SELCO FOUNDATION

ECOSYSTEM LANDSCAPE STUDY

FISHERIES IN ASSAM

A Deep Dive Into Oppurtunities Challenges acress the Agro-Climatic Zone

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Acknowledgment

At SELCO Foundation, we extend our sincere gratitude to all those who contributed to the successful completion of this report.

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We acknowledge the dedication and efforts of RGVN, our consulting partner, as well as the enumerators who ensured the smooth execution of data collection and analysis within tight timelines.

This report is the result of collective effort, collaboration, and commitment. We deeply appreciate the contributions of each individual and institution involved.

This report is intended for policymakers, development practitioners, and ecosystem enablers working to strengthen sustainable and inclusive fisheries in Assam. It also serves as a valuable resource for FPOs, NGOs, financial institutions, and researchers seeking insights into value chain gaps and opportunities in the aquaculture sector.

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FOREWORD

India is the second largest producer of fish through aquaculture, which provides livelihoods to more than three crore fishers and fish farmers at the primary level and many more along the value chain. With flagship initiatives like the Pradhan Mantri Matsya Sampada Yojana (PMMSY), the Government of India is promoting sustainable fish farming practices across the country, through inclusive approaches. Recognized as a "sunrise sector" with immense potential for localized, sustainable development, it benefits a broad spectrum of stakeholders from individual fish-farmers to cooperatives and entrepreneurs involved in processing and marketing. The state of Assam is championing fish farming as a primary livelihood for many rural families, including through state initiatives like *"Matsya Jagtaran-Ghare Ghare Pukhuri Ghare Ghare Maach" "Ponds in Every Home, Fish in Every Home"*.

Today, nearly 90% of Assam's population consumes fish; however, the state faces a deficit of approximately 21,000 metric tonnes, with nearly half of this demand being met through imports from other states. This illustrates the substantial opportunity to enhance local production capacities and increase income levels of the fish farming communities.

The sector stands at the precipice of transformation, and the integration of climate-smart technologies and sustainable practices along the value chain can be a critical catalyst for enabling both – impacts on people and planet.

The report highlights the need for decentralized, climate-smart technologies, ranging from solar powered aerators to ensure uninterrupted aeration, to RAS units as a flood resistant fish rearing practice, and solar dryers for preservation and value addition. This will accelerate the growth of small-scale, sustainable fisheries while addressing the challenges of farming communities. The true value of these solutions can be realized with affordable financing, introduction of local input providers, and reliable market linkages that can enhance the value chain. With climate disasters being more frequent than ever before, there is a dire need to introduce climate-resilient infrastructure and sustainable package of practices for aquaculture. This report sheds light on these opportunities and the learnings so far from on-ground experiences of fish farming.

We are grateful to the Government of Assam for prioritizing this livelihood sector and to partners like NABARD, and Kalong Kapili who are spearheading initiatives to build an ecosystem for climate-resilient fisheries in the state. We look forward to collaborating and partnering with fish farmers, cooperatives, entrepreneurs and stakeholders across the ecosystem to build on the learnings from this report and realize the impacts for last mile communities.

Huda Jaffer

Director

SELCO Foundation

ACRONYMS

APART :	Assam Agribusiness and Rural Transformation Project
CMSGUY:	Chief Minister's Samagra Gramya Unnayan Yojana
DO :	Dissolved Oxygen
DRE :	Decentralized Renewable Energy
FGD :	Focus Group Discussion
FFPO :	Fish Farmer Producer Organisation
FPC :	Farmer Producer Company
FPO :	Farmer Producer Organisation
FY :	Financial Year
GDP :	Gross Domestic Product
KCC :	Kisan Credit Card
KVK :	Krishi Vigyan Kendra
MT :	Metric Ton
NGO :	Non-Governmental Organization
NFDB :	National Fisheries Development Board
pH :	Potential of Hydrogen (acidity/alkalinity level)
PMMSY:	Pradhan Mantri Matsya Sampada Yojana
RAS :	Recirculatory Aquaculture System
SME :	Subject Matter Exper

EXECUTIVE SUMMARY

India’s fisheries sector plays a critical role in ensuring nutritional security and rural livelihoods, with inland aquaculture emerging as a fast-growing component. It contributes significantly to employment, income diversification, and climate adaptation—especially smallholder farmers. The sector also provides opportunities for women and youth to engage across the value chain, from production, processing to marketing.

In Assam, the fisheries sector has both ecological grounding and economic significance—built around its extensive network of rivers, floodplains, ponds, and beels (oxbow lakes). Fisheries here are more than just a livelihood; they serve as a crucial safety net against agricultural uncertainties, especially in the face of rising climate risks. Recognizing this, the Government of Assam is actively promoting the sector through a range of centrally and state-sponsored schemes such as the Pradhan Mantri Matsya Sampada Yojana (PMMSY), Chief Minister’s Samagra Gramya Unnayan Yojana (CMGUY), and Rashtriya Krishi Vikas Yojana (RKVY). As a result, fisheries have emerged as one of the major focus areas for sustainable rural development in the state.

This study presents a comprehensive analysis of the fishery value chain in Assam across 11 districts representing all six agro-climatic zones. It examines key stages such as input procurement, production, processing marketing, and institutional support, highlighting not just existing practices but also opportunities for climate-smart innovation and system-wide resilience.

A detailed look at the socio-economic profile of fish farmers selected for the study reveals that the sector is largely male-dominated (87%), although there is secondary data evidence suggesting that women participate more actively in sorting, drying, and retailing activities—especially in localized markets. With agriculture becoming increasingly unreliable due to climate uncertainties, many young farmers view fisheries as a more dependable and income-assured livelihood. Given that over 95% of Assam’s population consumes fish, there is also strong domestic market demand.

While 68% of respondents cite fish farming as their primary income source, their engagement is not always driven by high profitability alone. The practice is often rooted in familial tradition and occasional government training and support programs that make it an accessible livelihood option.

Unlike other seasonal occupations, fish farming in Assam is practiced year-round. However, farmers often pursue multiple livelihood activities simultaneously—such as paddy cultivation, piggery, poultry, goat or duck rearing—not because fisheries are insufficient, but to diversify income streams and build financial resilience.

Pradhan Mantri Matsya Sampada Yojana (PMMSY): Launched by the Government of India, PMMSY aims to enhance fish production, infrastructure, and livelihoods in the fisheries sector. It focuses on sustainable development, value chain strengthening, and post-harvest management

Chief Minister's Samagra Gramya Unnayan Yojana (CMGUY): CMGUY is a flagship scheme by the Government of Assam to double farmers' income by 2022 through holistic rural development. It supports fisheries through pond construction, input support, and infrastructure enhancement.

Rashtriya Krishi Vikas Yojana (RKVY): RKVY is a centrally sponsored scheme designed to incentivize states to increase public investment in agriculture and allied sectors. It provides financial assistance for innovations, infrastructure, and capacity building in fisheries.

Key Pain Points in Value Chain Operations:

Seed sourcing: 70% of respondents rely heavily on middlemen for procuring fish seed, which creates multiple challenges across the value chain. This dependency limits farmers' ability to trace the source or assess the quality of the seed, often resulting in poor survival rates. It also strips them of any control over pricing. The added transportation from distant states like West Bengal or Odisha further escalates costs. As a result, farmers are left with expensive, low-quality seed and minimal bargaining power— ultimately affecting productivity and profitability.

Feed practices: Feed management emerges as a major constraint for fish farmers. Most farmers rely on a mix of in-house formulations and commercial feed, typically used without any technical guidance. This leads to nutrient-deficient and inefficient feeding practices, resulting in a high feed conversion ratio (FCR) and inflated production costs. Commercial feed, despite being one of the most expensive inputs in aquaculture, often lacks proper certification or quality assurance. With feed costs comprising a large portion (almost 1/3rd) of the farmers' investment with little guarantee of returns, profitability is severely compromised.

Power supply: Frequent outages interrupt crucial activities like aeration, feeding, and drainage systems—raising operational costs, and causing variances in temperature and feed time which increases fish stress and mortality risks.

Most farmers rely on pond-based culture and sell their produce directly to consumers or through local markets. While some areas like Barak Valley fetch better prices for live fish, processed fish retains a minor share of overall production. As a result, farmers' incomes are closely tied to local demand and price fluctuations for fresh fish, limiting their ability to benefit from value addition and broader market opportunities. Expanding processing infrastructure and market linkages could help diversify income sources and improve economic resilience for fish farmers in the region. Wastewater management practices are poor, and water quality monitoring is inconsistent. Disease outbreaks are common, yet farmers lack training in prevention and treatment.

The impact of climate change is evident. Rising water temperatures, erratic rainfall, and frequent flooding affect fish habitat, health, infrastructure, and income stability. Mortality rates in some zones reach as high as 20%. Though awareness of these issues is growing, adoption of mitigation strategies—such as raised pond embankments, aeration systems, and water-quality diagnostics—remains low due to financial and technical barriers.

The study underscores that while fish farming in Assam remains rooted in tradition and accessible livelihood practices, it is also evolving into a more strategic and resilient economic activity. Key constraints such as dependence on middlemen for inputs and marketing of farm produce, lack of technical advisory, poor water management, and vulnerability to climate impacts continue to affect productivity and profitability. However, the presence of motivated youth, growing demand for fish, and gradual exposure to improved practices present an opportunity to transform the sector. Strengthening institutional linkages, decentralizing access to quality inputs and fish, and enabling adoption of climate-resilient infrastructure and technologies will be critical. With coordinated ecosystem support, Assam's fisheries sector can scale up from informal subsistence models to sustainable and scalable enterprises—anchoring both livelihood security and climate adaptation for rural communities.

Chapter 1

Introduction

Fisheries and aquaculture are critical pillars of food systems, nutrition security, and rural livelihoods across India and the world. In India, they support the livelihoods of over 28 million fishers and fish farmers, with nearly twice that number engaged in activities across the fisheries value chain—from hatcheries and input supply to processing and marketing. Beyond their economic significance, fish serve as a vital source of high-quality animal protein, essential fatty acids like omega-3, and key micronutrients, playing a central role in improving dietary diversity and addressing hidden hunger, especially among vulnerable and low-income communities. As the demand for sustainable and nutritious food continues to rise, the fisheries sector is increasingly recognized for its potential to drive inclusive development, enhance food systems resilience, and contribute meaningfully to national and global nutrition goals.

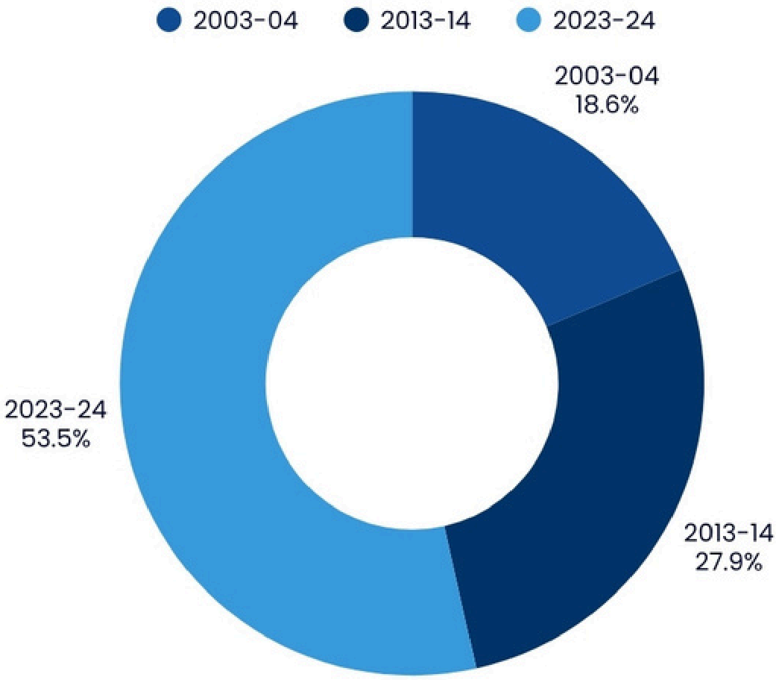


Figure 1.1: Overview of Fisheries Sector in India

At a global scale, India is the third largest fish producing country, contributing 8 percent to the global fish production. Additionally, India ranks second in aquaculture production Beyond its importance to local and global nutrition systems, fishing in India is a major sector within the national economy of India contributing 1.07% of the country's total GDP.

1.1 Indian Fisheries: Challenges and the Path to Sustainable Aquaculture

Fisheries in India play a critical role in ensuring food security, livelihood generation, and contributing to the rural economy. With a vast network of rivers, coasts, and inland water bodies, capture fisheries, which involves harvesting fish from natural ecosystems such as rivers, lakes, and seas, remain an essential part of thissector. However, they are increasingly under threat due to overfishing, pollution, habitat loss, and climate-induced disruptions. These pressures are leading to a decline in fish biodiversity and putting the livelihoods of traditional fishing communities at risk. To ensure long-term sustainability and reduce the dependency on marine culture and overfishing, there is a growing need to strengthen inland fisheries and aquaculture systems, the process of breeding, rearing, and harvesting shellfish, fish, algae, and other organisms in all types of water environments which offers a more controlled and regenerative approach to fish production while easing the burden on wild fish populations.

Aquaculture, often called "aquafarming," is the aquatic equivalent of agriculture, but instead of cultivating crops or raising livestock on land, it's done in water – whether freshwater or saltwater.

The Multifaceted Role of Aquaculture:

- **Food Security:** Ensures a stable food supply for communities
- **Employment:** Provides jobs for men and women in the industry
- **Economic Contribution:** Generates income for local and national economies
- **Environmental Impact:** Involves species restoration and habitat enhancement

Aquaculture plays a crucial role in ensuring food security, improving nutrition, and fostering sustainable livelihoods for both coastal and inland communities. for human consumption but also generates employment across its value chain and contributes substantially to the global fish supply. From small household ventures to large multinational enterprises, aquaculture supports food production, species restoration, and the enhancement of wild fish populations. It encompasses a wide range of technologies, from low-tech methods to highly mechanized systems that employ advanced feeding, harvesting, and processing techniques—ensuring year-round availability and nutritional security.

Fisheries in Assam

Fisheries in Assam are deeply woven into the state'ssocial, cultural, and economic fabric. With its vast network of rivers, wetlands, ponds, and floodplains, Assam has traditionally relied on inland fisheries not only for sustenance but also as a way of life. Fishing is an important livelihood activity for many rural households, and fish holds cultural significance in Assamese rituals, festivals, and cuisine—often symbolizing prosperity and well-being. Beyond cultural value, the fisheries sector in Assam contributes significantly to the broader Indian aquaculture system. As one of the top fish-producing states in NortheastIndia, Assam plays a vitalrole in enhancing food security, generating employment, and driving regional trade in aquatic products. Its growing focus on sustainable aquaculture, seed production, and integration of renewable energy into fisheries infrastructure makes it a model for inclusive and climate-resilient fish farming in the country.

1.2 Natural Resources for fisheries in Assam

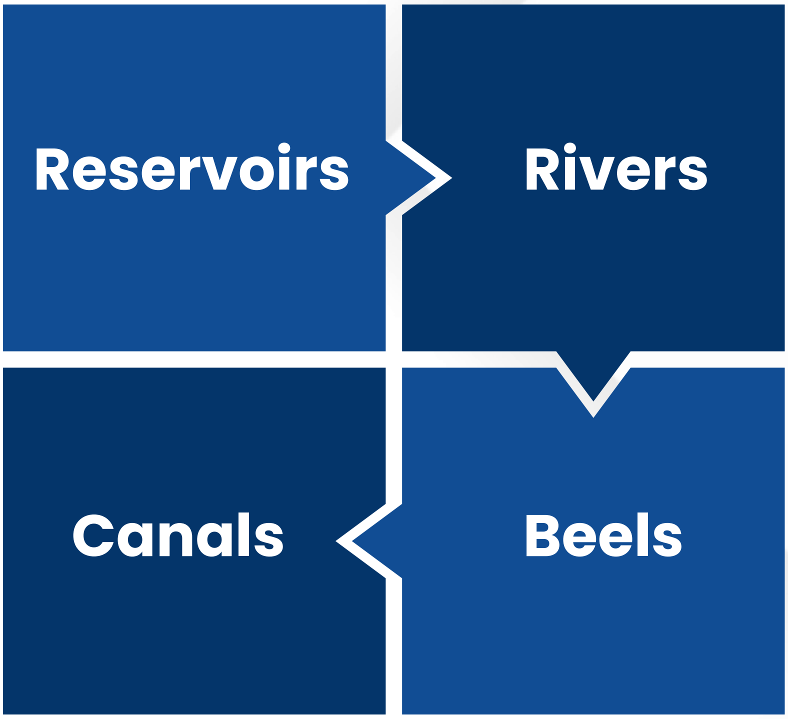


Figure 1.2: Fishery Resources in Assam

Assam, the largest source of wetlands in North-eastern India, is rich in fishery resources, particularly beels (oxbow lakes), which are abundant along the Brahmaputra, and Barak rivers. These wetlandssupport diverse indigenous fish species and are crucial for fisheries in Assam, West Bengal, Bihar, Uttar Pradesh, and Manipur. The Kamrup district has the highest number of beel fisheries, followed by Cachar. Assam also boasts significant river and forest fisheries, covering over 167,000 hectares and 4,835 hectares, respectively, contribute to its overall fishery resources.

The details of resources pattern in Assam with water spread in area is provided in the below:

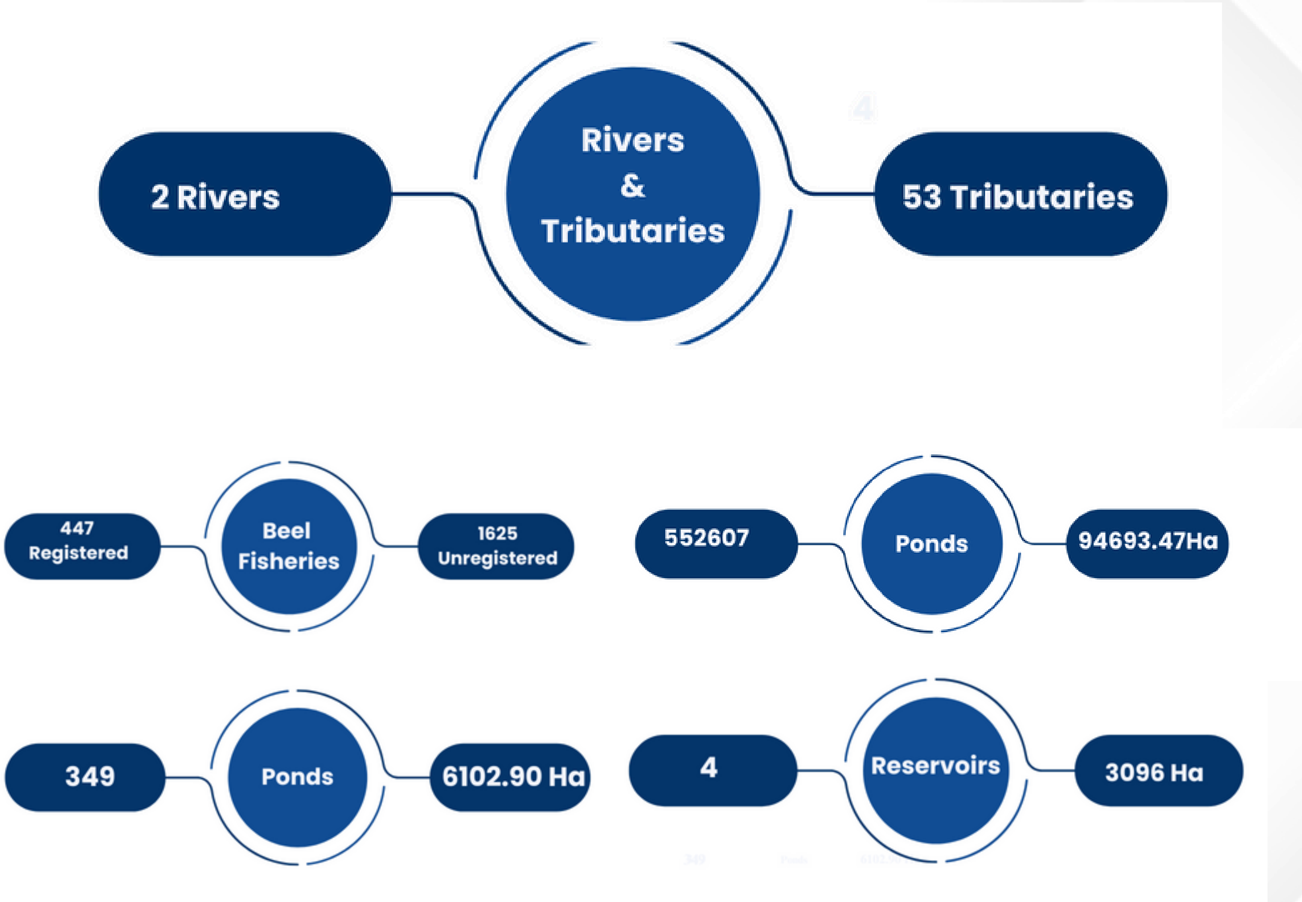


Figure 1.3: Fishery Resources in Assam

1.3 Fishery Sector in Assam at a Glance

The fishery sector in Assam is one of the key contributors to the state's economy and plays a vital role in providing employment, ensuring food security, and supporting rural livelihoods. Assam, with its abundant natural water bodies, has significant potential for the development of both inland and aquaculture-based fisheries. Here's an overview of the sector:

Production Trend:

Fish production in Assam has seen significant growth, nearly doubling from 2.94 lakh metric tonnes in 2016–17 to 4.43 lakh metric tonnes in 2022–23. This upward trend reflects the state's increasing focus on inland fisheries and aquaculture to meet rising demand.

Fish Consumption:

Approximately 35% of India's population consumes fish, with the current national per capita fish consumption at 9.8 kg, which is below the recommended 13 kg. Assam is nearing selfsufficiency in fish production, with per capita fish consumption at 11.72 kg, indicating a strong fish-eating culture and growing local availability.

