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Variation in Artisanal Fishers' Population across Chilika Lagoon

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ABSTRACT: For artisanal fishermen, Chilika Lagoon, India's largest brackish water lagoon, is an essential source of income. The volatility in fish abundance and its effects on the socioeconomic circumstances of these fishermen are examined in this research by considering the variation of fish catch and the population. The Objective here was to findout the reasons behind the population decline in artisanal fisheries. We hope to draw attention to the difficulties experienced by the fishing community and provide sustainable management techniques to guarantee ecosystem and livelihood resilience by investigating the biological, climatic, and human aspects affecting the lagoon.

Keywords: Artisanal Fishermen, Chilika, Population.

INTRODUCTION

The state of Odisha is home to Chilika Lagoon, a Ramsar Wetland of International Importance and a hotspot for biodiversity and highly productive ecosystem (Iwasaki & Shaw 2010). More than 150,000 artisanal fishermen rely on the lagoon's abundant aquatic resources for both income and subsistence. The Chilika Lagoon, located on the east coast of India, is the largest brackish water tropical lagoon with an estuarine character in Asia (Jayaraman *et al*., 2007). This unique ecosystem is home to a diverse array of terrestrial and aquatic flora and fauna, including the endangered Irrawaddy dolphin. In Rambha, Humma, and the vicinity of Chilika Base, brackish water species such as Scatophagus argus, Terapon Jabua, Strongylurastorgylura, Cyanoglossuspuncticeps, and Rita chrysea fishes are widely distributed (Baliarsingh *et al.,* 2014). The lagoon has been a crucial resource for the local artisanal fishing communities, who have long relied on its bountiful fisheries for their livelihoods. However, varying fish abundance brought on by ecological shifts, overfishing, and development activities is posing a growing danger to the livelihoods of the fishermen. In recent decades, the Chilika Lagoon has faced several threats, including siltation, eutrophication, and salinity changes, which have impacted the overall ecological health of the system and the abundance of its fishery resources (Jayaraman *et al.*, 2007). Developing flexible tactics for sustainable fishing methods requires an understanding of these variances. This paper aims to investigate the variation in the abundance of artisanal fishers dependent on the Chilika Lagoon and the factors contributing to these changes.

Social-ecological analysis values both humans' potential to modify the environment and their susceptibility to it (Halpern *et al.*, 2008; Steffen *et al.,* 2005) acknowledging that humans shape ecosystem processes and dynamics (Dale *et al*., 2000; Waltner-Toews & Kay 2005). In Chilika, the biophysical circumstances, scientific initiatives, human communities, and the variety of state policies are all complexly changing over time. In 2000, the opening of a man-made sea outlet had a positive impact on aquatic variety and ecosystem restoration, however the start of prawn culture in 1980 put further strain on lagoon ecosystems and negatively impacted the traditional management of lagoon fisheries. After an assessment of the ecological health of the lagoon, it was revealed that the different sectors of the lagoon exhibit varying trophic statuses, with the northern sector being classified as eutrophic and the southern, central, and outer channel sectors as mesotrophic (Barik *et al.*, 2019). These changes in the ecological status of the lagoon can have significant implications for the abundance and distribution of fishery resources, which in turn impact the livelihoods of the artisanal fishing communities.

One of the main social characteristics that mediate community ties and resource use is gender. Despite their vital participation, women are still under-represented in fishery governance structures (Galappaththi *et al.,* 2022). It is one of the universal issues that the fishermen's communities in Chilika Lagoon are facing has gender-specific effects and makes it difficult for their livelihoods to adapt to and respond to environmental change. Numerous illness outbreaks, including typhoid, gastroenteritis, skin conditions, malaria, encephalitis, and intestinal infections, have been mostly attributed to poor sanitation (Modassir & Ansari 2011). Fishermen are pushed out of fishing as a result of rights violations, institutional reorganizations, and problems with access to fishery resources, and many fisherwomen are disproportionately affected by these changes (Khan, 2017). Women in Chilika Lagoon are particularly affected by social-ecological regime changes as they cope with the fallout from swift change. Some changes are being made to address these effects, but to establish a more intersectional and comprehensive governance system that benefits both the men and women residing in this fishery commons, a more gender-sensitive approach to governance that takes into account the needs of women and emphasizes their empowerment is required (King, 2021). As the creation of a new sea mouth, modifications to fishing methods, and an increase in prawn aquaculture cause alterations of the lagoon mainly, the fishing community lacks long-term adaptation methods, and those do exist serve as catalysts for social-ecological system transformation. A lack of communication and disagreement among themselves is further hampering fisherman communities' ability to adapt (Selvaraj, 2015).

