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Alleviating Poverty in Small-Scale Fisheries: A Sustainable Livelihood Approach for the Jaffna Lagoon Shrimp Fishing community

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ABSTRACT

This study assesses the livelihood status of shrimp fishers in the Jaffna lagoon using the sustainable livelihoods approach. A structured questionnaire survey was carried out at all landing sites (n=39) in the Jaffna lagoon to gather data from 250 shrimp fishers between January 2022 and December 2023. The data were standardized and analyzed. The results showed that financial capital is the most vulnerable (0.41 ± 0.13), while social capital is the strongest (0.79 ± 0.15). Other capitals, including natural (0.48 ± 0.14), physical (0.48 ± 0.14), and human capital (0.48 ± 0.14), showed moderate levels of vulnerability. The fishing community faced major vulnerabilities due to economic instability, declining shrimp catches, and climate change. Fishers adopted several livelihood strategies; among them, aquaculture (0.65 ± 0.08), entrepreneurship (0.64 ± 0.08), and a combination of agriculture/animal husbandry and entrepreneurship (0.61 ± 0.01) were key strategies contributing to livelihood resilience against shocks and ongoing vulnerabilities. Ordinal regression analysis identified significant factors contributing to livelihood resilience, including savings (OR = 429.024, p < 0.0001), housing conditions (OR = 164.057, p = 0.0006), skills beyond fishing (OR = 4.917, p = 0.0304), and access to other natural resources (OR = 15.1, p = 0.0314). These findings suggest that strengthening financial security, diversifying livelihoods, and promoting skills development are crucial for enhancing the resilience and sustainability of shrimp fishers in the Jaffna lagoon.

Keywords: Small-scale shrimp fishing, Jaffna lagoon, livelihood resilience, sustainable livelihoods approach.

1.0 INTRODUCTION

Small-scale fisheries play a significant role in the global economy by providing livelihood opportunities to millions of people, ensuring food security, and contributing substantially to local economies, particularly in developing countries[1]. These fisheries are more prevalent in tropical and subtropical regions, especially in Asia[2]. Small-scale fisheries are often characterized by traditional fishing methods, low capital investment, and labour-intensive practices, making them a vital component of the socio-economic fabric of marginalized communities[3].

Small-scale fishing communities are highly vulnerable to poverty due to their heavy reliance on fishery resources as their primary source of income. Over time, this dependence has increased their livelihood vulnerability, especially as catch rates decline due to factors such as overfishing, climate change, habitat degradation, and pollution[4,2,5]. The resulting income loss undermines economic stability, threatens food security, and heightens the risk of malnutrition among fishing households. Consequently, poverty and food insecurity create a vicious cycle that further weakens the resilience of small-scale fishing communities[6].

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In response to declining catches, fishers often adopt coping strategies such as increasing fishing effort, changing fishing methods, or targeting new species[7]. However, intensified fishing pressure accelerates resource depletion, leading to the collapse of fish stocks and threatening the long-term sustainability of fisheries[8]. Effective interventions thus require a comprehensive understanding of livelihoods that incorporates not only assets but also the broader socio-political context, including institutions, power relations, and identity, that shapes access to resources and adaptive capacity. As Scoones[9] emphasizes, situating livelihoods within this political economic framework is critical for addressing the complex challenges facing fishing communities under environmental and socio-economic change.

Jaffna lagoon, the largest lagoon in Sri Lanka, has historically supported small-scale shrimp fisheries for many decades. Shrimp fishing was prominent in the Jaffna lagoon during 1980s, as observed by Chitravadivelu[10], and was conducted year-round using traditional fishing methods such as sirahuvalai, drag nets, hoop nets, kandi, and manual picking. These methods primarily targeted juvenile *Penaeus semisulcatus* and *Metapenaeus monoceros*, which utilize the lagoon as a nursery ground[11,12]. However, the fishery was severely disrupted during the civil conflict in the late 1980s, leading to the displacement of many fishers and the near cessation of fishing activities[13].

Resettlement efforts began in 2002, allowing fishermen to return and restart their fishing activities. However, strict restrictions such as limitations on fishing areas, fishing time, and fishing gear were implemented along with the introduction of a permit system[13]. These restrictions were gradually eased after 2009, with the full resumption of lagoon fisheries. Despite this progress, many fishers had lost their homes, assets, and boats during the conflict, further

deepening their poverty[13]. Although government subsidies and rehabilitation programs were introduced to support their recovery[14,15], the long-term effectiveness of these measures remains uncertain.

Recent studies have reported the signs of shrimp overfishing in the Jaffna lagoon and declining catch rates attributed to increased fishing pressure, habitat degradation, climate change, and illegal fishing[15–18]. However, the impacts of these stressors on fishery resources and fishers' livelihoods have not been systematically assessed, which poses a barrier to understanding the relationship between resource sustainability and fishers' livelihoods. This understanding is essential for developing management strategies that balance conservation goals with the socio-economic well-being of fishing communities.

Addressing this requires a focus on livelihood resilience, which is defined as the capacity of fishing households or communities to cope with and adapt to environmental, economic, and social challenges, while maintaining or improving their access to critical livelihood resources and ensuring long-term well-being. Therefore, the present study was designed to address and evaluate the livelihood status of Jaffna lagoon shrimp fishers using a sustainable livelihoods approach, and to identify the strategies and capital components that strengthen livelihood resilience and contribute to poverty eradication in the small-scale fisheries of Jaffna lagoon.

