

# Pathway for Climate Change Adaptation Strategies through Local Knowledge by Small-Scale Fisheries in Liberia

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## Abstract

The small-scale fishing sector in Liberia is essential for food security, livelihoods, and cultural legacy, however, it is becoming increasingly susceptible to the effects of climate change. This research examines the significance of Local Ecological Knowledge (LEK) in the adaptive strategies of small-scale fishing communities in West Point, Marshall, and the St. Paul River fishing zone. This research used the Theory of Planned Behavior framework to analyze the attitudes, subjective norms, and perceived behavioral control affecting fishers' adoption of climate adaptation techniques. Data were collected through cross-sectional research comprising 384 respondents and analyzed via qualitative and quantitative methodologies. The findings indicate that 58% of participants were male, whilst 42% were female, with 39% of both sexes lacking formal schooling. Climate change awareness correlates positively with educational attainment; 74% of individuals lacking formal education are aware of climate change, but 100% of those possessing higher education are aware. Local knowledge is essential for adaptation methods, with 48% of respondents implementing coping mechanisms such as relocating to new fishing zones, expanding fishing equipment, and pursuing alternative livelihoods like agriculture and small-scale enterprises. The research emphasizes the implementation of various coping methods, such as alternative livelihoods and community-oriented adaptation initiatives. Although local knowledge is acknowledged, opinions regarding its efficacy in comprehensively safeguarding small-scale fisheries from climate change are varied. The study advocates for the amalgamation of indigenous knowledge with empirical research, the enhancement of education and awareness, and the promotion of varied coping methods to foster resilience within small-scale fishing. These findings offer significant insights for policymakers and stakeholders in formulating comprehensive

adaptation strategies to tackle the distinct problems encountered by small-scale fisheries.

## Keywords

Small-Scale Fisheries, Climate Change Adaptation, Traditional Ecological Knowledge (TEK), Liberia, Resilience Building

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## 1. Introduction

Climate change presents considerable risks to small-scale fisheries (SSF), which employ more than 90% of the global fishing workforce and contribute approximately 50% of the worldwide fish supply for human consumption (Arthur *et al.*, 2022). Elevated sea levels, ocean acidification, and the growing prevalence of extreme weather events have exacerbated the susceptibility of small-scale fisheries (SSF) (Islam *et al.*, 2020), especially in low-income coastal areas where these fisheries are essential for food security and livelihoods (Andrews *et al.*, 2021).

By 2050, the worldwide fisheries sector might incur yearly economic losses ranging from \$17 to \$41 billion, attributed to rising ocean temperatures and unsustainable practices (FAO, 2022). Small-scale fishers, frequently marginalized, are immediately affected but exhibit adaptability and resilience in the face of these obstacles (Al-Hafidz *et al.*, 2024). Marine ecosystems worldwide are experiencing substantial alterations because of climate influences. The Earth's surface temperature has increased by roughly 1.2°C since the 20th century, resulting in rising sea levels, diminished Arctic ice, and increased weather-related catastrophes (Trégarot *et al.*, 2024). The Paris Agreement emphasizes the importance of adaptation measures, while the Global Adaptation Report indicates that each dollar invested in adaptation can generate returns of up to four times through mitigated losses and enhanced sustainability (Hussein *et al.*, 2024).

The amalgamation of local knowledge with scientific research presents a potent strategy for formulating context-specific solutions to these challenges (Yanou *et al.*, 2023). West Africa confronts distinct climatic issues, including coastline erosion, rising sea levels, and increasingly severe weather occurrences. From 2010 to 2019, the region encountered more than 540 climate-related incidents, in contrast to merely 85 in the 1970s, resulting in significant economic and social repercussions for sectors such as fisheries (UNCC, 2020). Regional organizations, like ECOWAS, have emphasized policies that integrate local knowledge to improve resilience and sustainability in small-scale fisheries (FAO, 2020).

Liberia characterized by its vast coastline and dependence on artisanal fishing, is similarly susceptible to these vulnerabilities. About 70% of coastal communities rely on small-scale fisheries for food and revenue; nevertheless, the sector has challenges including diminishing fish stocks and compromised ecosystems. Liberia's National Adaptation Plan (NAP) 2020-2030, created in collaboration with

the United Nations Development Program (UNDP), prioritizes the use of local ecological knowledge (LEK) in adaptation strategies (Iskra, 2024). This collaborative method engages stakeholders from government, commercial sectors, and civil society, to enhance governance, cultivate partnerships, and secure financial resources for sustainable fisheries (Alvin, 2021).

Small-scale fishers in Liberia offer unique local ecological knowledge, including insights into fish behavior, seasonal variations, and marine biodiversity, essential for effective adaptation (Alvin, 2021). Nonetheless, obstacles like insufficient institutional support, constrained financial resources, and prohibitive policies impede the integration of LEK into formal plans (Mozumder et al., 2023). Fishers that integrate traditional knowledge with contemporary resources such as advanced fishing gear and weather forecasts have enhanced adaptive capacity (Wandicleia et al., 2022). Overcoming these obstacles and fostering the integration of LEK and scientific research is essential for Liberia to formulate inclusive and effective climate adaptation strategies for its SSF (Walter et al., 2022). This study seeks to investigate climate change adaptation techniques by analyzing local knowledge, namely the attitudes, knowledge, and practices of small-scale fishers in Liberia amid escalating climate problems.

## 2. Theoretical Framework

The conceptual framework for this manuscript integrates the Theory of Planned Behavior (TPB) and the Local Knowledge Pathway to enhance climate change adaptation strategies (Figure 1). TPB, which posits that behavior is driven by intentions shaped by attitudes, subjective norms, and perceived behavioral control, provides a robust structure for understanding individual and collective actions towards climate adaptation. By incorporating local knowledge, which encompasses the experiential insights and practices of indigenous and local communities, this framework acknowledges the critical role of context-specific information and cultural practices in shaping adaptive behaviors. The integration of

