Demographics to Livelihoods: A Study of Fishing Communities in Chilika Lake, Odisha

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Abstract

Introduction:

Chilika Lake, Asia's largest brackish water lagoon and a designated Ramsar site, is a critical socio-ecological system supporting rich biodiversity and the livelihoods of nearly 200,000 fishers in Odisha, India. Despite its ecological and economic importance, the region faces mounting pressures from overfishing, mechanization, and climate change. While research has addressed ecological aspects, there remains a notable gap in understanding the socio-economic dynamics shaping fisherfolk livelihoods.

Methods

Employing a mixed-methods approach, primary data were collected from 384 fisher households across three high-intensity fishing villages. A structured questionnaire, refined through a pilot survey, captured information on income sources, operational costs, labor use, and perceptions of environmental change. Focus Group Discussions with fishers, cooperatives, state agencies, and the Chilika Development Authority provided qualitative depth, contextualizing the quantitative findings.

Results and Discussion

Stepwise regression analysis reveals that local fish sales are significantly and negatively associated with income, indicating limited profitability in local markets due to price suppression and restricted access. In contrast, fishing experience and formal education consistently emerge as strong positive predictors of income, underscoring the importance of both traditional ecological knowledge and human capital. Notably, hiring additional labor correlates negatively with income, suggesting inefficiencies in labor-intensive fishing models. These findings highlight critical trade-offs between scale and profitability in artisanal fisheries.

Conclusion

The study offers compelling evidence on the structural and knowledge-based drivers of fisherfolk income in Chilika. It calls for integrated policy responses focused on expanding market access, fostering skill development, optimizing labor use, and promoting cooperative models. Enhancing the socio-economic resilience of fishing communities requires aligning ecological sustainability with inclusive economic reform to unlock the full potential of this vital wetland system.

1. Introduction

Wetlands are among the most productive ecosystems globally, offering a multitude of ecological, economic, and social benefits. They serve as natural water filters, flood buffers, carbon sinks, and biodiversity hotspots. Importantly, wetlands support fisheries, agriculture, and other livelihood activities for millions of people worldwide (Mitsch & Gosselink, 2000; Ramsar Secretariat, 2016; Turner et al., 2000). According to the Ramsar Convention, wetlands can be natural or human-made, and their classification includes categories such as marshes, lakes, and reservoirs. Under this system, water impoundments and reservoirs used for storage or aquaculture, such as parts of Chilika Lake, are categorized as “Water Storage Areas” within the "Human-Made Wetlands" classification (Ramsar, 2013).

The ecological and socio-economic value of wetlands is well-established in scientific literature. They contribute significantly to food security through fisheries and aquatic farming (Barbier et al., 1997; Bassi et al., 2014), regulate hydrological cycles (MEA, 2005), and support endemic and migratory biodiversity (Davidson, 2014). Despite their importance, wetlands are among the most threatened ecosystems globally due to urbanization, pollution, hydrological disruption, and overexploitation (Finlayson et al., 2018; Adeli et al., 2020; Baral et al., 2016). In India, wetlands like the Chilika Lagoon exemplify the dual role of these ecosystems as biodiversity hotspots and livelihood hubs.

Chilika Lake, located on the east coast of Odisha, India, is Asia's largest brackish water lagoon, spreading across the districts of Puri, Khordha, and Ganjam. It lies between latitudes 19°28'N and 19°54'N and longitudes 85°05'E and 85°38'E. It was designated as India's first Ramsar site in 1981 due to its rich biodiversity, unique hydrology, and socio-economic significance (Pattnaik, 2007; Ramsar Sites Information Service, 2020). The lake receives an average annual rainfall of 1,400 mm, with the majority falling during the monsoon season (June–September), which strongly influences its hydrological regime and fish productivity (Mohanty et al., 2015).

Chilika is ecologically dynamic due to the mixing of freshwater from rivers and saline water from the Bay of Bengal. This mixture supports a complex aquatic ecosystem comprising freshwater, brackish, and marine species, making it one of the richest inland fisheries in India (CDA, 2021). Studies show that 85.49% of the lake's finfish diversity consists of migratory species that transit between the lake, rivers, and sea (Mohanty et al., 2015). Over 800 species of flora and fauna have been recorded in the lake, including endangered dolphins (*Orcaella brevirostris*), sea turtles, and numerous IUCN Red List species (BirdLife International, 2021; IUCN, 2023). In addition to its ecological value, Chilika serves as a critical wintering ground for more than one million migratory birds from as far as Siberia, Central Asia, and the Himalayas (Wetlands International, 2020).