2.0 MATERIALS AND METHODOLOGY

2.1 Study area

The Jaffna lagoon (9° 50' N and 79° 50' E to 9° 20' N and 80° 30' E), extends across Jaffna and Kilinochchi districts covering an area of 450 km^2 in the Northern Province of Sri Lanka was selected for this study (Figure 1).
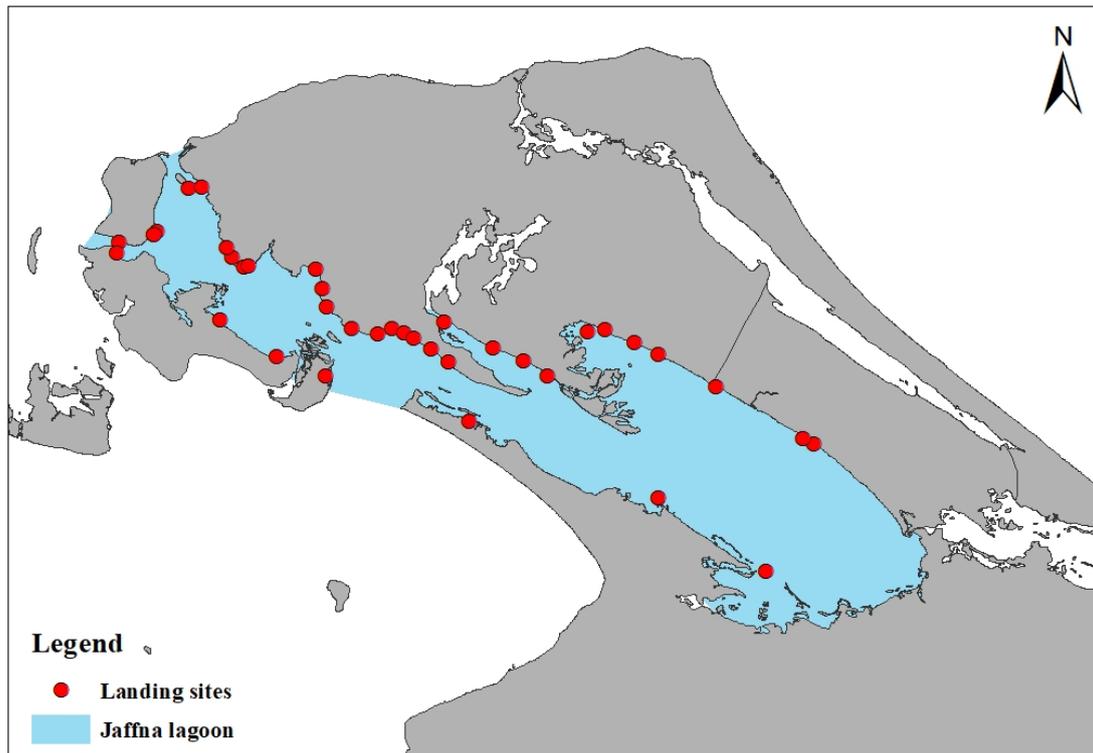
Figure 1. Map illustrating the shrimp landing sites around the Jaffna lagoon.

2.2 Data collection

A structured questionnaire was developed to assess the livelihoods of shrimp fishers in the Jaffna lagoon within the framework of the sustainable livelihoods approach. This questionnaire encompasses four key components: capital (human, social, physical, financial, and natural), livelihood strategies (intensification, diversification, migration, erosive coping strategies, and family support), vulnerabilities, and livelihood outcomes (human, social, financial, physical, and natural). The details of all five components and their measurement scales are provided in Tables 1 and 3.

The development of the questionnaire followed a systematic, multi-phase process. Initially, a set of open-ended questions was designed based on a review of relevant literature [19–28]. These questions were administered to 30 randomly selected fishers from major landing sites to capture the local context. Feedback from this preliminary survey informed subsequent revisions to the questionnaire, including the refinement of item wording and the incorporation of structured response formats such as Likert scales and multiple-choice options. A second round of pilot testing was conducted with another group of 30 fishers to evaluate the tool's reliability and clarity. Based on the results, a validated version of the questionnaire was finalized and used for data collection.

Ethical clearance for this study was obtained from the Ethics Review Committee, Faculty of Graduate Studies, University of Sri Jayewardenepura (Reference No: 2022/EC/22). Data on these components were collected through face-to-face interviews from randomly selected 250 fishers engaged in the lagoon shrimp fishery at all fish landing sites in the Jaffna lagoon, from January 2022 to December 2023.

Table 1. Indicators used to assess the capitals of shrimp fishers and the corresponding livelihood outcomes for each capital in the Jaffna lagoon, based on the sustainable livelihoods approach.

Capital	Capital assessment components	Livelihood outcome assessment components
Human capital		
	Education	Food security
	Skills	
Social capital		
	Safe social	Incidence of social conflicts
	Support	
	Available resources	
	Strength of community organization	
Physical capital		
	Housing condition	Ownership of key assets
	Ownership of fishing boat	
	Ownership of other than shrimp fishing gear	
	Market condition and infrastructure	
Financial capital		
	Total income	Debt burden
	Loans	Income stability
	Savings	
Natural capital		
	Available fishery resources	Pressure on fishery resources
	Available other natural resources	

During the interview, questions were often repeated or rephrased to ensure the respondents' understanding of the questions. Responses were recorded using a voice recorder with the permission of respondents to avoid any distractions during the interview, especially between asking questions and writing responses. Vulnerability scores were derived from perceptions of fishers using a Likert-type scales. Respondents were asked to rate the perceived impact of various vulnerability factors (e.g., economic instability, environmental changes, institutional barriers) on a five-point scale, ranging from 1 = no impact to 5 = very high impact.

Livelihood outcomes for each capital were assessed based on their current status compared to the past, using a ranked scale of 1 (worst) to 5 (highly improved), with 3 indicating no change. For example, in evaluating the financial capital outcome of savings, responses were categorized as: worsened (1), reduced (2), unchanged (3), improved (4), and highly improved (5). A similar approach was consistently applied across all livelihood outcome indicators of each capital (Table 2).