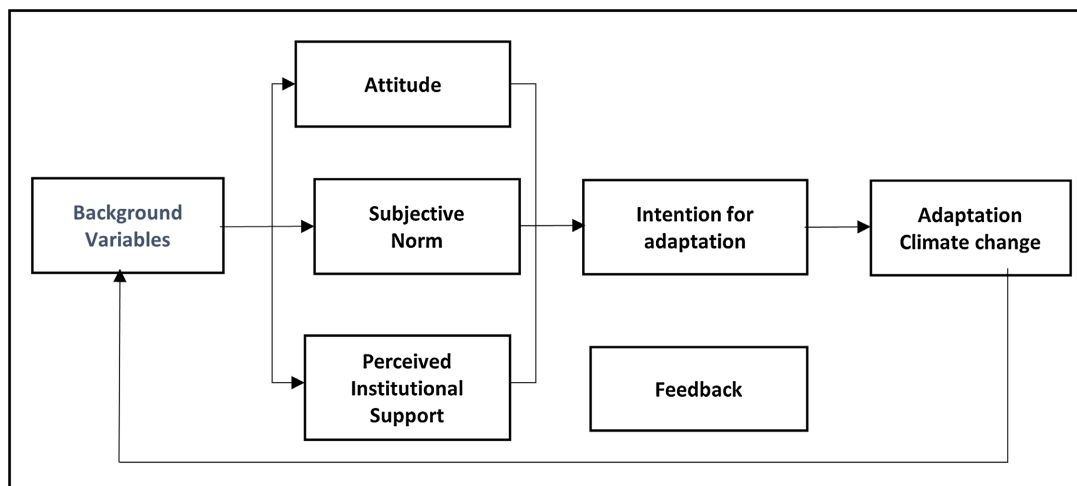


Figure 1. Conceptual framework.

these two approaches allows for a comprehensive understanding of how planned behavior theories can be effectively applied in diverse local contexts, thereby fostering more resilient and sustainable adaptation strategies.

## 2.1. Planned Behavior Theory

The Theory of Planned Behavior (TPB), initially developed by Ajzen and later modified by (Tapera *et al.*, 2020) provides a robust framework for understanding how individuals make decisions about new technologies, including strategies for adapting to climate change. The theory highlights three core factors attitude, subjective norms, and perceived behavioral control that influence behavioral intentions and actions (Nguyen & Drakou, 2021). In the context of Liberia's small-scale fisheries, these factors are critical for explaining fishermen's adaptation strategies to cope with climate change impacts.

Fishermen's attitudes toward these methods shape the adoption of climate adaptation strategies in small-scale fisheries, the social pressures they experience (subjective norms), and their perceived ability to execute these strategies (perceived behavioral control). Fishermen evaluate the feasibility of various adaptation approaches based on these factors. For instance, research shows that fishermen who feel confident in their ability to implement adaptive strategies and perceive strong social support are more inclined to adopt climate-resilient practices (Buyinza *et al.*, 2020). These elements of attitude, norms, and control are essential in contexts where resources such as information, finances, and social support are limited (Icek, 2024).

### Perceived Behavioral Control

Perceived behavioral control refers to fishermen's belief in their ability to implement specific climate adaptation measures. However, this perception may not always match their actual control due to obstacles like resource limitations or a lack of external support (Begum *et al.*, 2022). Such discrepancies can affect the accuracy of perceived behavioral control in predicting actual behavior, particularly in resource-constrained settings like rural Liberia (Martin *et al.*, 2022). Fishermen's confidence in their ability to adapt often hinges on their access to resources and knowledge. In Liberia, fishers who combine local ecological knowledge (LEK) with modern resources, such as advanced fishing gear and weather forecasting tools, feel more empowered to adapt (Nwankwo *et al.*, 2022). However, barriers such as inadequate financial resources or restrictive regulations can diminish their sense of control, limiting their ability to make necessary changes.

### Attitude

Attitudes toward adaptation, including how fishermen perceive the risks of climate change to their livelihoods, shape their willingness to adopt adaptive practices. A positive attitude, particularly when reinforced by an awareness of climate risks, increases the likelihood of adaptation (Begum *et al.*, 2022). Attitudes are shaped by factors such as prior experiences and access to information (Belay *et*

al., 2022). Fishers who recognize the risks of climate change and see adaptation practices, like using local knowledge of ocean currents and fish migration, as beneficial are more likely to adopt strategies that protect both their livelihoods and the environment (Benansio *et al.*, 2022). Additionally, positive framing of adaptation by governments, NGOs, or community leaders can reinforce these attitudes and make fishers more open to change.

### **Subjective Norms**

Subjective norms, or the social influences from peers and community leaders, also play a key role in fishermen's adaptation choices. Social pressures can either encourage or discourage adaptive behavior. In some cases, even weak social connections or external role models can influence decisions, especially when local networks are insufficient to drive change (Passafaro *et al.*, 2019). Research indicates that local knowledge, income, and social capital significantly enhance fishermen's ability to adapt. However, when adaptation is driven by social pressure without a full understanding of climate risks, it may lead to maladaptive behaviors (Mustonen *et al.*, 2022). For instance, fishermen motivated purely by social pressures might fail to grasp the true climate threats, leading to ineffective adaptation strategies (Belay *et al.*, 2022).

In Liberia, community elders, religious leaders, and local figures are instrumental in promoting adaptation by endorsing traditional knowledge and collective practices (Mario *et al.*, 2024). Social expectations and cultural norms often passed down orally, drive widespread adaptation efforts, particularly when endorsed by trusted figures (Hatamleh *et al.*, 2023). The TPB framework is a valuable tool for understanding how small-scale fisheries in Liberia adapt to climate change. By examining the interactions between perceived control, attitudes, and subjective norms, policymakers and researchers can better design interventions that promote sustainable and pro-environmental behavior in these communities (Si *et al.*, 2019).

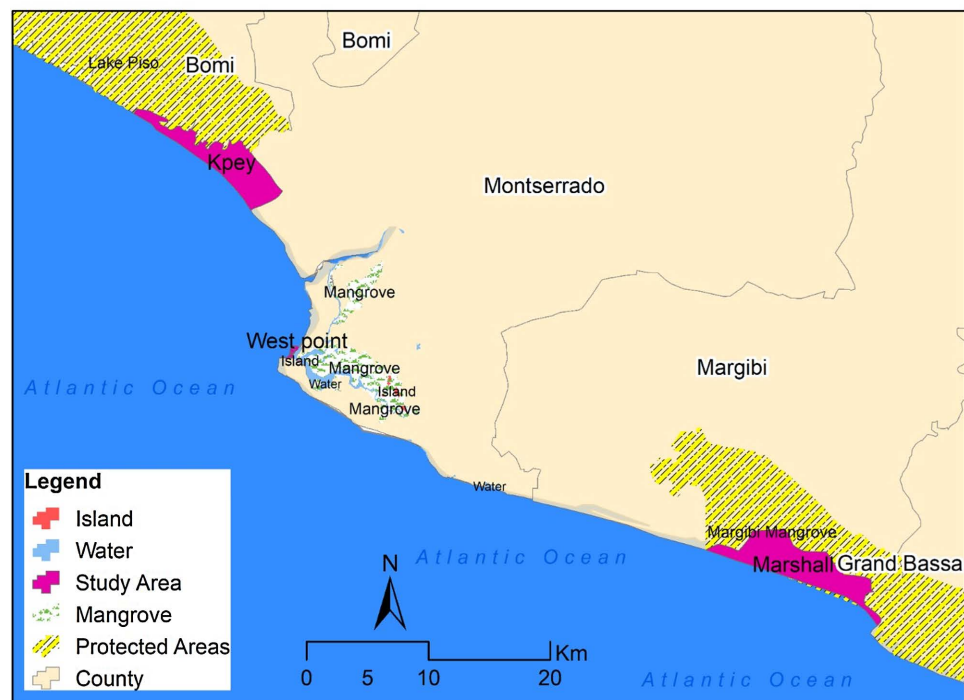
## **2.2. Local Knowledge Pathway for Climate Change Adaptation**

