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Perspective of Institutional Framework on Climate Change Adaptation Strategies and Local Knowledge Integration by Small-Scale Fisheries in Liberia

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Abstract

Small-scale fishing communities, including those in Liberia, face increasing threats from climate change. The FAO reports that these fisheries support over 120 million people globally, with 90% in developing nations like Liberia. Effective adaptation techniques depend on robust institutional frameworks at all levels. This paper evaluates climate change adaptation strategies in Liberia's small-scale fisheries using institutional capacities theory. Data was gathered from 384 fishers and 12 key stakeholders via questionnaires and analyzed using descriptive and inferential statistics. It found that most fishers are young men with low education levels, and many are single. There are significant links between gender, age, and education. Findings indicate that 62% of respondents believe local knowledge is insufficiently incorporated into adaptation policies, while 53% feel that existing laws have not been adapted to support climate resilience in fisheries. Furthermore, 66% perceive weak institutional coordination for climate adaptation, and 70% consider the current policies inadequate for supporting adaptation efforts. Statistical analysis (Chi-Square, $p < 0.05$) confirms these perceptions as significant, indicating widespread dissatisfaction with institutional responses to climate impacts. The study highlights the need for better integration of local ecological knowledge, updated laws, and stronger institutional coordination to support climate adaptation in Liberia's small-scale fishing sector. Respondents are dissatisfied with current policies and institutional responses, pointing to significant gaps that need to be addressed through targeted, community-informed strategies and improved institutional support.

Keywords

Institutional Framework, Local Knowledge Integration, Climate Resilience,

Policy Development, Community Based Adaptation, Fisheries Governance and Vulnerability Assessment

1. Introduction

Small-scale fishing communities in Liberia are profoundly impacted by climate change due to their dependence on vulnerable marine ecosystems. Rising sea levels, shifting ocean temperatures, and erratic weather patterns intensify existing challenges such as poverty, inadequate infrastructure, and limited institutional capacity (Wang et al., 2024). The Food and Agriculture Organization (FAO) estimates that over 120 million people worldwide rely on small-scale fisheries for their livelihoods, with many in developing nations like Liberia (Saye, 2024). These fisheries play a crucial role in food security, employment, and local economies, but remain highly susceptible to environmental disruptions. Climate change alters fish migration routes, degrades marine habitats, and increases extreme weather events, threatening the sustainability of Liberia's fisheries (Maulu et al., 2021). Local fishermen possess valuable traditional knowledge that could enhance climate adaptation strategies; however, their integration into formal policy frameworks remains inconsistent. Strong institutional structures are essential for bridging this gap, promoting inclusive governance that synthesizes traditional insights with scientific research. Studies highlight that incorporating local knowledge into adaptation efforts strengthens resilience while ensuring cultural relevance and sustainability (Manglem & Teresa, 2024).

This paper examines how institutional frameworks can facilitate effective climate adaptation by integrating local expertise into sustainable fisheries management in Liberia. It explores obstacles and opportunities, emphasizing best practices to enhance community resilience. The success of adaptation efforts depends on governance systems, policies, and funding channels that oversee fisheries operations and implement climate-responsive measures. Institutions serve as intermediaries linking grassroots communities, researchers, and policymakers. Effective governance fosters flexibility, harmonizing top-down directives with bottom-up engagement (Radtke & Renn, 2024). However, a World Bank assessment revealed poor coordination among institutions and limited resources, impeding climate response implementation in Liberia (Wuokolo, 2023). Centralized decision-making often marginalizes local stakeholders, reducing the cultural and economic relevance of adaptation strategies (Hossen et al., 2022).

Additionally, the reliance on oral traditions in transmitting ecological knowledge creates compatibility issues with scientific formats, restricting its formal recognition (Proulx et al., 2021). Addressing these challenges requires participatory governance and cross-sector collaboration. Successful examples in West Africa demonstrate that blending traditional knowledge with scientific evidence enhances resilience (Chuku et al., 2022). Co-management approaches empower communities to participate in resource stewardship and climate adaptation plan-

ning. Liberia is positioned to strengthen its institutional structures by incorporating localized expertise into adaptive strategies. Actively involving community fishers in decision-making ensures alignment with local needs, cultural sensitivity, and broader acceptance of adaptation measures. Participatory governance remains a best practice for reinforcing resilience in small-scale fisheries (Aguión et al., 2022). Innovative information-sharing mechanisms, such as digital archives and community-led mapping initiatives, bridge oral traditions with scientific research. Respecting local customs while ensuring policymakers and researchers access essential information is crucial (Yanou et al., 2023). Investment in infrastructure and technological training will further support adaptation efforts. Regional collaborations within West Africa offer valuable lessons in shared learning, capacity building, and resource mobilization (USAID, 2020). A national strategy targeting sustainable fish yields and eco-resilient practices must integrate local knowledge and address small-scale fishers' unique challenges through multi-stakeholder dialogues (Villasante et al., 2022).

Increasingly severe weather events threaten marine ecosystems and livelihoods, underscoring the urgency of robust institutional arrangements to facilitate effective adaptation. Liberia must address weak institutional coordination while capitalizing on opportunities for new solutions. Active participation and knowledge exchange programs aligned with national agendas and local realities will strengthen the foundation for long-term fisheries sustainability. Combining indigenous knowledge with scientific frameworks offers a path toward effective adaptation. The Intergovernmental Panel on Climate Change (IPCC) underscores the importance of locally driven adaptive strategies for lasting resilience and scalability (Werners et al., 2021).

1.1. Conceptual Framework of Institutional Capacities

Institutional capacities theory offers a critical lens through which to assess the preparedness and capacity of institutions to design and implement climate change adaptation strategies that are inclusive, resource-responsive, and contextually grounded (Figure 1). In the case of Liberia's small-scale fisheries, the theory serves as a foundational framework for understanding how well governance structures can use resources, incorporate diverse knowledge systems such as local ecological knowledge and forest collaboration among stakeholders to build resilience (Puig et al., 2025) The theory underscores three dimensions: analytical capacity (interpreting and using information effectively, operational capacity implementing decisions through adequate structures and personnel, and political capacity (ensuring legitimacy and stakeholder engagement (Mukherjee et al., 2021). This framework is especially relevant in climate-vulnerable settings like Liberia, where institutional strength determines the effectiveness of adaptation strategies. By diagnosing institutional gaps, such as fragmented governance, limited resources, and exclusion of LEK, the study advances theoretical discussions on the role of institutional capacities in shaping climate resilience.
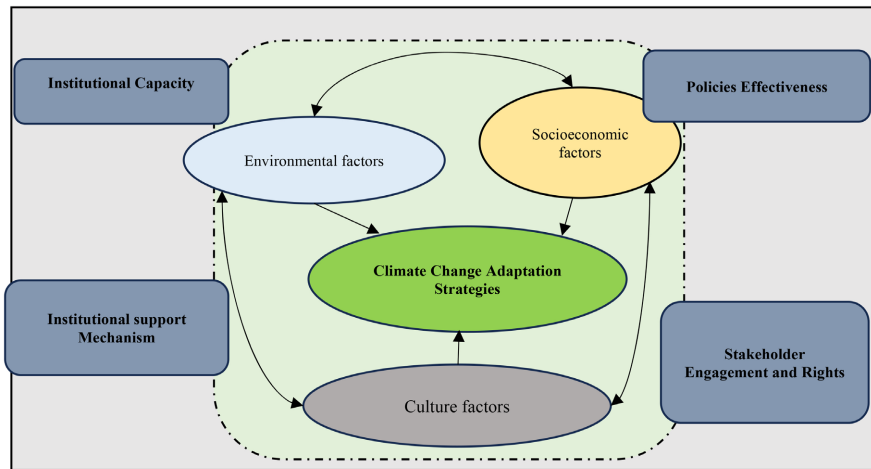
Figure 1. Institutional capacity theory.

