were transcribed and imported into MAXQDA(Mixed Methods Analysis, X-plorer Qualitative Data Analysis), a qualitative data analysis software, for systematic coding and analysis. The software facilitated systematic thematic coding, categorization, and content analysis, allowing for triangulation across actor groups and market segments. We employed an inductive hierarchical coding approach, allowing codes to emerge directly from the interview data. In this approach, initial open coding captured recurring issues and concepts, followed by axial coding to cluster codes under broader themes. Finally, selective coding refined these into core categories aligned with the study's objective. Thus, we have broad parent codes representing major thematic areas followed by sub-codes capturing more specific aspects of each theme. The hierarchical organization of codes facilitated the identification of patterns and relationships, which were subsequently grouped into overarching themes specific to each stakeholder group.

3.2.3 Analytical framework

The analytical framework took a three-pronged approach, combining value chain mapping, actor segmentation, and comparative analysis. First, the process began with a value chain mapping exercise, designed to identify key actors, their interconnections, and the directional flow of fish, inputs, labor, and finance from production to consumption. This mapping provided a spatial and functional overview of the EKW system, locating major production clusters, cooperative networks, transportation routes, wholesale markets, and retail nodes. Second, the study applied a segmented analytical framework that categorized the value chain into three interlinked tiers:

- The upstream segment, consisting of fish producers (owners and leaseholders) and cooperative societies, focused on governance, production practices, and ecological management.
- The midstream segment, comprising fish laborers (*Jeoni*) and transporters, captured the operational and logistical dimensions of harvesting, handling, and distribution.
- The downstream segment, including market intermediaries such as aggregators, wholesalers, and retailers, focused on market operations, price formation, and consumer linkages.

This segmentation facilitated actor-specific analyses while maintaining an integrated perspective on how value, risk, and benefit are distributed across the chain. Finally, we undertook a comparative actor analysis to synthesize the findings across actor categories to identify common challenges and structural constraints affecting value retention and livelihood stability. This rigorous approach of integrating value chain mapping, actor-based segmentation, comparative analysis, and MAXQDA-supported coding enabled us to understand the socio-economic, ecological, and institutional dynamics shaping the EKW aquaculture value chain.

3. Qualitative Findings

3.1 Mapping of Aquaculture Value Chain in EKW

Based on the mapping exercise of the wastewater aquaculture value chain in EKW, we present Figure 3 to detail the flow of fish from producers in rural areas to consumers in rural, peri-urban, and urban areas. The upstream segment begins with cooperatives, owners, and leaseholders who manage local ponds for fish production using wastewater and supplementary feed. Fish laborers, locally known as *Jeoni*, play a crucial role in fish harvesting, bringing specialized skills in netting and collection. They typically work as casual laborers, hired on demand whenever fish netting activities are required. Once fish are harvested, transporters carry them by cycle or van to wholesale markets (*Arats*), where they are sorted, auctioned, and priced. From there, aggregators (*Paikars*) distribute the fish through various channels — including logistics and redistribution aggregators to large retail and peri-urban markets, retail cum aggregators to urban retail outlets and neighborhoods, and direct delivery to hotels and restaurants. Finally, fish reach consumers through neighborhood markets, where they are cleaned, displayed, and sold fresh. This interconnected chain ensures efficient movement from pond to plate, supporting both livelihoods and urban food supply. Section 3.2 discusses further details of the value chain and its processes.

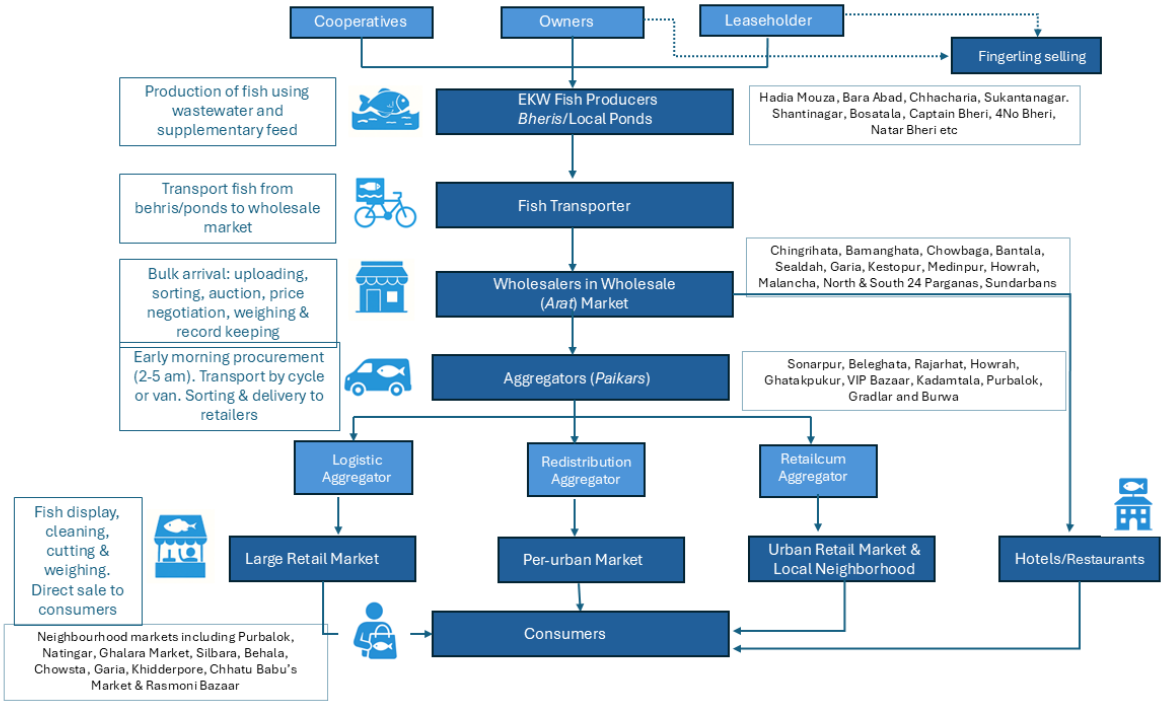


Figure 3. Wastewater Aquaculture value chain in East Kolkata Wetlands Source:Authors.

3.2 Stakeholder analysis

3.2.1 Upstream segment: Fish Producers and Cooperatives

The upstream segment of the aquaculture value chain comprises fishers (both owners and leaseholders) and cooperative societies. These stakeholders play a central role in activities such as pond preparation, water and waste management, fish stocking, feeding, and harvesting. The discussion begins with perspectives from fishers and is followed by insights drawn from KIIs with cooperative representatives.

(i) Fishers (Owners and Leaseholders)

Table 1 provides a summary of the key themes and sub-themes identified for fishers. The following sections will discuss each theme in detail to provide a deeper understanding of the challenges, practices, and dynamics influencing fishers' livelihoods and production systems.

Table 1: Summary of themes and sub-themes from fishers' Key Informant Interviews (KIIs)

Theme	Subthemes
1. Operational Profile of Fish Farmers	i. Ownership, lease tenure, and scale of operation
	ii. Experience and roles
2. Production Practices	i. Aquaculture system and wastewater use
	ii. Stocking practices
	iii. Harvest practice
	iv. Feeding practices
3. Capital, Operational Costs, and Income	i. Capital investment and land costs
	ii. Pond preparation and maintenance costs
	iii. Labor costs and gendered division of work
	iv. Operational inputs, infrastructure, and transportation expenditure
	v. Income sources and profitability
4. Market and Supply Chain Linkages	i. Sale mechanism
	ii. Value addition
5. Awareness, Perceptions, and Adoption of Innovations	i. Exposure to training
	ii. Awareness of new technologies
	iii. Perceived benefits and risks
	iv. Adoption barriers
6. Aquaculture Constraints and Recommendations	i. Wastewater management constraints
	ii. Institutional constraints
	iii. Infrastructure constraints
	iv. Market risks and price volatility

Theme 1: Operational profile of fish farmers

i. **Ownership, lease tenure, and scale of operation:** The study identifies two categories of fishers in EKW – pond owners and leaseholders. Pond owners are those who have inherited land from their families, often holding smaller plots ranging from 0.4 to 2 hectares. Sometimes these ponds are managed in partnership with family members. In contrast, leaseholders operate larger ponds that they rent from private landowners or local cooperatives. The leased ponds are managed either individually or collectively by groups of fishers.

   Lease arrangements were typically short-term, reflecting a high degree of tenure insecurity. Generally, lease agreements lasted between one and three years, but it could also be for a longer lease of up to five years. Even in longer-lease cases, annual renewals were required, leaving fishers without permanent or long-term rights to the land. This uncertainty discouraged long-term investment in pond infrastructure and maintenance. The size of leased holdings among interviewees ranged between 6 and 10 hectares, indicating that lease-based operations tend to be larger than inherited family ponds.

ii. **Experience and roles:** Aquaculture in the EKW is a long-established livelihood, often passed down through generations. Most respondents reported that their families have been engaged in fish culture for several decades, and they themselves had between 15 and 35 years of personal experience in the sector. Decision-making varies by ownership arrangement. Among pond owners, the owner or family head takes independent decisions related to stocking, harvesting, and input procurement. In contrast, members collectively make operational and financial decisions for group-leased ponds, often through informal consultations.

Theme 2: Production practices

i. **Aquaculture system and wastewater use:** Fishers predominantly practice traditional polyculture, cultivating multiple fish species simultaneously within the same pond. Fishers are entirely reliant on wastewater from the canal system as the source of pond water. This wastewater-based system functions as a nature-based solution, providing nutrient-rich water that supports natural food production and reduces dependence on costly commercial feed and chemical fertilizers.

ii. **Stocking practice:** The production cycle typically begins with stocking fish as either fingerlings or spawn[1], depending on the fisher's resource availability. Farmers often prefer fingerlings for faster growth and more predictable survival. On average, farmers stock approximately 8–10 fingerlings per kilogram; however, this may vary with fish species. Some fishers implement multiple stocking practices starting in late March–April, aiming for a rolling harvest that ensures continuous availability of fish for market throughout the year.

iii. **Harvest practice:** On average, fishers undertake two to three harvests per year, with each production cycle lasting approximately three to four months. Fishers usually harvest during the early morning hours, around 2–4 am, because fish are less active and water temperatures are cooler. Within a single cycle, they stagger harvesting instead of doing it all at once. Farmers employ a continuous netting approach over a period of about 10–15 days, enabling them to selectively harvest larger, market-ready fish while leaving smaller individuals to continue growing. Table 2 presents the species of fish harvested in EKW.

Table 2: Fish species prevalent in EKW

Type	Species
Big fish	Rohu, Catla, Mrigal, Bata, Silver Carp, Grass Carp, Black Carp, Common Carp, Freshwater Prawns, Hybrid catfish (Magur)
Small Indigenous Species (SIS)	Punti, Morula (naturally occurring)

iii. **Feeding practice:** Wastewater from the canal system serves as the primary source of nutrition for cultured fish, providing a naturally rich environment that supports the growth of plankton and other microorganisms. However, fishers often supplement this natural feed with additional inputs to maintain fish health, enhance growth, and stabilize water quality. Standard supplementary feeds include hotel or kitchen waste, mustard oil cake, yeast-molasses mixtures, rice bran, probiotics, and naturally occurring zooplankton. During the non-monsoon months, farmers particularly emphasize supplementary feeding because nutrient availability in wastewater is relatively low and natural productivity declines.

Theme 3: Capital and operational costs and income:

i. **Capital investment and land costs:** Aquaculture operations involve significant upfront and recurring costs. The lease cost, averaging ₹15,000–₹20,000 (~ 168-224 USD) per hectare annually, is one of the major expenditures for leaseholders. Land prices for purchase typically range from ₹3 lakh to ₹20 lakh (~3,354-2,2362 USD) per bigha, which translates to ₹18.75 lakh to ₹1.25 crore (~20,964-1,39,762 USD) per hectare. Land located closer to main wastewater canals or within well-connected wetland zones tends to be significantly more expensive, as such plots offer better water circulation and higher productivity potential. In contrast, peripheral or less connected areas are available at relatively lower prices but often require additional investment in water management infrastructure.

ii. **Pond preparation and maintenance costs:** Across both ownership types, annual pond preparation constitutes one of the largest recurring expenses, covering activities such as drying, desilting, soil excavation, embankment repair, installation of bird deterrents, and application of lime or fertilizers. These activities are critical for maintaining water quality, reducing disease risks, and ensuring optimal productivity. The cost and intensity of labor and input materials fluctuate seasonally, often peaking before the first stocking cycle, when ponds are prepared for a new round of production.

iii. **Labour costs and gendered division of work:** Labor costs also form a substantial component of the recurring operational expenses. Fishers engage workers for a range of activities, including pond preparation, feeding, harvesting, cleaning, and transportation. Patterns of labor use vary by ownership type and operational scale. Among pond owners, aquaculture activities are largely managed through family labor, minimizing the need for daily wage workers. However, during peak periods such as pond cleaning or harvesting, owners temporarily hire 8–10 additional workers at a rate of approximately ₹250 (~2.80

[1] Spawn refers to newly hatched fish, which require careful rearing until they reach a marketable size, whereas fingerlings are juvenile fish already grown to a small but robust size, ready to be stocked directly into ponds.

USD) per day, typically for around 10 days per month. In contrast, leaseholders, who operate in larger pond areas, are more dependent on hired labor. They generally employ 15–20 daily wage workers for different operational tasks. Some of these workers remain on informal rosters, receiving payment on a per-task basis rather than through fixed monthly wages.