2.3 Data analysis

All responses on the sustainable livelihood approach questionnaire were normalized using the following formula proposed by Nasrnia and Ashktorab[29]:

$$X_{normalized} = \frac{(X response - X min)}{X max - X min}$$

where; $X_{response}$ represents the individual fisher's response for a specific criterion, X_{min} is the minimum value assigned to the criterion, and X_{max} is the maximum value assigned to the criterion. This process normalized the data to a scale of 0 to 1. Each capital score was determined

by calculating the average of the normalized scores for all constituent indicators within that capital (e.g., for human capital, the normalized scores of educations, skills, and fishing experience were averaged).

The overall livelihood outcome score for each fisher was calculated by averaging their normalized scores across all five livelihood outcomes. Based on these scores, fishers were categorized into five livelihood resilience levels: Highly Resilient (0.81–1.00), Resilient (0.61–0.80), Moderately Secure (0.41–0.60), Vulnerable (0.21–0.40), and Extremely Vulnerable (0.00–0.20)[30]. The ordinal regression analysis was conducted to identify the most influential capital indicators in determining

livelihood resilience levels among the fisher population.

3.0 RESULTS AND DISCUSSION

3.1 Socio-economic characteristics of Jaffna lagoon shrimp fishers

Table 2 presents the demographic characteristics of Jaffna lagoon shrimp fishers. All the fishers belong to the Tamil ethnic group, with 47.46% Hindu and 52.54% Christian. Most fishers are between 31 and 40 age group (25.41%), followed by those in the 41–50 (23.77%) and 18–30 (21.31%). Additionally, 92.56% of fishers are married, and 82% are categorized as traditional fishers.

Table 2. Demographic characteristics of shrimp fishers in the Jaffna lagoon during the study period from January 2022 to December 2023.

Variables	Data	Percentage	Chi-square value	p-value
Ethnicity	Tamil	100%	-	-
Religion	Hindu	47.46%	0.31	0.5807
	Christian	52.54%		
Age group	<18	0.00%	32.13	0
	18-30	21.31%		
	31-40	25.41%		
	41-50	23.77%		
	51-60	16.39%		
	>60	13.11%		
Marital status	Single	7.44%	87.68	0
	Married	92.56%		
Family size	None	1.61%	136.24	0
	1 member	8.06%		
	2 members	18.55%		
	3 members	60.48%		
	More than 3 members	11.29%		
Types of fishers	Traditional	82.00%	40.96	0
	Non-traditional	18.00%		

3.2 Livelihood capitals of Jaffna lagoon shrimp fishers

Table 3 and Figure 2 summarize the livelihood capital of shrimp fishers in the Jaffna lagoon. A significant variation was observed among the five capitals ($p < 0.05$; one-way ANOVA). Social capital has the highest mean score (0.79 ± 0.15), indicating strong social cohesion within the community. In contrast, financial capital has the lowest mean score (0.41 ± 0.13), highlighting significant financial vulnerability. Human (0.54 ± 0.13), physical (0.48 ± 0.17), and natural (0.48 ± 0.14) capital exhibited intermediate levels.
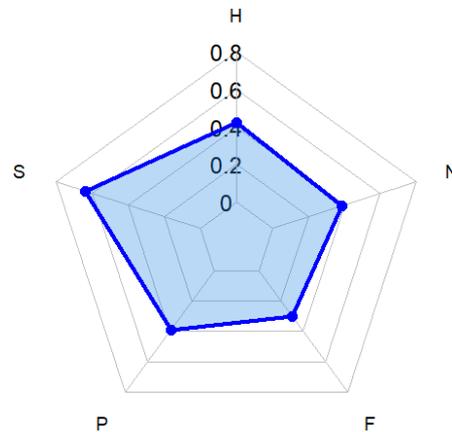

Figure 2. Radar plot representing the average scores for livelihood capitals of shrimp fishers in the Jaffna lagoon. H, S, P, F, and N denote human, social, physical, financial, and natural capital, respectively. Each capital score represents the average of its subcomponents, which were derived from fishers' responses on an ordinal Likert scale. These responses were normalized prior to aggregation to ensure comparability across capitals.

Table 3. Summary of livelihood capitals of shrimp fishers in the Jaffna lagoon from January 2022 to December 2023. Data were collected using a structured questionnaire. The table presents the percentage of responses across different indicator levels and the estimated mean ($\pm$SD) for each capital and its subcomponents.

Capital	Indicators	Levels	% of response	Mean ± SD
	Human capital			**0.54 ± 0.13**
	Education	Never attended school (1)	9.52%	
		Primary (2)	33.33%	
		Secondary (3)	18.25%	
		O/L (4)	23.02%	0.32 ± 0.20
		A/L (5)	11.90%	
		Diploma/certificate (6)	2.38%	
		Degree (7)	0.79%	
		Postgraduate (8)	0.79%	
	Health	Chronic Illness (1)	3.25%	
		Poor Health (2)	13.01%	0.65 ± 0.21
		Good Health (3)	67.48%	
		Healthy (4)	16.26%	
	Skills beyond fishing	None (1)	12.20%	
		Basic (2)	24.39%	0.63 ± 0.33
		Intermediates (3)	37.80%	
		Advanced (4)	25.61%	
	Social capital			**0.79 ± 0.15**
	Safe social	Not safe at all (1)	0.00%	
		Highly unsafe (2)	4.07%	
		Unsafe with occasional problems (3)	2.44%	0.95 ± 0.17
		Fairly safe with minor concerns (4)	3.25%	
		Completely safe (5)	90.24%	
	Support	No support at all (1)	0.81%	
		Very little support (2)	28.46%	0.70 ± 0.31
		High-level support (3)	33.33%	
		Very high-level support (4)	37.40%	
	Availability and access to resources	Very Poor (1)	0.00%	0.82 ± 0.18
		Poor (2)	2.44%	

