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DECLARATION

We hereby declare that this dissertation entitled, "**A STUDY ON THE ECONOMIC IMPACT OF FISHKILL IN THE PERIYAR RIVER**", submitted by us in partial fulfillment of the requirements for the award of an M.A Degree in Economics is my original work. This work has not previously formed the basis for other academic qualifications.

Signature of the supervisor

Dr. Pearly Antony O

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A STUDY ON THE ECONOMIC IMPACT OF FISHKILL IN THE PERIYAR RIVER

Dissertation submitted to

St. Teresa's College (Autonomous)

(Affiliated to **MAHATMA GANDHI UNIVERSITY, KOTTAYAM**)

In partial fulfilment of the requirements for the degree of

MASTER OF ARTS IN ECONOMICS

BY

LOPAMUDRA S

REGISTER NO: AM23ECO011

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LOPAMUDRA S

CHAPTER 1
INTRODUCTION

1.1: INTRODUCTION

The Periyar River, the longest river of Kerala, 152 miles long and is found in the Sivagiri Hills of the Western Ghats. The term 'Periyar' means 'huge', indicating the size and significance of the river. The Periyar River is referred to as "Kerala's lifeline" and it holds immense economic value. Along the banks of the Periyar River around 20% of Kerala's industry is situated. It also provides a huge volume of electricity in the state through the Idukki Dam. Also, the river is used for agricultural purposes as well as domestic purposes. A fish kill is when a large quantity of fish or other water animals (like crabs or prawns) die over a short space of time, usually in one location. Any of four culture systems—races, ponds, recirculating systems, or cages—is employed to raise fish. Cage aquaculture, also known as net pen aquaculture, is a method of fish, shellfish, and other marine animal rearing in mesh cages set in open water bodies such as lakes, rivers, and seas. The animals are trapped while the cages allow free movement of water, thus enabling the right farming of available water resources. In 2007, Indian cage culture made the transition from primitive, antiquated practices to a scientific, methodical industry, driven by the Central Marine Fisheries Research Institute (CMFRI) with the assistance of the Department of Animal Husbandry, Dairying and Fisheries (DAHD&F), an agency under the Ministry of Agriculture. CMFRI started India's first-ever open-sea cage culture programme at Visakhapatnam. Initial failures, including the first cage collapse, provided valuable information for improving mooring systems, net management, and design. The innovations were pushed by a multidisciplinary team of CMFRI with an expertise in marine biology, fisheries and engineering. Knowledge sharing and scaling up were facilitated through collaborations with state governments and fishermen. To place India as a world leader in sustainable mariculture, CMFRI's Research & Development is focused on frontier technology such as AI-based monitoring systems and deep-sea cages. To enhance the use of sea resources, the route joins together strategic partnerships, scientific precision and adaptability. In Kerala, cage farming has transitioned from disorganized traditional culture to contemporary freshwater aquaculture in recent years. High-yielding species like Genetically Improved Farmed Tilapia (GIFT) and Pangasius were the major impetus for this transition. .Kerala is now an emerging leader in India's freshwater cage culture. Cage farming fosters sustainable goals and ensures food security.

The article in The Hindu newspaper highlights the socio economic and environmental consequences of massive fish kill in the Periyar River, which is caused by extreme water pollution. It happened on May 21st, 2024, mainly affecting cage farmers and local inhabitants. Large volume of fish deaths in the Pathalam-Edayar section of the Periyar River shocked cage farmers and fishermen, they suffered enormous financial losses. The fish species of Asian sea bass, tilapia, and pearl spots are mainly kept in cages. Kerala University of Fisheries and Ocean Studies published a report which indicated low oxygen levels and the presence of chemical pollutants in the water as the major causes for the fish kill. Eloor- Edayar cluster is described as one of India's most polluting industrial zones. Pathalam-Edayar industrial cluster has 286 industrial units with 106 firms classified as high polluters. This is the ninth instance of fish kill in the river. According to activists, when such incidents cause significant public outcry or financial losses, they gain media attention. In the initial report of the Pollution Control Board (PCB) discovered no industrial pollutants in the water samples. Years of extreme pollution have made the Periyar river a "carrier of death," according to environmentalists. [THE HINDU]

Massive financial losses were incurred by more than 150 cage farmers in Varapuzha, Kothad, Cheranallore, Kadamakudy etc. Damages were crores of rupees. The financial burden on the farmers increased significantly, as they are not covered by insurance. The illegal pipeline outputs from chemical-leather-bone meal industries contribute to pollution. Through the pipes the industries released industrial wastes consisting of chemical pollutants and untreated effluents into the Periyar river, these are the major causes of fishkill. Lack of sufficient rainfall, which could have washed away pollutants, worsened the condition. Farmers had criticized the delayed notifications. Cage farming is abandoned by several farmers due to frequent cases of contamination and lack of any compensation. The district collector constituted a multi-departmental committee to investigate into the incident and asked the Pollution Control Board to conduct an urgent inquiry. No successful efforts have been made to make compulsory sewage treatment systems for the industries or to eliminate unauthorized pipe outlets. The cage farmer's union highlighted the government's negligence, and they asked the industries to take strict action against the industries which are responsible for the pollution. PCB was criticized by farmers for not acting against irresponsible industries and not enforcing stricter regulations. Fish population in Periyar has seriously dropped which will cause an ecological imbalance. [The New Indian Express]

In front of the Environmental Surveillance Centre of the Kerala State Pollution Control Board at Eloor, hundreds of citizens, fishermen, cage fish farmers, and environmental activists protested. To demand a strong action against the polluters and for compensation, dead fishes were put at the PCB headquarters. PCB officials were criticized for failing to identify the industrial polluters responsible for the pollution and the officials claimed that it was an oxygen depletion problem. A five-member committee has been constituted by Kerala University of Fisheries and Ocean Studies (KUFOS) to look into the fish kill. All India Youth Federation demanded judicial investigation into the fishkill incident. The PCB alleged that the irrigation department did not give adequate information on lifting the sluice gates at Pathalam. According to the Irrigation Department, the sluice gates were opened especially during rain, no prior information was usually given beforehand. [THE HINDU]

The Ashtamudi Lake in Kerala is a Ramsar site and is highly polluted. Recently, a large fish kill occurred due to an algal bloom caused by garbage and sewage. Even though the lake is a protected area, still it is polluted with plastic garbage, and untreated effluents from surrounding homes and firms. Locals, cage farmers and fishermen are concerned about the deteriorating condition of the lake. They have witnessed many changes in the ecology, such as decreased fish output and species extinction. Cleanup programmes has been initiated by the government. Experts stress the importance of the preservation of biodiversity, sustainable practices and proper waste management. [THE HINDU]

From the news reports it is clear that the losses suffered by the cage farmers are very high. The industrial wastes consisting of hazardous chemicals which led to low levels of oxygen in the river which resulted in the massive fish kill happened in May. The cage farmers conducted strikes but the no immediate actions were taken. Officials are passing the blame without taking necessary steps to support the farmers. Reports on fishkill in the Periyar river were published by KUFOS. In November another major fishkill was reported in Ashtamudi lake. This shows the need to implement stricter rules against industries that creates pollution not only to preserve the biodiversity but also to protect millions of people from diseases who depend on rivers like Periyar and Ashtamudi for drinking purposes.

1.2: REVIEW OF LITERATURE

Shashank Sarang and Vaishali U Somani (2016) examines a significant fish kill event in Jail Lake, Thane, Maharashtra, India, during October 2014. Thane is commonly referred to as the "City of Lakes," as it has many lakes that support urban biodiversity. but the lakes are polluted by sewage discharge, solid waste dumping, and idol immersion during festivals. Water samples collected after the fishkill event revealed low levels of oxygen and free carbon dioxide levels exceeding 60 mg/L. The lake was covered with an algal bloom, predominantly Microcystis aeruginosa. The bloom is caused by sewage and warm temperatures which led to oxygen depletion, ultimately causing the fish kill. Immediate cleanup efforts and aeration were taken by authorities, The study highlights the complex relationship between algal blooms, industrial effluents and fish mortality. It emphasizes the need for regular monitoring of water quality to control harmful algal blooms in urban lakes.