1.2. Institutional Capacities Theory

This study applied institutional capacities theory to critically evaluate the functionality of Liberia's governance systems in supporting climate adaptation within small-scale fisheries. The theory served as both a conceptual lens and an analytical tool, offering a structured framework to assess how institutions mobilize resources, coordinate actions, and engage stakeholders in response to climate-related challenges (Sady, 2024). It informed the research design by guiding the development of surveys and interview protocols that examined institutional responsiveness, stakeholder participation, and the integration of local ecological knowledge (LEK). During data analysis, the theory helped identify several critical capacity gaps, including weak cross-scale coordination, insufficient operational support for fishers, marginalization of local knowledge systems, and generally low adaptive capacity. These findings align with broader theoretical perspectives that advocate for polycentric, participatory, and place-based governance models, which argue that top-down, centralized institutions often lack the contextual sensitivity required to effectively support vulnerable communities (Emmanuel, 2022). Moreover, the research highlights persistent epistemic orders that privilege scientific expertise over local, experiential knowledge, underscoring the need for co-produced adaptation strategies that bridge diverse knowledge systems (Walter Lepore et al., 2025). In this regard, institutional capacities theory shaped the methodological approach. It enabled a nuanced critique of governance limitations, contributing empirical evidence to support more inclusive, equity-oriented, and reflexive adaptation frameworks.

1.3. Enabling Governance and Adaptive Capacity

Governance structures are central to enhancing adaptive capacity, particularly in socio-ecologically vulnerable sectors such as small-scale fisheries. This study reveals that Liberia's climate adaptation strategies are significantly hindered by fragmented legal frameworks, inadequate financial resources, limited human capital,

and minimal stakeholder engagement, all of which constrain institutional effectiveness. These structural deficits reflect a lack of operational and political capacity, as outlined in institutional capacities theory, which emphasizes the importance of coordination, stakeholder inclusion, and resource mobilization for effective adaptation (Wuokolo, 2023). The widespread dissatisfaction expressed by small-scale fishers regarding governmental support underscores a pressing governance deficit, weakening the ability of institutions to foster resilience at the local level. In contrast, successful examples from West Africa illustrate that adaptive governance must holistically integrate social equity, ecological sustainability, and economic viability to be effective (Adom et al., 2024; Cattivelli, 2021). For Liberia's adaptation initiatives to succeed, governance institutions must be strengthened not only through legal and policy reforms but also through genuine engagement with affected communities, ensuring that adaptation frameworks are locally grounded, inclusive, and implementation-ready.

1.4. Integrating Local Knowledge (LEK) with Scientific Insights

A core principle of institutional capacities theory is the integration of diverse knowledge systems, particularly local ecological knowledge (LEK), into governance and decision-making processes. This study highlights the limited incorporation of LEK in Liberia's climate adaptation strategies, revealing both weak analytical capacity and an underlying epistemic bias that privileges scientific over experiential knowledge. Despite its proven value in offering context-specific and adaptive insights, LEK remains largely excluded from policy formulation. This marginalization not only weakens institutional effectiveness but also isolates small-scale fishers, key stakeholders with direct experience of environmental change. The findings support theoretical arguments advocating for knowledge co-production and inclusive governance, where scientific and local knowledge are seen as complementary. By failing to institutionalize LEK, Liberia's governance systems forfeit valuable opportunities to enhance resilience, reinforcing the theoretical imperative for pluralistic and participatory knowledge integration in adaptation planning.

1.5. Socioeconomic Support and Resource Access

Institutions also play a critical role in enabling adaptation through socioeconomic support and equitable resource distribution. The study reveals that fishers in Liberia often lack access to adaptive tools such as climate-resilient gear, financial services, and educational programs, gaps that stem from institutional limitations in operational capacity and resource mobilization. Institutional capacities theory helps explain how under-resourced governance bodies contribute to adaptation failures. Effective institutional support, as illustrated in other African contexts, requires not just policy prescriptions but also on-the-ground delivery of adaptive resources, often facilitated by partnerships with NGOs and international organizations (Taoreed, 2024). The inability to provide this support contributes to vul-

nerability among small-scale fishers, further entrenching poverty and limiting long-term resilience.

1.6. Participatory Approaches and Inclusive Planning

Participatory governance is a cornerstone of adaptive capacity and institutional legitimacy. This study identifies a lack of participatory mechanisms in Liberia's adaptation processes, contributing to widespread dissatisfaction and policy misalignment. Drawing on institutional capacities theory, the study interprets this as a failure in political capacity, specifically, the ability to engage stakeholders, build consensus, and gain legitimacy. The exclusion of fishers from decision-making processes not only weakens policy outcomes but also perpetuates governance structures that are unresponsive and top-down. Comparative evidence from Senegal and other West African nations shows that participatory planning, including community consultations and co-managed marine protected areas, leads to more effective and socially accepted adaptation outcomes (Ba et al., 2019). In Liberia, embedding such participatory approaches could help bridge the disconnect between national adaptation agendas and community-level realities, aligning formal governance with bottom-up resilience strategies. The study thus reinforces the theoretical imperative of participatory, inclusive governance to enhance institutional capacity and support sustainable adaptation.

2. Materials and Methods

2.1. Study Area

The research was conducted in three prominent coastal communities within Liberia (Figure 2): West Point, which is situated near the Atlantic Ocean at coordinates 6˚38'N 10˚77'W, serves as a vibrant center with considerable aquatic diversity due to its proximity to freshwater sources that support various species (Pereyra et al., 2024). However, increasing temperatures are altering migration routes while pollutants from urban industrial runoff pose significant threats that jeopardize long-term sustainability in these areas (Kuletz et al., 2024). Marshall, located in southeast Monrovia between the Junk and Farmington Rivers, has historical importance linked to artisanal activities alongside lush mangrove forests that provide extensive breeding grounds crucial for maintaining diverse life forms (Suratman, 2021).

Nevertheless, detrimental impacts resulting from climate change-induced habitat degradation and rising salinity increasingly threaten stock stability and undermine the livelihoods of many families dependent on these resources (Alberto et al., 2024). It is important to recognize geographic limitations affecting Liberia's borders with neighboring countries, including Sierra Leone, Guinea, and Côte d'Ivoire. The coastline extends approximately 560 kilometers along the North Atlantic Ocean essential factor for both economic activity and food security (Togbah, 2024). The landscape predominantly consists of low-lying plains gradually transitioning into rolling hills leading up to Mount Wuteve's peak at an elevation
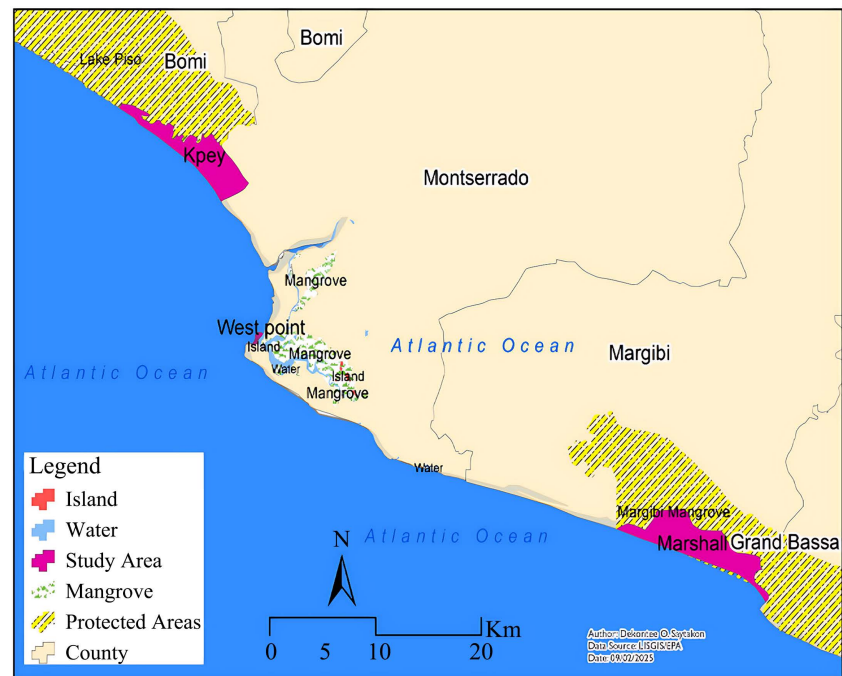
Figure 2. Map of the study area.