The socio-economic importance of Chilika is profound. It sustains the livelihoods of nearly 0.2 million fishermen and their families residing around the lake (CIFRI-ICAR, 2005; Bhowmik, 2020). According to the Chilika Development Authority (2021), more than 71% of the lake's ecosystem service value derives from its fishery resources. The fish economy includes the harvest of finfish, prawns, and crabs, which are recorded monthly at 35 landing stations. These records are vital for assessing stock sustainability and calculating maximum sustainable yields (Singhar & Gundimeda, 2024; ICAR, 2022).

However, Chilika's fishery sector is increasingly under stress due to anthropogenic pressures such as overfishing, habitat degradation, mechanization, and climate variability (Ray et al., 2018; Chatterjee et al., 2022). Mechanized boats and unsustainable gear use have intensified fishing pressure, contributing to species depletion, pollution, and competition among stakeholders. Studies have pointed out that economic motives often outweigh environmental considerations, threatening both biodiversity and long-term livelihoods (Chopra et al., 2004; Eppink et al., 2014). Furthermore, rising input costs such as fuel, gear, and labor are reportedly affecting the profitability of small-scale fishing operations, which in turn influence household well-being (FAO, 2020; Singh et al., 2021).

Gender dynamics and social equity issues also play a role in how environmental changes affect local communities. Research by Khan et al. (2018) in Chilika Lagoon revealed that fisherwomen are particularly vulnerable to climate change and economic shifts, though their roles in resource collection and post-harvest processes are indispensable. Similarly, studies from other wetland-dependent regions highlight the critical but often overlooked contribution of wetlands to broader rural economies through activities like ecotourism, farming, fodder collection, and herbal medicine gathering (Aazami & Shanazi, 2020; Das et al., 2015).

Despite the ecological and economic prominence of Chilika, scholarly literature on its fish economy—particularly in relation to long-term income patterns, cost trends, and standard of living—is limited. Most existing research has focused on ecological assessments or policy frameworks without in-depth economic analysis (Singhar & Gundimeda, 2024; Barbier, 2011). This study, therefore, aims to fill this gap by exploring how fishery production costs and income trends have evolved for fishing communities in Chilika Lake.

Through a socio-economic lens, the present research seeks to assess the extent to which fishermen's livelihoods have improved or deteriorated over time, and whether current practices align with the principles of sustainable resource use as outlined in the Ramsar Convention. The findings will offer insights that can inform evidence-based policies for wetland management, fishery regulation, and rural livelihood enhancement in Chilika and similar ecosystems.

2. Data and Methods

(i) Study Area

This study was conducted in and around Chilika Lake, a prominent brackish water lagoon located on the east coast of Odisha, India. Chilika is Asia's largest coastal lagoon and one of the most ecologically significant wetlands in India, recognized as a Ramsar site for its biodiversity and socio-economic importance. The lagoon stretches across the Puri, Khurda, and Ganjam districts and supports a mosaic of aquatic habitats. Hydrologically, Chilika Lake is divided into four zones: the North Channel, South Channel, Central Channel, and Outer Channel, each varying in salinity and aquatic species diversity (Samal, 2003). Approximately 273 villages surround the lake, with over 132 fishing villages dependent on it for their livelihood. The population of the fishing communities is estimated to be over 200,000 people, with nearly 30% of the residents directly engaged in fishing-related activities as their primary occupation.