Riju P Nair, Shine Raj Tholkudiyil, C P Shaji (2021) documents an unusual fish kill event in the Chandragiri River, Kasaragod district, Kerala, India, which occurred between May 18 and 24, 2019. The incident took place in Neyyankayam, where a large number of fish died due to a combination of environmental stressors. High concentration of fish in Neyyankayam led to severe oxygen depletion, along with stagnant water and high temperatures. Local residents reported fishkills on May 10, 2019. The study identified 22 fish species affected by the event, including economically significant and ornamental species. The extreme summer conditions, reduced water levels, and oxygen depletion are the immediate causes. The long-term impact on the ecosystem and river's fish population remains uncertain. The authors emphasize the need for further investigation into the consequences of such large-scale fishkill events and they argue that similar incidents will occur due to climate change and human activities.

Pravakar Mishra (2022) investigates a large fish kill event in the Chunnambar backwater of Puducherry, India, which occurred in September 2019. The fishkill was attributed to Pseudo-nitzschia algal bloom, hypoxia, and low-quality water. Backwater, one of the popular tourist destinations, recorded two large fish kill episodes on September 25 and 29, 2019. Analysis of the water quality showed dissolved oxygen values, ammonia, and phosphate concentrations at high levels. The investigation brings out the importance of untreated sewage in causing fishkill. To improve water exchange between the backwater and the sea the authors recommend periodic dredging. Also, they pointed out that with better wastewater treatment and regular monitoring will prevent future fish kill events.

Irfan Rashid (2021) examines a massive fishkill event that occurred on October 22, 2017, in the Jhelum River in Srinagar City, India. The event resulted in the death of thousands of fish within three hours, causing significant concern among government authorities and the local population. The researchers assessed the morphological features of the affected fish, including skin colour, skin texture, eye appearance, and analysed key water-quality parameters such as dissolved oxygen levels, pH, water temperature. The morphological examination revealed signs of chemical contamination, while the water quality analysis showed neutral pH, mildly depleted dissolved oxygen levels and normal temperature. The study highlights the lack of continuous water-quality monitoring system. The authors recommend establishing water-quality monitoring sites to prevent future fishkill episodes.

Amanda Thronson and Antonietta Quigg (2008) documents fish kill events in coastal Texas from 1951 to 2006, focusing on the causes, sources, and consequences of the fishkill events. Over the 55-year period, more than 383 million fish were killed. Most of the fish kills were reported in Galveston and Matagorda Bays, and the greatest fishkills are recorded in the hottest months, especially August. The primary reason for fish kills was low dissolved oxygen content due to human activities like industrialization, urbanization. The other reasons were temperature extremes, biotoxins from harmful algal blooms. The research emphasizes the importance of eutrophication, hypoxia and algal blooms in fishkill. The authors highlight the importance of enhanced conservation and management. The findings emphasize the significance of understanding the interplay between environmental factors and human activities in mitigating fish kill events

Hobbs and McDonald (2010) investigate the causes of fishkill events at the Cocos (Keeling) Islands in the northeastern Indian Ocean during the summers of 2007–2008 and April 2009. The authors documented over 592 fish deaths from at least 11 species. Reasons for fishkill are unusually high seawater temperatures, low dissolved oxygen levels. The study suggests that the combination of reduced oxygen levels and high temperatures exceeded the physiological tolerances of the fish, leading to mass fishkill. The events were most severe during the warmest days. The study underscores the importance of considering physiological tolerances of fish species along with the causes.

M Belchik (2004) examines the fishkill occurred in the Klamath river, which resulted in the death of over 34,000 adult Chinook salmon, the fishkill was caused by algal bloom, warm water temperatures and high fish density. The study stated that the low flow of water from Iron Gate Dam was the most significant controllable factor contributing to the fish kill. The study emphasizes that while many factors led to the fishkill event, the management of river flows is an important step to prevent future episodes of fishkill.

Hamed Mohammed Al Gheilani (2011) examines how Harmful Algal Blooms (HABs) caused massive fishkills. Harmful Algal Blooms simply referred to as red tides, have been on the rise in Omani waters, posing serious economic and environmental effects. The blooms are mainly induced by microalgae, which are capable of producing biotoxins, which reduce oxygen levels, and result in mass fishkills. HABs in Oman are often occur during the summer months (May to September), but recent observations show that the fishkill events can occur year-round. Oman has established a monitoring system to track environmental conditions, including water quality, nutrient levels to mitigate the impacts of HABs. There are limitations such as lack of advanced predictive models, inconsistent data collection.

James Kushlan (1974) examines the effects of a natural fish kill. The fish kill was caused by high temperature, oxygen depletion. Water quality parameters such as carbon dioxide, dissolved oxygen and pH varied considerably during the fish kill. The level of carbon dioxide rose, and pH fell during the decomposition of dead fish. The level of oxygen fell sharply, particularly during nighttime. Water quality normalized two months following the fish kill. Carbon dioxide levels increased, and pH decreased due to the decomposition of dead fish. Oxygen levels dropped drastically, especially at night. Water quality returned to normal within two months after the fish kill. A massive phytoplankton bloom occurred during the fish kill.

The fish population was severely impacted. Only six of the 22 fish species survived. Larger fishes particularly were more susceptible to mortality than smaller fish. The study concludes that the fish kill had no long-term effects on water quality.

Nicholas B D Phelps (2019) conducted retrospective and predictive investigation of fish kill events in Minnesota to analyse trends and assess data quality. The study used historical records from the Minnesota Department of Natural Resources (MNDNR) databases, examining 225 fish kills from 2003 to 2013. The highest number of fish kills occurred in 2007 and were most frequent in June. High temperature was the primary cause. Centrarchid species were most affected. Spatial analysis revealed that fish kills were more frequent in populated areas. The research identified significant data gaps. The study highlighted the need for standardized fish kill reporting, proactive monitoring strategies. The findings provide significant insights for developing early warning systems to prevent fishkills.

1.3: STATEMENT OF THE PROBLEM

Cage farming has become a risky business. The fishkill that occurred in May is the ninth major fishkill that happened in the Periyar river. The fishkill is caused by the industrial discharges which led to low oxygen levels and culminated in massive fishkill. The fishkill resulted in enormous financial loss to cage farmers as they are not covered by insurance. An important issue is the absence of government support. None of the farmers received any compensation from the government. Cage farmers have been conducting strikes frequently in hope of government support. Majority is continuing cage farming as it is their main source of income even if high risk is involved.

1.4: OBJECTIVES

- To identify the economic- social impacts of fishkill in the Periyar river.

- To analyse the economic challenges faced by cage farmers.

1.5: RESEARCH METHODOLOGY

The research methodology includes both primary and secondary data. Data is collected from 50 cage farmers who are affected by the fishkill through the methods of cluster and snowball sampling. The study was conducted in the month of January 2025. Data is collected from cage farmers in Varapuzha, Kadamakkudy, Cheranalloor, Kothad. Secondary data is obtained from research papers, articles, websites, books. Mean, standard deviation is used to find the differences in financial losses. For analysing data, tabular representations, diagrammatic representations such as bar diagrams, pie diagrams, histograms etc. were used. The study also included qualitative analysis.

1.6: SIGNIFICANCE OF THE STUDY

The study is important in economic social and environmental aspects. It showed the financial difficulties of cage farmers. The research calculated the immediate economic losses of cage farmers, it emphasizes stricter regulations for the industries responsible for pollution. The study also highlights the importance of implementing early warning systems, frequent checking of water quality. It also points out the need of government support during crisis. The study will be useful to policymakers for making policies for small scale cage farmers. It also shows how industrial pollution can lead to direct economic losses.

