Available on: https://jnsrr.ep-journals.org/ E-ISSN: 3051-3766 P-ISSN: 3051-3758

Journal of Natural Science Research and Review

Volume: 02 Issue: 02 February-2026

Sustainable Resource Use Challenges, Resilience and Livelihood Outcome Among Artisanal Fishers in Lake Victoria, Siaya County

Samwel Aura Audi
School of Business Economics and Social Sciences (SBESS), Taita Taveta University

Dr. Christopher Masila
School of Business Economics and Social Sciences (SBESS), Taita Taveta University

Prof. Maurice Ogada
School of Business Economics and Social Sciences (SBESS), Taita Taveta University.

Published Date: February 23, 2026 **Article DOI: 10.65150/EP-jnsrr/V2E2/2026-03**

ABSTRACT: Purpose of the Study: This study examined how sustainable resource use challenges influence livelihoods among artisanal fishers in Siaya County, Lake Victoria, with particular attention to the mediating role of household resilience.

Problem Statement: Despite ongoing fisheries management interventions, artisanal fishers continue to experience declining stocks, weak governance, and livelihood insecurity. Limited site-specific evidence and inadequate integration of ecological, institutional, and socio-economic dimensions constrain effective policy responses.

Methodology: Guided by the Sustainable Livelihoods Framework and Tragedy of the Commons Theory, the study adopted a mixed-methods design. Quantitative data were collected from 396 fishers, traders, and Beach Management Unit officials using structured questionnaires, complemented by qualitative key informant interviews. Data were analysed in SPSS using descriptive statistics, multiple regression, and mediation analysis to estimate both direct effects of ecological and governance pressures on livelihoods and indirect effects transmitted through household resilience.

Results: Findings revealed that overfishing and destructive gears, environmental degradation and climate change, and weak governance exerted significant negative effects on household livelihood outcomes. Mediation analysis showed that fishers' resilience partially mediated these relationships, indicating that adaptive strategies buffered, but did not fully offset the ecological and institutional stressors. Qualitative evidence highlighted enforcement gaps, limited livelihood alternatives, and uneven institutional support at landing sites.

Conclusion and Policy Recommendations: The study concludes that sustainable livelihoods in small-scale fisheries require integrated interventions addressing ecological sustainability, governance effectiveness, and household adaptive capacity. Policy actions should strengthen fisheries enforcement, promote participatory co-management, and expand livelihood diversification and resilience-building programmes to enhance long-term sustainability.

KEYWORDS: Sustainable resource use, Artisanal fisheries, Livelihood resilience, Socio-ecological systems, Lake Victoria Fisheries

INTRODUCTION

Freshwater ecosystems across the world are increasingly under pressure from overexploitation, pollution, weak governance arrangements, and climate change, resulting in declining fish stocks and widespread degradation of aquatic habitats. These pressures have undermined the ecological integrity of inland fisheries and raised concerns about their long-term sustainability (Kimani et al., 2018). Global assessments indicate that inland fisheries are among the most threatened food systems, yet they remain critical for nutrition, employment, and poverty alleviation, particularly in developing regions (FAO, 2022). Overfishing and habitat degradation have significantly reduced biodiversity and weakened ecosystem resilience, while climate-induced changes in temperature and hydrological regimes have further disrupted fish productivity and distribution (Reid et al., 2019). Small-scale and artisanal fishing communities are especially vulnerable to these dynamics because they rely directly on local ecosystems and often operate with limited access to capital, technology, and institutional support (Pauly & Zeller, 2017; FAO, 2022).

At the regional level, inland fisheries in Africa play a central role in food security and rural livelihoods, yet they face acute sustainability challenges. Small-scale fisheries support millions of households across the continent, but governance weaknesses, open-access exploitation, and limited enforcement capacity have accelerated resource depletion (Béné et al., 2018). Environmental degradation and climate variability have further intensified pressure on African freshwater systems, leading to altered breeding cycles, declining catches, and increased livelihood vulnerability among fishing households (Obiero et al., 2019). Studies across major African lakes indicate that conventional fisheries management approaches

License: This is an open access article under the CC BY 4.0 license: https://creativecommons.org/licenses/by/4.0/

often fail to account for local socio-economic realities, resulting in low compliance and persistent illegal fishing practices (Kolding et al., 2019). Consequently, African inland fisheries are increasingly characterized by ecological decline, livelihood insecurity, and governance constraints that threaten both sustainability and social welfare.

In Kenya, Lake Victoria contributes over 60% of national fish production (Kenya Fisheries Service, 2021), yet its ecological condition has deteriorated markedly. Declining native biodiversity, habitat degradation, pollution, and climate variability have disrupted fish stocks and fishing patterns (Njiru et al., 2021; Nyamweya et al., 2020; Omweno et al., 2024). These ecological pressures have translated into reduced incomes, food insecurity, and intensified competition among artisanal fishers (Kwena et al., 2020). Despite governance interventions such as Beach Management Units and regional fisheries management plans, enforcement gaps and institutional constraints persist (Ogutu-Ohwayo et al., 2018; Odende et al., 2022). Within this broader context, Siaya County which is located along the Kenyan shoreline of Lake Victoria, represents a localized manifestation of global, regional, and national fisheries challenges. The county's riparian communities are heavily dependent on artisanal fishing and small-scale agriculture for income and subsistence, yet they face declining fish stocks, inadequate landing-site infrastructure, weak enforcement of fisheries regulations, and limited alternative livelihood opportunities (Siaya County Government, 2018). Studies conducted along the Siaya shoreline, report widespread use of illegal fishing gears, increasing environmental degradation, and persistent governance weaknesses at Beach Management Unit level (Aura et al., 2019; Omweno et al., 2024). Despite the existing studies having documented these challenges, limited empirical attention has been given to how ecological pressures and governance constraints jointly influence household livelihood outcomes at the county level, particularly the role of resilience in mediating these effects.