	Fair (3)	8.94%	
	Good (4)	47.97%	
	Abundant (5)	40.65%	
Strength of community organization	Very weak (1)	0.81%	0.71 ± 0.15
	Weak (2)	5.69%	
	Moderate (3)	2.44%	
	Strong (4)	90.24%	
	Very strong (5)	0.81%	
Physical capital			**0.48 ± 0.17**
Housing condition	Temporary (1)	4.07%	0.43 ± 0.19
	Incomplete house (2)	63.41%	
	Basic permanent house (3)	30.89%	
	Well-built house (4)	1.63%	
Ownership of fishing boats	No ownership (1)	53.97%	0.56 ± 0.49
	Owns a fishing boat (2)	46.03%	
Assets (Market condition and infrastructure)	Very small markets (1)	42.28%	0.45 ± 0.45
	Small-sized market (2)	11.38%	
	Moderate-sized market (3)	6.50%	
	Larger market (4)	2.44%	
	Very large market (5)	37.40%	
Financial capital			**0.41 ± 0.13**
Total income	<20,000 (1)	28.69%	0.29 ± 0.30
	20-40,000 (2)	22.13%	
	40-60,000 (3)	17.21%	
	60-80,000 (4)	1.64%	
	80-100,000 (5)	5.74%	
	100-120,000 (6)	9.02%	
	120-140,000 (7)	13.93%	
	140-160,000 (8)	0.82%	
	>160,000 (9)	0.82%	
Loans	>500,000 (1)	3.20%	0.80 ± 0.33
	450,000 - 500,000 (2)	5.60%	

	400,000 - 450,000 (3)	4.80%	
	350,000 - 400,000 (4)	3.20%	
	300,000 - 350,000 (5)	3.20%	
	250,000 - 300,000 (6)	1.60%	
	200,000 - 250,000 (7)	5.60%	
	150,000 - 200,000 (8)	3.20%	
	100,000 - 150,000 (9)	4.80%	
	50,000 - 100,000 (10)	4.80%	
	<50,000	16.80%	
	Nil	43.20%	
Savings	Nil (1)	53.66%	
	<50,000 (2)	14.63%	
	50,000 -100,000 (3)	0.81%	
	100,000 - 150,000 (4)	6.50%	
	150,000 - 200,000 (5)	5.69%	
	200,000 - 250,000 (6)	5.69%	0.15 ± 0.22
	250,000 - 300,000 (7)	4.88%	
	300,000 - 350,000 (8)	3.25%	
	350,000 - 400,000 (9)	2.44%	
	400,000 - 450,000 (10)	0.81%	
	450,000- 500,000 (11)	1.63%	
Natural capital			**0.48 ± 0.14**
Fishery resources	None (1)	0.81%	
	Low availability (2)	12.20%	0.54 ± 0.16
	Moderate availability (3)	57.72%	
	High availability (4)	29.27%	
Available other natural resources	None (1)	5.69%	
	Low availability (2)	65.04%	0.43 ± 0.21
	Moderate availability (3)	25.20%	
	High availability (4)	4.07%	

3.3 Human capitals

The human capital of shrimp fishers was assessed based on their education, health, and skills beyond fishing. Educational attainment ranged from illiterate to postgraduate levels, with 33.3% of fishers having completed only primary education (Grades 1-5). Regarding health, 67% reported generally good health with occasional minor pains, while 16% considered themselves healthy. However, 13% of fishers reported chronic illnesses, and 4% described their health as poor. Regarding skills beyond fishing, 88% of fishers possessed job skills. However, proficiency levels varied: 26% demonstrated high proficiency, 37% had intermediate proficiency, and 24% exhibited basic skills.

3.4 Social capitals

Social capital within the shrimp fishing community was assessed based on perceived safety, community support, resource availability, and the role of community organizations. A high level of perceived safety was reported, with 90% of fishers feeling secure in their fishing and living environments. Regarding resource availability, 89% of fishers had access to labor, financial resources, and social connections, with 41% rating these resources as 'abundant' and 48% as 'good.' While community cohesion was evident, access to support networks varied among fishers. Specifically, 37% of fishers reported high levels of community support, while 33% reported occasional support, and 28% experienced limited support. Additionally, community organizations played a significant role, and 90% of respondents acknowledged their presence. Among them, 90% considered these organizations helpful in supporting the community, while only 6% perceived them as weak. This underscores the positive contribution of community organizations to overall well-being.

3.5 Physical capitals

The physical capital of lagoon shrimp fishers was assessed based on the ownership of fishing gear and crafts, housing conditions, and assets,

including market infrastructure. Nearly 50% of the fishers rely solely on fyke nets, limiting their ability to diversify fishing methods. While half of the fishers own their fishing crafts, the rest share or borrow boats. The majority of fishers (63%) live in incomplete homes that require further investment for completion. Additionally, the limited number of buyers in markets makes it difficult for fishers to secure expected prices for their catches.

3.6 Financial capital

The financial capital of shrimp fishers in the Jaffna lagoon was evaluated based on monthly income, loans, and savings. Fishers' monthly income ranged from 20,000 LKR to over 160,000 LKR, with an average of ~60,000 LKR, indicating a generally low-income level. More than half of the fishers (54%) reported having no savings. Regarding debt, fishers' loans ranged from none to amounts exceeding 500,000 LKR. The majority (43%) did not take any loans, while 17% had loans below 50,000 LKR. Loans were primarily obtained from middlemen, who imposed high-interest rates. Consequently, fishers experienced a significant reduction in their retained income, as middlemen not only purchased their catch at very low predetermined rates but also charged interest on the loans they provided.

