# Industrial Pollution and Fish Kill Impacts on Pizhala's Fishing Livelihoods

**Rani Maria Jose**
*St. Teresa's College, Ernakulam, Kerala, India*

**Anupa Jacob**
*Associate Professor & Research Guide*
*Department of Economics, St. Teresa's College, Ernakulam, Kerala, India*

**P.T. Raichel Florence**
*St. Teresa's College, Ernakulam, Kerala, India*

**A.M. Gayathri**
*St. Teresa's College, Ernakulam, Kerala, India*

**Amala Abel**
*St. Teresa's College, Ernakulam, Kerala, India*

**Sredha Joseph**
*St. Teresa's College (Autonomous), Ernakulam, Kerala, India*

**OPEN ACCESS**

Manuscript ID:
ECO-2026-140310463

Volume: 14

Issue: 3

Month: June

Year: 2026

P-ISSN: 2319-961X

E-ISSN: 2582-0192

Received: 21.03.2026

Accepted: 18.05.2026

Published Online: 01.06.2026

Citation:
Rani Jose et al., "Industrial Pollution and Fish Kill Impacts on Pizhala's Fishing Livelihoods." *Shanlax International Journal of Economics*, vol. 14, no. 3, 2026, pp. 1–11.

DOI:
https://doi.org/10.34293/economics.v14i3.10463



**Abstract**

*Pizhala, in Kerala's ecologically sensitive backwaters, faces severe socio-economic and environmental impacts due to recurrent fish kills caused by industrial pollution. This study examines the effects on fishing communities whose livelihoods rely on capture fisheries and aquaculture. This study combines primary data from field surveys with supporting secondary sources. The analysis reveals significant income losses, rising debt, and declining fish demand, with over half of the respondents losing more than ₹20,000 per incident. Adaptive strategies include alternative livelihoods, collective action, and environmental support. However, there are financial and structural constraints that limit their resilience. These findings highlight the urgent need for stringent pollution control, sustainable fishery management, and targeted support to safeguard livelihoods and restore ecological sustainability. Future research should focus on the long-term ecological monitoring of water quality and fish populations in Pizhala. This will help us better understand the frequency and causes of fish-kill events. There is also a need for economic valuation of environmental damage and livelihood losses faced by fishing households.*

**Keywords: Industrial Pollution, Fish Kill, Fishing Livelihoods, Pizhala, Socio-Economic Impacts, Livelihood Vulnerability, Environmental Economics**

## Introduction

The village of Pizhala is situated within the ecologically sensitive backwaters of Kerala. It is presently confronting an acute environmental crisis manifested in large-scale fish mortality, largely attributed to the discharge of untreated industrial effluents (The Hindu, 2023). This ecological degradation poses significant threats to the local community, whose socio-economic fabric is tied to fishing and aquaculture as primary sources of livelihood.

Pizhala's economy is closely interwoven with the health of its aquatic ecosystems which are now severely compromised by industrial pollutants. The majority of the residents, particularly small-scale fishers and aquaculture

farmers, face increasing economic uncertainty as fish deaths undermine their income and security. The repercussions extend beyond individual households. They spread through local businesses, trade networks, and associated commercial activities, thereby amplifying the economic consequences of the disaster.(Nair, 2020).

The unfolding crisis has profound implications of unchecked industrial pollution for vulnerable communities who are dependent on natural resources.

It is therefore imperative to assess the scale of economic losses, the degree of livelihood disruption, and the vulnerability of different socio-economic groups in Pizhala. Such an inquiry not only quantifies immediate impacts but also highlights the long-term implications for community resilience and adaptive capacity (Ramakrishnan & Thomas, 2021).

Beyond its economic repercussions, the fish mortality crisis threatens Pizhala's cultural heritage and social identity. Fishing and aquaculture practices are deeply embedded in the community's traditions, and their disruption signals risks to the fabric of local existence. (Singh, 2019).

Despite extensive studies on the ecological and economic impacts of fish kills, there is a lack of localized, community-level research that captures the specific socio-economic impacts and adaptive responses of fishing households in Pizhala. This study addresses these gaps by examining the economic impacts and resilience mechanisms of affected communities. The findings are expected to provide valuable insights for policymakers to support the design of sustainable development frameworks and collective action. This is necessary to safeguard the future of this ecologically fragile and economically vulnerable region.