Fishing Gears:

Traditional fishing in Assam involves a variety of locally made gear, including bamboo traps, cast nets (Seppa), Gill nets (Fasi Jaal), and wicker or cone-shaped baskets (Khaloi). These are often used with traditional fishing boats, reflecting the region's rich fishing heritage and dependence on riverine resources.

Livelihood and Employment:

The fisheries sector is a major source of livelihood in Assam. Employment spans fish production, input supply, fishing, fish farming, processing, marketing, and distribution, engaging a wide range of individuals and contributing to rural income and food security.

Value Addition of Fish:

Value addition enhances the market value of low-value fish and creates new job opportunities. While fresh fish remains the most preferred, value-added fish products such as dried, pickled, or packaged fish are gaining traction in supermarkets and urban retail spaces.

Fish Marketing in Assam:

Assam sees high demand for fresh Indian major carps, particularly in urban areas. Guwahati acts as a major distribution hub for fresh fish, while Jagiroad in Morigaon district is home to Asia's largest dry fish market, serving not only the state but also the broader Northeast region.

1.4 Importance of Fisheries in Assam Economy

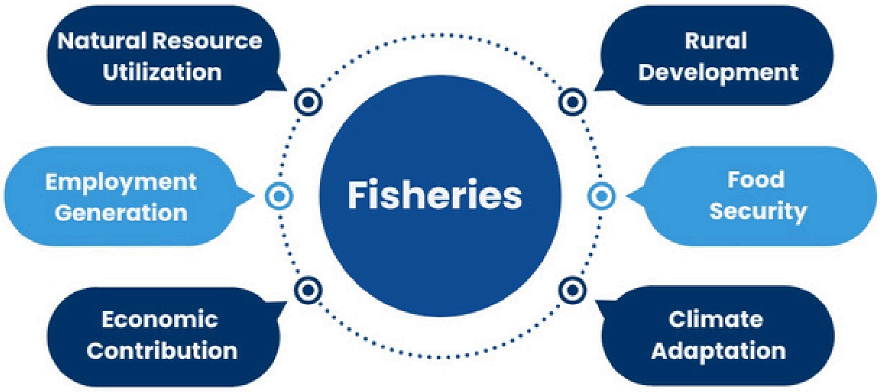


Figure 1.4: Contribution of Fisheries to Assam's Development

The fishery sector is a crucial component of Assam's economy, contributing significantly to the livelihoods, food security, and socio-economic development of the state. The following points outline the key aspects of the fishery sector's importance in Assam's economy:

Theme	Key Points
Sustainable Livelihoods and Rural Development	• The fishery sector supports rural development by providing an alternative livelihood to agriculture, especially in flood-prone areas. • It offers a sustainable income source for small and marginal farmers who rely on fish farming as a supplementary activity alongside crop cultivation.
Food Security	• Fish is a rich source of protein and essential nutrients, making it a dietary staple for many Assamese household • Fisheries play a crucial role in enhancing food security in Assam by supplying affordable and nutritious food to the population.

Adaptation to Climate Change

- Floodplain wetlands and beels act as natural reservoirs, absorbing excess rainwater during floods and supporting fish habitats, ensuring continuous production during agricultural disruptions.
- As the state experiences frequent floods, fisheries provide a way for communities to diversify their income and reduce their vulnerability to agricultural losses.

Contribution to the GDP and State Economy

- The fishery sector contributes over 2% to Assam's Gross Domestic Product, reflecting its significant role in the economic structure.
- With increasing production rates, Assam has established itself as the 7th largest growing inland producer in India.

Employment Generation

- The fishery sector is a key source of livelihood, providing employment to millions of people, especially in rural areas.
- This sector supports marginalized and economically disadvantaged communities and offers an alternative income source in agriculture-based regions.

Utilization of Natural Resources

- Assam is endowed with vast natural water resources, including rivers like the Brahmaputra and Barak, as well as numerous ponds, lakes, and floodplain wetlands (beels)
- The proper utilization of these rsources through sustainable fish farming practices boosts the local economy while conservation aquatic biodiversity.

Food Security

- The Government of Assam is supporting fish farmers through targeted schemes such as PMMSY, CMSGUY, and APART, which fund pond development, fish seed hatcheries, mini feed mills, and post-harvest infrastructure like insulated ice boxes and refrigerated vehicles.
- Additionally, training programs on Biofloc, Recirculatory Aquaculture Systems (RAS), aquaculture nutrition, and integrated farming systems are conducted in collaboration with KVKs, NFDB, and the College of Fisheries, Raha.
- The state is also promoting Fish Farmer Producer Organizations (FFPOs) to facilitate collective input procurement, market linkage, and credit access.

1.5 Objectives of the Study

The details of resources pattern in Assam with water spread in area is provided in the below:

- To understand the fishery sector dynamics in Assam
- To evaluate the existing infrastructure, facilities, and resources available for fish production, processing storage, transportation, and marketing across differentregions of Assam
- To identify key challenges, constraints, bottlenecks, and gaps in the fisheries value chain.
- To explore existing and emerging technologies and innovations relevant to the fisheries value chain.
- To document and disseminate best practices,successstories, case studies, and lessons learned from interventions and initiatives aimed at promoting sustainable fisheries value chain in Assam.

The above have been explored using both primary and secondary methodologies, hinged on engagement with key stakeholders in the fishery value chain in Assam.

1.6 Scope of the Study

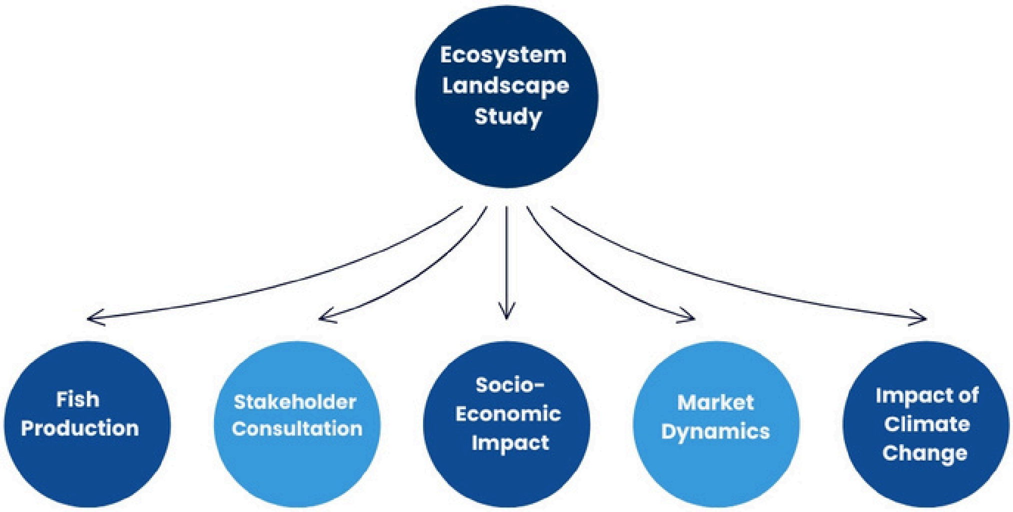


Figure 1.5: Scope of the Study

The scope of the study regarding the fishery value chain in Assam focuses on analyzing the entire process from fish production to market delivery, covering both freshwater and value-added fish products. It includes an assessment of the key stages such as fish farming, harvesting, postharvest processing, transportation, and distribution. The study examines the role of various stakeholders, including fish farmers, traders, and government agencies, and their influence on the value chain. Additionally, it evaluates the socio-economic impact of fisheries on local communities, the infrastructure supporting the sector, and market dynamics, including pricing and consumer demand. Challenges such assupply chain inefficiencies, resource management, and climate-related risks are also addressed, alongside potential opportunities for innovation and policy support aimed at strengthening the sector. Additionally, the study investigates the challenges posed by climate change and floods, which severely impact the fishery sector. Floods disrupt fish habitats, damage infrastructure, and affectfish farming productivity, while climate change brings unpredictability in water availability and quality, affecting overall fish yields. The study aims to identify solutions for building resilience in the fishery sector against these climate-induced risks.

Chapter 2

Methodology

2.1 Research Design

The current research utilizes both primary and secondary data to meet its objectives. Prior to conducting the field survey, the research team engaged in thorough planning, which involved reviewing existing literature to build a theoretical foundation. After data collection, the next phase is data analysis, where the collected information is organized, tabulated, and scrutinized. A mixed-method approach of both quantitative and qualitative survey was used to conduct the study. The data was collected in the form of a structured questionnaire, interview schedule, and focused group discussions.

2.2 Research Tool

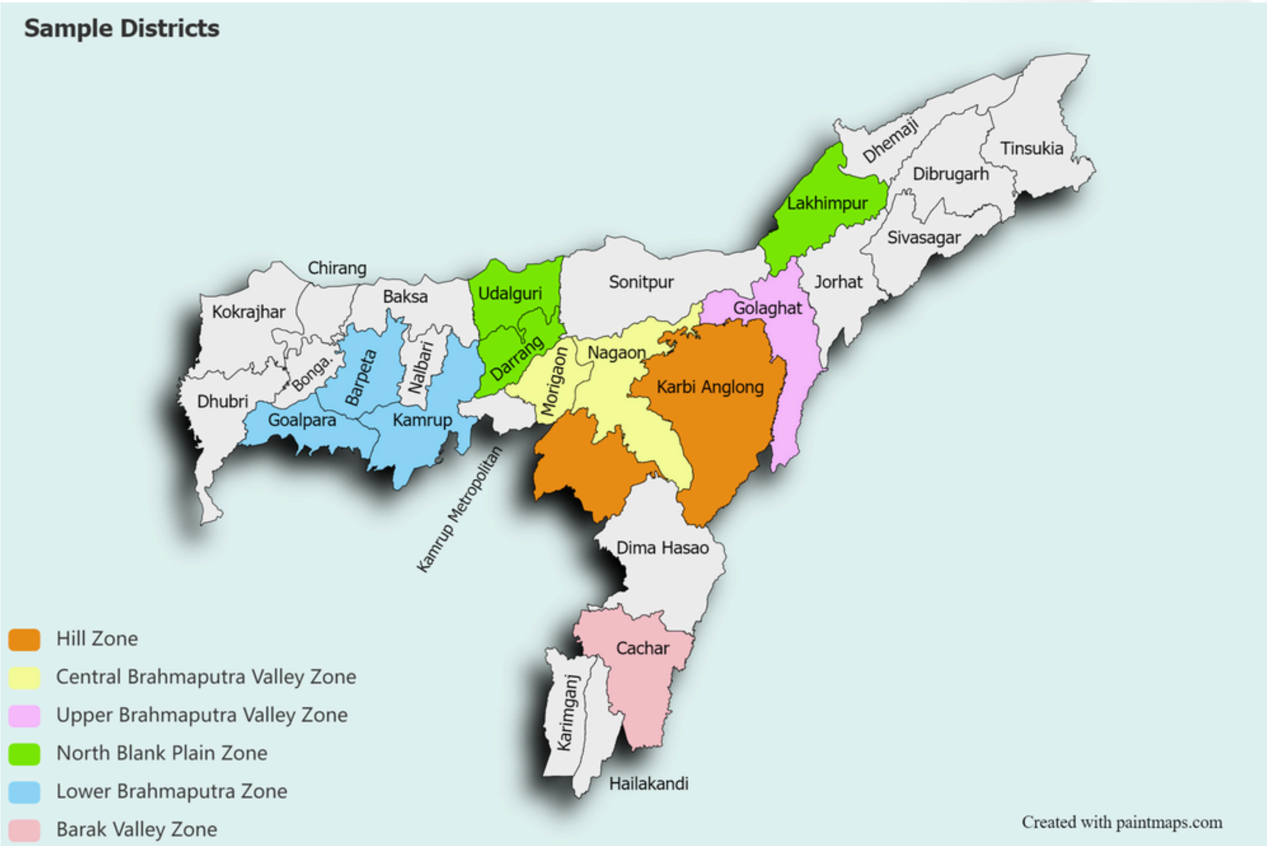
The technique allowed for comprehensive data collection across various aspects of fishery activities, with primary data offering direct insights from the selected districts. It covers various aspects of value chain of fishery sector in Assam, including ecosystem components, climatic effect, technologies, government schemes and the challenges faced by the fishermen and farmer producer organizations (FPOs) and farmer producer company (FPC) members. A structured questionnaire and an interview scheduled based on pre-identified key indicators used to collect the data. Both the tools contain single response, multiple response, and open-ended questions. A discussion guidewas also prepared to conductfocus group discussions (FGDs). The target respondents for the study were FPO/FPC in-charge and other members.

Figure 1.5: Scope of the Study

S.NO	Type of Data	Respondent	Tools
1	Primary Data	FPO/FPC Members	Questionnaire
2	Primary Data	FPO/FPC In-charge	Interview Schedule
3	Primary Data	Group discussion with FPO/FPCmembers	FGD Guide

2.3 Geographical Coverage

This segmentation is important as it allows for the identification of areas with the greatest potential for fish production and the implementation of targeted interventions to improve productivity and sustainability. Selecting districts based on their agro-climatic zones in a fishery ecosystem landscape study is critical to capturing the full range of ecological, environmental and socioeconomic factorsthat influence fish farming. It ensures that the study'sfindings are comprehensive, region-specific, and can beused todesign sustainable fishery practicesthat accountfor the diversity of Assam's ecosystems.



2.4 Sample Size

The procedure to determine sample size depends on the proposed research design characteristics, including the nature of the study's outcome of interest. The following is the sample size of different respondents for the study.

Table 2.2: Agro-climatic Zones and District-wise Sample Distribution

S NO.	AGRO-CLIMATIC ZONE	DISTRICTS	TOTAL SAMPLE SIZE
1	Barak Valley Zone	Cachar	13
2	North Bank Plain Zone	Lakhimpur Darrang Udalguri	13 13 13
3	Upper Brahmaputra Valley Zone	Golaghat	15
4	Central Brahmaputra Valley Zone	Morigaon Nagaon	13 15
5	Lower Brahmaputra Valley Zone	Kamrup (Rural) Barpeta Goalpara	13 15 15
6	Hill Zone	West Karbi Anglong	13
	TOTAL		151

However, during the survey conducted in both Barpeta and Goalpara districts, the number of FPC (Farmers Producer Company) members present at the time was comparatively lower than the targeted sample size. As a result, the survey included fewer members than initially planned, which may have impacted the representativeness of the data collected.

Chapter 3

Socio-Economic Profile

A socio-economic demographic profile referst o the detailed description and analysis of a population based on various socio-economic and demographic factors. This becomes important to understand the vulnerability and risk profile of the end user which is pertinent to choosing implementation pathways that account for risks associated with felt problem. The socioeconomic profile of fish farmers is multifaceted, encompassing a wide range of factors such as age, income, education, market access, and environmental conditions. Understanding these characteristics is essential for supporting the aquaculture industry and improving the livelihoods of fish farmers.

3.1 Age

The ages of fish farmers in the study range from 26 to 74 years, with an average age of 44.4 years, indicating a diverse age group in the sector. While many farmers are in their middle years, the presence of both younger and older farmers suggests a blend of experience and active involvement in fish farming.

3.2 Occupation

All of the respondents in the study are fish farmers, indicating that their primary occupation revolves around the cultivation of fish through aquaculture practices. This shared occupation highlights a common focus on fish farming as their main source of livelihood. The respondents' involvement in this sector suggests a deep reliance on aquaculture for income, food security, and the welfare of their families and communities. Many of the respondents also practice agriculture as a secondary activity, using it to supplement household needs and diversify income. In several households, women play a key role in managing fish farms while also tending to kitchen gardens and small-scale horticulture activities, further contributing to food security and household resilience.

3.3 Gender

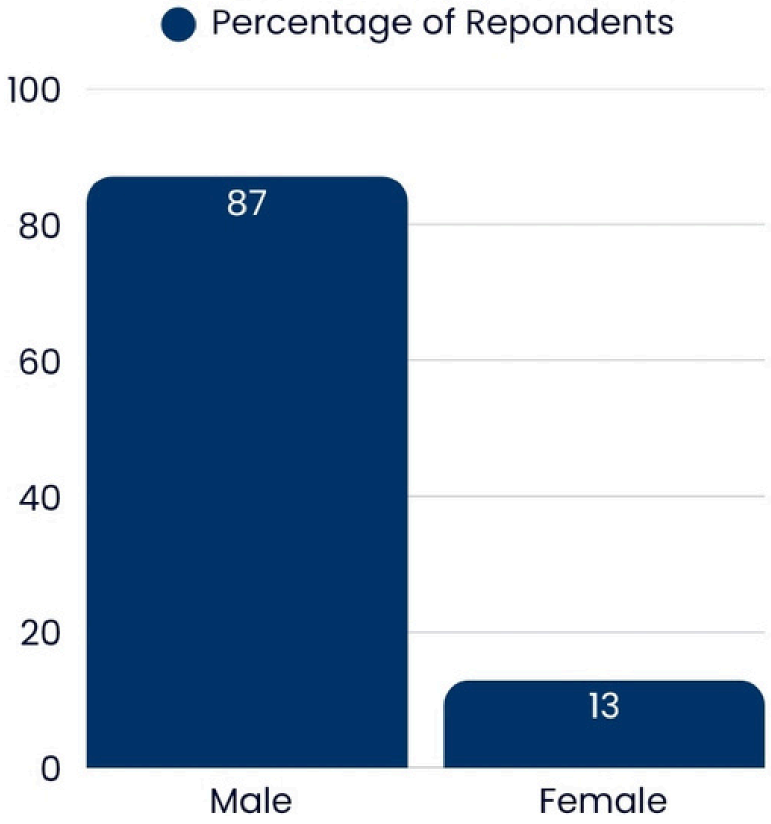


Figure 3.1: Gender Distribution of the Respondent Fish Farmers

The gender distribution of fish farmers shows a significant male dominance, with 87.07% of respondents being male and only 12.93% female. This reflects a broader trend of limited female participation in fish farming, often influenced by cultural, social, or economic factors.

Fishery as a Source of Income in Assam

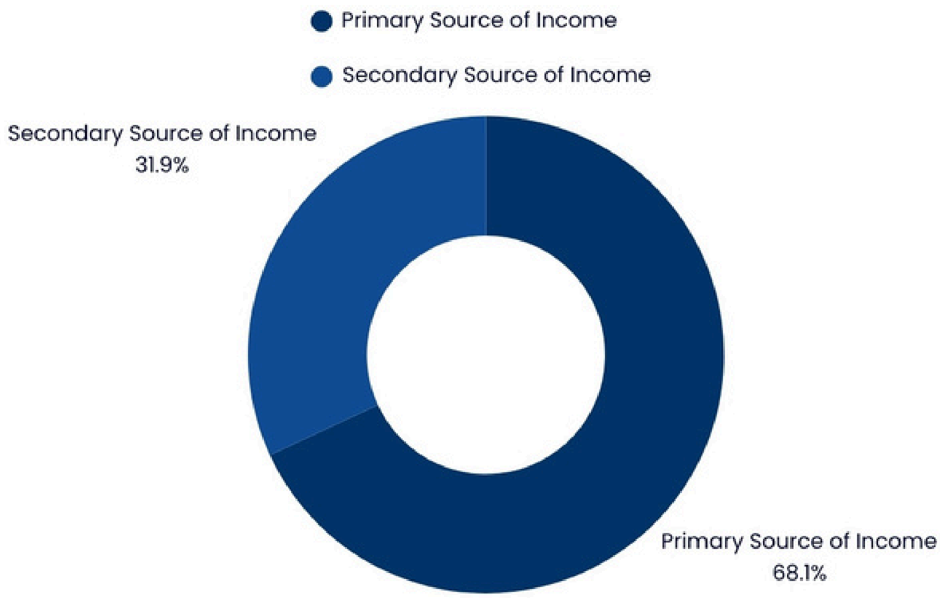


Figure 3.2: Distribution of Fishery as a Source of Income

The data shows that 68.10% of respondents rely on fish farming as their primary income source, highlighting its importance to their financial stability. In contrast, 31.90% consider it secondary income, indicating they supplement their earnings with other activities. Thisreflects varying levels of dependence on the fishery sector.

3.4 Motivations for Initiating Fish Farming

Most respondents reported taking up fish farming primarily for economic reasons, with 86.21% aiming to increase their income. In addition, 37.93% identified improved food security as a motivating factor, while 34.48% cited other reasons, including cultural practices. Fisheries have historically played a vital role in the livelihoods of communities in Assam, particularly those living near rivers, wetlands, and floodplains. The knowledge and skills related to fish cultivation and capture have been passed down through generations, supporting both household nutrition and income. These practices continue to be a primary occupation for many rural families, underscoring a long-standing dependence on aquatic resources. Moreover, 25% of respondents viewed fish farming as a means to diversify their income, indicating that income generation, food security, and livelihood diversification are key drivers for adopting aquaculture.

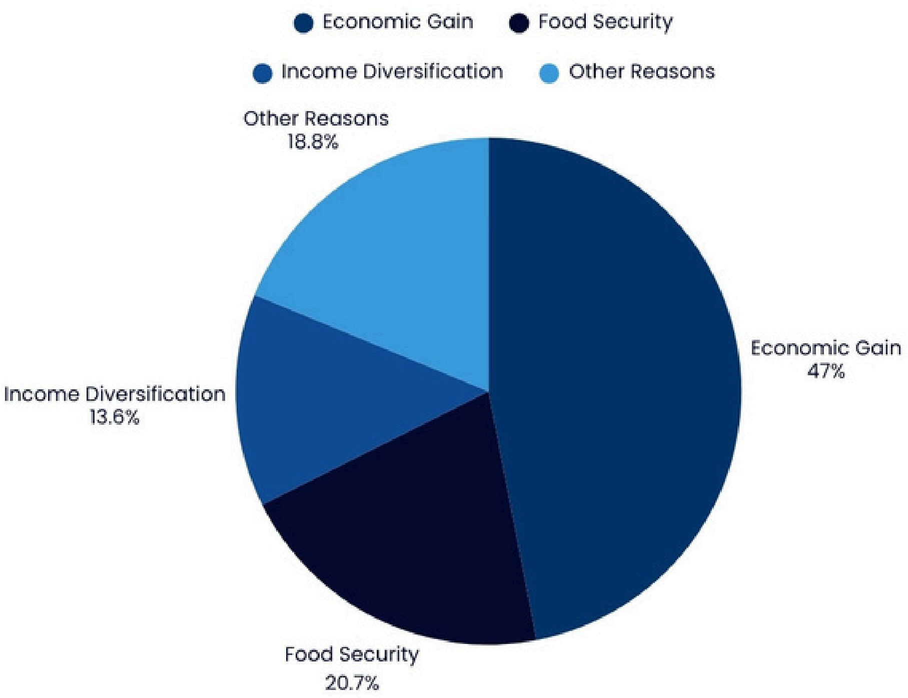


Figure 3.3: Reason for Starting Fish Farming

3.5 Type of Aquaculture Practices

The data reveals that 100% of respondents exclusively engage in pond culture for fish farming, with no adoption of alternative aquaculture methods or value-added activities. This indicates a clear preference for traditional, low-tech approaches, likely shaped by factors such as resource availability, scale of operations, and limited access to advanced technologies or markets. The absence of practices like Biofloc, Recirculatory Aquaculture Systems (RAS), fish processing, or organized marketing further underscores a dependence on basic, natural systems for production. This reliance reflects not only the entrenched nature of conventional methods but also points to systemic barriers—such as lack of awareness, technical knowledge, infrastructure, or financial support—that inhibit the uptake of more diversified and technology-driven practices. Subsequent sections of the study explore these constraints in greater detail, offering insights into the persistent challenges in transitioning toward modern aquaculture.