3.7 Natural capitals

The natural capital of lagoon fishers was assessed based on fishery resources and access to other natural resources. Fishery resources, particularly shrimp, were reported to be moderate: 58% of fishers considered them sufficient, 29% perceived them as highly available, and 12% noted low levels. However, access to natural resources such as agricultural land and space for animal husbandry was reported to be limited. The majority (65%) observed low availability, while 25% indicated moderate access.

3.8 Major vulnerabilities faced by shrimp fishers

This study identified seven key vulnerabilities: economic instability and inflation, increasing fishing pressure, declining fish catch, global warming and associated seasonal climatic variations, illegal fishing practices and poaching, pollution, and the expansion of aquaculture (Figure 3). The results revealed that economic instability and inflation were the most severe vulnerabilities among fishers (0.84 ± 0.37), followed by declining fish catches (0.58 ± 0.31). Global warming and associated seasonal climatic changes were noted as a moderate issue (0.47 ± 0.29), while illegal fishing activities (0.39 ± 0.25) and pollution (0.31 ± 0.37) had a similar impact. Aquaculture expansion (0.19 ± 0.31) emerged as a growing concern. However, no significant impacts of COVID-19 were reported during the study period.
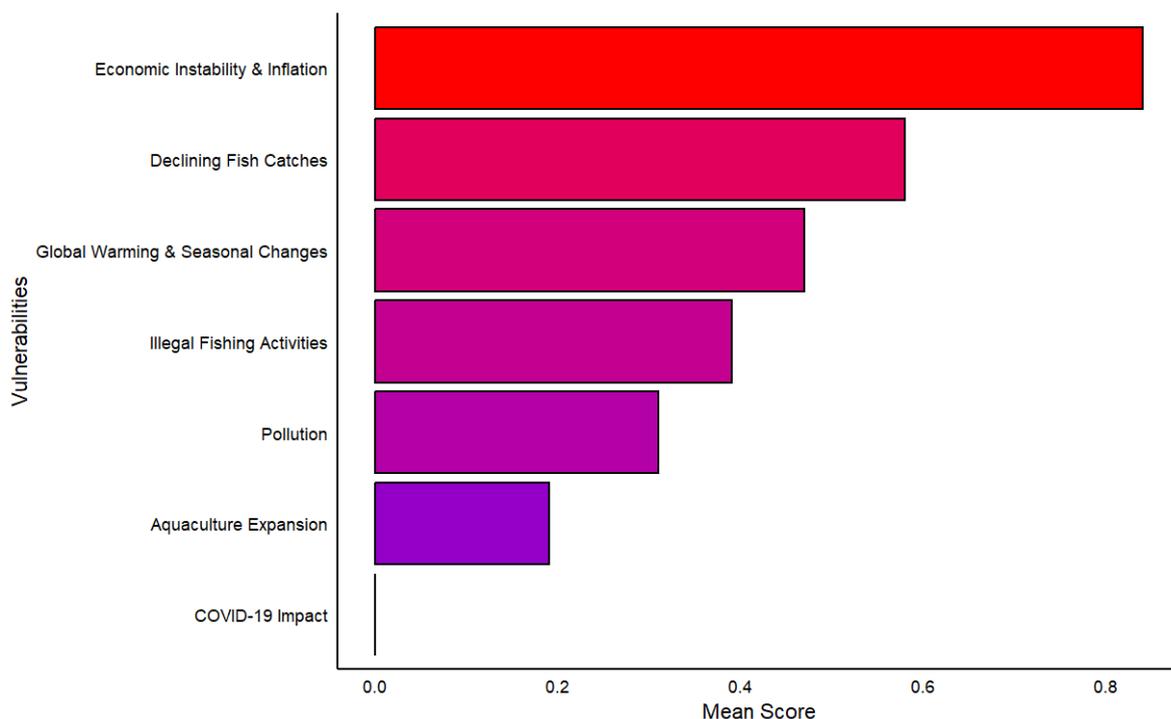

Figure 3. Degree of vulnerabilities reported by Jaffna lagoon shrimp fishers from January 2022 to December 2023. The identified vulnerabilities were scored based on fishers' perceptions using a Likert scale in the questionnaire. These scores were then normalized, and the mean values are presented in the figure.

3.9 Strategies to overcome vulnerabilities

A significant proportion of fishers (88.62%) adopted at least one livelihood strategy to mitigate vulnerabilities, while the remaining 11.38% continued with traditional fishing practices. Among those using alternative strategies, 88% relied on a single strategy, whereas 12% employed a combination of strategies (Figure 4).

Diversification into marine fishing practices emerged as the most prevalent strategy (45%), followed by intensification of fishing activities within the lagoon (19%). Other strategies mainly include diversification into many aspects such as marine fisheries and labor (6%), labor alone (6%), aquaculture (5%), entrepreneurship (4%), agriculture and animal husbandry (3%) and erosive coping mechanisms (illegal fishing and child labor) (3%).
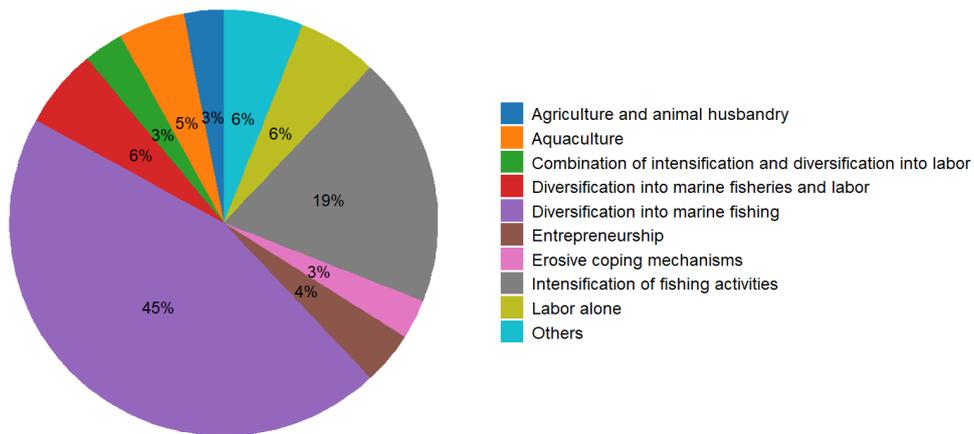
Figure 4. Livelihood strategies adopted by shrimp fishers in the Jaffna lagoon from January 2022 to December 2023. Data were collected using a standardized structured questionnaire, and the pie chart displays the percentage distribution of fishers adopting each livelihood strategy.