**Review of Literature**

Fish kills are a widely documented phenomenon across aquatic ecosystems and are often attributed to both natural and anthropogenic factors. Natural causes include low dissolved oxygen (anoxia), harmful algal blooms, abrupt temperature fluctuations, salinity changes, turbidity, and blackwater events. However, anthropogenic drivers have amplified the frequency and severity of fish mortality events, with acid spills, industrial effluents, and acid rain lowering water pH and deteriorating aquatic health. Such events not only signal ecological stress but also compromise water quality, recreational activities, and fisheries, resulting in substantial economic losses (Kibria, 2014).

Several global studies have examined the ecological and hydrological dynamics associated with fish mortality. Thronson and Quigg (2008) documented more than 383 million fish deaths along the Texas coast between 1951 and 2006. He identified low dissolved oxygen levels, eutrophication, algal blooms, and seasonal warming as the primary causes. Similarly, Ochumba (1990) described a catastrophic event in Lake Victoria in 1984, where over 400,000 fish perished due to the combined effects of low water levels, severe storms, suspended materials, hypoxia, and the proliferation of algae. More recently, Gaye-Siessegger et al. (2023) analyzed the long-term ecological impacts of a fertilizer spill in Germany's Jagst River, which devastated fish populations along a 50 km stretch and necessitated extensive restoration measures. Alosairi et al. (2021) employed numerical modelling in Kuwait Bay to simulate hydrodynamic and water-quality conditions during a major fish kill. This study provides insights into the dissolved oxygen dynamics and management strategies for shallow embayments. Similarly, Petriki et al. (2021) investigated mass fish kills in the Bogdanas River, Greece, and concluded that organic pollution, elevated nutrient loads, and reduced water flow exacerbated fish mortality.

Fish kills have also been widely reported in Asia and Africa. Benjamin et al. (1996) attributed large-scale fish mortality in Sankey Lake, Bangalore, to sewage inflow and sharp declines in dissolved oxygen levels. In Puducherry, Mishra et al. (2020) linked a 2019 fish kill in the Chunnambar River to algal blooms, untreated sewage inflow, and poor water exchange with the sea. Rashid et al. (2021)

described a 2017 fish kill in Srinagar's Jhelum River, noting morphological deformities indicative of chemical contamination. In Nigeria, Olopade et al. (2024) captured fishermen's perspectives on mass fish deaths, with most attributing the phenomenon to pollution. The study also documented species-specific impacts, such as the vulnerability of croaker fish.

Several studies have highlighted the Indian context. Pejavar and Somani (2000) reported zero dissolved oxygen levels following a fish kill in Railadevi Lake, Thane, which was caused by suspended organic matter and anaerobic conditions. Somani (2016) observed similar outcomes in Jail Lake, Thane, where algal blooms and sewage inflow induced hypoxia. Karuppasamy (1979) examined an earlier incident in the Chaliyar River, Calicut, linking fish deaths to effluents from the Gwalior Rayons Factory with high sulfuric acid concentrations that caused respiratory stress in fish. Shaji and Shankar (2018) reviewed fish kill events across Kerala's freshwater bodies between 1995 and 2014, identifying industrial effluents, pesticide poisoning, and waste disposal as leading causes, with key species such as Etroplus suratensis and Wallago attu heavily affected. More recently, Nair et al. (2021) documented an unusual fish kill in the Chandragiri River in Kasaragod. This study specified the ecological vulnerability of riverine ecosystems.

Beyond ecological consequences, studies have drawn attention to the socio-economic impacts. Sathiadhas et al. (2006) analysed the economic implications of environmental threats in Kerala's coastal fisheries, noting the combined effects of pollution, unsustainable fishing practices, and coastal erosion on marine landings and community livelihoods. These findings align with broader evidence that fish kills disrupt aquatic ecosystems and undermine the cultural and economic foundations of communities dependent on fisheries.

This connection between ecological disruption and economic vulnerability was reaffirmed in a more recent community-led investigation into the Periyar fish kill of May 2024. It reported an estimated loss exceeding Rs.41 crore to local fishing communities (The Hindu, 2024). The report attributed the crisis to unchecked industrial effluents and stressed the urgent need for ecological restoration and financial compensation for affected fishermen. This study illustrates the scale at which pollution-induced fish mortality can destabilize fishing livelihoods, reflecting the concerns noted by Sathiadhas et al. (2006).

