YANGON UNIVERSITY OF ECONOMICS
DEPARTMENT OF APPLIED ECONOMICS
MASTER OF PUBLIC ADMINISTRATION PROGRAMME

A STUDY ON THE CHALLENGES OF FISH HATCHERIES FOR THE DEVELOPMENT OF FRESHWATER FISH RESOURCES

(Case Study on Pathein Fish Hatchery)

ZAW MIN TUN
EMPA - 101 (20th BATCH)

June , 2025

YANGON UNIVERSITY OF ECONOMICS
DEPARTMENT OF APPLIED ECONOMICS
MASTER OF PUBLIC ADMINISTRATION PROGRAMME

A STUDY ON THE CHALLENGES OF FISH HATCHERIES FOR THE DEVELOPMENT OF FRESHWATER FISH RESOURCES (Case Study on Pathein Fish Hatchery)

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Public Administration (MPA)

Supervised by
Dr Cho Cho Thein
Pro-Rector
Yangon University of Economics

Submitted by
Zaw Min Tun
Roll No. 101
EMPA 20th Batch
(2023 – 2025)

June, 2025

YANGON UNIVERSITY OF ECONOMICS
DEPARTMENT OF APPLIED ECONOMICS
MASTER OF PUBLIC ADMINISTRATION PROGRAMME

This is to certify that this thesis entitled **"A Study on The Challenges of Fish Hatcheries for The Development of Freshwater Fish Rescources (Case Study on Pathein Fish Hatchery)"** submitted as a partial fulfillment towards the requirements for the degree of Master of Public Administration has been accepted by the Board of Examiners.

Board of Examiners

Dr Tin Tin Htwe
(Chairperson)
Rector
Yangon University of Economics

Dr. Cho Cho Thein
(Supervisor)
Pro-Rector
Yangon University of Economics

Dr. Tin Tin Wai
(Examiner)
Pro-Rector
Yangon University of Economics

Dr. Su Su Myat
(Examiner)
Professor/Head
Department of Applied Economics,
Yangon University of Economics

Dr.Khin Thu Thu Thein
(Examiner)
Lecturer
Department of Applied Economics,
Yangon University of Economics

June, 2025

ABSTRACT

The study aims to examine the challenges faced by fish hatcheries in the development of freshwater fish resources and to analyze the challenges faced by private fish entrepreneurs. It implements descriptive methods and applies both primary and secondary data sources. A questionnaire survey was conducted by interviewing the total number of respondents, 126, 48 of whom were government employees, 3 were researchers, and 75 of whom were fishing private industry. It assesses operational practices, stakeholder perspectives, environmental pressures, and institutional challenges surrounding hatchery management and fish fry stocking. The study's key findings indicate that both public and private hatcheries contribute significantly to the aquaculture supply chain, with private hatcheries dominating overall production. However, the freshwater fisheries sector faces considerable regulatory and policy challenges, financial challenges, environmental challenges, technological and infrastructure challenges, awareness and knowledge and operational challenges. Despite these challenges that better coordination and trust building mechanisms be established, clear mechanisms for dispute management and conflict resolution be established, and extensive education and training programs be established due to the lack of understanding of the impacts of overfishing and destructive fishing practices.

ACKNOWLEDGEMENTS

I have been indebted to many people for the completion of this thesis. First and foremost, I would like to express my sincere appreciation and deep gratitude to Professor Dr. Tin Tin Htwe, Rector of Yangon University of Economics, for her kind permission to undertake this study as a partial fulfillment towards the degree of Master of Public Administration.

I wish to express my deepest appreciation to Professor Dr. Kyaw Min Htun, Pro-Rector (Retired), at the Yangon University of Economics. My special thanks also to Professor Dr. Su Su Myat, program director of the MPA program and head of the Department of Applied Economics, Yangon University of Economics, for their enthusiastic and systematic guidance throughout the course and encouragement for the completion of this study.

I am also grateful to my supervisor, Professor Dr. Cho Cho Thein, Pro-Rector of the Yangon University of Economics, for her invaluable supervision, valuable guidance, and constructive suggestions throughout this thesis. Moreover, I am very thankful to the Department of Fisheries (DoF), Ayeyarwady Region, Pathein Fish Hatchery, and members for sharing valuable time and giving the updated data and kind help. In addition, I would like to extend my gratitude to all Pro-Rectors (Retired), Pro-Rectors, Professors, Assistant Professors, and all teachers at the Yangon University of Economics for invaluable knowledge transfer.

Finally, I would like to thank all my friends and colleagues for their kindness, encouragement, cooperation, and invaluable support during my study. I also would like to extend my deepest gratitude to my parents, and my wife for their encouragement, kind support and understanding.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURE

LIST OF ABBREVIATIONS

AFTA	ASEAN Free Trade Area
ASEAN	Association of South East Asian Nations
DoF	Department of Fisheries
EU	European Union
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GHP	Good Hygienic Practices
GMP	Good Manufacture Practice
HACCP	Hazard Analysis Critical Control Point
IEC	International Electrotechnical Commission
IFT	Institute of Fisheries Technology
ISO	International Organization for Standardization
MOALI	Ministry of Agriculture, Livestock and Irrigation
NGOs	Non-Government Organizations
SMEs	Small and Medium Enterprises
SPS	Sanitary and Phytosanitary
WTO	World Trade Organization

CHAPTER I

INTRODUCTION

1.1 Rationale of the study

Aquaculture has developed quickly in recent decades, contributing nearly as much to total fish production as capture fisheries. Aquaculture practices are believed to have originated around 3,000 years ago, likely in China, influenced by imperial interests. Early methods involved maintaining fish in constructed ponds, where fishers temporarily resided in submerged baskets within dammed sections of rivers an approach thought to stem from ancient Chinese fishing traditions.

Aquaculture is considered a vital approach for increasing food production from aquatic ecosystems in the future. However, it can affect biodiversity through the emission of greenhouse gases and the discharge of waste materials, including uneaten feed and other by-products, into surrounding environments. At present, significant quantities of wild fish are harvested to produce feed for farmed fish and shrimp, which serve as essential sources of protein and omega-3 fatty acids. Nevertheless, the growing demand from the aquaculture sector may contribute to overexploitation of wild fish stocks, raising concerns about the sustainability of such practices.

Over the past two decades, Myanmar's aquaculture arming has developed significantly and become increasingly essential to the fish supply. Fishing and aquaculture account for 2% of Myanmar's GDP and 50% of animal protein consumption.

In Ayeyawady Region, the freshwater fish sector contributes an annual average of 9.6% to the region’s GDP. The government remains dedicated to overseeing and advancing opportunities for the growth of aquaculture and fisheries production. Fish farming generates employment at twice the rate of paddy cultivation, supporting more than 456,000 full-time positions and approximately 1.37 million part-time jobs.

Freshwater fish stocks play a crucial role in sustaining livelihoods and ensuring food stability in many parts of the world, including Myanmar. Fish hatcheries are vital for ensuring the sustainable development of these resources. However, industry faces several challenges, including operational inefficiencies, environmental factors, and socio-economic pressures.

The Pathein Fish Hatchery serves as a case study for understanding these challenges, given its regional significance and potential for contribution to the aquaculture industry in Myanmar. This study aims to identify the hurdles faced by hatchery and suggest practical solutions for its development.

Despite the increasing demand for freshwater fish, hatcheries like the Pathein Fish Hatchery struggle with issues such as outdated technology, limited funding, environmental degradation, and a lack of skilled labor. These challenges hinder hatchery operations and pose significant obstacles to the sustainable development of freshwater fish resources in the region.

1.2 Objectives of the study

The objectives of the study are:

(1) To examine the challenges faced by fish hatchery in the development of freshwater fish resources.

(2) To analyze the challenges faced by private fish entrepreneurs.

1.3 Method of study

The study employed descriptive methods, integrating both quantitative and qualitative approaches. Secondary data was sourced from the Department of Fisheries, FAO publications, research articles, government documents and online resources related to aquaculture. Primary data was gathered through structured questionnaires distributed to hatchery personnel, local stakeholders, and aquaculture experts. In addition, field visits to the Pathein Fish Hatchery were conducted to observe operations and collect firsthand information. A descriptive method has been applied to interpret and present the findings.

1.4 Scope and Limitations of the study

The study aims to explore the Pathein Fish Hatchery and examines its operational, environmental, and socio-economic challenges. Limitations include time constraints, limited access to certain data, and the study's regional focus, which may not fully capture national trends. The sample size was (126) respondents from Department of Fisheries employees, employees from fish hatcheries, administrative staff, researchers, lake grant tender winners, fishpond owners, aquarium workers and fishermen of Pathein Township by formulating questionnaires.

1.5 Organization of the Study

The study is structured into five chapters. Chapter 1 outlines the rationale of the study, objectives of the study, methods of the study, scope and limitations of the study, and organization of the study. Chapter 2 includes a review of relevant literature. Chapter 3 provides an overview of freshwater fish resources. Chapter 4 describes the survey analysis conducted using questionnaires while Chapter 5 concludes the study with a summary of key findings and suggestions.

CHAPTER II
LITERATURE REVIEW

2.1 Overview of Fish Hatcheries

Fish hatcheries are an important role in the development of freshwater fish resources by ensuring the sustainable supply of fish for commercial fisheries, aquaculture, and conservation programs. Despite their significance, hatcheries face multiple challenges that hinder their effectiveness in promoting freshwater fish resources. These challenges range from environmental and genetic issues to economic and technical constraints.

Freshwater fish resources are natural fish stocks found in rivers, lakes, and ponds. They are used in aquaculture, food, industry, economy, and nature conservation. The benefits of freshwater fish resources include protein-rich food, economic growth, fish farming, and fish products. Conservation of these resources can reduce environmental pollution and create jobs in the fishing, dried fish industry, and fish product production sectors. Maintaining clean water resources is crucial for agriculture, the economy, and nature conservation.

Financial and economic factors that affect hatchery-reared fish are high operational costs, competition in the market, technological as well as managerial limitations, policy and regulatory limitations, and issues of sustainability. The excessively high investments in feeding facilities, infrastructure, and skilled labor, especially in the developing nations, are reflected as high operational costs.

Market competition dictates price and demand. Rearing and breeding challenges are among the technical and management limitations that demand specific technical knowledge and advanced techniques. Environmental and biosecurity standards may be strict and costly to achieve, and sustainability concerns include the aspect of ensuring released hatchery fish will not be harmful to the natural population or disrupt normal ecological balance.

Although fish hatcheries are crucial to supplement freshwater fish stocks, they are exposed to numerous challenges that may undermine their success. Enhancing hatchery management, innovation in technologies, and policy changes that foster sustainable fish production would address these challenges. A strategy will ensure long-term hatchery operations and protect freshwater biodiversity. (FAO,2020)

2.2 Types of Hatcheries and Methods of Fish Cultivation

Fish hatcheries can be broadly classified based on their operational strategies, which align with specific production goals and stocking philosophies. There are three types of hatcheries, which are production, supplementation, and conservation. Each type operates with distinct objectives that influence the physical, genetic, and behavioral traits of the fish they cultivate. Production hatchery primarily focuses on maximizing the output of fish for commercial or stocking purposes. Supplementation hatchery aims to enhance existing wild fish populations, often through restocking or supporting breeding programs. Conservation hatcheries, on the other hand, prioritize the preservation of endangered or declining fish species, maintaining genetic diversity and supporting population recovery.

In practice, many contemporary hatcheries do not operate exclusively within a single category. Instead, they often serve multiple roles simultaneously, functioning as hybrid facilities that carry out production, supplementation, and conservation activities within the same operational space. While the culture of commercial food, fish and ornamental species falls outside the scope of this chapter, it is noteworthy that their production goals closely resemble those of production-oriented hatcheries.

2.2.1 Production Hatcheries

Production hatcheries primarily aim to generate large quantities of fish to support recreational and commercial fisheries or to compensate for fishery losses caused by human activities. These hatcheries focus on enhancing fish population numbers, with success typically measured by the quantity of fish produced and stocked into natural water bodies.

Generally medium to large in scale, production hatcheries are capable of rearing

hundreds of thousands to millions of juvenile fish annually. Juvenile fish are often raised in outdoor environments, such as large raceways or ponds, and later released en masse into rivers, lakes, or other receiving waters.

Modern production hatcheries play a critical role in stocking public water bodies and sustaining fishing opportunities. However, this approach has faced criticism due to its potential ecological and genetic impacts on wild fish populations. Concerns include negative interactions between hatchery-raised and wild fish, genetic dilution of wild populations through the introduction of hatchery-selected traits, and continued exploitation of already pressured fish stocks. These issues have been discussed extensively in the literature (e.g., Naish et al., 2007). Despite such concerns, production-focused hatchery methods remain widely used, particularly in the context of put-grow-and-take fisheries or other intermittent stocking programs designed to meet specific fishery management goals.

2.2.2 Supplementation Hatcheries

Supplementation hatcheries typically make use of conventional production hatchery facilities but differ significantly in their approach. Rather than relying solely on domesticated broodstock, these programs often use wild-caught broodstock or gametes sourced from feral fish populations. In many cases, advanced breeding strategies are implemented to minimize genetic drift and avoid artificial selection, thereby preserving the genetic integrity of natural populations.

The primary objectives of supplementation hatcheries include reducing the immediate risk of extinction, facilitating population recovery, re-establishing fish in previously occupied habitats, and enhancing opportunities for sustainable harvests. One of the central challenges in supplementation programs is determining whether hatchery-origin fish that spawn in the wild contribute positively to the long-term viability of natural populations. Supplementation efforts should be viewed as experimental in nature and integrated within an adaptive management framework. This approach enables continuous monitoring, learning, and adjustment to ensure that supplementation practices align with conservation and resource management goals.

2.2.3 Conservation Hatcheries

Conservation hatcheries differ markedly from production and supplementation hatcheries in their objectives, operational methods, and criteria for success. The primary mission of a modern conservation hatchery is twofold: to preserve the genetic diversity of native fish populations and to support the recovery of wild stocks. These hatcheries are designed not merely to increase fish numbers but to protect the long-term viability of species through scientifically guided management and propagation practices.