(ii) Sources of Data

This study is primarily based on primary data, collected through extensive field surveys conducted in 2022. A convenient sampling technique was adopted to collect data from the fishing communities residing in the three districts that border Chilika Lake—Puri, Khurda, and Ganjam. Within these districts, three villages were purposively selected due to their high concentration of fishing activities: Barkul in Khurda, Rambha in Ganjam, and Satapada in Puri district. Prior to the main survey, a pilot study was carried out with 50 respondents to evaluate the reliability and contextual relevance of the questionnaire. Insights gained from this pilot helped refine the instrument to enhance clarity and reliability (Roy et al., 2022). To determine an appropriate sample size for the full-scale study, the Krejcie and Morgan (1970) formula was applied, which recommended a sample of 384 households. Accordingly, 128 households from each of the selected villages were surveyed using a well-structured questionnaire designed to collect data on key socio-economic indicators, including income patterns, production costs, and perceptions related to environmental changes (Sinthumule et al., 2021).

(iii) Data Collection Tools and Techniques

In addition to the household surveys, Focus Group Discussions (FGDs) were conducted with a range of stakeholders to gather qualitative insights and complement the quantitative data. These stakeholders included local fishermen and fisherwomen, members of fish cooperative societies, officials from the Fisheries and Animal Husbandry Department of the Government of Odisha, and experts and representatives from the Chilika Development Authority (CDA). The inclusion of these diverse voices provided valuable perspectives on the socio-economic dynamics, environmental challenges, and institutional responses affecting the fishing communities. This mixed-methods approach facilitated data triangulation, enhancing the validity of the research findings and offering a more nuanced and comprehensive understanding of livelihood patterns and socio-economic transformations in the region.

3. Results

The study utilized primary data collected from a total of 384 fisherfolk residing in the vicinity of Chilika Lake, employing econometric methods such as normality tests, linearity checks, heteroscedasticity tests, and multicollinearity diagnostics to validate the assumptions of the multiple linear regression model. These four key assumptions normality, linearity, heteroscedasticity, and multicollinearity. As shown in Table 1, the socioeconomic profile of respondents presents a diverse demographic and occupational structure. Although the mean age appears to be inaccurately low at 20 years, the actual data indicates that the majority of respondents are in the 51–60-year age group (154 individuals), suggesting a predominantly aging workforce in the sector. Of the 384 respondents, 285 are male and 99 are female, reflecting a clear gender imbalance in fishing-related activities, which may indicate gendered divisions in access to or involvement in fishing labor.

In terms of educational attainment, the majority of fisherfolk have only completed primary education (101 respondents), while a small segment has completed secondary (92) and upper primary (61) levels. A notably low number of respondents are illiterate (14), which is encouraging for community literacy but indicates limited access to higher education, as only 15 respondents hold a degree. Marital status data reveals that most respondents are married (332), suggesting stable household structures, which may influence livelihood resilience.

When analyzing fishing experience, the highest concentration of fisherfolk (119 individuals) fall in the 20–25 years' experience range, indicating a seasoned workforce. A smaller number (10) have less than 5 years of experience, showing low recent entry into the occupation, which may reflect declining interest among the youth. The distribution of fishing rights reveals that the largest proportion of respondents operate under a license system (239), followed by those working as labourers (78), and those who participate in shared rights arrangements (67). Interestingly, no respondents reported fishing under lease rights, suggesting possible institutional or regulatory constraints in access to such arrangements. Overall, the socioeconomic profile indicates a mature, male-dominated fishing community with limited educational attainment, but significant occupational experience, which has implications for both productivity and the design of policy interventions in the Chilika Lake region.

Table-1: Socioeconomic Characteristics of Local Fisherfolk in Chilika Lake

Socio Economic Variables	Range/ Classification	No of Respondents
Age Structure of the Respondents (years)	Below 20	0
	21–30	78
	31–40	19
	41–50	81
	51–60	154
	Above 60	52
	Total	384
Sex	Male	285
	Female	99
	Total	384
Education (in Years)	Illiterate	14
	Primary	101
	Upper Primary	61
	Secondary	92
	Higher secondary	55
	Degree	15
	Total	384
Marital status	Unmarried	52
	Married	332
	Total	384
Fish Experience	Less than 5 years	10
	5–10 years	50
	10–15 years	53
	15–20 Years	38
	20–25 Years	119
	25–30 Years	35
	30–35 Years	49
	35–40 Years	8
	40–45 Years	16
	More than 45 years	06
	Total	384
Fishing Rights	Share	67
	Lease	0
	Labour	78
	License	239
	Total	384
Source: Field Survey		

Table 2 presents the results of the normality tests for key variables involved in the study, including education level, cost of boat, fishing experience, annual fish catch weight, monthly fish sales in the local area, and number of fishermen hired during fishing activities. The sample size (N) for each variable is 10, reflecting a focused subset of the data used for this diagnostic check. The skewness and kurtosis statistics provide insight into the distributional characteristics of each variable, which are critical for validating the assumptions underlying parametric statistical models such as regression analysis.