Similarly, an economic assessment of coastal fisheries across southern Kerala conducted from 2001 to 2003 quantified the heavy losses incurred due to unsustainable practices and pollution (Azpdf.net, n.d.). The analysis revealed that juvenile fishing alone caused annual losses of nearly Rs. 600 crores across degraded landing centers. Pollution-related damages in villages such as Kochuveli and Alappad are estimated at Rs157.4 crore and Rs.647 crore, respectively, in present-value terms. Thus, environmental degradation results in long-term economic harm, reducing both fish stock productivity and fishing community resilience.

Existing research has examined the broader implications of environmental degradation for fisheries. However, there remains a need to generate context-specific evidence that captures both the immediate and long-term impacts of such crises on vulnerable fishing communities. Addressing this gap, the present study focuses on the village of Pizhala, where large-scale fish deaths have severely undermined the livelihoods and community well-being.

**Objectives of the Study**

In light of the reviewed literature, which focuses both the ecological and socio-economic repercussions of fish mortality events in Kerala's coastal and inland fisheries, the present study is designed with two specific objectives:

1. To examine the social and economic losses experienced by the fishing community due to large-scale fish deaths.
2. To analyse the adaptive strategies employed by the fishing community to mitigate and cope with the economic and social challenges arising from this crisis.

**Need for the Study**

The massive fish kill in Pizhala has created a

severe ecological and economic crisis in a region where inland fishing is the primary source of livelihood. Industrial effluents have been reported to cause widespread mortality, including losses in cage farming. This has left local fishers and aquaculture farmers with profound livelihood insecurity. Previous studies have drawn attention to the environmental and livelihood implications of such crises in Kerala. However, there is limited evidence on the specific strategies adopted by affected communities to cope with these disruptions. Such a multifaceted analysis is critical for designing effective policy interventions and ensuring the long-term sustainability of fishery-based livelihoods. Such insights are vital for informing targeted interventions, including financial assistance, alternative employment opportunities, and effective regulatory measures to curb pollution.

This study also situates the crisis within the framework of environmental economics. This research addresses a critical gap by linking environmental degradation to livelihood vulnerability. It offers valuable input for policymakers, environmental regulators, and local communities to safeguard both livelihoods and ecosystems in Pizhala.

**Methodology of the Study**

This study adopts a descriptive and analytical research design, consisting of both primary and secondary data sources. The study area, Pizhala Island, was purposively selected as it represents a community predominantly dependent on fishing and cage aquaculture for their livelihood. The region has experienced recurrent fish kills due to industrial pollution. This makes the region a representative site for examining the socioeconomic consequences of such environmental shocks.

Primary data were collected from the affected households through structured personal interviews using a pre-tested questionnaire. It gathered information on income loss, changes in household expenditure, employment patterns, perceptions of environmental degradation and coping strategies. The respondents were residents of Pizhala whose primary occupations were either traditional capture fishing or cage aquaculture. They were selected based on the nature of the study area and the similarity of their livelihood patterns. In the absence of a comprehensive sampling frame, snowball sampling was used to identify respondents through existing community networks. The use of snowball sampling may have introduced selection bias. As respondents are drawn from interconnected networks it might limit representativeness of sample. Sill this approach was suitable given the difficulty in locating fishing households within the general population. To ensure adequate representation, both traditional and aquaculture-based fishers were included in the sample. The samples were considered sufficient to capture the range of socio-economic impacts and experiences related to fish kill incidents in the study area.

In addition to primary data, secondary information was collected from published research, government reports, and credible media sources to provide contextual and corroborative insights into the issue. Together, these data sources enable a comprehensive understanding of livelihood disruptions and adaptive strategies of the fishing community in Pizhala.

**Results and Discussion**

The following section presents the empirical findings of the study based on data collected from the fishing community in Pizhala. The analysis focuses on the socioeconomic implications of industrial pollution-induced fish mortality, particularly the financial losses and livelihood disruptions experienced by fishermen. Attention was also paid to the coping mechanisms adopted by the community in response to recurrent fish kills. It offers deeper interpretive insights into the vulnerabilities and adaptive strategies of the affected community.

**Social-Economic Profile of the Respondents**

The socio-economic characteristics of the fishing community in Pizhala provide important insights into how people experience and respond to recurring fish kills. Factors such as gender, age, education, occupation, and years of fishing experience shape both the impact of these events and the coping strategies adopted by households. As fishing is the primary livelihood in the area, disruptions caused by industrial pollution and fish mortality directly affect income, household stability, and social well-being.