of about 1440 meters above sea level (World Bank, 2024). The region experiences tropical conditions marked by alternating wet and dry seasons annually. Increasing variability results in storm surges contributing to heightened erosion levels as well as habitat destruction, seriously impacting prospects across entire sectors involved therein (Badji et al., 2022).

Selected sites play a critical role in supporting overall livelihoods, necessitating urgent attention towards prevalent challenges such as overexploitation combined with weak institutional capacities amid hazards associated with changing environmental conditions threatening local fisher folk populations residing there (Mozumder et al., 2023). Addressing these issues requires a collaborative effort that harnesses Indigenous knowledge thoroughly integrated through empirical insights aimed at fostering adaptive management strategies conducive to sustainable environments (Ullah et al., 2023). This study emphasizes the pressing need for targeted interventions focused on promoting effective practices designed to protect coastlines alongside supportive regulatory frameworks governing seafood harvesting activities undertaken by individuals engaged within this sector.

2.2. Research Design

This study was conducted in three key fishing communities in Liberia: West Point, St. Paul into the Atlantic Ocean. The region, located at 6.3806˚N, 10.7778˚W, serves as a key fishing hub due to its proximity to both freshwater and marine ecosystems. Fishers in this area engage in both riverine and coastal fishing, benefiting from diverse fish species (Pereyra et al., 2024). However, rising temperatures, shifts in fish migration patterns, and pollution from urban and industrial

runoff pose significant threats to sustainable fishing (Kuletz et al., 2024). Marshall is a coastal town in Margibi County, situated southeast of Monrovia between the Junk and Farmington Rivers, with access to the Atlantic Ocean at 6.1367˚N, 10.3483˚W. The town has a long history of artisanal fishing and is known for its mangrove forests and estuarine ecosystems, which serve as crucial breeding grounds for fish and marine life (Suratman, 2021). Climate change has led to mangrove degradation, increased salinity, and habitat loss, all of which negatively impact fish stocks and local livelihoods (Alberto et al., 2024).

Liberia is located in West Africa, bordered by Sierra Leone to the northwest, Guinea to the north, and Côte d'Ivoire to the east. The country has a 560-kilometer (350-mile) coastline along the North Atlantic Ocean, which plays a vital role in its economy and food security (Togbah, 2024). Liberia's geographical coordinates range from 4˚21'N to 8˚33'N latitude and 7˚22'W to 11˚30'W longitude. The landscape consists primarily of coastal plains, gradually rising into rolling hills and a hilly plateau in the northern region, where Mount Wuteve (1440 meters/4724 feet) is the highest point (World Bank, 2024). The climate is tropical, characterized by a rainy season (May-October) and a dry season (November-April). Increasing temperature fluctuations, intensified storms, and rising sea levels are exacerbating coastal erosion, saltwater intrusion, and habitat destruction, which threaten Liberia's fisheries sector (Badji et al., 2022). The selected study areas are critical to Liberia's artisanal fishing industry, which provides employment and sustains local food security. However, challenges such as overfishing, weak institutional frameworks, and climate-induced risks threaten the livelihoods of fishers in these communities (Mozumder et al., 2023). Addressing these challenges requires integrating local ecological knowledge with scientific research to develop adaptive fisheries management strategies (Ullah et al., 2023). This study highlights the urgent need for climate adaptation interventions in these communities, focusing on sustainable fishing practices, coastal protection measures, and policy-driven support for fishers.

2.3. Data Collection and Analysis

The research used a mixed methods approach, combining quantitative surveys of 384 small-scale fishers with qualitative interviews of 12 key stakeholders to explore the integration of local ecological knowledge into climate change adaptation strategies in Liberia. Quantitative analysis involves descriptive statistics, cumulative mean comparisons, and Chi-square tests of independence to examine perceptions of climate change impact and assess associations between variables such as community, LEK integration, and institutional support, with a significance threshold of $p > 0.05$), and comparisons of cumulative mean scores on various Likert-scale items, though more robust inferential tests were not used (Mweshi & Muhyila, 2024). Quantitative data were analyzed thematically through transcripts, coding, and the development of core themes such as institutional fragmentation and policy exclusion. Triangulation of qualitative and quantitative findings enhanced the depth, validity, and contextual understanding of the factors shaping adaptation

practices in the study communities. The sample size was determined using Cochran's formula, and key informants were selected through purposive sampling (Cheruvalappil et al., 2024). Qualitative analysis included descriptive statistics (averages, standard deviations, frequency tables, bar charts, and percentages) comparisons of cumulative mean scores on Likert-scale items, and inferential tests such as chi-square, t-tests, and regression analysis, conducted using SPSS at a 95% confidence level ($p < 0.05$) (South et al., 2024). Qualitative data were gathered through in-depth interviews and focus group discussions, offering rich insights into participants' experiences and perceptions (Busetto et al., 2020). Findings were presented using tables, charts, frequencies, and thematic narratives to provide a comprehensive understanding of the subject (Qaissi, 2024).

2.4. Sample Size

The sample size for this study was calculated using Cochran's formula, a widely recognized method for estimating minimum sample sizes in large populations exceeding 10,000 to achieve statistical reliability. Using a 95% confidence level, a 5% margin of error, and assuming maximum variability ($p = 0.5$), the resulting minimum sample size was 384 participants (Nanjundeswaraswamy & Divakara, 2021). To further validate this estimate, Yamane's formula was applied using the same parameters, yielding a comparable result of approximately 385 respondents, thereby reinforcing the adequacy of the sample size derived from Cochran's approach (Oluigbo et al., 2024).

The formula is as follows:

$$n_0 = \frac{Z^2 (p)(1-p)}{e^2} \tag{1}$$

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 (Pahwa et al., 2023). The research employed Cochran's sampling formula (Equation (2)), resulting in a sample size of 384 respondents (Nanjundeswaraswamy & Divakar, 2021).

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

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

Where:

n_0 = required sample size;

Z = Z-score, which corresponds to the desired confidence level (e.g., $Z = 1.96$ for a 95% confidence level);

p = 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 character-

istic of interest); $1 - p$ = proportion of the population not having the characteristic (also 0.5 in this case);

e = margin of error (confidence interval), such as 0.05 for a ±5% margin of error.