This study addresses this gap by examining sustainable resource use challenges in Siaya County and their effects on artisanal fishers' livelihoods, conceptualizing resilience as a mediating mechanism. By generating site-specific empirical evidence and integrating ecological, governance, and socio-economic dimensions, the study seeks to inform policy and practice aimed at strengthening sustainable fisheries management while enhancing the adaptive capacity and livelihood resilience of riparian fishing communities

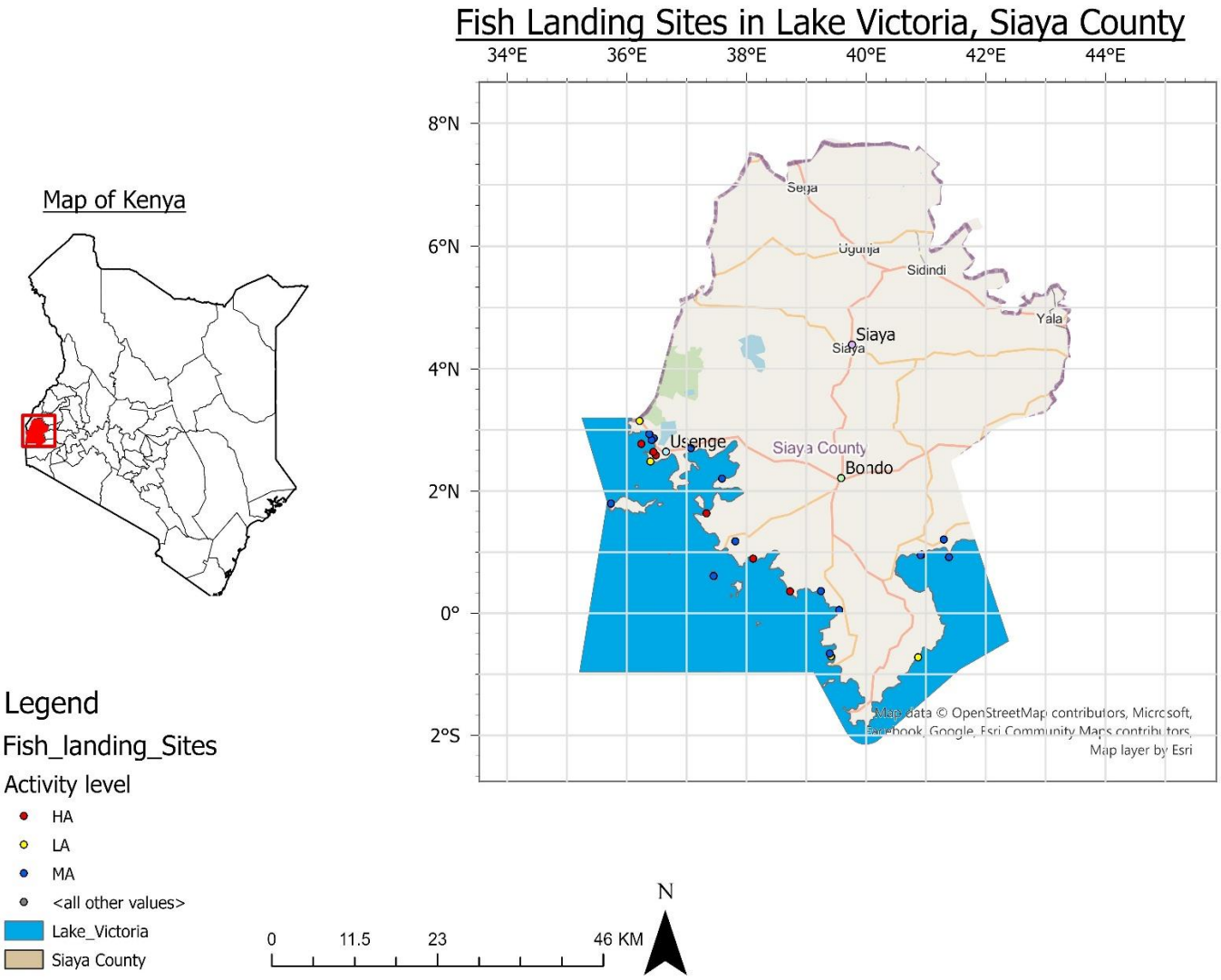


Figure 1: Geographic Location of the Landing Sites

Statement of the Problem

Freshwater fisheries are critical for food security and livelihoods, yet artisanal fishers in Siaya County, Kenya, persistently face escalating ecological, socio-economic, and governance challenges. Overfishing driven by rising demand, population pressure, and the use of illegal gear has

License: This is an open access article under the CC BY 4.0 license: https://creativecommons.org/licenses/by/4.0/

depleted commercially important fish stocks, undermining biodiversity and ecosystem resilience (Aura et al., 2020; Njiru et al., 2021). Simultaneously, environmental degradation, through agricultural runoff, urban effluents, shoreline encroachment, and sedimentation, has disrupted breeding habitats and reduced water quality (Onyango et al., 2022). Climate variability, including erratic rainfall, rising temperatures, and extreme weather events, further destabilizes traditional fishing calendars and fish distribution patterns (Fiorella et al., 2024). Socio-economic vulnerabilities, such as limited access to financial services, weak market integration, and constrained livelihood diversification, exacerbate household fragility and marginalization (World Bank, 2022).

Despite extensive research on Lake Victoria's fisheries, critical gaps persist. A paradox remains whereby regulatory reforms and co-management approaches are widely promoted, yet ecological degradation and livelihood vulnerability continue, suggesting weak enforcement and limited alignment with local socio-economic realities (Aura et al., 2020). Conceptually, most studies examine ecological processes or livelihood outcomes in isolation, with limited attention to resilience as a mediating mechanism linking resource-use pressures to fisher wellbeing (Fiorella et al., 2024). Methodologically, prior work relies largely on either ecological assessments or household surveys, constraining integrated analysis of biophysical change and lived experience (Onyango et al., 2022). Contextually, Siaya County remains under-studied despite its heavy dependence on artisanal fisheries, uneven regulatory enforcement, and inadequate landing infrastructure (Siaya County Government, 2018). Collectively, these gaps highlight the need for place-based, mixed-methods research that explicitly links sustainable resource use challenges, resilience, and livelihood outcomes.

Research Objectives

To evaluate the relationship between sustainable resource use challenges and livelihood outcome among artisanal fishers in Siaya County, Lake Victoria, Kenya.

Research Hypothesis

H_0: Sustainable resource use challenges have no statistically significant effect on the livelihood outcome of artisanal fishers in Lake Victoria, Siaya County.