A key aspect of conservation hatcheries is the application of intensive monitoring and control over breeding protocols, ensuring that the sourcing, rearing, and mating processes maintain the genetic integrity of the fish. These hatcheries are expected to reflect up-to-date scientific research and best practices in conservation biology, aiming to safeguard both genetic variability and natural behaviors, while also reducing the short-term risk of extinction in vulnerable populations. To achieve these goals, conservation hatcheries employ a variety of rearing protocols that are carefully tailored to mimic natural life cycles. The objective is to produce fish stocks that remain genetically similar to their wild counterparts and are capable of surviving and reproducing successfully in their native habitats. Comprehensive and species-specific culture techniques are adopted to ensure that fish developed in conservation hatcheries possess the appropriate physiological and behavioral traits required for successful reintroduction into the wild.

Such hatcheries strive to replicate natural environmental conditions, thereby enhancing juvenile fish health and survival while minimizing artificial influences on genetic and behavioral traits. This approach helps to reduce the ecological and genetic disruptions that hatchery-reared fish may otherwise introduce into wild populations upon release.

Standard operational procedures have been established for Pacific salmon conservation hatcheries, and many of these can be adapted for other species. Although conservation hatchery models are relatively recent and still undergoing evaluation, early results suggest that these approaches can mitigate maladaptive traits, lessen ecological impacts, and improve survival rates (Maynard et al., 2005; Flagg et al., 2005; Hebdon et al., 2005). In the Pacific Northwest, conservation hatcheries have played a crucial role in restoring depleted salmon populations and reviving weakened spawning

runs. These initiatives are consistent with broader conservation efforts for other vertebrate species and illustrate the potential of hatchery-based strategies, when guided by conservation principles, to support the long-term survival of at-risk fish populations (DeBlieu, 1993; Olney et al., 1994; Bryant, 2003; Flagg & Nash, 1999).

2.3 The Role of Fish Hatcheries in Freshwater Fish Resource Development

Fish hatcheries play a crucial role in freshwater fish resource development, particularly for species that are threatened or have declined due to overfishing, habitat degradation, or other human-induced factors. They serve as a primary tool for reintroducing or supplementing fish populations, contributing to the conservation and sustainable management of these resources. Hatcheries are also instrumental in providing fish for recreational fishing, stocking lakes and rivers with desirable species to enhance angling opportunities and support local economies. The use of hatcheries for these purposes can be particularly beneficial in areas where natural reproduction rates are low or where populations have been impacted by environmental stressors.

A fish hatchery is an aquaculture facility that cultivates aquatic animals during their earliest and most vulnerable life stages, when mortality rates are typically high. By offering controlled rearing conditions, hatcheries significantly enhance survival during these critical periods. In the Great Lakes region, “hatchery” generally refers to culture systems that raise fish intended for release or “planting” into wild habitats as part of conservation or resource enhancement efforts. However, hatcheries serve broader purposes, providing optimal early growth environments for fish used in various systems, serving purposes such as stocking, food production, bait supply, or ecological restoration. Key hatchery functions include gamete collection (eggs and sperm), egg incubation, and larval rearing through juvenile stages. Broodstock may be sourced from captive populations or wild adults. After initial rearing, hatchery-raised fish may continue to grow in the same facility, be transferred to other grow-out systems, or be released into natural waters for conservation, restoration, or recreational fishing. Hatcheries thus support commercial, recreational, and charter fisheries by producing fish that can reach catchable size in natural environments (e.g., state and provincial release of Pacific salmon fingerlings and yearlings into the Great Lakes). They also aid

in bolstering spawning populations and reintroducing species in areas where they have declined or disappeared, such as native fish and mussels.

In the Great Lakes region, hatcheries are operated by a mix of private organizations. The overlapping functions of public versus private hatcheries stocking-focused under natural resource agencies versus food production under agriculture departments have led to regulatory ambiguity and complicated economic assessments of these industries.

Freshwater fish hatcheries are important to the breeding, development, and survival of freshwater fish species. These hatcheries contribute significantly to aquaculture, conservation, and fisheries management. The key functions of freshwater fish are hatcheries and their importance in sustaining fish populations and supporting the aquaculture industry.

(1) Egg Collection and Development Maintenance

The first stage in the fish hatchery process involves the careful collection and maintenance of fish eggs. This stage includes that the collecting eggs from selected parent fish, maintaining eggs in a controlled environment with optimal temperature and water quality and monitoring the development stages, including incubation process management. The proper management at this stage ensures the successful fertilization and hatching of fish eggs, leading to higher survival rates of larvae.

(2) Larvae Breeding

Once the eggs hatch into larvae, careful breeding and monitoring are required to ensure their survival and healthy development. This stage includes that Maintaining the health of larvae as they mature into fry, regulating feeding schedules and ensuring proper nutrition, maintaining water hygiene to prevent disease outbreaks and Implementing disease prevention measures and improving survival rates. This stage is essential in determining the overall health and viability of the fish population in aquaculture systems.

(3) Fingerling Stage

At the fingerling stage, young fish undergo further growth before they are transferred to larger environments. This stage includes Preparing fish for further growth

by providing optimal nutrition and care, promoting growth through appropriate feeding techniques Regulating water quality to create a compatible freshwater environment for the fish. It ensures that the fish reach maturity with strong survival capabilities.

(4) Distribution of Fish for Aquaculture

When the fish reach an appropriate size, they are distributed for various aquaculture and fishery programs. This includes that Transporting fish to commercial fish farms, Supplying fish to aquaculture centers for breeding and production and Enhancing fish stock in natural lakes and rivers to support ecosystem balance and fishery industries. Efficient distribution supports sustainable fisheries and ensures the availability of high-quality fish for commercial and conservation purposes.

(5) Additional responsibilities

These additional efforts contribute to the sustainability of freshwater fish populations and support the long term growth of the aquaculture industry. Since freshwater fish hatchery played a fundamental role in fisheries and aquaculture by ensuring the controlled breeding, growth, and distribution of fish. Their contributions extend beyond economic benefits to include species conservation, research advancements, and ecosystem management. As the demand for freshwater fish continues to grow, hatcheries will remain vital in ensuring a stable and sustainable fish supply.

2.4 Importance of Freshwater Fish Resources for Food and Nutrition.

Freshwater fish resources play a crucial role in food security, economic development, environmental sustainability, and human health. As a vital source of nutrition, employment, and ecological balance, freshwater fish contribute significantly to both local and global wellbeing. It examines the importance of freshwater fish resources in terms of food and nutrition, economic and social development, environmental conservation, and human health.

2.4.1 Importance of Food and Nutrition

Freshwater fish serve as a primary source of essential nutrients, making them indispensable for human health and well-being.

(1) High Nutritional Value

Human health requires high-quality protein, necessary amino acids, and Omega-3 fatty acids from freshwater fish. These fish are cheaper than other protein sources, making them accessible to low-income communities. They also include vitamin D, B12, and A, which boost bone, immunological, and overall health. (Smith et al., 2021).

(2) Contribution to Food Security

The availability of freshwater fish significantly enhances food security, particularly in regions dependent on fisheries and aquaculture. Wild freshwater fish provide a sustainable food source for local communities, while fish farming contributes to stable food production and economic growth (Anderson & Brown, 2019). Sustainable fisheries help meet the increasing global demand for protein while reducing the pressure on marine fish stocks (Zhang et al., 2021).

2.4.2 Economic and Social Development

The fishing and aquaculture industries play a vital role in economic growth and job creation, providing livelihoods for millions of people worldwide.

(1) Fishing and Aquaculture Industry

The freshwater fishing and aquaculture sectors generate employment and income for fishers, farmers, and traders. Increased fish production stimulates local and international trade, creating opportunities for economic expansion (Garcia et al., 2020). The development of sustainable aquaculture practices further enhances food availability and economic resilience in rural areas (Cheng & Wong, 2023).

(2) Maintaining Clean Freshwater Ecosystems

Freshwater fish contribute to maintaining the health of aquatic ecosystems by regulating populations of other organisms and contributing to nutrient cycling. Healthy fish populations support water quality by preventing the overgrowth of algae and other harmful species (Jones & Brown, 2019).

2.4.3. Environmental Conservation and Biodiversity

Freshwater fish resources are essential for preserving ecological balance and maintaining biodiversity.

(1) Role in the Food Chain

As key organisms in freshwater ecosystems, fish serve as both predators and prey, playing an essential role in the natural food chain. Their presence helps regulate aquatic species populations and maintain ecosystem stability (Hernandez et al., 2019).

(2) Biodiversity Conservation

The conservation of diverse freshwater fish species is crucial for sustaining ecological balance. Preserving biodiversity ensures the resilience of aquatic ecosystems, allowing them to adapt to environmental changes and support other wildlife (Miller & Adams, 2019). Sustainable fishing practices and habitat conservation efforts are necessary to protect these vital resources (Nguyen & Lee, 2020).

2.4.4 Health and Social Development

Consuming freshwater fish contributes to improved human health and supports regional social development.

(1) Health Benefits

Freshwater fish consumption is associated with numerous health benefits, including cardiovascular health, brain development, and immune system support. The Omega-3 fatty acids found in freshwater fish reduce the risk of heart disease and inflammation, while essential vitamins and minerals enhance cognitive function and overall well-being (Williams et al., 2018; Zhao et al., 2021).

(2) Social and Regional Development

Fishing and aquaculture industries create employment opportunities in rural areas, promoting social development and economic independence for local communities. Investment in sustainable fisheries and fish farming enhances food security and economic growth, particularly in developing regions (Smith et al., 2021).

2.5 Challenges facing freshwater fish resource conservation.

The conservation of freshwater fish resources is increasingly threatened by a complex array of interrelated challenges. These include environmental degradation, unsustainable human activities, technological gaps, economic pressures, and weak institutional frameworks. As global demand for fish continues to rise, ensuring the sustainable management of freshwater ecosystems has become a critical concern for both ecological stability and food security. Freshwater aquaculture is a major contributor to global fish production, especially in Asia, where intensive aquaculture practices have achieved significant yields despite limited land and water availability. However, in other regions such as Africa and Latin America, although there remains substantial potential for growth, freshwater aquaculture is increasingly constrained by rapid urban expansion and intensifying competition for essential natural resources like land and freshwater. These limitations pose significant barriers to the expansion of inland fish farming systems, thereby affecting both conservation efforts and food supply (Food and Agriculture Organization (FAO,2014).

2.5.1 Environmental Challenges

Freshwater fish populations are increasingly vulnerable to a range of environmental stressors that threaten their long-term survival and the sustainability of aquatic ecosystems. As global and regional environmental conditions continue to deteriorate, the viability of inland fisheries and aquaculture systems is severely compromised. The cumulative effects of pollution, habitat degradation, climate instability, and the spread of invasive species have placed immense pressure on freshwater biodiversity, making conservation efforts more urgent than ever.

(1) Water Pollution

One of the primary threats to freshwater fish conservation is water pollution. Various pollutants, including industrial chemicals, agricultural pesticides, and household waste, contribute to the degradation of water quality, making it difficult for fish species to thrive. Studies have shown that toxic substances from industrial zones and agricultural runoff disrupt aquatic ecosystems, leading to reduced oxygen levels and the decline of fish populations (Smith et al., 2020).

(2) Habitat Destruction

Habitat destruction due to urban expansion, deforestation, and dam construction poses a severe risk to freshwater fish species. Urbanization leads to increased sedimentation and contamination, while deforestation disrupts the natural water cycle, affecting fish breeding grounds (Jones & Brown, 2019). The construction of dams alters water flow patterns and migration routes, leading to habitat fragmentation and species endangerment (Anderson, 2018).

(3) Invasive Species

The introduction of invasive fish species, such as Pacu and Snakehead, presents another significant challenge. These non native species compete with indigenous fish for food and habitat, often outcompeting and displacing native populations (Garcia et al., 2021). Furthermore, some invasive species exhibit predatory behaviors, further reducing biodiversity in freshwater ecosystems.

(4) Thermometry and Climate Change

Climate change has led to rising freshwater temperatures, which affect fish respiration and metabolic rates. Higher temperatures reduce dissolved oxygen levels, making it difficult for fish to survive (Williams et al., 2017). Additionally, extreme weather events such as droughts and flooding disrupt breeding cycles and fish habitats, leading to further declines in populations.

2.5.2. Challenges Caused by Human Activities

The degradation of freshwater ecosystems and the decline of fish populations are increasingly attributed to human-induced pressures. Among these, unsustainable fishing practices, illegal harvesting methods, and the unregulated expansion of aquaculture pose significant threats to freshwater biodiversity and ecological balance. These anthropogenic activities disrupt the natural reproductive cycles of fish, degrade habitats, and undermine long-term conservation efforts.

(1) Overfishing

One of the foremost challenges is overfishing, driven by unregulated and excessive exploitation of natural fish stocks. In many regions, the absence of sustainable fishery management systems has led to the depletion of key species, particularly in inland water bodies. Furthermore, bycatch—the incidental capture of non-target species intensifies this decline, while the widespread use of unskilled and indiscriminate fishing methods accelerates resource exhaustion (Kim & Patel, 2022).

(2) Illegal Fishing Practices

The use of environmentally destructive techniques, such as chemical poisoning, dye application, and electric fishing, inflicts severe damage on aquatic ecosystems. These practices not only target commercial species but also harm a wide range of non-target organisms, disrupting food chains and habitat integrity. Unregulated netting and pole fishing also contribute to the loss of aquatic biodiversity and the destruction of essential breeding grounds (Nguyen & Lee, 2020).

(3) Unregulated Aquaculture

The unregulated growth of aquaculture has emerged as another pressing concern. In the absence of proper environmental safeguards, many fish farms release untreated waste and chemical effluents directly into surrounding water bodies. This discharge contributes to pollution and eutrophication, reducing dissolved oxygen levels and altering water chemistry. The use of substandard feed and additives further compromises water quality, negatively impacting both cultured and wild fish populations (Hernandezetal,2019). These human-driven activities highlight the urgent need for integrated and enforceable regulatory frameworks to ensure sustainable management of freshwater resources. Without timely intervention, the cumulative

effects of these practices may lead to irreversible ecological damage and the collapse of local fisheries.