Now, applying the finite population correction:

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

$$n = 384$$

3. Results

The study provides key demographic insights into small-scale fishers, examining gender distribution, education, age, and marital status regarding 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 (χ^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 (χ^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 (χ^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.
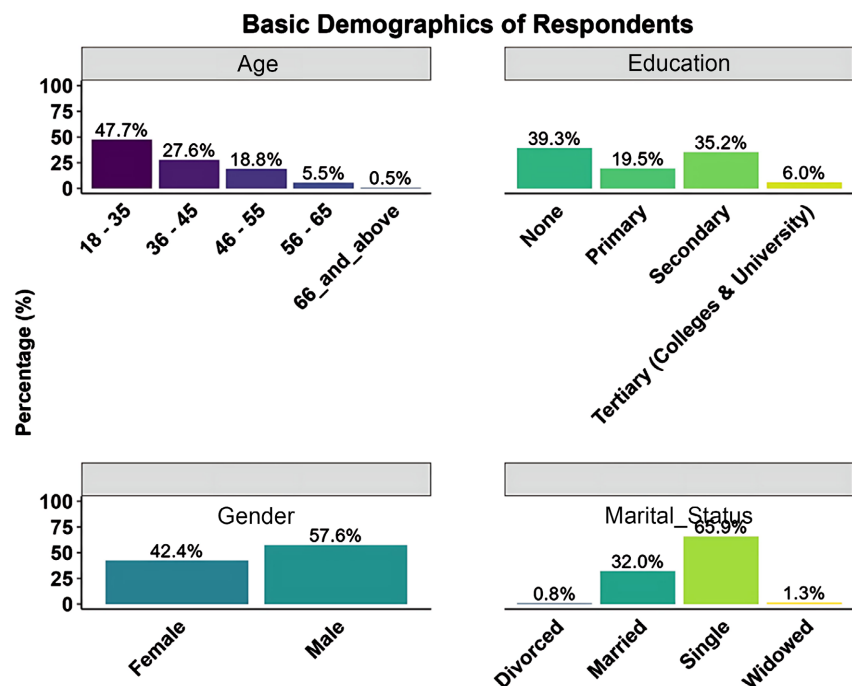

Figure 3. Basic demographics of respondents.

Figure 4 indicates a perceived gap in the capacity of institutions to deliver climate change training to fisheries communities. While 43% of respondents believe such training has been provided, 57% disagree. The *p*-value of 0.499 indicates no statistically significant difference between the groups, suggesting the observed disparity could be attributed to random variation. This underscores the need for further research into institutional capacity and the effectiveness of training programs.
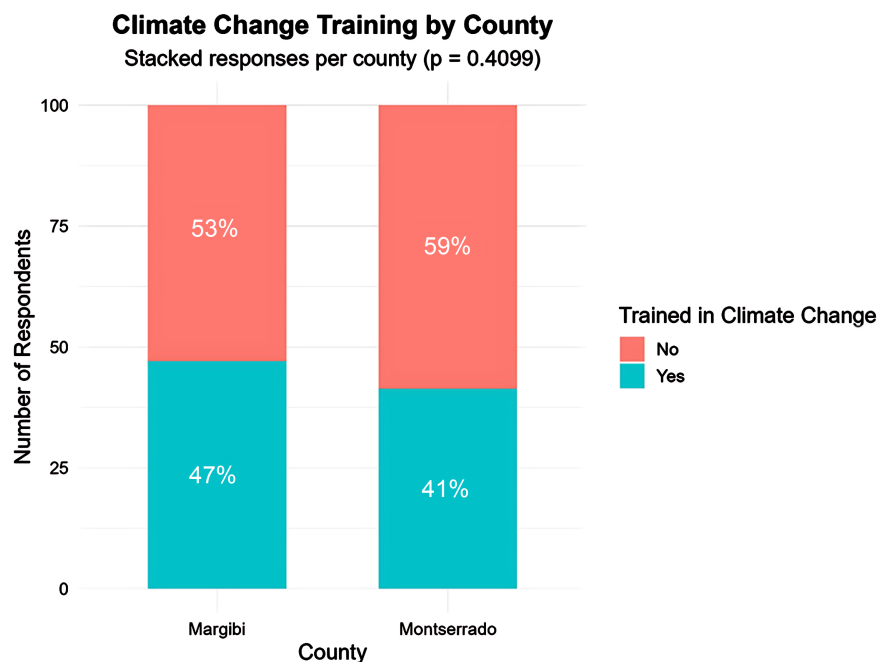

Figure 4. Fisheries trained on climate change in Liberia.

Figure 5 of the results indicates mixed perceptions of capacity-building efforts. While 42% of respondents agree or strongly agree that capacity building has been provided, 34% disagree or strongly disagree, and 24% remain neutral. The mean score of 2.97 suggests general agreement, but the standard deviation of 1.27 indicates moderate variation in opinions. This highlights potential inconsistencies in institutional capacity and the need for further investigation.

Figure 6 results show that significant disparities in public awareness of institutions addressing climate change in Liberia. While 90% of respondents are familiar with the National Fisheries & Aquaculture Authority (NaFAA), only 18% recognize the Environmental Protection Agency (EPA), and a mere 2% are aware of the Ministry of Agriculture. Awareness of the Liberia Maritime Authority and the Liberia Artisanal Fisheries Association is less than 1%. International NGOs, including CAFOD, CAE, FAD, and EJF, are acknowledged for their contributions to climate change initiatives. These findings emphasize the need to enhance institutional capacity and strengthen public engagement with local organizations.

The results in Figure 7 show that 42% of respondents agreed to have received training from the National Fisheries and Aquaculture Authority (NaFAA),
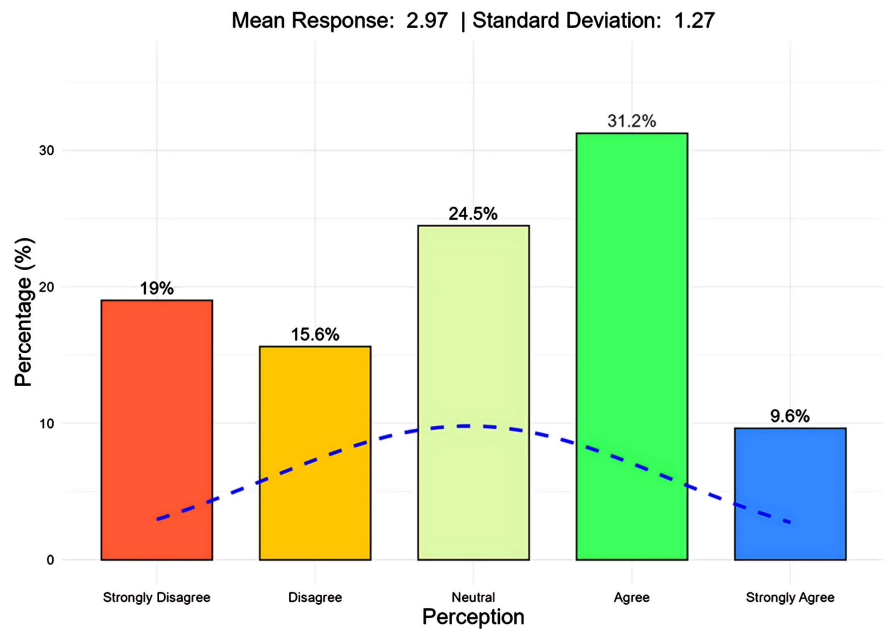
Mean Response: 2.97 | Standard Deviation: 1.27