Local ecological knowledge (LEK) serves as a crucial adaptation tool, offering fishers the expertise to respond to environmental changes. This knowledge, passed down through generations, includes insights into fish behavior, seasonal shifts, and marine biodiversity. When combined with scientific data, LEK strengthens fishers' ability to develop effective, context-specific responses to climate risks (Cavole *et al.*, 2020). Moreover, fishermen with strong perceived control, supported by the integration of local knowledge and external assistance from NGOs or government programs, are more likely to engage in climate-resilient practices (Lomonico *et al.*, 2021). Policies that align national climate strategies with the values and practices of small-scale fishers, coupled with financial or technical assistance, can further enhance perceived control and encourage the widespread adoption of sustainable practices (Cavole *et al.*, 2020; van Asseldonk *et al.*, 2023).

### 3. Materials and Methods

#### 3.1. Study Area

The research was conducted in West Point, a highly populated slum in Monrovia, the capital of Liberia. West Point is situated on a slender peninsula between the Atlantic Ocean and the Mesurado River, at coordinates 6.3234° N, 10.8007° W (Figure 2). The St. Paul Bridge fishing hamlet, located on the periphery of Monrovia adjacent to the St. Paul River, which empties into the Atlantic, is a prominent fishing area at the bridge across the river, with coordinates 6.3806°N, 10.7778°W. Marshall, a coastal municipality in Margibi County southeast of Monrovia, is situated between the Junk and Farmington Rivers, providing access to the Atlantic Ocean at coordinates 6.1367°N, 10.3483°W. Liberia, situated in West Africa on the North Atlantic coast, is bordered by Sierra Leone to the northwest, Guinea to the north, and Côte d'Ivoire to the east. The coastline stretches 560 kilometers (350 miles) along the Atlantic to the south and southwest. Monrovia, the capital, is located on the coast in the central-western part of the country. Liberia is situated geographically between latitudes 4°21'N and 8°33'N, and longitudes 7°22'W and 11°30'W. The landscape mostly comprises coastal plains, ascending to rolling hills and a hilly plateau in the northern region, which houses Mount Wuteve, the highest elevation at 1440 meters (4724 feet), located (World Atlas, 2021).



**Figure 2.** Environmental Protection Agency (EPA) and Liberia Institute of Statistics and Geo-Information Services (LIGIS) tracks map. Source: Author.

#### 3.2. Research Design

A one-month evaluation was performed in three research areas, accompanied by

visits to governmental offices and international and local organizations, to assess small-scale fishermen's climate change adaptation tactics. Relevant officials provided information regarding the impact of climate change on small-scale fishing and their comprehension of the local dynamics influencing these communities. The research employed a cross-sectional methodology to gather Knowledge, Attitudes, and Practices (KAP) data from the three zones. A triangulation strategy was utilized to improve data validity by including several data sources and methodologies. The primary focus was on qualitative analysis (Sujarwoto *et al.*, 2022), however, quantitative methods were employed to examine correlations between variables. This mixed-methods approach yielded a thorough comprehension of participants' viewpoints and direct experiences, providing significant insights into the obstacles encountered (Saraswati *et al.*, 2024).

### 3.3. Data Collection and Analysis

The research used a mixed-methods approach to examine stakeholders' knowledge, attitudes, and behaviors about adaptation strategies of climate change, institutional frameworks, and obstacles. Quantitative data were collected via structured surveys and questionnaires, documenting demographic information, awareness of local knowledge, coping techniques, and the amalgamation of local knowledge with scientific research. The sample size was calculated via Cochran's formula, and key informants were selected via purposive sampling (Rafael *et al.*, 2022). Qualitative data were gathered through in-depth interviews and focus group discussions, providing profound insights into participants' experiences and perceptions (Tenny *et al.*, 2024). Descriptive statistics, including averages, standard deviations, frequency tables, bar charts, and percentages, were employed to summarize quantitative data. Inferential approaches, such as T-tests, regression analysis, and chi-squared tests, yielded population-level results at a 95% confidence level and  $p < 0.05$ , analyzed via SPSS software (Kaliyadan & Kulkarni, 2019). Thematic and contextual analyses of qualitative data identified repeating patterns, with findings displayed via tables, charts, frequency, and thematic narratives, offering a comprehensive comprehension of the subject (Chad, 2024).

### 3.4. Sample Size

The sample size for this investigation was determined using the Cochran formula, then simplified and modified by Bostley (Bostley, 2024). The Cochran formula ( $N = Z^2pq/e^2$ ) stipulates that for populations greater than 10,000, a minimum sample size of 384 is adequate. The criterion was achieved with a total population of 172,818 in the three research areas: West Point, Marshall, and St. Paul Bridge. The sample size of 384 was allocated according to the population proportions of each zone: Marshall (25%), West Point (55%), and St. Paul Bridge (20%) to guarantee proportional representation. Furthermore, six important informants were deliberately chosen to offer comprehensive insights (Dept, 2021). The research employed Cochran's sampling formula, resulting in a sample size of 384 respondents

(Ganesh, 2024).

$$\frac{Z\text{-score}^2 (\text{Standard Deviation})(1 - \text{Standard Deviation})}{\text{Confidence interval}^2} = \text{Sample Size}$$

So, using Cochran's sample size formulation above, one gets a sample size of 384:

$$\frac{Z^2 (p)(1 - p)}{e^2} = n_o$$

where  $n_o$  is the required sample size.  $Z$  is Z-score which corresponds to the desired confidence level (e.g.,  $Z = 1.96$  for a 95% confidence level).  $p$  is the estimated proportion of the population (e.g. 0.5 is used as a conservative estimate, meaning there's a 50/50 chance of a respondent possessing a characteristic of interest),  $1 - p$  is the proportion of the population not having the characteristic (also 0.5 in this case),  $e$  is the margin of error (confidence interval), such as 0.05 for a  $\pm 5\%$  margin of error.