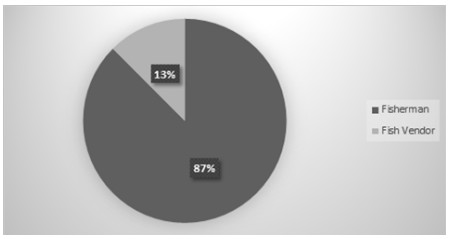
Therefore, understanding the demographic and occupational profiles of the community is essential for assessing the scale of losses due to fish kills. It also helps identify the resilience and vulnerabilities that define their responses to this crisis.

The gender composition of the respondents indicates that fishing in Pizhala is predominantly male-dominated, with more than four-fifths of those engaged in the sector being men. Women accounted for less than one-fifth of the participants. This can be attributed to the physically demanding nature of fishing, entrenched gender roles, and limited opportunities for women to participate in this occupation.

In terms of age distribution, the fishing community is largely composed of middle-aged and older individuals, with nearly three-fourths falling into the 45–60 and above 60 age categories. Younger generations are less represented, suggesting a declining interest in fishing as a livelihood. This disinterest is likely influenced by challenges such as declining fish availability due to industrial pollution, the strenuous nature of fishing, and the attraction of alternative employment opportunities in the region.

The respondents' educational attainment was modest, with the majority having completed matriculation or higher secondary schooling. This level of education provides basic literacy and numeracy. This helps fishermen understand market dynamics, manage their finances, and explore supplementary livelihoods. Only a small proportion of respondents reported education beyond the higher secondary level. This reflects their economic constraints, occupational demands, and limited access to higher education. While higher qualifications are not generally required for fishing, those who possess them are better positioned to transition into alternative jobs during crises.

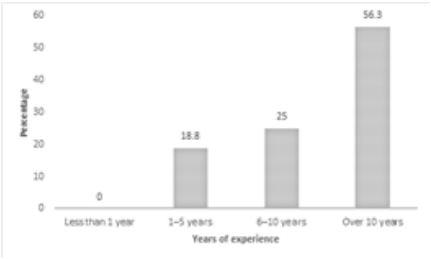
Occupational data show that fishing remains the principal livelihood for most respondents. More than 88 percent depend directly on it as their main source of income. This heavy reliance makes the community particularly vulnerable to disruptions, such as industrial pollution and fish kills. Both fishermen and associated vendors face economic setbacks when fish supply declines. The interdependence between fishermen and fish sellers illustrates how livelihood shocks trickle down the broader supply chain.




**Source:** Primary Survey

**Figure 1 Distribution of Respondents by Occupation**

Years of involvement in fishing further highlights its role as a long-term and skill-based livelihood. Over half of the respondents have been engaged in fishing for more than a decade. This gives them deep traditional knowledge and expertise in the community.




**Source:** Primary Survey

**Figure 2 Years of Experience of Respondents**

The absence of newcomers also reflects the waning appeal of fishing among younger generations, who increasingly seek more secure and less physically demanding occupations.

The social profile of the respondents reveals the deep-rooted nature of fishing in Pizhala. It also reveals generational and gender disparities, modest educational levels, and a high dependence on this traditional livelihood. These characteristics highlight both the strengths of community resilience and the vulnerabilities that intensify when external shocks, such as industrial pollution and fish kills, disrupt their lives.

**Economic Vulnerability of Fishing Households.**

The economic characteristics of the Pizhala

fishing community show the extent to which industrial pollution and recurrent fish kill incidents undermine their financial stability and livelihood security. To study this, key indicators such as household income, frequency of fish kill events, occupational diversification, income losses, and dependence on credit were considered. This reflects the community's economic vulnerability to environmental stressors. These factors also offer significant insights into the coping mechanisms adopted by fishers and the structural barriers that limit their transition to alternative livelihood.

**Income Distribution**

An analysis of the monthly household income of the respondents revealed significant variations in earnings. The data indicate that a large proportion of the fishing community falls within the low- to middle-income categories, with only a few households achieving relatively high earnings. The majority of respondents (28.1%) fall within the income range of ₹10,000-₹15,000, followed by 25% earning between ₹15,000-₹20,000. Only a small proportion (9.4%) of respondents have a monthly income exceeding ₹20,000.