Among the variables, education (-0.651 skewness; -0.974 kurtosis) and cost of boat (-0.919 skewness; -0.549 kurtosis) exhibit slight negative skewness, indicating that values tend to be moderately concentrated above the mean with relatively light tails. The fishing experience variable shows minimal skewness (-0.0452) and kurtosis (-0.242), suggesting a near-normal distribution, which supports its suitability for linear modeling. In contrast, weight of fish catch per year shows a positive skewness of 1.768 and kurtosis of 1.384, indicating a right-skewed distribution with heavier tails, which may necessitate transformation or the use of robust statistical methods. Similarly, the number of fishermen hired during fishing activity also shows positive skewness (1.162) and kurtosis (1.000), reflecting a tendency toward extreme values.

Conversely, fish sold in the local area per month has a slight negative skew (-0.226) but pronounced negative kurtosis (-1.900), suggesting a flatter distribution with fewer extreme values than a normal distribution. Overall, while some variables approximate normality, others show deviations that should be carefully considered during model specification. These findings highlight the importance of testing and, if necessary, adjusting for distributional assumptions to ensure the robustness of subsequent regression analyses.

Table-2: Normality Test

Variables	N	Skewness	Kurtosis
	Statistic	**Statistic**	**Statistic**
Education	10	− .651	− .974
Cost of Boat	10	− .919	− .549
Fishing Experience	10	.-0452.	.-242.
Weight of Fish Catch per year in ton	10	1.768	1.384
fish sell in local area per month in ton	10	− .226	-1.900
Fishing men hire during the fishing activity	10	1.162	1.000
Valid N (listwise)	10		
Source: Authers own calculation			

Table 3 summarizes the results of the linearity tests conducted to examine the relationships between annual income and various explanatory variables, including cost of boat, education, fishing experience, annual fish catch weight, fish sold locally per year, and number of fishermen hired during fishing activities. The test evaluates both the linearity of the relationship (Between Groups Linearity) and any deviations from linearity, with significance values (Sig.) indicating whether linearity assumptions hold. For all variables, the Between Groups Linearity test shows significant F-values ($p < 0.05$), such as for annual income and cost of boat ($F = 3.5$, $p = .042$), education ($F = 3.36$, $p = .038$), and fishing experience ($F = 4.99$, $p = .026$), suggesting that these variables exhibit a significant linear relationship with annual income. The strongest linear relationship is observed between annual income and fish sold in the local area ($F = 30.53$, $p = .000$), indicating a highly significant positive correlation.

Importantly, the Deviation from Linearity tests for all variables show non-significant p-values (all $p > 0.05$), such as for cost of boat (.882), education (.092), and number of fishermen hired (.937), indicating that there is no significant departure from linearity in the relationships tested. This confirms that linear regression models are appropriate for analyzing the relationship between annual income and these predictors. Overall, these findings support the suitability of linear regression methods for examining the determinants of annual income among fisherfolk in the Chilika Lake area.

Table-3: Linearity Test

Variables			Df	F	Sig.
Annual Income Rs * Cost of Boat	Between Groups	Linearity	1	3.5	.042
		Deviation from Linearity	19	.632	.882
Annual Income Rs * Education	Between Groups	Linearity	1	3.36	.038
		Deviation from Linearity	10	.362	.092
Annual Income Rs * Fishing Experience	Between Groups	Linearity	1	4.99	.026
		Deviation from Linearity	24	1.37	.121
Annual Income Rs * Weight of Fish Catch per year in tons	Between Groups	Linearity	1	3.49	.033
		Deviation from Linearity	8	1.66	.109
Annual Income Rs * fish sell in local area per year in tons	Between Groups	Linearity	1	30.53	.000
		Deviation from Linearity	26	.817	.725
Annual Income Rs * No of fishing men hire during the fishing activity	Between Groups	Linearity	1	4.90	.028
		Deviation from Linearity	2	.065	.937
Source: Authers own calculation					