Labor use in aquaculture is highly gendered and socially stratified. Most physical and technically skilled work, such as netting, pond excavation, or harvesting, is performed by male laborers, while women workers are primarily involved in cleaning, de-weeding, and occasionally feeding fish. Women are typically paid ₹200–₹225 (~2.24-2.52 USD) per day, slightly lower than the ₹250 (~2.80 USD) paid to men, reflecting the persistent gender wage gap and limited participation of women in decision-making or skilled operational roles. Labor supply in the wetlands remains abundant and flexible, with most workers available on a casual, need-based basis. Many of them belong to marginalized communities such as *Adivasi* and Scheduled Caste groups, who rely on such wage labor as a key livelihood source.

iv. **Operational inputs, infrastructure, and transportation expenditure:** Operational costs are significantly influenced by expenditure on fingerlings, supplementary feed, fuel for pumps, and rented equipment such as nets and boats. The quantity and cost of fingerlings depend on the size of the pond and production strategy. For example, for an average pond of 1.6 hectares (about 10 bigha), farmers typically purchase 600–1000 kg of fingerlings per production cycle. In some cases, fishers also purchase spawn from external sources, with prices varying seasonally between ₹1,200 (~13.42 USD) and ₹2,000 (~22.36) per *bati*[2]. Large ponds may require 30–40 *batis* of spawn per cycle. Fingerlings and spawn are sometimes obtained on credit from local suppliers, with payments settled after harvest, reflecting the cash-flow management strategies adopted by fishers. Furthermore, fishers use one 40 kg bag of supplementary feed every 2–3 days, at a cost of approximately ₹1,800 (~20.13 USD) per bag, resulting in supplementary feed expenditures of ₹20,000–₹25,000 (~223.62-279.52 USD) per cycle for ponds of this size. Renting infrastructure is another important operational expenditure. This includes renting nets, boats, and water pumps. Small fishers typically pay around ₹200–₹300 (~2.24-3.35 USD) per production cycle for the combined activities of netting, harvesting, and transporting fish to wholesale markets, which can significantly affect overall profitability, especially for small-scale operators. In contrast, larger or more established fishers often own boats, vehicles, and small on-site huts, enabling more efficient pond management and reducing reliance on external rentals. Small leaseholders, however, usually operate with temporary shelters and shared tools, making them more vulnerable to delays or operational bottlenecks. Water management, a critical component in the wastewater-based polyculture system, relies on both electric and diesel-powered pumps to regulate inflows, circulation, and water levels in ponds. Table 3 summarizes the capital and operational costs for wastewater aquaculture for each production cycle for a 10-bigha pond. Excluding the capital cost of land purchase and the commission fees paid to wholesalers, the total operational expenditure for a single production cycle in a 1.6-hectare pond (equivalent to 10 bigha) is estimated to range between ₹1.63 lakh (~1,822 USD) and ₹2.32 lakh (~2,594 USD) (Table 3). Among these recurring expenses, the most significant cost components are pond preparation and maintenance, labor wages, and stocking materials, including fingerlings and spawn. Pond preparation, however, is an annual cost and is not recurring in each production cycle. These costs reflect the intensive labor and input requirements of wastewater-based polyculture and highlight the financial pressures faced by fishers in managing operational efficiency and productivity.

Table 3: Capital and operational costs of aquaculture in EKW for one production cycle for a 1.6 hectare pond.

Cost Component	Details	Approximate Cost (₹ per 10 bigha pond)	Assumptions
Land / Lease	Lease cost per ha/year	15,000 – 20,000 (~168-224 USD)	Average for 1.6 ha: ₹24,000 – 32,000 (~268-358 USD) per year
Land Purchase	Price per ha (1 bigha = 0.16 ha)	18.75 lakh – 1.25 crore (~20,964-1,39,762 USD)	Only relevant for owners; not included in cycle cost for leaseholders
Pond Preparation & Maintenance	Drying, desilting, soil excavation, embankment repair, bird deterrents, lime/fertilizer	45,000 – 50,000 (~ 503-559 USD) per production cycle	Varies by pond size and condition; major recurring cost
Labor – Male	Daily wage, 8–20 workers, ~10 days	20,000 – 50,000 (~224-559 USD) per production cycle	Assumes 8–20 male workers hired for ~10 days per cycle at ₹250/day (~2.8 USD/day);

[2] Bati is a traditional unit of volume of spawn in EKW – a standard 'bati' of 160 ml volume hold about 80,000 carp spawn. https://www.rakvknimpith.org.in/fishery.htm

Cost Component	Details	Approximate Cost (₹ per 10 bigha pond)	Assumptions
			leaseholders hire more, owners use family labor.
Labor – Female	Daily wage, cleaning/de-weeding/feeding	4,000 –13,500 per production cycle	Slightly lower wage; limited decision-making role. Female workers, earning about ₹200–₹225 (~2.24-2.52 USD) per day, are typically engaged for 10–15 days per 4-month cycle, with 2–4 women hired per 1.6 ha pond.
Fingerlings	600–1000 kg per 1.6 ha	18,000 – 30,000 per production cycle	Sometimes purchased on credit; depends on species and season
Spawn	30–40 batis per production cycle, ₹1,200–2,000/bati	36,000 – 80,000	Seasonal variation; optional depending on stocking method
Supplementary Feed	Mustard oil cake, rice bran, yeast, probiotics, etc.	20,000 – 25,000	Mainly used during non-monsoon months; 1 bag/2–3 days at ₹1,800/bag (~20.13 USD)
Equipment Rental	Nets, boats, pumps	200 – 300 per cycle	Cost higher if multiple cycles per year; owners of larger ponds may own equipment
Energy	Diesel/electric pumps for water management	5,400 – 13,500	Varies by pump type and duration of use. Estimated assuming ~20–25 pumping sessions per 3–4-month cycle; pumps run 3–4 hrs/session using 1–1.5 ltr diesel/hr at ₹90/ltr (~1 USD/ltr)
Transport	Fish to wholesale/market	Included in equipment rental	Paid to net/transport teams; may vary by distance
Commission to Wholesalers (Aratdar)	Service charge deducted at sale	3-4% of total sales revenue	Usually deducted at source; covers handling, auctioning & sale facilitation

v. **Income sources and profitability:** Income from fish sales varies by species, size, and market demand. Most fishers do not keep detailed species-wise accounts. Harvest is usually mixed (see Table 2 for a list of species). Fishers typically earn income from three to four production cycles per year, but returns fluctuate due to price volatility, mortality rates, and market deductions by middlemen. Table 4 presents the average prices of different species of fish in markets around EKW.

Table 4: Prices of fish by species

Species	Price (Rs per kg)
Rohu	110-160 (~1.23-1.8 USD)
Catla	160-180 (~1.8-2.01 USD)
Silver Carp	90-100 (~1.01-1.12 USD)
Bata	130-190 (~1.45-2.12 USD)
Tilapia	90 (~1.01 USD)
Large Putni	400 (~4.5 USD)
Hotel chhaara	80-100 (~0.89-1.12 USD)
Mrigal	90-110 (~1.01-1.23 USD)

Theme 3: Market and supply-chain linkages

i. **Sale mechanism:** Fish in EKW is harvested approximately four days a week. The primary buyers are wholesalers (*aratdars*) or aggregators (*paikars*), who function as intermediaries between fishers and the wholesale market or retail market. Typically, wholesalers send their own laborers to the ponds to net the fish, weigh them in containers, and transport them to wholesale markets using cycle vans or other vehicles. Fishers are provided with a paper slip documenting details of the quantity harvested and wholesaler

information. Aggregators purchase fish in bulk directly from fishers in the village and subsequently sell it to wholesalers at the wholesale market. Several factors, including size and accessibility of the market, established networks and long-term relationships with wholesalers, and concentration of wholesalers in a particular market, influence the choice of market.

ii. **Value Addition:** Fishers generally sell mixed harvests in bulk, without engaging in value addition activities such as sorting, grading, or species-specific packaging. Wholesalers or traders perform these activities and typically charge 2–4% commission for their services, covering sorting, grading, and the sale of fish at the market. Wholesalers or traders then sell the fish to smaller traders who supply them to retailers and hotels. Thus, the fishers do not get higher prices that the fish fetch at the wholesale or retail market.

Theme 4: Awareness, perceptions, and adoption of innovations

i. **Exposure to training:** Most fishers in EKW continue to rely on traditional aquaculture practices. However, a subset of fishers has gained exposure to new practices, species, and technologies through training programs conducted by the Krishi Vigyan Kendra (KVK) and the Agricultural Department. These initiatives aim to enhance productivity, manage risks, and introduce sustainable practices. Fishers reported training of the following new practices:

   1) Catfish (*Singhi*) culture in separate ponds, enabling diversification and higher-value production.
   2) Experimentation with new species such as *Sona, Tangra, Gulsa Tangra*, and *Pangasius* through on-site trials to assess feasibility and productivity.
   3) Disease management and problem-solving techniques, including steps to take when fish mortality occurs.
   4) Practical use of technology, for example, aerators that create oxygen bubbles to address oxygen depletion in wastewater-fed ponds.

ii. **Awareness of new technologies:** Although aquaculture predominantly relies on wastewater-based polyculture, fishers reported awareness of emerging technologies and innovations that could supplement or enhance traditional practices. These included:
   1) **Enhanced feed formulations**: New types of pellets with higher protein content that can improve growth rates and overall fish health, potentially reducing reliance on conventional feed such as mustard oil cake and rice bran.
   2) **Probiotics and water-quality management products**: Alternatives such as beneficial bacteria and zooplankton-based supplements that can help maintain water quality, reduce disease incidence, and improve feed conversion efficiency.
   3) **Fast-growing fish varieties**: Introduction of new seed varieties that reach marketable size more quickly, thereby shortening production cycles and increasing profitability.
   4) **Innovative pond management tools**: While not universally adopted yet, some fishers are aware of technologies such as aerators, oxygen monitoring devices, and automated feeders that can address critical challenges like oxygen depletion and uneven feeding.

iii. **Perceived benefits and risks:** Several respondents highlighted awareness about potential benefits of adoption of new technologies and scientific methods, such as improved growth rates, higher production, and reduced disease incidence. However, fishers also emphasized the risks and constraints associated with adopting these innovations. Many of the new technologies are capital-intensive, requiring substantial upfront investment in feed, probiotics, or equipment. Respondents also highlighted concerns that inadequate application or mismanagement of new practices can lead to complete loss of a batch, representing a high financial risk. Respondents repeatedly cited a lack of technical knowledge and expertise as a major barrier that could negate the potential benefits.

iv. **Adoption barriers:** Most fishers primarily rely on traditional aquaculture practices, but some are open to adopting new methods and technologies when the need arises or when they observe successful implementation in small-scale trials. However, adoption is generally cautious, as the risks of failure are substantial. Several barriers limit widespread adoption:

   1) **Financial constraints**: Many new technologies and inputs require substantial upfront investment, which is difficult without access to credit or subsidies.

2) **Technical knowledge requirements**: Innovations often demand specific technical skills, and a lack of expertise can lead to losses, deterring adoption.
3) **Traditional practices and cultural inertia**: Fishers tend to rely on methods that have proven effective over generations, demonstrating a low tolerance for risk.
4) **Labor system constraints**: The traditional labor arrangements, including reliance on daily wage workers and unionized systems, limit the flexibility needed to implement new, labor-intensive practices.
5) **High operational risk**: Innovations such as feed-intensive culture increase capital and operational costs, and any mismanagement or environmental failure can result in severe economic and food security impacts.

Theme 5: Aquaculture constraints and recommendations

i. **Wastewater management constraints:** Fishers face multiple environmental challenges that significantly impact aquaculture production. During the summer months, water scarcity is a recurring problem, limiting the ability to maintain optimal pond conditions. Conversely, during the monsoon season, managing the inflow of sewage-laden wastewater becomes a primary concern. The canals supplying wastewater require regular maintenance, including de-silting, to ensure adequate water flow into the interior EKW ponds. Poor canal management can lead to waterlogging in some areas while restricting water availability in others. Furthermore, respondents also indicated that the quality of wastewater has declined in recent years due to increased pollution from urbanization and human activities. Moreover, climate-related issues such as oxygen depletion during hot or stagnant conditions can result in mass fish mortality. Another critical challenge is siltation, which reduces water depth, pond volume, and ultimately fish growth and productivity. Changes in rainfall patterns and sediment load closely relate to this problem, showing the vulnerability of the EKW aquaculture system to climatic and environmental variability.

ii. **Institutional constraints:** A significant barrier for fishers in EKW is the limited access to formal institutional support. Many fishers lack access to credit, subsidies, or government-backed financial assistance, which constrains their ability to invest in new technologies, improved inputs, or high-value species. This financial limitation also restricts participation in training programs and capacity-building initiatives that could enhance their knowledge and skills. Furthermore, the short-term nature of leases, combined with the need for annual renewal, exposes leaseholders to considerable financial and operational risks. This uncertainty reduces their incentive to invest in pond maintenance and infrastructure, which in turn negatively impacts overall productivity.

iii. **Infrastructure constraints:** Infrastructure limitations pose significant challenges to aquaculture productivity and market access in EKW. Silting and reduced water depth in ponds and canals are major issues, as they restrict fish growth, increase stress, and can lead to higher disease incidence. Regular desilting and deepening of canals is essential to ensure adequate water flow and maintain optimal pond conditions. Access to proper roads is another critical factor that influences market connectivity. Because of poor road infrastructure, transportation time and costs increase, and fish perish more quickly. This is because most fish are transported in traditional containers with water since cold storage facilities are lacking.

iv. **Market risks and price volatility:** Aquaculture in EKW remains a high-risk livelihood due to significant price volatility. Fishers sell mixed batches of fish and generally act as price-takers, with limited negotiation power. Prices are often determined after deducting the weight of water and containers, further reducing the returns. Since production is unpredictable, daily income fluctuates, making financial planning challenging. The lack of storage facilities forces fishers to sell all harvested fish immediately, even during periods of low market prices, which can exacerbate income instability. The risk of fish mortality during transport is largely mitigated by wholesalers or traders who handle transportation once the fish are loaded. Wholesalers set prices daily, leaving fishers with little control over pricing. Fishers have identified several potential solutions to address market-related challenges:

1) **Collective marketing:** Cooperatives or Farmer-Producer Companies (FPCs) could consolidate fish from multiple producers, increasing bargaining power and reducing dependency on individual wholesalers.
2) **Diversification into high-value species:** Cultivating Small Indigenous Species (SIS) and other high-demand fish could improve profitability due to their market demand and nutritional value. Successful

adoption would require technical guidance, knowledge transfer, and hands-on training for scientific cultivation at scale.

3) **Real-time market information:** Access to daily prices across wholesale fish markets could enable better negotiation, enhancing price transparency.
4) **Cold storage and improved logistics:** Establishing storage facilities near ponds would reduce distress sales, prevent post-harvest losses, and allow fishers to time sales strategically for higher prices.

Table 5: Constraints and recommendations

Constraint Type	Challenges	Recommendations
Environmental / Wastewater Management	✓ Water scarcity during summer and excess inflow during monsoon. ✓ Canals require regular maintenance (de-silting) to ensure flow. ✓ Declining wastewater quality due to pollution. ✓ Irregular rainfall affects water availability and production cycles. ✓ Oxygen depletion and siltation reduce pond depth, fish growth, and productivity.	1. Regular desilting and maintenance of canals. 2. Measures to improve wastewater quality and manage sediment load. 3. Development of water management strategies to cope with variable rainfall. 4. Adoption of nature-based solutions to improve water retention and quality
Institutional / Financial	✓ Limited access to credit, subsidies, and government support. ✓ Short-term leases and annual renewal reduce investment incentives. ✓ Financial constraints limit the adoption of new technologies, pond maintenance, and high-value species cultivation	1. Provision of formal credit schemes or low-interest loans. 2. Institutional support for subsidies and technical assistance. 3. Longer lease agreements to encourage investment in pond infrastructure. 4. Capacity-building and hands-on training programs for fishers
Infrastructure	✓ Silting reduces water depth in ponds and canals, affecting growth and increasing disease risk. ✓ Poor road access limits market connectivity. ✓ Lack of cold storage increases perishability and reduces profitability	1. Investment in canal maintenance and dredging. 2. Improvement of road infrastructure to reduce transportation costs and time. 3. Development of cold storage and improved transport solutions near ponds.
Market / Price Risks	✓ High price volatility: fishers are price-takers with limited negotiation power. ✓ Daily income fluctuations due to unpredictable production. ✓ Lack of storage forces immediate sale, often at low prices. ✓ Mortality during transport (mostly borne by wholesalers)	1. Collective marketing through cooperatives or Farmer-Producer Companies (FPCs). 2. Diversification into high-value species such as Small Indigenous Species (SIS). 3. Real-time market price information for better negotiation. 4. Cold storage and improved logistics to reduce distress sales and post-harvest losses

(ii) Cooperatives

A total of five interviews were conducted with office bearers of fish cooperatives, including the Chairman, Secretary, Vice-President, and Manager. The objective was to understand the governance framework and internal functioning of the cooperatives, as well as to identify the key operational and institutional challenges they face in managing collective aquaculture activities. Table 6 summarizes the main themes and sub-themes that emerged from the hierarchical coding of KIIs.