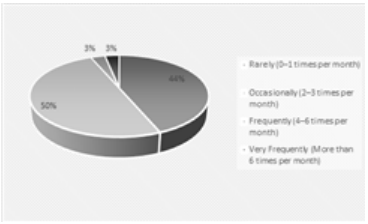

**Source:** Primary data

**Figure 3 Monthly Household Income of Respondents**

This income disparity highlights the uneven profitability of these sectors. Factors such as seasonal fluctuations, market demand, type of fishing gear used, and investment capacity significantly influence earnings. Moreover, recurrent environmental disruptions, particularly fish kills associated with industrial pollution, further worsen financial instability and contribute to persistent insecurities in livelihood.

**Frequency of Fish Kills**

The frequency of fish-kill events further compounds the economic instability of the community. The high incidence of fish kills emphasizes their prevalence and direct economic implications. Nearly half of the respondents (50%) reported experiencing fish kills two to three times per month, while 43.8 percent indicated that such incidents occurred once or less per month. Only a small share of respondents reported frequent (4–6 times per month) or very frequent (more than six times per month) occurrences of these events.




**Source:** Primary Data

**Figure 4 Frequency of Fishing Activity among Respondents**

Even occasional fish kills can drastically reduce catches, leading to financial loss and heightened dependence on credit. Respondents attributed these recurring incidents to industrial effluents, declining water quality, climatic variability, and overfishing, all of which degrade the aquatic ecosystem and erode the sustainability of traditional livelihood.

**Occupational Shifts and Coping Constraints**

Economic hardships also influence the occupational aspirations of the Pizhala fishing community. Many fishers are aware of the risks associated with continued dependence on fishing, but systemic and structural barriers hinder their ability to diversify their livelihoods. A substantial proportion of respondents (59.4 percent) identified inadequate financial resources as the primary constraint in shifting to alternative occupations. Other reported barriers included insufficient commercial prospects (9.4%), limited community support (15.6%), and a lack of other skilled personnel (15.6%).

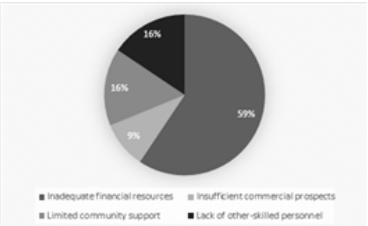
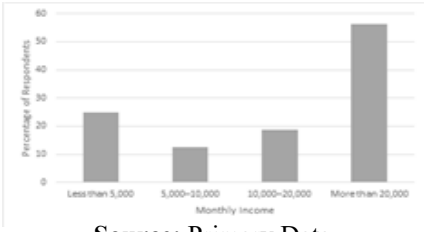



**Figure 5 Reasons for Occupational Shifts**

The lack of financial capital restricts investment in alternative income-generating activities, while inadequate skill training and weak institutional or community support limit transition opportunities. Consequently, despite their willingness to adapt, most households remain locked in the fishing economy. This perpetuates a cycle of economic vulnerability and dependence on environmentally stressed resources.

**Financial Losses per Incident**

The financial repercussions of fish kill events are substantial and further exacerbate the vulnerability of fishing households. More than half of the respondents reported incurring losses exceeding ₹20,000 per incident.




**Source:** Primary Data

**Figure 6 Loss per Fish-kill Incident**

This points to the severe economic toll on families already operating within narrow financial margins. Given the community's heavy dependence on fishing as the principal source of livelihood, even moderate or occasional losses can destabilize household income and consumption patterns. Such recurrent shocks not only reduce savings capacity but also compel households to rely on credit, intensifying their financial insecurity over time.

**Decline in Earnings and Rising Loan Dependency**

A comparison of pre- and post-incident monthly earnings clearly illustrates the magnitude of the economic disruption caused by recurrent fish-kill events. Prior to these incidents, most fishermen reported moderate income levels, though nearly one-third earned less than ₹10,000 per month. In the aftermath of repeated fish kills, however, the situation deteriorated sharply; 78.1 percent of respondents reported earning below ₹10,000 per month, with only a marginal share achieving higher income levels. This steep decline highlights the direct link between environmental degradation and erosion of household financial stability.

The growing dependence on loans further emphasizes economic fragility. Nearly two-thirds of the respondents reported relying on borrowed funds to cover fishing-related expenses, gear maintenance, and basic household needs. Only a limited number of respondents had access to government subsidies, insurance, or debt relief mechanisms, suggesting inadequate institutional support. Such credit dependence not only reflects the insufficiency of household income but also deepens long-term indebtedness, making economic recovery from fish kills increasingly difficult for the affected households.