3.6 Variety of Fish Cultured, Processed and Marketed

The varieties of fish cultured, processed, and marketed by the respondents were highly diverse, with a wide range of species mentioned across different groups. Common species include Rohu, Catla, Grass carp, and Common carp, which appear repeatedly as primary fish in the respondents' farms. Other notable species include Bicket, Mirika, Silver carp, Chital, and Rupchanda, among many others. Some respondents also process and market a mix of these fish, including rarer types like Koi, Bahu, Magur, and Bhokua. The data suggests that fish farmers are cultivating a broad array of both indigenous and exotic species, reflecting the region's rich aquaculture practices and diverse market preferences. This wide variety likely caters to different consumer demands and regional tastes, making the sector adaptable and multifaceted.

3.7 Integrated Resource Management

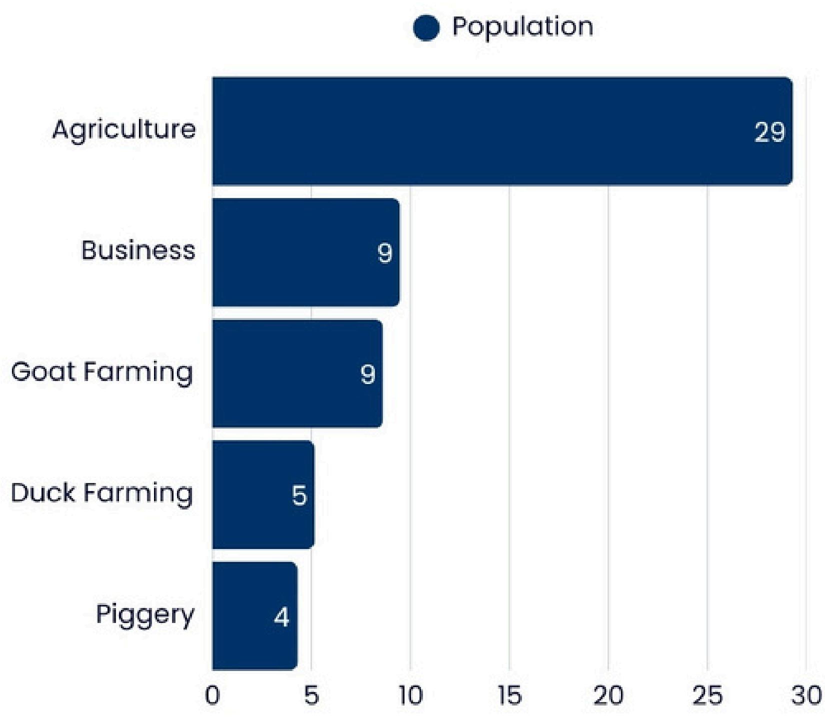


Figure 3.7: Diversification of Livelihoods

The figure shows the other livelihoods combined with fishery activities. The majority of respondents (29.3%) also engage in paddy cultivation, followed by business activities at 9.5%. Smaller percentages of farmers are involved in goat farming (8.6%), duck farming (5.2%), and piggery (4.3%). This indicates that while fishery is a primary livelihood, many farmers diversify their income sources by integrating other agricultural and livestock activities.

Alongside fish farming, farmers typically engage in small-scale livestock farming and moderate-scale paddy cultivation, contributing to their diversified livelihoods. The table provides the average herd sizes and land cultivation area for different activities. On average, farmers keep 5 goats and 7 pigs per household. Additionally, the average area for paddy cultivation is 5.28 bigha.

Activities like paddy cultivation and livestock farming help optimize resources. The fish farmers were asked how they utilize these integrated livelihoods along with fisheries.

Integrated fish farming systems offer multiple ecological and agricultural benefits by promoting efficient use of resources. Livestock manure fertilization plays a key role, as manure from livestock is used to enrich both fishponds and rice fields. This, in turn, contributes to improved soil health, with fish waste acting as a natural fertilizer for rice crops. Additionally, such systems support land and water efficiency by combining fish farming with paddy cultivation, maximizing the use of available resources. These practices foster ecosystem balance through closed-loop systems that repurpose waste to maintain environmental stability. Ultimately, this model promotes resource efficiency by reducing waste and encouraging sustainable agriculture.

Figure : 3.8 Utilization of Integrated Livelihoods along with Fisheries

Chapter 4

Fishery Value Chain Analysis

A livelihood value chain refers to the interconnected series of activities and processes that are involved in providing goods and services to support the livelihoods of individuals or communities within a sector. This includes everything from the production and processing of raw materials to distribution, marketing, and consumption. The concept emphasizes understanding how different stakeholders and activities connect to enhance the economic viability of specific livelihoods, particularly in underserved or marginalized communities. The study on value chains is intended to achieve comparative advantage through cost minimization and attaining consumersatisfaction. It isthe preliminary step in the mapping of market. The aim of value chain studies is to identify cost effective value chains for the actors separately or for the whole value chain. The study delves deeper into: The maturity of the actors and their motivations. The nodes within the value chain are the interactions and the status of those interactions throughout the value chain.

4.1 Fishery Value Chain

The fisheries and aquaculture value chain encompasses the entire spectrum of activities involved in the production, processing, and marketing of fish and aquaculture products. This value chain is essential for enhancing food security, providing income, and supporting livelihoods for millions of people globally

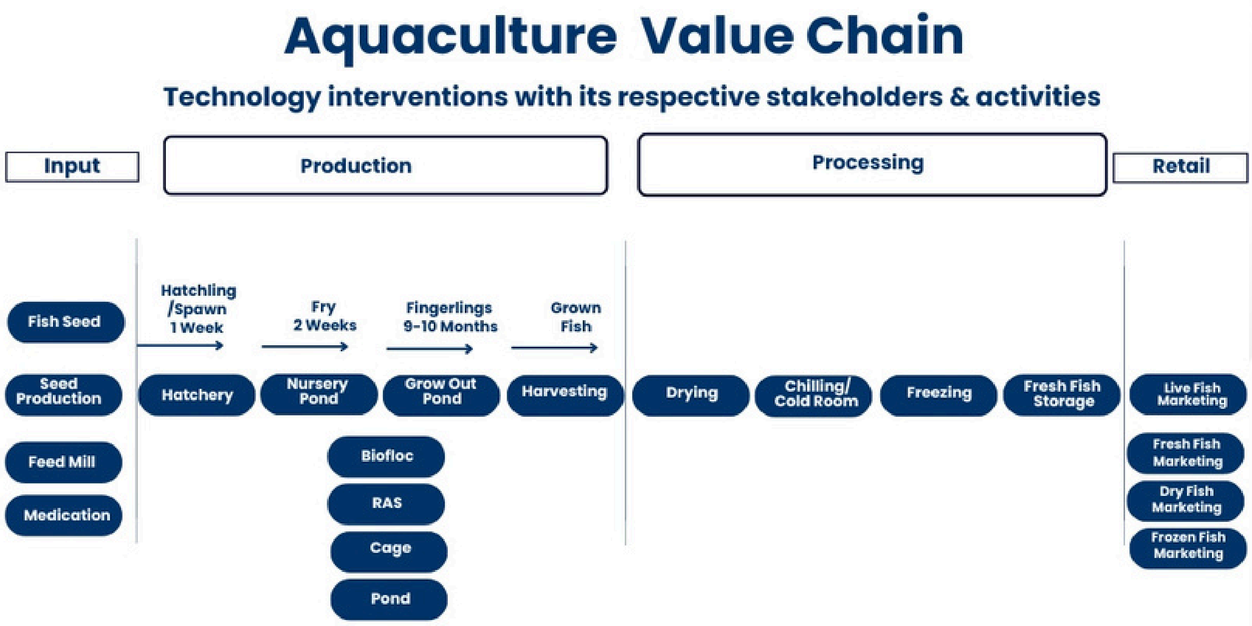


Figure 4.1: Fishery Value Chain

The objective of this chapter is to provide a detailed analysis of the value chain of the fishery sector. It provides data on the types and volumes of fish cultivated and harvested, as well as seasonal availability patterns. Economic analysis includes cost breakdowns, pricing trends, and income generation, highlighting the sector's contributions to local economies. Understanding value chain dynamics involves examining input suppliers, processing facilities, and distribution channels. This section comprises the information gathered through the survey of the individual fish farmers, FPC in-charge, and through FGDs with fish farmers. The research tool comprised both closed-ended and open-ended questions involving both qualitative and quantitative analysis.

4.2 Input

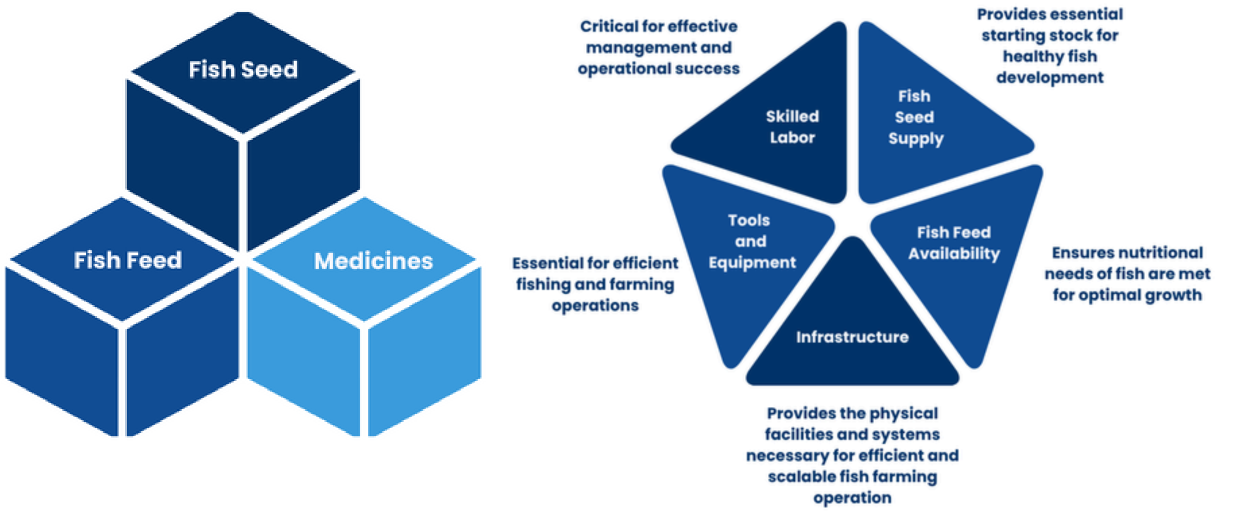


Figure 4.2: Fishery Input Value Chain

4.2. Source of Seeds

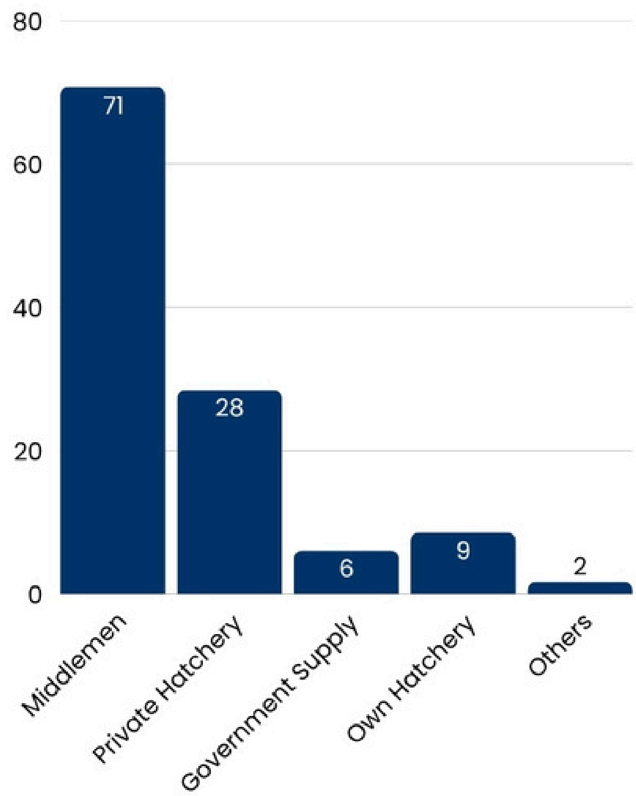


Figure 4.3: Distribution of Source of Seeds

The respondent fish farmers were asked about the procurement of fish seeds, as the source, availability, and quality of seeds play a critical role in determining the success of aquaculture operations. The data revealed that many farmers (70.69%) procure seeds from middlemen, followed by 28.45% who source them from other farmers' hatcheries, 6.03% from government supply, while only 8.62% of farmers own hatcheries. An additional 1.72% procure from informal sources such as hawkers selling fish seeds on motorbikes, a practice similar to vegetable vending in urban areas. Middlemen play a central role in the seed supply chain, especially in remote and rural areas where direct access to hatcheries is limited. While they bridge the gap between hatcheries and farmers by delivering seeds closer to the point of use, this convenience often comes at a cost.

Middlemen typically add a margin to the seed price, which can reduce farmers' profit margins. Additionally, farmers have limited control over seed quality when purchasing through intermediaries, which may lead to poor survival rates or reduced productivity if the seeds are of substandard quality. Not all farmers can operate their own hatcheries due to several constraints. Setting up and managing a hatchery requires substantial initial investment, technical know-how, reliable power supply, and consistent access to quality broodstock—all of which are often unavailable to small or marginal farmers. Moreover, hatcheries demand regular monitoring, biosecurity measures, and trained manpower, making them impractical for individual ownership at scale. In many rural areas, remoteness and lack of infrastructure further hinder direct access to high-quality seeds, compelling farmers to depend on whatever sources—formal or informal—are available to them locally. Hence, the current seed procurement landscape reflects a combination of practical limitations and accessibility challenges, with middlemen continuing to play a dominant but mixed role in the aquaculture input supply chain.

4.2. Source of Feed

A diverse range of feed sources allows farmers to optimize fish nutrition while managing costs, thereby enhancing the efficiency and sustainability of aquaculture practices. It was found that 33.62% of the fish farmers use only in-house feed, followed by 16.38% who rely solely on commercial fish feed, and 29.31% who use a combination of both.

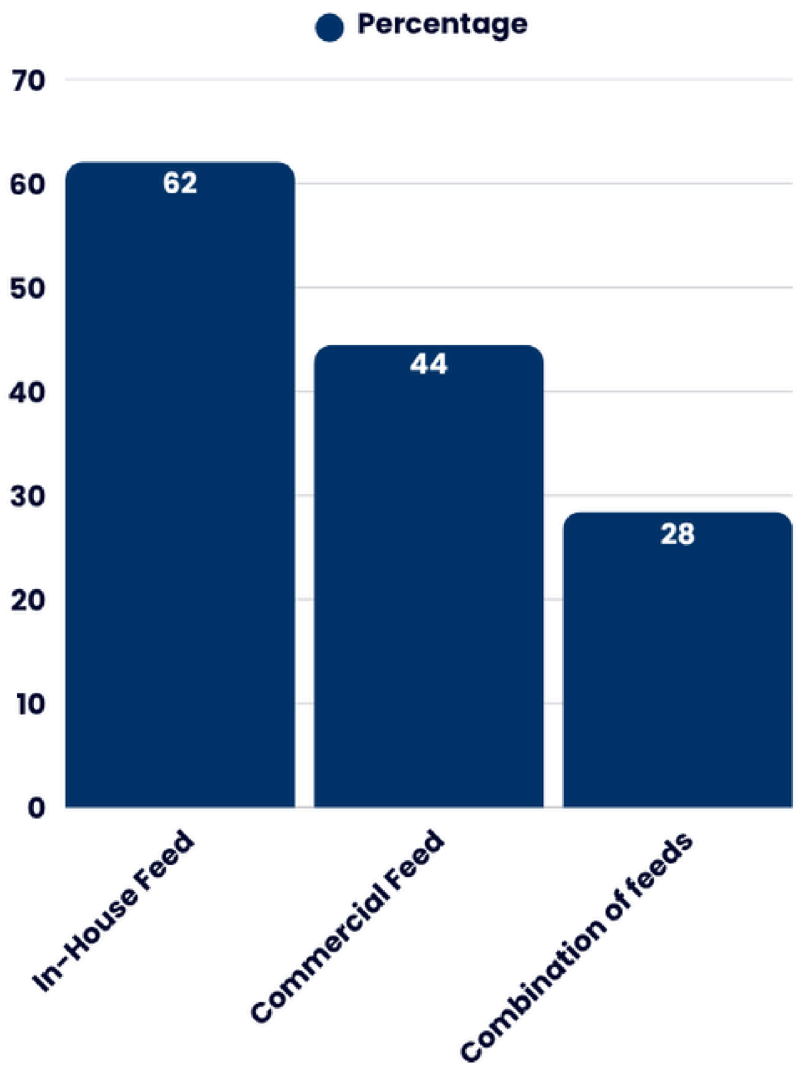


Figure 4.4: Distribution of Source of Feed

Moreover, the focused group discussion analysis of the general practices of feeding by the farmers has been provided in the table below:

Table 4.1: General Practices of Feeding in Different Agro-climatic Zones

Agro-climatic Zone	General Practices of Feeding
Upper Brahmaputra Valley Zone	• Rice bran, a by-product of rice milling is a nutritious supplementary feed rich in proteins,fats, and carbohydrates used in aquaculture. Pellets of various sizes and formulations cater to different fish species and growth stages, while powdered feeds are typically used for very young fish or fry unable to consume larger particles.
North Bank Plain Zone	• Farmers enhance commercial fish feeds with mustard oil waste, rich in protein, and paddy waste for added nutrients. They also use rice polish and balance seeds as supplements. Both sinking and floating feeds are utilized, with sinking feed catering specifically to bottom-feeding fish.
Central Brahmaputra Valley Zone	• Farmers use a mix of sinking and floating feeds, benefiting bottom-feeders with domestic options like mustard oil and paddy waste, while commercial feeds provide balanced nutrition for optimal fish growth. This combination helps manage costs while meeting the diverse nutritional needs of various fish species.
Hills Zone	• Farmers use cow dung, grass, fertilizers, and fish feed in aquaculture to boost pond productivity and fish health. Cow dung enriches water with nutrients, promoting beneficial microorganisms and plankton as natural feed. Grass provides additional nutrients and habitat, while fertilizers enhance ecosystem balance. Quality fish feed establishes a healthy population, supporting sustainable practices and maximizing yields.
Barak Valley Zone	• Fertilizers increase nutrient levels for a healthy ecosystem, while cow dung enriches the water, promoting beneficial mi- croorganisms and plankton. Grass provides additional nu- trients and habitat. Sinking feeds benefit bottom-feeders, ensuring food reachesthe pond floor,while floating feeds cater to surface feeders. This integrated approach enhances productivity and supportssustainable aquaculture.

4.2. Average Frequency of Feeding

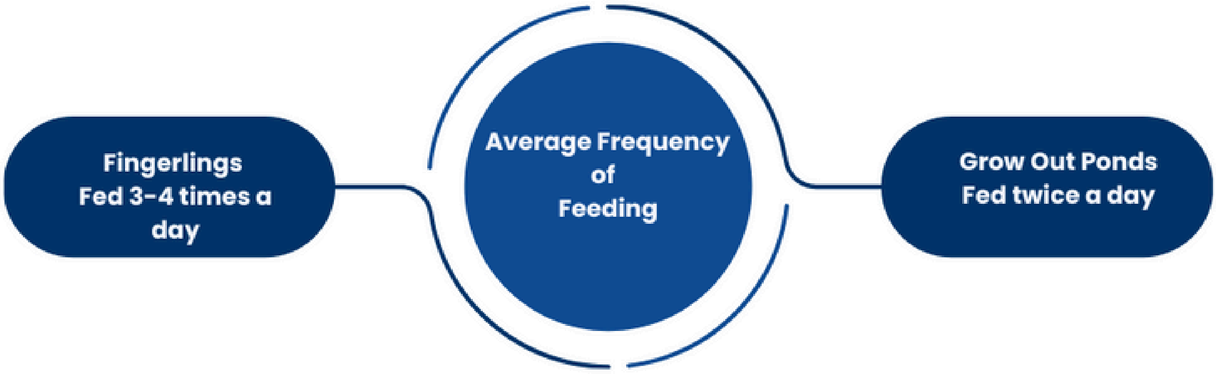


Figure 4.5: Average Frequency of Feeding

The fish growers reported that they feed their fish an average of twice a day. This feeding frequency helps ensure that the fish receive adequate nutrition for optimal growth while managing feed efficiency. However, fingerlings are usually fed 3-4 times a day, as their dietary needs increase, and they can start to handle larger feed particles.