Figure 5. Perceptions of capacity building provided for small-scale fisheries institutions.
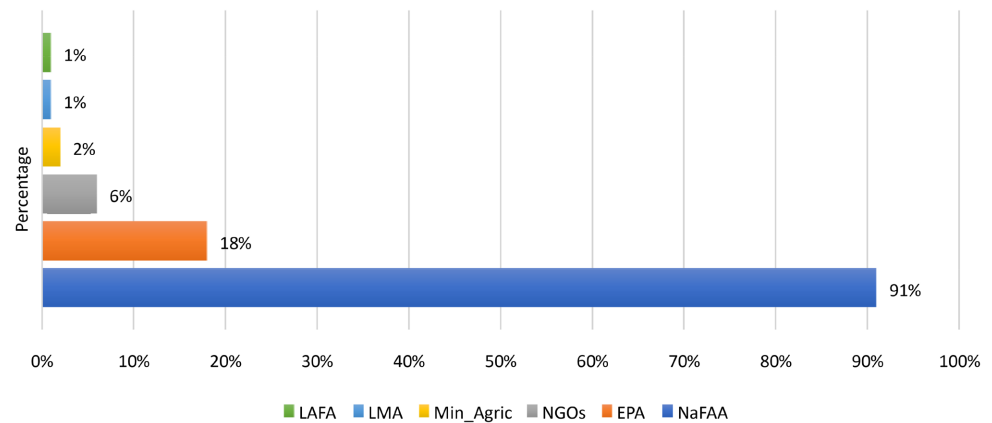

Figure 6. Respondent's awareness of institutions mandated to address climate change in Liberia.
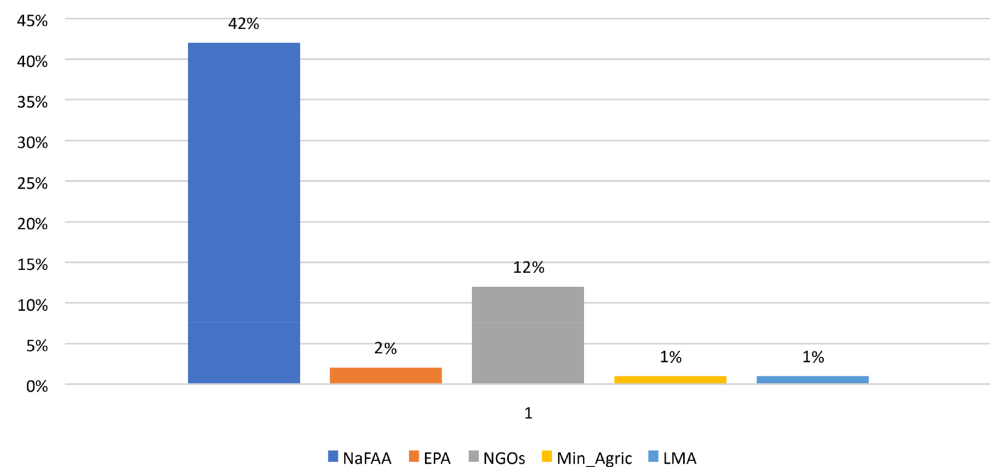

Figure 7. Institutions that have administered training in Liberia.

whereas 12% of respondents were trained by non-governmental organizations (NGOs) (Figure 7). Additionally, 2% received training from the Environmental Protection Agency (EPA), with the Ministry of Agriculture (MoA) and the Liberian Maritime Authority (LMA) each accounting for 1% of respondents who acknowledged receiving training from these institutions. When asked about the type of training they received, the most frequently mentioned was training on how to navigate offshore and unpredictable environments using a compass. Additionally, they received training on safety issues during fishing activities, where they were provided with lifesaving equipment such as life jackets, motor engines, and fishing nets. Fishmongers were trained in fish preservation and village savings. However, no specific training on climate change adaptation was received.

The results in (Figure 8) indicate significant disparities in public awareness of key climate change policies in Liberia. While 71% of respondents are aware of the National Fisheries and Aquaculture Policy and Strategy (NFAPS), only 18% recognize the National Adaptation Plan (NAP), and just 12% are familiar with the National Policy and Response Strategy (NPRS). These findings underscore the need to strengthen institutional capacity and public engagement to ensure that all key policies are widely recognized and well understood.
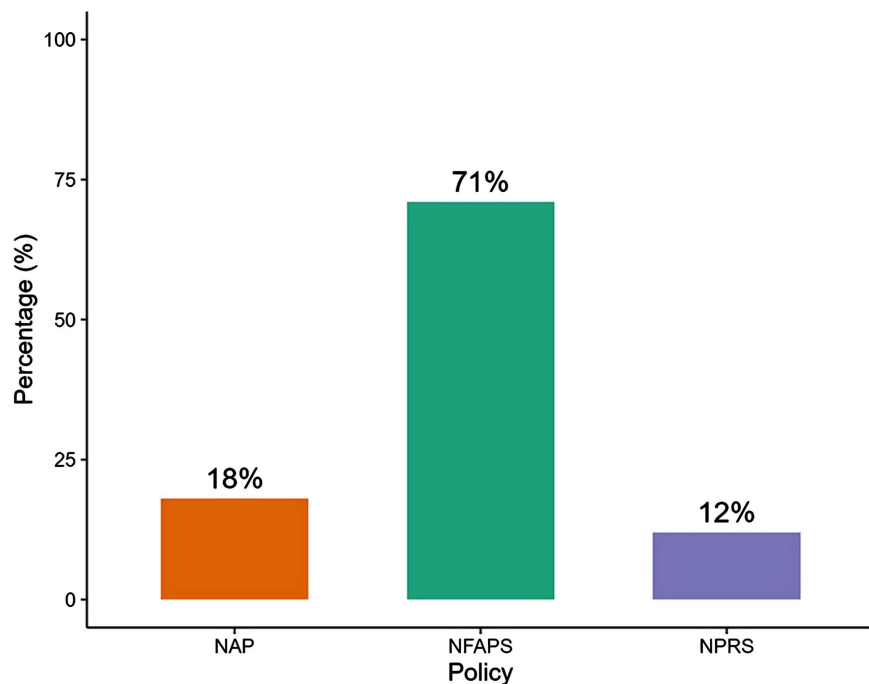

Figure 8. Awareness of policies to address local knowledge of climate adaptation strategies.

The results in Table 1 highlight widespread perceptions of inadequacies in local adaptation strategies, policies, and institutional coordination for climate change adaptation in Liberia's small-scale fishing sector. A majority of respondents (60%) feel that local adaptation strategies are insufficient, 70% believe that policies addressing climate change adaptation are inadequate, and 66% perceive a lack of

coordination among institutions. These statistically significant findings ($p < 0.05$) reflect a general dissatisfaction with current efforts and emphasize the need for targeted improvements in strategies, policy frameworks, and institutional collaboration.

Table 1. Perception of institutions mandated to address climate change.

Parameter	Agree (Positive) %	Disagree (Negative) %
Local adaptation strategies have prevented small-scale fisheries from climate change	40 ± 0.10[a]	60 ± 0.10[a]
Policies are in place to address climate change adaptation in the small-scale fishing sector	30 ± 0.20[a]	70 ± 0.20[a]
There is coordination among institutions as it relates to climate change adaptation strategies.	34 ± 0.16[a]	66 ± 0.16[a]

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

The results in Table 2 show the relationship between institutional mandates and the provision of training related to climate change adaptation in Liberia's fisheries sector. The p-values indicate that there is no statistically significant relationship between the mandates of most institutions and the provision of training. The only institution with a p-value close to significance is the National Fisheries and Aquaculture Authority (NaFAA) at 0.0933363, suggesting a potential but not definitive relationship. This highlights the need for improved institutional capacity and coordination to enhance training efforts in this sector.

Table 2. Relationship between institutional mandate and training.