1.7: SCHEME OF STUDY

The whole study is divided into four chapters. First chapter deals with introduction consisting of news reports, literature review, methodology, objectives. Second chapter covers overview of cage farming and third chapter includes the analysis. The final chapter consists of findings and suggestions.

1.8: LIMITATIONS

- The research is not presented with direct measurements or laboratory tests of water quality parameters like dissolved oxygen, pollutant levels, pH, turbidity, it is focused on the economic impacts of cage culture.
- The study involves a relatively small sample of respondents.

CHAPTER 2

OVERVIEW OF CAGE FARMING

"Cage is an enclosed space to rear organisms in water that maintains free exchange of water with the surrounding water body. Cage aquaculture is a technology of culturing fishes from fry to fingerling, or fingerling to table size in cages. The cages are generally enclosed on all sides by nets, except for leaving an opening at the top for feeding and handling the stock. They can be positioned at the bottom, middle or surface of the water column. The floating cages are very popular and easy to manage. Cages are of many shapes (round, square or rectangular). Cage culture is suitable to a wide range of open freshwater ecosystems, especially reservoirs. It efficiently utilises water bodies, harnessing of their natural productivity and thereby reducing pressure on other resources. It uses simple technology and easily available resources for cage construction and operation. In nutshell, the cage aquaculture is economically, socially, ecologically and environmentally sound. Culture of fish in enclosures such as cages and pens installed in open water bodies offer scope for increasing production obviating the need for more land-based fish farms. Considering India's rich and varied open water resources like reservoirs, lakes and floodplain wetlands, enormous scope exists to increase production through enclosure aquaculture. Utilizing a modest fraction of their surface area, large and medium reservoirs can contribute a substantial quantity of fish to the total inland fish production basket. Although cage culture has not yet reached the desired commercial proportions capable of making any impact on the production figures, it is growing at a very fast pace giving hopes and also causing some concern." [MISSION CAGE CULTURE-2022 DEPARTMENT OF ANIMAL HUSBANDRY, DAIRYING & FISHERIES MINISTRY OF AGRICULTURE & FARMERS WELFARE GOVERNMENT OF INDIA]

2.1: HISTORICAL CONTEXT OF CAGE FARMING

Fishermen who used cages to harvest fish for market are likely the ones who came up with cage culture. They later began feeding fish in the cages in a bid to make them larger and healthier. The fish in these initial cages, made of bamboo or wood, were given food waste and trash fish. Southeast Asia is likely where the first fish culture cages were built around the late 18th century.

Cage Materials: Cages are made of synthetic material that doesn't degrade in water, e.g., Netlon. The cages range from 1 m^2 to 500 m^2, and cages are combined in large numbers for intensive farming.

2.2: STEPS INVOLVED IN CAGE FARMING

1. Site Selection: Select places with good quality water, depth (>5m), and wind protection.
2. Procurement of Materials: Using materials like, metal or plastic pipes, HDPE nets, and steel drums.
3. Frame Fabrication: Construct structures with, metal or plastic pipes jointed by welding.
4. Installation: In order to prevent damage cages need to be firmly anchored so that they are 1-2 meters above the bottom of the lake.
5. Stocking: Cage farmers choose fish species based on demand, environmental factors
6. Grow-Out Period: Time needed for the fingerlings to reach saleable size.
7. Supplementary Feeding: Providing additional food to fishes in the cages, it includes both natural and commercial formulated feeds
8. Maintenance: It includes Cleaning of cages, checking for disease or damage and monitoring the water quality.

Structure of Cages and Mooring: Cage Frame is typically made up of galvanized iron (GI) pipes or high-density polyethylene (HDPE). Cages can be of square, rectangular, or spherical shapes. Inside grow-out net and an outer predator net are employed. Mesh size depends on the species and stage of growth of the fish. Plastic drums are often used to keep the cage afloat. In open waters, single mooring is adopted, allowing for a 360-degree rotation of the cage. In lakes, double mooring is employed.

Site Selection: Flow of water, depth, salinity, temperature. Site should be protected high winds, waves. Market proximity should be considered. Inland water bodies, calm bays are ideal sites.

2.3: WATER QUALITY MEASUREMENTS

Table 2.3

SL. NO	PARTICULARS	EFFECTS	PREFERENCE
1	Temperature	Affects metabolic rate and growth of fishes	26-28°C
2	Salinity	Affects ionic balance of fishes and growth	25-40 ppt
3	Dissolved oxygen	Required to perform essential functions such as respiration, digestion, assimilation of food, maintenance of osmotic balance, and activity	6 mg l^{-1}
4	Ph	Impacts toxicity of several pollutants in water	7.8-8.4
5	Turbidity	High levels of suspended solids cause mortality of fishes	<2 mg l^{-1}
6	Inorganic nitrogen	Indicates the degree of pollution; chronic exposure increases susceptibility to diseases and reduces growth	<0.1 mg l^{-1}
7	Total inorganic phosphorus	Phosphorus is needed for fish growth, but excess	<0.015 mg l^{-1}

		concentrations result in algal blooms	
8	Chemical Oxygen Demand	The amount of oxygen required to oxidize all the organic matter in water	<1 mg l^{-1}
9	Chlorine	Toxicity to fish	<0.02 mg l^{-1}
10	Heavy metals (Mercury, Lead, and Copper)	Toxicity to fish	Mercury – <0.05 mg l^{-1} Lead – <0.1 mg l^{-1} Copper – <0.02 mg l^{-1}
11	Pesticides from agricultural runoff, industrial effluents, and aquaculture farms	Bioaccumulation of pesticides such as DDT, Aldrin, Dieldrin, Heptachlor, Chlordane, etc., in fish	<0.025 µg l^{-1}

Source: secondary data, Rao et al., 2013

Fish Species: Suitable species for freshwater are tilapia, common carp and catfish. Marine species are sea bass, pompano, lobsters, cobia, groupers. Brackish water species are seabass, red snapper, pearl spot and milk fish.

Stocking density: It varies upon species. Low density stocking is suitable for large fish and high- density stocking is recommended for large fish.

Rate of Survival: High survival rates can be achieved with well managed cages.

Feeding: Should be cost effective and of high quality.

Net Cleaning: To prevent fouling and clogging nets should be cleaned regularly. As fish grows, mesh size need to be adjusted.

Water Quality: In order to avoid fishkill, regular assessment of water must be there. The levels of oxygen, salinity need to be checked.

Maintenance: Cages, nets need to be regularly checked for repairs in order to ensure durability.

Harvesting: It can be done in single lot or in batches depending on market demand.

Cage Types:

1. Fixed cage is used in shallow waters.
2. Floating cage is suitable for deeper waters.
3. Submersible cages consist of net bags and they are suspended from the surface during bad weather to avoid damage.
4. Submerged cage culture where fishes are farmed in cages that are submerged in water.

2.4: COST COMPONENTS IN CAGE FARMING

A. Capital Investment

1. Cost of cage frame

2. Cost of nets

3. Cost of floats and accessories

4. Mooring and installation charges

Total fixed cost

5. Depreciation

6. Interest on fixed capital

B. Operational costs

1. Cost of seed

2. Cost of feed

3. Labour charges

4. Boat hiring, harvesting and miscellaneous expenses

5. License fee

Total operational cost

Total cost(A+B)

Factors Influencing Cage Culture: Poorly farmed economies, declining wild fish sources, and increased consumption of fish.

2.5: CONTROLLING DISEASES IN CAGE AQUACULTURE

Increased stocking rates, environmental stressors, and exposure to pathogens enhance the susceptibility to disease in intensive aquaculture practices threatening both economy and environmental sustainability.