4.2. Cost Associated with Input

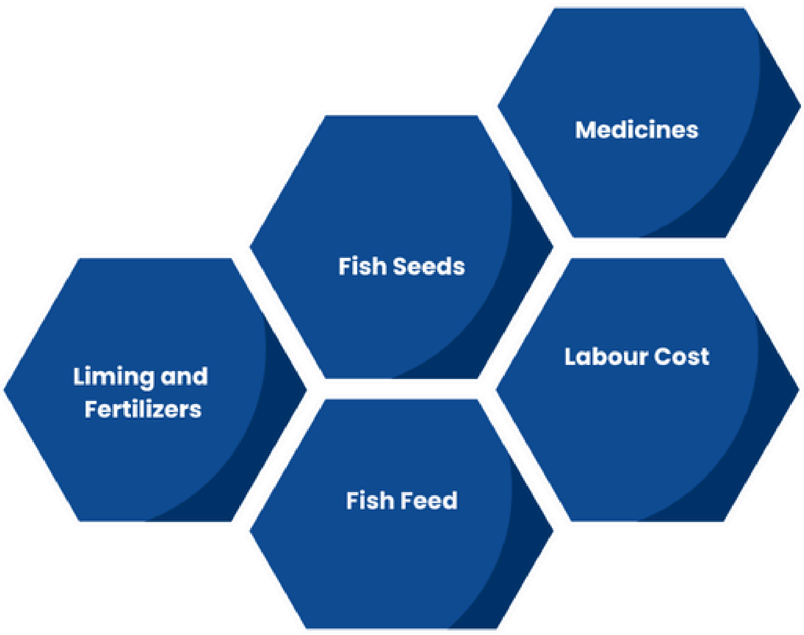


Figure 4.6: Cost Associated with Input

Fish farming involves various costs, including fish seeds, feed, liming and fertilizers, medical treatments, and raw materials like equipment. Labor costs coverstaff and outside workers, while miscellaneous expenses include consultancy, conveyance, and communication. Managing these diverse costs is essential for ensuring profitability and the sustainability of fish farming operations. The respondents were asked about the cost of input associated with the various fish farming activities. The average costs are shown in the table below, for fish farmers with average landholdings of 10.27 bighas:

Table 4.2: Breakdown of Fish Farming Input Costs

Fish seeds	Feed Cost	Fertilizers	Medical	Raw material
Rs. 78,870.26	Rs. 20,837.50	Rs. 2,950.00	Rs. 10,330.60	Rs. 7,252.29

4.2. Labor Cost

Labor costs in fish farming cover wages for tasks like feeding fish, monitoring water quality, and maintaining equipment. Notably, the Hills and Barak Valley Zones do not employ outside workers or staff for these activities, unlike the other agro-climatic zones. However, the data from the other agro-climatic zone is provided in the table given below:

Table 4.3: Average Monthly Labor Cost

S NO.	AGRO-CLIMATIC ZONE	STAFF SALARY	OUTSIDE WORKERS
1	Lower Brahmaputra Valley Zone	10000	10250
2	North Bank Plain Zone	7500	7125
3	Upper Brahmaputra Valley Zone		9000
4	Central Brahmaputra Valley Zone		7518.18
	Total	17,500	33,893.18

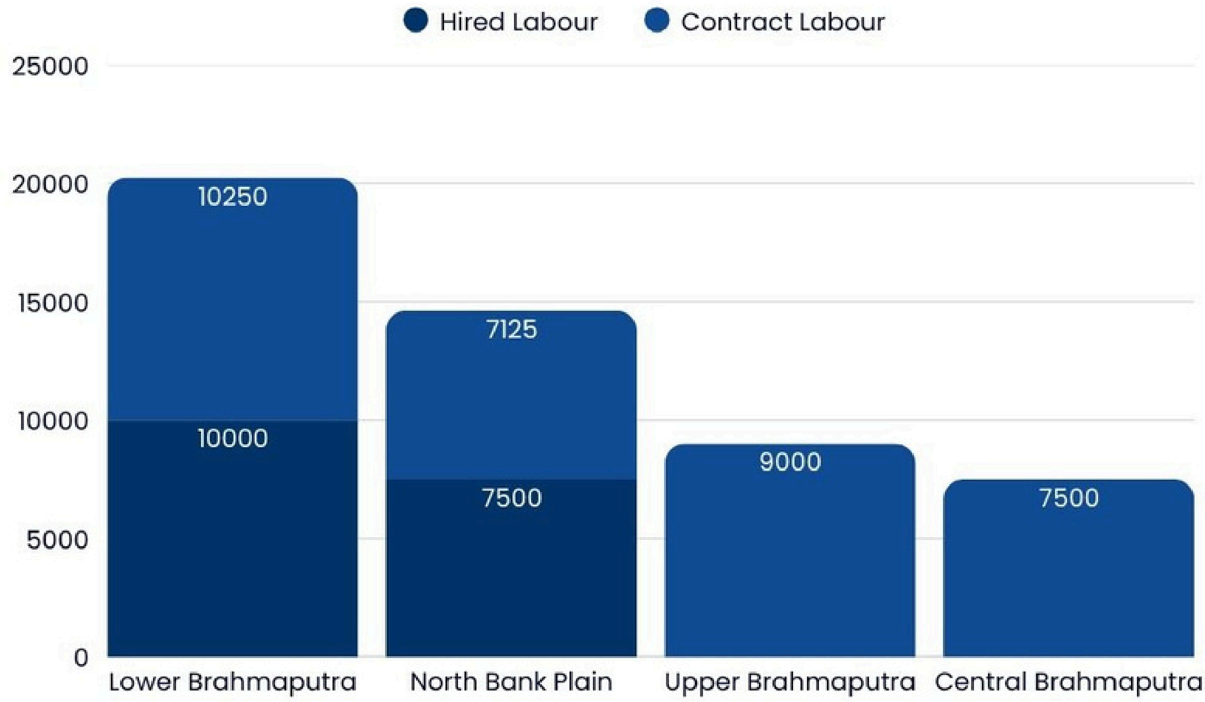


Figure 4.7: Average Monthly Labour Cost

Labor costsin fish farming vary acrossregions. In the Lower Brahmaputra Valley Zone, staff earn 10,000 and outside workers earn 10,250. The North Bank Plain Zone has lower salaries, with staff earning 7,500 and outside workers earning 7,125. In the Upper Brahmaputra Valley Zone, outside workers earn 9,000, and the Central Brahmaputra Valley Zone has outside worker costs of 7,518.18. These variations affect the financial management of fish farming operations.

4.2.6 Miscellaneous Cost

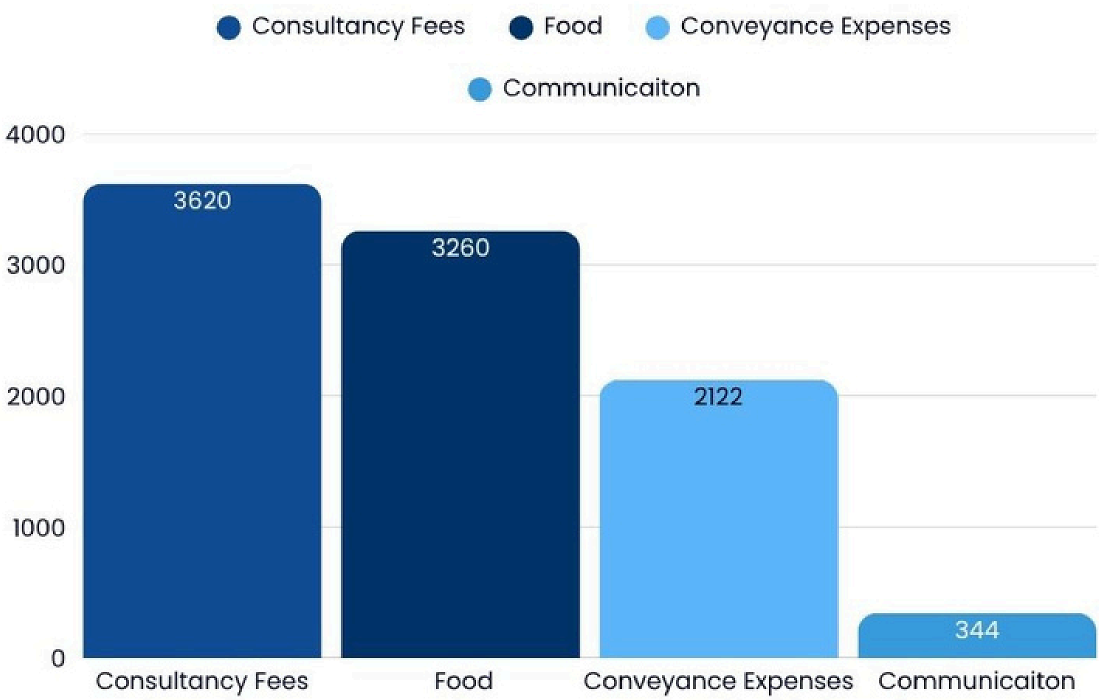


Figure 4.8: Average Monthly Miscellaneous Cost

Monthly miscellaneous costs in fish farming include essential expenses like consultancy fees (INR 3,620.69), conveyance/ diesel for transportation (INR 2,122.02), and communication bills (INR 44.83). These costs support daily operations and effective farm management. The average total production cost (per month) is provided in the table given below:

Table 4.4: Average Total Production Cost (Per Month)

S NO.	AGRO-CLIMATIC ZONE	Fish Seed Cost	Feed Cost	Liming/ Fertilizers	Medical	Raw Material	Staff Salary	Workers	Food	Convey a-nce	Phone	Consult a-ncy
1	Barak Valley Zone	229700	117500	33700	24400	15300	-	-	-	-	-	-
2	Central Brahmaputra Valley Zone	50570.59	255150	30168.18	19504.55	24000	-	7518.18	13000	2590.91	-	-
3	Hills Zone	88500	40125	6350	15400	7357.14	-	-	-	-	-	-
4	Lower Brahmaputra Valley Zone	111048.39	129431.25	9893.75	15475	42966.67	10000	10281.3	2333.33	2000	-	-
5	North Bank Plain Zone	53146.55	29174.19	5678.06	3222.22	1800	7500	7125	3328.57	1500	400	4200
6	Upper Brahmaputra Valley Zone	6875	2395.83	583.33	481.82	616.67	-	9000	3500	-	-	-

4.3 Factors Affecting Production Stage of Value Chain

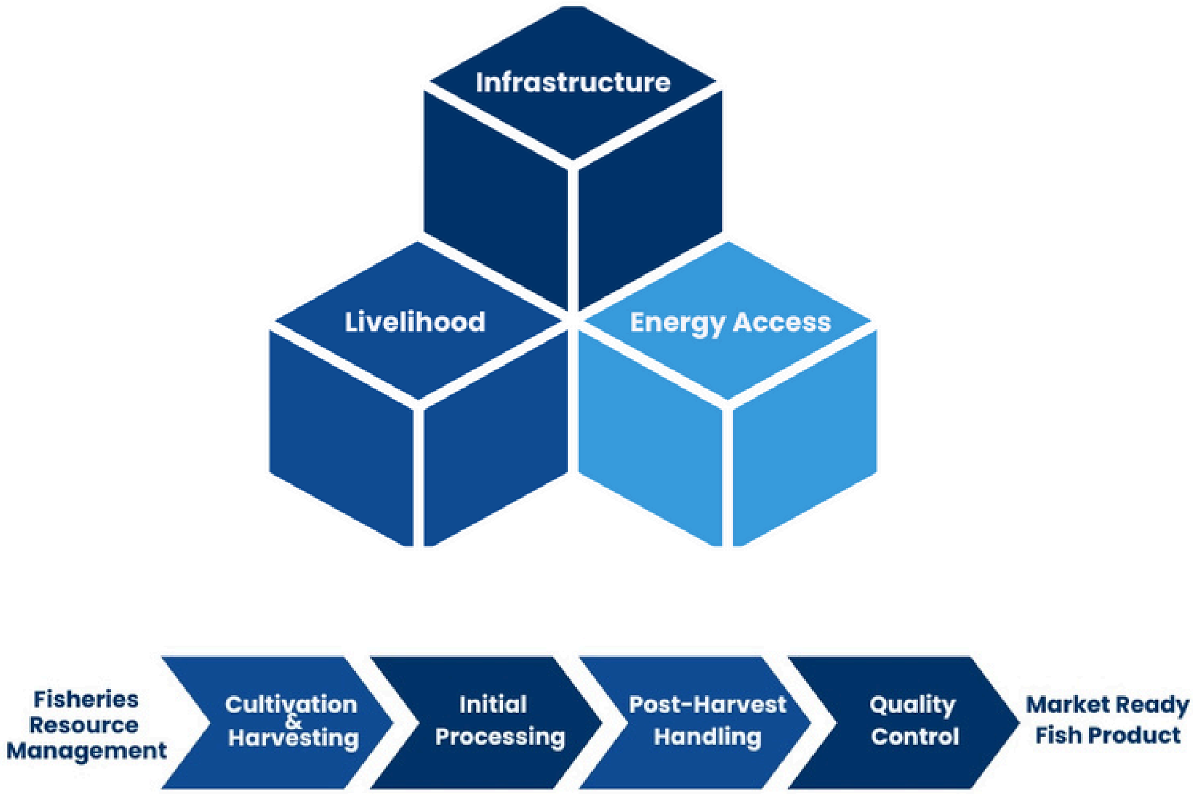


Figure 4.9: Fishery Production Value Chain

4.3 Fishery Resource Management

4.3 Type of Pond and its Water Source

The study unanimously found that all respondent fish farmers in the six agro-climatic districts of Assam exclusively use earthen ponds for aquaculture.

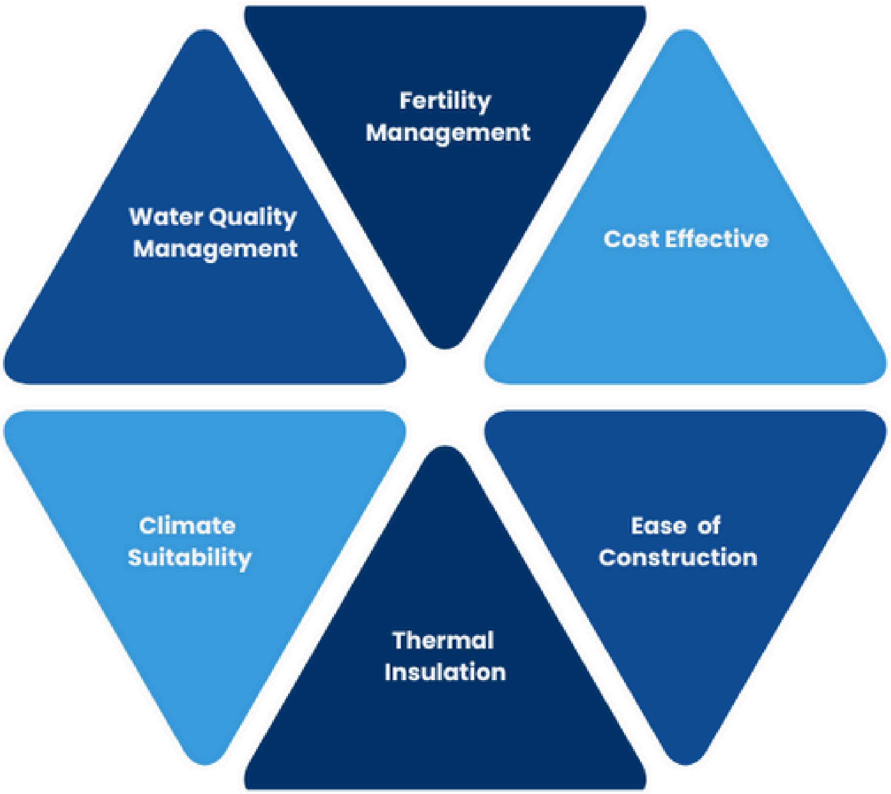


Figure 4.10: Earthen Ponds and Advantages

These ponds, made from natural soil, offer advantages such as cost-effectiveness, ease of construction, and good thermal insulation, which helps maintain stable water temperatures for fish growth. Well-suited to the region's climate, earthen ponds facilitate effective water quality management and fertility through natural processes.

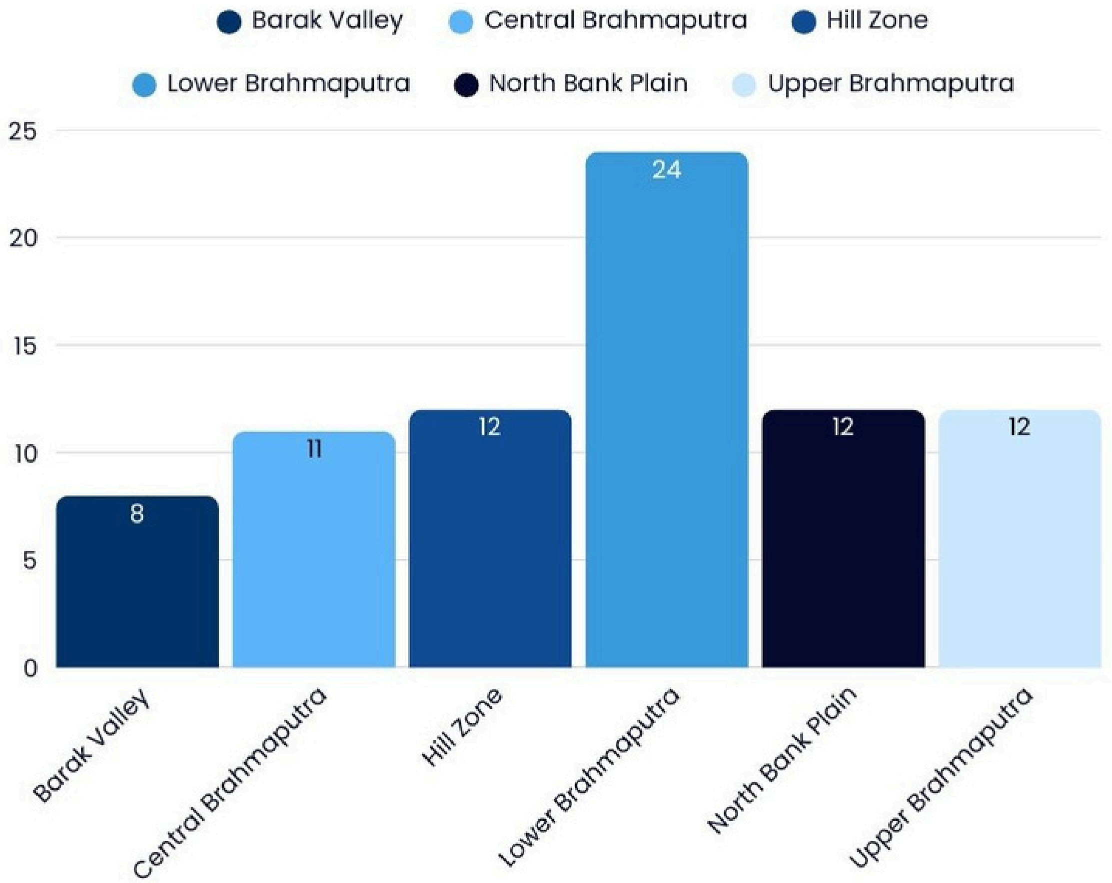


Figure 4.11: Water Sources for Ponds

The figure outlines the sources of water for ponds across different agro-climatic zones, detailing the percentages attributed to rainfall, pumps, and ground water. The North Bank Plain Zone receives the highest water source from rainfall at 27.59%, while the Lower BrahmaputraValley Zone follows with 22.41%. The Central Brahmaputra Valley Zone combines substantial rainfall (18.10%) with contributions from pumps (4.31%) and ground water (10.34%). The Barak Valley Zone relies primarily on ground water (5.17%), with minimal rainfall (7.76%). In the Hills Zone, both rainfall (6.90%) and ground water (0.86%) are low, indicating a limited water supply. The Upper Brahmaputra Valley Zone has a moderate rainfall of 10.34% but lacks additional sources. This variation reflects the different water availability and reliance across the regions, which is crucial for effective aquaculture management.

4.3. Average Duration of Crop Batch

The duration of the fish production cycle varies across agro-climatic zones, ranging from 3-24 months. Production in the Barak Valley Zone has a cycle of 4-8 months, while in the Central Brahmaputra Valley Zone, itspans 4-11 months, 7-12 months in the Hills Zone, and the Lower Brahmaputra Valley Zone has a wide range of 6-24 months. The North Bank Plain Zone ranges from 4-12 months, while the Upper Brahmaputra Valley Zone spans 3-12 months.

4.3 Infrastructure

Fish farm infrastructure in the surveyed regions shows considerable variation in size and design. Pond infrastructure refers to the physical structures and systems required to construct, maintain, and operate a fish farming pond. This includes the pond itself (earthen, lined, or concrete), inlet and outlet channels for water flow, embankments for containment, drainage systems, and fencing or protective barriers to safeguard the pond environment and support efficient aquaculture practices. On average, farmsspan about 10.27 bigha, with the total area ranging from just a few acres to several hundred, depending on the scale of operations. Most farms have an average of three ponds, although this number can vary based on the farm layout and the type of fish species being cultivated. The average pond size is around 3.51 bigha, with variations influenced by individual farm design and water management practices. A variety of tank types are used to support different stages of fish growth and seed production. These include water tanks, water running tanks, stock tanks, seed production tanks, and nursery tanks, all contributing to an efficient and controlled hatchery environment. Hatcheries

The findings reveal that nearly all the respondent fish farmers from the Barak Valley Zone, Hills Zone and Upper Brahmaputra Valley Zone rely on middlemen to procure seeds. This suggests that fish farmers are dependent on external suppliers for key resources, which could affect the quality and cost of the seeds they receive. This reliance on middlemen might also indicate a lack of access to resources or infrastructure needed to establish independent hatcheries, potentially limiting the farmers' control over breeding practices and their overall production efficiency.

However, some of the respondent fish farmers of Central Brahmaputra Valley zone, Lower Brahmaputra Valley Zone and North Bank Plain zone have their own hatchery. Hatcheries play a critical role in supporting fish farming by supplying quality seeds and maintaining essential infrastructure. The seed quality produced is reported to be very good, which supports healthy fish development acrossfarms. The mortality rate within these hatcheries is currently around 8%, indicating relatively good survival rates under existing management practices.