3.10 Livelihood outcomes of the strategies

Table 4 summarizes the distribution of livelihood outcomes of the fishers under each capital. The average outcome scores for each capital ranged from 0.40 ± 0.19 for natural capital to 0.47 ± 0.15 for financial, physical (0.47 ± 0.11), and social capital (0.47 ± 0.11). The average outcome for human capital was intermediate (0.42 ± 0.14). These findings suggest a general decline in natural capital and marginal outcomes for financial, physical, and social capital.

Among the livelihood strategies, diversification into aquaculture (0.65 ± 0.08), entrepreneurship (0.64 ± 0.08), and a combination of agriculture/animal husbandry and entrepreneurship (0.61 ± 0.01) ranked among the top three in promoting livelihood resilience. In contrast, erosive coping strategies ranked the lowest (0.19 ± 0.07), indicating a strong association with vulnerability. Other livelihood strategies exhibited varying degrees of livelihood resilience, falling between these extremes.

Table 4. Average livelihood outcomes across different capitals for various livelihood strategies of Jaffna lagoon shrimp fishers

Livelihood strategies	Human capitals	Social capitals	Financial capitals	Physical capitals	Natural capitals	Overall outcomes
Aquaculture diversification	0.83 ± 0.10	0.45 ± 0.21	0.88 ± 0.15	0.55 ± 0.11	0.55 ± 0.21	0.65 ± 0.08
Diversification into entrepreneurship	0.73 ± 0.14	0.56 ± 0.13	0.75 ± 0.14	0.59 ± 0.12	0.56 ± 0.13	0.64 ± 0.08
Diversification into agriculture/animal husbandry and entrepreneurship	0.67 ± 0.01	0.50 ± 0.00	0.63 ± 0.01	0.50 ± 0.00	0.75 ± 0.00	0.61 ± 0.01
Diversification into agriculture/animal husbandry and labor	0.58 ± 0.01	0.50 ± 0.01	0.50 ± 0.01	0.50 ± 0.00	0.50 ± 0.01	0.52 ± 0.00
Diversification into agriculture and animal husbandry	0.47 ± 0.04	0.50 ± 0.00	0.50 ± 0.01	0.50 ± 0.00	0.50 ± 0.01	0.49 ± 0.01
No strategies used	0.46 ± 0.04	0.50 ± 0.00	0.48 ± 0.05	0.50 ± 0.00	0.50 ± 0.01	0.49 ± 0.01
Diversification into marine fisheries and migration	0.42 ± 0.02	0.50 ± 0.01	0.5 ± 0.01	0.50 ± 0.00	0.50 ± 0.01	0.48 ± 0.02
Diversification into marine fisheries	0.38 ± 0.07	0.50 ± 0.00	0.46 ± 0.07	0.47 ± 0.09	0.43 ± 0.14	0.45 ± 0.04
Diversification into labor alone	0.39 ± 0.10	0.50 ± 0.00	0.38 ± 0.11	0.46 ± 0.10	0.50 ± 0.00	0.44 ± 0.06
Intensification of fishing activities	0.45 ± 0.08	0.38 ± 0.17	0.45 ± 0.07	0.49 ± 0.09	0.31 ± 0.25	0.42 ± 0.08
Diversification into marine fisheries and labor	0.32 ± 0.06	0.50 ± 0.00	0.42 ± 0.10	0.42 ± 0.13	0.33 ± 0.13	0.40 ± 0.05
Migration	0.34 ± 0.01	0.50 ± 0.00	0.25 ± 0.01	0.50 ± 0.00	0.25 ± 0.00	0.37 ± 0.01
Intensification and diversification into marine fisheries	0.32 ± 0.03	0.40 ± 0.14	0.43 ± 0.17	0.45 ± 0.21	0.15 ± 0.14	0.35 ± 0.06
Intensification and diversification of labor	0.28 ± 0.04	0.33 ± 0.14	0.46 ± 0.26	0.42 ± 0.14	0.01 ± 0.01	0.30 ± 0.08
Erosive coping mechanisms	0.11 ± 0.04	0.33 ± 0.14	0.01 ± 0.00	0.17 ± 0.14	0.34 ± 0.14	0.19 ± 0.07
Overall	0.42 ± 0.14	0.47 ± 0.11	0.47 ± 0.15	0.47 ± 0.11	0.40 ± 0.19	0.45 ± 0.10

3.11 Livelihood resilience of shrimp fishers in the Jaffna lagoon

The livelihood resilience assessment revealed that 68% of fishers have a moderate level of livelihood security. Vulnerable households accounted for 24%, followed by resilient (5.69%) and extremely vulnerable (2.44%). However, no households classified under the 'highly resilient' category reported.

3.12 Capital factors and livelihood resilience of shrimp fishers

The logistic regression analysis identified key factors influencing livelihood resilience (Table 5). Financial capital, particularly savings (OR = 429.024, $p = 0.0001$), had a strong positive effect. Housing conditions (OR = 164.057, $p = 0.0006$) within physical capital also contributed positively, while reliance on boats (OR = 0.2117, $p = 0.0138$) negatively affected livelihood resilience. Human capital, particularly skills (OR = 4.917, $p = 0.0304$), was a positive predictor. Under natural capital, access to other resources (OR = 15.1, $p = 0.0314$) enhanced livelihood resilience. Social capital showed a negative effect for societies (OR = 0.006, $p = 0.0093$). Other variables, including education, loans, and health, were not significant ($p > 0.05$). These results highlight the importance of financial security, housing, skills, and diversified resources for improving livelihood resilience.