Now, applying the finite population correction:

$$\frac{0.9604}{0.0025} = 384$$

#### 4. Results

The study provides key demographic insights into small-scale fishers, examining gender distribution, education, age, and marital status about their climate change awareness and adaptation strategies. As shown in **Figure 3**, 58% of respondents are male, whereas 42% are female. Educational attainment is low, with 39% of participants having no formal education. A chi-square test indicates a significant relationship between gender and education levels ( $X^2 = 7.8106$ ,  $df = 3$ ,  $p = 0.05$ ). Age analysis reveals that 47% of respondents are aged 18–35 years. Additionally, age and education levels are significantly associated ( $X^2 = 29.337$ ,  $df = 12$ ,  $p = 0.00351$ ), suggesting a notable link between these factors. Regarding marital status, 66% of respondents are single, with a significant relationship observed between marital status and education levels ( $X^2 = 24.001$ ,  $df = 9$ ,  $p = 0.0043$ ). These findings offer a comprehensive view of the socio-demographic characteristics of the respondents, providing essential context for understanding their responses to climate change and related adaptation practices.

**Figure 4** indicates that males have an average residence duration of 24 years in the study area, slightly longer than the 22 years for females. Gender roles are distinctly defined, with males exclusively engaged in fishing and females solely working as fishmongers.

**Figure 5** shows a significant relationship between respondent awareness of climate change by education. Awareness increases with higher education levels, with 74% of respondents without formal education reporting awareness compared to 100% of those with tertiary education. A chi-square test confirmed this association as statistically significant ( $X^2 = 10.657$ ,  $df = 3$ ,  $p = 0.01373$ ),

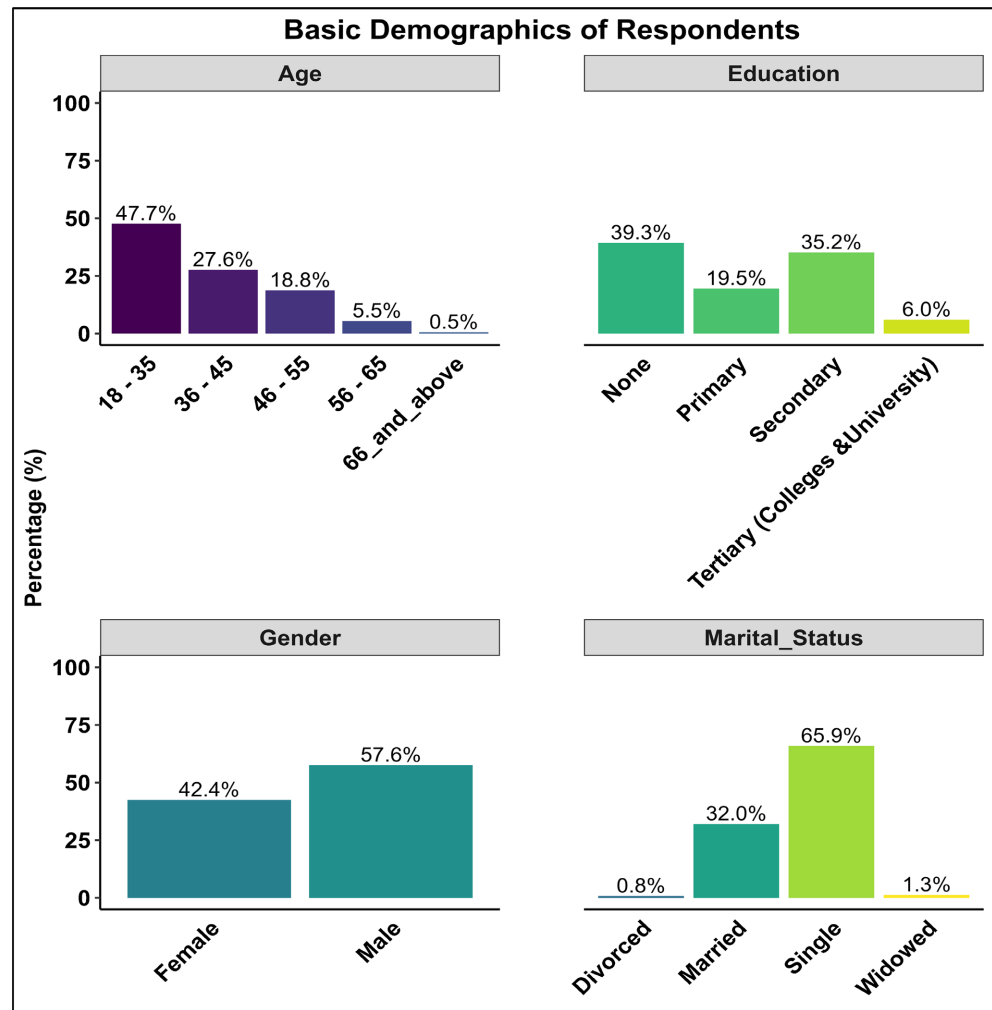


Figure 3. Basic demographics of respondents.

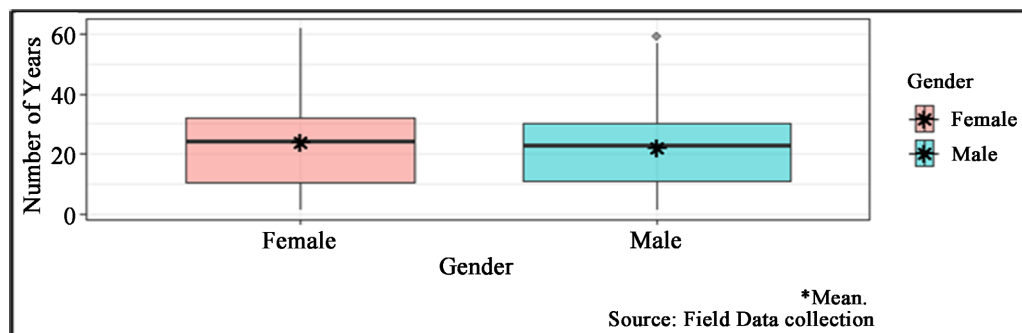
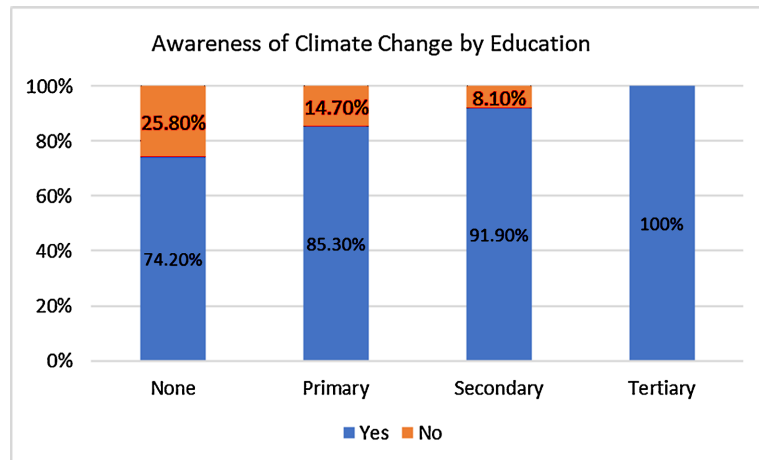