THEORETICAL FRAMEWORK

The Tragedy of the Commons Theory, introduced by Garrett Hardin (1968), explains how individually rational behavior under open-access conditions leads to collective resource depletion, particularly where regulation is weak. In fisheries, this dynamic manifests through overexploitation of shared stocks. However, subsequent scholarship has challenged Hardin's deterministic assumptions, demonstrating that local communities can establish collective norms and participatory institutions that support sustainable resource management (Ostrom, 1990; Béné et al., 2009). Critics further note that the theory underplays external drivers such as market pressures, policy failures, and governance fragmentation (FAO, 2016). In this study, the theory provides a foundational lens for interpreting overfishing in Lake Victoria, while being complemented by governance and community-based perspectives to better capture institutional influences and pathways toward sustainable resource stewardship.

The Sustainable Livelihoods Framework (SLF), developed by Chambers and Conway (1992), explains how households mobilize five forms of capital; human, natural, financial, social, and physical, within broader institutional and policy contexts to pursue livelihood strategies under vulnerability. The framework emphasizes that sustainable livelihoods are those that can cope with shocks, maintain productivity, and enhance well-being without degrading the natural resource base. In small-scale fisheries, SLF provides an integrated lens for examining how access to resources, markets, and social networks shapes household adaptation and livelihood outcomes.

Despite its widespread application, the SLF has been critiqued for its limited attention to power relations, inequality, and macro-level political–economic forces that constrain asset access and livelihood choices. Scholars also note that structural barriers, such as gender disparities, weak governance, and market distortions, are often underrepresented in SLF analyses (Béné et al., 2016).

In this study, the SLF informs the livelihoods dimension by linking sustainable resource use challenges and resilience to household welfare among artisanal fishers. Its people-centred and multidimensional approach enables assessment of how ecological pressures and institutional conditions interact to shape adaptive capacity and livelihood sustainability.

Resilience Theory, originating from Holling (1973), explains how social-ecological systems absorb disturbances, adapt, and reorganize while maintaining essential functions. In small-scale fisheries, resilience reflects the capacity of communities to respond to pressures such as resource depletion, climate variability, and economic shocks through learning, flexibility, and livelihood adaptation (Béné et al., 2016). Contemporary applications emphasize adaptive capacity and transformation, highlighting that resilience involves not only persistence but also structural change toward sustainability. Recent critiques note that resilience frameworks may understate power relations, equity, and governance dynamics, potentially shifting responsibility for adaptation onto vulnerable communities (Brown, 2014; Tanner et al., 2015). Consequently, current scholarship integrates social dimensions, stressing that institutional support and collective action are central to building equitable resilience. In this study, Resilience Theory informs the mediating mechanism by explaining how adaptive strategies and social organization partially transmit the effects of resource-use pressures to livelihood outcomes.

EMPIRICAL REVIEW

The utilization of natural resources remains central to sustaining the livelihoods of artisanal fishers in Lake Victoria, yet ecological degradation and resource competition continue to threaten the sector's sustainability. Nyboer et al. (2022) examined climate change adaptation strategies among fishing households in the Lake Victoria Basin of Kenya and Uganda, documenting coping mechanisms such as increasing fishing effort, migrating, and targeting alternative species. While these approaches provide short-term relief, the study observed that they often exacerbate ecological decline, with livelihood diversification outside the fisheries sector proving more sustainable. However, the authors note a gap in linking these adaptive strategies with broader governance frameworks. Complementing this, Magego, Obel, and Kinaro (2021) investigated livelihood coping strategies among artisanal fishing households along the Kenyan shores of Lake Victoria. Using household surveys and qualitative interviews, the study found

License: This is an open access article under the CC BY 4.0 license: https://creativecommons.org/licenses/by/4.0/

that fisher's resort to diversified activities, including subsistence farming, sand harvesting, wage labor, and small-scale trade. While such strategies mitigate income shocks, the findings underscore a vulnerability trap, as most remain dependent on fishing and face limited access to formal safety nets. The study leaves unexplored the predictive strength of specific ecological pressures, such as declining stocks and post-harvest losses on household livelihoods. From a governance perspective, Tubman, Muigua, and Muthama (2021) evaluated the performance of Beach Management Units (BMUs) on Migingo Island. They found that while BMUs effectively managed revenue collection and gear confiscation, their weak structures and inequitable representation limited their ability to enforce by-laws or address ecological decline. These governance gaps have direct implications for resource use but the study did not extend to how they translate into household livelihood outcomes.

Overfishing and destructive fishing practices are among the most significant threats to the sustainability of Lake Victoria's fisheries and the livelihoods of artisanal fishers. Odoli et al. (2019) investigated fishing pressure in the Kenyan waters of Lake Victoria, employing household surveys and catch data analysis. The study revealed that high population density and rising demand for fish have intensified exploitation, with economic vulnerability driving fishers to use illegal gear such as beach seines and undersized nets. While the study highlighted ecological impacts, it provided limited insight into household-level socio-economic consequences. Aura et al. (2020) assessed the ecological effects of destructive fishing gear in Kenya, using field sampling and gear-use surveys. Findings indicated that small-mesh gillnets and mosquito nets capture juvenile fish and damage breeding grounds, accelerating stock depletion. Although the study documented ecological harm, it offered limited understanding of the socio-economic pressures compelling fishers in resource-constrained areas like Siaya County. Ogwang, Odongkara, and Luswata (2021) examined illegal, unreported, and unregulated (IUU) fishing across Lake Victoria using cross-country data and stakeholder interviews. The study identified weak enforcement, corruption, and inconsistent regulations among Kenya, Uganda, and Tanzania as enabling widespread IUU fishing. While governance barriers were well-documented, the research did not explore the localized implications for artisanal fishers' livelihoods.