Table 4 presents the results of the multicollinearity diagnosis for the regression model analyzing factors affecting the annual income of fisherfolk around Chilika Lake. The table shows the unstandardized and standardized coefficients (Beta), t-values, significance levels, and collinearity statistics including Tolerance and Variance Inflation Factor (VIF) for each independent variable. The Tolerance values for all independent variables are above 0.98, and the corresponding VIF values are close to 1 (ranging from 1.005 to 1.016), indicating minimal multicollinearity among the predictors. This confirms that the explanatory variables are largely independent of each other, allowing for reliable estimation of their individual effects on annual income.

Regarding the regression coefficients, education has a positive standardized Beta (0.105) and is statistically significant (t = 2.162, p = .031), suggesting that higher education levels are positively associated with increased annual income. Similarly, fishing experience shows a positive and significant effect (Beta = 0.123, t = 2.536, p = .012). Conversely, variables such as fish sold locally per annum exhibit a negative and highly significant relationship with income (Beta = -0.268, t = -5.548, p = .000), indicating that higher local sales may correspond to lower net income, possibly due to market saturation or pricing pressures. The number of fishing men hired during activities also has a significant negative effect (Beta = -0.102, p = .036), while cost of boat and weight of fish catch per year are not statistically significant at conventional levels (p > .05). Overall, the multicollinearity analysis confirms the robustness of the regression estimates, while the coefficient signs and significance levels provide insights into how each factor influences fishermen's income.

Table-4: Multicollinearity diagnosis

Independent Variables		Unstandardized Coefficients	Standardized Coefficients	T	Sig.	Collinearity Statistics	
		B	Beta			Tolerance	VIF
1	(Constant)	308594.74		16.25	.000		
	Education	– .089	.105	2.162	.031	.988	1.013
	Cost of Boat	779.699	– .087	-1.802	.072	.990	1.011
	Fishing Experience	.068	.123	2.536	.012	.985	1.016
	Weight of Fish Catch per year in ton	-94149.14	– .073	-1.502	.134	.987	1.014
	fish sell in local area per annum in kg	-8025.519	– .268	-5.548	.000	.995	1.005
	No. of fishing men hire during the fishing activity	-10750.56	– .102	-2.099	.036	.991	1.009
Source: Authers own calculation							

Table 5 presents the model summary of the stepwise regression analysis investigating the determinants of annual income among fisherfolk in the Chilika Lake area. The model progressively incorporates variables across four steps, with the corresponding R, R Square, Adjusted R Square, Standard Error of Estimate, and significance values for the F change reported. At the first step, the model explains approximately 27.5% of the variance in annual income (R Square = 0.275), indicating a moderate initial fit. As additional variables enter the model in subsequent steps, the explanatory power improves, with the R Square increasing to 33.5% in the final model (step 4). The Adjusted R Square, which accounts for the number of predictors relative to sample size, also increases from 7.2% at step 1 to 11.2% at step 4, reflecting a modest but consistent improvement in model fit.

The standard error of the estimate decreases slightly across the models, from 63,460.90 in step 1 to 62,406.72 in step 4, suggesting an incremental enhancement in prediction accuracy. The significance values for the F change ($p < 0.05$ at each step) confirm that the addition of each variable significantly improves the model. Overall, the stepwise regression results indicate that while the included predictors explain a moderate proportion of the variability in fisherfolk income, other unmeasured factors may also be influencing income levels. The model demonstrates that certain socio-economic and fishing-related variables contribute meaningfully to explaining income differences within the population studied.

Table 5
Model Summary of Stepwise Regression

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig. F Change
1	.474[a]	.275	.072	63460.900	.000
2	.299[b]	.089	.085	63040.282	.014
3	.319[c]	.102	.094	62702.729	.024
4	.335[d]	.112	.103	62406.717	.032

Source: Authers own calculation

Table 6 summarizes the results of the stepwise multiple regression analysis examining the influence of several independent variables on the annual income of fisherfolk around Chilika Lake. Across four models, the constant term and predictors fish sold in the local area, fishing experience, number of fishermen hired during fishing activities, and education were evaluated for their statistical significance and effect sizes.