2.5.3. Technology Economic and Institutions Challenges

Sustainable freshwater fish conservation is not only hindered by ecological and human behavioral factors, but also by a range of technological, economic, and institutional limitations. These interconnected challenges reduce the capacity of local communities and fishery stakeholders to adopt sustainable practices, invest in long-term aquaculture development, and effectively enforce conservation policies. Addressing these systemic issues is crucial for enhancing productivity, ensuring environmental protection, and supporting the livelihoods of small-scale fish farmers.

(1) Lack of Fish Farming Technology

A major constraint is the lack of access to modern fish farming technologies. In many developing regions, aquaculture practices remain largely traditional and inefficient. The absence of advanced systems for water quality management, disease control, and feed optimization has led to low productivity and resource overuse. Moreover, limited access to education, technical training, and extension services restricts farmers' ability to implement innovative and sustainable aquaculture methods (Zhang et al., 2021).

(2) Economic and Sales Competition

Another significant barrier arises from economic and market competition. The increasing availability of low-cost imported fish products in local markets has created intense competition for domestic producers. This not only reduces the profitability of local fish farming but also destabilizes their income and investment capacity. As a result, many fish farmers are discouraged from adopting sustainable practices or engaging in conservation initiatives, especially when facing volatile prices and uncertain market conditions (Cheng&Wong,2023).

(3) Weak Institutions

Weak institutional structures pose a critical challenge to effective freshwater fish resource management. Many regulatory frameworks lack clarity, coherence, and enforceability. The absence of strong institutional mechanisms for policy implementation, monitoring, and enforcement contributes to unchecked overfishing, habitat degradation, and illegal activities. Inadequate governance undermines coordinated efforts to conserve aquatic ecosystems and support sustainable fisheries development (Miller&Adams,2018).

2.6 Review of the previous studies on the fish farming sector

Shitote, Wakhungu (2013) analyzed the "Challenges Facing Fish Farming Development in Western Kenya, the challenges faced by fish farmers in Siaya County, Kenya. The research, which involved 192 households, used stratified random sampling and data collection methods such as structured questionnaires, interviews, and focus group discussions. The findings revealed that the main challenges faced by farmers include high costs of fish feed, a shortage of quality fingerlings, poor management practices, environmental issues, and financial constraints. It highlights inadequacies in government support and the fragmented promotion of fish farming, leading to confusion among farmers. The study recommends improved government involvement, particularly in ensuring the quality of fish feed and fingerlings, and the establishment of coherent policies to support the fish farming sector. It also calls for training initiatives to enhance farmers' management practices. Addressing these challenges is crucial for sustainable growth in fish farming in the region. To analyze the study, one should examine its contextual significance within the broader literature on aquaculture, scrutinize the methodological choices made by the authors, and critically review the implications of the study's findings on existing fish-farming policies. Identifying gaps for future research could involve exploring the long-term effectiveness of the recommended strategies or investigating the impact of external factors on fish farming dynamics. This approach enriches the understanding of the study and situates it within a broader scholarly dialogue on aquaculture.

The study "A Study on Fishery Export in Myanmar" was carried out by Su Hlaing Moe (2018). According to this analysis, both the public and private sectors must

build the necessary onshore infrastructure, including cold storage facilities, processing facilities, and ice factories. Fish, prawns, shrimp, and other seafood should be exported as fresh goods to other countries. In order to boost their worth, fish products must be upgraded to be semi-processed or value-added. Regular energy supply is beneficial to the fishing industry. In the fishing industry, production procedures must be upgraded to meet international standards. The implementation, validation, and promotion of HACCP, GMP, GHP, and improved laboratory practices, the promotion and conduct of training programs to upgrade the technical skills and competencies of personnel in the private sector, and the strengthening of the fisheries industry's compliance with regional and international requirements are all ways that the fishery sector should develop and implement fish quality and safety management systems that support the current competitive position of Myanmar fishery products in the regional and global markets.

In actuality, government initiatives are the most significant contributor to the general expansion and advancement of the fishing industry. To enhance Myanmar's fisheries exports, the government should create policies that encourage more investment in fisheries production and supply infrastructure like power, which is essential for cold storage in the fish value chain. There is a growing introduction of new technologies for production and processing. Myanmar exports the majority of its fisheries products as raw materials. These raw seafood from Myanmar are reprocessed or transformed by the importers before being sold to other outside markets. In this sense, it is crucial to improve the fish product by making it semi-processed or value-added in order to raise its worth. The efficiency of fisheries exports also depends on strategies to modernize conventional fishing processing and preservation techniques as well as market marketing. Fish and fisheries goods are in considerable demand on the global market these days. As a result, they must be in high-quality, appropriately rated packaging. To do this, many actions must be taken: Before being exported, hygienic and quality control procedures must be implemented, and sufficient processing and ice-making facilities must be provided, appropriately matched to growing fishing exploitation.

Thet Thet Zaw (2019) analyzed the “Small- Scale Fish Farming in Kayin State, this study comprehensively explores the significance of small-scale fish farming, particularly in developing countries. It establishes a conceptual framework by defining

fish farming and highlighting its role in enhancing food security and promoting economic growth. Additionally, the review delves into various challenges such as limited resources, access to markets, and environmental factors that influence the viability of fish farming in these regions. Relevant policies, including international frameworks that advocate sustainable practices, are also discussed to underscore their impact on local fish farming initiatives. To further enrich the discussion, the study incorporates survey data obtained from 47 fish farmers in the Hpa-an township, utilizing both quantitative and qualitative methods. This mixed-method approach allows for a nuanced analysis of the farmers' practices, challenges, and outcomes in their aquaculture efforts. The survey includes carefully designed questionnaires that capture information about production levels, market access, and the training received by farmers. This data not only quantifies the current state of fish farming but also elucidates the barriers faced by the farmers, such as inadequate feeding practices and water quality management issues. Analyzing the survey data involved employing descriptive statistical methods to present findings clearly and effectively. By organizing the data into tables, charts, and frequency distributions, the research highlights patterns and trends within the small-scale fish farming sector. These analytical results provide essential insights into the relationship between farmers' practices, resources, and challenges. The study's findings and recommendations aim to enhance the sustainability and productivity of small-scale fish farming in the region.

Thiri Aung (2019) studied the "Development of Fishery Sector in Myanmar". This study found that the freshwater fisheries, the fishery sector should develop fishery production through rehabilitating and restoring habitats for freshwater fish and restocking indigenous fish species. For the marine fisheries, the fishery sector should implement comprehensive policies through licensing and community fish rights, the improvement of vessel registration system. Fishery exporters need to comply with the quality of international standard. For export, quality is the crucial determinant for every product, especially food products. Export quality is the crucial determinant for every products especially food products. The skills and expertise of the employees are also important for improving quality in the production process. In this regard, the 57 fishery exporting companies needs to provide training programs and knowledge and commitment for improving the quality.

The fishery export enterprises also need to care about the promotional activities to entice potential new customers. Private enterprises solely depend on their regular customers. To take advantage of the bargaining power of buyers, the private enterprises need to attract new customers, not only from ASEAN member countries but also from other regions of the globe. Moreover, ahead of implementing ASEAN Free Trade Agreement (AFTA) in ASEAN in 2015, the companies should maintain or expand market share. Last but not the least, the private fishery exporting companies need to watch the environmental changes, the possible risks and vulnerability, like unusual bad weather conditions, natural disasters and impacts of climate changes. To effectively address the current challenges within the fisheries sector, a series of targeted interventions must be implemented. One essential measure involves organizing fisheries training programs by government agencies or non-governmental organizations at least three to four times annually. These programs should aim to educate both producers and consumers on best practices in fish harvesting and responsible consumption. Enhancing public awareness through structured educational initiatives is also critical. The Ministry of Agriculture, Livestock, and Irrigation, as the principal authority in this domain, should take the lead in developing and disseminating informative materials tailored to the needs of marine farmers and coastal fishers.

Furthermore, the private sector should be consolidated under a well-established and large-scale cooperative framework. This unified approach can foster collaboration, generate collective decision-making, and facilitate solutions to industry-wide problems through consensus-based strategies. Defining strategic goals focused on improving demand-side efficiency and promoting structural reforms will strengthen the overall competitiveness of the sector. To leverage emerging market opportunities and expand global market presence, it is imperative to adopt environmental regulations and align with European Union directives as early as possible. Compliance with such standards will not only enhance product quality but also improve international competitiveness and increase export volumes. To capitalize on these opportunities while aligning with national capabilities, the government should formulate a comprehensive long-term fisheries strategy. This strategy must address both capture fisheries and aquaculture systems, with a particular emphasis on sustainable inland aquaculture development. Priority should consistently be given to projects that contribute to the resilience and sustainability of inland and capture fisheries.

CHAPTER III

OVERVIEW ON FRESHWATER FISHERIES INDUSTRY IN MYANMAR

3.1 Freshwater Fish and Hatchery Development in Myanmar

Freshwater fish are species that inhabit non-saline environments such as rivers, streams, lakes, ponds, dams, and natural waterfalls. These fish are physiologically adapted to survive in low-salinity habitats and cannot tolerate the high salt concentration of seawater. Their ability to maintain osmotic balance and regulate internal water content enables them to thrive in freshwater ecosystems. Additionally, many freshwater fish possess efficient gas exchange systems, which allow them to survive in environments with varying oxygen levels.

In Myanmar, approximately 128 freshwater fish species have been recorded, reflecting the country's rich aquatic biodiversity (DoF, 2020). These species range from widely consumed varieties such as catfish, carp, and tilapia to lesser-known endemic species that are important for ecological balance and local cultural practices.

A fish hatchery is a controlled facility designed for the artificial breeding, hatching, and early-stage rearing of fish species, including both finfish and shellfish. Hatcheries play a crucial role in aquaculture by providing a sustainable and consistent supply of larval and juvenile fish, which are later transferred to grow-out systems such as ponds or tanks for commercial or community-based fish farming. The hatchery system supports fish stock enhancement programs, biodiversity conservation efforts, and contributes significantly to food security and rural development in Myanmar.

Myanmar's freshwater fisheries sector is not only biologically diverse but also strategically important for the nation’s food system, economy, and ecological stability. The country is endowed with vast freshwater resources, supported by major river basins such as the Ayeyarwady, Chindwin, Sittaung, and Thanlwin Rivers, as well as

numerous natural and man-made lakes, wetlands, and floodplains. These water bodies sustain a wide variety of freshwater fish species.

Over the centuries, Myanmar's freshwater fisheries have transitioned from traditional capture fishing practices to a more modernized aquaculture approach, in line with advancements in hatchery technology, feed management, and sustainable farming practices. Today, the sector contributes substantially to domestic fish consumption, ensuring nutritional security for millions, and also supports international trade through fishery exports. It plays a pivotal role in rural employment generation, poverty reduction, and environmental stewardship.

As the sector continues to grow, Myanmar faces challenges such as resource degradation, climate impacts, and the need for effective policy and regulatory frameworks to support long-term sustainability. Strengthening hatchery capacity, expanding aquaculture extension services, and conserving indigenous fish species through scientific breeding programs are essential priorities for sustainable sectoral development.

The freshwater fisheries sector in Myanmar has a long and culturally significant history, originating centuries ago when traditional fishing techniques were used primarily for subsistence and local trade. Over time, the sector has undergone substantial transformation with the integration of modern aquaculture technologies, the adoption of improved fishing gear, and the implementation of regulatory policies. Furthermore, government-led initiatives and international collaborations have been instrumental in promoting the development and sustainability of freshwater fisheries (Win & Aung, 2019).

Myanmar's freshwater fisheries are supported by its rich and diverse inland aquatic ecosystems. The country encompasses approximately 8.2 million hectares of inland water bodies, including rivers, lakes, reservoirs, and seasonal floodplains. Among these, the Ayeyarwady River Basin, which spans about 60% of Myanmar's land area, stands out as the most critical freshwater fish production zone (DoF, 2020). Seasonal monsoon flooding plays a key role in enhancing fish breeding and migration cycles, making the sector highly reliant on the natural hydrological dynamics of the region.

Freshwater fisheries are vital to Myanmar's national economy, food security, and rural livelihoods. The sector provides employment for millions of people, especially in rural communities. According to the Department of Fisheries, freshwater fish constitute a significant share of the country's total fish production, with key species including **carp, catfish**, and **tilapia** (Htun et al., 2020). The availability of fish at affordable prices ensures its role as a staple protein source across the country (Than et al., 2021).

3.1.1 Contributions of the Freshwater Fisheries Sector in Myanmar

The freshwater fisheries sector in Myanmar holds a pivotal and multidimensional role in advancing national food security, driving economic development, and supporting biodiversity conservation. As a vital component of rural livelihoods and ecological preservation, this sector directly contributes to the welfare of millions of people while safeguarding essential aquatic ecosystems.

In terms of food security, freshwater fish represent a staple in the Myanmar diet, functioning as a primary source of animal protein. Traditional fish products such as fermented fish paste (ngapi), dried fish, and fish sauce are widely consumed across both rural and urban populations (Htun et al., 2021). The affordability and accessibility of freshwater fish ensure consistent dietary inclusion across all socioeconomic strata, thereby playing a critical role in mitigating protein deficiency and enhancing nutritional outcomes at the national level.

Economically, the sector provides an essential source of income for small-scale fishers and aquaculture operators, particularly within rural and peri-urban communities. These fisheries significantly contribute to household earnings and local economic resilience. At the macroeconomic level, the sector fosters national growth by creating employment opportunities along the entire fisheries value chain, encompassing harvesting, farming, processing, and distribution. Furthermore, freshwater fish products are a key export item, facilitating cross-border trade and generating valuable foreign exchange (Win & Aung, 2022).

Regarding biodiversity and ecological significance, Myanmar is endowed with a rich diversity of freshwater fish species, many of which are endemic and hold

important ecological functions. The conservation of these species is vital for sustaining aquatic food webs, maintaining ecosystem equilibrium, and preserving the genetic diversity of indigenous fish populations. Habitat protection and sustainable resource management also align with broader efforts to conserve Myanmar's distinctive environmental heritage (Than et al., 2021).