The following are significant causes leading to disease outbreaks:

- Ecological stressors: Abrupt changes in water quality (temperature, salinity, dissolved oxygen, etc.) are one of the causes of disease.
- Pathogens: Bacteria, viruses, parasites, fungi, and ectoparasites.
- Organic pollution, nutritional deficiencies.
- "Wild reservoirs" are pathogens transmitted by wild fish or intermediate hosts.

The following are the control strategies:

- While considering selection of sites, minimize areas susceptible to pathogens.
- Regular monitoring of fish behaviour and water quality.
- A nutritious diet to boost the immune system
- Biosecurity: Minimizing exposure to intermediate hosts and wild fish.

2.6: LIMITS SET FOR CAGE CULTURE IN RESERVOIRS

Table 2.6

RESERVOIR AREA (ha)	MAXIMUM NUMBER OF CAGES ALLOWED
<1000	NOT ALLOWED
1001 to 2000	500
2001 to 3000	1000
3001 to 4000	1500
4001 to 5000	1900
5001 to 10000	3000
>10000	5000

Source: secondary data, National Fisheries Development Board

2.7: CAGE FARMING OF GIFT TILAPIA

Net cage specifications:

Table 2.7.1

Net Cage Specifications	Fish Weight
Fish net cage without top cover made of HDPE 0.75/16mm mesh size webbings with rope (Cage size: 5m x 5m x 5m)	50 - 150 grams

Fish net cage without top cover made of HDPE 1.25/20mm mesh size webbing with rope (Cage size: 5m x 5m x 5m)	150 – 250 grams
Fish net cage without top cover made of HDPE 1.25/24mm mesh size webbing with rope (Cage size: 5m x 5m x 5m)	250 – 500 grams, till harvest

Source: secondary data, National Fisheries Development Board

Tilapia stock management:

Table 2.7.2

Items	Details
Cage Size	5m x 5m x 4m
Mesh Sizes	16 mm, 20 mm, 24 mm
Body weight, Feed Pellet Size & Protein Content	50-150 grams – 2 mm (28% protein) 150-500 grams – 3 mm (28% protein) 500-600 grams – 4 mm (25% protein) 600 grams and above – 5 mm (22% protein
Stocking Density	40/m3
Cage Changing	Fortnightly
Nursery	Not permitted in Reservoirs; minimum stock able size is 50 grams

Source: secondary data, National Fisheries Development Board

Tilapia's Feeding chart

Table 2.7.3

S. No	ABW (g)	Feeding rate (% of Body Weight)
1	1-5	8%
2	6-10	6%

3	10-15	5.5%
4	15-20	4%
5	20-50	4.0 - 2.5%
6	50-100	2.5 -1.7%
7	100-200	1.7 - 1.3%
8	200-300	1.3 - 1.0%
9	300-500	1.0 - 0.9%
10	500-700	0.9 - 0.8%
11	>700	1.8 - 0.6%

Source: secondary data, National Fisheries Development Board

2.8: ADVANTAGES

- Wide applicability
- Environmental benefits
- High survival rates
- Low initial investment
- Simplified harvesting and observation
- Use of existing water bodies
- Low carbon emissions
- Removes land constraints
- Customizable

2.9: DISADVANTAGES

- Requires nutritionally complete feed
- Pollution risks
- Fouling of nets
- Diseases spread

Cage farming is highly profitable as it has low initial investment costs. But event like fishkill can have drastic economic impact on cage farmers. Policies and regulatory measures are limited in the case of cage farming. Government should adopt programmes for supporting small scale farmers,

CHAPTER 3

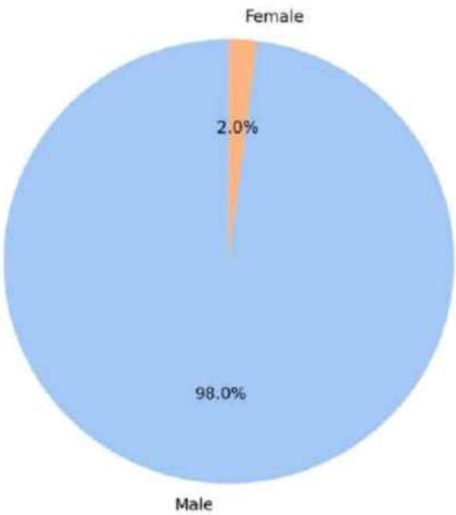
THE ANALYSIS OF ECONOMIC IMPACT OF FISH KILL IN THE PERIYAR RIVER

STATISTICS

For many people cage farming is a significant source of livelihood. Fish kills have serious economic impacts. The income losses, increasing debts, socio economic factors form the goals of the study. The study includes the costs incurred by cage farmers such as fish purchase cost, fish food cost, cage maintenance cost. It also shows the wider implications of fish kills such as increased need of loans, and requirement of secondary sources of income. My objective is to examine the financial impact of fishkill on cage farmers. Data is gathered from 50 samples.

3.1: GENDER DISTRIBUTION

Figure 3.1.1



Source: primary data

This survey has just one female respondent who provides a minority gender perspective in the cage farming industry. Conservative gender norms, safety issues, physical demands of labor, and limited access to resources all work to limit the low rate of female participation in the cage farming.

3.2: AGE GROUP DISTRIBUTION

Table 3.2.1

AGE GROUP	COUNT
UNDER 30	4
30-39	17
40-49	11
50-59	11
60 AND ABOVE	7

Source: primary data

Table 3.2.2

COUNT	50
MEAN	44.64
STANDARD DEVIATION	12.39
MAXIMUM VALUE	74
MINIMUM VALUE	23

Source: primary data

The mean age of respondents is nearly 44.64 years, having a median of 45 years. There is closeness between mean and median, as there is well balanced spread. The age of the only female respondent is 54 years. Her age is higher than the average and median age. High number of cage farmers lie in the age group of 30-39. Oldest cage farmer is 74 years old and youngest is 23 years.

3.3: EDUCATIONAL QUALIFICATIONS

Table 3.3.1

EDUCATIONAL QUALIFICATIONS	COUNT
PLUS TWO	17
SSLC	13
9th	5
8th	3

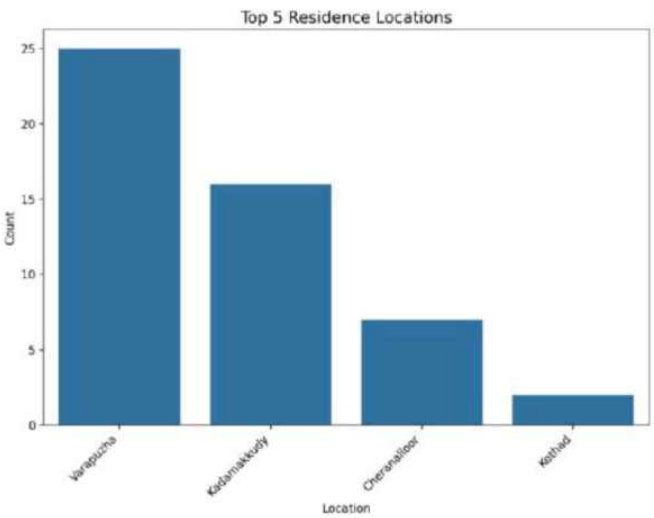
6th	2
7th	2
4th	2
ITI	2
DEGREE	2
BBA	1
DIPLOMA	1

Source: primary data

Most farmers have completed Plus Two, and 13 have completed SSLC (10th grade). This means that a significant percentage of farmers have at least basic secondary education, which will enable them to understand financial management and farming techniques. Beyond SSLC, there is a drop-off. This shows that a good percentage of the working population lacks formal education, which will make them incapable of adopting modern farming methods. Vocational training for some farmers can be useful in technical aspects such as equipment operation, cage building, and maintenance.