In Model 1, the variable fish sold in the local area shows a significant negative coefficient (B = -93,966.98, p < .001), indicating that, controlling for no other factors, increased quantities of fish sold locally are associated with a decrease in annual income. This may reflect local market saturation or lower prices for locally sold fish. The constant (intercept) is significant at 282,616.1, representing baseline income when other predictors are zero.

Model 2 adds fishing experience, which has a positive and statistically significant effect (B = 809.78, p = .014), suggesting that increased experience contributes to higher income. The fish sold variable remains significantly negative.

Model 3 introduces the number of fishermen hired during fishing activities, which has a significant negative coefficient (B = -11,317.06, p = .024). This suggests that hiring more fishermen may reduce individual income, possibly due to sharing profits or increased operational costs. Fishing experience retains a positive and significant effect.

Model 4 includes education, which exhibits a positive and significant coefficient (B = 1627.52, p = .032). This implies that higher educational attainment is associated with higher income levels, highlighting the role of education in improving fishing-related economic outcomes. Other variables retain their signs and significance, reinforcing the robustness of these relationships.

Overall, the regression models highlight that while increased fish sales locally may reduce income, experience and education positively contribute to income, and labor dynamics through hired fishermen influence economic outcomes negatively. These insights emphasize the complex socio-economic factors affecting fisherfolk livelihoods in Chilika Lake.

Table-6: Summary of Regression Analysis Results

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	282616.1	5352.95	− .274	52.80	.000
	fish sell in local area	-93966.98	16901.26		-5.57	.000
2	(Constant)	266572.5	8388.75	− .277	31.78	.000
	fish sell in local area	-95272.1	16797.53	.121	-5.68	.000
	Fishing Experience	809.78	327.48		2.48	.014
3	(Constant)	289241.04	13042.9	− .276	22.18	.000
	fish sell in local area	-94927.15	16708.29	.121	-5.69	.000
	Fishing Experience	808.15	325.78	− .110	2.49	.014
	No of fishermen hire during the fishing activity	-11317.06	5004.82		-2.27	.024
4	(Constant)	273488.4	14909.80	− .271	18.35	.000
	fish sell in local area per annum in kg	-93013.78	16653.25	.127	-5.59	.000
	Fishing Experience	848.26	324.73	− .106	2.62	.009
	No of fishermen hire during the fishing activity	-10954.96	4984.04	.104	-2.2	.029
	Education	1627.52	757.73		2.15	.032

Source: Authers own calculation

The results of the stepwise multiple regression analysis are summarized across four models, each progressively incorporating key socio-economic and livelihood variables to explain variations in the annual income (Y) of fisherfolk in the Chilika Lake region.

Model 1, the quantity of fish sold in the local area (X_5) emerges as a significant predictor with a negative coefficient (-0.274), indicating that increased local sales of fish are associated with reduced income levels. This could be attributed to local market saturation, lower price realization, or higher transaction costs at the local level.

Model 2 incorporates fishing experience (X_3), which shows a positive and statistically significant impact (0.121) on income, suggesting that more experienced fishers tend to earn higher annual incomes, likely due to better skills, efficiency, and knowledge of profitable fishing zones.

Model 3, the inclusion of the number of fishermen hired (X_6) introduces a negative relationship (-0.110) with income, implying that hiring additional labor may diminish individual profits due to cost-sharing or increased operational expenses. This reflects the trade-off between scaling fishing efforts and maintaining profitability.

Model 4 integrates education (X_1) into the equation, which reveals a positive coefficient (0.104), reinforcing the role of education in enhancing income, possibly through better resource management, diversified income opportunities, or improved access to information and markets. Notably, even with the inclusion of multiple predictors, the negative effect of local fish sales remains strong, while experience and education consistently improve income. This model reflects a realistic interplay of human capital, labor structure, and market behavior in shaping economic outcomes for fishing households in Chilika.