3.1.2 Role of Hatcheries in Sustainable Aquaculture in Myanmar

Fish hatcheries represent a foundational component in promoting sustainable aquaculture practices in Myanmar. These facilities are instrumental in artificially breeding, rearing, and strategically releasing juvenile fish into both natural and controlled aquatic systems. By increasing the supply of fingerlings for both capture and culture-based fisheries, hatcheries help stabilize fish availability and reduce pressure on wild stocks. This, in turn, supports the livelihoods of communities reliant on aquaculture.

Hatcheries also play a pivotal role in conserving aquatic biodiversity and ensuring the continued availability of commercially valuable fish species. Their utility is especially critical for species experiencing population declines or those in high market demand. Nevertheless, ecological concerns have been raised in the literature. These include the potential erosion of genetic diversity due to limited broodstock, as well as the risks of disease transmission, altered behavior, and ecological competition between hatchery-raised and wild fish. The sustainability of hatchery programs can be undermined if these risks are not carefully managed.

3.1.3 Challenges Facing the Freshwater Fisheries Sector and Conservation Strategies

Despite its economic and ecological importance, Myanmar's freshwater fisheries sector faces several persistent obstacles that threaten its long-term viability. These challenges include:

(i) Overexploitation of both commercially important and ecologically sensitive fish species

(ii) Habitat degradation and fragmentation

(iii) Escalating water pollution from agriculture and industry

(iv) Climate change impacts water systems and fish migration patterns

Furthermore, the prevalence of illegal fishing methods, coupled with weak enforcement of existing regulations, continues to accelerate the depletion of fishery resources (Min et al., 2022).

In response to the pressing environmental and resource management challenges, a series of conservation initiatives has been initiated in cooperation with international development partners and community-level stakeholders. These initiatives include the creation of freshwater fish sanctuaries, the promotion of eco-friendly aquaculture practices, and the strengthening of fisheries law enforcement. Long-term success also depends on continued investment in scientific research, the development of data-driven policy frameworks, and the expansion of community-based co-management models (Zaw & Moe, 2023).

3.1.4 Socioeconomic Contributions of Freshwater Fisheries

Freshwater fisheries remain vital to Myanmar's food security and rural economy. The sector supports the livelihoods of millions, particularly in remote and peri-urban communities with limited alternative employment opportunities. According to the Department of Fisheries, a substantial portion of national fish production is sourced from freshwater systems, with key species such as carp, catfish, and tilapia widely farmed and consumed (Htun et al., 2020). Fish is not only an affordable protein source but also deeply ingrained in Myanmar's food culture. Products like fermented fish paste, salted fish, and fish sauce are culinary staples across social and economic groups. The affordability and accessibility of these products ensure widespread dietary intake, reinforcing the sector's central role in sustaining food security and supporting rural development (Than et al., 2021).

3.2 Roles of Department of Fisheries

Department of Fisheries (DOF) under Ministry of Agriculture, Livestock and Irrigation is the responsible institution for the management of fishery sector in Myanmar. In 2011, the fisheries sector of Myanmar implemented the mission policy objectives focused on ensuring food security, enhancing food safety, and promoting the sustainable development of the sector through the conservation of fisheries resources in alignment with existing fisheries legislation. The mission of the Department of Fisheries (DOF) are as follows:

(a) Conservation and rehabilitation of fishery resources;

(b) Promotion of fisheries researches and surveys;

(c) Collection and compilation of fishery statistics and information;

(d) Extension services;

(e) Supervision of fishery sectors;

(f) Sustainability of fishery resources;

The sustainable development of the fisheries sector fundamentally depends on the conservation of aquatic resources and the maintenance of ecological balance. In this context, resource management initiatives extend to the preservation of freshwater ecosystems including ponds, lakes, rivers, and reservoirs as well as the application of ecosystem-based management approaches in marine environments. These efforts aim to safeguard the biodiversity and functionality of aquatic habitats that support a wide variety of plant and animal species. (DoF, 2011).

In 2017, the Department of Fisheries (DOF) has established a series of objectives aimed at ensuring sustainable development and continuous improvement of the fisheries sector, as outlined below:

(a) To promulgate the fisheries laws and implementation of action plans in line with the sustainable development goals.

(b) To be availability of qualified information and collection of statistical data related to fisheries sector in line with the standard indicators.

(c) To conduct systematic implementation of fisheries co-management and ecosystem approach to improve fisheries management.

(d) To develop the aquaculture industry by implementation of advanced techniques including Good Aquaculture Practices.

(e) To implement research and development, extension and awareness services, and human resources development oriented towards sustainable use of fisheries resources.

(f) To compliance with quality standards of fishery products aligned with the market requirements.

3.2.1 Policies for Fishery Development in Myanmar

The Government of Myanmar places significant emphasis on ensuring food security, food safety, and the sustainable development of the fisheries sector by conserving aquatic resources in accordance with existing fisheries legislation. The Ministry of Agriculture, Livestock and Irrigation (MOALI) has articulated several key objectives to guide this sectoral development:

(a) To promote rural development through the expansion of aquaculture activities;

(b) To enhance foreign exchange earnings through shrimp aquaculture exports;

(c) To conserve and increase the productivity of inland and marine fishery resources;

(d) To accelerate integrated fisheries development without adversely impacting the natural environment; and

(e) To adopt and implement effective extension programs that support long-term sustainability of the fisheries sector.

In alignment with its broader agenda for poverty alleviation and rural development, MOALI has also prioritized aquaculture as a key component. As part of

this commitment, a National Aquaculture Development Plan was initiated to ensure the long-term viability of Myanmar's fish supply (Thiha, 2018).

To support effective governance of the fisheries industry and to protect aquatic biodiversity, the Government of Myanmar has enacted four principal laws:

(a) The Law Relating to the Fishery Rights of Foreign Fishing Vessels (1989),

(b) The Aquaculture Law (1989),

(c) The Myanmar Marine Fisheries Law (1990), and

(d) The Freshwater Fisheries Law (1991).

To further improve legal oversight and enhance administrative efficiency, these laws are undergoing revisions. For example, the Freshwater Fisheries Law has been delegated to state and regional authorities for localized enforcement. Meanwhile, efforts are underway to merge the 1989 and 1990 marine fisheries laws into a comprehensive Union Fishery Law. Revisions are also being made to the Aquaculture Law to align with modern aquaculture practices and sustainability goals.

In terms of financial support, the Mya Sein Yaung (Emerald Green) Development Project played a crucial role in strengthening the fisheries sector. During the fiscal year 2017–2018, a revolving fund of 30 million kyats was allocated to each of the 375 villages identified as having strong potential for fisheries development across 15 Regions and States. These funds were disbursed from the government's capital budget (DoF, 2018). Additionally, financing options are also available through the Myanmar Livestock and Fishery Bank, allowing stakeholders to access further credit for aquaculture development.

3.2.2 Plans of DoF in Myanmar

In 2017, the Department of Fisheries (DoF) in Myanmar established a comprehensive set of strategic plans to promote sustainable development. These plans are designed to align with national priorities and global best practices. The key components of the DoF's plans are outlined below:

(a) Strengthening collaboration with local and international organizations for fisheries sector development.

(b) Revising and aligning fisheries laws, rules, and regulations to reflect international standards and best practices.

(c) Acquiring technical assistance from domestic and international partners for the development of systems to support data collection, analysis, and dissemination for effective fisheries management.

(d) Establishing a robust operational framework to systematically improve and implement co-management practices and an ecosystem-based approach to fisheries governance.

(e) Implementing fisheries co-management strategies through the promotion of community fisheries organizations, and the provision of technical support to stakeholders.

(f) Enhancing collaboration with relevant ministries and local, regional, and international organizations to implement global and ASEAN level agreements and declarations related to fisheries.

(g) Establishing and protecting marine and freshwater conservation areas in ecologically sensitive habitats.

(h) Promoting the role of community-based fisheries organizations to support resource management and rural development.

(i) Permitting the import of high quality fish and shrimp seeds and broodstock, and encouraging the production of genetically improved aquatic species.

(j) Conserving indigenous fish species and undertaking scientific research into their breeding and culture.

(k) Fostering cooperation with public, private, local, and international stakeholders to support the development of sustainable freshwater and marine aquaculture industries.

(l) Introducing and adopting climate-resilient fish species and associated breeding and farming techniques.

(m) Collaborating with regional and international organizations to prevent and manage diseases affecting fish and shrimp.

(n) Expanding research initiatives that support the sustainable management and development of fisheries resources.

(o) Engaging in conservation research focused on the protection of endangered aquatic species and their habitats.

(p) Facilitating the export of fishery products in accordance with international market standards, including compliance with Sanitary and Phytosanitary (SPS) agreements under the World Trade Organization (WTO).

(q) Providing technical support to Small and Medium Enterprises (SMEs) to improve both the quantity and quality of fishery products.

(r) Maintaining and enhancing the capacity of laboratories certified under ISO/IEC 17025 to perform reliable testing and inspection of fishery product quality. (DoF,2017)

3.2.3 Technical Assistances by DOF in Myanmar

The Department of Fisheries (DoF) plays a pivotal role in strengthening aquaculture development in Myanmar by providing technical assistance through structured training programs and capacity-building initiatives. These efforts target both departmental staff and aquaculture farmers and are delivered in collaboration with national plans as well as through partnerships with international organizations. The primary aim is to promote sustainable aquaculture practices across the country.

To support its training efforts, DoF has established three national fisheries training centers and 27 hatchery stations throughout the country. These facilities provide vital infrastructure for fisheries education, research, and technical dissemination.

Locations of Fisheries Training Centers:

(a) Institute of Fisheries Technology (IFT), Gyogone, Yangon Region

(b) Upper Myanmar Fisheries Training Center, Sagaing Region

(c) Lower Myanmar Fisheries Training Center, Pyapon, Ayeyarwady Region

These centers offer a range of technical training courses specifically designed for small-scale aquaculture farmers. The training curriculum includes both theoretical knowledge and practical skills essential for modern aquaculture management.

The key training courses for the fish farmers are as follows and these training programs aim to empower rural communities, enhance productivity, and promote sustainable practices among aquaculture practitioners.

- Introduction to fish culture practices
- Procedures for site selection, pond construction, pond preparation, and overall pond management
- Basic bookkeeping and legal processes for acquiring licenses for fish pond construction
- Techniques in small-scale hatchery operations and seed production
- Core farmer model training for seed production and sales
- Farmer-to-farmer aquaculture extension methodologies
- Techniques for integrated rice-fish farming (paddy-cum-fishery systems)

According to data from the Department of Fisheries, during the fiscal year 2016–2017, a total of 48,672 fish and shrimp farmers were engaged in various aquaculture systems across the country. Notably, Myanmar's aquaculture industry is predominantly pond-based, and labor participation is largely male dominated. During the same period, 57,957 male workers were employed as permanent laborers in fish and shrimp farming operations (DoF, 2017).

3.3 Type of Fisheries in Myanmar

Three primary types are encompassed within Myanmar's freshwater fisheries sector such as capture fisheries, leasehold fisheries, and aquaculture. A distinct role is played by each type in the country's food system, livelihoods, and biodiversity management.

(1) Capture Fisheries

Capture fisheries involve traditional and commercial harvesting of fish from natural water bodies such as rivers, lakes, and floodplains. This form of fishery remains the most widespread in Myanmar. Local fishing communities commonly use methods such as cast nets, fish traps, and traditional fishing weirs. These practices are deeply rooted in cultural traditions and often serve as a primary income source for rural households.

(2) Leasehold Fisheries

Leasehold fisheries are managed through a system in which the government grants fishing rights over designated water areas to private individuals or enterprises. These leases are subject to regulations intended to ensure sustainable use of aquatic resources. Leasable fisheries are particularly significant in the production of freshwater fish and contribute to habitat conservation through controlled harvesting. This system allows for the management of indigenous fish species and supports the preservation of local aquatic ecosystems. While leasehold fisheries operate on a larger scale, open-access fishing is permitted primarily for small-scale and subsistence fishers. Such differentiation aims to balance conservation goals with community-level food security need.

(3) Aquaculture

Aquaculture in Myanmar includes two major systems: freshwater pond culture and brackish water pond culture. Freshwater finfish farming, predominantly using pond-based systems, is the most widely practiced form of aquaculture. In coastal areas, additional forms such as soft-shelled crab farming and seaweed cultivation have also been introduced. The aquaculture industry has experienced substantial growth, particularly in the Ayeyawady Delta and Yangon Region. Key farmed species include

rohu (*Labeo rohita*), *catfish* (*Pangasius* spp.), and *tilapia* (*Oreochromis* spp.) (Min et al., 2022). These species contribute significantly to both local consumption and export revenues.

Fish farming has expanded rapidly in recent years, particularly in regions like the Ayeyawady Delta and Yangon Division. Major farmed species include rohu (Labeo rohita), catfish (Pangasius spp.), and tilapia (Oreochromis spp.) (Min et al., 2022). The freshwater fisheries sector in Myanmar faces multiple challenges, including overfishing, habitat degradation, water pollution, and climate change. Illegal fishing practices and weak enforcement of fishery regulations further threaten the sustainability of fish populations (Min et al., 2022). Conservation efforts, such as establishing fish sanctuaries, promoting responsible aquaculture, and enforcing stricter regulations, have been implemented to address these issues. Scientific research and policy development are essential for ensuring the long-term sustainability of Myanmar's freshwater fish resources (Zaw & Moe, 2023).