Table 6: Summary of themes and sub-themes for cooperative

Theme	Sub-theme
Production Practices	i. Sourcing fingerlings
	ii. Stocking and harvesting regime
	iii. Feeding and nutrient management
	iv. Fish species composition
	v. Role of small indigenous species (SIS)
Capital, Operational Costs, and Income	i. Major recurring costs
	ii. Labor and member payments
	iii. Input and feed expenditure
	iv. Infrastructure maintenance and utilities
	v. Equipment, transport, and miscellaneous costs
	vi. Income sources and profitability
Market and Supply-Chain Linkages	i. Sale mechanism
	ii. Value addition
Awareness and Adoption of Innovations	i. Awareness about new technologies
	ii. Knowledge of government training programs
	iii. Adoption of new technologies
	iv. Challenges of adoption
Infrastructure and Physical Resources	i. Infrastructure and physical resources
Challenges Faced by Fish Cooperatives	i. Water management
	ii. Institutional and administrative
	iii. Financial and operational challenges
	iv. Environmental and technical concerns
	v. Market and governance issues
Recommendations	i. Restoration of water flow and ecosystem health
	ii. Financial support and access to credit
	iii. Technical support and capacity building
	iv. Institutional strengthening, governance, and youth inclusion
	v. Livelihood diversification through eco-tourism
	vi. Policy and lease reforms

Theme 1: Production practices

i. **Sourcing fingerlings:** Wastewater aquaculture operations under the fish cooperatives follow a cyclical production system that integrates both internal fingerling rearing and external procurement. Most cooperatives undertake three cycles annually, adjusting stocking and harvesting schedules according to water availability and market demand. Cooperative operators use two primary approaches to stocking.

   a) **Internal fingerling rearing:** Some cooperatives maintain small nursery ponds, typically ranging from 3 bighas[3] to 10 kathas[4] in total area, where eggs or spawn sourced from areas such as *Bankura, Naihati*, and *Sealdah* are reared until they reach fingerling size (approximately 1–1.5 inches or 100–150 grams). These fingerlings are then transferred to larger ponds (ranging between 27 and 57 bighas) for grow-out. Cooperative using this approach highlighted that internal rearing reduces production costs by minimizing dependence on external hatcheries and allows better control over seed quality and survival rates.

   b) **External procurement:** Some cooperatives also source fingerlings directly (average weight 100 g) from commercial hatcheries located *in Bardhaman, Naihati, Hooghly, Ramsagar, Bandel, Magra*, and *Pandua*. This approach requires a higher initial investment but reduces the labor and time needed for nursery management.

[3] 1 bigha=0.16 hectare
[4] 1 bigha=20 katha

ii. **Stocking and harvesting regime:** Fish farmers stock fish at approximately 100 g and rear them to 250–500 g before harvesting. Harvesting practices vary across cooperatives:

a) **Continuous harvesting**: Some operators practice near-daily harvesting during active netting periods, yielding around 1 ton of fish per day.
b) **Seasonal or batch harvesting**: Others conduct three to four major harvests per year, each lasting 12–15 days, with an average yield of 500–600 kg per netting.

Across both approaches, operations typically involve about 100 days of netting annually, though these are interspersed with restocking and pond maintenance intervals.

iii. **Feeding and nutrient management:** Similar to individual farmers, members of cooperatives also follow a nature-based approach that uses Kolkata's wastewater for aquaculture. The process involves retaining water for 5–7 days to encourage the growth of phytoplankton, which forms the primary natural feed for fish. Although the cooperative continues to uphold this traditional practice, respondents also highlighted that they can no longer implement it effectively because of the discontinuation of wastewater supply. Since this source is often insufficient, fishers supplement nutrient management with various other feeds. These include mustard oil cake, rice bran, wheat dust, and cow dung manure, with some members also purchasing hotel waste at ₹180 (~2 USD) per drum. The government provides subsidized feed, including mustard oil cake and rice bran, with some receiving approximately 50 bags (1500-2000 kg) annually. While some members report an annual expenditure of ₹7-8 lakhs on feed and manure, others spend around ₹2-3 lakhs (~2.8 thousand USD) on supplementary feed.

iv. **Fish species composition:** Aquaculture operations within the cooperatives exhibit a diverse polyculture system, with fishers cultivating a mix of indigenous and exotic species suited to the wastewater-fed environment of EKW. The dominant species across most cooperative-managed ponds include *Rohu, Catla, Mrigal*, and *Bata*—all preferred for their market demand, growth efficiency, and adaptability to the nutrient-rich wastewater ecosystem. In addition to these, some cooperatives also rear *Silver Carp*, *Common Carp*, *Tilapia, Pangas,* and *Tangra* to enhance species diversity and market resilience. However, attitudes toward certain species vary. Even though Tilapia and Common Carp grow rapidly and tolerate variable water conditions, several operators avoid cultivating them because they reproduce quickly, which can cause overpopulation and competition for resources, thus reducing the growth potential of other stocked fish. Some fishers also maintain a smaller-scale culture of *Rohu* and *Catla*, often in mixed systems, to meet localized market preferences and ensure year-round availability.

v. **Role of small indigenous species (SIS):** SIS do not constitute a primary component of aquaculture practices amongst cooperatives in EKW. Punti and other species occur naturally in the wastewater-fed ponds, but the cooperatives do not deliberately culture or manage them as part of the production system. People usually harvest these species incidentally during regular netting operations, and then they sell them in mixed consignments alongside larger commercial species. On average, SIS contributes approximately 200 kg per netting cycle, representing a minor share of the overall harvest volume. This limited focus on SIS reflects the prevailing production orientation toward larger, fast-growing market species such as *Rohu, Catla,* and *Mrigal*. Similarly, certain species like *Pangasius*, though introduced in some ponds, remain peripheral to mainstream aquaculture practices due to lower local demand and the sector's reliance on traditional polyculture models optimized for wastewater-fed environments.

Theme 3: Capital and operational costs and income

i. **Major recurring costs:** Table 7 presents a summary of operational expenditure across fish cooperatives in EKW. Annual operational costs ranged widely from approximately ₹36 lakhs (~40 thousand USD) in smaller cooperatives to over ₹9 crores (~ 1 million USD) in large, member-based entities with extensive holdings and staff networks.

The most substantial cost components include member stipends or wages, feed and manure, canal dredging, and pond preparation. One cooperative reported annual expenses of ₹8.76 crores (~ 0.9 million USD) solely on member stipends, alongside ₹7–8 lakhs (~8 thousand USD) for feed and manure, ₹4–5 lakhs (~5 thousand USD) for canal dredging, and ₹1.5–2 lakhs (~ 2 thousand USD) for pond preparation. These figures underscore the labor-intensive and maintenance-heavy nature of aquaculture operations in wastewater-fed systems. Additional recurring costs encompass net repair (₹1.8 lakhs or ~2 thousand USD), boat repair (₹1.5 lakhs , ~1.7 thousand USD), watchman hut maintenance (₹1 lakh or ~1 thousand USD), diesel for vehicles

(₹1.2 lakhs, ~1,341 USD), fuel for grass-cutting machines (₹12,000 or ~ 134 USD), and electricity bills (₹3,600 or ~40.25 USD). Notably, cooperatives also allocate significant funds toward community and cultural expenditures, such as an annual temple festival (₹2.5 lakhs or ~2.8 thousand USD) and book distribution events, reflecting their embeddedness within the local socio-cultural fabric.

ii. **Labor and member payments:** Labor costs represent a dominant share of total expenditure. Member wages vary substantially by cooperative size and membership structure. One cooperative reported monthly wage payments of ₹18–19 lakhs (~21 thousand USD) (amounting to ₹2.16–2.28 crores (~0.2 million USD) annually), while another indicated ₹15.84 lakhs (~17 thousand USD) annually for 22 members, supplemented by ₹6–7 lakhs (~7.3 thousand USD) annually for external daily-wage labor employed for netting and maintenance tasks. These figures highlight the cooperative's dual reliance on member labor for routine management and external workers during peak production and harvesting periods.

iii. **Input and feed expenditure:** Input costs fluctuate depending on whether cooperatives rear their own seed or purchase externally. Spawn and fry purchases range from ₹1–2 lakhs (~1.7 thousand USD) annually, with some instances of ₹1 lakh (~ 1.1 thousand USD) spent on spawn and ₹60 lakhs (~ 67 thousand USD) on Indian Major Carp (IMC) fingerlings, reflecting large-scale grow-out operations. Supplementary feed—mainly mustard oil cake and rice bran—accounts for approximately ₹2–3 lakhs (~2.8 thousand USD) annually, although government feed provision programs can substantially reduce these costs for some entities. Certain cooperatives also purchase hotel waste as supplementary feed at approximately ₹180 (~2 USD) per drum, with an estimated 1,650 drums used per season, underscoring a cost-effective yet informal input strategy.

iv. **Infrastructure maintenance and utilities:** Maintenance of physical infrastructure constitutes another major cost component. Pumping and water management expenses are particularly high due to the dependence on diesel and electric pumps for maintaining wastewater flow. One cooperative reported annual diesel pumping costs of ₹1.5 lakhs (~1.7 thousand USD), while others paid ₹8,000–9,000 (~ 95 USD) every three months in electricity charges under commercial tariffs. Embankment (bundh) repairs are a recurring necessity, with expenses ranging from ₹80,000–90,000 (~950 USD) for minor breaches to ₹ 4 lakhs (4.5 thousand USD) annually for major repair works. Across 15 ponds, the estimated cost for broader pond maintenance, including dewatering, liming, and general upkeep, was ₹10–15 lakhs (~14 thousand USD) annually, and lime application alone cost ₹6,600–7,700 (~ 78 USD) per year.

v. **Equipment, transport, and miscellaneous costs:** Other operational costs include net rentals (₹250 per day or ~2.8 USD per day), net repairs (₹1.5–2 lakhs or ~1.7 thousand USD), vehicle maintenance (₹6 lakhs or ~6.7 thousand USD for trucks and vans), and general maintenance supplies (tools, nails, etc.) at about ₹2 lakhs (~2.2 thousand USD) annually. Lease rent and taxes typically amount to ₹7.35 lakhs (~8.2 thousand USD) per year, while donations and community support activities average ₹1.5 lakhs (~1.7 thousand USD) annually. Capital assets such as land, boats, nets, and pumps were gradually accumulated over decades, making it difficult to assign precise current valuations. Most land holdings remain government-leased, reflecting the cooperative model's dependence on public land allocation within the EKW.

Table 7: Operational costs of Fish Cooperatives in EKW

Cost Component	Items	Approximate Annual Cost (₹/ USD)	Remarks
Labor and Wages	Member stipends or salaries	8.76 crore (~ 0.9 million USD) (large cooperative); 15.84 lakh (~17 thousand USD) (medium cooperative)	Major recurring expenditure; varies by membership size
	External daily-wage labor (netting, maintenance)	6–7 lakh (~7.3 thousand USD)	20–25 laborers hired during peak operations
Feed and Inputs	Supplementary feed (mustard oil cake, rice bran)	2–3 lakh (~2.8 thousand USD)	Reduced in cooperatives receiving government-supplied APIC feed
	Hotel waste for feed	₹180 (~2 USD) per drum × ~1,650 drums = ~3 lakh per season (~3.4 thousand USD per season)	Informal but cost-effective nutrient source

Cost Component	Items	Approximate Annual Cost (₹/ USD)	Remarks
	Spawn and fingerlings purchase	1–2 lakh (~1.7 thousand USD) (small) to 60 lakh (~ 67 thousand USD) (large)	Cost varies with species mix and stocking scale
Pond and Canal Maintenance	Canal dredging	4–5 lakh (~5 thousand USD)	Annual maintenance to maintain the wastewater flow
	Pond preparation (drying, liming, de-silting)	1.5–2 lakh (~2 thousand USD)	Pre-stocking annual maintenance
	Embankment (bundh) repair	0.8–4 lakh (~2 thousand USD)	Varies by the extent of erosion or breaches
	Pond maintenance (lime, general repairs, dewatering)	10–15 lakh (~14 thousand USD) (for 15 ponds)	Annual maintenance cycle
Infrastructure and Equipment	Boat repair	1.5 lakh (~1.7 thousand USD)	Annual maintenance
	Net repair/rental	1.5–2 lakh (~1.7 thousand USD); ₹250/day (~2.8 USD/day) (rental)	Frequent use and replacement
	Watchman hut/site maintenance	1 lakh (~1.1 thousand USD)	Routine structural upkeep
Utilities and Energy	Diesel for vehicles	1.2 lakh (~1.3 thousand USD)	Local transport of fish and materials
	Pumping (diesel/electric)	1.5 lakh (diesel) (~1.7 thousand USD)/ ₹8,000–9,000 (~95 USD) quarterly (electric)	High energy costs due to wastewater circulation
	Electricity bills (miscellaneous)	3,600 (~40 USD)	Excludes pumping charges
Transportation and Vehicles	Vehicle maintenance (trucks/vans)	6 lakh (~6.7 thousand USD)	High due to frequent use in fish transport
Miscellaneous Expenditure	Grass cutting machine fuel	12,000 (~134 USD)	Seasonal expense
	Maintenance materials (tools, nails, etc.)	2 lakh (~2.2 thousand USD)	General operational upkeep
	Lease rent / taxes	7.35 lakh (~8.2 thousand USD)	Annual government lease payments
	Festivals, donations, and community events	2.5 lakh (~2,795 USD) (temple festival); 1.5 lakh (~1.7 thousand USD) (donations)	Reflects socio-cultural obligations

vi. **Income sources and profitability:** The cooperative does not maintain detailed production records by fish species; fish are generally sorted and sold according to species or size categories. Selling prices vary significantly depending on species, size, and target market. Bata fetches between ₹130–180 (~1.5 USD) per kilogram, Rohu and Catla range from ₹90–190(~1.5 USD)/kg, Mrigal sells for ₹120–135(~1.5 USD)/kg, Silver Carp for ₹70–90(~1 USD)/kg, Tilapia ranges widely from ₹60–180(~1.5 USD) /kg, and very small mixed fish destined for hotels are priced around ₹70(~0.8 USD)/kg.