METHODOLOGY

A mixed-method approach was used in the study, integrating both qualitative and quantitative studies. To evaluate trends in abundance, fish catch data from 2010 to 2023 were examined. Fishermen were interviewed in semi-structured interviews and focus groups to learn more about their perceptions of changes, coping strategies, and socioeconomic effects. Environmental changes in the lagoon were assessed using GIS and remote sensing techniques.

RESULT

Trends in Fish Catch Data (2010–2023)

The following trends are observed based on the analysis of fish catch data from Chilika Lagoon:

1. Total Fish Catch: A consistent decline in total fish catch was observed, decreasing from 2,000 tonnes in 2010 to 1,200 tonnes in 2023, reflecting a 40% drop over 14 years (Fig. 1). The sharpest declines occurred in 2013 (-7.3%) and 2020 (-6.7%), coinciding with severe cyclonic events and ecological disruptions.

2. Species-Specific Trends: Significant decline of **Hilsa** from 500 tonnes in 2010 to 150 tonnes in 2023 (-70%). The species is highly sensitive to salinity changes caused by hydrological disruptions. Gradual decline of **Mullet** from 600 tonnes to 430 tonnes (-28%). Despite the drop, mullet remains a relatively stable resource due to its adaptability. **Prawn** reduced from 600 tonnes to 500 tonnes (-16.7%). The decline is less pronounced compared to other species, indicating their resilience. Drastic reduction of **Crabs** from 300 tonnes in 2010 to 120 tonnes in 2023 (-60%). Habitat degradation and overharvesting are likely contributors.

3. Year-over-Year (YoY) Changes: Total fish catch shows consistent negative YoY changes after 2011, with no recovery years. Hilsa experienced the steepest YoY declines, peaking at -16.7% in 2023.

Trends in Fishermen Population

1. Overall Population Change: The fishermen population in Chilika Lagoon initially increased from 150,000 in 2010 to a peak of 159,000 in 2016 (Fig. 2). A gradual decline followed, with the population decreasing to 145,000 in 2023, representing an overall drop of 9% from the peak.

2. Year-over-Year (YoY) Changes: From 2010 to 2016, there was a consistent increase in fishermen numbers, with YoY growth averaging 0.8%. Post-2016, the population started declining, with the sharpest drops occurring in 2021 (-1.96%) and 2023 (-2.03%).

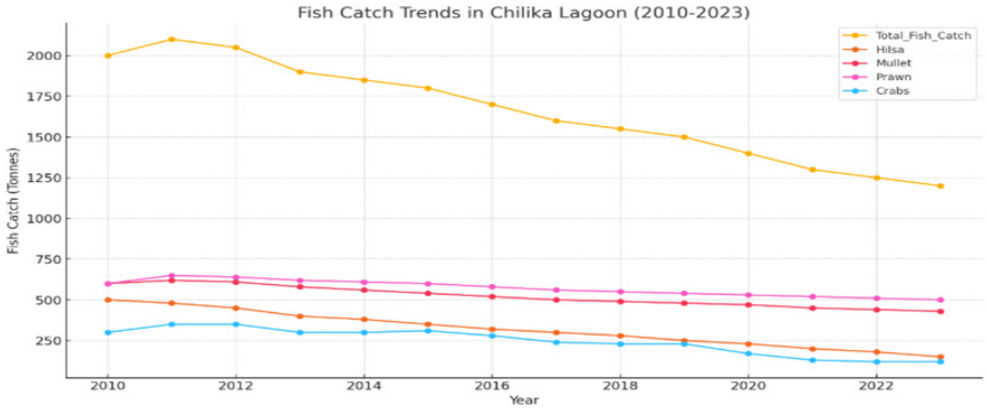

Fig. 1. Trends in Fish Catch in Chilika lagoon (2010–2023).