Institution Mandated	Institution Training	p-Value
National Fisheries and Aquaculture Authority	NaFAA	0.0933363
Environmental Protection Agency (EPA)	EPA	0.6897052
Non-Governmental Organizations	NGOs working in fisheries development	1
MoA - Fisheries Division (Agric, Min)	MoA - Fisheries Division (Agric, Min)	1
Liberia Maritime Authority (LMA)	LMA	1
Liberia Artisanal Fishermen Association (LAFA)	LAFA	1

The results in Figure 9 indicate significant disparities in awareness of climate change policies among different age groups in Liberia's small-scale fisheries sec-

tor. A majority (91%) of respondents aged 18 - 35 are unaware of these policies, highlighting a gap in engaging younger fishers. In contrast, 14% of respondents aged 56 - 65 are aware of the policies. This underscores a systemic lack of communication and education regarding climate change adaptation strategies, with younger people being particularly underserved. The policies mentioned include Liberia's National Adaptation Plan (NAP) and the National Fisheries and Aquaculture Policy and Strategy (LNFAPS).
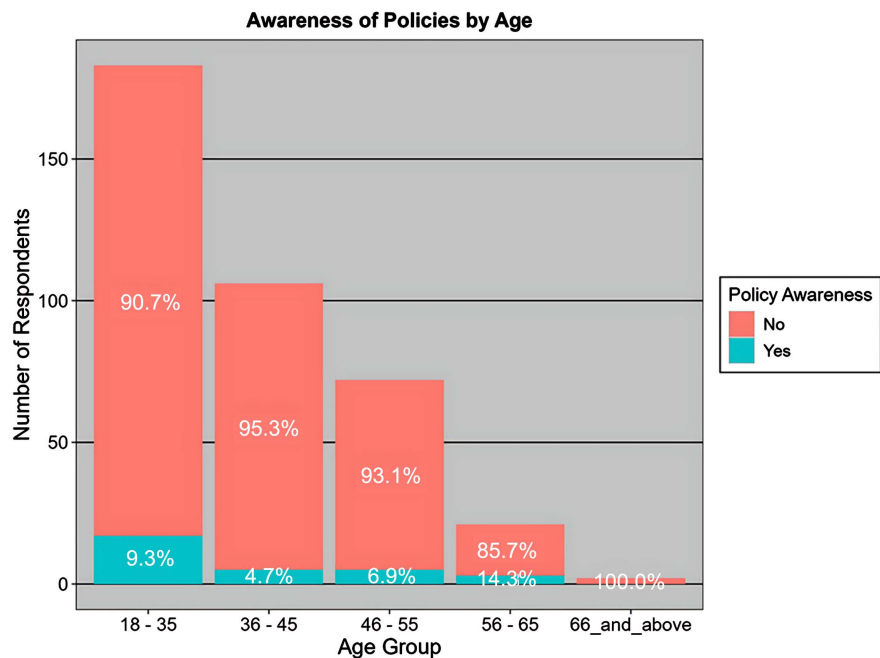

Figure 9. Awareness of policies by age.

Figure 10 of the results shows significant perceived inadequacies in incorporating local knowledge into climate change adaptation policy development for Liberia's small-scale fisheries sector. Specifically, 62% of respondents disagreed or strongly disagreed that local knowledge has been integrated, while only 27% agreed or strongly agreed. A mean score of 2.45 suggests a general tendency toward disagreement, while the standard deviation of 1.25 reflects moderate variability in opinions. These findings underscore the need to strengthen institutional capacity to better incorporate local knowledge into policy-making processes.

Figure 11 reveals significant perceived inadequacies in the implementation of climate change adaptations within Liberia's small-scale fisheries sector. A majority (53%) of respondents disagree or strongly disagree that such adaptations have been made, while 36% agree or strongly agree. The mean score of 2.8 indicates a slight tendency toward disagreement, with a standard deviation of 1.23 reflecting moderate variability in opinions. Overall, the findings suggest that many respondents feel existing laws and strategies have not been adequately adjusted to address climate change adaptation, highlighting the need for improved institutional capacity.
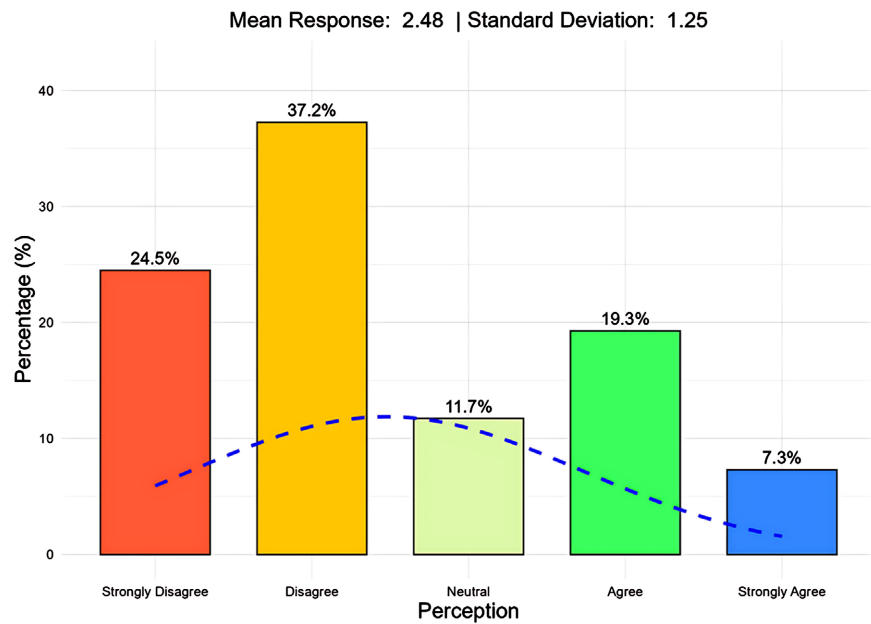
Mean Response: 2.48 | Standard Deviation: 1.25

Figure 10. Local knowledge usage in developing climate change adaptation policy in Liberia.

Mean Response: 4.15 | Standard Deviation: 0.74
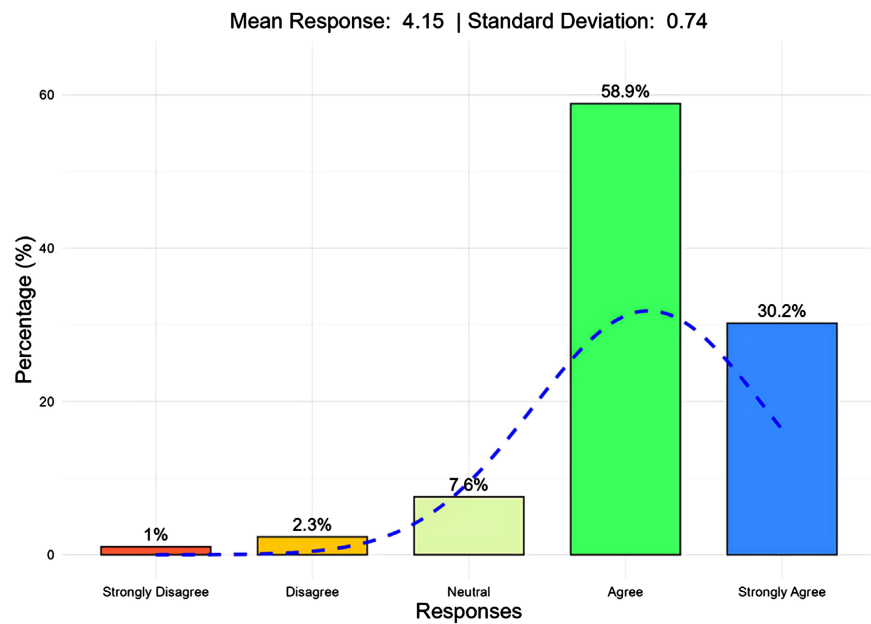

Figure 11. Local fisheries' adaptation of existing laws for climate change.