Environmental degradation and wetland loss constitute major threats to the ecological integrity and fishery productivity of Lake Victoria. In Siaya County, these pressures are driven by deforestation, wetland reclamation, agricultural encroachment, and increasing pollution. Aura et al. (2020) employed ecological surveys and fisher interviews in Kenyan riparian counties to show that wetland reclamation for agriculture and settlement significantly reduced nursery habitats for Nile perch and tilapia, thereby lowering fish recruitment. The study highlighted weak regulatory enforcement as a key driver but offered limited insight into socio-economic impacts on local livelihoods. Climate change constitutes a significant barrier to the sustainable utilization of Lake Victoria's resources, with increasing rainfall variability, rising surface water temperatures, and frequent extreme weather events disrupting ecological balance and threatening artisanal fishing livelihoods. Aura et al. (2020) employed household surveys and ecological monitoring across Kenyan riparian communities to show that irregular rainfall and prolonged droughts reduced fish breeding habitats and altered seasonal fish availability. Fishers reported heightened vulnerability to storms, lightning strikes, and capsizing, particularly among non-motorized boats, illustrating the direct erosion of income stability and food security. However, the study provided limited insights into adaptive livelihood strategies beyond fishing.

Effective governance and coherent policy frameworks are critical for sustainable resource management in Lake Victoria. However, persistent institutional and policy gaps, weak enforcement mechanisms, and limited integration of scientific evidence undermine these efforts. Ogwang et al. (2021) analysed regional fisheries governance across Kenya, Uganda, and Tanzania through policy document reviews and key informant interviews. The study found that fragmented enforcement, overlapping agency mandates, and inconsistent regulations facilitated widespread illegal, unreported, and unregulated (IUU) fishing. While highlighting the need for strengthened transboundary institutions, the research did not examine localized governance challenges at artisanal landing sites. Sambuo et al. (2021) evaluated institutional weaknesses in fisheries markets and governance structures using household surveys and policy analysis. Findings revealed that weak institutional oversight allowed middlemen to exploit artisanal fishers, reinforcing unsustainable fishing practices and depressed incomes. The study underscored gaps in regulating markets and pricing systems but did not consider how local governance reforms, particularly through Beach Management Units (BMUs), could enhance fisher empowerment.

Together, these studies reveal a pattern of adaptation and diversification among artisanal fishers in Lake Victoria, with significant attention given to resource use practices, governance structures, and emerging alternatives. However, gaps remain in quantifying the direct impacts of ecological challenges on livelihood outcomes in Siaya County and in linking governance reforms with household resilience. The present study addressed critical gaps in understanding the socio-ecological dynamics of artisanal fisheries in Siaya County by integrating ecological, governance, and resilience perspectives. It examined the effects of overfishing and destructive fishing gear on household income, food security, and fishing productivity through structured surveys and key informant interviews, linking localized resource-use pressures to livelihood outcomes. The study also explored the impacts of environmental degradation and climate variability on fishing households, quantifying ecological stressors and their socio-economic consequences. Governance effectiveness was evaluated at landing-site level by assessing leadership capacity, enforcement practices, and gender-inclusive decision-making within Beach Management Units, providing insight into institutional strengths and limitations. Furthermore, both immediate coping mechanisms and long-term adaptive strategies were analyzed to assess the resilience of artisanal fishers, highlighting how adaptive capacity mediates the relationship between resource-use challenges and livelihood outcomes. This integrated approach generates site-specific empirical evidence to inform sustainable fisheries management and resilience-building interventions.

CONCEPTUAL FRAMEWORK

The conceptual framework contained three components; Resource use pressures (independent variables), Resilience (mediating variable) and livelihood outcome (dependent variable).

License: This is an open access article under the CC BY 4.0 license: https://creativecommons.org/licenses/by/4.0/

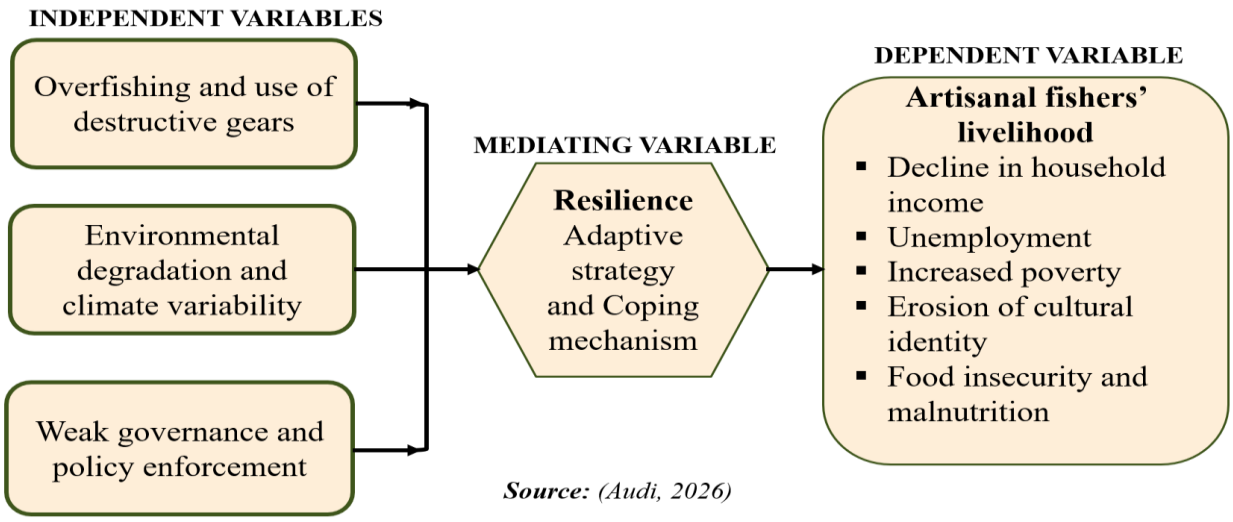


Figure 2: Conceptual framework

RESEARCH METHODOLOGY

This study employed a descriptive cross-sectional research design to examine the interactions between sustainable resource use challenges, governance, resilience, and the livelihoods of artisanal fishers in Siaya County, Kenya. The design was appropriate because it allowed for simultaneous collection of quantitative and qualitative data, providing a comprehensive snapshot of existing practices, perceptions, and socio-ecological dynamics (Creswell & Creswell, 2018; Kothari, 2014). The target population comprised approximately 38,000 artisanal fishers and fisheries-dependent actors operating across 25 geo-referenced landing sites in Bondo and Rarieda sub-counties, including fish traders, processors, gear owners, and Beach Management Unit (BMU) officials (State Department for Fisheries, Aquaculture and the Blue Economy, 2020). A census-of-sites approach was applied to include all 25 landing sites, with stratified random sampling within each site to ensure representation of the three main stakeholder groups (Fishers, Fish traders and Beach officials). Sample size was determined using Yamane's (1967) formula at 95% confidence and 5% margin of error, yielding 396 respondents.