3.3.1 Fish Fry and Fingerling Production

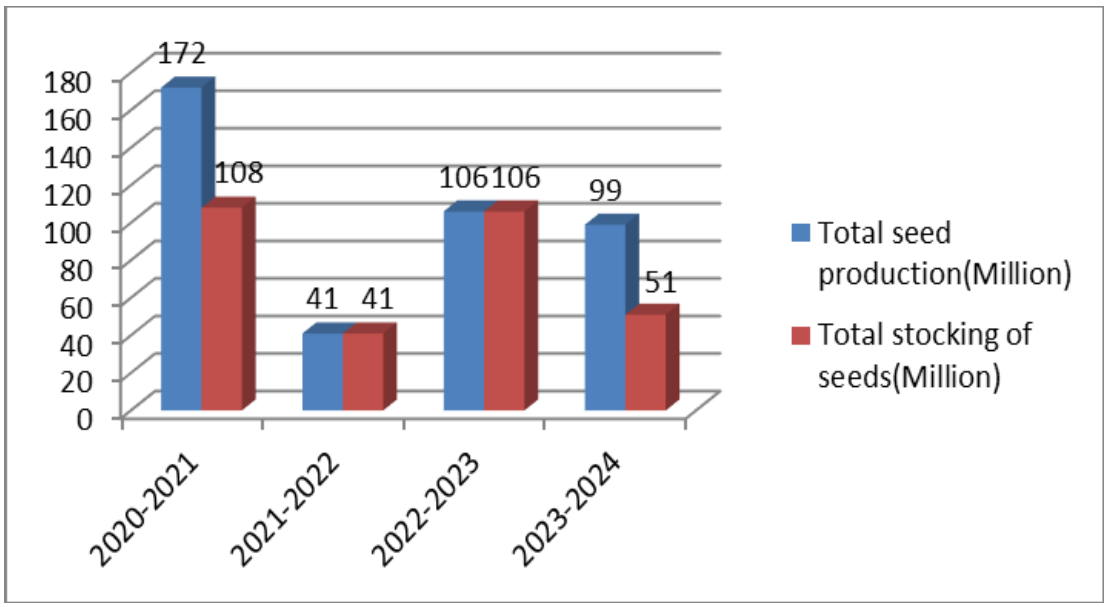
Currently, the Department of Fisheries (DoF) operates 26 freshwater fishery stations strategically located across Myanmar. These stations are actively engaged in seed production and stock enhancement initiatives aimed at promoting the growth of the aquaculture industry. During the fiscal year 2023–2024, DoF hatcheries successfully produced millions of freshwater fish fingerlings (approximately 2 inches in size). In addition, a network of 43 private hatcheries across the country contributed significantly by producing approximately 2,665 million fry and 151 million fingerlings of various freshwater fish species (DoF, 2024).

As part of its national resource management strategy, the Department of Fisheries implements stock enhancement programs in natural water bodies, including man-made reservoirs and major river systems. These initiatives aim to establish healthy populations of high-quality fish species in open waters, thereby contributing to food security and enhancing the livelihoods of rural communities dependent on fisheries.

In 2023–2024, approximately was released into natural water bodies for stock enhancement purposes, while the remaining 50% was sold and distributed to aquaculture farmers at subsidized prices to support local production. This dual strategy not only reinforces biodiversity in natural ecosystems but also strengthens smallholder aquaculture development.

A graphical representation of seed production and stocking activities from 2020–2021 to 2023–2024 is presented in Figure [3.1], illustrating the scale and impact of hatchery operations over the past four years.

Fig (3.1) Fish Fry and Fingerling Production and Stocking



Source: Fishery Statistics 2024 Department of Fisheries

3.3.2 Operational Models and Innovations in Hatchery Management

Myanmar Operational efficiency in hatchery management is crucial for sustainable fisheries development. Advances in technology and process optimization have led to significant improvements in hatchery productivity and sustainability. Modern innovations such as Recirculating Aquaculture Systems (RAS), selective breeding programs, and enhanced larval rearing techniques have contributed to increased fish production while minimizing environmental impact. Research

underscores the importance of water quality management, disease prevention, and feed efficiency in ensuring operational success. While comparative studies from various regions highlight diverse strategies, the application of these models in Myanmar remains underexplored.

(a) Technological Innovations Contemporary hatchery operations incorporate various models designed to improve efficiency and sustainability:

(b) Recirculating Aquaculture Systems (RAS): These systems maintain water quality by continuously filtering and recycling water, reducing water consumption and environmental impact.

(c) Selective Breeding Programs: Genetic selection enhances fish growth rates, disease resistance, and adaptability to hatchery conditions.

(d) Larval Rearing Techniques: Advances in larval nutrition and controlled rearing environments have improved survival rates and growth performance.

(e) Automated Monitoring and Smart Hatcheries: Digital monitoring systems help track water parameters, detect diseases early, and optimize feeding schedules, leading to increased efficiency.

The integration of these innovations varies significantly by region due to differences in economic capacity, regulatory frameworks, and environmental conditions. Myanmar has abundant freshwater fish resources, but it has not yet widely implemented these technological advancements.

3.4 Department of Fisheries (DoF), Ayeyarwady Region

The Department of Fisheries (DoF), Ayeyarwady Region operates under Myanmar's Ministry of Agriculture, Livestock, and Irrigation. Ayeyarwady Region office plays a critical role in ensuring the sustainable management and development of fisheries and aquaculture in Myanmar. It is instrumental in implementing national fisheries policies at the regional level, ensuring sustainable utilization of aquatic resources.

One of the most significant recent advancements in aquaculture infrastructure in the Ayeyarwady Region is in Pantanaw Township, where a large-scale striped catfish farming project has been initiated. This integrated aquaculture complex covers over 900 acres and encompasses a complete value chain, including:

(a) Hatchery and grow-out pond systems

(b) Fish feed production facilities

(c) Cold storage and processing plants

(d) On-site accommodation for staff and administrative offices

This facility is designed to produce up to 100 metric tons of fish per acre annually, making it one of the largest and most advanced aquaculture operations in Southeast Asia. The development represents a model for industrial-scale aquaculture and is expected to serve as a benchmark for replication in other regions of Myanmar.

(1) Government and Private Hatcheries in Ayeyawady region

Freshwater fish hatcheries in the Ayeyawady Region are categorized into two main types: government-run hatcheries and privately operated hatcheries. It was found that the Ayeyawady Basin hosts a total of 14 fish hatcheries, with 4 operated by the Department of Fisheries and 10 are privately owned. Fish Hatchery Situation in Ayeyawady Region is shown in Table (3.1).

Table (3.1) The situation of fish hatcheries in Ayeyawady region

No	Township	No of Camp	Property
1	Pathein	1	Dof
2	Hathada	1	॥
3	Maubin	2	॥
4	Pathein	3	Private
5.	Shwethaungyan	1	॥
6	Laputa	2	॥
7	Maubin	2	॥
8	Pantanaw	2	॥
	Total	14	

Source: Ayeyawady Region DoF

Table (3.1) shows the number of fish hatcheries in Ayeyarwady Region is 28.57% DoF-owned and 71.43% private. It can be concluded that the private sector is producing more fish fry.

(2) Contribution of the Ayeyawady Basin to National Aquaculture Output

Freshwater fish production and contribution to GDP in the Ayeyawady Region are shown in Table (3.2).

Table (3.2) Ayeyawady Region Freshwater Fish Production and Contribution to GDP

No	Year	Freshwater Fish Production(ton)	Freshwater Fish Production Change (%)	GDP(%)	GDP Change (%)
1	2015-2016	1366543.43	nan	9.48	nan
2	2016-2017	1420232.50	3.93	9.50	0.21
3	2017-2018	1298663.66	-8.56	9.70	2.11
4	2018-2019	1296121.55	-0.2	9.55	-1.55
5	2019-2020	1324111.67	2.16	9.40	-1.57

6	2020-2021	1342395.00	1.38	10.48	11.49
7	2021-2022	804250.00	-40.09	9.20	-12.21
8	2022-2023	1396611.67	73.65	9.54	3.7
9	2023-2024	1445023.33	3.47	9.74	2.1
10	2024-2025	1445141.00	0.01	9.66	-0.82

Source: Ayeyawady Region planing Department

Table (3.2) Shows Freshwater fish production in Ayeyarwady Region generally remained robust throughout the period, often exceeding 1.3 million tons annually. However, there was a notable decline in 2017-2018 and 2018-2019, dropping to around 1.29 million tons. The most significant drop occurred in 2021-2022, when production plummeted to 804,250 tons, a substantial decrease compared to previous years. Production rebounded strongly in the subsequent years, reaching 1,396,611.67 tons in 2022-2023 and continuing to rise to 1,445,141.00 tons in 2024-2025, which marks the highest production figure in the given dataset.

The contribution of freshwater fish production to the regional GDP has been relatively stable, hovering around 9% to 10% for most of the years. The highest contribution was recorded in 2020-2021 at 10.48%. Despite the sharp drop in production in 2021-2022, the GDP contribution only saw a minor dip to 9.20%. This suggests that while the volume of fish production fluctuated, its economic significance to the region remained consistently strong. The contribution for 2023-2024 and 2024-2025 remains healthy at 9.74% and 9.66% respectively, reflecting the continued importance of this sector to the regional economy.It highlighted the basin's critical importance in the national fisheries economy.

The dominance of the Ayeyarwady Basin in aquaculture production underscores its strategic value in achieving several national development goals, including enhanced food security, poverty alleviation in rural communities, and increased foreign exchange earnings through fishery exports. Moreover, the sector's performance has demonstrated the success of integrated approaches that combine community participation, government regulation, private investment, and technological advancement. The sales situation of the fish farmers states that in Table (3.3).

Table (3.3) Sales situation of fish farmers in the Ayeyawady region

No	Respondent Category	No. of Respondents	Sales location	Percentage (%)
1	Fishpond Owners	5	Export	83.4
2	Fishpond Owners	1	Domestic	16.6
	Total	6		100
3	Lake Grant Tender Winners	4	Local	66.6
4	Lake Grant Tender Winners	2	Yangon Fish Depot	33.4
	Total	6		100
5	Fishermen	27	Local	100

Source: Survey data

Table(3.3) shows the Fishpond owners highlight a strong export-oriented approach within the fish farming sector. The responses from Lake Grant Tender Winners indicate that Yangon, as a major urban center, remains an important market for fish from the Ayeyawady Region, even for those primarily focused on local sales. The response from fishermen is in stark contrast to that of fish farmers, suggesting that traditional fishermen primarily serve local consumption needs within the Ayeyawady Region. They do not have the infrastructure or scale to engage in export or large-scale long-distance distribution like "Grant Inns" Overall Sales Situation of Fish Farmers in the Ayeyawady Region:

Based on this table, the sales situation of Fishpond owners in the Ayeyawady region is characterized by a strong export orientation. The majority of Fishpond owners surveyed are selling their products to international markets. This implies that fish farming in this region is likely focused on species and quality suitable for export, and these farmers have the necessary connections or infrastructure to access these markets. The relatively small percentage of domestic sales for fish farmers suggests that their production is not primarily intended for local consumption within Myanmar.

3.5 Procedures of the auction of granaries in Ayeyawady Region.

The auctioning of granaries plays a crucial role in ensuring transparent and efficient management of agricultural assets. Establishing clear, standardized procedures is essential to ensure fairness, accountability, and compliance with legal frameworks during the disposal or leasing process. This section outlines the detailed procedural steps involved in the auction of granaries, encompassing announcement protocols, eligibility criteria, bidding processes, evaluation, and final allocation. These procedures aim to minimize disputes, enhance stakeholder confidence, and align with governance standards, thereby promoting best practices in resource management.

The procedures for auctioning granaries are as follows:

(a) Granary auctions are conducted annually between April 1 and July 15.

(b) Auctions are organized on a district-wise basis.

(c) Auction regulations are published within the respective townships at least 30 days prior to the auction date. The eligibility criteria include:

(i) Applicants must not have outstanding tax liabilities.

(ii) Applicants must not have been convicted within the last three years for violations of the Freshwater Fisheries Law.

(iii) Applicants wishing to operate fisheries within granaries must have an active bank account and must deposit the previous year's tax amount for the granary in question to obtain an auction purchase ertificate.

(iv) Applicants must be residents of the Ayeyawady Region.

(d) Interested individuals must submit an application to the Township Head of Department using Application Form (2) for granting auction rights.

(e) The Auction Committee follows these steps during the granary auction:

(i) Prior to the auction, the auction rules and terms pertaining to each granary are clearly read out and announced.

(ii) Auctions proceed according to the pre-announced schedule.

(iii) Bidders must submit additional payment ("table money") to the Auction Committee for the granary they intend to purchase.

(iv) Granaries are leased to the highest bidders who offer prices exceeding the established floor price.

(v) Upon approval by the Divisional Head, a Lease Grant Form (6) is issued to successful bidders within 15 days from the auction date.

(f) For granaries designated for stocking fish fry, 1% of the granary's value corresponding to the fish species shall be paid to the Fisheries Department during the auction period. Subsequently, the Fisheries Department stocks 45-day-old, 2-inch fingerlings into these granaries.

3.6 Department of Fisheries (DoF), Pathein Township

The Pathein Township Department of Fisheries (DoF) carries out several critical functions, including:

(1)Fisheries Resource Management: The DoF enforces laws and regulations governing fishing activities. Responsibilities include issuing fishing licenses, monitoring compliance with fishing seasons, and designating protected or restricted areas to prevent overexploitation and support fish stock regeneration.

(2)Aquaculture Development: The department promotes freshwater and coastal aquaculture by providing technical assistance and capacity-building programs for fish farmers. It also supports the operation of government hatcheries and encourages the adoption of sustainable aquaculture practices within the private sector.

(3)Data Collection and Research: The DoF conducts regular fishery surveys, monitors fishing activities, and collects data on fisheries production and resources. These statistics support evidence-based decision-making and policy development at regional and national levels.

(5)Stakeholder Engagement: Actively engaging with local communities, NGOs, international partners, and private enterprises, the DoF fosters inclusive and resilient fisheries governance through participatory management approaches.

3.6.1 Freshwater Fish Hatcheries in Pathein Township,

The Ayeyarwady Region is not only a hub for agricultural production but also a major center for inland aquaculture development. Pathein Township plays a significant role in the regional aquaculture supply chain through its network of government and private hatcheries.The Pathein Fish Hatchery has emerged as a critical facility for resource conservation. The hatchery contributes to the replenishment of natural fish populations by releasing Fish fry fingerlings into local rivers, lakes, and reservoirs annually. This effort supports ecological sustainability while also enhancing wild fishery stocks. The Pathein fish hatchery releases 40 percent of its annual fry fish Production into the natural waters of rivers and streams. The annual fish fry production, Fry Fish Stocking of the Pathein Hatchery and Freshwater Fish Production in Pathein Hatchery is shown in the Table (3.4).