Revenue and profitability differ considerably across the cooperative's operations. One cooperative report annual revenue of approximately ₹46 lakh (~51 thousand USD), generating a net profit of ₹10 lakh (~11 thousand USD). In contrast, other reports operating at a loss due to high operational costs, estimated at ₹22–23 lakh per year. Weekly income and expenses fluctuate considerably, but fishers do not systematically track these figures. The Chairman of one of the cooperatives noted that low market prices result in only modest profits after covering substantial operational expenses, particularly salaries, which are then distributed among members. Individual member earnings vary annually: in a good year, members may receive ₹40,000–50,000 (~503 USD), whereas in a poor year, returns can fall to ₹20,000 (~223 USD) or even result in a net loss, especially if restocking is required.

Table 8: Income and profitability of Fish Cooperatives

Parameter	Details
Production Records	No precise species-wise data; fish are sorted and sold by species or size category.
Selling Prices (₹/kg)	Bata: ₹130–180 (~1.3- 2.0 USD); Rohu/Catla: ₹90–190 (~1-2.1 USD) ; Mrigal: ₹120–135 (~1.3-2 USD);Silver Carp: ₹70–90(~0.8-1 USD)/ ; Tilapia: ₹60–180(~0.7-2.0 USD) ; Small mixed fish (for hotels): ₹70 (~0.8 USD)
Marketing Strategy	Fish sorted by size and species; sales targeted to hotels, local markets, and traders.
Value Addition	Moderate, through sorting, grading, and targeting premium buyers; no processing or branding.
Annual Revenue	Approximately ₹46 lakh (~51 thousand USD) (reported by one operational unit).
Net Profit	Around ₹10 lakh (~11.2 thousand USD)in profitable units; others report operational losses.
Annual Operational Costs	₹22–23 lakh (~25 thousand USD) (includes labor, feed, maintenance, transportation, and salaries).
Weekly Income and Costs	Highly variable; not systematically recorded.
Member Earnings (Annual)	✓ Good year: ₹40,000–50,000 (~503 USD) per member ✓ Poor year: ₹20,000 (~223 USD) or less; may result in loss if restocking required
Key Cost Components	Salaries, fish feed, pond maintenance, fuel, and restocking expenses.
Profitability Trend	Margins currently low due to depressed market prices and high operating expenses.
Challenges	Lack of systematic record-keeping, fluctuating market prices, and high recurrent costs.
Opportunities	Improved record management, market linkages, cold storage, and fish processing for higher value realization.

Theme 4: Market and supply-chain linkages

i. **Sale mechanism:** Typically, cooperative members or hired daily-wage laborers harvest fish in the early morning. After cooperative members or hired daily-wage laborers weigh and sort the fish by species, they transport them to the wholesale market for auction using personal vehicles, bicycles, or freezer vans. Some cooperatives also engage local unemployed youth to assist with transporting fish to the markets. Travel times generally range between 20 and 40 minutes, which helps maintain the freshness and quality of the fish. Once at the market, the transporters sell the fish through auction, after which wholesalers issue a paper slip confirming the sale. The transporters usually return to the pond area within 1 to 1.5 hours, minimizing the risk of spoilage.

While respondents stated they do not face major logistical challenges in terms of transport time or spoilage, they consistently identified police harassment and traffic restrictions as significant problems. Often, traffic police stop vehicles carrying fish and demand informal payments, even with proper transport documents. Additionally, respondents pointed out that poor road conditions, particularly during the rainy season, slow down vehicle movement and occasionally cause delays in reaching markets. A few members also mentioned that limited access to reliable vehicles forces them to hire private transport, increasing operational costs and reducing scheduling flexibility.

ii. **Value addition:** A key distinction between the cooperative and individual small-scale farmers lies in value addition and marketing strategy. The cooperative engages in partial value addition by sorting fish by species and size, targeting niche markets such as hotels that pay a premium for smaller or specialized fish. In contrast, individual farmers often sell mixed-species in bulk, typically at lower prices. While this bulk sale reduces labor and operational costs, it limits potential income.

Theme 5: Awareness and adoption of innovations

i. **Awareness about new technologies:** Respondents expressed familiarity with several novel feed and input sources, such as the use of Black Soldier Fly Larvae (BSFL) as a sustainable alternative to conventional fish feed. They also demonstrated an awareness of the potential use of water hyacinth for producing bio-manure, recognizing its dual role in waste management and value addition. In terms of species diversification, the respondents showed an interest in cultivating small indigenous species (SIS) and other high-value varieties such as *Shingi, Koi,* and *Mourala*, which are increasingly sought after in local markets for their nutritional and economic value.

ii. **Knowledge of government training and extension programs:** The interviewees reported having some exposure to government-sponsored training programs on intensive aquaculture techniques, including those that emphasize high feeding frequency, use of formulated feeds, and disease management. These training initiatives have contributed to a basic understanding of how intensive systems differ from their traditional wastewater-fed model and how such methods can enhance productivity if adequate resources and infrastructure are available.

iii. **Adoption of new technologies:** Despite their awareness, the practitioners have not adopted intensive aquaculture technologies such as biofloc systems or mechanical aeration. They consider these methods unsuitable for the large-scale wastewater-fed *bheries*, citing both technical and contextual incompatibility. A previous trial of such technologies reportedly failed, reinforcing their skepticism about their applicability in their environment. Instead, they continue to prioritize natural feeding practices, relying on mustard cake and other traditional inputs to maintain good water quality and produce healthy, naturally grown fish for human consumption. Members avoid what they describe as "bad feed" linked with hybrid or chemical-intensive systems, emphasizing the importance of maintaining both fish health and consumer trust.

> Some respondents have also experimented with brackish water fish culture, particularly with *Parshe*, in their wastewater ponds. Respondents indicated that these trials produced unexpectedly strong growth performance and highly positive taste feedback. In addition, they are exploring ecotourism initiatives around their aquaculture landscapes to generate supplemental income while preserving the natural wetland environment.

iv. **Challenges of adoption:** Respondents identified multiple factors that limit the adoption of new technologies within wastewater-fed aquaculture systems. First, the unsuitability of available technologies, such as biofloc or aeration, which are primarily designed for small, controlled freshwater ponds rather than large, semi-natural wastewater-fed systems. Second, high capital investment requirements and ongoing operational costs further discourage experimentation with such technologies, particularly in a context where profit margins are modest and financial risks are high. Respondents also cited past unsuccessful experiences with recommended training interventions, which have reinforced a sense of skepticism toward new and untested methods. Beyond financial and technical barriers, there is a clear philosophical preference for natural, low-input aquaculture systems over intensive methods. Members believe that their traditional wastewater-fed system remains sustainable and potentially profitable, provided it receives adequate support in terms of consistent water supply and infrastructure maintenance. Finally, the lack of appropriate infrastructure, including suitable pond conditions, reliable, clean water sources, and technical support, further limits their capacity to adopt new approaches.

Theme 6: Infrastructure and physical resources:

i. **Infrastructure and physical resources**: The cooperative's physical and operational infrastructure varies significantly across locations but is generally basic and functionally driven. Generally, cooperative operates with a small fleet of around five boats, a variety of fishing nets ranging from 125–250 feet for large *bheries* to smaller nets used in subsidiary ponds, one owned truck for fish transport, and a modest office space that serves as the administrative hub. These assets collectively enable day-to-day operations but offer little redundancy or buffer against breakdowns and seasonal disruptions. However, some accounts indicate even more limited infrastructure, with one or two boats and no owned nets, necessitating frequent equipment rentals for harvesting and maintenance. A common and critical gap across all sites is the absence of cold storage and post-harvest facilities. Only one cooperative reported having access to a 500-litre freezer, acquired through a government scheme, which remains insufficient for large-scale fish preservation or marketing during supply fluctuations.

Theme 7: Challenges faced by fish cooperatives

i. **Water management**: One of the most critical challenges confronting the cooperative is the inconsistent inflow of wastewater, which serves as the foundation for its aquaculture operations. The primary cause is the siltation and blockage of feeder canals, resulting in inadequate water depth for effective fish culture. This has forced cooperatives to rely heavily on mechanical pumping to maintain water levels, thereby escalating diesel consumption and operational costs. In addition, annual embankment repairs represent a significant recurring expense, consuming a substantial portion of

cooperative revenues. The combination of poor water inflow, degraded canal infrastructure, and high maintenance costs threatens both the productivity and financial sustainability of cooperatives.

ii. **Institutional and administrative:** A major institutional barrier stems from the lack of formal registration of several cooperatives. This prevents access to essential government subsidies, development programs, and credit facilities, leaving them dependent on internal or informal sources of capital. Despite repeated attempts spanning over a decade, some cooperatives have been unable to complete the registration process due to bureaucratic delays and procedural hurdles, which are often perceived as opaque and prone to misappropriation. The absence of institutional recognition also restricts their engagement with policy frameworks and technical support programs. As a result, even when government assistance is available, it is often ill-timed, poorly coordinated, or misaligned with on-ground realities, limiting its practical impact.

iii. **Financial and operational challenges:** The cooperatives face mounting financial pressures driven by a combination of high operational costs and declining productivity. Major expenses include member stipends, diesel fuel, feed, and labor wages, compounded by government lease rents. Furthermore, the reduction in wastewater inflow and sedimentation in both main and subsidiary canals has led to decreased fish yields, translating into direct financial losses. Locals further exacerbate the issue by dumping solid waste into canals, worsening blockages and necessitating costly dredging operations to restore flow. Many cooperatives operate with limited infrastructure, including dilapidated embankments, poor access roads, the absence of cold storage facilities, and a lack of owned transport vehicles, which increases dependence on external actors such as wholesalers for logistics. Additionally, private hatcheries are the main source of fish spawn, creating supply dependencies and limiting quality control.

v. **Environmental and technical concerns:** Members have observed a noticeable decline in fish growth rates, which they attribute to deteriorating wastewater quality or poor-quality spawn. This environmental degradation, coupled with reduced nutrient inflow, poses a threat to the ecological balance that underpins the wastewater-fed aquaculture system. Although the government provided training programs, members say the sessions are too theoretical and often impractical, focusing on intensive aquaculture models that are unsuitable for their large-scale, open-water bheri systems. The lack of customized, hands-on technical support continues to hinder the adoption of improved practices.

vii. **Market and governance issues:** Market-related challenges further compound the cooperative's difficulties. Fish prices remain volatile and generally low, reducing profit margins. During transportation, members frequently encounter police harassment and traffic restrictions, even after maintaining proper documentation, adding both stress and informal costs to operations. Inadequate market infrastructure, including cold chain facilities and organized market linkages, further limits their ability to access better prices or negotiate directly with larger buyers.

Theme 8: Recommendations

i. **Restoration of water flow and ecosystem health:** The respondents expressed that the most urgent intervention required is the dredging and de-silting of both main and subsidiary wastewater canals to restore the steady flow of nutrient-rich water into the *bheries*. This action is essential for sustaining the ecological productivity and long-term viability of the wastewater-fed aquaculture system. The restoration of natural inflow would significantly reduce dependence on artificial feed, lower production costs, and improve overall fish health and yield. Respondents emphasized that without canal rehabilitation, other forms of institutional or financial support would remain ineffective or unsustainable. Additionally, respondents highlighted regular maintenance and repair of embankments (bundhs) and improvement of internal access roads as critical infrastructure priorities to prevent flooding and erosion and to ensure smooth transportation of harvested fish.

ii. **Financial support and access to credit:** There is an urgent need for targeted financial assistance to support both operational continuity and long-term modernization. Cooperatives recommend the provision of soft loans, grants, or subsidized credit for capital investments such as equipment, vehicles, cold storage, and infrastructure upgrades. Furthermore, respondents highlighted that the distribution of government subsidies and schemes must be transparent, accountable, and direct, avoiding the influence of local political intermediaries to ensure that benefits reach the cooperatives promptly and fairly.

iii. **Technical support and capacity building:** Training and extension support need to be context-specific, focusing on the unique wastewater-based ecosystem of EKW rather than on generic freshwater aquaculture models. Cooperative members strongly advocate for practical, on-site technical demonstrations, where experts can train fishers directly within their operational environments. Establishing demonstration projects and pilot initiatives would help showcase effective, eco-compatible technologies and build confidence in adopting improved practices. These should include components on disease management, water quality monitoring, sustainable feeding strategies, and species diversification suitable for wastewater-fed systems.

iv. **Institutional strengthening, governance, and youth inclusion:** Simplifying and expediting the cooperative registration process is a key priority, as formal recognition would enable access to government schemes, subsidies, and credit facilities. Improved coordination between cooperatives and government departments is necessary to ensure timely delivery and appropriate alignment of interventions with local realities. Respondents also highlighted the need for improving internal governance of cooperatives through collective decision-making, transparency in financial management, and regular audits to prevent mismanagement and enhance trust among members. In addition, they felt that including youth members in cooperative activities is also recommended to preserve traditional knowledge, foster intergenerational continuity, and attract younger participants through exposure to modern, sustainable aquaculture practices.

v. **Livelihood diversification by promoting eco-tourism:** To enhance income stability and community engagement, cooperatives propose the promotion of ecotourism and educational tourism within the wetlands. This could include creating visitor facilities, guided tours, and interpretive centers to raise awareness about the ecological importance and cultural heritage of EKW, while generating supplementary livelihoods for cooperative members.

vi. **Policy and lease reforms:** Cooperatives call for a transparent and equitable process in lease tenders, ensuring fair access and reducing administrative uncertainty. Policy reforms should recognize the ecological and livelihood value of traditional wastewater-fed fisheries, integrating them into urban planning, environmental management, and food system strategies at the state level.