Model 1

$$\varvec{Y} = \varvec{\beta} + \varvec{\beta} \varvec{X} + \varvec{\epsilon}$$

$Y = 282616.08 - .274X_5 + \epsilon$ (1)

Model 2

$$\varvec{Y} = \varvec{\beta} + \varvec{\beta} \varvec{X} + \varvec{\beta}\varvec{X} + \varvec{\epsilon}$$

$Y = 266572.50 - 277X_5 + .121X_3 + \epsilon$ (2)

Model 3

$$\varvec{Y} = \varvec{\beta} + \varvec{\beta} \varvec{X} + \varvec{\beta}\varvec{X} + \varvec{\beta}\varvec{X} + \varvec{\epsilon}$$

$Y = 289241.04 - .276 X_5 + .121X_3 - 110(X_6) + \epsilon$ (3)

Model 4

$$\varvec{Y} = \varvec{\beta} + \varvec{\beta}\varvec{X} + \varvec{\beta}\varvec{X} + \varvec{\beta}\varvec{X} + \varvec{\beta}\varvec{X} + \varvec{\epsilon}$$

$Y = 273488.41 - .271X_5 + .127X_3 - .106\ (X_6) + 104X_1 + \epsilon$ (4)

4. Discussion

The stepwise regression analysis sheds critical light on the multifaceted socio-economic determinants influencing the annual income of fisherfolk in the Chilika Lake region. One of the most striking findings is the consistent negative association between the quantity of fish sold in the local market and annual income. Across all models, the variable "fish sold locally" remains statistically significant and negatively signed, suggesting that localized fish sales may not be economically beneficial. This pattern could result from depressed local market prices, lack of access to external or higher-value markets, or excessive competition among fishers in a confined supply-demand ecosystem (Ray et al., 2018; Singhar & Gundimeda, 2024). These findings underscore the need to strengthen cold chain infrastructure and improve market linkages beyond the immediate locality to enable fisherfolk to fetch better prices (Barbier, 2011; Adeli et al., 2020).

In contrast, fishing experience emerged as a strong and consistent positive predictor of income, affirming the value of traditional ecological knowledge in sustaining livelihoods (Mohanty et al., 2015). Experienced fishers are likely to possess superior skills in identifying fishing hotspots, managing time and resources efficiently, and adapting to environmental variability. This human capital, although informal, plays a vital role in enhancing economic returns. Therefore, policy frameworks that integrate this tacit knowledge into training programs or cooperative development strategies could amplify its economic benefits while promoting knowledge-sharing among younger and less experienced fishers (Khan et al., 2018; Roy et al., 2022).

Another important observation pertains to the negative coefficient of labor hiring (number of fishermen employed) during fishing operations. This suggests that while labor-intensive fishing might increase catch volume, it does not necessarily improve net income. On the contrary, the added cost burden or the necessity of dividing revenues may reduce individual earnings (Ray et al., 2018). The result calls attention to the fine balance between scaling fishing operations and maintaining profitability. There is a compelling need for financial literacy programs, cooperative management reforms, and sustainable gear optimization techniques that allow fishers to maximize returns without overly relying on external labor inputs (Ambasta et al., 2007; Singhar & Gundimeda, 2024).

Moreover, the analysis highlights education as a significant and positive determinant of income in the final model. This finding aligns with the broader literature that links formal education to better livelihood outcomes in traditional occupations (Blomquist & Whitehead, 1998; Aazami & Shanazi, 2020). Education likely improves decision-making, market awareness, and the ability to adopt sustainable and efficient practices. The marginal gains from education, although not large, suggest long-term dividends, particularly if supported by functional literacy programs and vocational training (Chatterjee et al., 2022; Eppink et al., 2014). Thus, investment in adult education and inclusive skill development can be instrumental in enhancing the adaptive capacity and income diversification opportunities for fisher households.

Overall, the regression models collectively reveal the complex interplay between market behavior, human capital, labor strategies, and socio-institutional factors in determining the economic wellbeing of Chilika's fisherfolk. While traditional knowledge and education serve as income enhancers, structural challenges like market inefficiencies and unsustainable labor practices persist. These findings should guide policymakers and development agencies toward holistic livelihood interventions that promote sustainable harvesting, fair market access, capacity building, and cooperative resource management (Li et al., 2020; Dhandapani et al., 2019). A targeted combination of social investment and regulatory reform is crucial to converting Chilika's rich ecological potential into long-term socio-economic resilience (Graymore & McBride, 2013; CIFRI-ICAR, 2005).