Data were collected through triangulated instruments, including structured questionnaires featuring both closed and Likert scale items for quantitative data, key informant interviews (KIIs) with BMU officials and community leaders, and structured observation checklists documenting landing site infrastructure and environmental conditions. Questionnaires were administered face-to-face, while KIIs were conducted in English or Luo, with notes and audio recordings captured with consent. Quantitative data were analyzed using SPSS v.22, to generate descriptive and inferential statistics enabling the study to establish meaningful patterns and relationship among key variables. Mediation analysis was conducted using PROCESS Model 4 (Hayes, 2022) to examine the mediating role of fishers' resilience in the relationship between resource use challenges and livelihood outcomes. Qualitative data from KIIs and observations were thematically analyzed and triangulated with survey findings to ensure credibility and comprehensive interpretation (Creswell & Creswell, 2018).

RESULTS AND DISCUSSION

This chapter presents the results and discussions of the reliability tests, descriptive statistics, correlation analysis, regression analyses, mediation analyses and ANOVA test to explain how sustainable resource use challenges influence the livelihood outcome of artisanal fishers in Lake Victoria, Siaya county. The analysis is based on data obtained from 396 valid questionnaires issued to respondents within the 25 geo-referenced landing sites.

Reliability Test

Table1: Case Processing Summary (Reliability test)

Cronbach's Alpha	N of Items
.936	5

The reliability test results in the table above show that the research instrument achieved a Cronbach's Alpha of 0.936, which falls within the "good" reliability range (≥0.8), indicating strong internal consistency. The instrument was therefore considered reliable and consistent.

Descriptive statistics

The descriptive statistics provide a summary of the key variables analyzed in this study, Overfishing and use of destructive gears, environmental degradation and climate variability, Weak governance and policy enforcement, resilience and artisanal fishers' livelihoods. These statistics help to describe the general trends, variability, and distribution of responses collected from the 396 participants. The mean and standard deviation values offer insights into the central tendency and consistency of responses, forming the foundation for subsequent correlation and regression analyses.

License: This is an open access article under the CC BY 4.0 license: https://creativecommons.org/licenses/by/4.0/

Table 2: Case Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Fisherfolk Livelihoods	396	2.50	5.00	3.9752	.72457
Overfishing and Use of Destructive Gears	396	2.55	5.00	3.9773	.67484
Environmental Degradation and Climate Change	396	2.64	5.00	3.9715	.69045
Governance Frameworks, Institutions, And Policy Enforcement	396	2.82	5.00	3.8726	.58865
Fishers' Resilience, Adaptive Strategies, And Coping Mechanisms	396	2.70	5.00	3.9779	.70908
Valid N (listwise)	396				

The descriptive results indicated that the mean score for adoption, the mean score for fisherfolk livelihoods was 3.98 (SD = 0.72), indicating a moderate level of livelihood outcomes among the respondents. Overfishing and use of destructive gears recorded a mean of 3.98 (SD = 0.67), while environmental degradation and climate change had a mean of 3.97 (SD = 0.69), suggesting that these sustainable resource use challenges were widely perceived as significant. Governance frameworks, institutions, and policy enforcement recorded a slightly lower mean of 3.87 (SD = 0.59), indicating a moderate perception of governance effectiveness in fisheries management. Fishers' resilience, adaptive strategies, and coping mechanisms recorded a mean of 3.98 (SD = 0.71), reflecting relatively high levels of resilience among the respondents.

Pearson Correlation Analysis

The correlation analysis directly supports the general objective of evaluate the relationship between sustainable resource use challenges and livelihood outcome. It helped to examine if there was correlation between the dependent and independent variables.

Table 3: Correlation matrix

		Fisherfolk Livelihoods	Overfishing and Use of Destructive Gears	Environmental Degradation and Climate Change	Governance Frameworks, Institutions, And Policy Enforcement	Fishers' Resilience, Adaptive Strategies, And Coping Mechanisms
Fisherfolk Livelihoods	Pearson Correlation	1				
Overfishing and Use of Destructive Gears	Pearson Correlation	.788**	1			
	Sig. (2-tailed)	.000				
Environmental Degradation and Climate Change	Pearson Correlation	.806**	.829**	1		
	Sig. (2-tailed)	.000	.000			
Governance Frameworks, Institutions, And Policy Enforcement	Pearson Correlation	.678**	.665**	.699**	1	
	Sig. (2-tailed)	.000	.000	.000		
Fishers' Resilience, Adaptive Strategies, And Coping Mechanisms	Pearson Correlation	.768**	.765**	.771**	.675**	1
	Sig. (2-tailed)	.000	.000	.000	.000	

**. Correlation is significant at the 0.05 level (2-tailed).

b. Listwise N=396

The results showed that overfishing and use of destructive gears was strongly positively correlated with livelihoods (r = 0.788), environmental degradation and climate change also showed a strong positive correlation (r = 0.806), governance frameworks, institutions, and policy enforcement had a moderate positive correlation (r = 0.678), and fishers' resilience, adaptive strategies, and coping mechanisms was strongly correlated with livelihoods (r = 0.768). All correlations were statistically significant, with p-values less than 0.05 at the 95% confidence level, indicating that these relationships were unlikely to have occurred by chance. The consistently low p-values across all variables confirmed the robustness and reliability of these correlations, indicating that ecological pressures, governance, and fishers' resilience were significantly associated with the livelihoods of artisanal fishers in Siaya County, highlighting the important role of sustainable resource management, institutional effectiveness, and adaptive strategies in supporting livelihood outcomes.

Regression Analysis

The regression results were summarized in the model summary, ANOVA table and regression coefficients to jointly demonstrate the significance of the study variables included in the regression model.