In terms of production, each hatchery produces an average of 5,042.04 kg of seed annually. The selling price for the seeds is approximately 291.67 per kilogram, which sets the market value for input costs in fish farming. Regarding reproductive management, the hatcheries follow a one breeding cycle per year, with a single change of broodstock per cycle, maintaining genetic quality and consistency in production

4.3 Availability of Labour

A vast majority, 98%, have access to the necessary labor for their fish farming operations. However, a small percentage (2%), particularly in the Lower Brahmaputra Valley Zone, face challenges in securing the required labor, which may impact timely management of tasks such as daily feeding and harvesting. Feeding is typically carried out three times a day, while harvesting involves manually dragging nets through the pond—both of which require regular labor support. Although these activities are not considered highly drudgerous, the availability of reliable labor remains essential for smooth farm operations.

4.3 Other Factors Affecting Production

4.3. Energy Access

The availability of 24-hour electricity for businesses varies across the state. In the Barak Valley, Hills, and Upper Brahmaputra Valley Zones, businesses face frequent power interruptions. The Central Brahmaputra Valley Zone has a 50-50 split, with half having reliable electricity. The Lower Brahmaputra Valley and North Bank Plain Zones have very low availability, with only 18.7% and 9.3% of businesses having 24-hour power, respectively, highlighting significant power supply challenges in these regions.

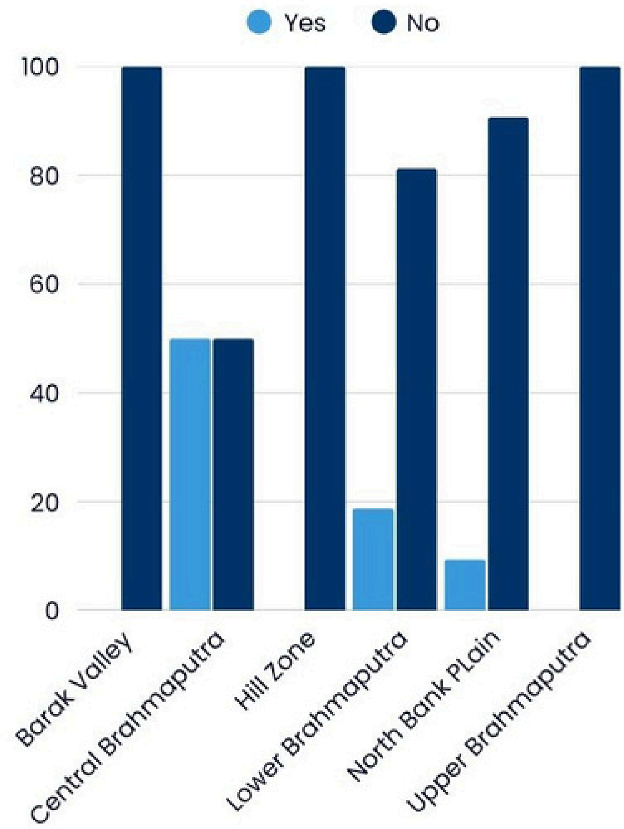


Figure 4.14: Availability of 24 Hours of Electricity for Business

4.3.3.2 Source of Power Backup

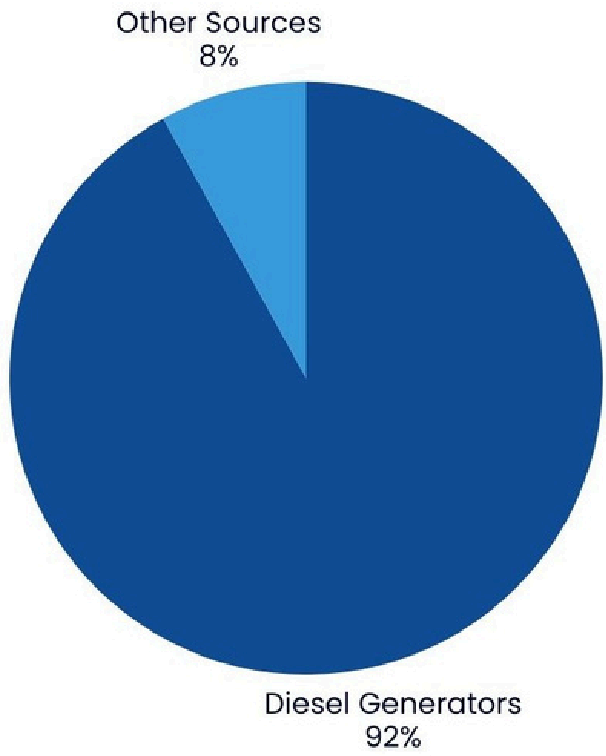


Figure 4.15: Sources of Power Backup

The figure shows that 8% of businesses use “Other” sources of backup power, such as inverters or battery storage, while 92% rely on diesel engine generators. This indicates a diverse approach to power backup, combining both traditional and alternative solutions to maintain a steady power supply during out- ages. Solar energy offers a dependable, renewable, and clean power source, functioning both independently and as a backup.

However, this comes at a cost. 34.48% of expenses are due to fuel for generators, followed by 31.03% for grid electricity tariffs. Connection fees account for 19.83%, and battery replacement costs make up for 9.48%. This highlights the significant financial burden of backup power systems, with fuel and grid electricity being the primary cost drivers.

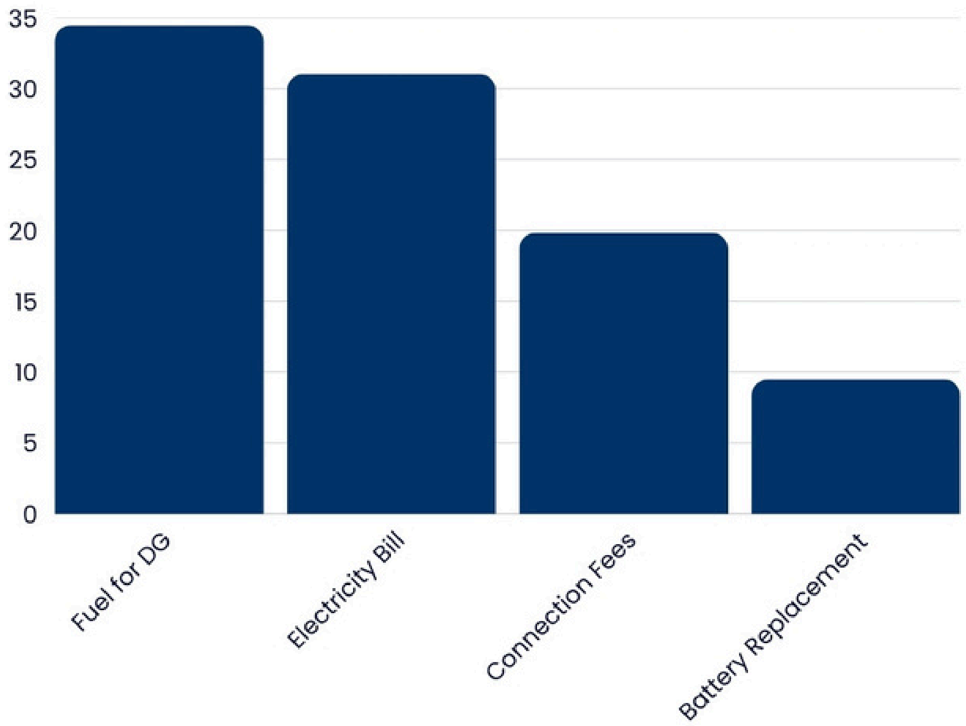


Figure 4.16: Breakdown of Energy-Related Costs

4.4 Marketing and Sales

4.4. Selling Method

Most fish farmers (51%) sell directly to consumers, benefiting from direct relationships and higher profit margins. 19% sell through Fishery Producer Organizations (FPOs), while only 4% engage with private companies. Additionally, 26% use other methods, including middlemen and local markets,showing a diverse range ofsales channels with a clear preference for direct sales.

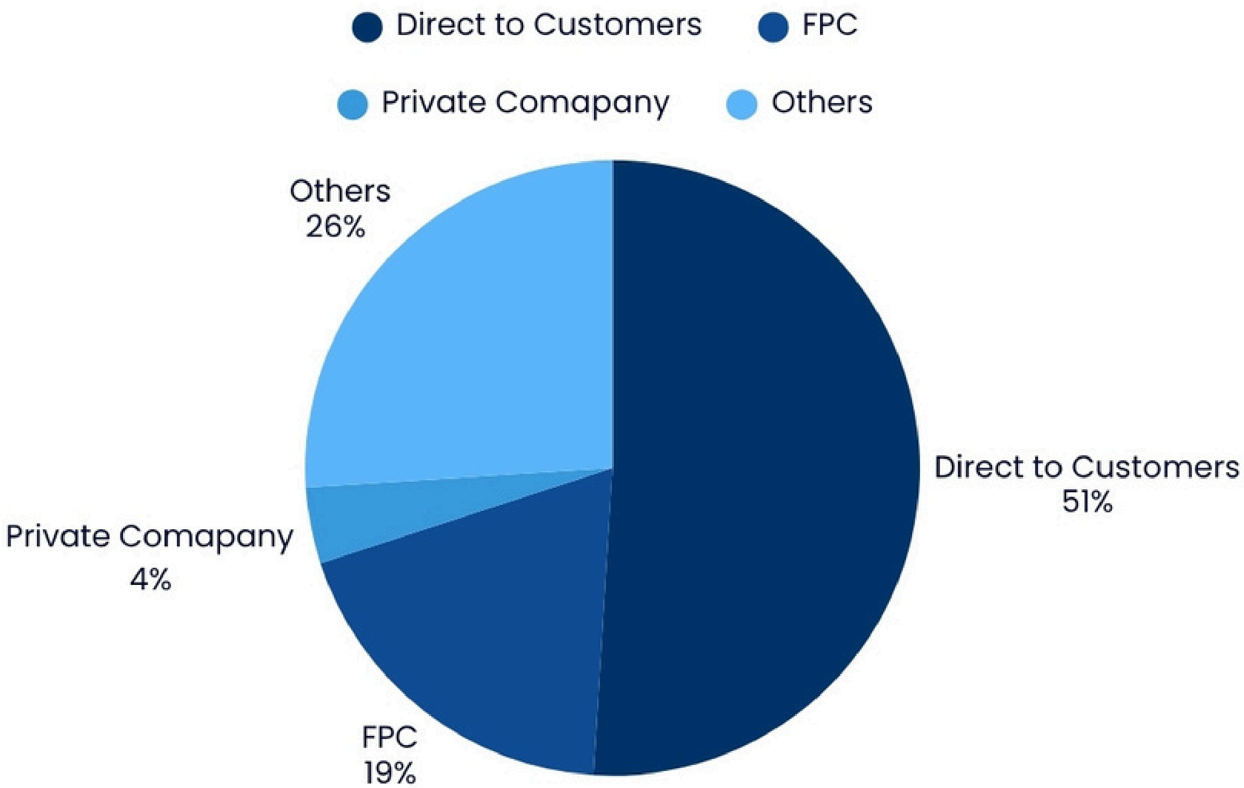


Figure 4.17: Selling Method

Regional variances in sales channels exist, as represented by the diagram ahead. In the Barak Valley, Hills, and Upper Brahmaputra Valley Zones, all fish (100%) is sold directly to consumers. In the North Bank Plain Zone, 53.375% of fish issold through FPOs, and 46.625% directly to consumers. The Lower Brahmaputra Valley Zone has a more varied distribution, with 50% sold directly to consumers, 31.25% through FPOs, and 18.75% to private companies. The Central Brahmaputra Valley Zone also shows a mix, with 68.18% sold directly to consumers and smaller portions through FPOs and other channels. The data indicates that FPOs might prove to be a strong starting point for service delivery and strengthening for fish farmers in the area, along with direct interventions for fish farmers at their pond sites.

4.4. Type of Product Sold

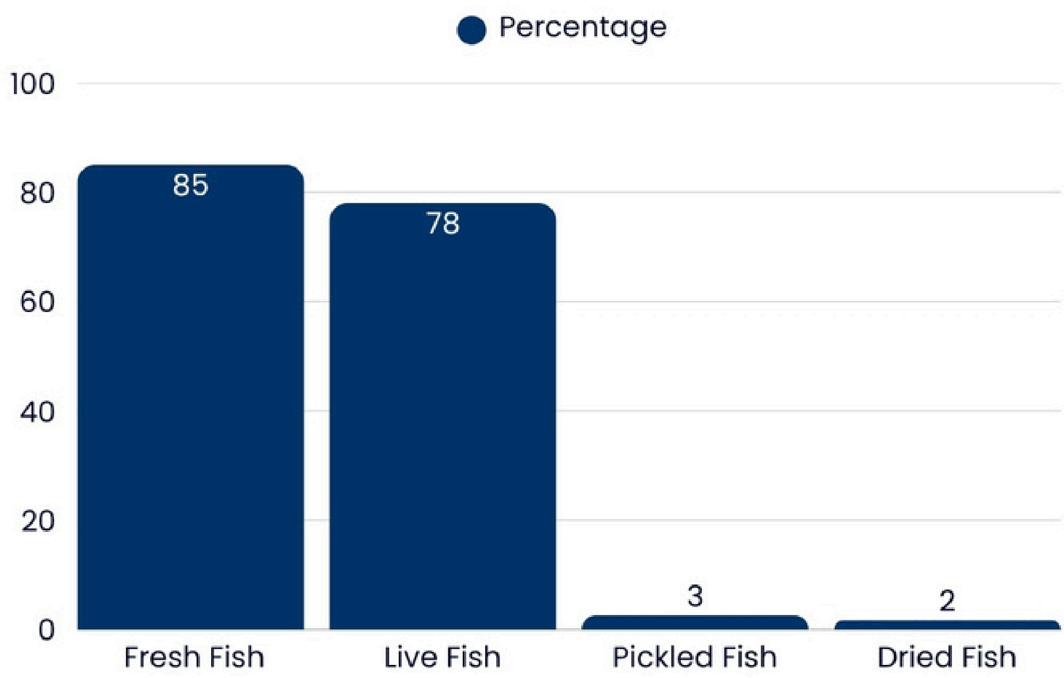


Figure 4.18: Type of End-Product Sold

The figure given above presents the various end products of fish sold by a fish farmer, with their respective proportions. Fresh fish accounts for the largest share at 85.34%, followed by live fish at 78.45%. This shows a significant overlap where many farmers engage in selling both fresh and live fish rather than exclusively one form. The high numbers in both categories indicate that fresh and live fish sales dominate the market, while value-added products like fish pickle (2.59%) and dried fish (1.72%) remain niche activities for a small fraction of farmers. This overlap also suggests that the majority of fish farmers are focused on direct fish sales at the production level, with limited engagement in processing or value addition. There is considerable potential to develop value addition initiatives — especially at the FPO level — to diversify income streams and strengthen the entire fish value chain in Assam.

4.4. Average Selling Price per kg

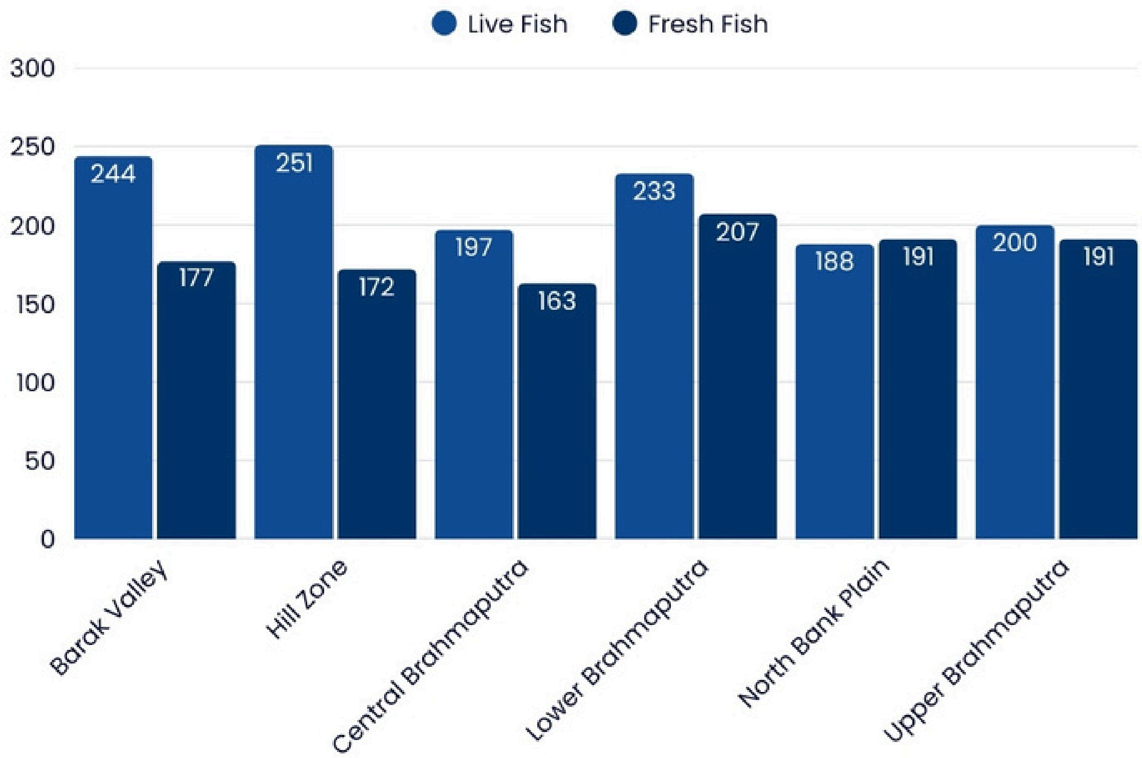
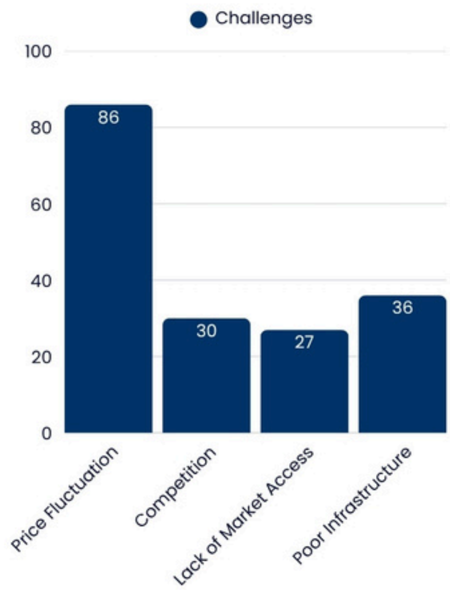


Figure 4.19: Average Selling Price per kg

The figure shows that live fish generally commands a higher price than fresh fish across most zones. In the Barak Valley, Hills, and Lower Brahmaputra Valley Zones, live fish is sold at a premium compared to fresh fish. However, in the North Bank Plain Zone, fresh fish is priced slightly higher than live fish. This highlights regional variations in fish pricing, with live fish typically being more expensive.

The fisheries and aquaculture value chain in Assam involves interconnected activities spanning from input procurement to fish production, processing, and marketing. Most farmers depend on middlemen for fish seed procurement due to limited access to hatcheries and infrastructure, although this raises concerns about quality and pricing. Feed practices vary, with a majority using in-house or commercial feed, and feeding frequency tailored to fish growth stages. Cost components include inputs like seed and feed, labor, and miscellaneous expenses, with noticeable regional variations. Labor is generally available, although some zones face shortages. All farmers use earthen ponds, and pond infrastructure and farm sizes vary considerably. The average fish production cycle ranges from 3 to 24 months depending on the zone. While some regions have their own hatcheries producing high-quality seed, most still rely on external sources. Many farmers engage in diversified livelihoods like paddy cultivation, goat and pig farming, enhancing resource utilization and ecological balance through integrated farming systems. Energy access remains a challenge, with most farmers relying on costly diesel generators due to unreliable grid supply. Solar energy emerges as a promising but underutilized solution. In terms of marketing, over half the farmers sell directly to consumers, while FPOs and private companies also serve as important channels. Fresh and live fish dominate the market, but value-added products like fish pickle and dried fish remain underdeveloped.

4.5 Challenges in Selling Fish



The figure highlights the major challenges faced by fish farmers in selling their produce. Price fluctuation emerged as the most prominent issue, reported by 86.21% of farmers, indicating significant difficulty in securing stable incomes. Poor infrastructure and lack of storage facilities affected 36.21%, while competition from other sellers was a concern for 30.17%, contributing to pricing pressure. Additionally, 27.59% of farmers reported limited access to markets, restricting their ability to reach buyers or secure fair prices. These overlapping challenges collectively undermine profitability and the long-term sustainability of fish farming in the region.

There are several promising opportunities to strengthen the fishery value chain in Assam. Firstly, investing in localized hatcheries and seed banks—especially through FPOs—can reduce dependence on middlemen, improve seed quality, and enhance production efficiency. Secondly, promoting sustainable feed practices and training on nutrient optimization can lower costs and improve yields. The development of decentralized renewable energy (DRE) solutions like solar-powered aerators and cold chains can address power challenges while lowering long-term operational expenses. Additionally, supporting value addition activities (e.g., fish pickles, dried fish) and establishing decentralized processing units can increase income, especially for women and smallholder farmers. Strengthening FPOs as hubs for input supply, training, processing, and collective marketing could ensure better price realization and bargaining power. Lastly, capacity-building efforts focusing on integrated farming and ecosystem-based approaches can lead to more resilient and sustainable livelihoods across the region.

Chapter 5

Challenges in Aquaculture Production

The production stage in Assam's fishery value chain, encompassing activities from breeding and farming to fish health management, faces several critical challenges that impede efficiency, profitability, and sustainability. As seen in previous chapters, many Assam's fish farmers are exclusively engaged in the production nodal point as a primary livelihood. Certain hurdles affect fish farmers' ability to optimize output and manage risks effectively. Key production challenges identified include:

1. Technical Expertise

Technical Support Access: A more significant gap exists in accessing specialized technical guidance for fish farmers. While basic inputs and market access may be somewhat available, most fish farms receive infrequent or irregular support from feed experts, aquaculture technicians, or other relevant specialists. This lack of consistent, hands-on technical assistance limits farmers' ability to adopt best management practices, optimize feed utilization, and effectively prevent or manage diseases. Without regular expert advice, many farmers struggle to troubleshoot common production challenges in a timely manner, leading to reduced productivity and increased risks of losses. Strengthening the availability and frequency of technical support could play a critical role in improving farm performance, encouraging the adoption of innovative technologies, and ultimately enhancing the sustainability and profitability of fish farming operations.