3.4: LOCATION DISTRIBUTION

Figure: 3.4.1



Source: primary data

Data is collected from cage farmers in Varapuzha, Kadamakkudy, Cheranalloor, Kothad. These regions were heavily affected by the massive fishkill. Highest number of respondents is from Varapuzha and least from Kothad.

3.5: TOTAL FINANCIAL LOSS DUE TO FISH KILL

Table 3.5.1

COUNT	50
MEAN	734260
STANDARD DEVIATION	1103436.3451305663
MAXIMUM VALUE	8000000
MINIMUM VALUE	100000

Source: primary data

The average loss is ₹734,260. Small farmers also experience huge losses indicating the huge economic disruption. The standard deviation is higher than the mean, 1,103,436.35. This means loss is extremely unequal, some farmers experiencing gigantic losses such as ₹8,000,000 and some negligible ones such as ₹100,000.

3.6: FISH PURCHASE COSTS

Table 3.6.1

COUNT	50
MEAN	101192
STANDARD DEVIATION	147249.51174861
MAXIMUM VALUE	1000000
MINIMUM VALUE	15000

Source: primary data

The average cost incurred by farmers impacted by fishkill in buying fish is ₹101,192. The standard deviation, 147,249.51, is higher than the mean. While some farmers spent relatively low, with the minimum being ₹15,000, others spent very high, with the maximum being ₹1,000,000. A high standard deviation indicates that some farmers spend much higher in purchasing fish compared to other farmers. Maybe the variation occurs depending on market demand, farm size, fish species.

3.7: FISH FOOD COSTS

Table 3.7.1

COUNT	50
MEAN	247268
STANDARD DEVIATION	361497.8580905863
MAXIMUM VALUE	2500000
MINIMUM VALUE	35000

Source: primary data

The average cost of fish food stands at ₹247,268. The high standard deviation at 361,497.86 gives a very high differences in the expenses, some of the farmers spend as less as ₹35,000, while the other spends way more and up to as high as ₹2,500,000, the range of the cost of fish food is very high which shows some farmers running smaller-scale operation while others are running way larger and investing in high-quality feed.

3.8: CAGE COSTS

Table 3.8.1

COUNT	50
MEAN	346800
STANDARD DEVIATION	368987.5281339023

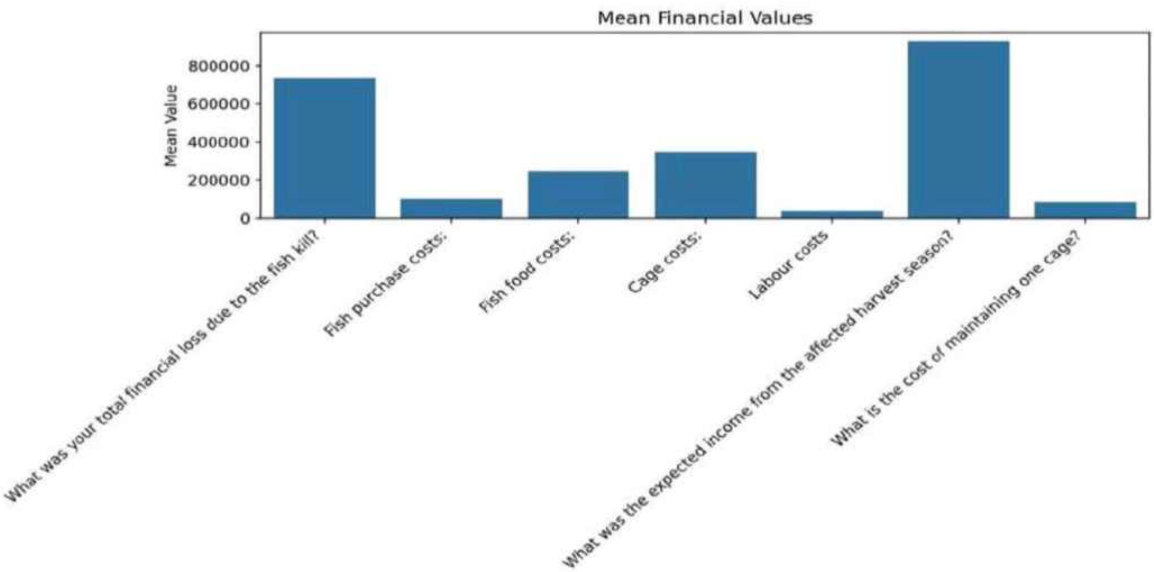
MAXIMUM VALUE	2600000
MINIMUM VALUE	50000

Source: primary data

The research computes the costs of cages for the affected farmers. The mean is about ₹346,800. Since the standard deviation of ₹368,987.53 is more than the mean. The range of cost is from the lowest of ₹50,000 to the highest of ₹2,600,000. This shows that there are enormous variations in the cost of constructing and maintaining cages, and whereas some farmers pay very high amounts, some pay low amounts. Some of the probable reasons are differences in cage size, technical integration, material quality, and market factors.

3.9 MEAN FINANCIAL VALUES

Figure 3.9.1



Source: primary data

3.10: EXPECTED INCOME FROM THE AFFECTED HARVEST SEASON

Table 3.10.1

COUNT	50
MEAN	927000
STANDARD DEVIATION	1375151.5686405967
MAXIMUM VALUE	10000000
MINIMUM VALUE	150000

Source: primary data

This research looks at how much each farmer expects to make from the affected crop season. The mean expected income is ₹927,000. However, the standard deviation is as high as ₹1,375,151.57, which is higher than the mean. Income expectations are very wide. Minimum income expectation could be as low as ₹150,000, while maximum income expectation is as high as ₹10,000,000,000. Some farmers have low expectations regarding their income while others have high income projections. It might due to variations in farm size, crop or livestock yield, access to high-value markets.

3.11: COST OF MAINTAINING ONE CAGE

Table 3.11.1

COUNT	50
MEAN	86325
STANDARD DEVIATION	42904.8543944883
MAXIMUM VALUE	200000
MINIMUM VALUE	30625

Source: primary data

This study estimates the costs that the affected farmers paid for maintaining a cage. The average cost has been determined to stand at ₹86,325 with standard deviation as 42,904.85, It is well a wide range from ₹30,625 up to ₹200,000. The big range shows that some farmers are having costs more than double the average or half of the average, although the standard deviation is less than the mean.

3.12: CAGE STATISTICS BEFORE THE FISH KILL

Table 3.12.1

COUNT	50
MEAN	4.06
STANDARD DEVIATION	2.1703944906
MAXIMUM CAGES	13
MINIMUM CAGES	1

Source: primary data

From the data, there are huge disparities in the number of cages. The standard deviation of 2.17 gives a moderate dispersion, showing that some farmers operate on a far larger scale than others. While one farmer can have as many as thirteen cages, some have as few as one. Reasons for these are differences in capital investment, experience and market limits. Due to this difference, the financial implications of the fish kill are distributed unevenly, farmers owning more cages are likely to experience higher losses.

3.13: CAGE STATISTICS AFTER THE FISH KILL

Table 3.13.1

COUNT	50
MEAN	4.24
STANDARD DEVIATION	2.5758691816

MAXIMUM CAGES	15
MINIMUM CAGES	0

Source: primary data

There was great variation in the number of cages after fish kill, with the mean number of cages increasing from 4.06 before kill to 4.24 after kill, showing an increase in farmers' activity regardless of fish kills. The standard deviation increased from 2.17 to 2.58, showing that while some farmers increased cage farming phenomenally, as is clear through the increase in maximum cages from 13 to 15, others decreased or dropped out. Cages also decreased from 1 to 0, showing that some farmers abandoned cage farming due to a lack of assistance or insufficient funds.