License: This is an open access article under the CC BY 4.0 license: https://creativecommons.org/licenses/by/4.0/

Table 4: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.842[a]	.709	.707	.39241	.709	318.236	3	392	.000

a. Predictors: (Constant), Governance Frameworks, Institutions, And Policy Enforcement, Overfishing and Use of Destructive Gears, Environmental Degradation and Climate Change

The multiple regression analysis indicated a strong positive relationship between the independent variables and fisherfolk livelihoods, with a multiple correlation coefficient of R = 0.842. The model explained a substantial proportion of the variance in livelihoods, with $R^2 = 0.709$. This means that approximately 70.9% of the variation in fisherfolk livelihoods was accounted for by overfishing and use of destructive gears, environmental degradation and climate change, governance frameworks, institutions, and policy enforcement, and fishers' resilience. The high F-value of 318.236 indicates that the regression model was statistically significant, showing that the predictors collectively provide a reliable explanation of the variation in fisherfolk livelihoods.

Table 5: Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.032	.138		.235	.814
	Overfishing and Use of Destructive Gears	.361	.054	.337	6.751	.000
	Environmental Degradation and Climate Change	.431	.055	.410	7.883	.000
	Governance Frameworks, Institutions, And Policy Enforcement	.205	.048	.167	4.274	.000

a. Dependent Variable: Fisherfolk Livelihoods

The regression coefficients show the impact of each predictor on fisherfolk livelihoods. For every one-unit increase in overfishing and use of destructive gears, fisherfolk livelihoods increased by 0.271 units, indicating that higher levels of destructive fishing practices substantially affect livelihood outcomes. A one-unit increase in environmental degradation and climate change corresponded to a 0.343 unit increase in livelihoods. For governance frameworks, institutions, and policy enforcement, a one-unit rise was associated with a 0.143-unit increase in livelihoods, reflecting that improvements in governance moderately enhance livelihood conditions. Finally, a one-unit increase in fishers' resilience, adaptive strategies, and coping mechanisms led to a 0.250-unit increase in livelihoods, emphasizing the role of resilience in supporting livelihood outcomes. All predictors were statistically significant ($p < 0.05$), confirming the reliability of these effects at the 95% confidence level.

Table 6: ANOVA test

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	147.015	3	49.005	318.236	.000[b]
	Residual	60.364	392	.154		
	Total	207.378	395			

a. Dependent Variable: Fisherfolk Livelihoods

b. Predictors: (Constant), Governance Frameworks, Institutions, And Policy Enforcement, Overfishing and Use of Destructive Gears, Environmental Degradation and Climate Change

ANOVA is done in regression analysis to test whether the overall regression model is statistically significant, that is, to determine if the independent variables collectively have a meaningful effect on the dependent variable. The variation explained by the regression sum of squares (Regression SS = 151.144) was substantially higher than the unexplained variation in the residuals sum of squares (Residual SS = 56.234), reflecting a strong fit of the model. The F-value of 262.727 shows that the model was highly significant, while the significance level ($p = 0.000$) demonstrates the statistical significance of the predictors in explaining the variation in fisherfolk livelihoods.

Mediation Analysis

The analysis was performed through regression analysis using PROCESS Model 4 by Hayes (2022), which tests whether the effect of each independent variable; overfishing and use of destructive gears (X_1), environmental degradation and climate change (X_2), governance frameworks, institutions, and policy enforcement (X_3) on livelihoods occurs directly or indirectly through fishers' resilience (M), while controlling for the other predictors/covariates.

License: This is an open access article under the CC BY 4.0 license: https://creativecommons.org/licenses/by/4.0/

In the X1 → M → Y pathway, overfishing had a direct effect on livelihoods (B = 0.271, p < 0.05), and the indirect effect through resilience was 0.090 (95% CI: 0.041 to 0.150). For the X2 → M → Y pathway, environmental degradation had a direct effect (B = 0.343, p < 0.05), with an indirect effect through resilience of 0.088 (95% CI: 0.044 to 0.140). In the X3 → M → Y pathway, governance had a direct effect on livelihoods (B = 0.143, p < 0.05), with an indirect effect through resilience of 0.062 (95% CI: 0.026 to 0.105). The substitution of the direct effect values in the initial mediation model produced a resultant joint mediation model; $\mathbf{Y = -0.013 + 0.271X_1 + 0.343X_2 + 0.143X_3 + 0.250M + \mathcal{E}}$. These findings show that fishers' resilience (M) had statistically significant partial mediation effects, with both direct and indirect effects of overfishing, environmental degradation, and governance on livelihoods being significant, indicating that a portion of each predictor's influence operates through resilience.

Qualitative Data Analysis

Qualitative data were analyzed manually using a thematic analysis approach to identify key patterns related to sustainable resource use challenges, governance conditions, resilience and livelihood outcomes among artisanal fishers in Siaya County. Audio-recorded interviews and field notes were first transcribed verbatim and read repeatedly to achieve familiarity with the data. Consistent with the statistical analysis, respondents identified overfishing, the use of illegal gears, environmental degradation, and climate variability as major stressors contributing to declining fish stocks, reduced catches, and increasing income instability. *As one fisher observed, "nowadays we go to the lake very early and come back late, but the catch is very little compared to the past," adding that "too many people are fishing and many are using illegal nets that catch even small fish."* The increasing number of fishers and fishing vessels was perceived to intensify competition for limited resources, resulting in reduced catch per unit effort and declining incomes.

Governance and institutional factors emerged as critical determinants of both resource sustainability and livelihood outcomes. Weak enforcement of fisheries regulations, limited institutional capacity, and perceived corruption were reported to enable the persistence of illegal fishing practices and undermine compliance with conservation measures. *As was elaborated by a BMU official, "The laws are there, but enforcement is weak. Some people continue using illegal nets because they know they can escape or bribe their way out."* Such governance failures were viewed as accelerating resource depletion and disadvantaging compliant fishers, thereby reinforcing livelihood insecurity.

The qualitative evidence also supports the mediating role of resilience identified in the quantitative analysis. Fishers adopted a range of adaptive strategies and coping mechanisms, including livelihood diversification, adjustment of fishing practices, reliance on social networks, and participation in community-based initiatives. *One respondent noted that, "If fishing fails, I have nothing else to depend on. I would like to do business, but I don't have capital."* This indicated that households with stronger adaptive capacity demonstrated greater ability to buffer livelihood shocks and recover from environmental and economic stressors. However, respondents emphasized that household-level resilience remains limited in the absence of effective governance frameworks and institutional support.