Table 9: Summary of challenges and recommendations for fish cooperatives

Themes	Challenges	Recommendations
Water Management & Ecosystem Health	- Inconsistent wastewater inflow due to silted and clogged canals. - Insufficient water depth for fish culture, leading to high pumping costs. - Annual embankment damage and costly repairs. - Degradation of water quality and declining productivity.	- Immediate dredging and de-silting of main and subsidiary canals to restore natural flow. - Regular embankment repair and maintenance to prevent flooding and erosion. - Invest in sustainable water management infrastructure to reduce pumping dependency and improve ecosystem resilience.
Institutional & Administrative Constraints	- Many cooperatives remain unregistered, restricting access to government schemes and subsidies. - Cumbersome, bureaucratic registration processes and lack of institutional recognition. - Limited engagement with government agencies and poor coordination.	- Simplify and expedite registration for traditional cooperatives. - Ensure direct and transparent delivery of government schemes and subsidies, bypassing intermediaries. - Establish coordination mechanisms between government departments and cooperatives for regular communication and timely assistance.
Financial & Operational Challenges	- High operational costs (diesel, labor, feed, and lease rent). - Dependence on private hatcheries for spawn and feed. - Lack of owned transport, cold storage, and post-harvest facilities. - Declining profitability due to low fish prices and rising costs.	- Provide soft loans, grants, and financial products tailored to small cooperatives. - Support modernization of infrastructure (vehicles, storage, processing units). - Introduce price stabilization mechanisms and promote collective marketing strategies to improve bargaining power.
Technical Capacity & Training	- Lack of modern technical training; existing programs too theoretical and unsuitable for wastewater systems. - Limited awareness of sustainable technologies adapted to local conditions.	- Offer context-specific, practical, and on-site technical training focused on wastewater-fed aquaculture. - Establish demonstration projects for adaptive technologies (e.g., sustainable feeding, water quality management).

Themes	Challenges	Recommendations
	- No demonstration models to showcase innovation.	- Provide continuous extension support and mentoring through trained professionals.
Infrastructure & Access	- Poor road connectivity hampers transport and market access. - Weak embankments increase risk of flooding. - Absence of cold storage and processing facilities.	- Invest in infrastructure upgrades, including road repairs, embankment strengthening, and cold chain development. - Facilitate collective ownership of equipment (boats, nets, vehicles) through cooperative funding or government assistance.
Market & Governance Issues	- Low and volatile market prices for fish. - Police harassment and transport delays during market delivery. - Weak market linkages and lack of institutional marketing support.	- Develop direct market linkages and explore contract or cooperative marketing models. - Establish designated transport routes or permits for fish vehicles to reduce harassment. - Promote price transparency and digital trading platforms for cooperative sales.
Governance & Youth Inclusion	- Weak internal governance and transparency issues in financial management. - Limited involvement of younger members, risking knowledge discontinuity. - Instances of mismanagement and poor decision-making.	- Strengthen internal governance systems, regular audits, and participatory decision-making. - Encourage youth engagement through mentorship programs and exposure to eco-innovation. - Build leadership and financial management skills within cooperatives.
Diversification & Ecotourism	- Overreliance on fish production as the sole income source. - Lack of diversification or alternative livelihood activities.	- Promote ecotourism and educational tourism linked to the East Kolkata Wetlands. - Develop visitor infrastructure and awareness programs to generate additional income while conserving the ecosystem.
Policy & Lease Management	- Uncertainty over lease renewals and non-transparent tender processes. - Policy neglect of traditional wastewater-fed fisheries.	- Ensure a transparent, fair, and timely lease tender process. - Integrate wastewater-fed aquaculture into state-level wetland management and food system policies. - Recognize cooperatives as key ecological and livelihood stakeholders.

3.2.2 Midstream segment: Fish Laborers (*Jeoni*) and Transporters

1. Fish Laborers (*Jeoni*)

A focus group discussion with seven fish laborers was conducted to gain insights into their roles and experiences within the cooperative structure. These workers form a distinct category of specialized laborers, locally referred to as *Jeoni*, who are primarily responsible for fish netting and related harvesting activities for fish cooperative societies.

Table 10: Summary of themes and sub-themes for Fish laborers (*Jeoni*)

Theme	Sub-Theme
1. Work Profile	Tenure and Association
	Type of Work
	Seasonality and Working Hours
	Fish Species Handled
	Payment Structure
2. Livelihood and Health Risks	Income Insufficiency and Coping Strategies
	Occupational Health Risks
3. Institutional Support and Labour Relations	Lack of Institutional and Cooperative Support
	Absence of Registration and Entitlements
	Structural Barriers to Support and Representation
4. Aspirations and Future Outlook	Desired Changes in Work Conditions
	Aspirations for the Next Generation
	Expectations from Government and NGOs

Theme 1: Work profile

i. **Tenure and association:** The group represented a mix of experience levels, ranging from relatively new entrants with 2–3 years in the profession to long-term workers with 8–20 years or more of experience.

ii. **Type of work:** Their work is highly specialized, focusing exclusively on fish netting operations. Their main responsibilities involve casting nets into the ponds, herding fish by splashing water and creating noise through rhythmic thumping on the pond floor to guide them into the net, then hauling the filled nets onto boats and transporting the catch to a central collection point along the bank. Activities such as sorting, weighing, or selling the fish in the market fall outside their scope of work.

iii. **Seasonality and working hours:** The work of *Jeoni* laborers follows a distinct seasonal pattern and fixed daily schedule. The warmer months mark the peak season when fish are more active and easier to catch, resulting in higher yields and consistent work opportunities. In contrast, the winter months (roughly December to February) form the lean period, as fish become sluggish, settle near the pond bottom, and are harder to net. This increases the physical effort required while reducing returns. To ensure the prompt transport and sale of freshly caught fish, the fishermen work from around 4:00 AM to 8:00 or 8:30 AM, to align with the timing of the morning markets.

iv. **Fish species handled:** The *Jeoni* laborers primarily work with large, commercially valuable fish species such as *Rohu, Catla, Mrigel,* and *Tilapia,* which form the mainstay of the cooperative's production for bulk market sales. Although small indigenous species (SIS) like *Singhi, Magur, Tangra, Punti*, and *Koi* are occasionally caught during netting, these are typically released back into the water, as they hold limited commercial value in the wholesale trade targeted by the cooperative. The workers are not engaged in any specialized harvesting or management of these smaller species.

v. **Payment structure:** The *Jeoni* laborers are not salaried members of the cooperative but operate entirely on a commission-based payment system, with their earnings directly tied to the day's catch. The laborers receive ₹6 for every kilogram of fish they harvest, and the team members divide the total commission from each haul equally. This system offers no fixed daily wage, bonuses, or access to advances, meaning that income is earned solely when fish are successfully caught, leaving them financially vulnerable during lean periods or poor catch days.

Theme 2: Livelihood, and health risks

i. **Income insufficiency and coping strategies:** The income earned from fishing is generally insufficient to sustain households year-round, particularly during the lean winter months when catches decline sharply. As a result, all *Jeoni* laborers are compelled to pursue supplementary livelihoods. Common secondary occupations include agricultural work in local gardens, construction labor, small businesses such as fish trading, and various forms of daily wage labor in nearby areas. During lean seasons, they cope primarily by cutting down on household expenses and depending on earnings from these alternative jobs. However, there is no institutional or financial support—such as credit, advances, or subsidies—from the cooperative or *bheri* owners, leaving them to manage these difficult periods independently.

ii. **Occupational health risks:** The *Jeoni* laborers face considerable health and safety risks due to constant exposure to polluted and stagnant water. Common ailments include frequent fevers, severe colds, and skin infections such as rashes and lesions resulting from prolonged contact with contaminated water. Injuries from fish species like *Singhi* and *Magur*—whose sharp spines can cause painful wounds—are also common, alongside the persistent risk of snake bites while working in the ponds. All medical expenses are borne personally by the workers, as there is no provision for health insurance, medical reimbursement, or institutional support from the cooperative.

Theme 3: Institutional support and labour relations

i. **Lack of institutional and cooperative support:** The *Jeoni* laborers receive no formal support or benefits from either the cooperative or *bheri* owners. Their relationship with these entities is purely transactional, limited to a commission-based payment per kilogram of fish caught. There are no

provisions for loans, advances, health care, widow assistance, or food support during the lean season, leaving workers without a safety net in times of hardship.

ii. **Absence of registration and entitlements:** These laborers are not formally registered members of the cooperative but are engaged as contract or daily-wage workers. As a result, they are excluded from welfare schemes and social protection measures, including pensions, ration cards, or insurance benefits, and remain outside the purview of institutional entitlements available to formal members.

iii. **Structural barriers to support and representation:** The workers' informal and precarious employment status prevents them from organizing or demanding improved working conditions. The absence of a representative platform or grievance mechanism means that they have no channel to seek assistance or advocate for rights, reinforcing their economic vulnerability and dependence on daily earnings.

Theme 4: Aspirations and future outlook

i. **Desired changes in work conditions:** The *Jeoni* laborers' priorities for improvement are straightforward and centered on economic security and basic welfare. Their primary demand is a higher commission rate, suggesting an increase from the current ₹6 to ₹12 per kilogram of fish to make their earnings more sustainable. They also seek basic social benefits, particularly medical support for work-related health issues, and emphasize that greater work availability, through improved fish yields, would directly enhance their income and livelihood stability.

ii. **Aspirations for the next generation:** All participants expressed a strong desire for their children to pursue different livelihoods, highlighting a shared aspiration to break the cycle of poverty and hardship associated with this occupation. The reasons cited include low and irregular income, physically demanding and hazardous working conditions, and a perceived lack of dignity and future prospects in fishery labor. Education is viewed as the key pathway for their children to attain secure, respected, and better-paying employment outside the fishery sector.

iii. **Expectations from Government and NGOs:** The laborers articulated clear expectations from external agencies, emphasizing the need for skill training programs to enable transition into alternative livelihoods, employment facilitation in more stable sectors, and financial support through accessible loans or small enterprise schemes. They also urged direct government intervention in improving bheri infrastructure—particularly through dredging and de-silting canals—to restore fish production, which would in turn increase their work opportunities and earnings.

2. Fish Transporters

Fish transporters play a vital role in the aquaculture value chain of the East Kolkata Wetlands. To gain insights into their work patterns, transportation and marketing practices, and the challenges they face, we conducted in-depth interviews with three transporters.

Table 11: Summary of themes and sub-themes from Fish transporter KIIs

Theme	Sub-Themes
Work Profile and Adaptive Livelihood Strategies	i. Work and occupational profile
	ii. Nature of work
	iii. Institutional links and support
	iv. Livelihood insecurity
	v. Alternative livelihood
Transportation Practice and Market Linkages	i. Transportation process
	ii. Challenges in transportation
Recommendations	i. Canal management and environmental restoration
	ii. Access to infrastructure and modern equipment
	iii. Institutional support
	iv. Financial access and government support

Theme 1: Work profile and adaptive livelihood strategies

i. **Work and occupational profile**: Fish transporters engage in a diverse range of activities that extend beyond transportation alone. In addition to carrying fish to markets, many also work as laborers involved in netting fish, maintaining ponds, and assisting with other aquaculture-related tasks as needed. This multifunctional engagement reflects the flexible and interdependent nature of livelihoods within the wetlands. Several respondents reported being involved in this occupation for over two decades, highlighting a deep-rooted familiarity with the trade. In many cases, fish transportation and related work have been passed down through generations, forming an integral part of family livelihood systems. The geographical proximity to water bodies and the abundance of aquaculture opportunities in the East Kolkata Wetlands have historically enabled local communities to sustain themselves through these interconnected, fish-related activities.

ii. **Nature of work**: Fish transporters in EKW typically engage in dual roles, functioning both as fishers and as transporters. Their workday begins well before dawn, around 2 a.m., at the fishpond, where they participate in a range of activities such as pulling nets, collecting fish, and assisting in the initial stages of harvest. Some transporters do not directly engage in catching fish themselves but work collaboratively with groups of 10–20 individuals involved in the process. The daily wage typically ranges from ₹150 to ₹300 (~2.2 USD), depending on the distance to the market and the volume of fish transported. This payment generally covers the entire set of activities involved in the process, including fishing, carrying, and selling. On average, transporters are engaged in work for approximately 10 to 20 days each month, with the frequency often influenced by seasonal fish availability and market demand. Each pot generally contains between 18 and 30 kilograms of fish. However, during the monsoon season, when roads become muddy and difficult to navigate, the load per pot is reduced to about 18–20 kilograms to ensure the fish's survival and to prevent accidents during transit. Upon reaching the market, the fish are weighed again to verify quantities before being handed over to wholesalers (kata or arat). The wholesalers then sort the fish by species and finalize the sale. The transporter is responsible for safely delivering and weighing the fish and settling the transaction.

iii. **Institutional links and support**: Fish transporters generally operate independently and lack formal institutional representation. There are no dedicated unions or associations specifically formed to address their occupational concerns or safeguard their interests. As a result, they often work on an individual basis, negotiating their own terms of employment and payments directly with fish farmers or traders. However, some transporters maintain regular engagement through local fish cooperatives, which provide more consistent work opportunities. These cooperatives typically allocate tasks related to harvesting, transportation, and marketing based on need and availability.

iv. **Livelihood insecurity:** Respondents expressed that the occupation of fish transportation does not provide sufficient income or financial stability to sustain a household. With low daily wages, the earnings are often inadequate to meet regular family expenses. Many highlighted that the nature of this work is highly uncertain, as employment opportunities depend largely on *bheri* owners and the frequency of fish harvests. This irregularity in earnings, combined with the low wage rates, creates a sense of economic insecurity. Respondents also voiced concern that declining fish production in the wetlands could further reduce their opportunities for work in the coming years. The lack of social protection or institutional support adds to their vulnerability, forcing them to rely on alternative sources of livelihood to supplement their income.

v. **Alternative livelihoods:** To cope with the instability of income from fish transportation, many transporters diversify their income. Common secondary occupations include working as daily wage laborers in fisheries-related tasks such as pond cleaning, soil digging, feeding fish, and maintaining *bheris*. Some transporters also operate small businesses like grocery shops, mobile recharge outlets, or petty trading ventures that provide a more consistent year-round income. In addition to fisheries-based work, a few engage in agricultural activities such as small-scale vegetable farming or livestock rearing, while others take up general manual labor within their villages or nearby areas. These diversified livelihood strategies help mitigate the financial uncertainties associated with seasonal fish transport work.

Theme 2: Transportation practice and market linkages

i. **Transportation process:** Once the fish are harvested, they are sorted immediately at the *bheri* based on species and size. The sorted fish are then carried to the nearby landing point, where transportation to the market begins. For this purpose, fish are placed into large aluminum pots known locally as *haṛi*, each filled with water and weighing around 18-30 kilograms when loaded. However, depending on season and road quality, transporters may also have to carry less to the market. Most transporters do not have ice boxes, plastic containers or any modern storage facilities. At the ghat, the fish are weighed to record the quantity before being packed for transport. Typically, people transport fish by bicycle. According to labour union regulations, fish transporters are permitted to make only one trip per day to the wholesale market. The main markets where fish are sold are *Chingrighata, Bamanghata, Garia, Bantala, Chowbaga, Gangajoara* and *Nayabad*. The owner decides which market is suitable for the fish sale.

ii. **Challenges in transportation:** Fish transporters encounter a range of challenges that affect both their efficiency and income stability. One of the primary difficulties relates to poor road infrastructure, particularly during the monsoon season. Muddy and uneven roads make cycling extremely difficult, forcing transporters to reduce the load they can carry and thereby lowering their daily earnings. Another major issue is the irregularity of work opportunities and the fluctuation of fish prices in the market. Since payments often vary depending on the distance to the market and the volume transported, income remains uncertain and inconsistent. The perishable nature of fish further compounds these challenges — any delay or spoilage directly impacts both the farmers and the transporters, leading to financial losses. Maintaining the freshness and survival of fish during transit is a significant concern, especially in the absence of modern facilities such as cold storage, oxygen supply, or ice. Without these basic infrastructure supports, ensuring that fish remain in good condition until they reach the market becomes a daily struggle for transporters.