Table 5. Results of the logistic regression analysis examining the influence of different capital components on livelihood resilience

Predictor	Estimate	Odds Ratio (OR)	Confidence Interval (CI)		p-value
			Lower CI	Upper CI	
Saving (F)	6.0615	429.024	20.613	8929.39	0.0001*
Housing conditions (P)	5.1002	164.057	8.8831	3029.906	0.0006*
Community strength (S)	-5.0869	0.006	0.0001	0.2848	0.0093*
Skills (H)	1.5927	4.917	1.1622	20.803	0.0304*
Boats (P)	-1.5526	0.2117	0.0615	0.7283	0.0138*
Other resources (N)	2.7147	15.1	1.2746	178.895	0.0314*
Loans (F)	-0.4774	0.62	0.1139	3.3801	0.5809
Education (H)	2.9711	19.513	0.9183	414.653	0.0567
Resources (S)	5.0134	150.413	0.5515	41025.68	0.0798
Safe (S)	2.0951	8.126	0.1596	413.653	0.2961
Support (S)	0.4163	1.516	0.13	17.689	0.7398
Assets and market (P)	0.4231	1.527	0.3131	7.4452	0.6007
Health (H)	0.2566	1.293	0.1295	12.897	0.8269
Income (F)	0.9481	2.581	0.3083	21.601	0.3818
Fishery resources (N)	-2.6822	0.068	0.0027	1.7179	0.1029

(S) represents Social Capital, (P) represents Physical Capital, (F) represents Financial Capital, and (H) represents Human Capital, while (N) refers to Natural Capital

* *denotes* $p < 0.05$ indicates statistical significance

The application of the sustainable livelihoods approach to the shrimp fishery in the Jaffna lagoon reveals key livelihood strategies that fishers employ to mitigate poverty. Similar to small-scale fisheries worldwide, these strategies are shaped by the availability and interaction of livelihood capitals, such as natural, human, social, financial, and physical[4]. The findings indicate a strong dependence on social capital, with weak financial capital posing challenges to economic resilience. This pattern aligns with studies in other developing fisheries, such as those in Southeast Asia and West Africa, where fishers rely heavily on social networks and informal credit systems to sustain their livelihoods[31–33].

In the Jaffna lagoon, social capital is a crucial asset that enables fishers to cope with economic uncertainties. Safe conditions for living and fishing, community support, available resources, and strong community organizations provide essential support, mirroring the findings in Bangladesh and Indonesia, where collective action helps buffer against financial instability[34,35]. However, despite these strong social capitals, the financial capital of shrimp fishers remains weak. Low incomes, lack of savings, and high debt levels limit access to formal credit, restricting opportunities for economic growth. This challenge is widely observed in small-scale fisheries across developing countries, where fishers often experience unstable incomes and lack access to sufficient financial infrastructure[6,36,37].

Human capital is a critical factor in the livelihood resilience of fishers. In the Jaffna lagoon, fishers generally possess strong health conditions and good skills beyond fishing, which are essential for maintaining their livelihoods. However, a significant portion of the fishing population has low educational attainment, limiting their ability to transition into alternative employment outside the fisheries sector. Similar patterns have been observed in small-scale fisheries in India and Zimbabwe, where limited education reduces opportunities for livelihood diversification and economic resilience[38–41].

Physical capital in the Jaffna lagoon presents both opportunities and challenges. Approximately half of the fishers own boats and fishing gear, enabling them to actively engage in other fishing practices, including marine fisheries. However, inadequate housing conditions, limited essential assets, and weak market infrastructure restrict economic growth. The prolonged civil conflict resulted in extensive degradation of physical capital in the region[14]. Post-conflict reconstruction efforts by government agencies and non-governmental organizations have primarily focused on the restoration and provision of fishing vessels and gear, yielding measurable improvements in these domains. Nonetheless, housing conditions remain suboptimal, as a significant proportion of fishers continue to reside in incomplete brick houses, reflecting a lag in infrastructural recovery. This reflects the conditions in African fisheries, where poor access to landing sites, cold storage, and transportation networks constrains the profitability of fishers[42,43]. In contrast, small-scale fishers in Latin America have benefited from cooperative initiatives that improve infrastructure and market access[44].

Natural capital remains a crucial resource for the sustainability of livelihood. In the Jaffna lagoon, fish and shrimp resources are reported to be at moderate levels, however, other natural resources remain scarce, increasing the dependency of fishers on the lagoon fisheries. This situation is comparable to the Mekong Delta in Vietnam, where declining natural resources have intensified competition and overfishing[45]. However, cases from community-based fisheries management in the Philippines suggest that community-driven conservation efforts can improve resource availability, offering a potential pathway for sustainable fisheries management in the Jaffna lagoon[46].

The livelihoods of fishers in the Jaffna lagoon are intricately linked to poverty, as multiple vulnerabilities constrain economic stability and resilience. Economic shocks, including inflation, high living costs, and shortages of fuel and fishing gear, exacerbate financial insecurity,

reflecting broader patterns observed in small-scale fisheries where poverty traps limit economic mobility[47,48]. Declining catch rates, driven by overexploitation, climate change and habitat degradation, further reduce income potential, a phenomenon widely documented in coastal fisheries[49,50].