CONCLUSION

The study demonstrates that sustainable resource use challenges are key determinants of livelihood outcomes among artisanal fishers in Siaya County. Overfishing, use of destructive gears, environmental degradation, climate variability, and weak governance significantly undermine fishing productivity, income stability, and household welfare. Governance frameworks, though influential, exert a comparatively weaker effect due to persistent institutional weaknesses and limited enforcement capacity.

Fishers' resilience was found to partially mediate the adverse effects of ecological and governance pressures. While adaptive strategies and coping mechanisms enhance recovery capacity and reduce vulnerability, they are insufficient to fully offset the impacts of unsustainable resource use and weak institutional support. This underscores the need for integrated interventions addressing ecological sustainability, governance effectiveness, and household adaptive capacity simultaneously (Béné, Arthur, & Kelman, 2021; Wilson, Kaunda, & Chirwa, 2023). The study contributes theoretically and empirically by integrating the Sustainable Livelihoods Framework with the Tragedy of the Commons Theory, providing site-specific evidence on how ecological, institutional, and socio-economic factors interact to shape livelihood outcomes. Mediation analysis offers novel insights into how resilience buffers, but does not fully mitigate, the negative impacts of resource depletion and weak governance, filling gaps in localized fisheries research.

Policy implications include the need for regulations that balance ecological sustainability with socio-economic needs, promotion of household adaptive capacity through livelihood diversification, access to credit, training, and social protection, and strengthening of institutional enforcement (Asiedu, Mwangi, & Gitau, 2020; Munyoki, Njiru, & Ochieng, 2021). Practically, the findings inform fisheries managers, community organizations, and BMUs to design targeted interventions, such as sustainable fishing practices, community-based monitoring, and resilience-building programs, that enhance both resource sustainability and household well-being (Kolding, van Zwieten, & Mkumbo, 2019). Future research could explore longitudinal and comparative analyses across riparian counties, investigate gendered dimensions of resilience, and evaluate the long-term effectiveness of integrated ecological and socio-economic interventions in small-scale fisheries.

RECOMMENDATIONS

Based on the study's findings, integrated policy and managerial interventions are essential to enhance artisanal fishers' livelihoods and resource sustainability in Siaya County. The study recommends strengthening fisheries governance through consistent enforcement of regulations, reducing corruption, and investing in monitoring, control, and surveillance systems. Policies should also promote participatory co-management by empowering Beach Management Units (BMUs) and ensuring fisher involvement in planning and decision-making. Climate adaptation measures, such as habitat protection, early warning systems, and climate-resilient fishing practices, should be integrated. Expanding social protection and livelihood support; affordable credit, insurance, and alternative livelihood financing, can reduce economic vulnerability and incentivize compliance with conservation measures.

License: This is an open access article under the CC BY 4.0 license: https://creativecommons.org/licenses/by/4.0/

For Managerial, the study recommends education and awareness programs on sustainable fishing, and the long-term impacts of destructive practices, reinforced through community-based monitoring and peer enforcement. Managers should promote livelihood diversification via vocational training, aquaculture, microfinance, value addition, and small-scale enterprise support. Improving market infrastructure, including storage, transport, and cooperative marketing, will enhance income stability. Community resilience should be strengthened through savings groups, cooperatives, social safety nets, and skills development, reflecting the partial but critical mediating role of resilience in buffering environmental and governance pressures.