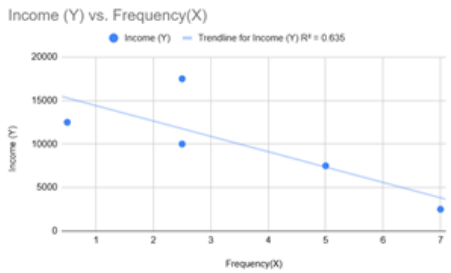
**Empirical Analysis: Relationship Between Fish Kill Frequency and Income**

Industrial pollution and recurrent fish kill incidents in Kerala, particularly in the Pizhala region, exert substantial socio-economic and ecological impacts on local fishing community. Pollution-induced deterioration of water quality disrupts aquatic ecosystems, alters species diversity, and diminishes the overall productivity of inland fisheries. Consequent fish mortality not only reduces the availability and quality of fish but also triggers a decline in consumer demand and market value, thereby intensifying income insecurity among fishermen and related occupational groups in the region.

Primary data revealed that 68.8 per cent of respondents reported a decline in fish demand attributable to pollution, while a majority experienced notable income reductions following major fish kill events, signifying widespread financial distress. Although factors such as rising healthcare costs were perceived as relatively less critical, the predominant economic burden was linked to instability in livelihood. The findings highlight the urgent necessity for comprehensive environmental governance, stringent pollution control measures, and the promotion of sustainable fishing practices to restore aquatic ecosystem health and secure the socio-economic resilience of the coastal and inland

fishing communities of Kerala.

Efforts have been made to quantify the economic impact of recurring fish kills on the livelihoods of Pizhala's fishing community. A simple linear regression analysis was undertaken with income as the dependent variable and fishing frequency as the independent variable. The estimated regression equation, $\hat{y}=16{,}060-1{,}857X$, indicates a negative relationship between fishing frequency and income. The slope coefficient of –1,857 suggests that for every unit increase in fish kill frequency, the fishermen's monthly income declines by approximately ₹1,857. The coefficient of determination ($R^2 = 0.635$) shows that approximately 63.5% of the variation in income is explained by changes in fishing frequency, reflecting a moderately strong negative correlation. The regression coefficient was statistically significant ($p < 0.05$), confirming that frequent fish kills substantially reduce fishing opportunities and earnings.




**Source:** Primary Data

The scatter plot above illustrates the relationship between the income of the fishermen on Pizhala and the frequency of fish kills. The trend line included in the graph shows a negative correlation between these two variables, with an $R^2$ value of 0.635. This decline in income can be attributed to the loss of fish stock, reduced market demand due to concerns about contamination, and financial instability caused by recurrent environmental hazards. These results establish the economic vulnerability of Pizhala fishermen. Hence, there is a need for effective pollution control and sustainable fisheries management to mitigate adverse livelihood impacts.

## Ecological and Social Implications

Environmental stressors, such as overfishing, pollution, and climate change, have influenced fish diversity in Pizhala. Over half of the respondents (53.1%) reported missing species, while 37.5 per cent observed a decline in abundance. No new species were noted, indicating possible biodiversity loss and the need for sustainable management practices.

Health problems in Pizhala are often associated with poor water quality, environmental pollutants, and economic stress, which affect both physical and psychological well-being. Many respondents (81.3%) reported no significant health concerns, indicating generally good health conditions within the community. However, a small fraction of patients experienced respiratory problems (9.4%), gastrointestinal issues (6.3%), and skin infections (3.1%). This may be associated with environmental factors such as water contamination and pollution. While most individuals remain unaffected, these findings highlight the need for targeted health interventions for vulnerable minorities.

## Preventive Measures and Recovery Strategies

Preventive strategies to address fish kills require a comprehensive approach that encompasses the enforcement of more stringent regulations on industrial waste discharge, promotion of sustainable agricultural methods, and enhancement of water quality monitoring systems.

In Pizhala, proactive measures were evident in the community's response to fish-kill events. Approximately 31 per cent of respondents reported engaging in environmental activism, such as participating in clean-up drives, monitoring water quality, and promoting sustainable fishing practices. Residents also collaborate with local authorities to report industrial pollution and participate in awareness programs organized by Panchayats and NGOs. These initiatives demonstrate the community's active role in pollution mitigation and conservation, collectively aiming to protect aquatic ecosystems and sustain local fisheries in the long term.

Recovery from fish-kill incidents in Pizhala involves environmental restoration, financial assistance, and community engagement in sustainable fishing practices. Over half of the respondents (56.3%) reported that they were still recovering,

indicating long-term socioeconomic impacts. While some regained normalcy within six months, a few required over a year, reflecting the enduring nature of the crises.