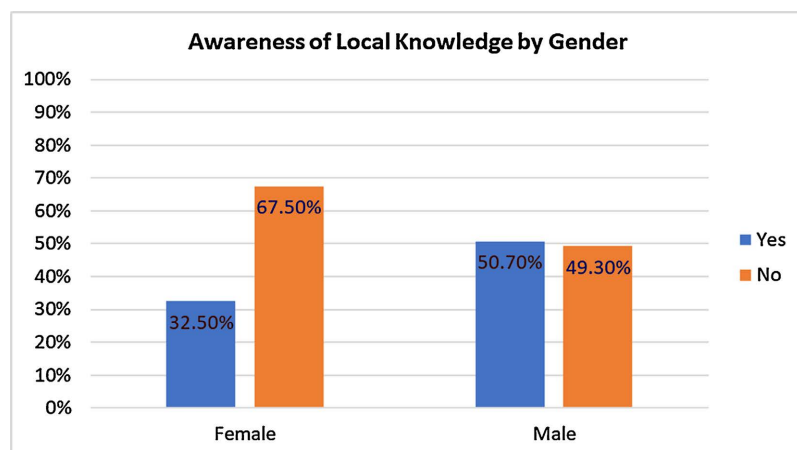
Figure 4. Average residence duration by gender.

highlighting the strong impact of education on local knowledge. Respondents identified key indicators of climate change, including irregular weather patterns, heavy windstorms, colder coastal conditions, shifts in fish distribution, and flooding. These changes directly affect fisheries by complicating trip planning due to erratic weather, increasing safety risks, damaging equipment, and altering fish behavior and distribution. Moreover, colder coastal conditions and flooding disrupt

ecosystems, damage infrastructure, and may force fisheries to relocate, intensifying the challenges to their livelihoods. This analysis demonstrates that education significantly influences climate change awareness and shapes fisheries' attitudes toward adopting effective adaptation strategies.



**Figure 5.** Respondents awareness of local knowledge by education.

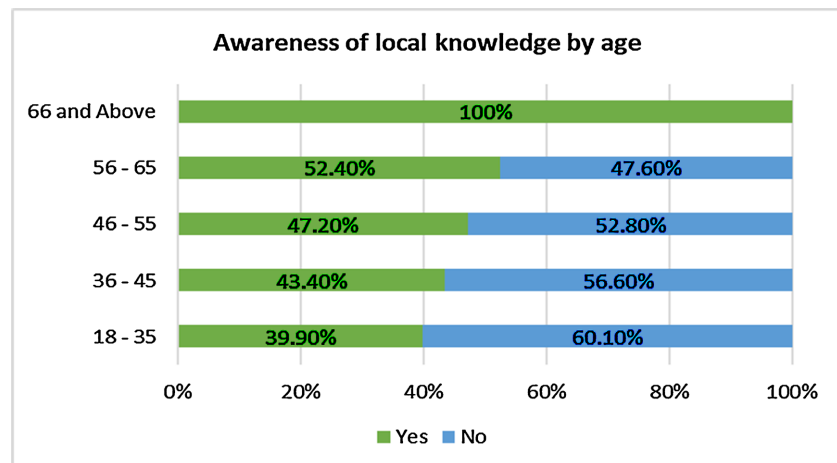


**Figure 6.** Awareness of local knowledge by gender.

**Figure 6** shows that 51% of male respondents are aware of local knowledge, compared to only 32% of female respondents, with 68% of women reporting no awareness. A chi-square test revealed a statistically significant association between gender and local knowledge awareness ( $X^2 = 11.899$ ,  $df = 1$ ,  $p = 0.0005617$ ), indicating that gender plays a crucial role in shaping local knowledge awareness. This disparity impacts climate adaptation strategies in small-scale fisheries. Men, who are primarily involved in fishing, depend on community norms and local knowledge to adapt to climate change. However, the exclusion of women, who play vital roles in post-harvest activities, undermines the inclusivity and effectiveness of these strategies.

The analysis shows no statistically significant association between local knowledge and age ( $X^2 = 4.6433$ ,  $df = 4$ ,  $p = 0.3259$ ), indicating that awareness of local

knowledge does not vary significantly across age groups. However, **Figure 7** highlights that age does influence the distribution of local knowledge awareness. Among respondents aged 18 - 35 years, 60% are unaware of local knowledge, compared to 57% in the 36 - 45 age group. Awareness increases with age, with 53% of respondents aged 46 - 55 years and 100% of those aged 66 and above reporting full awareness.



**Figure 7.** Awareness of local knowledge by age.

In contrast, a statistically significant relationship was found between age and education ( $X^2 = 29.337$ ,  $df = 12$ ,  $p = 0.00351$ ), suggesting variations in education levels across age groups. This indicates that education may have a stronger impact on local knowledge awareness than age alone. These findings highlight the need for age-targeted educational initiatives to enhance the understanding and application of local knowledge, especially among younger age groups.

**Table 1** shows that 48% of respondents have adopted various strategies to cope with the impacts of climate change. These strategies include migrating to new fishing areas, using larger fishing gear, and diversifying livelihoods through farming, mining, and small micro-enterprises (SMEs). Among these approaches, using larger fishing gear to access deeper waters stands out as the most effective strategy, with a significant relationship ( $p = 3.11$ ) indicating its success in reaching fish in deeper areas. Farming is widely practiced as an alternative livelihood, especially during periods of low fish stocks, with a strong correlation ( $p = 2.22$ ) highlighting its role in providing supplemental income.

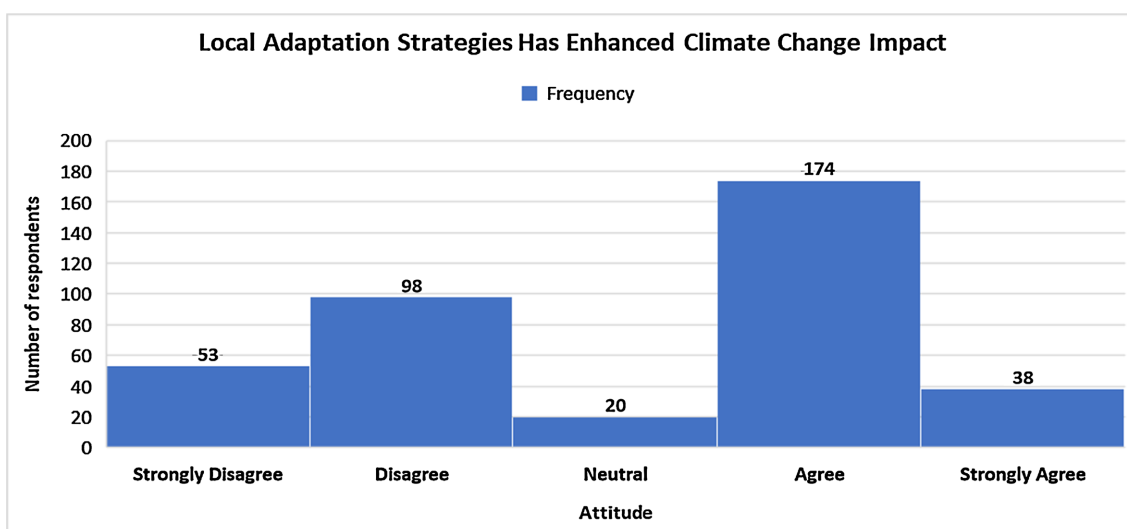
Migration, while helpful in sustaining fishing activities, shows a more moderate significance ( $p = 7.85$ ) due to geographical constraints, and its long-term effectiveness appears limited, as suggested by the weak correlation ( $p = 0.29$ ). Small businesses, though less commonly established, show low significance ( $p = 0.12$ ), reflecting their limited role as a coping strategy for declining fish stocks. Fishers also rely on local ecological knowledge of weather patterns and seasonal changes to adjust their fishing methods and timing, significantly influencing the success of strategies like migration and using larger gear.