Climate change compounds these challenges by altering fish distribution, increasing salinity, and disrupting seasonal patterns, thereby reducing the adaptive capacity of fishers[51,52]. In the Jaffna lagoon, shrimp catches have been significantly affected by unpredictable seasonal variations. Extreme temperatures during April and May lead to reduced harvests, as shrimp, being ectothermic organisms, tend to avoid high-temperature waters, resulting in decreased catch rates. Literature indicates that such thermal stressors directly impact shrimp physiology, migration patterns, and availability[53].

Additionally, the increased frequency of strong winds, a consequence of climate change, has damaged fishing gear and led to higher maintenance and operational costs. These climatic uncertainties hinder fishers' ability to plan their fishing activities effectively. Additionally, illegal fishing, poaching, and aquaculture expansion restrict access to traditional fishing grounds, intensifying competition and resource conflicts[45]. These cumulative stressors reinforce livelihood vulnerability.

Lagoon shrimp fishers employ multiple strategies to cope with vulnerabilities, including intensification, diversification, migration, and erosive coping mechanisms. Among these, diversification is the most common, with many fishers shifting to marine fisheries due to their existing expertise. However, a lack of formal education and skills outside the fisheries sector limits their ability to transition into alternative livelihoods, forcing many to work as low-wage laborers during the off-season. Similar patterns have been observed in small-scale fisheries worldwide, where fishers struggle to diversify

beyond fisheries due to skill constraints and institutional barriers[38,54].

Agriculture and animal husbandry could offer alternative income sources, as seen in Indonesia, where fishers engage in seasonal farming[55]. Aquaculture and entrepreneurship remain underutilized due to high capital investment requirements, similar to the constraints observed in South and Southeast Asia, where only a fraction of fishers engage in aquaculture despite its potential for income stability[56,57].

Fishing intensification, often a short-term strategy, leads to resource depletion. This pattern is similar to findings in overfished regions such as the Philippines and Indonesia, where increased fishing effort results in declining catch rate (CPUE), trapping fishers in a cycle of poverty[35]. Migration is a widely adopted strategy in fisheries worldwide. In Bangladesh, for example, fishers seek employment in urban centers or abroad due to the decline of local fisheries[58].

Erosive coping strategies, such as child labor and forced female employment, though not widespread in the Jaffna lagoon, remain a concern. The protracted civil war in Sri Lanka severely disrupted livelihoods and social structures in the region, exacerbating poverty and vulnerability among fishing communities. The destruction of physical and social capital during the conflict limited economic opportunities, forcing some households to adopt short-term survival strategies that compromise long-term well-being, including the engagement of children in labor and the increased economic burden on women through forced employment. Similar trends have been reported in vulnerable fisheries-dependent communities in Africa and South Asia, where extreme poverty forces households to sacrifice long-term human capital for immediate survival[59].

It is evident that among the various adaptation strategies, aquaculture, agriculture, animal husbandry, and entrepreneurship offer greater livelihood resilience for fishers. These strategies provide alternative livelihood opportunities, reducing dependency on fishery resources and

enhancing economic stability. They not only mitigate environmental stress but also generate higher profits, allowing fishers to sustain their livelihoods. In contrast, erosive coping mechanisms, such as withdrawing children from education or forcing family members into low-paying labor, exacerbate vulnerability and contribute to long-term socio-economic instability[4].

Although livelihood strategies like aquaculture, agriculture, animal husbandry, and small-scale entrepreneurship were classified as relatively resilient, none of the respondents attained the designation of "highly resilient." This outcome stems from livelihood resilience being evaluated as the mean performance across all five livelihood capitals. For example, while aquaculture enhanced financial capital, it frequently involved trade-offs in other domains. Fishers reported declines in health due to additional labor demands, such as farm security responsibilities, indicating a reduction in human capital. These findings corroborate earlier study by Béné *et al.*[31], which emphasize that uneven improvements across livelihood capitals can undermine overall livelihood resilience.

The correlation analysis highlights multiple factors, such as housing conditions, assets, savings, access to resources, safety, community engagement, education, health, and skills, are positively linked to resilience of livelihood of shrimp fishers in the Jaffna lagoon. These factors collectively contribute to the ability of fishers to adapt to economic and environmental challenges.

Among them, savings, education, and skill development emerge as particularly critical components of resilience. Savings act as a financial buffer, enabling fishers to withstand economic shocks such as rising fuel costs, market fluctuations, and seasonal declines in catch. Higher savings also allow for investment in alternative income-generating activities like aquaculture or small-scale entrepreneurship, reducing dependence on overexploited marine resources.

Education plays a fundamental role in enhancing adaptive capacity. Fishers with higher educational attainment are more likely to access alternative employment opportunities outside the fisheries sector, reducing vulnerability to declining fish stocks[60,61]. Education also improves financial literacy, helping fishers to manage their income more effectively, avoid exploitative lending practices, and make informed decisions about investing in resilient livelihood strategies[62].

Skill development is equally vital. While many fishers have practical fishing skills, a lack of formal training limits their ability to transition into other economic sectors. Developing skills in aquaculture, boat repair, marketing, and sustainable fishing techniques can provide new income opportunities while minimizing environmental degradation[63]. Additionally, government or NGO-led capacity-building programs could strengthen fishers' ability to manage resources sustainably and engage in value-added fisheries-related businesses.

4.0 CONCLUSION

The research concludes that shrimp fishers in the Jaffna lagoon face significant vulnerabilities due to weak financial capital, low education, and limited access to alternative livelihoods. While social capital helps mitigate some challenges, the depletion of natural resources and economic instability exacerbate poverty. Strategies like diversification, migration, and intensification offer short-term relief but often lead to resource depletion. However, aquaculture, agriculture, and entrepreneurship show promise for enhancing livelihood resilience by reducing dependency on overexploited fisheries. Key interventions, including education, skill development, and savings, are essential for breaking the poverty cycle and improving adaptive capacity.

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