Theme 3: Recommendations

i. **Canal management and environmental restoration:** The foremost concern raised by respondents is the deteriorating condition of the canals that connect the *bheris*. Over time, heavy siltation and pollution have significantly reduced water flow, adversely affecting fish production. This decline has a direct impact on work opportunities for transporters, whose livelihoods depend on regular fish harvests. Respondents strongly recommended dredging, cleaning, and maintaining these canals to restore proper water circulation and improve the ecological health of the wetlands.

ii. **Access to infrastructure and modern equipment:** Transporters emphasized the need for modern fish transport containers to improve handling and reduce fish mortality during transit. The current system relies on basic aluminum pots without oxygen supply or ice, which often leads to spoilage and financial loss. Introducing improved containers and aeration systems could help maintain fish quality and ensure better prices in the market. Additionally, the lack of proper storage facilities and transportation infrastructure, particularly during the monsoon season, continues to challenge their efficiency and earning potential. respondents expressed the need for investment in simple cold storage tools and road infrastructure to improve their productivity and income stability.

iii. **Institutional support:** Respondents expressed concern over the absence of cooperative registration for the *bheri* they are associated with, which restricts access to government schemes, subsidies, and formal management systems. Respondents highlighted that since registered cooperatives are better organized, they can provide more consistent work opportunities and higher wages for members. Therefore, indirectly, registration of cooperatives ensures stability in fish transporters' livelihoods.

iv. **Financial access and government support:** A recurring recommendation from respondents is the need for financial and policy support from government institutions. Access to low-interest loans, subsidies, and welfare schemes would benefit both fish farmers and transporters. Transporters emphasized that when farmers receive financial support and incentives to increase fish production, it indirectly creates more stable and regular work for them. They believe that strengthening support mechanisms for fish farmers—through credit facilities, input subsidies, and extension services—would have a multiplier effect across the entire aquaculture value chain, ensuring better wages, steady employment, and improved livelihood security for transport workers.

Table 12: Summary of challenges and recommendations for fish transporters

Challenges	Description	Recommendations
1. Poor Road Conditions	Muddy and uneven roads, especially during the monsoon, make cycling difficult and reduce load capacity, leading to income loss.	- Improve rural road infrastructure and drainage.
2. Lack of Modern Transport Facilities	Use of basic aluminum pots (haṛi) without oxygen or ice results in high fish mortality and spoilage.	- Introduce modern, aerated fish transport containers. - Provide access to cold storage and ice facilities near landing points (ghats).
3. Irregular Work and Low Income	Work opportunities depend on bheri harvest schedules; average 10–20 working days per month with low and fluctuating wages.	- Support diversification of livelihoods. - Create more stable employment opportunities through improved fish production and cooperative linkages.
4. Poor Canal and Water Management	Siltation and pollution reduce water flow, lowering fish yield and overall livelihood opportunities.	- Undertake regular canal dredging and cleaning. - Implement community-based canal maintenance programs.
5. Lack of Institutional Support / Unregistered Cooperatives	Absence of cooperative registration limits access to government schemes, financial assistance, and structured work allocation.	- Facilitate cooperative registration for unorganized *bheris*. - Strengthen existing cooperatives with training and management support.
6. Limited Access to Finance	Transporters and small-scale fishers lack access to credit or government subsidies.	- Provide low-interest loans and subsidies through cooperative banks or microfinance institutions. - Include transporters in fisheries welfare schemes.
7. Declining Fish Production	Reduced water quality and poor canal connectivity are lowering yields, resulting in fewer work days and lower earnings.	- Promote sustainable aquaculture practices. - Support farmers with inputs, training, and financial incentives to boost production.
8. Lack of Cold Storage and Handling Infrastructure	Absence of ice, oxygen, or storage facilities affects fish quality and market price.	- Establish shared cold storage units at markets. - Provide portable aeration systems for transporters.

3.2.3 Downstream Segment: Market intermediaries

The section discusses the specific roles, responsibilities, and interactions of key market actors, highlighting how they contribute to the overall functioning of the aquaculture value chain within the East Kolkata Wetlands. Table 13 summarizes the main themes and sub-themes emerging from the analysis, capturing how fish market intermediaries' function, adapt, and experience constraints.

Table 13: Summary of themes and sub-themes from Fish intermediaries KIIs

Theme	Sub-Theme	Description
1. Work and Occupational Profile	i. Type of Market Intermediary	Captures the diversity of intermediary roles — wholesalers, aggregators, and retailers — and how their interconnected functions sustain the flow of fish from producers to consumers.
	ii. Location of Market Intermediaries	Highlights the spatial spread and clustering of intermediaries across key Kolkata markets.
	iii. Experience and Entry into Trade	Shows how participation is shaped by generational inheritance, informal learning, and social capital.

Theme	Sub-Theme	Description
	iv. Working Hours and Nature of Workday	Demonstrates the demanding, irregular, and labor-intensive character of the work.
2. Role of Intermediaries in the EKW Fish Value Chain	i. Wholesalers	Illustrates the organizational and coordinating role of wholesalers in aggregating, auctioning, and redistributing fish.
	ii. Aggregators (Paikars)	Captures how aggregators bridge wholesale and retail markets, managing logistics, quality control, and timely supply to maintain freshness and efficiency.
	iii. Retailers	Depicts the central role of retailers in ensuring last-mile delivery, adding value through presentation, consumer interaction, and small-scale processing.
3. Income, Market Volatility, and Livelihood Diversification	i. Profit-Based Earnings	Reflects daily income fluctuations driven by market competition, species type, and seasonality.
	ii. Commission-Based Earnings	Captures reliance on commission-based systems and informal trust arrangements.
	iii. Seasonal and Market Volatility	Demonstrates how income instability aligns with seasonal supply, cultural consumption cycles, and environmental conditions.
	iv. Livelihood Security	Reveals dependence on fish trade as a primary livelihood, but also the precarity of earnings and coping strategies such as income diversification and informal safety nets.
	v. Alternative Livelihoods	Shows adaptive livelihood diversification among intermediaries to offset income insecurity.
4. Operations and Supply Chain Flow	i. Fish Sourcing and Marketing Channel	Explains the multilayered supply network linking EKW bheris to regional markets.
	ii. Handling, Preservation, and Transportation	Highlights practices that ensure freshness and minimize spoilage.
	iii. Challenges in Market Operations	Captures the operational vulnerabilities created by inadequate infrastructure, perishability, high costs, and external disruptions such as weather and enforcement pressures.
5. Market Dynamics and Price Determination	i. Pricing Mechanism and Payment Practices	Explores how prices are negotiated through auction systems and relational trust.
	ii. Consumer Preferences and Species Demand	Shows how consumer preferences for specific species and live freshness drive pricing, marketing, and stocking decisions among intermediaries.
	iii. Seasonal Fluctuations in Supply and Demand	Reveals cyclical patterns of abundance and scarcity shaped by festivals, weather, and cultural norms.
6. Quality Standards and Value Addition	i. Quality Perception and Handling Practices	Highlights the social and sensory criteria defining fish quality, linking freshness and careful handling to reputation and customer loyalty.
	ii. Value Addition through Sorting, Grading, and Packaging	Captures how traders enhance value through manual grading and display practices, while noting limited investment in modern processing.
	iii. Constraints to Value Addition	Identifies financial, infrastructural, and demand-side barriers that restrict technological upgrading and limit movement toward higher-value markets.
7. Challenges and Recommendations	i. Operational and Financial Challenges	Synthesizes key barriers to efficient operations, including infrastructure deficits, price instability, and weak institutional support.

Theme	Sub-Theme	Description
	ii. Cold Storage and Preservation Facilities	Emphasizes the need for preservation infrastructure to reduce losses.
	iii. Market Infrastructure	Stresses the importance of improved hygiene, market design, and digital systems to enhance efficiency and customer experience.
	iv. Skill Development	Highlights the demand for technical training in auctioning, handling, and management.
	v. Access to Financial Support	Demonstrates the central role of affordable credit and subsidies in enabling capital investment.

Theme 1: Work and occupational profile

i. **Type of market intermediary:** Between the primary fish producers and the end consumers, there exists a network of market intermediaries who play crucial roles in the distribution and sale of fish. In the East Kolkata Wetlands, these intermediaries primarily include wholesalers, aggregators (locally known as *paikars*), aggregators cum retailers, and retailers. Each group performs distinct yet interconnected functions that ensure the efficient movement of fish from the *bheris* to local markets and ultimately to consumers.

ii. **Location of market intermediaries:** The respondents were located across several major fish markets within Kolkata. The most frequently mentioned market sites include *Chingrihata Market, Bamanghata Market, Beliaghata Jora Mandir Market, Sonarpur Market, Bantala Market*, and *Chowbaga Market*—all of which are central to the region's aquaculture-based economy. In addition to these prominent markets, the study identified several other trading locations such as *Purbalok and Nitaingar, Chhatu Babur Market, Garia Market,* and *Sealdah Market*, reflecting the broad distribution network through which fish from the wetlands reach urban consumers.

iii. **Experience and entry into trade:** Fish market intermediaries in the East Kolkata Wetlands exhibit a wide range of professional experience, spanning from as little as two years to over five decades in the business. For many, this occupation is part of a generational livelihood tradition, passed down from fathers and grandfathers who were involved in fish trading, wholesaling, or retailing. These inherited networks provided crucial advantages such as market access, mentorship, and established trust among traders and customers. At the same time, a few intermediaries entered the trade independently, driven by personal initiative and observation-based learning. These individuals built their businesses from the ground up, starting as helpers, partners, or small traders, and eventually expanding through relationship-building.

iv. **Working hours and nature of workday:** Fish market intermediaries typically maintain long and irregular working hours, shaped by the early timing of fish auctions and the fast-paced nature of the trade. Most begin their workday in the early morning, usually between 2:00 AM and 5:00 AM, to reach wholesale markets before the first auctions. The duration of work varies considerably depending on the intermediary's role in the value chain. Wholesalers and aggregators, who handle bulk transactions, often complete their major trading activities by late morning or midday, while retailers typically continue working into the afternoon or evening to serve customers. Overall, workdays can range from 5–6 hours to as long as 12–14 hours. The end of the workday is generally determined by the sale of stock, demand, and transportation schedules rather than a fixed time. Respondents emphasized that this unpredictable schedule, combined with physically demanding tasks such as loading, unloading, and handling fish, makes the occupation intensive and laborious.

Theme 2: Role of intermediaries

i. **Wholesaler:** Wholesalers serve as a critical intermediary link in the fish value chain, facilitating the movement of fish from production sites to a wide network of markets and retailers. Major wholesale markets such as *Bantala*, *Chingrihata*, and *Chowbaga* serve as central trading hubs for these operations. Fish are sourced not only from the surrounding bheri systems but also from distant regions, including North and South 24 Parganas, Medinipur, and the Sundarbans, before arriving at wholesale points. Upon arrival, wholesalers oversee the receiving, sorting, and grading of fish according to species and quality. Then, they organize auctions for aggregators and smaller traders, quickly redistributing fish to retail markets and restaurants within and beyond Kolkata.

In addition to market facilitation, wholesalers manage several logistical and administrative functions. These include weighing fish, maintaining sales records, managing transactions, and coordinating payments between sellers and buyers. Many wholesalers operate as commission agents, earning income by charging a small percentage—typically around 4% from both the seller and buyer—rather than engaging in direct purchase and resale. While some wholesalers limit their role to organizing and mediating market transactions, others take on end-to-end coordination, from collection at the *bheris* to ensuring timely distribution to downstream traders.

ii. **Aggregators (*paikars*):** Fish aggregators play an essential intermediary role in the fisheries value chain, the gap between large wholesale markets and smaller retail outlets or end consumers. They are key to maintaining the continuous flow of fish through the marketing network, ensuring that fresh produce reaches retail markets and consumers across Kolkata and its surrounding areas. Aggregators travel to major wholesale markets, where they participate in fish auctions or negotiate prices, selecting fish based on species, size, quality, and freshness. Prices tend to fluctuate daily depending on market demand, season, and availability, requiring aggregators to make quick, experience-based purchasing decisions. Once the fish are procured, they organize transportation to their respective retail destinations. Depending on the scale of operations and distance, they may use bicycles, vans, or small trucks, sometimes with the help of hired laborers. The fish are then distributed to a network of markets. While some aggregators also operate their own retail stalls and sell directly to consumers, many act primarily as distributors, supplying multiple small-scale retailers, roadside vendors, and restaurants. Their work requires efficient coordination of procurement, transport, handling, and delivery, typically completing distribution by mid-morning to ensure that fish reach the market while still fresh.

iii. **Retailer:** The retailer plays a crucial role as the final link in the fish value chain, connecting wholesale markets to end consumers. Retailers are responsible not only for selling fish directly to customers but also for managing a range of activities that ensure a steady supply of fish to local markets. Respondents engaged in retailing reported purchasing fish from multiple wholesale markets, including Bamanghata, Khoribari, Garia, and Gangajoara , often through auction systems. The selection of markets depends on the availability, price, and demand for particular species. In some cases, retailers specialize in value-added activities, such as cleaning, cutting, packaging, or even organizing interstate supply chains. Transportation methods vary depending on distance and scale of operation. Retailers typically use small trucks, bicycles, or hired laborers with bicycles to transport fish from wholesale markets to their retail stalls located in areas such as Sonarpur Market or other neighborhood markets within the East Kolkata Wetlands region. Their work involves multiple interconnected tasks, including purchasing, transporting, weighing, cutting, displaying fish, handling cash transactions, and engaging directly with customers.

Table 14: Roles of market intermediaries in the fish value chain

Category	Primary Role	Functions	Significance
Wholesaler	Acts as a bulk trader and market facilitator between producers and downstream traders.	- Receives and sorts fish from producers. - Organizes auctions for aggregators and smaller traders. - Negotiates prices and manages bulk sales. - Handles weighing, record-keeping, and payment transactions. - Operates as a commission agent (earning ~4% from both buyer and seller).	Ensures efficient market operations, price regulation, and steady fish supply to downstream actors.
Aggregator (*Paikar*)	Functions as a distributor and intermediary linking wholesale markets to local retailers and consumers.	- Purchases fish in bulk from wholesale markets through auctions or negotiations. - Sorts, arranges, and transports fish to smaller retail markets. - Coordinates logistics and timely delivery. - May sell directly to consumers or supply multiple retailers.	Maintains the flow of fish through the supply chain, balancing demand between wholesalers and retailers.