**Table 1.** Coping strategies for mitigating the impact of climate change on fisheries and livelihoods.

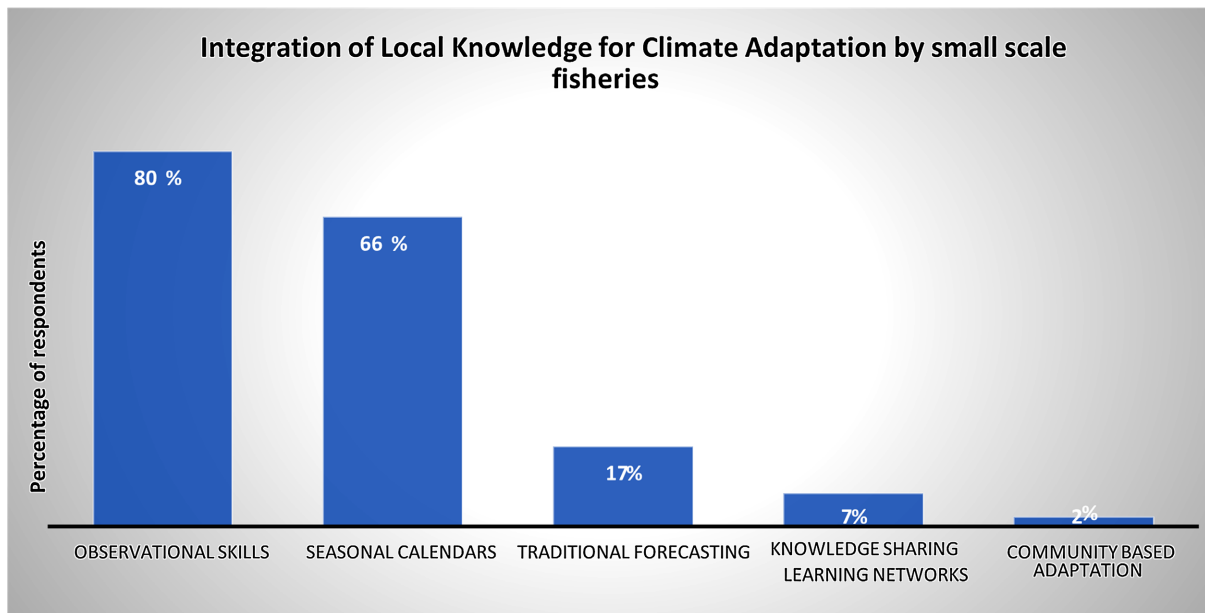
Climate Impact	Coping Strategy Applied	P-Value
Shift in fish distribution	Enlarging Fishing gear	3.11
Change in Fish Catch caused a decline in the level of income and an increase in the cost of living	Mining	2.49
	Farming	0.08
	Venturing into business	0.12
	Saving and taking loans from banks and village groups	0.04
	Changing the fishing environment from fishing in the ocean to fishing in the rivers	0.97
	Enlarging Fishing gear	0.43

**Figure 8** of the result shows that 55% of respondents believe local adaptation strategies have effectively enhanced their ability to mitigate the impacts of climate change, as indicated by their agreement or strong agreement with the statement. While, 39% disagree or strongly disagree, suggesting that a significant portion of the population does not perceive these strategies as effective. The mean score of 3.12 reflects a generally positive view of the effectiveness of these strategies, indicating that, on average, respondents tend to agree. The standard deviation of 1.29 indicates enough variability in the responses, suggesting that while most respondents agree, there are differences in opinion. This variation may stem from differences in personal experiences, awareness levels, or regional factors that influence how respondents perceive the success of these strategies.

**Figure 9** of the results show that most fishers (80%, n = 384) rely on observational skills, such as recognizing dark clouds as precursors to windstorms, to monitor weather changes and ensure safety. Seasonal calendars are used by 66%



**Figure 8.** Local adaptation strategies and their impact on climate change.



**Figure 9.** Integration of local knowledge for climate adaptation by small scale fisheries.

of respondents, with fishing concentrated during the calm, dry season from October and March. In contrast, the rainy season from April and September prompts a shift to river fishing or alternative livelihoods like farming, mining, or small and medium enterprises (SMEs). To support SME activities, fishers collaborate with non-state organizations for loans, repaying them after the dry season. Seventeen percent of respondents use traditional forecasting methods, and 7% engage in knowledge-sharing networks, exchanging insights on fishing techniques, weather patterns, equipment, and market conditions.

Adaptation strategies include mangrove conservation such as substituting coconut husks for mangrove wood in fish drying and participation in village savings and credit groups. Traditional forecasting, which helps fishers predict optimal fishing times remains significant, incorporating local knowledge, cultural practices, and natural observations. Experienced fishers mentor younger ones on weather and fishing patterns. Cultural beliefs also influence decisions, with some fisheries seeking guidance or blessings from spiritual or traditional leaders. This blending of cultural and practical approaches ensures safer and more effective fishing practices.