2. Risk Management and Fish Health

a) Disease Prevalence: Fish diseases pose a substantial risk, with 75% of respondents reporting encounters with common diseases. Fungal and bacterial infections are widespread across most agro-climatic zones, although the specific disease types vary regionally (e.g., viral infections and red spot disease are more noted in the Hills Zone).While diseases are reported asminimal in the LowerBrahmaputraValley, they remain a common concern affecting fish's health and survival elsewhere.

b) Mortality Rates: Disease outbreaks and other factors contribute to varying, and sometimes high, fish mortality rates, representing significant production losses. There is considerable regional variation:

Table 5.1: Average Mortality Rate Across Different Agro-Climatic Zones

S.NO	Type of Data	Respondent
1	Barak Valley Zone	20%
2	Central Brahmaputra Valley Zone	12%
3	Hill Zone	12%
4	Lower Brahmaputra Valley Zone	10%
5	North Bank Plain Zone	3.4%
6	Upper Brahmaputra Valley Zone	1.7%

3. Technology Adoption and Infrastructure Gaps

a) Energy Supply Issues: The adoption of modern, efficient aquaculture technologies is significantly hampered by unreliable electricity. Frequent power cuts are widespread, with almost half of the farmer respondents (49%) experiencing" High" frequency in cuts, and 17% reportedly experiencing" Very High" frequency interruptions. **No respondents reported having uninterrupted power.**

b) Impact on Operations: These power outages severely affect farms relying on aeration systems, water pumps, or refrigeration. This can lead to poor water quality, fish stress or mortality, feed spoilage, increased costs due to backup power needs, and general inefficiency, thus discouraging investment in advanced farming systems.

4. Environmental Sustainability and Resource Management

a) Management Practices: In Assam, water management in fish farming focuses on maintaining optimal water quality and ensuring sustainability, especially in the face of seasonal challenges such as floods and droughts. In the Barak Valley and Hills Zone, farmers primarily rely on aeration techniques to maintain adequate oxygen levels in ponds, supporting healthy fish growth. Meanwhile, other agro-climatic zones have adopted diverse water management practices, as detailed in Table 10: Agro-Climatic Zone-wise Water Management Practices below.

Table 5.2: Agro-Climatic Zone-wise Water Management Practices

Agro-climatic Zone	Water Management Practices
Central Brahmaputra Valley Zone	• Waste Management: Implementing systems to remove fish waste and uneaten food to maintain water quality. • Water Pumps: Use of water pumps for regular water exchange and circulation to ensure proper water flow and prevent stagnation.
Lower Brahmaputra Valley Zone	• Water Quality Monitoring: Regular monitoring of water parameters(like pH, dissolved oxygen, ammonia) to ensure a stable environment for fish. • Monitoring and Record Keeping: Systematic recording of water quality and fish health data to track trends and make informed management decisions.
North Bank Plain Zone	• Ground Water: Use of bore wells for water extraction, especially in areas where surface water sources are limited. • Traditional Practices: Use of traditional water management practices, such as manual water exchange and natural filtration methods.
Upper Brahmaputra Valley Zone	• Temperature Control: Regulating water temperature through cooling or heating mechanisms to optimize fish growth. • Water Quality Monitoring: Regular testing and adjustment of water parameters to maintain optimal conditions for fish farming. • Pond Management: Proper maintenance of pond systems,including periodic cleaning,waste removal, and water exchange to ensure sustainable farming conditions.

b) Water Quality Monitoring: Focus is often limited to pH and ammonia, with Dissolved Oxygen (DO) and alkalinity – both crucial parameters – frequently neglected. Many farmers rely on traditional methods (pH paper, visual checks for iron content) rather than accurate testing equipment.

c) Water Temperature Monitoring: Monitoring is predominantly informal, relying on visual observation orself-checking rather than thermometers or dedicated meters.

d) Disposal of Wastewater from Ponds: The most common method for disposing of pond wastewater (78.5%) is direct drainage. While simple, this practice may pose environmental risks depending on the receiving water bodies and the wastewater quality, indicating a potential need for improved disposal or treatment strategies. Only a minority hold wastewater before disposal (15.5%) or use other methods (6%).

Building Capacity and Technical-Know How

Kalong Kapili, a grassroots NGO based in Assam, has been playing a pivotal role in promoting sustainable fish farming through hands-on training and capacity building. Under its flagship programs—Community Resource Person and Aqua Entrepreneur—the organization has partnered with various stakeholders to train farmers across more than 13 districts in Assam on end-to-end fish production practices. These training sessions are conducted at the Aquaculture Field School, a dedicated residential facility provided by ICAR-CIFA, enabling farmers to gain practical, experiential learning in a structured environment. Through this model, farmers are exposed to best practices in pond preparation, seed stocking, feeding, water quality management, disease prevention, and harvesting. The combination of technical know-how and hands-on exposure builds farmer confidence and improves adoption of scientific and climate-resilient techniques. This scalable and replicable approach holds immense potential to transform aquaculture across Assam, creating a network of well-trained practitioners and resource persons who can support localized growth and sustainability in the fisheries sector.

Chapter 6

Ecosystem Analysis

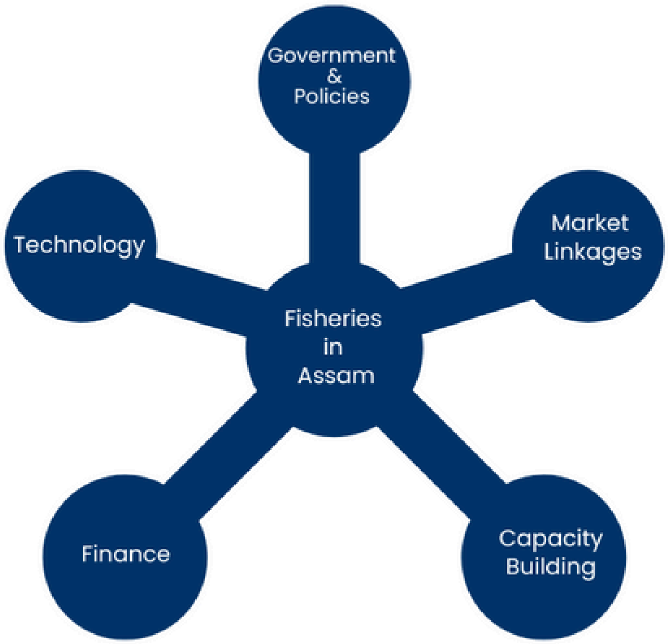


Figure 6.1: Ecosystem Component of Fishing

An ecosystem refers to the interrelations and interdependencies of parts of the system of things, in this case, fisheries in Assam. It is important to understand and respond to changing ecosystem conditions to be able to best reach objectives concerning improvement of fish farmers, that are at the center of the system, and their livelihoods. The approach entails a holistic perspective towards the conditions that enable or disable positive livelihood impacts.

The ecosystem of fishermen is a dynamic network where various components—such as government policies, technology, capacity building, stakeholders, and finance—interact to grow, develop and sustain the sector.

- Government schemes provide technical and financial support and decide regulatory frameworks for fish farmers, at scale

- Technology enhances efficiency and sustainability of end user enterprises and the larger ecosystem within which they exist

- Training and extension services improve awareness of and access to resources, technical and business know-how, improve networks

These factors and their interrelations have a significant bearing on productivity and business growth, which in turn impacts end user confidence, ownership, bargaining power, income, and other aspects. Stakeholders share resources and knowledge and have a crosscutting role to play inevery ecosystem component, that can enable a system that fosters the growth, sustainability, and profitability of the fishing sector. Awareness of Government initiatives or program

Farmer awareness and participation in government schemes vary significantly across agroclimatic zones in Assam. In the Barak Valley Zone, none of the farmers surveyed were aware of any government initiatives. While all farmers in the Hills Zone were aware of available schemes, none had accessed them. In the Lower Brahmaputra Valley Zone, 87.5% of farmers reported to be unaware of government schemes related to fisheries and aquaculture, and only 12.5% had reportedly participated in any programs. The Central Brahmaputra Valley Zone reflected slightly better engagement, with 22.7% participating in programs related to the fisheries sector, while 77.3% of respondents were unaware. Fish farmers in the In the North Bank Plain Zone area — 62.5% of respondents reported no awareness of any programs or schemes related to the sector, while 37.5% had accessed support, which is a larger proportion compared to other regions. The Upper Brahmaputra Valley Zone had the highest level of engagement, with 58.3% of farmers reported to have participated in government schemes.

6.1 Assam Aquaculture: Floods & Financial Gaps

Flooding poses significant challenges to fish farming, leading to substantial financial losses to fish production and subsequent losses to revenue and farmer income. In recent years, it has been observed that Assam can experience significant flooding for up to 7 months a year. For example, in 2022, floods reportedly started as early as April and continued until the end of October, covering a period of seven months. Physical infrastructure often suffers severe damage, including the destruction of ponds and embankments and the loss of essential equipment. Floods also disrupt road networks, limiting market access and causing major delays in transportation, which in turn results in market disruptions.

Additionally, as seen in Chapter 2, farmers spend significant amounts towards the cost of diesel fuel for business-related transportation – further exacerbating the financial conditions of their business and personal incomes.

Negative climate impacts extend to the ecosystem as well, with increased water contamination levels leading to a reduction in fish diversity, disease outbreaks, and fish stock losses.

Farmers reported that they are further burdened by a lack of institutional support towards finance unlocking —there is often no timely assistance, limited or no compensation, and an overall lack of government backing. These factors collectively hinder the resilience and recovery of fish farmers during floods and other climate-related events in Assam, making it a critical area of concern for sustainable aquaculture in flood-prone regions.

The table given below gives the detailed analysis of the impact of flood and the support from government:

Agro-climatic Zone	Financial Losses Due to Flood and Government Compensation
Barak Valley Zone	• Fish farmers in Cachar suffer significant financial losses from flooding that damages ponds, infrastructure, and fish stocks, with no government compensation or assistance, exacerbating their economic hardship.
Central Brahmaputra Valley Zone	• Fish farmers in the Central Brahmaputra Valley suffer significant financial losses from flooding, including damaged embankments,lost fish stocks, and disrupted markets,with no government assistance to help them recover,worsening their economic hardship.
Hills Zone	• Fish farmers in the Hills Zone have faced severe financial losses due to flooding, with half of their production lost, compounded by the loss of income and market access, yet no government assistance or compensation has been provided.

Agro-climatic Zone	Financial Losses Due to Flood and Government Compensation
Lower Brahmaputra Valley Zone	• Fish farmers in the Lower Brahmaputra Valley Zone have incurred heavy losses due to flooding, with damages ranging from 150,000 to 350,000, yet no government compensation or assistance has been provided, leaving them to bear the full financial burden.
North Bank Plain Zone	• Fish farmers in the North Bank Plain Zone have suffered significant losses from flooding, including damaged infrastructure and lost income, with no government compensation or assistance to help them recover.
Upper Brahmaputra Valley Zone	• Fish farmers in the Upper Brahmaputra Valley have suffered financial losses from flooding, including fish stock loss and market access disruptions, with no government support, leaving them to bear the full recovery costs.

6.2 Support Needed to Adapt Aquaculture Operations to Climate Change Impacts

Adapting aquaculture to climate change requires a combination of effective strategies, robust management plans, and proactive government support. A comprehensive support system for rural aquaculture should focus on strengthening infrastructure, offering targeted financial aid, providing technical training, and improving market access to ensure enhanced productivity, sustainability, and economic resilience.

Among the most critical policy and on-ground interventions is financial assistance, which enables farmers to upgrade infrastructure, adopt climate-resilient technologies, and recover from extreme weather events. Investments in solar-powered aerators, for instance, can help maintain adequate oxygen levels during temperature fluctuations or power outages, optimizing for business efficiencies and sustainability, while reducing reliance on conventional and polluting energy sources simultaneously.

Equally important is the provision of specialized equipment and training for integrated farming systems that combine fish, paddy, and duck farming. These systems not only optimize resource use but also promote circular economy models and increase income resilience. However, the lack of effective pond insurance and management techniques leaves farmers vulnerable to losses from climate shocks and disease outbreaks.

To empower aquaculture communities, targeted subsidies for climate-resilient infrastructure, lowinterest loans, and capacity-building programsfocused on climate adaptation should be prioritized. These efforts will help farmers manage water resources more effectively, diversify income during the off-season, and build long-term resilience to ever increasing climate variabilities.

6.3 Technology

Technology is vital in fish farming, improving productivity, sustainability, and efficiency through innovations like RAS, precision farming, and disease management. It helps optimize water quality, monitor fish health, and reduce environmental impact, while also enabling cost management and adaptation to challenges like climate change. Additionally, DRE technology, using renewable energy sourceslike solar and wind, enhances operations in remote areas, supporting sustainable and efficient fisheries practices.

6.4 Aeration Practices

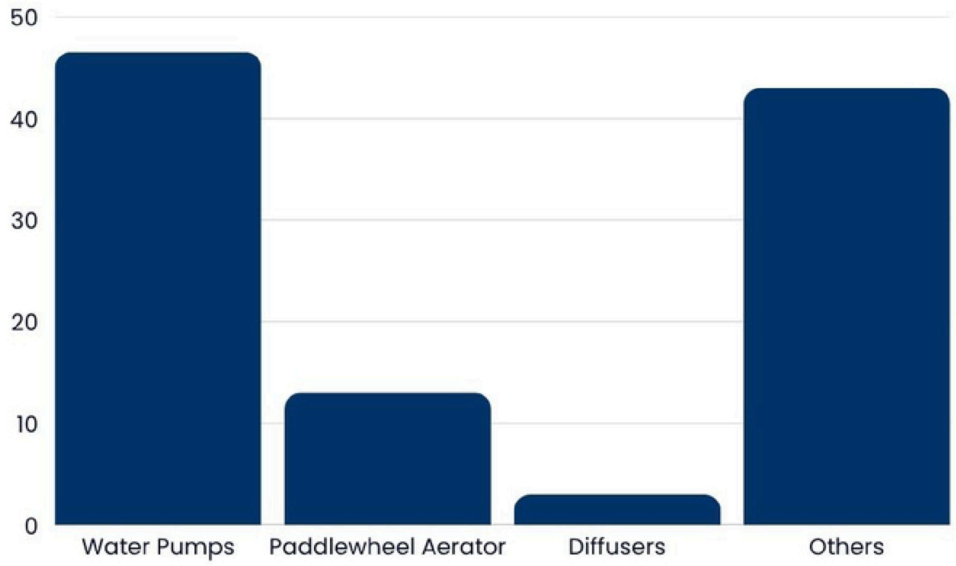


Figure 6.2: Aeration Practices in Aquaculture

In Assam's aquaculture, different methods of traditional aeration are in use, particularly in resource-limited settings. Bamboo is commonly employed for aeration, with methods like manual stirring, using bamboo poles to break the water surface and enhance oxygen transfer for fish and hatchlings. Bamboo aeration devices, such as pipes and diffusers, release air bubbles into the water, improving oxygen levels. Other reported practices include using floating plants like water lilies, water hyacinth and duckweed to naturally absorb nutrients, which help oxygenate the water besides forming food for some varieties of fish. Additionally, natural aeration from wind action and water inflows from rivers or streams contribute to oxygenation. While these traditional methods are cost-effective and accessible, they can be labor-intensive and less effective at larger scales.

The importance of disinfection in fish farming, including practices like using foot-dips, cannot be overstated. It is a critical component of biosecurity. The adoption of foot-dip pits for disinfection at fish farm entry points is minimal across most agro-climatic zones. In the Barak Valley, Central Brahmaputra Valley, Hills, and Upper Brahmaputra Valley Zones, none of the respondents reported to have used them. Only a small number of respondents in North Bank Plain (6.25%) and Lower Brahmaputra Valley (9.38%) Zones have implemented this practice, indicating limited awareness and adoption of biosecurity measures.

6.6 Pest-repelling On-farm Biosecurity Measures

Birds can cause significant destruction to fish production and are natural pests for fisheries. In most zones, including the Barak Valley, Central Brahmaputra Valley, Hills, and Upper Brahmaputra Valley, no farmer respondents reported to be using bird-repelling nets, wires or any other repellant mechanism. However, in the Lower Brahmaputra Valley and North Bank Plain Zones, a small proportion of farms (6.25% and 21.88%, respectively) have adopted these biosecurity measures, showing some regional variation in implementation.

6.7 Access to Fish Healthcare

There is a clear regional disparity in access to veterinary and fishery consultancy services across Assam's agro-climatic zones. The Upper Brahmaputra Valley exhibits significantly higher access to consultancy services, indicating stronger institutional or infrastructural support in that region. Similarly, the Lower Brahmaputra Valley also enjoys better access, comparable to the Upper Valley. The North Bank Plain demonstrates relatively higher access as well, though slightly less than the two Brahmaputra zones. In contrast, the Barak Valley and Hills Zones face limited access to both veterinary and fishery consultancy services, highlighting a critical gap that may affect the effectiveness and sustainability of aquaculture and livestock practices in these areas. Addressing these regional disparities is essential for ensuring equitable support to farmers and enhancing overall productivity.

The data in the figure below indicates that access to fishery healthcare services is highly limited in the Barak Valley and Hills Zones, with no respondents having access. In contrast, other regions like the Upper Brahmaputra Valley, North Bank Plain, and Lower Brahmaputra Valley Zones show significantly higher access, suggesting a regional disparity in the availability of professional consultancy services for fish farmers.

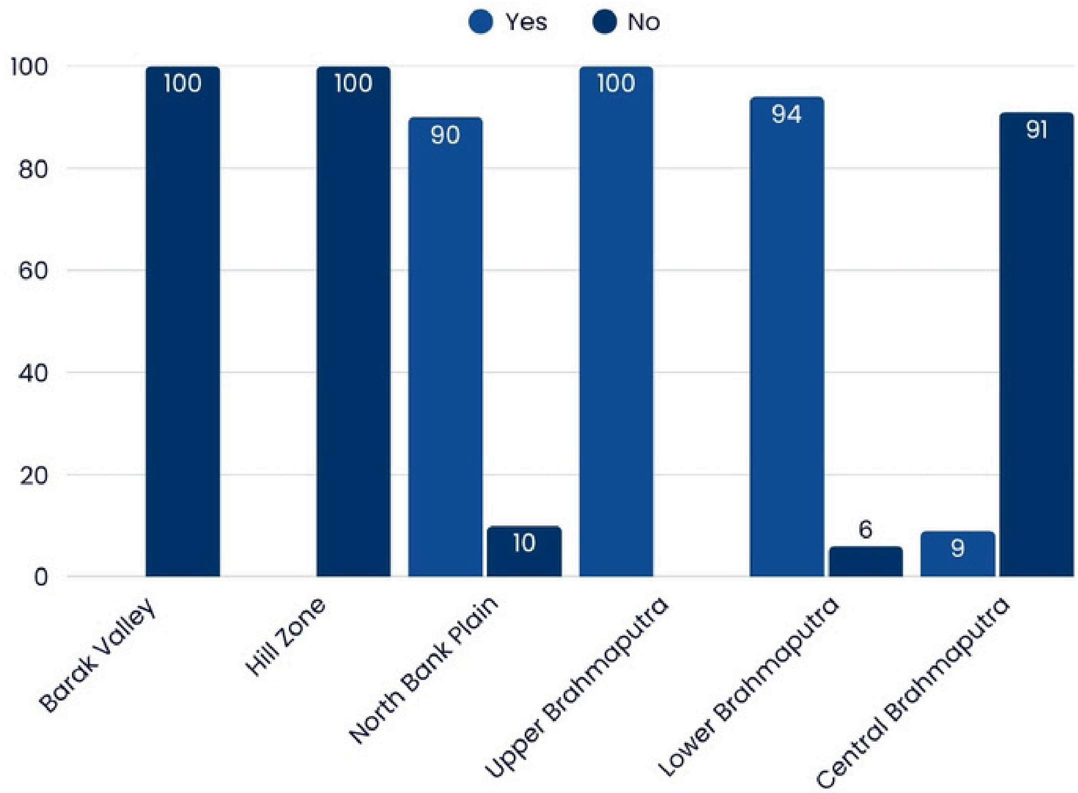


Figure 6.5: Access to Fishery Healthcare

6.8 Effectiveness of Traditional Pond Management Practices

In the Barak Valley and Hills Zones, 100% of respondents dismiss traditional pond management practices as ineffective. In contrast, 40-44% of respondents in the North Bank Plain, Central Brahmaputra Valley, and Lower Brahmaputra Valley Zones find them effective, while the Upper Brahmaputra Valley Zone shows a more mixed view, with 50% acknowledging their effectiveness.