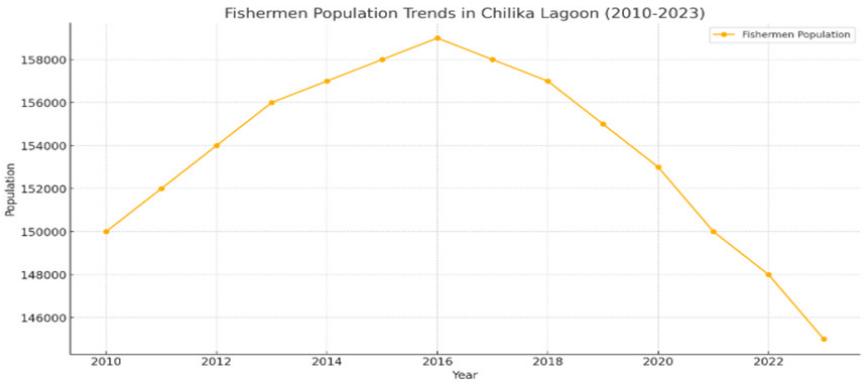

Fig. 2. Trends in Fishermen Population (2010–2023).

DISCUSSION

The observed decline in total fish catch, decreasing by 40% from 2,000 tonnes in 2010 to 1,200 tonnes in 2023, can be attributed to several interconnected factors. Severe cyclonic events, such as those in 2013 and 2020, caused ecological disruptions that directly impacted fish populations and their habitats. Species-specific trends further highlight the challenges: the sharp decline in Hilsa catch (-70%) is largely due to its high sensitivity to salinity changes caused by hydrological disruptions, such as altered river flows and increased coastal pollution. Mullet, while relatively stable, experienced a 28% decline, reflecting broader environmental stresses despite its adaptability. Prawn catches showed a moderate decline (-16.7%), suggesting resilience but still being affected by habitat degradation and overfishing pressures. Crabs suffered a drastic reduction (-60%), primarily due to overharvesting and the destruction of critical habitats like mangroves. The persistent year-over-year negative changes, particularly the steep declines in Hilsa (-16.7% in 2023), underscore the compounded effects of climate change, unsustainable fishing practices, and habitat loss, leaving no opportunity for recovery during the observed period and also aligns with the study by Nair & Nayak (2023) who identified the close relation between changes in water quality and the degree of vulnerability in Chilika Lagoon's small-scale fisheries.

Ecological Drivers of Fish Abundance Variation

a. **Hydrological Fluctuations**: Seasonal and annual changes in salinity and water levels significantly influence fish species composition and abundance (Griffiths, 2001). Opening and closing of the lagoon mouth to the Bay of Bengal have had profound effects on the breeding and migration patterns of key species such as mullet, prawn, and crabs.

b. **Climate Change**: Increased frequency of cyclones, altered rainfall patterns, and rising temperatures have disrupted ecological balance (Klug *et al*., 2012). Fishers reported a decline in traditional species such as hilsa due to changes in salinity gradients.

c. **Anthropogenic Pressures**: Overfishing, unregulated aquaculture, and pollution have exacerbated the degradation of fish habitats (Ogidi & Akpan 2022). Additionally, encroachments and the conversion of lagoon areas for agriculture and shrimp farming have reduced fish nursery grounds.

2. Socio-Economic Implications. Declining fish abundance has led to reduced income, forcing many fishers to seek alternative livelihoods such as agricultural labor or migration to urban centers (Allison & Ellis 2001). Women, who play a significant role in fish processing and marketing, have faced heightened economic vulnerability. The cultural identity of fishing communities, deeply tied to Chilika, is under threat due to declining fish-related activities.

3. Adaptive Mechanisms and Challenges. Fishers have adopted practices such as targeting alternative species and using advanced fishing gear to maintain catch levels. However, these methods are often unsustainable and exacerbate resource depletion. Community-based organizations and cooperatives have emerged as platforms for collective action, yet they face challenges in enforcement and resource management (Berkes, 2006).

Drivers of Decline of Fisher Population:

The changes in the fishermen population around Chilika Lagoon reflect shifting socio-economic and environmental conditions over the years. Between 2010 and 2016, the population increased steadily, with an average annual growth of 0.8%, likely driven by the abundance of fish resources and the perception of fishing as a stable livelihood. However, post-2016, the population began to decline, dropping by 9% from the peak to 145,000 in 2023. This decline aligns with the sharp reductions in fish catch, which likely reduced income and livelihood opportunities, prompting some fishermen to leave the profession. Additionally, younger generations may have sought alternative livelihoods in response to declining returns from fishing, further contributing to the population decrease.

Several environmental, socioeconomic, and climate-related factors have combined to gradually undermine fishing's viability as a source of income, which has led to a decrease in the number of fishermen in Chilika Lagoon. Below is a breakdown of these drivers:

— Environmental: Cyclones (e.g., Phailin 2013; Fani 2019) and altered salinity regimes disrupted breeding cycles.