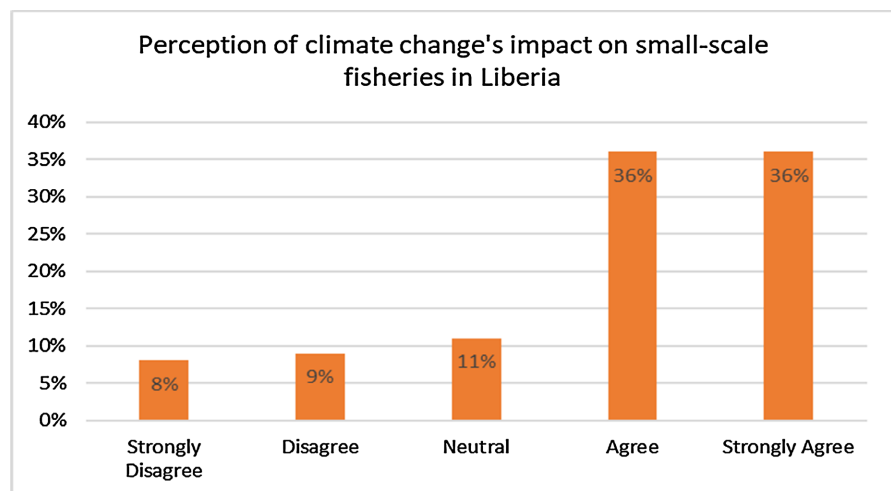
**Table 2** shows the key role of local knowledge in climate adaptation strategies among small-scale fishers in Liberia. Local knowledge is strongly correlated with the ability to predict weather patterns (p-value: 0.00076), suggesting that fishers rely on their understanding of environmental cues to make informed decisions. In contrast, migration between fishing areas shows a weaker correlation with local knowledge (p-value: 0.39596), indicating that migration decisions are influenced more by external factors, such as environmental conditions or market demands, rather than by personal attitudes or traditional knowledge.

**Figure 10** of the results show that 72% of respondents agree or strongly agree

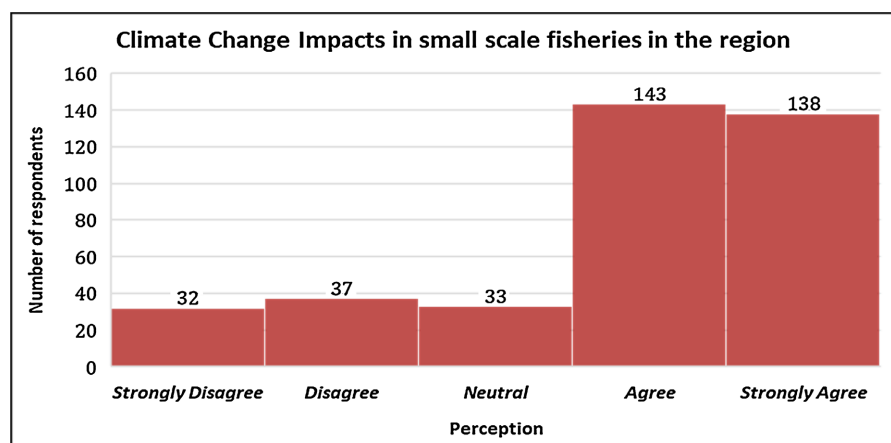
that climate change affects small-scale fisheries, reflecting widespread recognition of its impact. However, 17% disagree or strongly disagree, suggesting that a minority either perceives climate change as less significant or lacks awareness of its effects. These differing views may be influenced by personal experiences, limited exposure to climate impacts, or a lack of awareness about the link between environmental changes and climate factors.

**Table 2.** Role of local knowledge in climate adaptation strategies in Liberia.

Perceived significance of local knowledge	Coping strategy	P-value
Predicting weather patterns	Migrating from one fishing area to another	0.0007570231
Adapting fishing practices	Enlarging fishing gear	8.635374e-17



**Figure 10.** Respondents’ perception of climate change impact in small-scale fisheries.



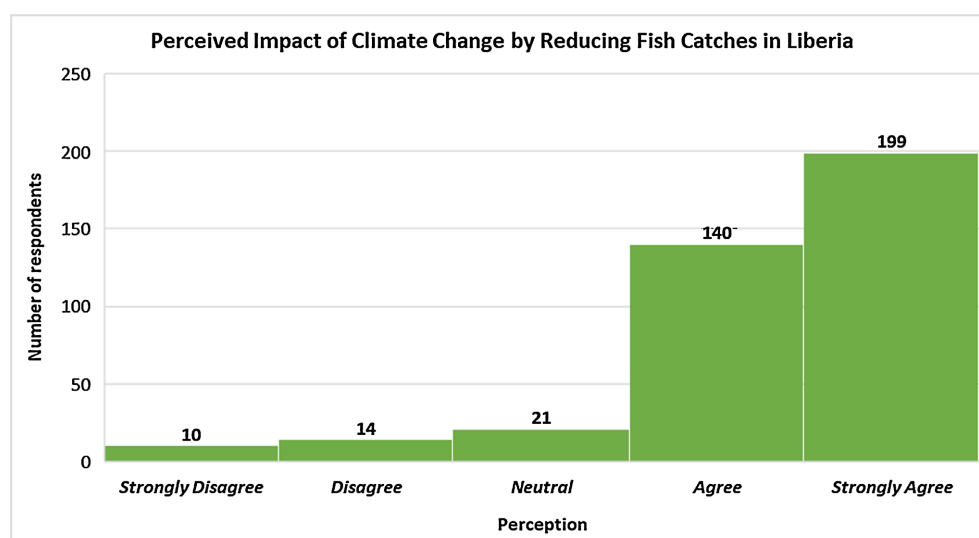
**Figure 11.** Perceived impacts of climate change in reducing fish catches.

**Figure 11** shows that 73% of respondents agree or strongly agree that climate change affects small-scale fisheries in the region, while 17% disagree or strongly disagree.

disagree. The mean score of 3.83 indicates overall agreement, with a standard deviation of 1.25, suggesting that while most respondents share this view, there is some variability in opinions. This variation may reflect differences in personal experiences, awareness, or understanding of climate change's impact on fisheries.

**Figure 12** shows that 93% of respondents agree or strongly agree that climate change significantly reduces fish catches, reflecting a strong positive attitude toward the impact of climate change on fisheries. The mean score of 4.31 indicates widespread agreement, while the low standard deviation of 0.93 suggests a consistent pattern of responses with minimal variability. This suggests that most respondents perceive a significant reduction in fish catches due to climate change, with limited differences in their views.

**Table 3** of the results shows that 62.8% of respondents agree that local



**Figure 12.** Climate change effects on smallscale finsheries in the region.

**Table 3.** Perceived effectiveness of local knowledge and adaptation strategies in enhancing resilience to climate change impacts on small-scale fisheries.