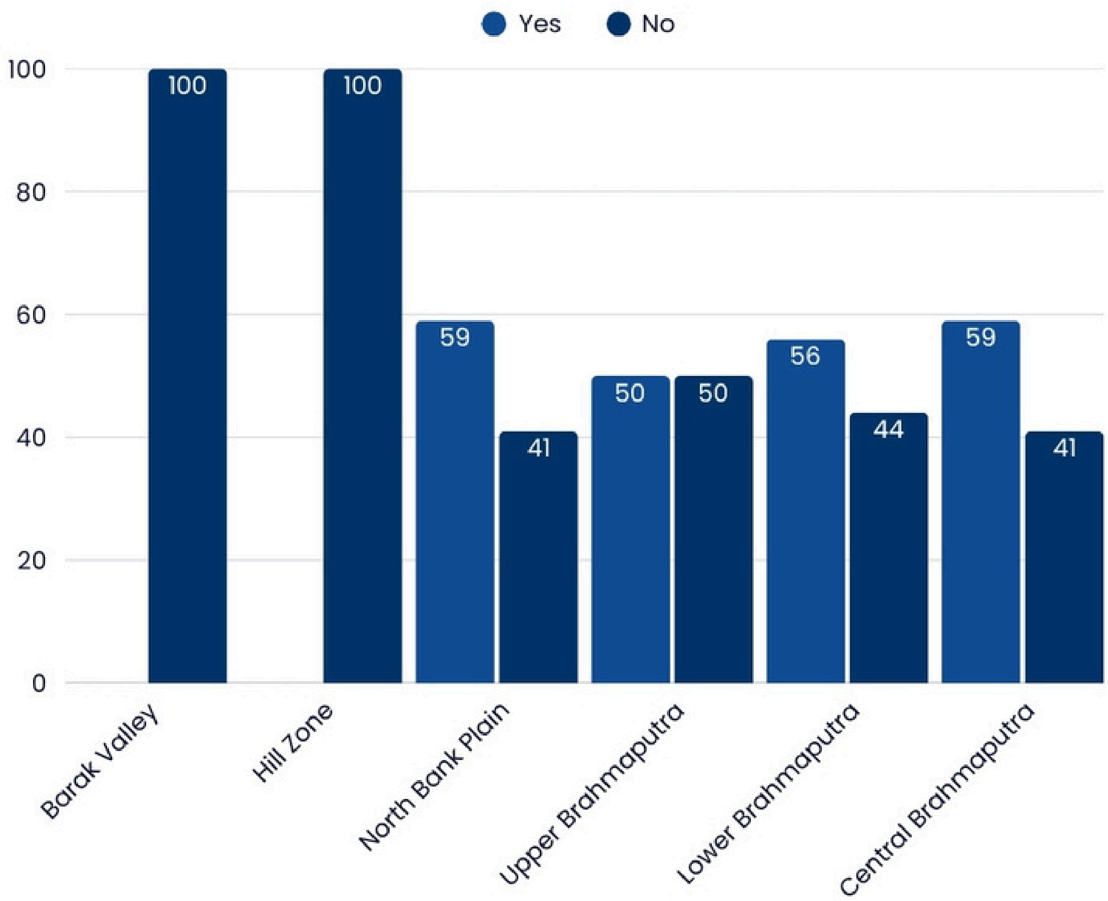


Figure 6.6: Effectiveness of Traditional Pond Management Practices

6.9 Electricity Supply in Hatchery Operation

Out of the six agro-climatic zones, only a small number of fish farmers in the Lower Brahmaputra Valley, Central Brahmaputra Valley, and North Bank Plain zones operate their own hatcheries. Farmers in the remaining zones primarily rely on middlemen or external hatcheries for seed supply. Electricity availability for hatchery operations also varies by region. In both the Lower Brahmaputra Valley and Central Brahmaputra Valley zones, 100% of hatcheries reported having a steady electricity supply. In contrast, the North Bank Plain Zone shows a mixed scenario, with only 50% of hatcheries having reliable electricity access, while the other 50% face inconsistencies.

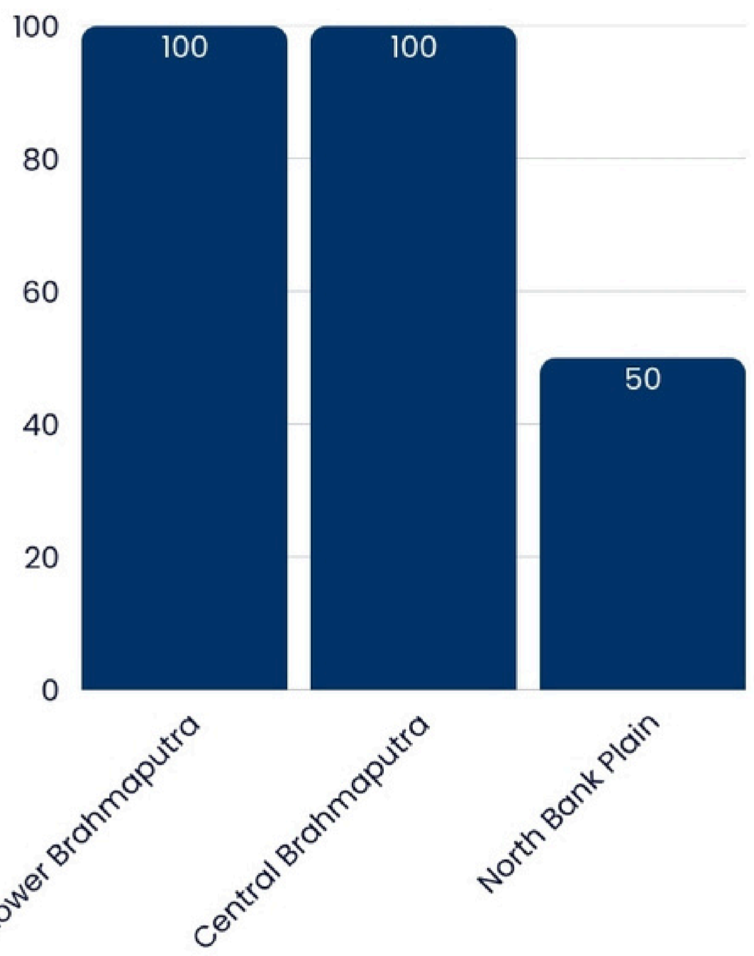


Figure 6.7: Electrical Supply in Hatchery Operations

6.10 Challenges Posed by Lack of Access to Grid Supply

In the Lower Brahmaputra Valley Zone, 100% of respondents reported the lack of electricity affecting the hatching process. In the North Bank Plain and Central Brahmaputra Valley Zones, 50% of respondents in each zone experienced impacts, while the other half reported no effect, highlighting regional variation in the impact of electricity supply disruptions on hatchery operations.

6.11 Measures to Ensure Water Quality

Water quality management practices vary across agro-climatic zones in Assam, with fish farmers adopting different tools and approaches depending on their region. In the Lower Brahmaputra Valley and Central Brahmaputra Valley zones, 100% of respondents reported using filters to maintain water quality. In the North Bank Plain Zone, 50% of respondents use filters, while the remaining 50% rely on water testing kits to assess water conditions.

Across all three zones, farmers reported monitoring key parameters such as pH and nitrogen levels using water testing kits and other tools. In the Lower Brahmaputra Valley Zone, all respondents indicated the use of such tools, whereas in the Central Brahmaputra Valley and North Bank Plain Zones, only 50% reported doing so. This reflects a clear variation in the adoption of water quality management practices across regions— practices that are vital for maintaining healthy and productive aquaculture systems.

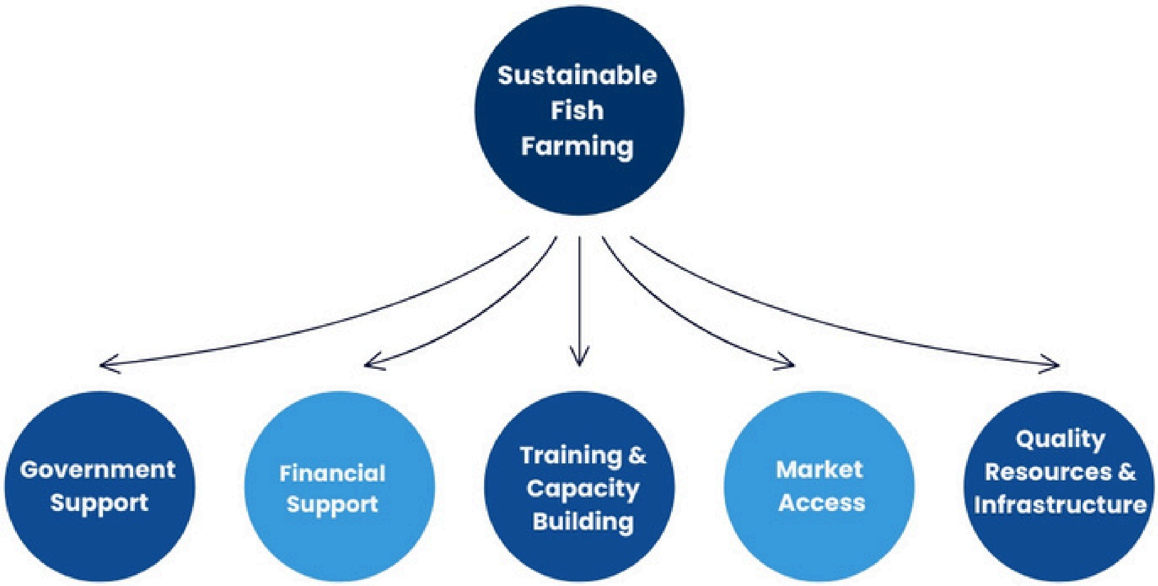


Figure 6.8: Sustainable Fish Farming

Fish farmers seek better training, financial support, and access to affordable resources like high-quality fish seeds and feed. They request government subsidies, compensation for flood losses, improved infrastructure, and advanced technology to enhance productivity. Farmers also emphasize the need for better market access, reduced costs, and support to tackle environmental challenges.

This chapter underscores the pivotal role of fisheries in Assam's food security and rural economy yet reveals their acute vulnerability to persistent challenges. The most pressing among these is the increasing frequency and duration of floods, which annually inflict devastating financial losses on fish production, infrastructure, and farmer incomes, often extending for up to seven months a year. This economic burden is exacerbated by disrupted market access, increased operational costs like diesel, and severe environmental degradation leading to reduced fish diversity and disease outbreaks.

A critical finding is the significant institutional void in financial support. Across all agroclimatic zones, fish farmers face substantial economic hardship with little to no government compensation or timely assistance, leaving them to bear the full cost of recovery. This stark lack of government backing severely hinders their resilience and perpetuates a cycle of vulnerability.

Beyond finance, the sector grapples with significant regional disparities in infrastructure, technology adoption, and access to essential services. While zones like the Lower and Upper Brahmaputra Valleys demonstrate better access to fishery consultancy and more consistent electricity for hatcheries, the Barak Valley and Hills Zones consistently report limited or no access to healthcare services, minimal adoption of biosecurity measures (like foot-dips and bird-repelling nets), and a perception of traditional pond management practices as largely ineffective. These regional variations highlight unequal capacities to adapt and recover. Inconsistent electricity supply, particularly in the North Bank Plain Zone, and varied water quality management practices across different zones further compound the challenges.

Ultimately, strengthening Assam's aquaculture for long-term sustainability demands a comprehensive and urgent response. This must prioritize robust financial assistance—including subsidies, low-interest loans, and effective pond insurance—coupled with targeted investments in climate-resilient infrastructure, advanced technology, and capacity-building programs in climate adaptation and integrated farming. Addressing these multifaceted gaps, particularly in financial and institutional support, is paramount to enabling fish farmers to adapt, recover, and ensure the continued viability of this vital sector in a rapidly changing climate

Chapter 7

Climate Change and its Effect on Fisheries

Climate change poses a growing threat to the sustainability of Assam'sfisheries, primarily through rising watertemperatures, erratic rainfall patterns, and increased frequency and intensity of floods. These shifts directly impact fish health, breeding cycles, habitat stability, and the livelihoods of communities dependent on fisheries.

With the Earth's average temperature steadily rising, water bodiessuch asrivers, ponds, lakes, and wetlands in Assam are experiencing higher temperatures. Even minor increases can disruptfish physiology and lead to reduced appetite, lower feed efficiency, and increased stress. Warmer water holds less dissolved oxygen, which is vital for fish survival, particularly in high-density aquaculture systems. Elevated temperatures also lower reproductive success and heighten susceptibility to diseases. One such condition is the spread of Saprolegnia fungi, which causes cotton-like growths on fish skin, gills, and eggs—often emerging under stress and poor water quality.

Changes in rainfall patterns are another critical challenge. Assam's monsoon is becoming increasingly erratic, with prolonged dry periods followed by sudden, intense storms. These shifts affect the availability and quality of water for fishponds and hatcheries, disrupt naturalspawning cycles, and lead to sedimentation and runoff, which may cause eutrophication or toxic algal blooms. Maintaining consistent water levels and quality becomes increasingly difficult for fish farmers, especially those with limited infrastructure.

Floods, which were once seasonal, are now more frequent and unpredictable due to climate change. These extreme events damage pond embankments, cages, hatcheries, and community infrastructure. Fish stocks are lost as ponds overflow, and invasive species or pollutantsfrom nearby water bodies infiltrate aquaculture systems. Floods also interfere with fish migration routes and limit access to traditional breeding and feeding zones, further endangering native fish populations.

Collectively, these climate-related disruptions undermine the productivity and reliability of both capture fisheries and aquaculture. Smallholder fish farmers—often lacking access to adaptive technologies or early warning systems—are particularly vulnerable. For these communities, fisheries are not just a food source but a primary or supplementary livelihood, making them highly sensitive to climate shocks and environmental unpredictability

To build resilience, there is a need to promote climate-adaptive aquaculture models, such as deeper ponds, Biofloc, and Recirculatory Aquaculture Systems (RAS). The introduction of floodresilient infrastructure, solar-powered aerators, and real-time water quality monitoring tools can help mitigate risk. In parallel, conservation of wetlands and support for community-based institutions can enhance local capacity for risk-sharing, knowledge exchange, and sustainable management of aquatic resources. In 2018, the state launched the World Bank assisted 'Assam Agribusiness and Rural Transformation Project (APART)' with fisheries as a subcomponent. Through this project, WorldFish is extending technicalsupport to the statewith itsinternational experience and expertise. One of the focus areas of WorldFish is climate-proofing the fishery sector of the state by developing and promoting climate-resilient technologies. The purpose is to counter the negative impacts of climate change, mainly the pond aquaculture and Beel fisheries, and to push the fish production of the state upward. (Source-World Fish, Climate Resilient Technologies/Practices to Support Pond Aquaculture and Beel Fisheries under APART, Assam, India).

The potential impact of the climate variation on fisheries and aquaculture have been elucidated by World Fish Centre as summarized below: (A.P. Sharma, February 2014)

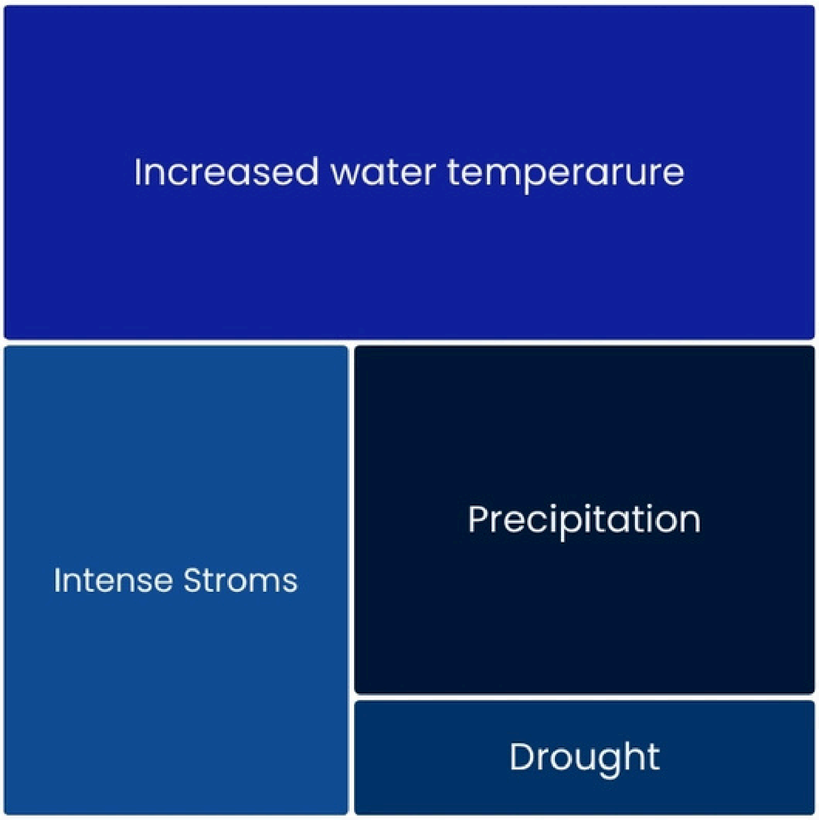


Figure 7.1: Climate Change Impacts of Fisheries and Aquaculture

This chapter aims to provide insights into how climate fluctuations are impacting various stages of the fishery value chain across diverse regions in Assam. In addition, this chapter discusses how to address these issues, which call for a multipronged strategy that includes resource management plans, the adoption of resilient aquaculture practices, government initiatives to support climate-resilient aquaculture practices in Assam, the updating of policy frame- works to effectively support local communities, etc. By implementing these strategies, Assam can strive towards a more productive and sustainable fishing industry that satisfies both environmental and financial demands.

This information is gathered through three separate tools: an FGD guide for fish farmers, an interview schedule for FPC in-charges, and a questionnaire for FPC members, incorporating both quantitative and qualitative data.

Climate Change Adaptation Strategies for Fish farmers To adapt to climate change, especially in regions vulnerable to flooding and changing weather patterns,strategies like raised ponds, flood barriers, feeding regimes and aeration levels are critical. Therefore, the question of what tactics fish farmers have used to address climate change was posed to them.

This indicates a focus on physical measures for managing water-related climate impacts.

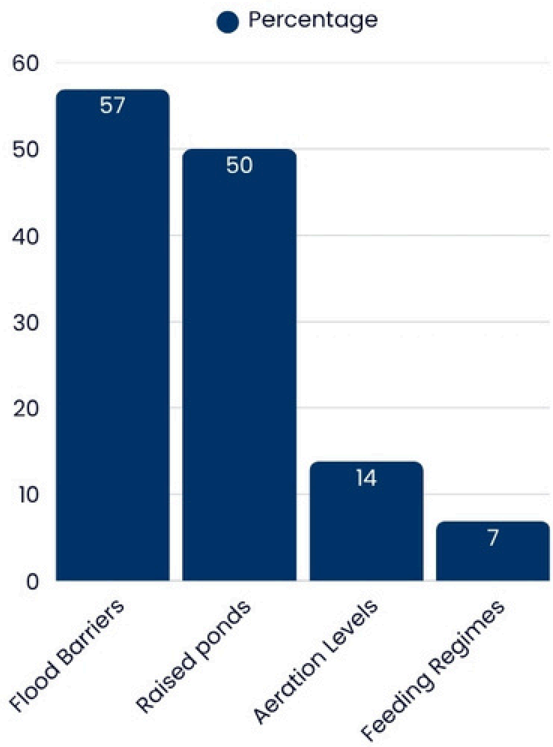
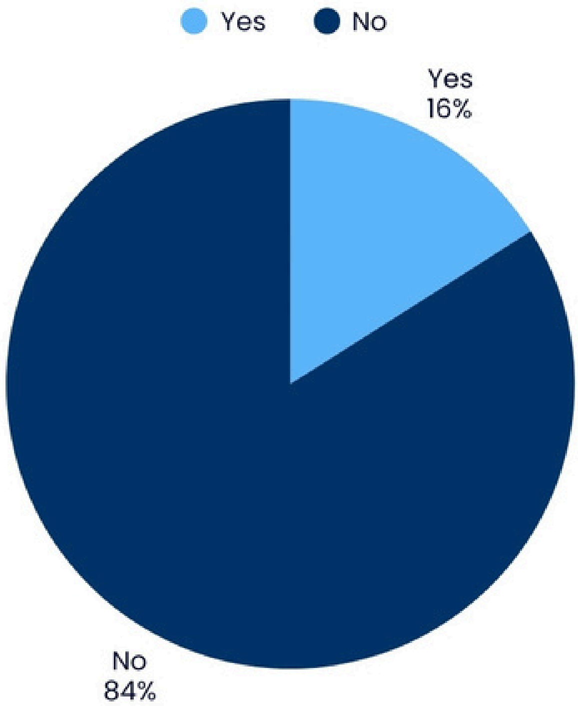


Figure 7.2: Strategies to Deal with Climate Change



7.1 Observed Changes in Water Temperature in Aquaculture Operation

Fish farmers were also asked to share their observations on changes in water temperature within their aquaculture operations for environmental monitoring. Based on different agro-climatic zones of Assam, following observations were collected:

Agro-climatic Zone	Observation
Lower Brahmaputra Valley Zone	• The fish farmers observechanges in watertemperature in their aquaculture operations through two primary methods: personal observation and the use of temperature measurement machines.While some farmers manually check the conditions, others rely on these machinesfor accurate readings. Many of them have adoptedthese machines for measuring temperature, suggesting a shift towards more modern methods.They also mentioned that extreme heat is not a significant concern in their operations. However, some farmers still use traditional methods, indicating a mix of old and new practices in monitoring water temperature.

Agro-climatic Zone	Observation
Upper Brahmaputra Valley Zone	• The fish farmers in this zone observe changes in water temperature primarily through self-monitoring, with many relying on personal, visual observations. They note that changes are sometimes only noticeable when there is a shift in climate. Most farmers emphasize that their observations are done manually and visually, relying on their own experience and senses rather than specialized equipment. This hands-on approach highlights their dependence on traditional methods to track environmental changes in their aquaculture systems.
North Bank Plain Zone	• The fish farmers monitor water temperature and pH levels using a variety of methods. Some use pH paper and pH meters to check the water's chemical balance, while others rely on personal observation and experience to assess water temperature, often without specialized equipment. A few farmers mention using temperature devices to measure surface water, but many still depend on manual, self-checking methods, citing a lack of equipment. Traditional approaches, such as visually observing the pond or using guidance from fishery experts,are common, with some adding lime or other substances to manage pH levels based on their observations.
Central Brahmaputra Valley Zone	• The fish farmers observe changes in water temperature through a mix of manual methods and the use of meters or test kits. While some rely on technology like meters to get accurate readings, others still depend on traditional, manual techniques, such as observing fish behavior or visually assessing the pond. Many farmers mention checking the water manually without equipment, indicating that traditional practices are still prevalent in their aquaculture operations, despite some adoption of modern tools like meters and test kits.

Agro-climatic Zone	Observation
Hills Zone	• The fish farmers primarily rely on visual observation to monitor changes in water temperature in their aquaculture operations. This method involvesassessing the water and the behavior of the fish based on their own experience, without the use of specialized equipment. Visual observation remains the dominant approachamong these farmersfor tracking environmental changesin their ponds
Barak Valley Zone	• The fish farmers primarily rely on traditional methods to observe changes in water temperature in their aquaculture operations. These methods are based on years of experience and involve manually assessing the water conditions and the behavior of the fish without using modern equipment. Despite the availability of newer technologies, these farmers continue to trust and apply these time-tested, hands-on practices to monitor their ponds.