**Measures Adopted in Response to Fish Kill**

In response to fish kills in Pizhala, several measures have been implemented, including environmental assessments, cleanup drives, educational programs on sustainable fishing practices, and financial support for the affected families. These interventions aim to enhance community resilience while protecting the fishery resources.

Following the incidents, 34 per cent of respondents shifted from fishing to alternative livelihoods such as farming or tourism. Approximately 31.3 per cent engaged in environmental activism, reflecting strong awareness and commitment to sustainability. Others sought employment outside the fishing sector, while a small fraction took no action, likely because of limited options. Overall, the data indicate that most respondents adopted proactive strategies to mitigate the impact of fish kills, demonstrating adaptability and resilience through income diversification or active participation in environmental conservation.

**Community and Regulatory Measures for Future Prevention**

Preventing future fish kills in Pizhala requires a comprehensive strategy involving stronger environmental regulation, improved waste management, sustainable aquaculture, and active community participation. The majority of respondents (78.1%) emphasized the need to strengthen industrial pollution regulations, while 37.5 per cent highlighted the importance of stricter enforcement of existing laws. Approximately 25 per cent suggested better waste management infrastructure, and 21.9 per cent advocated for greater public awareness, indicating that both regulatory action and education are crucial for long-term ecological stability.

The role of the local community in pollution prevention and environmental conservation is equally vital. Residents of Pizhala actively report pollution incidents (41.9%), engage in cleanup campaigns, and promote sustainable practices, reflecting collective responsibility and environmental awareness. Together, these responses indicate that the effective prevention of fish kills depends on the synergy between institutional regulation and grassroots participation in protecting aquatic ecosystems.

In light of the above study, the following recommendations are put forward.

**Recommendations**

**a.** Strict enforcement of pollution control norms is essential for industries discharging effluents into water bodies.

**b.** Sustainable fishing practices should be encouraged alongside strict prohibition of household and plastic waste dumping into water bodies.

**c.** Measures such as financial assistance, skill development programs, and alternative employment opportunities should be provided to affected fishermen.

**Conclusion**

This study highlights the significant and wide-ranging impact of recurrent fish-kill incidents on the livelihoods of Pizhala's fishing community. The key contributing factor has been identified as industrial pollution. By examining both the socioeconomic losses and coping strategies adopted by affected households, the study highlights the extent of vulnerability and resilience of local fishers. The findings reveal that more than half of the respondents experienced financial losses exceeding Rs 20000 per incident. This shows the severity of the income disruption. Regression analysis shows that 63.5 percent of the variation in income is explained by fish kill incidents, which exhibit a negative relationship between fishing frequency and income. Although the community has adapted through various strategies, long-term solutions are required. This includes coordinated efforts by government authorities, environmental agencies, and industries. Strengthening pollution control, promoting sustainable fishing practices, and ensuring economic support for affected households are essential for protecting their livelihoods. Timely and collective action is necessary to prevent further environmental degradation and socioeconomic distress in the region.

Future research may expand the scope of the present study by analyzing the long-term

socioeconomic and environmental impacts of recurrent fish-kill incidents on fishing communities. Comparative studies across different coastal and inland fishing regions may provide broader insights into regional variations in vulnerability, adaptation strategies, and livelihood outcomes.

**References**

Alosairi, Yousef, et al. "Numerical Modelling of Hydrodynamics and Dissolved Oxygen Dynamics during a Major Fish Kill in Kuwait Bay." *Marine Pollution Bulletin*, vol. 165, 2021, pp. 112–124.

Benjamin, R., et al. "Fish Mortality in Sankey Lake, Bangalore, India." *Environmental Ecology*, vol. 14, no. 2, 1996, pp. 465–468.

Gaye-Siessegger, Jessica, et al. "Long-Term Impacts of Ammonium Nitrate Spill on Fish Populations in the Jagst River, Germany." *Environmental Science and Pollution Research*, vol. 30, no. 4, 2023, pp. 5567–5579.

Karuppasamy, R. "Large-Scale Fish Mortality in the Chaliyar River near Calicut." *Journal of the Inland Fisheries Society of India*, vol. 11, no. 1, 1979, pp. 45–50.