Parameter	Agree (Positive) %	Disagree (Negative) %
Local knowledge is significant in coping with climate change's impact	62.8 ± 0.128 <sup>a</sup>	37.2 ± 0.128 <sup>a</sup>
Local adaptation strategies have enhanced the resilience of fisheries to climate change impacts.	58.1 ± 0.08 <sup>a</sup>	41.9 ± 0.08 <sup>a</sup>
Local adaptation strategies have prevented small-scale fisheries from climate change impact	43 ± 0.08 <sup>a</sup>	57 ± 0.07 <sup>a</sup>
There are Limited Coping Strategies for small-scale Fisheries to adapt to climate change in Liberia	83 ± 0.33 <sup>a</sup>	17 ± 0.33 <sup>a</sup>

a, b: Different letters in the same row differ statistically by Chi-Square,  $p < 0.05$ , Positive: respondents agree on the significance of local knowledge in climate change adaptation in the small-scale fishing sector of Liberia, Negative: respondents of the contrary views of the positive responses, Negative: respondents of the contrary views of the positive responses.

knowledge is essential for coping with climate change, whereas 37.2% disagree. While 58.1% believe adaptation strategies enhance resilience, 41.9% are skeptical. Only 43% feel these strategies effectively prevent climate change impacts, with 57% disagreeing. Additionally, 83% agree that there are limited coping strategies available, indicating a need for more robust solutions. Statistical analysis ( $p < 0.05$ ) reveals significant differences in respondents' views, highlighting that factors such as personal experience and awareness influence their perceptions of the effectiveness of local knowledge and adaptation strategies in supporting small-scale fisheries.

## 5. Discussion

Integrating local ecological knowledge (LEK) into climate adaptation strategies is essential for strengthening the resilience of small-scale fisheries to climate change. The research indicates that many fishers depend on observational abilities and seasonal calendars to monitor weather patterns and organize fishing activities. These practices, such as interpreting dark clouds as signals of heavy windstorms and using seasonal calendars to determine fishing periods, demonstrate the practical application of LEK. These findings align with studies by other scholars that emphasize the significance of Indigenous knowledge in climate adaptation, which highlights the importance of Indigenous knowledge in climate change adaptation (Mozumder *et al.*, 2023; Walter *et al.*, 2022).

However, perceptions of the effectiveness of local adaptation strategies vary, signaling a need for continuous assessment and enhancement. While 58% of respondents assert that these measures have enhanced the resilience of fisheries, 42% express doubts. This disparity indicates that while LEK is a valuable resource, it may not be sufficient on its own. Enhancing its effectiveness by integrating it with scientific research is critical. This mismatch suggests that although LEK is a useful asset, it may not be adequate. Integrating it with scientific research is essential for enhancing its effectiveness. Previous research propose that integrating conventional weather forecasting techniques with modern meteorological data can produce more accurate and reliable predictions, thereby improving decision-making and planning processes (Yanou *et al.*, 2023).

Education plays a central role in increasing climate change awareness and fostering adaptive capacity. The study shows a clear link between higher education levels and greater awareness of climate risks, supporting findings by (Kolenatý *et al.*, 2022). Educational initiatives designed for undereducated demographics are essential to close this disparity. These initiatives should emphasize the value of LEK, the impacts of climate change, and effective adaptation strategies to empower communities to respond more effectively to climate challenges.

Diversification of livelihoods is an essential method for strengthening resilience. The implementation of alternative livelihoods, including agriculture, mining, and small enterprises, diminishes reliance on fishing and generates supplementary income sources. This method aligns with the findings by other scholars, who highlight the role of diversifying livelihoods in building resilience to climate

change. Community-based initiatives, such as mangrove restoration and afforestation, augment resilience by safeguarding aquatic ecosystems, alleviating coastal erosion, and offering extensive ecological advantages (Sunkur *et al.*, 2023). Notwithstanding the acknowledgment of LEK and adaptation measures, apprehensions persist regarding their capacity to adequately safeguard small-scale fisheries from climate impacts.

Only 43% of respondents assert that these techniques have been effective, whereas 57% harbor skepticism. This highlights the need for more comprehensive and robust adaptation measures tailored to the unique challenges faced by small-scale fisheries. Policymakers and stakeholders must prioritize the integration of local ecological knowledge with scientific research, the development of specialized educational programs, and the endorsement of varied coping methods to tackle these challenges. Enhancing community-based strategies and investing in comprehensive adaptation frameworks can secure the sustainability of small-scale fisheries and improve the resilience of the communities that are reliant on them.

## 6. Conclusion

This study provides an in-depth analysis of climate change adaptation strategies by small-scale fishers in Liberia, emphasizing the importance of local ecological knowledge (LEK) in enhancing resilience. The study demonstrates that the integration of Local Ecological Knowledge (LEK) with scientific data will significantly improve fishers' capacity to formulate effective, context-specific strategies for addressing climate challenges. Fishers possessing a robust sense of perceived control, reinforced by local ecological knowledge and external backing from NGOs or governmental programs, are more likely to embrace climate-resilient strategies. Harmonizing national climate policy with the principles and methods of small-scale fishermen, while providing financial and technical assistance, can enhance perceived control and promote sustainable practices.

The research, carried out in the coastal settlements of West Point, St. Paul Bridge, and Marshall, encompasses a varied representation of Liberia's fishing industry. Its robust methodology, incorporating a cross-sectional design and triangulation techniques, ensured the reliability and validity of the findings. The research used a mixed-methods approach, combining qualitative and quantitative data to provide a thorough knowledge of participants' experiences and perspectives. The findings highlight the pivotal role of education in fostering local knowledge awareness and climate adaptation strategies, stressing the necessity for specialized educational initiatives.

The research also identified gender disparities in local knowledge awareness, highlighting the importance of gender-inclusive strategies to strengthen the resilience of the fisheries value chain. Prominent coping strategies included the use of larger fishing gear and farming, but the study stressed the need for more diverse and robust adaptation measures. Additionally, traditional forecasting methods and knowledge-sharing networks were recognized as valuable tools for anticipating

weather patterns and shaping adaptation strategies. Finally, this study emphasizes the necessity of integrating LEK into climate adaptation strategies to enhance the resilience and sustainability of small-scale fisheries. Addressing problems such as inadequate institutional support, constrained financial resources, and restricted rules, while promoting collaboration between LEK and scientific research, is crucial. These initiatives will foster the creation of more inclusive and effective climate adaptation methods, thereby ensuring the sustainability of fisheries and the lives of the coastal populations reliant on them.

## 7. Recommendations

The study offers four principal recommendations to strengthen the resilience and sustainability of fishing communities in adapting to climate change:

- Develop educational initiatives to engage younger generations in local ecological knowledge (LEK) to ensure the long-term sustainability of fisheries.
- Promote community-oriented education and resilience enhancement through the provision of microloans, fishing equipment, and capacity-building programs while prioritizing gender-inclusive policies to ensure equitable access to resources and leadership opportunities for women.
- Policymakers should focus on delivering financial aid and technical expertise to assist fishing communities. Key areas of support include promoting sustainable fishing practices, encouraging alternative livelihoods, and integrating traditional forecasting methods with modern techniques to improve adaptive capacity and climate resilience.
- Strengthen knowledge-sharing networks to exchange innovative practices, resource management strategies, and climate adaptation techniques and foster collaboration among local stakeholders to integrate traditional and modern approaches, enabling more effective responses to environmental challenges.

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## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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