7.2 Frequency and Impact of Floods

Fish farmers were surveyed on the frequency and impact of floods affecting the production of fish value chain across various agro-climatic zones in Assam, resulting in the following observations.

Table 7.2: Frequency and Impact of Floods Affecting the Production of Fish Value Chain Across Various Agro-Climatic Zones in Assam

Agro-climatic Zone	Observation
Lower Brahmaputra Valley Zone	• The fish farmers report that floods occur once or twice a year, causing significant damage to their operations. These floods lead to the loss of fish stock as ponds overflow and fish escape into rivers or nearby fields. Infrastructure such as fish ponds, cages, nets, and dykes are often severely damaged or destroyed. The floods also introduce pollutants, predatory species, and alter water quality,resulting in increase dfish mortality and diseases. Farmers face immediate income loss and financial in stability due to the damage, with the added burden of replacing essential equipment like boats, nets, and aerators. The recurring floods not only disrupt their aquaculture activities but also cause long-term financial challenges.
Upper Brahmaputra Valley Zone	• The fish farmers report that floods typically occur once a year, leading to significant losses in fish stock and business. In some areas, floods are not very frequent or severe, but when they do happen, they cause damage to fishing gear, nets, traps, and storage facilities, resulting in immediate in- come loss and financial instability. Farmers also mention that during floods,market activities slow down or are disrupted, further contributing to the economic impact. While some farmers note that recent floods have been less severe, others still face substantial losses when flood shit, particularly in terms of fish stock and business operations.

Agro-climatic Zone	Observation
North Bank Plain Zone	• The fish farmers report that floods occur yearly, sometimes twice a year, causing severe damage to their operations. The floods destroy markets, fishing equipment like boats and nets, and disrupt fishing activities, leading to significant income losses. The destruction of tools imposes heavy financial bur- dens on fishermen, with little to no government assistance. Floods not only wash away fish from ponds and rivers, reducing stock, but also disrupt supply chains, making it difficult to sell fish. Additionally, floodwaters carry pollutants, pathogens, and parasites, degrading water quality and in- creasing the risk of diseases in both fish and fishermen. Es- caped fish often cannot be recovered, leading to further financial losses. In some areas, floods are less frequent, but when they occur, they cause heavy losses in stock and infrastructure, further training fishermen's livelihoods.
Central Brahmaputra Valley Zone	• Fish farmers from the Central Brahmaputra Valley Zone report varying experiences with floods. While some areas are not affected by floods, others face significant challenges. Floods, occurring once or twice a year, often cause pond embankments to overflow,allowing fish to escape into open waters,leading to immediate financial losses. Additionally, sudden changes in water quality during floods increase fish mortality rates.The most recentsevere floods occurredin 2004 and 2022, causing extensive damage. For farmers in flood-affected areas, the loss of fish stock and damage to infrastructure present major challenges to their livelihoods, although some regions remain unaffectedby floods.
Central Brahmaputra Valley Zone	• Fish farmers from the Central Brahmaputra Valley Zone report varying experiences with floods. While some areas are not affected by floods, others face significant challenges. Floods, occurring once or twice a year, often cause pond embankments to overflow,allowing fish to escape into open waters,leading to immediate financial losses. Additionally, sudden changes in water quality during floods increase fish mortality rates.The most recentsevere floods occurredin 2004 and 2022, causing extensive damage. For farmers in flood-affected areas, the loss of fish stock and damage to infrastructure present major challenges to their livelihoods, although some regions remain unaffectedby floods.

Agro-climatic Zone	Observation
Hills Zone	• Fish farmers from the hill zone of Assam report that floods, occurring once or twice a year, significantly impact their operations. These floods introduce pollutants, sediments, and debris into aquaculture systems, leading to poor water quality and health issues among the fish. Additionally, the floods can result in fish escaping from ponds or tanks, causing stock losses and reduced production. Disruptions caused by flooding block access to fishing sites and markets, wash away significant quantities of fish seed, and create challenges in supply chains for fish feed and other essential supplies. This leads to delays or shortages that further harm fish health and production, ultimately hindering transportation and distribution networks and affecting income and market stability for the farmers.
Barak Valley Zone	• Fish farmers from the Barak Valley region of Assam report that floods occur approximately two to three times a year, although the exact frequency can be unpredictable. These floods have devastating impacts, often washing away significant quantities of fish seed and resulting in the complete loss of fish stocks from ponds due to excessive water. Farmers note that during these events,the over flooding causes most fish to escape, severely affecting their production capabilities and overall livelihood. The recurring nature of these floods poses a significant threat to their aquaculture operations, leading to considerable financial losses and instability in the fish farming sector.

7.3 Infrastructure damage or loss of stock due to extreme weather events

Fish farms often rely on carefully constructed ponds, tanks, nets, and filtration systems. Floodwater or strong winds can damage these structures, resulting in breached pond walls, broken nets, or compromised filtration and aeration equipment. In severe cases, farms may suffer total infrastructure collapse, requiring costly repairs or complete rebuilding. Damage to access roads, storage facilities, and supply chains further disrupts operations, reducing productivity and increasing expenses. Fish farmers were surveyed on whether they had experienced infrastructure damage or stock loss due to extreme weather events, impacting the production of fish value chain across various agro-climatic zones in Assam. This survey yielded the following observations:

Table 7.3: Observations on Infrastructure Damage or Loss of Stock Due to Extreme Weather Events

Agro-climatic Zone	Observation
Lower Brahmaputra Valley Zone	• Fish farmers reported experiencing infrastructure damage during floods.
Upper Brahmaputra Valley Zone	• Floods have caused embankments to breach, leading to the escape of fish and significant damage to pond infrastructure. This results in the loss of fish seed and other infrastructural damages, causing severe financial losses for fish farmers.
North Bank Plain Zone	• Extreme weather conditions, such as floods and storms, have led to an increased mortality rate among fish, severely im- pacting fish farming. Floodshave caused embankments to breach, leading to the escape of fish.

Hills Zone

- Fish farmers reported that, in response to extreme weather events, pond barriers break during floods, leading to infrastructure damage and potential stock loss.

Barak Valley Zone

- During floods, there is a heavy loss of fish stock, leading to financial instability.

7.4 Increasing Frequency and Severity of Harmful Algae Blooms in Recent Years

To gain insights into environmental changes impacting fish farming, the fish farmers were asked if they have observed any increase in the severity of harmful algal blooms in recent years. This question aimed to explore potential patterns or shifts in the frequency, duration, or intensity of these blooms, which can pose serious threats to fish health and water quality.

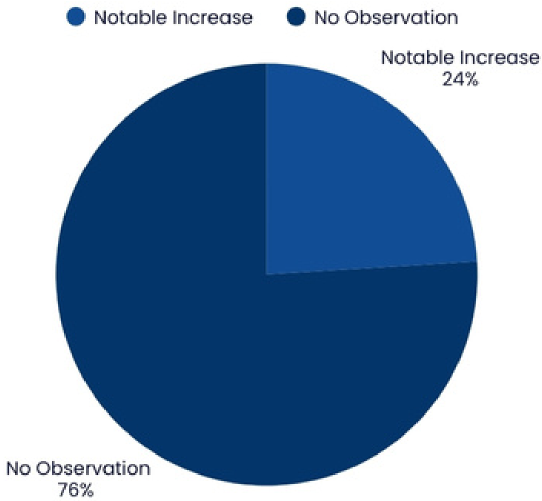


Figure 7.4: Perception of Fish Farmers on Harmful Algae Blooms

In conclusion, while there are ongoing efforts to adapt to the impacts of climate change on fisheries in Assam through both traditional knowledge and modern technology, the sectorremains under significant threat from environmental changes. Continued support for resilient practices and infrastructure development will be crucial for safeguarding the livelihoods of those affected by fisheries in the region.

In the stakeholder consultations, key emphasis was on climate-related challenges such as increased temperatures and irregular rainfall that impactfish breeding cycles and shifting stocking periods. The stakeholders advocated for climate-resilient interventions like Integrated Farming Systems (IFS), where fish farming is integrated with horticulture and livestock to recycle waste and increase income resilience. The stakeholders dispalyed climate change as a major concern impacting various stages of fish production, including breeding cycles, seed stocking, and overall output. I t w a s pointed out that shifting rainfall patterns, global warming, and delayed monsoons are key factors disrupting natural water habitats' breeding responses and seed stocking timelines, consequently affecting the entire value chain from input to marketing. The stakeholders stressed the crucial need for strategies to mitigate these disruptions to enhance efficiency and profitability within the sector.

It was also highlighted innovations in decentralized renewable energy (DRE) technology. Examples of a local entrepreneur who developed a solar-powered, insulated van equipped with an aerator for fish transport, demonstrating the potential of renewable energy solutions to foster sustainability, reduce operational costs, and im- prove fish preservation was cited. Such innovations underscore the potential of green energy inmodernizing fisheriesin Assam.Regarding the impact of climatic changes, particularly high summer temperatures, the stakeholders noted their adverse effects on fish productivity and breeding cycles. It was highlighted that technological interventions such as Recirculatory Aquaculture Systems (RAS), Pen-Culture, nursery tanks, and solar aerators as effective strategies to mitigate these effects and stabilize fishery management. However, the stakeholders also pointed out that implementing these technologies requires significant financial and technical support. In conclusion, there was an emphasis on the importance of adopting advanced technologies like RAS and solar aerators, promoting value-added products, supporting cooperative societies, and minimizing post- harvest losses through improved infrastructure and practices to unlock the full potential of Assam's fisheries sector. It was suggested that these measures, combined with enhanced training and financial support, can lead to sustainable growth and better opportunities for farmers, entrepreneurs, and all stakeholders in the sector.

Chapter 8

Conclusion and Recommendations

This study has mapped the inland fishery value chain in Assam across input, production, marketing, and ecosystem layers. It reveals a sector that is central to rural livelihoods in Assam but constrained by systemic gaps—limited access to quality inputs, inefficient farm management practices due to lack of mechanisation and energy innovations, poor value addition, and the growing threat of climate change. This chapter synthesizes the findings, highlights systemic implications, and recommends targeted interventions to enable an inclusive, climate-resilient and market-responsive aquaculture ecosystem.

8.1 Profile of Fish Farmers and Farming Systems

Fish farming in Assam is practiced across age groups and is often the main source of livelihood for rural households. Most fish farmers are men, though there is some participation by women. Households often depend on fish farming for income and food security, and many combine it with other activities like paddy or livestock farming. The sector is almost entirely based on pond culture, with a wide variety of fish species farmed depending on local preferences and resource availability. These patterns show both the economic centrality of aquaculture and the potential for more inclusive, diversified livelihood approaches.

Key findings:

- Fish farmers range in age from 26 to 74 years, with an average age of 44
- 87% of farmers are men; 13% are women.
- 68% rely on fish farming as their main livelihood.
- 86% entered fish farming to improve income; 38% also wanted better food security.
- All respondents practice pond-based aquaculture no other methods reported.
- Common species include Rohu, Catla, Grass Carp, and less common ones like Koi, Magur, and Bhokua.

8.2 Systemic Challenges in the Fisheries Value Chain

The fisheries value chain in Assam faces structural weaknesses across input procurement, production management, and marketing. These weaknesses are interconnected—poor access to quality inputs affects productivity, which in turn limits income and reinvestment capacity. In turn, weak market infrastructure and price volatility further undermine the sector's viability, particularly for small-scale and marginal farmers. The following subsections break down these challenges stage-wise.

8.2.1 Input-Level Challenges

Fish farmers in Assam face multiple constraints at the input stage, especially in accessing quality seeds and affordable feed. The majority depend on middlemen due to poor availability of hatcheries or government supply. Feeding practices vary, with many farmers relying on in-house solutions. Labor and operational costs are significant and vary across zones, adding pressure on already tight profit margins. These input-stage limitations affect the quality and sustainability of production downstream.

Key findings:

- Seed sourcing: 70.6% depend on middlemen; 28.4% on hatcheries; only 6% use government supply.
- Own hatcheries: Only 8.6% have their own hatchery infrastructure.
- Feed type: 33.6% use only in-house feed; 16.4% use commercial feed; 29.3% use both.
- Feeding frequency: Fish are usually fed twice daily; fingerlings 3–4 times daily.
- Labor costs: Outside worker salaries range from INR 7,125 to INR 10,250 depending on the zone.
- Other operational expenses: Key costs include consultancy (INR 3,620), transport (INR 2,122), and communication (INR 345) per month.

8.2.2 Production-Level Challenges

The production phase varies across agro-climatic zones, with some regions having longer cycles and more favorable conditions. Most farmers use earthen ponds and depend on rainfall or groundwater. While the average farm size is considerable, power shortages, reliance on manual methods, and lack of backup infrastructure are serious limitations. Many farmers supplement their incomes through paddy, goat, or duck farming, indicating opportunities for integrated systems.

These production challenges are further exacerbated by infrastructure gaps, including irregular electricity supply, lack of backup systems and limited access to hatchery services.

Key findings:

- Production cycle: Duration ranges from 3 to 24 months depending on zone.
- Farm size: Average farm size is 10.27 bigha.
- Water sources: Rainfall is dominant in some zones; groundwater is preferred in others.
- Livelihood diversification: 29.3% grow paddy; 8.6% raise goats; 5.2% rear ducks.
- Power reliability: Many zones suffer frequent outages; few have reliable 24-hour electricity.
- Backup systems: Use of inverters, diesel generators, and batteries is common—but costly.
- Hatchery ownership: Most farmers in Barak, Hills, and Upper Brahmaputra depend on middlemen.

8.2.3 Marketing and Post-Harvest Challenges

Fish marketing is dominated by direct-to-consumer sales, especially in remote areas where FPO and market infrastructure is weak. While fresh and live fish fetch good prices, there is minimal value addition through processing. Regional price variations exist, but processed products like pickles or dried fish remain underutilized, signaling a missed opportunity for income diversification and enterprise development. The limited development of value-added products and dependence on local, informal markets highlight the urgent need for post-harvest infrastructure and stronger FPO-led aggregation systems.

Key findings:

- Sales channels: 51% sell directly to consumers; 19% use FPOs; 26% go through middlemen/local markets.
- Remote zone behavior: In Barak Valley, Hills and Upper Brahmaputra, 100% of fish is sold directly
- Product types: 85.3% sell fresh fish; 78.5% sell live fish; only 2.6% sell pickles; 1.7% dried fish.
- Price variations: Live fish sells at a premium in Barak, Hills, and Lower Brahmaputra; fresh fish is costlier in the North Bank zone.

8.3 Institutional and Ecosystem Gaps

Despite being a significant livelihood sector, inland fisheries in Assam remain under-supported institutionally. Access to government schemes, veterinary services, AquaTech innovations, and collective platforms like FPOs and SHGs is limited and inconsistent across zones. While some Fisheries FPCs exist, only a few are functional, and farmers frequently report low awareness of available support programs. Weak last-mile service delivery and poor coordination between stakeholders have led to fragmented ecosystem support, especially in remote areas like Barak Valley and the Hills Zone.

Key findings:

- 100% of farmers in Barak Valley are unaware of relevant government schemes; Upper Brahmaputra shows the highest participation (58.3%).
- No respondents reported receiving benefits under PMMSY.
- Access to fishery consultancy and aquatic health services is extremely limited in Barak and Hills Zones.
- Traditional knowledge is dismissed by most respondents in Barak and Hills Zones; elsewhere, some still rely on it.
- Adoption of aeration and biosecurity tools is low: only 33.6% use paddlewheel aerators; few use bird nets or foot-dip pits.
- Electricity reliability for hatcheries is inconsistent—steady in some zones, disrupted in other

8.4 Climate Risks and Adaptation Challenges

Climate change has emerged as a pervasive threat to fish farming in Assam. Recurring floods, irregular rainfall, and rising water temperatures affect everything from pond infrastructure to fish mortality and market disruption. Most fish farmers use informal methods (visual observation) for temperature monitoring and lack the training or tools to adapt proactively. While techniques like raised ponds, Biofloc systems, and rainwater harvesting are being piloted, their uptake remains minimal. Without reliable adaptation measures or insurance support, climate risks continue to threaten livelihoods and profitability.

Key findings:

- Most zones experience floods annually, leading to infrastructure damage, fish escapes, and water contamination.
- 84% of respondents reported no increase in climate-related disease outbreaks, but monitoring is weak.
- Algal blooms are increasingly reported; 16% linked them to fish mortality and water stress.
- Most farmers rely on visual cues to monitor water temperature; only a few use digital tools.
- Adaptation practices like raised ponds or Biofloc systems are rare and limited to demonstration sites.

8.5 Strategic Opportunities and Pathways Forward

While the study surfaces several structural and environmental challenges, it also identifies strong opportunities for revitalizing the fisheries ecosystem in Assam:

- It was observed that while conventional hatcheries are operations-heavy and demand high civil construction costs, fiber reinforced plastic (FRP) hatcheries offer a cost-effective, portable alternative that ensures equally efficient breeding. Requiring less water and minimal infrastructure, FRP units can be easily relocated, expanded modularly, and used to rear multiple species—making them ideal for decentralized, resource-conscious fish farming.
- Based on field implementations, bridging ecosystem training gaps requires better use of Aquaculture Field Schools and AquaTech Parks for hands-on, peer-led learning. Building champion farmer networks can accelerate adoption through localized mentoring. Integrating AI and VR can further enhance training by delivering immersive, multilingual content directly to farmers—making learning accessible, scalable, and impactful.
- High dependency on imported feed and high transaction costs have made fish farming input-intensive and costly. The study highlights that localized feed production, powered by clean energy and entrepreneurship, can reduce costs and improve access. With abundant local raw materials and government support for decentralization, quality feed can become more affordable and accessible to farmers.
- Participation in aquaculture can be increased through targeted skilling and support for post-harvest enterprises like drying and packaging.

These pathways, if supported through convergence of government schemes, institutional capacity-building, and investment in rural AquaTech ecosystems, can unlock a more sustainable and inclusive future for Assam's fish farmers.

8.6 Recommendations for Sector Strengthening

This study highlights that Assam's fisheries sector, while vital to rural livelihoods, remains constrained by fragmented infrastructure, weak market linkages, low technology adoption, and climate vulnerability. Addressing these challenges requires ecosystem-wide interventions that are contextrelevant, locally driven and inclusive. Key interventions and strategies are presented ahead.

Decentralizing seed production through low-cost, portable FRP (Fibre-Reinforced Plastic) hatcheries—supported by community nurseries and localized brood banks—is a crucial starting point for strengthening Assam's aquaculture ecosystem. Quality seed forms the backbone of productive fish farming, yet many farmers currently rely on distant hatcheries or middlemen, leading to delays, higher costs, and inconsistent seed quality. By enabling localized seed production, farmers gain timely and affordable access to healthy fingerlings, reduce dependency on external supply chains, and improve survival and growth rates. This approach also encourages community-led entrepreneurship, allows for species diversification, and builds the foundation for scaling other decentralized inputs like feed and health services—making the entire value chain more resilient, efficient, and farmer-friendly.

As a positive trend, central and state-sponsored schemes have begun promoting technologies such as RAS, Biofloc units, feed mills, and aerators, which enable improved efficiency and productivity along the value chain. However, there is scope to focus on decentralized clean energy technologies that further enable and strengthen the fisheries sector and the lives of fish farmers.

Clean energy as an enabler: Frequent power outages disrupt vital operations like aeration and water circulation, directly affecting fish health and increasing mortality. Additionally, the absence of cold storage facilities, compounded by unreliable electricity, leads to high post-harvest losses and restricts farmers' access to better markets. To address these challenges, there is a pressing need for policies to integrate clean energy solutions into aquaculture schemes. Promoting solar-powered aerators, pumps, and cold storage systems can help reduce dependency on erratic grid electricity and costly diesel alternatives. These decentralized climate-smart technology interventions ensure continuous, energyefficient operations, lower production costs, and enhance farmers' resilience to both climatic and infrastructural vulnerabilities—ultimately enabling more sustainable and profitable fish farming.

Building trust and ownership: Addressing misconceptions around clean energy technologies is essential for accelerating their adoption in the fisheries sector. As highlighted through interviews, many farmers remain hesitant due to perceived high costs, doubts about effectiveness, or lack of familiarity with operation and maintenance of these technologies. By prioritizing on-ground demonstrations, offering reliable after-sales support, and implementing Entrepreneur Development Programs (EDPs) that enable a strong, local supply ecosystem, these doubts can be systematically dispelled. This builds trust and ownership that is crucial in enabling users to feel confident and supported using these technologies. Doing this early on is imperative—it lays the groundwork for smoother uptake, reduces technology abandonment, and helps establish a strong ecosystem of local service providers who can sustain adoption over the long term.

Climate-smart strategies: Promoting flood-resistant fish breeds and structural adaptations such as raised pond designs and flood buffers is a critical first step in building climate resilience for Assam's fish farmers. With floods occurring almost annually across several districts, conventional pond systems and commonly reared species often suffer heavy losses—displacing livelihoods and damaging infrastructure. Introducing hardy, flood-tolerant species (such as Magur, Singhi, Koi, Murrel, etc) alongside climate-smart infrastructure can significantly reduce mortality, protect assets, and stabilize incomes.

Engaging local institutions: To effectively implement these solutions, collaboration with key institutions like the College of Fisheries (Raha), Krishi Vigyan Kendras (KVKs), and innovation hubs like the AquaTech Park is essential. These local knowledge hubs and platforms can provide hands-on training in adaptive systems such as Biofloc and RAS, equipping farmers with the skills and knowledge needed to adopt and sustain these practices. Early promotion of such interventions sets the foundation for a more robust and future-ready aquaculture ecosystem.

As Assam navigates the dual challenges of climate vulnerability and rural livelihood stress, the fisheries sector offers a powerful lever for equitable growth, ecological resilience, and local entrepreneurship. With the right mix of training, policy support, institutional strengthening, and community-led innovation, fish farming can transform into a dignified, secure, and climate-smart livelihood across the state's diverse agro-climatic regions.

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