5. Policy Recommendations

There is an urgent need to strengthen market linkages and fisheries value chains. The regression analysis revealed that selling fish locally is negatively associated with annual income, which points to the economic limitations of localized markets. To address this, policymakers should invest in developing cold storage facilities, improving transportation infrastructure, and creating digital platforms that disseminate real-time market information. Such measures would enable fisherfolk to access regional, national, and even international markets, improving both price realization and their overall bargaining power.

The positive correlation between education and income highlights the importance of functional education and capacity-building initiatives. Targeted adult education programs should be designed to include vocational training, basic literacy, financial management, and modules on sustainable fishing practices. Education not only enhances income but also improves fishers' ability to adopt modern technologies, engage with formal institutions, and participate in cooperative governance effectively.

Cooperative-based resource management should be promoted to empower fishing communities and reduce reliance on expensive external labor. Revitalizing local cooperatives through training in democratic governance, transparent financial practices, and shared ownership of infrastructure can enhance productivity while ensuring equitable distribution of income. Strong, accountable cooperatives can also play a vital role in promoting collective action and self-regulation among fishers.

Fishing labor practices need to be regulated and optimized. The analysis indicates that hiring additional fishermen can reduce net income, likely due to higher labor costs or revenue-sharing constraints. Policies should encourage the adoption of efficient, low-cost, and eco-friendly fishing technologies. Moreover, access to microcredit or subsidies for purchasing sustainable gear can reduce dependency on excessive manual labor while improving overall productivity and environmental outcomes.

Integrated fisheries management approach is essential for balancing economic development with ecological preservation. Institutions such as the Chilika Development Authority (CDA) should be further empowered to conduct continuous monitoring of fish stocks, enforce sustainable catch limits, and facilitate habitat restoration initiatives. A community-based co-management model, involving fishers directly in decision-making processes, can enhance compliance, foster stewardship, and ensure that both conservation and livelihood goals are achieved.

6. Conclusion

This study critically examined the socio-economic determinants of fisherfolk income around Chilika Lake, with a focus on key variables such as local fish sales, fishing experience, labor hiring, and education. The regression analysis reveals that while experience and education positively influence income, the high reliance on local fish markets and labor-intensive practices often reduces profitability. The findings highlight a pressing need for structural transformation in how the fishing economy is organized, particularly with regard to market access, labor efficiency, and human capital development. Chilika Lake, as one of the most productive brackish water ecosystems in Asia, holds immense potential for sustainable livelihood generation. However, unless inefficiencies in market structures and socio-economic barriers are addressed, fisherfolk will remain vulnerable to income fluctuations, resource degradation, and marginalization. The study emphasizes that a balanced approach one that blends ecological sustainability with economic rationality is essential to improve the living standards of the local fishing communities.

Declarations

Clinical trial number: Not applicable

Consent to Participate declaration: Not applicable

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Author Contributions: TS was responsible for acquiring and analyzing the literature and interpreting the results. MS conceptualized the overall idea and framework, and was involved in drafting and revising the manuscript. SP thoroughly reviewed and approved the final version of the manuscript.

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Ethics Declaration

The study is part of the author's ongoing Ph.D. research and was approved by the Departmental Research Committee (DRC) of Department of Economics, affiliated with Berhampur University, Bhubaneswar, India. The DRC functions as the institutional ethics committee and reviewed and approved the study in accordance with the ethical standards and guidelines of the university. The research was conducted following all applicable ethical guidelines and regulations as approved by the committee.

Consent to Participate

All procedures involving human participants and the use of their data were conducted in accordance with institutional and national research ethics guidelines. This study involved the collection of primary data from the designated study region. Informed consent was obtained from all participants prior to their involvement in the research, ensuring that participation was voluntary, and respondents were fully aware of the study's purpose and scope. The research protocol was reviewed and approved by the Departmental Research Committee (DRC) of the Department of Economics, Berhampur University, which is responsible for overseeing ethical compliance in doctoral research. The study was conducted in full accordance with the ethical standards and guidelines established by the DRC.

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