Kibria, Golam. "Fish Kill: Causes, Environmental Impacts, and Management." *Global Aquatic Research Journal*, vol. 2, no. 3, 2014, pp. 1–15

Mishra, A., R. Saravanan, and G. Prasad. "Causes of Fish Kill in the Chunnambar River, Puducherry, India." *International Journal of Fisheries and Aquatic Studies,* vol. 8, no. 6, 2020, pp. 210–215.

Nair, R. "Industrial Pollution and Its Impact on Inland Fisheries in Kerala." *Journal of Environmental Studies*, vol. 15, no. 2, 2020, pp. 45–59.

Nair, R., P. Jose, and P. Ramesh. "An Unusual Fish Kill in the Chandragiri River, Kasaragod District, Kerala, India." *Indian Journal of Environmental Protection*, vol. 41, no. 4, 2021, pp. 335–341.

Ochumba, P. B. O. "Massive Fish Kills within the Nyanza Gulf of Lake Victoria, Kenya." *Hydrobiologia,* vol. 208, nos. 1–2, 1990, pp. 93–99.

Olopade, O. A., B. A. Ekeke, and B. Amadi. "Fishermen's Perceptions of Massive Fish Kills in Rivers State, Nigeria." *Journal of Environmental and Sustainability Studies*, vol. 12, no. 1, 2024, pp. 55–66.

Pejavar, M., and V. Somani. "Fish Mortality in Railadevi Lake, Thane City." *Journal of Environmental Biology*, vol. 21, no. 2, 2000, pp. 125–130.

Petriki, O., E. Smeti, and E. Dimitriou. "Mass Fish Kill in the Bogdanas River, Greece: Causes and Implications." *Ecohydrology & Hydrobiology*, vol. 21, no. 3, 2021, pp. 442–452.

Ramakrishnan, S., and A. Thomas. "Community Vulnerability and Resilience in the Face of Ecological Crises: Case Studies from Kerala's Backwaters." *South Asian Journal of Development*, vol. 27, no. 1, 2021, pp. 89–108.

Rashid, I., S. Aneaus, and S. Shukla. "Massive Fish Kill in the Jhelum River, Srinagar City: Environmental Implications." *Environmental Monitoring and Assessment,* vol. 193, no. 11, 2021, p. 689.

Sathiadhas, R., T. M. Najmudeen, and P. U. Zacharia. Economic Evaluation of Environmental Threats on Marine Fisheries in Kerala. *Marine Fisheries Information Service,* no. 190, 2006, pp. 1–15

Sathiadhas, R., T. M. Najmudeen, and P. U. Zacharia. Economic Implications of Environmental Issues in Coastal Fisheries of Kerala. *Central Marine Fisheries Research Institute,* 2006.

Shaji, C., and R. Shankar. "Incidences of Fish Kills in Kerala's Freshwater Bodies: 1995–2014." *Indian Journal of Fisheries*, vol. 65, no. 2, 2018, pp. 42–49.

Singh, P. "Socio-Economic Consequences of Water Pollution on Traditional Fishing Communities in India." *International Journal of Social and Economic Research*, vol. 9, no. 3, 2019, pp. 112–126.

Somani, V. "Observation of Fish Kill in Jail Lake, Thane City, Maharashtra." *Journal of Environmental Research and Development*, vol. 10, no. 4, 2016, pp. 933–938.

The Hindu. "Fish Mortality in Pizhala Backwaters Raises Ecological Concerns." *The Hindu*, 14 Aug. 2023, www.thehindu.com.

The Hindu. "Fish Kill in Periyar Causes ₹41 Crore Loss: Study." *The Hindu*, 18 May 2024, www.thehindu.com.

Thronson, A., and A. Quigg. "Fifty-Five Years of Fish Kills in Coastal Texas." *Estuaries and Coasts*, vol. 31, no. 4, 2008, pp. 802–813.

## Author Details

**Rani Maria Jose,** *St. Teresa's College, Ernakulam, Kerala, India*

**Anupa Jacob,** *Associate Professor & Research Guide, Department of Economics, St. Teresa's College, Ernakulam, Kerala, India*
***Email ID:*** *anupajacob@gmail.com*

**P.T. Raichel Florence,** *St. Teresa's College, Ernakulam, Kerala, India*

**A.M. Gayathri,** *St. Teresa's College, Ernakulam, Kerala, India*

**Amala Abel,** *St. Teresa's College, Ernakulam, Kerala, India*

**Sredha Joseph,** *St. Teresa's College (Autonomous), Ernakulam, Kerala, India*