Category	Primary Role	Functions	Significance
Retailer	Serves as the final link between markets and consumers, ensuring the availability of fresh fish.	- Purchases fish from wholesalers or aggregators. - Handles all retail-level tasks: weighing, cutting, cleaning, arranging, and selling fish. - Manages finances and customer interactions. - Some engage in value-added processing, packaging, or interstate supply.	Ensures last-mile delivery of fish to consumers, adding value through preparation, presentation, and customer service.

Theme 3: Income, market volatility, and other sources of livelihood

i. **Profit-based earnings:** Many intermediaries, including retailers and aggregators (paikars), earn their income through profit margins on fish sales. Their earnings are determined by the difference between purchase and resale prices, which can vary daily based on market conditions. On profitable days, individuals may earn between ₹1,000 (~11 USD) and ₹ 1,500 (~17 USD), and occasionally up to ₹2,000 (~22 USD), whereas on slower days, they may make little to no profit or even incur losses. Profit margins are closely linked to factors such as market competition, fish species, size, freshness, transport and labor costs, and the tightness of supply. Some traders aim for a targeted profit per kilogram, often between ₹20 (~0.2 USD) and ₹50 (~0.6 USD), while others report average daily profits of ₹300–₹700 (~3.3-7.8 USD), depending on volume and market demand. Incomes are inherently volatile and unpredictable, particularly during the monsoon or lean fishing periods.

ii. **Commission-based earnings:** Wholesalers and some intermediaries earn income through commissions rather than direct trading. Commission rates generally range from 2% to 6% of the total sales value, though they may rise to 10% in certain agreements or high-value transactions. The commission structure often depends on specific business relationships, including whether the intermediary provides advance payments (*dadon*), operates on cash or credit, or manages transactions for both *bheri* owners and buyers. While some maintain formal records in registers or ledgers to track sales and payments, many rely on informal, trust-based arrangements with verbal settlements at the end of daily auctions. The simplicity of this system reflects the traditional nature of fish markets, but it also contributes to financial insecurity and a lack of documentation for future planning or access to formal credit.

iii. **Seasonal and market volatility:** The earnings of fish market intermediaries in the East Kolkata Wetlands are shaped by a mix of profit-based trading and commission-based arrangements, both of which depend heavily on market dynamics, fish availability, and individual business models. Incomes are highly sensitive to seasonal variations. During the monsoon, when fish supply decreases and road conditions deteriorate, earnings tend to decline sharply. Conversely, peak fishing seasons or festive periods bring higher volumes and demand, leading to temporary increases in profit. The instability of income—driven by changing fish prices, competition, and unpredictable harvests—makes long-term financial planning difficult for intermediaries.

iv. **Livelihood security:** Fish market intermediaries largely depend on their trade as their primary or sole source of income, with many noting that it continues to sustain their households. However, their earnings remain highly unstable, fluctuating with daily sales, market prices, and variable demand and supply conditions. To cope with this uncertainty, some diversify their livelihoods through supplementary work such as grocery employment, promotional activities, night guard duties, or jobs in the railways. While a few respondents report relative stability and long-term satisfaction, others describe persistent challenges, including credit defaults, seasonal downturns, declining fish availability, and the physical and financial risks of the occupation.

v. **Alternative livelihoods:** Many fish market intermediaries pursue diversified income sources alongside their primary occupation in fish trading to cope with the uncertainties of the market. This diversification reflects both economic necessity and adaptability, as income from fish marketing alone is often irregular and insufficient to sustain household expenses throughout the year. A number of respondents reported engaging in secondary occupations through local, informal activities—running small household trading ventures, taking up night shifts as guards or caretakers at large *bheris*, or working as land brokers. Some intermediaries hold more formal or structured secondary jobs, including employment in the railways,

managing shops selling plastic goods, operating vehicle rental or transport businesses, or maintaining kerosene oil dealerships. A few also derive additional income from agriculture, fishery cooperative work, or landholding activities, reflecting a blend of traditional and modern livelihood practices. However, a substantial portion of intermediaries stated that they depend solely on fish marketing—either as wholesalers, *paikars*, or retailers—for their livelihood. Many emphasized that despite past attempts at other ventures, they have remained committed to the fish trade, viewing it as both a familial and occupational identity.

Theme 4: Operations and supply chain flow

i. **Fish sourcing and marketing channel:** Fish market intermediaries in the East Kolkata Wetlands (EKW) source fish daily from major wholesale markets across Kolkata, which serve as key aggregation hubs. Most of the supply comes from EKW wetland ponds, supplemented by local ponds, small farms, and tank fisheries. Additional fish arrive from nearby districts such as Medinipur, Howrah, North and South 24 Parganas, and occasionally the Sundarbans. This network ensures a steady supply of fish to Kolkata markets, even during lean-harvesting periods. Procurement typically occurs through daily auctions where prices vary by species, size, and availability. Supply frequency depends on harvesting cycles—some *bheris* sell every two weeks, others less often. Intermediaries strategically adjust purchases, increasing volumes before weekends or festivals. Following auctions at key wholesale points, distributors send the fish to retail and secondary markets across Kolkata, Howrah, suburban areas, and adjacent districts, as well as to hotels and restaurants serving urban consumers.

ii. **Fish handling, preservation, and transportation practices:** Fish intermediaries use various methods to maintain freshness and reduce spoilage. Ice is widely used during transport and at markets, stored in plastic containers or small processing units. Many follow a “buy today, sell today” model to ensure quick turnover and avoid long storage. Live fish are carried in water drums or tanks, sometimes with aeration and ice to maintain temperature. Transport methods vary—from bicycles and auto-rickshaws to vans, trucks, and boats—depending on distance and volume. Wholesalers usually rely on local transporters engaged by *bheri* operators or retailers. At markets, fish are immediately sorted, auctioned, and sold, as few places have cold storage. Unsold fish are kept temporarily on ice or sold at a discount, since traders believe deep freezing reduces taste and quality.

iii. **Challenges in market operations and infrastructure:** Fish market intermediaries encounter multiple challenges linked to market dynamics, perishability, infrastructure gaps, and external pressures. Seasonal demand fluctuations, cultural factors (such as reduced fish consumption during festivals), and slow sales days often result in distress selling and reduced profit margins. To prevent spoilage, traders sometimes sell at much lower prices, as carrying unsold stock is rarely viable. Spoilage remains a major concern, worsened by transport delays, inadequate ice supply, high temperatures, and limited access to cold storage facilities. Poor infrastructure further compounds these issues, with vendors frequently citing inadequate drainage, leaking roofs, unhygienic market conditions, and waterlogging, especially during monsoons. Although some improvements—like better roads, raised platforms, and improved lighting—have eased operations in certain markets, persistent issues such as police harassment, poor road quality, flooding, and high maintenance costs continue to affect profitability. Additionally, fish mortality during transport, rising input costs, and labor shortages create further strain on the intermediaries’ livelihoods.

Theme 5: Market dynamics and price determination

i. **Pricing mechanisms and payment practices:** Fish pricing is shaped by a mix of wholesale purchase costs, market demand, and auction-based competition. Most intermediaries determine their selling rates by adding a variable profit margin—typically ₹20–₹50 (~0.2-0.6 USD) per kilogram—over the wholesale purchase price. These margins fluctuate daily depending on fish quality, freshness, and customer willingness to pay. Auctions play a central role in setting prices, beginning with a base rate announced by the seller and followed by competitive bidding among buyers. Multiple factors influence final prices, such as species, size, freshness, and real-time demand. While some wholesalers establish prices for retailers based on market trends, others engage directly in auctions to secure

better margins. Prices remain highly dynamic and can shift daily, sometimes resulting in losses when demand is low. Most transactions are conducted in cash, as digital payments are uncommon. Trust-based credit arrangements are widespread among regular buyers, but these carry financial risks due to delayed payments or defaults, occasionally causing notable annual losses for intermediaries.

ii. **Consumer preferences and species demand:** Fish demand among consumers and intermediaries varies widely, though large carps such as *Rohu (Rui)* and *Catla* remain the most sought-after across markets for their taste, size, and suitability for household consumption. Other common choices include Mrigel, Silver Carp, and Bata. Freshness and quality are key buying factors, with many customers preferring live fish when available. Alongside large carps, there is strong demand for small indigenous species (SIS) such as *Tangra, Koi, Mourala, Punti,* and *Singhi,* prized for their flavor and nutritional value. These smaller species often fetch higher prices, especially when scarce or seasonal; however, respondents highlighted that availability has declined due to environmental pressures and replacement by farmed varieties. Preferences also vary by region, community, and buyer type—some markets serve middle-income households, while others cater to hotels or budget-conscious customers. Many intermediaries stock a wide range of fish to meet these diverse demands.

Table 15: Consumer preferences and species demand

Category	Species	Characteristics
Large Carps (High Demand)	*Rohu (Rui), Catla, Mrigel, Silver Carp, Bata*	Large size, traditional preference, good taste, family-friendly portions
Small Indigenous Species (SIS)	*Tangra, Koi, Mourala, Punti, Singhi*	Strong flavor, local taste, perceived health benefits
Farmed Alternatives	*Hybrid Koi, Pangas, Tilapia*	Readily available, lower cost, consistent size
Key Determinants of Choice	Freshness, live condition, size, price, taste	Consumers prioritize quality and freshness; willingness to pay premium for live or local fish

iii. **Seasonal fluctuations in supply and demand:** Demand for fish in the East Kolkata Wetlands value chain is highly variable, shaped by seasonal cycles, cultural norms, and weekly consumption patterns. Intermediaries consistently report peak demand on Sundays and during major festivals such as Durga Puja, Kali Puja, Jamai Shasthi, and wedding seasons, when household consumption and gifting practices drive up both prices and supply requirements. Conversely, certain religious or cultural occasions—such as Ganesh Chaturthi, Diwali, and the period between Guru Purnima and Rakhi Purnima—are associated with a temporary decline in fish consumption, as many households abstain from non-vegetarian food or are preoccupied with festivities. The monsoon season also introduces mixed effects: while some traders observe increased fish availability and reduced prices, others note depressed consumer turnout due to rain and the reduced appeal of fish carrying eggs. During low-demand periods, intermediaries often curtail purchases or rely on preservation techniques such as icing or storing live fish in tanks for next-day sales. Periodic supply gaps, particularly during *Chaitra–Falgun* when *bheris* are cleaned and production halts, further constrain availability, prompting some traders to deal in smaller quantities or substitute with dried fish. These intertwined seasonal and cultural cycles thus play a critical role in shaping both market rhythm and livelihood stability across the fish value chain.

Theme 5: Quality standards and value addition

i. **Quality perception and handling practices:** Freshness is the foremost determinant of fish quality for both customers and retailers. Buyers assess quality through visible and tactile cues such as clear eyes, bright red gills, firm texture, and active movement—and occasionally through smell or touch. Intermediaries emphasize that maintaining freshness is essential not only for higher prices but also for building consumer trust and loyalty, often sourcing fish from reliable fishponds and avoiding the sale of dead or visibly damaged fish. To preserve freshness, actors across the chain employ a range

of handling and preservation strategies. These include rapid transportation from landing points to markets, minimizing storage time, and ensuring careful handling during loading and unloading. Some traders transport live fish in oxygenated drums or aerated tanks, while others use ice for short-term preservation—particularly for fish that have just died but remain suitable for sale. The auction system itself promotes freshness by ensuring quick turnover and limited stockholding. Uniform size, cleanliness, and presentation further enhance perceived quality, reinforcing customer preference and sustaining market competitiveness.

ii. **Value addition through sorting, grading, and packaging:** Many intermediaries engage in value addition primarily through grading, sorting, and packaging, which enhance both product quality and market appeal. At the wholesale level, particularly within auctions , grading and sorting are systematic and economically significant. Fish are categorized by species and size, as mixed lots typically fetch lower prices. Sorting may occur at multiple points—at the *bheri* during harvest, upon arrival at the market, or during the auction process—often carried out by workers under the supervision of wholesalers. Higher-value species such as *Rohu*, *Catla*, and *Bata* are commonly separated from smaller indigenous varieties to meet buyer preferences and resale requirements. At the retail end, value addition remains limited but visible through basic sorting, separating weak or dead fish, and performing final consumer-oriented tasks such as cleaning or cutting. While extensive processing is uncommon, many retailers emphasize display aesthetics and hygiene to appeal to customers. Across the value chain, the degree of value addition varies according to market position, buyer expectations, and operational capacity, but it remains an important mechanism through which intermediaries differentiate products and enhance market returns.

iii. **Constraints to value addition:** Fish market intermediaries enhance value primarily through strategic market segmentation and freshness management. They target specific markets for different fish species to align with consumer preferences and avoid losses, ensuring that the right products reach the right buyers. Despite these adaptive strategies, value addition beyond freshness and variety remains limited. Most intermediaries cite significant barriers to adopting modern practices such as packaging, branding, cold storage, or pre-cleaning. These challenges stem from high operational costs, inadequate infrastructure, low capital availability, and limited technical knowledge. Moreover, consumer demand in these markets continues to favor bulk, fresh, unpackaged fish, discouraging investment in advanced processing or branding. Consequently, manual sorting, basic grading, and species segregation mainly add value, while retailers usually cut and prepare the fish.

Theme 6: Challenges and recommendations

i. **Operational and financial challenges:** Fish market intermediaries face multiple challenges, primarily related to infrastructure and finance. Many operate with inadequate facilities, including limited cold storage, inconsistent ice supply, poor drainage, and waterlogging during rains, all of which increase the risk of fish spoilage. High ice costs and unreliable electricity further strain daily operations. Financial difficulties are equally significant. Frequent price fluctuations, auction-driven volatility, and declining seasonal demand affect profit margins, while credit defaults and delayed payments from buyers often lead to financial losses. Rising input and labor costs, combined with risks of oversupply, add to the uncertainty. External pressures—such as police harassment, poor road conditions, and transport delays—further complicate business operations. Despite these constraints, a few intermediaries report smoother operations and relatively stable infrastructure, reflecting the uneven nature of challenges across the sector.

ii. **Improving cold storage facilities:** Fish market intermediaries emphasize a strong need for infrastructure enhancement and financial support to improve efficiency and reduce losses. The most frequently cited priorities include establishing cold storage facilities, developing ice plants, and ensuring a reliable ice supply to maintain fish quality and extend shelf life. Improved transport and cold-chain logistics, including vans and insulated containers, are also viewed as essential for minimizing spoilage during delivery.

iii. **Improving market infrastructure:** Respondents also stress the importance of better market infrastructure, such as covered spaces, proper drainage, clean water access, shaded stalls, and organized display areas, to improve hygiene and attract customers. Additional equipment, like weighing machines, insulated boxes, and display trays, is seen as crucial for smoother operations.