Table (3.4) Pathein Fish Hatchery Fish Fry Production, Fry Fish Stocking and Pathein Freshwater Fish Production

No	Year	Fish Fry Production (million)	Fish Fry Stocking (million)	Freshwater Fish Production (Ton)	Annual Percentage Change (%)
1	2015-2016	4.95	2.00	1225.22	-
2	2016-2017	5.09	2.00	1187.43	-3.08
3	2017-2018	4.55	2.00	1235.50	4.05
4	2018-2019	6.02	2.40	1212.33	-1.88
5	2019-2020	6.55	2.80	1388.31	14.52
6	2020-2021	5.92	2.40	1162.50	-16.27
7	2021-2022	2.16	0.80	638.66	-45.06
8	2022-2023	5.35	2.00	1296.55	103.01
9	2023-2024	4.85	2.00	1357.31	4.69
10	2024-2025	4.94	2.00	1360.22	0.21

Source: Pathein fish hatchery

The data presented in Table 3.4 illustrates notable fluctuations in fish fry production, stocking, and freshwater fish production in Pathein over the period from 2015–2016 to 2024–2025. Fish fry production demonstrated significant variability, with a marked decrease of 63.51% in 2021–2022, followed by a robust recovery of 147.69% in 2022–2023. Production commenced at 4.95 million fry in 2015–2016 and concluded at 4.94 million in 2024–2025, reflecting a marginal overall decline across the decade. Fish fry stocking levels remained relatively stable at 2.00 million fry in most years. However, increments were observed in 2018–2019 (20% increase to 2.40 million) and 2019–2020 (16.67% increase to 2.80 million). A sharp contraction of 66.67% to 0.80 million fry occurred in 2021–2022, attributable primarily to the impacts of the COVID-19 pandemic. Stocking rebounded significantly by 150% in 2022–2023, coinciding with improvements in hatchery operations and sector recovery.

Freshwater fish production exhibited considerable variation over the study period. A slight decline of 3.08% in 2016–2017 was largely due to flooding events, while a substantial reduction of 45.06% in 2021–2022 was again linked to pandemic-related disruptions. This was succeeded by an impressive production increase of 103.01% in 2022–2023. Despite these fluctuations, an overall upward trend is evident, with fish production increasing from 1225.22 tons in 2015–2016 to 1360.22 tons in 2024–2025. The concurrent declines observed in 2021–2022 across fish fry production, stocking, and freshwater fish yield highlight a challenging period for the fisheries sector in Pathein. Conversely, the significant recoveries in 2022–2023 suggest a resilient rebound post-pandemic. The close correlation between fish fry stocking and freshwater fish production implies that stocking levels exert a direct influence on production outcomes, though external factors such as environmental conditions and market demand also play a role.

It can be found that while fish fry production showed a slight decline over the decade, the overall increase in freshwater fish production underscores a positive trajectory for the sector. Continued efforts are required to ensure that fry production and stocking practices are stabilized to sustain and enhance freshwater fish yields in Pathein

3.6.2 Fisheries Production in Pathein Township, Ayeyawady Region

The Ayeyarwady Region holds a dominant position in Myanmar's fisheries sector, particularly in the production of both inland capture fisheries and freshwater aquaculture. The region's extensive deltaic landscape, interlacing river systems, and abundant water bodies, the region provides highly favorable environmental conditions for fish breeding, farming, and harvesting. Pathein Township, as a central administrative and operational hub within the Ayeyawady Region, contributes significantly to the region's overall fisheries output.

In 2024, Pathein township recorded a total fishery production volume which is around 1360.22 ton. This figure represents a substantial growth compared to previous years and reflects multiple factors including increased efficiency in fish hatcheries, the wider adoption of improved aquaculture technologies, and strengthened institutional support from the Department of Fisheries. The upward trend in production is also indicative of rising demand for freshwater fish in both domestic and export markets, as well as the sector's growing role in enhancing rural livelihoods and food security.

3.6.3 Challenges Faced by the Department of Fisheries in Pathein Township

The Department of Fisheries (DoF) in Pathein Township plays a vital role in the development, management, and conservation of freshwater fishery resources in the Ayeyarwady Region. It faced several challenges that hinder the effective implementation of fisheries development programs. These challenges are categorized into institutional, technical, environmental, and socio-economic domains.

(1) Institutional and Administrative Challenges

One of the major institutional challenges is the shortage of skilled human resources. The department often operates with limited staff capacity, which affects its ability to conduct regular field inspections, data collection, and outreach programs. Additionally, there is a lack of training and capacity-building opportunities for field-level officers, reducing the department's ability to adopt modern management practices and technological innovations. Another issue lies in budgetary constraints, which limit the department's ability to expand infrastructure, maintain hatchery facilities, and

support community-based fisheries initiatives. Delays in funding disbursement also affect the timely execution of seasonal activities, such as fingerling distribution and conservation campaigns.

(2) Technical and Operational Challenges

The Department of Fisheries in Pathein Township encounters operational limitations in the form of inadequate hatchery equipment and outdated technology. Many hatchery facilities lack modern breeding and water quality management systems, resulting in lower fry survival rates and inconsistent production outputs.Furthermore, the department has limited access to scientific data and digital tools for stock assessment, resource mapping, and aquaculture forecasting. This limits the ability to make evidence-based decisions and to monitor the sustainability of fishery activities in real time.

(3) Environmental Challenges

Environmental factors, such as seasonal flooding, water pollution, and habitat degradation, pose a serious threat to fish production and resource sustainability. Deforestation, erosion, and agricultural runoff contribute to deteriorating water quality, which adversely affects hatchery operations and the survival of fish larvae. Climate change has also introduced new risks, such as temperature fluctuations and irregular rainfall patterns, which disrupt the breeding cycles of freshwater species and the functioning of aquaculture ponds. These environmental stressors require adaptive management approaches that are currently limited in scope and application.

(4) Socio-Economic Challenges

The fisheries sector in Pathein Township is deeply linked to the livelihoods of rural communities. However, weak compliance with fishing regulations, particularly among small-scale fishers, remains a persistent issue. Despite awareness campaigns, overfishing, the use of illegal gear, and fishing during closed seasons continue due to economic pressures and limited enforcement capacity. Moreover, the sector suffers from poor market linkages and fluctuating prices, which discourage investment and innovation in aquaculture. Smallholder fish farmers often lack access to credit facilities and are vulnerable to exploitation by intermediaries, limiting their ability to expand or upgrade their operations.

It is also observed that the Department of Fisheries in Pathein Township is faced with a range of interlinked challenges that can delay sustainable fisheries development. Addressing these issues requires a multidimensional strategy, including institutional strengthening, technical upgrading, environmental conservation, and socio-economic support. Collaborative engagement between government authorities, local communities, and private stakeholders will be essential in overcoming these challenges and unlocking the full potential of the region's fisheries sector.

CHAPTER IV

SURVEY ANALYSIS

4.1 Survey Profile

Ayeyawady Region which is situated in the southwest of Myanmar, shares borders with Yangon Region to the east, Bago Region to the northeast, and Rakhine State to the north. The region is a delta enriched with rivers, streams, and lakes. It is composed of 26 townships, the population is approximately 6.32 million, making it the fourth most populous region in Myanmar. Ayeyawady Region has 4 state-owned fish hatchery, 10 private fish hatchery, and 80769 acres of individual fishponds, producing around 128,000 metric tons of fish annually.

Pathein Township, one of the major townships in Ayeyawady, contains 219 fishponds, spanning 678.07 acres and produces approximately 1350 metric tons of fish per year. Fish farming in 29 villages of Pathein Township constitutes a significant proportion of the region's overall fish production. Based on the survey data, fish fingerlings were obtained through four main sources which are natural breeding, FoC fish stocking from the DoF hatchery, purchases from the Department of Fisheries, and fish production sites run by private entities. The cost per fingerling ranges from 10 MMK (DOF) to 50–80 MMK (private farms) depending on size (1–3 inches). Some fish farmers used fingerlings produced in their own farms. The survey was primarily conducted via interviews with individual fish farmers.

4.2 Survey Design

The survey aims to assess the challenges faced in developing freshwater fish resources. It was focused on the Pathein Fish Hatchery and its associated inland fisheries, riverine ecosystems, and aquaculture facilities. It was also formulated in combination with secondary data and primary data. The information for the primary data was obtained by interviewing the total number of respondents was 126 which are included Department of Fisheries employees, employees from fish hatcheries, administrative staff, researchers, lake grant tender winners, fishpond owners, fishermen, and aquarium

workers of Pathein Township by formulating questionnaires. Secondary data was obtained from the FAO

reports, the statistics of DOF and other international organizations relating to fish hatcheries. The data collection period was conducted in April 2025 and May 2025.

This study utilized comprising two structured questionnaires, each tailored to a specific target group within the fishery and aquaculture sectors. The objective was to obtain a comprehensive understanding of stakeholder perspectives on hatchery management, conservation practices, regulatory frameworks, and the broader challenges affecting the freshwater fish farming industry in the Pathein region. The questionnaires responses were assessed based on a 5-point Likert scale ranging from strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree as (5) respectively. The total questionnaires consisted of three set which were assessed with 65 questions.

Table (4.1) Nubmer of Respondents' Category

Respondent Category	Respondents
Questionnaire for DoF Employees	
DoF Employees	30
Questionnaire for Hatcheries	
Employees from Fish Hatcheries	17
Administrative staff	1
Researchers	3
Questionnaire for Fishing Industry	
Lake Grant Tender Winners	6
Fishpond Owners	6
Fishermen	27
Aquarium Workers	36
Total	126

Source: Survey data, 2025

There are three distinct sets of structured questionnaires that were developed for the purpose of data collection. The first set, titled *"*Questionnaire for Dof employees*,"*

was distributed to 30 respondents comprising Department of Fisheries employee. It consisted of a total of 20 questions categorized under thematic areas, which are (1) Regulatory and Policy Challenges, (2) Financial Challenges, (3) Environmental Challenges, (4) Operational and Supply Challenges, (5) Technological Challenges,

The second set, entitled *"*Employees from Fish Hatcheries*,"* was designed to target key stakeholders directly engaged in field operations, including Employees from Fish Hatcheries, Administrative staff and Researchers with a total of 21 respondents. This questionnaire also consisted of 20 systematically structured questions, organized into five thematic sections, which are comprised of (1) Financial Challenges, (2) Environmental Challenges, (3) Operational and Supply Challenges, (4) Technological and infrastructure challenges

The thirds set, entitled *"*Questionnaire for private Fishing Industry*,"* was designed to target key stakeholders directly engaged in field operations, including lake grant tender winners, fishpond owners, fishermen and aquarium workers with a total of 75 respondents. This questionnaire also consisted of 25 systematically structured questions, organized into five thematic sections, which are comprised of (1) Regulatory and Policy Challenges, (2) Financial Challenges, (3) Environmental Challenges, (4) Operational and Supply Challenges, (5) Operational challenges.

4.3 Survey Results

This section presents the results of the survey conducted in Pathein Township and provides a detailed interpretation of the responses received from participants regarding the development of freshwater fish resources.

4.3.1 Background Information of Respondents

The demographic characteristics of the 126 respondents were assessed based on five key variables: gender, age, education level, occupation, and experience. Table 4.2 summarizes the frequency and percentage distribution for each variable.

Table 4.2 Background Characteristics of Respondents

Description	Total Respondents =126	
	No. of Respondents	Percentage
Gender		
Male	88	70
Female	38	30
Total	126	100
Age		
Less than 20 years old	4	3
21-30 years old	27	22
31-40 years old	44	35
41-50 years old	31	25
51 years old and above	20	15
Total	126	100
Education		
Middle School	20	15
High School	47	37
Bachelor Degree	55	45
Master Degree and above	4	3
Total	126	100
Occupation		
Department of Fisheries Employees	30	24
Employees from Fish Hatcheries	17	13
Administrative Staffs	1	1
Researchers	3	2
Lake Grant Tender Winners	6	5
Fish Pond Owners	6	5

Fishermen	27	21
Aquarium Workers	36	29
Total	126	100
Experience		
Under 6 months	8	6
6 months to 1 year	15	12
1 year to 2 years	44	35
2 years and above	59	47
Total	126	100

Source: Survey data, 2025

The survey reveals that, regarding Gender, out of 126 participants, 88 were male (70%) and 38 were female (30%). This indicates that male respondents are more dominant in the sample group, suggesting a higher male involvement in the fisheries and hatchery-related sectors.

Concerning for the age, the majority of respondents (35%) were between the ages of 31–40, followed by 25% in the 41–50 age group. Those aged 21–30 accounted for 22%, and 15% were above 51 years old. Only 3% of participants were younger than 20 years old. This distribution reflects that the majority of stakeholders are in their prime working age, with sufficient professional exposure and physical involvement in fisheries operations.

In regard to educational qualifications, a significant portion of respondents (45%) held a bachelor's degree. Participants with a master's degree or higher accounted for 3%. Meanwhile, 37% completed high school, 15% had middle school education, The data reveals a relatively well-educated respondent group, which is essential for the adoption of modern aquaculture and conservation practices.

In relation to occupation, the highest number of respondents (27%) were Fisheries. Fishermen, followed by 24% who were employed by the Department of Fisheries. hatchery employees 13%, researchers 2%, and lake grant tender winners and fishpond owners each accounted for 5%. Only 1% of the respondent is administrative

staff and Aquarium Workers were 29%. This variety of roles highlights the diversity of stakeholders involved in freshwater fisheries in Pathein.

Regarding experience, most respondents 47% had more than two years of professional experience in their respective fields. Respondents with one to two years of experience accounted for 35%, those with six months to one year represented 12%, and 6% had less than six months of experience. The predominance of experienced individuals indicates a knowledgeable and practically engaged survey population.

4.3.2 Survey Data of the DoF Employees, Fish Hatcheries's Employees and Private Fishing Industry

(i) Challenges for DoF Sectors

This section presents the challenges encountered by the Department of Fisheries (DoF) in conserving freshwater fish resources. The analysis is based on survey responses from DoF employees who assessed five key challenge domains: regulatory and policy, financial, environmental, operational and supply, and technological aspects. The respondents rated each statement using a 5-point Likert scale, and the results are summarized in Table 4.3 below.