3.14: CAGE STATISTICS WITH AGE INTERVALS

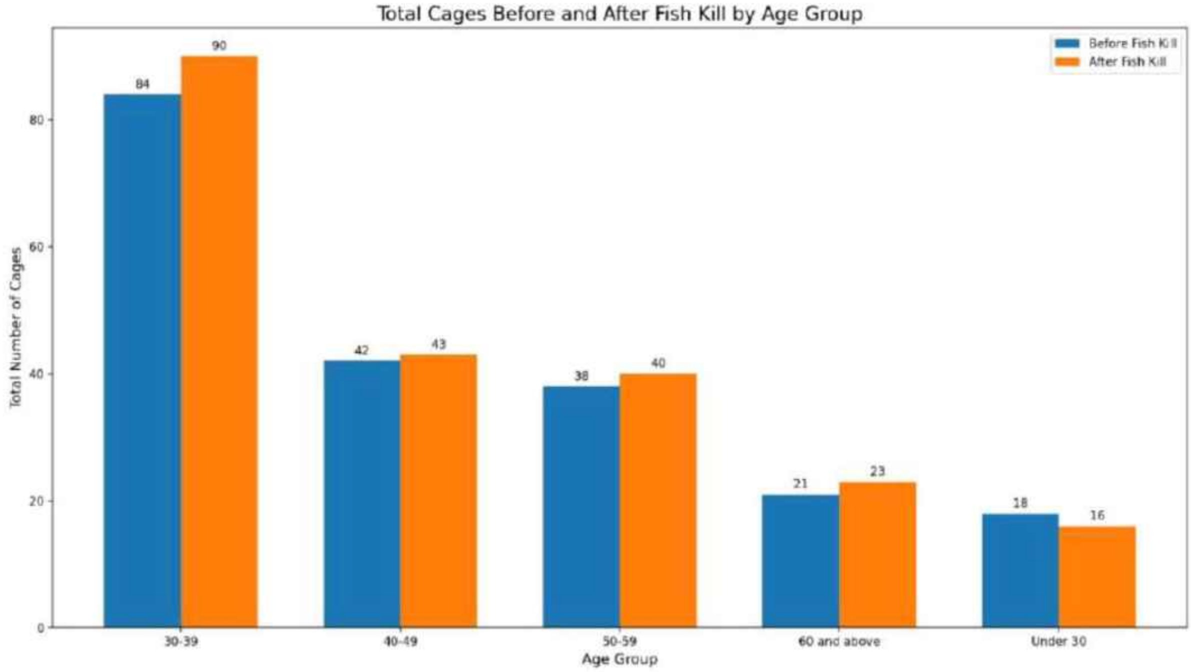
Table 3.14.1

AGE	COUNT	TOTAL CAGES BEFORE THE FISH KILL	TOTAL CAGES AFTER THE FISH KILL
UNDER 30	4	18	16
30-39	17	84	90
40-49	11	42	43
50-59	11	38	40
60 and above	7	21	23

Source: primary data

The 30–39 age group had the highest number of cages before and after the fishkill. They demonstrated their resilience by increasing their cages from 84 to 90 after suffering from fishkill. There was a slight increase (42 to 43 cages) in the 40–49 group, which showed stability. The cages for the 50–59 and 60 above groups were expanded, showing that experienced farmers are remaining in the cage farming despite danger. Young adults are less active in cage farming. Aversion to risk, lack of finances, or preference to other jobs may be the reasons.

Figure 3.14.1



Source: primary data

3.15: TOTAL COST COMPONENTS

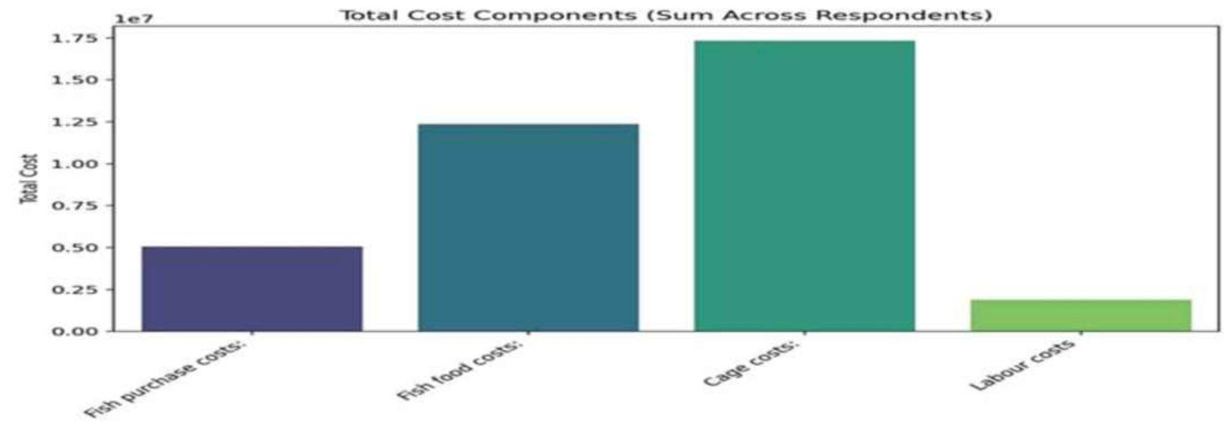
Table 3.15.1

FISH PURCHASE COSTS	5059600
FISH FOOD COSTS	12363400
CAGE COSTS	17340000
LABOUR COSTS	1900000

Source: primary data

The highest expense is the cost of the cage, which amounts to ₹17,340,000 (47.3% of the total). This indicates a high investment in cages, whether through maintenance, expansion, or the installation of new cages. The second highest expense is fish food. The fact that feed costs ₹12,363,400 (33.7%). The purchase cost of fish is ₹5,059,600 (13.8%), indicating that it is cheaper than feed and cage cost. Fish species and market demand would influence these inputs. The farmers have essentially used family labour since labour costs are only ₹1,900,000 (5.2%).

Figure 3.15.1



Source: primary data

3.16: LOAN INVOLVEMENT

Table 3.16.1

YES	41
NO	9

Source: primary data

To finance their farms, 41 farmers (82%) have borrowed loans. Nine farmers (18%) do not have any loans. Cage farming requires high financial investment, due to the high costs of cages, feed, and fish purchase. A majority of farmers lack significant personal savings. High credit dependence increases economic vulnerability.

3.17: GOVERNMENT COMPENSATION

Table 3.17.1

YES	0
NO	50

Source: primary data

There are zero farmers (0%) who are compensated. Fifty farmers (100%) receive no financial support from the government as they are hit by a massive fishkills. This makes the farmers more vulnerable to financial shocks because they use loans or personal savings. With 82% of farmers depend on loans, the inability to repay loans leads to potential defaults or even closing down of farms.

3.18: INSURANCE COVERAGE

Table 3.18.1

YES	0
NO	50

Source: primary data

Fifty farmers (100%) have no insurance. Only large cages farms with hundreds of cages are eligible for insurance. Small-scale farmers face all financial risks because they are without insurance coverage from pollution, outbreak of diseases and fish kill. This makes them dependent on borrowing, which raises their financial crisis.

3.19: PLAN TO CONTINUE CAGE FARMING

Table 3.19.1

YES	46
NO	3
MAY BE	1

Source: primary data

Forty-six farmers (92%) want to continue cage farming, Three farmers, or 6%, discontinued farming. One farmer (two percent) is not decided yet. Most (92%) intend to continue with cage farming, showing a strong desire to stick with the business despite financial losses. This suggests that cage farming remains an important source of income even though the business is suffering a financial loss. Cage farming has thus been abandoned only by 6% of the farmers. Most farmers are waiting to be rescued through government support and insurance.