REFFERENCES

1) Allison, E. H., & Ellis, F. (2021). The livelihoods approach and management of small-scale fisheries. *Marine Policy, 132*, 104689.
2) Anyango, S. F. (2021). *Incentivizing Private Landowners for the Sustainable Management of Wetlands in Kenya: a Case of Nyando Wetland* (Doctoral dissertation, UON).
3) Asiedu, A., Mwangi, P., & Gitau, J. (2020). Governance and livelihood vulnerability in small-scale fisheries: Evidence from East Africa. *Marine Policy, 118*, 103980. https://doi.org/10.1016/j.marpol.2020.103980
4) Aura, C. M., Nyamweya, C. S., & Masese, F. O. (2020). *Enhancing the management of Lake Victoria fisheries resources*. Nebraska Cooperative Fish and Wildlife Research Unit.
5) Awange, J. (2021). *Lake Victoria monitored from space* (pp. 1-321). Berlin/Heidelberg, Germany: Springer.
6) Béné, C., Barange, M., Subasinghe, R., Pinstrup-Andersen, P., Merino, G., Hemre, G. I., & Williams, M. (2018). Feeding 9 billion by 2050 – Putting fish back on the menu. *Food Security, 10*(4), 921–934. https://doi.org/10.1007/s12571-018-0812-6
7) Chambers, R., & Conway, G. (1992). Sustainable rural livelihoods: Practical concepts for the 21st century. *Institute of Development Studies Discussion Paper 296*. University of Sussex.
8) *Development in Practice, 30*(2), 237–247. Economic implications for artisanal fishers in Lake Victoria, Kenya. *Fisheries Research, 229*, 105594.
9) Fiorella, K. J., Aura, C. M., & Omweno, J. (2024). Climate variability and adaptive strategies of fishing households in the Lake Victoria Basin. *Climatic Change, 173*(1-2), 15–32.
10) Food and Agriculture Organization (FAO). (2022). *The State of World Fisheries and Aquaculture* governance structures in East Africa. *World Development Perspectives, 21*, 100286.
11) Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). *Multivariate data analysis* (8th ed.). Cengage Learning
12) Hardin, G. (1968). The tragedy of the commons: the population problem has no technical solution; it requires a fundamental extension in morality. *science*, *162*(3859), 1243-1248.
13) Hayes, A. F. (2022). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach* (3rd ed.). Guilford Press.
14) Holling, C. S. (1973, November). *Resilience and stability of ecological systems*.
15) InfoNile. (2022). *Illegal fishing and the struggle for sustainability in Lake Victoria*. InfoNile institutional support, and adaptive capacity of artisanal fisherfolk in Siaya County, Kenya. *Environment, Development and Sustainability, 25*(12), 11875–11894.
16) Kenya National Bureau of Statistics. (2020). *Kenya economic survey 2020*. https://www.knbs.or.ke
17) Kwena, A. O., Raburu, P., Odhiambo, B., & Njuguna, M. (2023). Indigenous knowledge, institutional support, and adaptive capacity of artisanal fishers in Siaya County, Kenya. *Environment, Development and Sustainability, 25*(12), 11875–11894. Mamboleo, M., Lukhabi, D. K., Mwenga, M., & Lomodei, E. (2025). Lake Victoria. In *Aquatic Biomes* (pp. 169-182). Academic Press.
18) LVFO (Lake Victoria Fisheries Organization). (2020). *State of fisheries resources report for Lake Victoria.*
19) M'Marete, C. K., Macharia, J., & Okungu, J. (2020). Agricultural runoff and nutrient loading in Kenyan inflow rivers to Lake Victoria. *Water, Air, & Soil Pollution, 231*(9), 456.Magego, M., Obel, H., & Kinaro, Z. (2021). Livelihood coping strategies of artisanal fishing management of fisheries in Lake Victoria. *Fisheries Research, 229*, 105610.
20) Management Units on Migingo Island, Lake Victoria. *Journal of African Law and Governance, 13*(2), 88–104.
21) Masese, F. O., Wanderi, E. W., & Nyangweso, H. N. (2025). Challenges and strategies for management and conservation of water resources and freshwater biodiversity in the Lake Victoria Basin. *Frontiers in Conservation Science*, *6*, 1544429.
22) Munyoki, J., Njiru, M., & Ochieng, E. (2021). Environmental stressors and livelihood vulnerability in small-scale fisheries in East Africa. *Marine and Freshwater Research, 72*(5), 601–615. https://doi.org/10.1071/MF20210
23) Nassali, J., Yongji, Z., & Fangninou, F. F. (2020). A systematic review of threats to the sustainable utilization of transboundary fresh water lakes: a case study of Lake Victoria. *International Journal of Scientific and Research Publications (IJSRP)*, *10*(02). Lake Victoria's Ugandan shoreline. *Ecological Indicators, 158*, 111423.
24) Njiru, J., Omukoto, J. O., Kimani, E. N., Aura, C. M., & Van der Knaap, M. (2021). Kenya marine fisheries: The next frontier for economic growth. *Aquatic Ecosystem Health & Management*, *24*(1), 97-104.Kenyan inflow rivers to Lake Victoria. *Water, Air, & Soil Pollution, 231*(9), 456.
25) Njiru, M., Aura, C. M., & Ogari, Z. (2021). Emerging challenges of fisheries sustainability in Lake Victoria.
26) Njiru, M., Ojuok, J., & Wakwabi, E. (2021). Biodiversity decline and ecosystem imbalance in Lake Victoria fisheries. *Aquatic Conservation: Marine and Freshwater Ecosystems, 31*(8), 1963–1977. https://doi.org/10.1002/aqc.3587
27) Njiru, M., Ojuok, J., & Wakwabi, E. (2021). Biodiversity decline and ecosystem imbalance in Lake Victoria fisheries. *Aquatic Conservation: Marine and Freshwater Ecosystems, 31*(8), 1963–1977. https://doi.org/10.1002/aqc.3587
28) Nyanza Gulf of Lake Victoria: Ecological and human health implications. *Environmental Monitoring and Assessment, 195*(6), 745.

License: This is an open access article under the CC BY 4.0 license: https://creativecommons.org/licenses/by/4.0/

29) Obiero, K. A., Odongkara, K. O., & Aura, C. M. (2019). Small-scale fisheries and livelihoods
30) Obiero, K. O., Ochieng, J., & Mwanja, W. (2019). Livelihood vulnerability in African inland fisheries under environmental change. *Fisheries Research, 211*, 152–162. https://doi.org/10.1016/j.fishres.2019.03.012
31) Odende, P., Okeyo, E., & Wanjala, R. (2022). Governance challenges in Kenya's Lake Victoria fisheries. *Journal of Environmental Management, 309*, Article 114688. https://doi.org/10.1016/j.jenvman.2022.114688
32) Odoli, C., Ouma, H., & Oketch, R. (2019). Fishing pressure and illegal gear use in Kenyan waters of Lake Victoria fisheries resources. *Frontiers in Conservation Science, 6*, 1544429.
33) Ogutu-Ohwayo, R., Manyala, J. O., & Wakhungu, J. (2018). Institutional interventions and fisheries sustainability in Lake Victoria, Kenya. *Environmental Policy and Governance, 28*(3), 205–217. https://doi.org/10.1002/eet.1800
34) Oyediran, A., et al. (2025). Demographic patterns and livelihood characteristics in artisanal fisheries: A comparative study. *Oceanography & Fisheries Open Access Journal, 12*(2), 45–60.
35) Pauly, D., & Zeller, D. (2016). Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining. *Nature Communications, 7*, Article 10244. https://doi.org/10.1038/ncomms10244
36) Pauly, D., & Zeller, D. (2017). Catch reconstructions reveal that global marine fisheries catches riparian communities in western Kenya. *Climate and Development, 13*(7), 645–657.
37) Scoones, I. (2018). *Sustainable livelihoods and rural development* (2nd ed.). Practical Action Publishing
38) Siaya County Government. (2018). *Siaya County fisheries report*. Department of Agriculture, small-scale fisheries in East Africa. *Journal of Environmental Management, 338*, 117660.
39) Tabachnick, B. G., & Fidell, L. S. (2019). *Using multivariate statistics* (7th ed.). Pearson.
40) Van der Knaap, W. O., Mkumbo, O. C., & Njiru, M. (2019). Enhancing the management of Lake *Victoria 2020*. Lake Victoria Fisheries Organization.
41) Victoria fisheries resources. *African Journal of Aquatic Science, 44*(1), 1–10.
42) Were, P. O., Achieng, A., & Omondi, R. (2022). Water pollution, invasive weeds, and fisheries.
43) Wilson, M., Kaunda, E., & Chirwa, P. (2023). Adaptive strategies and social resilience in small-scale fisheries: Mediating livelihood outcomes under environmental and governance pressures. *Sustainability, 15*(6), 5124. https://doi.org/10.3390/su15065124

License: This is an open access article under the CC BY 4.0 license: https://creativecommons.org/licenses/by/4.0/