Table 4.3 Challenges for Dof Employees

No	Statement	Mean	Std. Deviation
I.	**Regulatory and policy challenges**		
1	The rules that fishing operators must follow are effective in preventing the depletion of fish species..	3.2	1.3
2.	Fish conservation laws are adequate to prevent fish species from becoming extinct.	3.0	1.0
3.	There is full cooperation between government departments and private entrepreneurs in conservation activities.	3.1	1.3

4.	Failure to comply with fishing regulations hinders efforts to conserve fish resources.	2.6	1.3
5.	Illegal fishing in my area makes it difficult to conserve fish resources.	2.6	1.1
II.	**Financial challenges**		
6	Lack of funding and financial support is a major challenge for conservation activities.	3.1	1.2
III.	**Environmental Challenges**		
7.	Loss of natural fish stocks is affecting conservation success.	3.1	1.1
8.	Water discharged from large factories (paper mills, distilleries) pollutes natural waters.	3.2	1.0
9.	Water pollution and destruction of fish habitats reduce the growth and survival.	3.4	1.2
10.	Invasive species are affecting native fish.	3.2	1.2
IV.	**Operational and supply challenges**		
11.	Disease outbreaks are a major challenge in the fish farming industry.	3.2	1.4
12.	The Department of Fisheries collaborates with international organizations to develop fish resources.	2.7	1.2
13.	Transport and distribution challenges limit the reach of conservation programmes.	3.2	1.4
14.	There is sufficient cooperation between the governing bodies in freshwater fish conservation work..	2.8	1.4
15.	Local fishing organizations help promote sustainable fishing practices.	2.5	1.3
16.	The Department of Fisheries has long-term plans for the development of fish resources.	3.4	1.1
17.	There are no disputes with agricultural operators over the use of irrigation water by fish farms.	2.6	1.4
V.	**Technological challenges**		

18.	There are technological requirements to breed marketable fish.	3.8	1.0
19.	The Department of Fisheries conducts a survey on the effectiveness of fish resource development activities.	2.8	1.4
20	The Department of Fisheries conducts research for the development of aquaculture.	2.8	1.3
Overall Mean Value		3.0	

Source: Survey data, 2025

The analysis reveals a range of perceptions among Department of Fisheries personnel regarding the challenges they face. The highest-rated challenge is related to technological requirements for breeding marketable fish (Mean = 3.8), indicating that respondents believe technical capacity is essential for advancing aquaculture practices.

Regulatory challenges also emerged as significant. The belief that current fishing regulations are effective in preventing depletion of species scored a mean of 3.2, reflecting moderate agreement. However, lower scores were found in areas such as collaboration between local fishing groups and governing bodies (Mean = 2.5–2.8). These findings suggest institutional coordination and local-level engagement remain areas of concern.

Environmental factors such as water pollution, loss of natural stocks, and invasive species all scored above 3.0, signaling that respondents perceive these as major barriers to conservation efforts. The average mean score of 3.0 across all challenge areas indicates a moderate level of concern, highlighting both progress and the remaining gaps in DoF's conservation capacity.

(ii) Challenges for Fish Hatcheries Employees

This section explores the key challenges confronting fish hatchery operations, with a specific focus on the Pathein Fish Hatchery. The analysis is based on survey responses from hatchery employees who evaluated the influence of four major areas: financial challenges, environmental challenges, operational and supply challenges, and technological and infrastructure challenges.

Table 4.4 Challenges for Fish Hatcheries Employees

No	Statement	Mean	Std. Deviation
I.	**Financial challenges**		
1	Selling fish fry at a fixed price hinders the operation.	2.4	1.3
2.	Investment in modern hatchery equipment is a financial burden.	3.0	1.0
II.	**Environmental Challenges**		
3.	The hatchery is not affected by water pollution from external sources.	4.0	1.1
4.	Climate change impacts (e.g., temperature fluctuations, drought) are threatening the productive capacity of hatcheries.	3.8	1.1
5.	Natural disasters (e.g., floods) threaten the hatchery at Pathein Fish Hatchery.	2.8	1.0
6.	Water pollution and destruction of fish habitats reduce the growth and survival of fish fry.	3.5	1.2
III.	**Operational and supply challenges**		
7.	Quality fish feed has an impact on hatchery performance.	3.1	1.3
8.	Disease outbreaks are a major challenge in the fish farming industry.	2.8	1.1
9.	Insufficient stock of adult fish has an impact on the production of fry.	3.1	1.1
10.	Transport and distribution challenges limit the reach of conservation programmes.	3.2	1.2
11.	There is a plan to involve external investors in the restoration of endangered fish species.	2.6	1.3
12.	Water quality and temperature in Pathein Fish Hatchery are always maintained at the optimal level for fish health.	3.1	`1.4
13.	The Pathein fish hatchery has sufficient staff.	3.4	1.3

14.	Regular training and skill development opportunities are available for employees.	2.8	1.2
IV	**Technological and infrastructure challenges**		
15.	There are technological requirements to breed marketable fish.	2.7	1.3
16.	The staff at Pathein Fish Hatchery has sufficient technical knowledge and skills to manage the hatchery.	3.4	1.1
17.	Inadequate hatchery systems (e.g., Water circulation system) are hampering conservation efforts.	3.6	1.0
18.	The fish hatchery has analytical equipment.	3.1	1.2
19.	Pathein Fish Hatchery is conducting a survey on the effectiveness and efficiency of fish farming.	3.5	1.5
20.	The Pathein Fish Hatchery Station collaborates with academic or research institutions.	3.2	0.9
Overall Mean Value		3.3	

Source: Survey data, 2025

This section indicates that technological and environmental factors are among the most significant challenges identified by fish hatchery staff. The highest-rated challenge (Mean = 4.0) reflects the perception that the hatchery is not currently impacted by external water pollution, which is a positive sign for environmental control. However, climate-related issues, particularly temperature fluctuations and drought received a high score of 3.8, highlighting their negative impact on hatchery productivity.

In terms of financial concerns, respondents viewed investment in modern hatchery equipment as a considerable burden (Mean = 3.0). Additionally, fixed pricing for fish fry (Mean = 2.4) was seen as a constraint that limits operational flexibility and economic sustainability. These responses underscore the ongoing need for financial reform and increased funding in the hatchery sector.

Operational and supply-related challenges also appear significant, particularly in relation to disease management, fish feed quality, transportation, and human resource development. For instance, the availability of staff and skill training received relatively

modest scores (Mean = 2.8 to 3.4), suggesting room for improvement in human resource support and capacity-building.

On the technological and infrastructure front, several concerns were raised. Notably, inadequate hatchery systems, such as outdated water circulation infrastructure, received a relatively high concern score (Mean = 3.6). While technical knowledge among staff (Mean = 3.4) was considered sufficient, the need for updated systems and greater institutional collaboration remains evident.

(iii) Challenges for Private Fishing Industry

This section highlights the challenges faced by the private fishing industry in the conservation of freshwater fish resources. The analysis is based on responses from key stakeholders including lake grant tender winners, fishpond owners, and individual fishermen. The evaluation covered five major domains: regulatory and policy challenges, financial challenges, environmental challenges, awareness and knowledge gaps, and operational challenges.

Table 4.5 Challenges for private Fishing Industry

No	Statement	Mean	Std. Deviation
I.	**Regulatory and policy challenges**		
1	Government regulations support practices that conserve freshwater fish resources.	3.5	1.1
2	The fishing license and permit process is clear and easy.	2.6	1.1
3	There is insufficient cooperation between government agencies and private sector in conservation efforts.	2.6	1.1
4	Local fishing organizations help promote sustainable fishing practices.	3.5	1.1
II	**Financial challenges**		
5	Low family income hinders fish conservation efforts.	3.5	1.1

6	Government subsidies and financial incentives for conservation are insufficient.	3.2	1.2
7	Investment in modern fishing equipment is a financial burden.	2.7	1.4
III.	**Environmental Challenges**		
8	Loss of natural fish stocks is affecting conservation success.	2.8	1.3
9	Invasive species are a challenge to freshwater fish conservation.	3.2	1.0
10	Climate change is affecting fish populations and catch conditions.	2.7	1.3
11	Discharge of polluted water into rivers harms aquatic eco systems.	3.2	1.1
IV	**Awareness and knowledge**		
12	I understand the impact of overfishing.	2.4	1.4
13	Destruction of fish breeding habitats (e.g. deforestation) is reducing fish availability	2.9	1.2
14	Fishing with battery shocks and poisoned fish are known to be destroying fish species..	2.4	1.0
15	Over the years, fish catches have been declining	2.8	1.1
16	I believe that conservation efforts will benefit my livelihood in the long term.	2.8	1.2
17	The seeking of fish fry has significantly increased the number of fish in freshwater rivers, streams, lakes, and ponds, and has resulted in large numbers of fish being caught.	2.9	1.3
18	It is free for egged fish, Fish Fry and Fingerling to make my fishing operations sustainable.	3.0	1.1
V	**Operational challenges**		
19	The support from the government and local authorities is sufficient.	2.8	1.4

20	The Grant Inn business can conveniently resolve conflicts with surrounding farmers and agriculturalists regarding water storage and water extraction.	2.3	1.1
21	The use of fertilizers and pesticides in agriculture has a negative impact on aquatic life in the lake	3.5	1.0
22.	The Grant Inn fishery is important for local job creation.	3.8	1.0
23.	Illegal fishing can be prevented at Grant Inn.	2.4	0.9
24.	The Grant Inn auction price is a reasonable price for business owners.	3.4	1.3
25	Invasive fish species in the lake have a significant impact on native fish.	2.4	1.4
Overall Mean Value		3.1	

Source: Survey data, 2025

This sector result shows that the private fishing sector faces several intertwined challenges that hinder effective freshwater fish resource conservation. From a policy perspective, while government regulations and local organizations are viewed as generally supportive (mean = 3.5), issues such as the complexity of license procedures and insufficient collaboration between authorities and private actors (mean = 2.6) emerge as critical barriers.

Financial challenges are evident, especially among low-income households (mean = 3.5), with many respondents highlighting the inadequacy of governmental financial support and the burdensome cost of modern fishing equipment.

Environmental threats are also prevalent, with invasive species (mean = 3.2) and river pollution (mean = 3.2) seen as significant challenges, although the effects of climate change and habitat degradation appear to be moderately recognized. The relatively low mean scores (2.7–2.9) in this category suggest a need for broader ecological education.

CHAPTER V

CONCLUSION

5.1 Findings

This study explored five key challenges that hinder the sustainable development of freshwater fish hatchery operations and the conservation of fish resources in Pathein Township, Ayeyawady Region. Institutionally, while governmental policies were found to be supportive of conservation goals, there was a noticeable gap in effective implementation mechanisms.

For financially, both private operators and local fishermen typically function under constrained income levels, limiting their capacity to adopt sustainable practices or invest in advanced hatchery infrastructure. Existing government subsidies and incentive programs were either inadequate or not easily accessible to those in need.

Regarding environmental challenges, concerns were equally pressing; the degradation of aquatic ecosystems due to agricultural runoff, climate change, and the presence of invasive species posed serious threats to native biodiversity. Industrial waste discharge and poorly managed agricultural activities further diminish water quality in the region.

On an operational level, most hatchery facilities were outdated and lacked the necessary technologies for effective disease control, water management, and modern feeding systems. There was also a clear gap in technical expertise among hatchery staff and fish farmers, many of whom lacked training in sustainable aquaculture techniques. Illegal fishing methods, such as electrofishing and poisoning, continued to be a problem, undermining long-term conservation efforts.

Finally, while there was general awareness among the community regarding fish conservation, specific knowledge about issues like overfishing and ecosystem-based management was limited. Many community members showed some willingness to engage in conservation activities but were not equipped with the tools, training, or

organizational support necessary for active participation. Community-based organizations and local cooperatives, which could play a vital role in conservation, were found to have a minimal presence or impact on the current system.

5.2 Suggestions

A comprehensive strategy is essential to ensure the sustainability of freshwater fish resources in the Pathein Township. The study's findings highlight the importance of addressing institutional, environmental, financial and social constraints through coordinated action. First, there is a need to strengthen cooperation between the Department of Fisheries and local stakeholders such as fishing communities and cooperatives, and to improve governance and collective responsibility. The results of the survey suggest that cooperation scores suggest that better cooperation and trust-building mechanisms should be established at the community level. Economic constraints such as the price of fish fry limit the operational flexibility of hatchery operators and smallholder farmers.

Secondly, private fish entrepreneurs face significant environmental and land-use challenges that threaten the viability of aquaculture operations. Issues such as environmentally driven farm closures, disputes over land and water use with agricultural stakeholders, and the degradation of surrounding aquatic ecosystems have emerged as key barriers. Addressing these problems requires the implementation of integrated water resource management practices and the establishment of effective conflict resolution mechanisms that can balance the interests of fish farmers, local communities, and agricultural users.

Thirdly, among fishermen, the limited awareness of the detrimental effects of overfishing and destructive fishing practices underscores the need for targeted education and capacity-building initiatives. Comprehensive training programs should be introduced to enhance understanding of sustainable fishing techniques and to promote long-term stewardship of aquatic resources within fishing communities.

Finally, institutional support continues to present a significant challenge that must be addressed to achieve sustainable fisheries development. It is suggested that better coordination and trust-building mechanisms be established, clear mechanisms for dispute management and conflict resolution be established, and extensive education and training programs be established due to the lack of understanding of the impacts of

overfishing and destructive fishing practices.

Implementing these integrated suggestions will establish the way for a more resilient, inclusive and environmentally responsible fisheries sector in the Ayeyawady Region.

REFERENCES

Asian Development Bank (ADB). (2019). *Sustainable Fisheries Development Southeast Asia*.

Ayeyarwady Regional Government. (2019). *Aquaculture and Fisheries Development Report*. Pathein: Department of Fisheries, Myanmar.

Ayeyarwady Basin Development Project. (2019). *Aquatic Biodiversity and Fisheries: Status and Challenges*. Pathein: Environmental Conservation Department

Belton, B., & Little, D. C. (2011). "Improvements in Aquaculture Practices: Case Studies from Southeast Asia." *Aquaculture Research, 42*(8), 1123-1135.