3.20: BELIEF IN REGULATIONS

Table 3.20.1

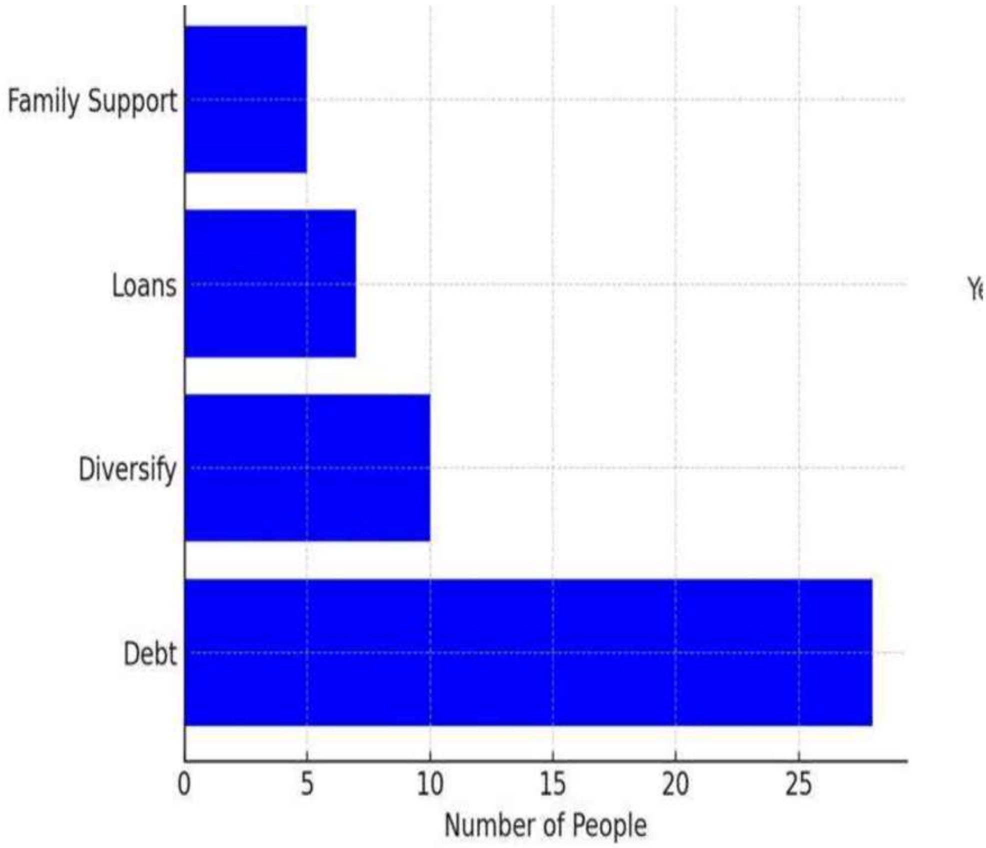
YES	50
NO	0

Source: primary data

50 farmers (100 percent) believe in stronger industrial discharge regulations. Inaction and lack of compensation led to widespread discontent. Their protests are an attempt to push the government to make impactful changes.

3.21: MANAGEMENT STRATEGIES

Figure 3.21.1

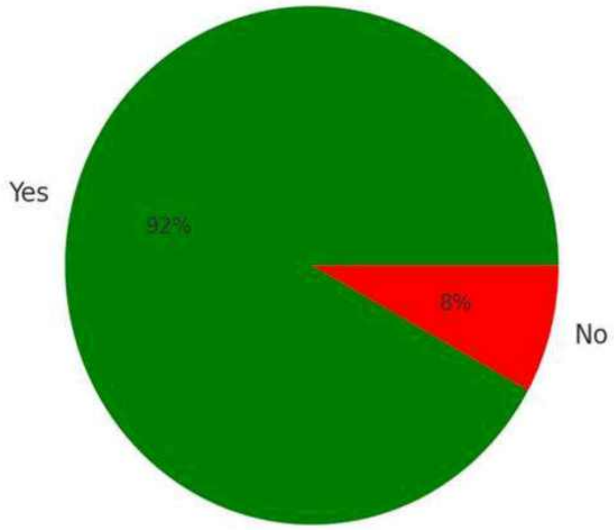


Source: primary data

The data shows that majority does not have management strategies and are going into debt. In contrast, only 20% (10 farmers) looked for diversifying income streams, while smaller percentages used family assistance (10%) or loans (14%). Debt at high levels indicates financial pressure and the possibility of insufficient resources or sustainable alternatives. Income diversification potentially decrease long-run risk.

3.22: MAIN INCOME

Figure 3.22.1



Source: primary data

Cage farming is a main source of income for 46 out of the 50 respondents (92 percent). Just 4 (8%) of the farmers have other sources of primary income.

3.23: OTHER INCOME SOURCES

Table 3.23.1

NO	2
YES, FISHING	35
YES, BUSINESS	3
YES, WOOD CUTTING	2
YES, DRIVING	2
YES, WORKING IN A COMPANY	3
YES, CATERING	1
YES, CARPENTRY	2

Source: primary data

This research explores the extra income sources for farmers. Fishing is the major additional source of income for 70%, or 35 of 50 farmers. Business 6%, wood-cutting 4%, driving 4%, working for a firm 6%, catering 2%, and carpentry 4%, are much less common. Two farmers, report having no other extra sources of income. Fishing may not be able to stabilize financial instability completely. Greater diversification of income is a solution to reduce economic vulnerability.

3.24: PARTNERSHIPS

Table 3.24.1

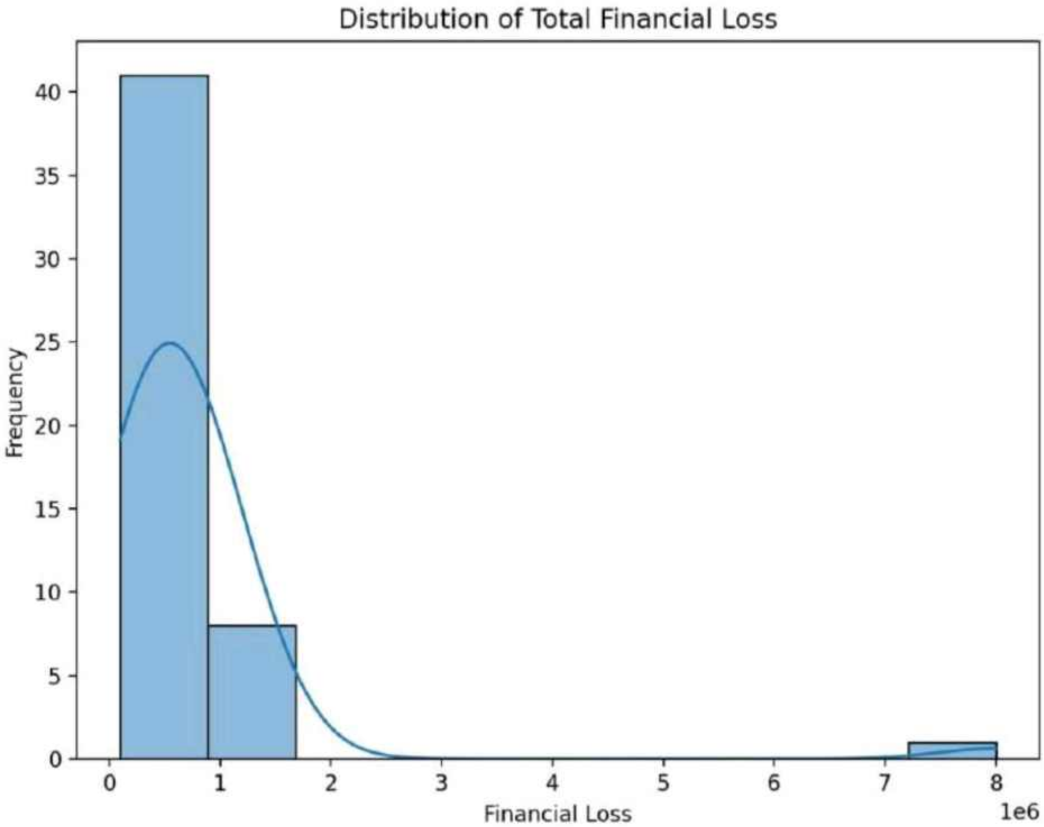
YES, JOINT PARTNERSHIP	18
NO	32

Source: primary data

32 farmers are independent of partnerships, and 18 are in joint partnerships. Partnership helps in sharing of financial problems, especially in emergencies. Still, most of the respondents (32) prefer independent businesses, perhaps because they can have more say in decisions and profits.