Cyclone Phailin in 2013 and Cyclone Fani in 2019 are two examples of severe cyclonic occurrences that have severely damaged the lagoon environment (Karmakar & Roy, 2022). By changing the salinity of the water and damaging aquatic vegetation—essential spawning and nursery habitats—cyclones interfere with breeding

cycles. Because species like Hilsa are especially susceptible to these conditions, the changing salinity regimes—which are frequently made worse by upstream hydrological changes—have negatively impacted them, resulting in fewer fish available and increased pressure on fishermen's populations.

— Overfishing: The drop in catch-per-unit-effort (CPUE) highlights overexploitation.

A measure of the effectiveness and productivity of fishing operations, catch-per-unit-effort (CPUE), has significantly decreased as a result of the overexploitation of fish resources (Kantoussan *et al*., 2014). Fish stocks were overfished as more fishermen fought for fewer resources, which decreased their ability to regenerate. Fishing has become less feasible as a result of this unsustainable exploitation, especially for smaller-scale fishermen who do not have the funds to invest in alternate fishing techniques or additional revenue streams.

— Pollution: Increased nutrient loading and habitat degradation have reduced fish nursery grounds.

Water quality has declined as a result of increased nutrient loading from industrial outflow, human developments near the lagoon, and agricultural runoff (Panigrahi *et al.*, 2009). Fish populations have further declined as a result of pollution and eutrophication, which have destroyed important fish nursery sites. Degradation of habitat, such as the loss of seagrass beds and mangroves, has made matters worse by reducing the number of places where fish may reproduce and thrive, which has an immediate effect on the livelihoods of fishermen.

— Economic Pressures: Declining fish stocks have reduced income, prompting some fishers to leave the profession.

Fishermen, many of whom work for subsistence, have seen a sharp drop in revenue as a result of the loss in fish stocks (Nayak, 2017). Families are finding it more and more difficult to maintain their conventional way of life as their income declines. Financial resources have been further stretched by the growing expense of fishing gear and the requirement for more work to produce fewer catches, which has led to some fishermen quitting fishing completely.

— Migration: Younger generations are increasingly shifting to non-fishing occupations in urban areas due to limited opportunities in traditional fisheries (Mistri & Das 2020; Nayak, 2017).

Traditional fishing jobs are becoming less and less popular among younger generations, who are choosing alternative urban livelihoods. Many young people perceive greater options in cities, where they can pursue careers that give more secure income and less reliance on erratic environmental circumstances, after receiving education and being exposed to non-fishing opportunities. The population's fall has been accelerated by this migration pattern, which has decreased the recruitment of new fishermen.

— Climate Vulnerability: Frequent cyclones and environmental degradation have disrupted fishing activities, further discouraging reliance on the lagoon (Mistri & Das 2020).

The difficulties faced by fishermen have been made worse by the region's high susceptibility to climate change. The safety and predictability of fishing as a profession are diminished by frequent cyclones, rising sea levels, and unpredictable weather patterns. The natural balance of the lagoon is impacted by these climate changes, and fishing is discouraged because of the risks and uncertainties involved, which make it a less desirable source of income.

The difficulties that the fishing community in Chilika Lagoon faces are brought to light by these interconnected factors, which show how socio cultural changes, economic stress, and environmental deterioration have all contributed to the population's decline.

In population trend divisions, growth during the early growth period (2010–2016) reflects reliance on Chilika's fisheries as a stable livelihood source despite ecological challenges. The recent declining trend (2017–2023) mirrors falling fish catches, climate impacts, and socio-economic pressures, underscoring the need for livelihood diversification.

Recommendations:

To address the challenges of the decline in the fisher population, the following measures are suggested:

1. Sustainable Fishing Practices: Implement size and species-specific catch limits and seasonal bans to allow fish stocks to replenish.

2. Community Engagement: Strengthen fisher cooperatives and involve them in co-management frameworks.

3. Ecological Restoration: Prioritize habitat restoration projects such as mangrove replantation and pollution control.

4. Policy Interventions: Develop and enforce integrated lagoon management policies that balance conservation and livelihood needs.

5. Capacity Building: Provide training on alternative livelihoods and equip fishers with climate-resilient fishing techniques.