Many advocates for digital payment systems to streamline transactions, reduce cash dependence, and enhance financial security.

iv. **Skill development:** While some intermediaries prioritize capital investment over training, others express interest in skill development related to auctioning, value addition, storage management, nursery management, financial management, and modern retail practices

v. **Access to financial support:** Many fish market intermediaries emphasize the need for financial assistance to sustain and expand their operations. Access to affordable credit and small business loans is viewed as essential for purchasing larger fish volumes, managing cash flow during peak demand periods, and investing in essential equipment. Some respondents prioritized direct financial aid over training, citing extensive practical experience; others stress the importance of targeted subsidies—particularly for ice, storage, transport, and fish handling tools.

Table 16: Constraints and recommendations for fish market intermediaries

Sub-Theme	Constraints	Recommendations
1. Operational and Financial Challenges	✓ Inadequate market facilities (limited cold storage, poor drainage, irregular ice supply, unreliable electricity). ✓ Price volatility and declining seasonal demand reduce profit margins. ✓ Credit defaults and delayed payments from buyers. ✓ Rising input and labor costs; transport delays; police harassment.	✓ Upgrade market infrastructure, drainage, and electricity access. ✓ Establish price stabilization and transparent auction mechanisms. ✓ Strengthen financial accountability and credit management systems. ✓ Improve road networks and regulatory oversight to reduce harassment.
2. Cold Storage and Preservation Facilities	✓ Lack of cold storage units and ice plants. ✓ High cost and inconsistent ice supply. ✓ Limited cold-chain logistics and poor-quality containers.	✓ Establish decentralized cold storage and ice production units near markets. ✓ Promote cooperative or shared cold-chain logistics (vans, insulated boxes). ✓ Provide subsidies or credit for preservation equipment.
3. Market Infrastructure and Facilities	✓ Inadequate hygiene conditions, uncovered spaces, poor drainage, and lack of shaded stalls. ✓ Limited access to clean water and proper display facilities. ✓ Predominant reliance on cash-based transactions.	✓ Renovate and modernize market facilities with proper drainage, roofing, and clean water. ✓ Install weighing machines, insulated boxes, and organized display areas. ✓ Encourage adoption of digital payment systems for transparency and efficiency.
4. Skill Development	✓ Limited technical knowledge of auctioning, value addition, or fish handling. ✓ Few formal training opportunities for intermediaries. ✓ Some traders undervalue training, relying on experience.	✓ Conduct targeted training on auction practices, fish handling, and quality control. ✓ Build capacity in value addition, financial literacy, and cooperative management. ✓ Link training with incentive schemes to encourage participation.
5. Access to Financial Support	✓ Limited access to affordable credit or formal loans. ✓ Dependence on informal lenders and *dadon* systems. ✓ Lack of tailored subsidies for equipment and operations.	✓ Develop microcredit and low-interest loan schemes for small traders. ✓ Introduce targeted subsidies for ice, storage, and transport. ✓ Encourage financial inclusion through cooperatives and digital banking.

3.3 Comparative analysis of value chain actors

Based on the themes and sub-themes identified for each stakeholder group in Sections 4.2.1 to 4.2.3, this section undertakes a comparative analysis to highlight the cross-cutting challenges and recommendations to support various stakeholders of the aquaculture value chain in the East Kolkata Wetlands (EKW).

3.3.1 Cross-cutting challenges faced by stakeholders

While the nature and intensity of constraints vary among fishers, cooperatives, transporters, market intermediaries, and laborers, several common issues emerge that collectively shape the sector's overall performance and sustainability. The following discussion synthesizes these shared concerns under broad categories, including environmental and infrastructural constraints, institutional and financial barriers, market and operational risks, and labor vulnerabilities. Table 17 summarizes these constraints across value chain stakeholders in EKW.

Table 17: Matrix of constraints across value chain stakeholders in EKW

Stakeholder Group	Environmental & Infrastructure	Institutional & Financial	Market & Operational	Labor & Social Protection
Fishers (Owners & Leaseholders)	☑ Water scarcity, siltation, wastewater fluctuation, pond damage	☑ Limited access to credit & subsidies, short-term leases	☑ Price volatility, lack of storage, weak bargaining power	○ Limited welfare access
Cooperative Societies	☑ Poor road infrastructure, canal blockage, de-silting burden	☑ Bureaucratic delays, lack of registration, funding gaps	○ Market coordination issues	○ Member welfare constraints
Transporters / Aggregators	☑ Poor road conditions, lack of cold-chain facilities	○ Informal operations, limited financial support	☑ Price fluctuations, transport delays, spoilage risk	○ No formal protection mechanisms
Market Intermediaries	○ Limited infrastructure, electricity issues	○ Informal business practices, limited credit access	☑ High input costs, credit defaults, harassment	○ No formal welfare systems
Laborers (Jeoni)	○ Exposure to polluted water	○ Excluded from welfare and formal institutions	○ Income instability during low production	☑ No fixed wages, high health risks, no insurance or grievance redressal

Note: ☑ Major constraint ○ Indirect constraint

(i) Environmental and infrastructure constraints

A common theme that emerged across all stakeholders is that aquaculture operations in this region are conducted under persistent environmental and infrastructural constraints. Seasonal fluctuations in water availability, including scarcity during summer and an oversupply of sewage-laden wastewater during the monsoon, pose serious challenges for fish farmers. The problem is compounded by the declining quality of wastewater inflow due to rapid urbanization and changes in upstream discharge patterns. Siltation in ponds and feeder canals progressively reduces water depth, impeding fish growth and heightening disease risks, thereby necessitating frequent and costly de-silting operations. Furthermore, climate-related stresses, such as oxygen depletion during temperature fluctuations, often lead to large-scale fish mortality. Additionally, poor road infrastructure in and around the wetland limits access to local and urban markets, increasing transportation costs and post-harvest losses due to the absence of reliable cold storage or ice facilities. Moreover, irregular wastewater inflows caused by blockages in feeder canals force fishers to depend on energy-intensive mechanical pumping, while the annual repair of earthen embankments further strains the limited financial resources of cooperatives. These constraints faced by fishers downstream also have consequences for other stakeholders such as fish laborers and transporters, as a reduction in productivity reduces the earning potential of these actors.

(ii) Institutional and financial barriers

Fishers and cooperatives in EKW face a range of institutional and financial barriers that restrict growth and sustainability. Limited access to formal credit, subsidies, and government assistance prevents investment in improved aquaculture inputs, modern equipment, or high-value fish species. The prevalence of short-term leases and annual renewals introduces uncertainty and discourages long-term pond maintenance and infrastructure upgrades. Many cooperatives remain unregistered or only partially formalized, which excludes them from availing themselves of government programs, credit schemes, or training initiatives. Bureaucratic delays and opaque registration procedures further exacerbate this issue. As a result, both fishers and laborers remain largely outside the purview of welfare schemes and social protection. Rising operational costs, particularly for diesel, feed, and labor, combined with declining productivity and frequent crop losses, intensify financial stress and reduce profitability across the value chain.

(iii) Market risks and operational challenges

The actors of the aquaculture value chain face significant market and operational vulnerabilities. Fishers generally operate as price-takers, with limited bargaining power against middlemen and wholesalers, resulting in unstable and often unfavorable price realizations. Production variability leads to fluctuating daily incomes, while the lack of cold storage or holding facilities compels immediate sale of fish, even at depressed market rates.

Transporters and intermediaries face additional difficulties, including deteriorated road conditions, especially during monsoons, that restrict load capacity and delay deliveries. The perishable nature of fish, combined with limited access to ice, oxygen cylinders, and reliable electricity, contributes to spoilage and financial losses. Market intermediaries also contend with volatile input prices, credit defaults, and institutional challenges such as harassment, informal levies, and unpredictable transport delays, all of which erode operational efficiency and profitability.

(iv) Laborer vulnerabilities and lack of support

Jeoni laborers, who form the backbone of harvesting operations, work under highly precarious conditions. Typically engaged on a commission basis, they earn irregular incomes that drop sharply during the lean winter months, forcing them to pursue alternative livelihoods. They receive no fixed wages, bonuses, or advance payments, making them particularly vulnerable during periods of low catch. Furthermore, constant exposure to contaminated wastewater leads to chronic health problems such as skin infections, fevers, and minor injuries, yet medical costs are entirely borne by the workers themselves due to the absence of health insurance or institutional assistance. As unregistered and informal workers, *Jeoni* are excluded from cooperative membership, labor protections, and welfare schemes, leaving them without representation or grievance mechanisms. This lack of social and institutional support perpetuates their economic and occupational vulnerability.

3.3.2 Integrated strategies for strengthening the EKW aquaculture value chain

Building on the comparative analysis of challenges across stakeholders, this section outlines a set of integrated recommendations aimed at improving the sustainability, efficiency, and inclusivity of the aquaculture value chain in EKW. The recommendations are organized around key thematic areas—market and infrastructure improvements, water management and environmental restoration, financial, institutional, and capacity building support—to design interventions by government agencies and NGOs.Table 18 summarizes the key recommendations for the EKW wastewater aquaculture value.

(i) Market and infrastructure improvements

Fishers and intermediaries highlight the need for collective marketing mechanisms, such as cooperatives or Farmer-Producer Companies (FPCs), to strengthen bargaining power and reduce dependence on individual wholesalers. Diversification into high-value species, including Small Indigenous Species (SIS), is also recommended, supported by technical guidance and training. Furthermore, stakeholders highlighted the need for improved market intelligence systems providing real-time price information to enhance transparency and negotiation. A recurring theme on investment in cold storage facilities near ponds and marketplaces, alongside better road networks and logistics, emerged as an essential intervention to reduce post-harvest losses and prevent distress sales. Additionally, it was highlighted that modern fish transport containers with aeration systems are required to maintain product quality. Upgrading physical market infrastructure—with covered spaces, efficient drainage, clean water supply, and digital payment facilities was also suggested to further improve hygiene, efficiency, and traceability.

(ii) Water management and environmental restoration

A major priority that emerged amongst stakeholders is the dredging and de-silting of primary and secondary wastewater canals to restore water flow and maintain ecological balance. Stakeholders also highlighted the importance of regularly maintaining embankments and internal access roads for efficient operation. Respondents emphasized that the adoption of nature-based solutions for water retention, quality enhancement, and sediment

management, combined with strategies to address fluctuating rainfall and wastewater inflows, would strengthen environmental resilience and reduce dependency on artificial feed inputs.

(iii) Financial, institutional, and capacity building support

Targeted financial assistance, such as soft loans, grants, and subsidized credit, emerged as a crucial requirement for investments in equipment, transport vehicles, and pond infrastructure. Stakeholders also discussed the pressing need to ensure transparent and direct delivery of government subsidies and schemes to beneficiaries, bypassing intermediaries to improve accessibility. Furthermore, for leaseholders, longer lease durations are critical to incentivizing long-term investment in pond maintenance and productivity. Other institutional reforms, such as simplifying and accelerating cooperative registration processes, were also highlighted as an important intervention to enable formal access to credit and government support. Moreover, the cooperative highlighted that strengthening internal governance through participatory decision-making, financial transparency, and accountability within cooperatives will further enhance institutional effectiveness. Moreover, comprehensive, context-specific training for fishers on wastewater-based aquaculture practices, with a focus on disease management, water quality monitoring, and sustainable feeding, emerged as an important recommendation amongst downstream actors.

Table 18: Summary of key recommendations for the EKW aquaculture value

Themes	Key Recommendations
1. Market and Infrastructure Improvements	✓ Promote collective marketing through cooperatives/FPCs to strengthen bargaining power. ✓ Diversify production into high-value species (e.g., Small Indigenous Species – SIS). ✓ Establish real-time market information systems for price transparency. ✓ Invest in cold storage, modern fish transport containers with aeration systems, and improved logistics. ✓ Upgrade market infrastructure with covered spaces, drainage, clean water, and digital payment facilities.
2. Water Management and Environmental Restoration	✓ Undertake regular dredging and de-silting of wastewater canals and ponds. ✓ Maintain embankments and internal access roads. ✓ Implement nature-based solutions for water retention and quality improvement. ✓ Develop strategies for managing variable rainfall and wastewater inflows.
3. Financial and Institutional Support	✓ Provide soft loans, grants, and subsidized credit for equipment and infrastructure. ✓ Ensure transparent and direct delivery of government subsidies and welfare schemes. ✓ Extend lease durations to promote long-term investments. ✓ Simplify cooperative registration and strengthen governance through transparency and participation.
4. Capacity Building and Policy Reforms	✓ Offer hands-on technical training on wastewater-based aquaculture, disease management, and sustainable feeding. ✓ Provide continuous extension support and mentoring. ✓ Reform lease and policy frameworks to integrate EKW aquaculture into urban planning and environmental policies. ✓ Recognize wastewater-fed fisheries as a sustainable urban livelihood system.

Themes	Key Recommendations
5. Livelihood Diversification and Youth Engagement	✓ Promote ecotourism and educational tourism to diversify income sources. ✓ Develop visitor facilities and guided wetland tours. ✓ Engage youth through mentorship and exposure to modern aquaculture technologies. ✓ Encourage intergenerational transfer of traditional knowledge.

4. Conclusion

The livelihood systems in the East Kolkata Wetlands (EKW) showcase a rare model of urban ecological symbiosis, where waste becomes a productive resource, supporting livelihoods and demonstrating the principles of a circular economy. However, environmental degradation, urban encroachment, and socio-economic marginalization increasingly threaten this delicate balance, which jeopardizes both ecological integrity and community well-being.

This research study employs a qualitative approach to examine the aquaculture value chain in the East Kolkata Wetlands (EKW) in order to understand the roles, relationships, and challenges faced by different stakeholders. Using inductive hierarchical coding of data collected KIIs and FGDs across different stakeholder groups—fishers, cooperative members, transporters, market intermediaries, and laborers—the study systematically identifies key themes and patterns. The study organizes the analysis around two core components: (1) a mapping of the aquaculture value chain to capture the flow of resources, products, and relationships among actors, and (2) a stakeholder-wise examination of operational processes, major challenges, recommendations, and perceptions regarding the adoption of new technologies within the system. Following these insights, a comparative analysis identified cross-cutting issues that affected all stakeholder groups, such as environmental degradation, infrastructure deficits, institutional barriers, financial constraints, and market vulnerabilities. This synthesis highlights both the diversity and interconnectedness of stakeholder experiences, illustrating how systemic challenges collectively shape the efficiency, equity, and sustainability of the EKW aquaculture system. The findings point toward the need for integrated interventions—combining environmental management, institutional strengthening, and market reforms—to enhance resilience and ensure the long-term viability of this unique urban ecological system.

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