3.25: HISTOGRAM SHOWING THE DISTRIBUTION OF TOTAL FINANCIAL LOSS

Figure 3.25.1



Source: primary data

In the figure, different levels of financial loss are shown. Financial loss in millions ranging from 0 to 8 million has been measured on the X-axis. The Y-axis gives frequency. The majority of people loss between zero and one million dollars. High loss is rare and low loss is common.

3.26: ONE SAMPLE T TEST

One sample t test is used to evaluate whether the fishkill had a statistically significant economic impact. Null hypothesis (H0) is average financial loss is equal to zero. Alternative hypothesis (H1) is average financial loss is greater than zero. In the result of t test, the t statistic obtained is 4.705032915254246 and computed p value is small below 0.05. We reject the null hypothesis, that is, average financial loss is equal to zero. The fish kill had a significant economic impact.

CHAPTER 4

KEY FINDINGS, SUGGESTIONS AND CONCLUSION

4.1: INTRODUCTION

I conducted a study on the economic impact of fishkill in the Periyar river, The study aimed to analyse the direct financial losses to cage farmers due to fish kill and also to evaluate social impacts. I utilized both primary and secondary data for my research. Data from 50 samples were taken. I used cluster sampling and snowball sampling methods. "Cluster sampling is a method of probability sampling that is often used to study large populations, particularly those that are widely geographically dispersed". "Snowball sampling is a non-probability sampling method where new units are recruited by other units to form part of the sample. Also known as chain sampling or network sampling, snowball sampling begins with one or more study participants. It then continues on the basis of referrals from those participants". The cage farmers who were affected by the fish kill was spread across regions like Kadamakkudy, Cheranallor, Varapuzha, I divided the population into clusters and from each cluster samples are taken. As some farmers referred other cage farmers who are the victims of fishkill events so I also employed snowball sampling method in my study. On the basis of the analysis (previous chapter) this chapter includes the key findings and important suggestions.

4.2: MAJOR FINDINGS

- The average financial loss is estimated is 734260/-. One sample t test is used to determine whether the fishkill had a statistically significant economic impact. The result showed that the average financial loss is greater than zero, the fishkill had a significant economic impact.

- The farmers mainly farmed fishes like Asian Sea Bass, Pearl Spot, Tilapia.

- Farmers with more cages suffered high losses during the fishkill.

- In the case of fish purchase costs, fish food costs, cage costs, the standard deviation is higher than the mean which indicates that some farmers invested more in fish purchase, fish food, cage maintenance while some others invested less. The difference depends on farm size, market dynamics, high quality food etc.

- Income expectations from the affected harvest season among cage farmers are very wide. Some farmers expect high income while some others have low expectations.

- There is also wide disparity in the number of cages held by farmers, after the fish kill, some farmers increased the number of cages but some others decreased the number of cages due to financial crisis.

- The highest expense was for the building and maintenance of cages, followed by fish food costs.

- Around 82% of cage farmers took loans, this indicates that majority were financially weak and fishkill further increased their atrocities.

- After fishkill around 56% of cage farmers went into high debts, some took new loans while some others are supported by their families.

- Even though the cage farmers suffered high financial losses, none of them received any government compensation, the cage farmers have formed associations and they are conducting strikes for making the officials, government understand their crisis and to get compensations for the loss suffered. But many don't have hope that their issues will be considered sooner. Even though government promised compensations at the time of massive fish kill, the cage farmers received none.

- ❖ No insurance coverage was available for cage farmers. Only farmers who are doing large scale cage farming operations consisting of hundreds of cages are eligible. If insurance was there many farmers wouldn't have gone into high debts.

- ❖ Even though, the cage farmers faced high financial losses. 92% of them decided to continue cage farming as this the main source of income for majority.

- ❖ Fishing is the major extra income source for cage farmers. But fishing cannot provide financial stability fully, they should diversify their income streams.

- ❖ Around 64% of farmers are doing cage farming independently, while others are doing in partnerships.

- ❖ Majority of people incur loss within the range of 0 to 1 million. Low financial losses are common and high losses are rare.

- ❖ All cage farmers believe that the situation will change if there are stricter regulations on industrial discharges. But the government and officials are not implementing stricter rules.

4.3: <u>SUGGESTIONS</u>

- Government should provide compensation to the cage farmers. Some farmers pointed out that they don’t directly want the government to give compensations but the government must take necessary steps to compel the industries which are responsible for the discharges that led to massive fish kill to make compensations. The government can at least provide subsidies for fish purchases and fish food which will be a great help to the farmers.

- Insurance schemes should also cover small scale cage farming. If that’s difficult, small scale cage farmers should be formed into groups, these groups should be eligible for insurance coverage.

- Government must implement stricter regulations on industrial discharges. These discharges not only affect the cage farmers but also the population using the water for different purposes. Periyar river is a source of water for millions of people in Kerala. There is no surprise in the increase of dialysis centres. The industries responsible for discharges must be fined or punished.

- Water quality of river must be checked frequently, there should be automated alerts to warn the cage farmers before fishkill happens.

- Farmers should diversify their income sources. Depending only on cage farming and fishing will put the farmers in debt.

- Forming unions among cage farmers will give them a sense of unity, leadership to fight against the atrocities faced by them.

- Legal actions should be taken against the industries responsible for discharges.

- Low oxygen levels in the river due to discharge led the massive fishkill, installation of proper aeration systems maintain adequate oxygen levels in the water during emergencies.

- Establish effluent treatment plants for all industries situated near the Periyar river.

- Implement zero liquid discharge systems

4.4: <u>CONCLUSION</u>

Fishkill had an enormous effect on cage farmers, they faced huge economic losses, many of them fell into debt traps as they didn't receive any compensation from government or insurance. Not only financially they were also affected emotionally, mentally. Few cage farmers stopped farming. Farmers who continued cage farming are living in fear as they are not ready to face a similar massive fish kill happened in May 2024. The fishkill inflicted a huge financial blow to farmers. Compensations, stricter regulations, diversifying income sources can improve the financial conditions of cage farmers. Government and officials must consider the financial grievances of cage farmers and should take actions against the industries responsible for the discharge which resulted in the fishkill.

QUESTIONNAIRE

THE ECONOMIC IMPACT OF FISH KILL IN THE PERIYAR RIVER

1.Name:

2.Gender:

3.Age:

4. Residence Location:

5. Education:

6. How long you have been doing cage farming?

7. What types of fish do you farm in your cages?

8. Before the fish kill, how many cages did you own?

9. At present, how many cages do you own?

10. What was your total financial loss due to the fish kill?

11. Classification of economic loss

☆Fish purchase costs:

☆Fish food costs:

☆Cage maintenance costs:

☆Labour costs:

12.Is cage farming your main source of income?

13.What was the expected income from the affected harvest season?

14.What is the cost of maintaining one cage per season?

15. Does your cage farming business involve loans?

16. How are you managing the economic losses caused by the fish kill?

17. Is cage farming your main source of income?

18. Do you have any other income sources? If yes, please mention:

19. Do you work in partnership for cage farming? If yes, mention the type of partnership

20. Have you received any compensation from the government?

21. Is your cage farming business covered by insurance?

22. Do you plan to continue with cage farming in the future?

23. Do you think the situation will change if industrial discharges are subjected to stronger regulations?

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PHOTOGRAPHS

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