Again, adaptive measures must be put in place to address the loss in fish numbers and aid in the rehabilitation of fishing villages in Chilika Lagoon. Fish population regeneration may be greatly aided by the enforcement of size and seasonal fishing limits. Fish stocks can be restored and long-term sustainability is ensured by limiting the fishing of juvenile fish and enforcing seasonal limits during important breeding times. Furthermore, enhancing nursery and spawning conditions requires the restoration of important habitats like mangroves. In addition to providing fish with vital refuge and food during their early life stages, mangroves act as natural barriers against cyclones. A healthy ecosystem can be produced by combining sustainable fishing methods with habitat restoration projects, allowing for both ecological recovery and financial stability for the fishing industry. For these policies to be implemented successfully and be successful in the long run, local stakeholders, legislators, and environmentalists must work together.

To address the challenges of fish abundance variation, the following measures are suggested:

1. Livelihood Alternatives: Implement training programs for fishers to explore supplementary income sources such as eco-tourism, aquaculture, or crafts.

2. Youth Retention Programs: Incentivize younger generations to engage in sustainable fisheries through skill development and modernized practices.

3. Social Support Systems: Enhance access to financial aid and insurance to support fishers during periods of ecological stress.

Steps Taken by State and Central Governments. Several measures have been implemented by the state and central governments to support artisanal fishermen and sustain their traditional occupation. Key initiatives include:

1. *Financial Support and Subsidies:* Schemes like *Mo Pokhari* (a flagship program of Odisha government) provide financial assistance for developing fish ponds and enhancing aquaculture production. This initiative allows fishermen to diversify their income sources while staying within the fisheries sector.

2. *Infrastructure Development:* Under the *Pradhan Mantri Matsya Sampada Yojana (PMSSY)*, significant investments have been made in modernizing fishing infrastructure. This includes setting up cold storage units, fish landing centers, and processing facilities, which help artisanal fishermen access better markets and reduce post-harvest losses.

3. *Skill Development:* Capacity-building programs are organized to train fishermen in sustainable fishing practices, value addition, and alternative livelihoods like cage aquaculture and seaweed farming. These programs aim to improve their economic resilience.

4. *Access to Credit and Insurance:* Governments have facilitated access to low-interest loans and introduced comprehensive insurance schemes to cover risks related to life, equipment, and fishing activities, providing financial security to artisanal fishermen.

5. *Conservation and Habitat Restoration:* Steps have been taken to restore critical ecosystems such as mangroves and wetlands, which support the fishery sector. Community participation in these conservation efforts is encouraged through co-management models.

Further Steps

1. Strengthening Fisheries Governance: Strict enforcement of size and seasonal catch limits, combined with robust monitoring systems, is essential to curb overfishing and ensure resource sustainability.

2. Enhanced Subsidies and Grants: Expanding schemes like *Mo Pokhari* and offering targeted subsidies for fuel, nets, and eco-friendly fishing equipment can reduce operational costs and incentivize sustainable practices.

3. Promotion of Alternative Livelihoods: Encouraging supplementary activities such as eco-tourism, pearl farming, and ornamental fish culture can provide additional income streams while reducing pressure on natural fish stocks.

4. Climate-Resilient Infrastructure: Developing cyclone-resilient boats, early warning systems, and community shelters will help mitigate the impacts of climate change and ensure the safety of fishing communities.

5. Direct Market Linkages: Governments should create platforms that connect fishermen directly to buyers, reducing the influence of middlemen and enabling fishermen to receive fair prices for their produce.

6. Community Participation and Awareness: Collaborative efforts involving fishermen in decision-making processes and raising awareness about sustainable practices can strengthen compliance and foster long-term conservation efforts.

7. Focus on Youth Retention: Offering scholarships and skill-based programs for the younger generation in artisanal fishing communities can encourage them to continue in the profession while embracing modern, sustainable techniques.

By combining ongoing efforts with these additional measures, governments can ensure the retention of artisanal fishermen in their traditional occupation while fostering a sustainable and resilient fisheries sector.

CONCLUSION

The artisanal fishers of Chilika Lagoon are at the frontline of ecological and socio-economic challenges. Ensuring their livelihoods while conserving the lagoon's biodiversity requires a multi-stakeholder approach emphasizing sustainability, resilience, and inclusivity. This study underscores the need for urgent interventions to safeguard both the ecological health of Chilika and the well-being of its dependent communities.

FUTURE SCOPE

The research on "Variation in Artisanal Fishers' Population across Chilika Lagoon" can guide sustainable fisheries management, policy-making, and climate adaptation strategies. It provides insights into socio-economic challenges, habitat conservation, and community engagement, serving as a model for similar ecosystems globally.

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Conflict of Interest. None.

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