4. Discussion

Integrating Local Ecological Knowledge (LEK) into climate adaptation strategies is a critical yet often overlooked aspect of effective climate change governance, particularly in sectors like fisheries, which are highly vulnerable to environmental changes. Despite the potential of LEK to enhance adaptation, 62% of respondents in this study indicated that it has not been adequately incorporated into policy development. This finding is consistent with global trends, as LEK has frequently

been sidelined in favor of top-down policy frameworks that do not always consider the realities of local communities (Brodie et al., 2024). LEK offers invaluable insights, such as fishers' firsthand observations of shifting marine ecosystems, migratory patterns, and seasonal variations, which can be critical for crafting adaptation strategies tailored to local conditions (Dushkova & Ivlieva, 2024). A compelling example comes from Tanzania, where LEK-informed policies have proven effective in enhancing climate change adaptation efforts in small-scale fisheries, improving community engagement and resilience (Brodie et al., 2024). By integrating such knowledge, Liberia could better align its climate policies with practical, community-driven solutions, thereby improving both its relevance and effectiveness.

The study also revealed that 53% of respondents believe that existing laws governing Liberia's fisheries have not been adequately adapted to support climate resilience. Legal frameworks, while essential for regulating fisheries and protecting marine resources, often fail to incorporate climate risks, resulting in policy gaps that leave small-scale fishers vulnerable. A notable example comes from Ghana, where legal reforms have specifically targeted climate vulnerabilities within the fisheries sector. These reforms include seasonal fishing bans aimed at protecting fish stocks during critical breeding periods, thus mitigating the impacts of climate change on marine biodiversity (Wang et al., 2024). Such reforms are proactive and adaptive, aligning with sustainable fisheries management practices that address both climate and ecological factors. Adopting a similar approach in Liberia could provide a more robust legal framework for ensuring the long-term sustainability of its fisheries sector in the face of climate change. Institutional coordination remains another critical challenge, with 66% of respondents perceiving a lack of effective collaboration among institutions responsible for fisheries management and climate adaptation.

The National Fisheries and Aquaculture Authority (NaFAA) has taken steps to engage with fishers by training 42% of respondents, yet other key institutions such as the Environmental Protection Agency (EPA) and the Ministry of Agriculture (MoA) have been far less involved, with only 2% and 1% of respondents reporting engagement, respectively. This lack of coordination can significantly undermine the effectiveness of climate adaptation strategies, as it hinders the ability to address the multi-dimensional nature of climate impacts on the fisheries sector. Senegal offers a successful example of multi-stakeholder collaboration, where coordinated efforts between government agencies, NGOs, and local communities have led to the successful management of fisheries and climate adaptation projects (Townhill et al., 2023).

By adopting a similar model, Liberia could improve coordination, streamline adaptation efforts, and ensure that resources are allocated more effectively, particularly to vulnerable fishing communities. Furthermore, the study found that 70% of respondents believe current climate adaptation policies in Liberia's fisheries are inadequate. This is indicative of significant gaps in policy development and communication, which are essential for fostering effective community participa-

tion and engagement. Research consistently shows that well-communicated policies not only improve community engagement but also enhance compliance with climate resilience strategies (Ntontis et al., 2020). In Liberia, expanding the scope of frameworks such as the National Adaptation Plan (NAP) and National Fisheries and Aquaculture Policy and Strategy (LNFAPS) to address climate-specific challenges could help close these gaps.

Additionally, providing clear and accessible information about these policies to local fisher communities is crucial for increasing awareness, participation, and compliance, ultimately strengthening the resilience of the fisheries sector. An important observation from the survey is the significant awareness gap among respondents, with 71% familiar with the National Fisheries and Aquaculture Policy and Strategy (NFAPS), while awareness of climate-related policies such as the NAP and National Policy and Response Strategy (NPRS) was much lower (18% and 12%, respectively). This underscores a pressing need for better communication and education regarding climate adaptation policies. (Dushkova & Ivlieva, 2024), emphasize that effective policies must be responsive to local adaptation needs, ensuring that communities are actively engaged in shaping their climate resilience. The generational gaps in policy awareness are particularly concerning, with 91% of respondents aged 18 - 35 unaware of climate policies, compared to only 14% of respondents aged 56 - 65. This suggests that younger fishers are not being adequately reached through traditional policy communication channels. As noted by (Smith et al., 2023), bridging these generational gaps requires innovative approaches that integrate an engaging communication strategy. By engaging younger fishers more effectively and ensuring the integration of both LEK and scientific knowledge, Liberia can promote broader awareness and build a more resilient fishing community capable of adapting to climate change.

5. Conclusion

This study investigated how institutional frameworks shape the integration of local ecological knowledge (LEK) into climate change adaptation strategies among small-scale fisheries in three coastal communities in Liberia. Utilizing a mixed-methods approach, combining survey data from 384 fishers with qualitative interviews from 12 key stakeholders, the research uncovered critical deficiencies in institutional coordination, policy implementation, and stakeholder engagement. The findings reveal a persistent disconnect between formal adaptation strategies and the lived experiences of fishing communities, particularly regarding the inclusion of LEK and the responsiveness of institutional actors.

Respondents expressed widespread dissatisfaction with existing adaptation initiatives, citing limited institutional support, inadequate access to timely climate information, and a lack of recognition for their traditional knowledge systems. Quantitative analysis identified statistically significant associations between community location and perceptions of institutional effectiveness and LEK integration, while qualitative data provided deeper insight into the structural and gov-

ernance-related barriers hindering effective adaptation. These challenges reflect a broader governance gap and limited adaptive capacity among institutions responsible for climate resilience, key issues at the heart of institutional capacities theory. Institutional capacities theory offered a valuable framework for assessing the performance of adaptation governance by emphasizing analytical, operational, and political dimensions of institutional capacity. The study's findings, such as weak inter-agency coordination, insufficient participatory mechanisms, and the marginalization of community knowledge, highlight the urgent need for more inclusive, locally grounded, and adaptive policy responses. These insights align with and contribute to ongoing global debates around participatory governance, knowledge co-production, and equity in climate adaptation planning.

In conclusion, achieving effective climate change adaptation in Liberia's small-scale fisheries demands a transformative shift in governance structures. Strengthening institutional capacities, embedding local knowledge systems into formal decision-making processes, and ensuring meaningful stakeholder participation are essential steps toward building more resilient and inclusive adaptation frameworks. This research not only enriches the academic discourse on adaptation governance but also provides actionable guidance for policymakers and practitioners working to support vulnerable coastal communities.

6. Recommendations

1) Policymakers should prioritize the integration of local ecological knowledge (LEK) into climate adaptation policies by establishing mechanisms for regular community consultations, ensuring that local fishers' insights directly inform policy development.

2) The government should also amend existing laws to incorporate climate resilience provisions for small-scale fisheries, such as seasonal fishing bans and other adaptive regulations.

3) Furthermore, climate resilience training should be central to institutional programs, focusing on sustainable fishing practices, adaptation techniques, and risk management to equip fishers with practical tools for coping with climate impacts.

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Conflicts of Interest

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

References

Adom, R. K., Simatele, M. D., Das, D. K., Mukalazi, K. A., Sonwabo, M., Mudau, L. et al.