Boyd, C. E., & Tucker, C. S. (2012). *Pond Aquaculture Water Quality Management*. Springer Science & Business Media.

Bryant, B. P. (2003).The role of artificial propagation in vertebrate conservation: Lessons from salmon. *Conservation Science and Practice*, *5*(2), 125–137.

DeBlieu, R. (1993). Recovery strategies for vertebrate species using artificial propagation. *Conservation Biology*, *7*(3), 547–558.

Department of Fisheries. (2018). *Annual Fisheries Statistics*. Yangon: Ministry of Agriculture, Livestock, and Irrigation.

Department of Fisheries (2020). *Annual Fisheries Statistics*. Nay Pyi Taw: Ministry of Agriculture, Livestock, and Irrigation.

Department of Fisheries. (2021). *Annual Fisheries Statistics*. Nay Pyi Taw: Ministry of Agriculture, Livestock, and Irrigation.

Department of Fisheries. (2022). *Annual Fisheries Statistics*. Nay Pyi Taw: Ministry of Agriculture, Livestock, and Irrigation.

Department of Fisheries. (2023). *Annual Fisheries Statistics*. Nay Pyi Taw: Ministry of Agriculture, Livestock, and Irrigation.

FAO (2014), The State of World Fisheries and Aquaculture 2014, Rome, FAO.

FAO (Food and Agriculture Organization). (2020). *The State of World Fisheries and Aquaculture 2020: Sustainability in Action*. Rome: FAO.

FAO (2021). *The State of World Fisheries and Aquaculture.*

Flagg, T. A., & Nash, C. E. (Eds.). (1999). *A conceptual framework for conservation hatchery strategies for Pacific salmonids (NOAA Technical Memorandum NMFS-NWFSC-38). Northwest Fisheries Science Center.*

Flagg, T. A., Nash, C. E., & Fairgrieve, W. T. (2005). *Application of conservation hatchery strategies to reduce negative impacts on salmon ecology and behavior*. In *Use of hatchery fish for conservation, restoration, and enhancement of fisheries* (pp. 267–280). American Fisheries Society Symposium 44.

Hebdon, J. L., Kline, P. A., Taki, D., & Flagg, T. A. (2005)**.** *Reintroduction strategies for captive broodstock progeny of Redfish Lake sockeye salmon*. In *Use of hatchery fish for conservation, restoration, and enhancement of fisheries* (pp. 267–280). American Fisheries Society Symposium 44.

Jones, N. E., & Brown, R. S. (2019). *Habitat fragmentation and urban pressures on freshwater fish: A global synthesis. Water, 12(6), 1699*

Khin Maung Soe. (2008). *Trends of Development of Myanmar Fisheries: With References to Japanese Experiences*

Maynard, D. J., Flagg, T. A., & Mahnken, C. V. W. (2005). *Conservation hatchery protocols for Pacific salmon*. In *Use of hatchery fish for conservation, restoration, and enhancement of fisheries* (pp. 267–280). American Fisheries Society Symposium 44.

Myanmar Fisheries Federation. (2020). *Hatchery Innovations and Best Practices*.

Nguyen, T. T., & Lal, K. S. (2014). *Advancing Aquaculture: Strategies and Technologies*. WorldFish Center.

Nguyen, H. T., & Tran, M. D. (2019). Challenges in freshwater aquaculture development in Southeast Asia. *Journal of Aquaculture Research*, 34(2), 145-156.

Olney, P. J., Mace, G., & Feistner, A. (1994). Case study: Use of captive breeding in wild species recovery. *Oryx*, *28*(4), 275–283.

Su Hlaing Moe (2018), 'A Study on Fishery Export in Myanmar," Yangon University of Economics.

Shitote, Z. & Wakhungu, Jacob & China, Samuel Soita. (2013). Challenges Facing Fish Farming Development in Western Kenya. Greener Journal of Agricultural Sciences. 3. 305-311. 10.15580/GJAS.2013.3.012213403.

Thet Thet Zaw (2019), "Small-Scale Fish Farming in Kayin State," *Unpublished EMPA Thesis*, Yangon University of Economics.

Thiri Aung (2019), "Development of Fishery Sector in Myanmar," *Unpublished Master of Development Studies Thesis*, Yangon University of Economics.

Trushenski, Jesse & Flagg, Thamas & Kohler, Christopher. (2011). Use of hatchery fish for conservation, restoration, and enhancement of fisheries.

Thiha Ko Ko. (2018). Fishery exports break 20-year record, could double within two years. *Myanmar Times*.

World Bank. (2020). *Fisheries and Aquaculture in Myanmar: Opportunities and Challenges*.

World Bank. (2023). *Myanmar Fisheries Sector: Opportunities and Challenges in Exporting Marine Products.*

WEBSITES

http:// www.dof.mm.com

https://www.sciencedirect.com/science/article/pii/S2666049022000421

https://openknowledge.fao.org/handle/20.500.14283/bm084e

https://www.mdpi.com/journal/water

http://www.fao.org/3/Y2876E/y2876e09.htm.

http://www.fao.org/fishery/countrysector/naso_indonesia/en

https://setkab.go.id/en/gdp-of-indonesias-fisheries-sector-rises-significantly-minister-of-marine-and-fisheries/

Appendix

Appendix(A)

A STUDY ON THE CHALLENGES OF FISH HATCHERIES FOR THE DEVELOPMENT OF FRESHWATER FISH RESOURCES

(Case Study on Pathein Fish Hatchery)

Survey Questionnaire (Department of Fisheries Employees**)**

Part 1: Type equation here.Characteristic of respondent

1. Gender

☐ Male ☐ Female

2. Age

☐ Less than 20 old ☐ 20-30 Years old

☐ 31-40 Years old ☐ 41-50 Years old

☐ 51 years old and above

3. Education Qualification

☐ Primary School ☐ Middle School

☐ Higher School ☐ Bachelor Degree

☐ Master Degree and higher

4. Occupation

☐ Fish Department of Fishery staff ☐ Administrative staff

5. Work experience (years of service)

☐ Less than 6 months ☐ 6 months to 1 year

☐ 1 year to 2 years ☐ 2 years and above

Part (2): Based on freshwater fish resource conservation activities, please indicate the extent to which you agree (or disagree) with the following statements.For each statement, please tick (☑) the box that best matches your level of satisfaction. There are no right or wrong answers. What you think is most important is the one you agree with.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

No	Statement	1	2	3	4	5
I.	**Regulatory and policy challenges**					
1	The rules that fishing operators must follow are effective in preventing the depletion of fish species..					
2.	Fish conservation laws are adequate to prevent fish species from becoming extinct.					
3.	There is full cooperation between government departments and private entrepreneurs in conservation activities.					
4.	Failure to comply with fishing regulations hinders efforts to conserve fish resources.					
5.	Illegal fishing in my area makes it difficult to conserve fish resources.					
II.	**Financial challenges**					
6.	Lack of funding and financial support is a major challenge for conservation activities.					
III.	**Environmental Challenges**					
7.	Loss of natural fish stocks is affecting conservation success.					
8.	Water discharged from large factories (paper mills, distilleries) pollutes natural waters.					

9.	Water pollution and destruction of fish habitats reduce the growth and survival.					
10.	Invasive species are affecting native fish.					
IV	**Operational and supply challenges**					
11.	Disease outbreaks are a major challenge in the fish farming industry.					
12.	The Department of Fisheries collaborates with international organizations to Develop fish resources.					
13.	Transport and distribution challenges limit the reach of conservation programmes.					
14.	There is sufficient cooperation between the governing bodies in freshwater Fish conservation work.					
15.	Local fishing organizations help promote sustainable fishing practices.					
16.	The Department of Fisheries has long-term plans for the development of fish resources.					
17.	There are no disputes with agricultural operators over the use of irrigation water by fish farms.					
V.	**Technological and challenges**					
18.	There are technological requirements to breed marketable fish.					
19.	The Department of Fisheries conducts a survey on the effectiveness of fish resource development activities.					
20	The Department of Fisheries conducts research for the development of aquaculture.					

Recommendations related to the conservation of freshwater fish resources----------
---

Appendix(B)

A STUDY ON THE CHALLENGES OF FISH HATCHERIES FOR THE DEVELOPMENT OF FRESHWATER FISH RESOURCES

(Case Study on Pathein Fish Hatchery)

Survey Questionnaire (Employees from Fish Hatcheries)

Part 1:Characteristic of respondent

1. Gender

☐ Male ☐ Female

2. Age

☐ Less than 20 Years old ☐ 20-30 Years old

☐ 31-40Years old ☐ 41-50Years old

☐ 51 years old and above

3. Education Qualification

☐ Primary School ☐ Middle School

☐ Higher School ☐ Bachelor Degree

☐ Master Degree and higher

4. Occupation

☐ Employees from Fish Hatcheries ☐ Administrative staff

5. Work experience (years of service)

☐ Less than 6 months ☐ 6 months to 1 year

☐ 1 year to 2 years ☐ 2 years and above

Part (2) Based on freshwater fish resource conservation activities, please indicate the extent to which you agree (or disagree) with the following statements.
For each statement, please tick (☑) the box that best matches your level of satisfaction. There are no right or wrong answers. What you think is most important is the one you agree with.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

No	Statement	1	2	3	4	5
I.	**Financial challenges**					
1	Selling fish fry at a fixed price hinders the operation.					
2.	Investment in modern hatchery equipment is a financial burden.					
II.	**Environmental Challenges**					
3.	The hatchery is not affected by water pollution from external sources.					
4.	Climate change impacts (e.g., temperature fluctuations, drought) are threatening the productive capacity of hatcheries.					
5.	Natural disasters (e.g., floods) threaten the hatchery at Pathein Fish Hatchery.					
6.	Water pollution and destruction of fish habitats reduce the growth and survival of fish fry.					
III	**Operational and supply challenges**					
7.	Quality fish feed has an impact on hatchery performance.					
8.	Disease outbreaks are a major challenge in the fish farming industry.					
9.	Insufficient stock of adult fish has an impact on the production of fry.					

10.	Transport and distribution challenges limit the reach of conservation programmes.					
11.	There is a plan to involve external investors in the restoration of endangered fish species.					
12.	Water quality and temperature in Pathein Fish Hatchery are always maintained at the optimal level for fish health.					
13.	The Pathein fish hatchery has sufficient staff.					
14.	Regular training and skill development opportunities are available for employees.					
IV.	**Technological and infrastructure challenges**					
15.	There are technological requirements to breed marketable fish.					
16.	The staff at Pathein Fish Hatchery has sufficient technical knowledge and skills to manage the hatchery.					
17.	Inadequate hatchery systems (e.g., Water circulation system) are hampering conservation efforts.					
18	The fish hatchery has analytical equipment.					
19.	Pathein Fish Hatchery is conducting a survey on the effectiveness and efficiency of fish farming.					
20.	The Pathein Fish Hatchery Station collaborates with academic or research institutions.					

Recommendations related to the conservation of freshwater fish resources-------------
----

Appendix(C)

A STUDY ON THE CHALLENGES OF FISH HATCHERIES FOR THE DEVELOPMENT OF FRESHWATER FISH RESOURCES

(Case Study on Pathein Fish Hatchery)

Survey Questionnaire (Fishing industry)

Part 1: Characteristic of respondent

1. Gender

☐ Male ☐ Female

2. Age

☐ Less than 20 Years old ☐ 20-30 Years old

☐ 31-40 Years old ☐ 41-50 Years old

☐ 51 years old and above

3. Education Qualification

☐ Primary School ☐ Middle School

☐ Higher School ☐ Bachelor Degree

☐ Master Degree and higher

4. Occupation

☐ Grand Inn entrepreneur ☐ Fish Pond Owners

☐ Fishermen ☐ Fishpond workers

5. Work experience (years of service)

☐ Less than 6 months ☐ 6 months to 1 year

☐ 1 year to 2 years ☐ 2 years and above

Part (2) Based on freshwater fish resource conservation activities, please indicate the extent to which you agree (or disagree) with the following statements.
For each statement, please tick (☑) the box that best matches your level of satisfaction. There are no right or wrong answers. What you think is most important is the one you agree with.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

No	Statement	1	2	3	4	5
I.	**I. Regulatory and policy challenges**					
1	Government regulations support practices that conserve freshwater fish resources.					
2.	The fishing license and permit process is clear and easy					
	There is insufficient cooperation between government agencies and private sector in conservation efforts.					
4.	Local fishing organizations help promote sustainable fishing practices.					
II.	**Financial challenges**					
5.	Low family income hinders fish conservation efforts.					
6.	Government subsidies and financial incentives for conservation are insufficient.					
7.	Investment in modern fishing equipment is a financial burden.					
III.	**Environmental Challenges**					
8.	Loss of natural fish stocks is affecting conservation success.					
9.	Invasive species are a challenge to freshwater fish conservation.					

10.	Climate change is affecting fish populations and catch conditions.					
11.	Discharge of polluted water into rivers harms aquatic ecosystems.					
IV.	**Awareness and knowledge**					
12.	I understand the impact of overfishing.					
13.	Destruction of fish breeding habitats (e.g. deforestation) is reducing fish availability.					
14.	Fishing with battery shocks and poisoned fish are known to be destroying fish species.					
15.	Over the years, fish catches have been declining.					
16.	I believe that conservation efforts will benefit my livelihood in the long term.					
17.	The seeking of fish fry has significantly increased the number of fish in freshwater rivers, streams, lakes, and ponds, and has resulted in large numbers of fish being caught.					
18	It is free for egged fish, Fish Fry and Fingerling to make my fishing operations sustainable.					
V.	**Operational challenges**					
19.	The support from the government and local authorities is sufficient.					
20	Grant Inn entrepreneur can conveniently resolve conflicts with surrounding farmers and agriculturalists regarding water storage and water extraction.					
21	There is sufficient labor force for the fishing industry.					
22.	The Grant Inn fishery is important for local job creation.					
23.	Grant Inn has difficulty preventing illegal fishing activities.					

24.	The Grant Inn auction prices are a burden for business operators.					
25.	Invasive fish species in the lake have a significant impact on native fish.					

Recommendations related to the conservation of freshwater fish resources--------------
----