(2024). Enhancing Climate Change Adaptation Governance through Transforming Institutions in Kwa-Zulu Natal Province, South Africa. *International Journal of Climate Change Strategies and Management, 16,* 413-438.
https://doi.org/10.1108/ijccsm-12-2022-0157

Aguión, A., Ojea, E., García-Flórez, L., Cruz, T., Garmendia, J. M., Davoult, D. et al. (2022). Establishing a Governance Threshold in Small-Scale Fisheries to Achieve Sustainability. *Ambio, 51,* 652-665. https://doi.org/10.1007/s13280-021-01606-x

Alberto, R. P., Teano, J. A., Paz-Alberto, A. M., Tangonan, M. A. B., Villamar, H. J. E., Clement, S. et al. (2024). Impacts of Climate Change on Mangrove Subsistence Fisheries: A Global Review. *Marine Life Science & Technology, 6,* 610-630.
https://doi.org/10.1007/s42995-024-00231-3

Ba, A., Chaboud, C., Schmidt, J., Diouf, M., Fall, M., Dème, M. et al. (2019). The Potential Impact of Marine Protected Areas on the Senegalese Sardinella Fishery. *Ocean & Coastal Management, 169,* 239-246. https://doi.org/10.1016/j.ocecoaman.2018.12.020

Badji, A., Ibanda, A., Akello, S., & Ekwamu, A. (2022). Climate Change Impacts and Adaptation Strategies in Africa: Selected Case Studies. *Researchgate.*

Brodie, L. P., Caballero, S. V., Ojea, E., Taylor, S. F. W., Roberts, M., Vianello, P. et al. (2024). A New Framework on Climate-Induced Food-Security Risk for Small-Scale Fishing Communities in Tanzania. *Food Security, 16,* 1125-1145.
https://doi.org/10.1007/s12571-024-01472-x

Busetto, L., Wick, W., & Gumbinger, C. (2020). How to Use and Assess Qualitative Research Methods. *Neurological Research and Practice, 2,* Article No. 14.
https://doi.org/10.1186/s42466-020-00059-z

Cattivelli, V. (2021). Climate Adaptation Strategies and Associated Governance Structures in Mountain Areas. the Case of the Alpine Regions. *Sustainability, 13,* Article 2810.
https://doi.org/10.3390/su13052810

Cheruvalappil, J., Suresh, A., Rajeev, K., & Manzil, N. R. Z. (2024). Awareness and Perception Regarding the E-Waste Management among a Population in Northern Kerala. *International Journal of Research in Medical Sciences, 12,* 2482-2489.
https://doi.org/10.18203/2320-6012.ijrms20241901

Chuku, E. O., Effah, E., Adotey, J., Abrokwah, S., Adade, R., Okyere, I. et al. (2022). Spotlighting Women-Led Fisheries Livelihoods toward Sustainable Coastal Governance: The Estuarine and Mangrove Ecosystem Shellfisheries of West Africa. *Frontiers in Marine Science, 9,* Article 884715. https://doi.org/10.3389/fmars.2022.884715

Dushkova, D., & Ivlieva, O. (2024). Empowering Communities to Act for a Change: A Review of the Community Empowerment Programs Towards Sustainability and Resilience. *Sustainability, 16,* Article 8700. https://doi.org/10.3390/su16198700

Emmanuel, F. B. (2022). Planning as Polycentric: Institutionalist Lessons for Communicative and Collaborative Planning in Global South Contexts. *Planning Theory, 22,* 131-153.
https://journals.sagepub.com/doi/10.1177/14730952221115871?icid=int.sj-abstract.citing-articles.10

Hossen, M. A., Netherton, C., Benson, D., Rahman, M. R., & Salehin, M. (2022). A Governance Perspective for Climate Change Adaptation: Conceptualizing the Policy-Community Interface in Bangladesh. *Environmental Science & Policy, 137,* 174-184.
https://doi.org/10.1016/j.envsci.2022.08.028

Kuletz, K. J., Ferguson, S. H., Frederiksen, M., Gallagher, C. P., Hauser, D. D. W., Hop, H. et al. (2024). A Review of Climate Change Impacts on Migration Patterns of Marine Vertebrates in Arctic and Subarctic Ecosystems. *Frontiers in Environmental Science, 12,* Article 1434549. https://doi.org/10.3389/fenvs.2024.1434549

Lepore, W., L. Hall, B., & Tandon, R. (2025). *Bridging Knowledge Cultures: Rebalancing Power in the Co-Construction of Knowledge.* BRILL. https://doi.org/10.1163/9789004687769

Manglem, A., & Teresa, K. (2024). Integrating Indigenous Knowledge in Community-Based Climate Change Adaptation. *Indian Journal of Natural Products, 14,* 65301-65305.

Maulu, S., Hasimuna, O. J., Haambiya, L. H., Monde, C., Musuka, C. G., Makorwa, T. H. et al. (2021). Climate Change Effects on Aquaculture Production: Sustainability Implications, Mitigation, and Adaptations. *Frontiers in Sustainable Food Systems, 5,* Article 609097. https://doi.org/10.3389/fsufs.2021.609097

Mozumder, M. M. H., Schneider, P., Islam, M. M., Deb, D., Hasan, M., Monzer, M. A. et al. (2023). Climate Change Adaptation Strategies for Small-Scale Hilsa Fishers in the Coastal Area of Bangladesh: Social, Economic, and Ecological Perspectives. *Frontiers in Marine Science, 10,* Article 1151875. https://doi.org/10.3389/fmars.2023.1151875

Mukherjee, I., Coban, M. K., & Bali, A. S. (2021). Policy Capacities and Effective Policy Design: A Review. *Policy Sciences, 54,* 243-268. https://doi.org/10.1007/s11077-021-09420-8

Mweshi, G. K., & Muhyila, M. (2024). Determining a Statistical Analysis for the Quantitative Study in Research. *Advances in Social Sciences Research Journal, 11,* 187-231. https://doi.org/10.14738/assrj.117.17018

Nanjundeswaraswamy, T. S., & Divakar, S. (2021). Determination of Sample Size and Sampling Methods in Applied Research. *Proceedings on Engineering Sciences, 3,* 25-32. https://doi.org/10.24874/pes03.01.003

Ntontis, E., Drury, J., Amlôt, R., Rubin, G. J., & Williams, R. (2020). What Lies Beyond Social Capital? The Role of Social Psychology in Building Community Resilience to Climate Change. *Traumatology, 26,* 253-265. https://doi.org/10.1037/trm0000221

Oluigbo, C. U., Ngozi, E. C., & Ohaegbu, P. M. N. I. (2024). *Determination of Sample Sizes in Research Using Taro Yamane Formula: An Overview.*

Pahwa, M., Cavanagh, A., & Vanstone, M. (2023). Key Informants in Applied Qualitative Health Research. *Qualitative Health Research, 33,* 1251-1261. https://doi.org/10.1177/10497323231198796

Pereyra, P. E. R., Ospina-Alvarez, A., Dutra, M. C. F., Schallenberger, B. H., Hallwass, G., Begossi, A. et al. (2024). Integrating Fishers' Knowledge on Fish Use with Ecological Networks to Assess the 'Silent Threat' of Mercury Contamination in Tropical Marine and Freshwater Fisheries. *Environment, Development and Sustainability.* https://doi.org/10.1007/s10668-024-04990-y

Proulx, M., Ross, L., Macdonald, C., Fitzsimmons, S., & Smit, M. (2021). Indigenous Traditional Ecological Knowledge and Ocean Observing: A Review of Successful Partnerships. *Frontiers in Marine Science, 8,* Article 703938. https://doi.org/10.3389/fmars.2021.703938

Puig, D., Adger, N. W., Barnett, J., Vanhala, L., & Boyd, E. (2025). Improving the Effectiveness of Climate Change Adaptation Measures. *Climatic Change, 178,* Article No. 7. https://doi.org/10.1007/s10584-024-03838-8

Qaissi, A. (2024). Exploring Thematic Analysis in Qualitative Research. In B. Bentalha, & L. Alla (Eds.), *Data Collection and Analysis in Scientific Qualitative Research* (pp. 253-294). IGI Global. https://doi.org/10.4018/979-8-3693-8689-7.ch010

Radtke, J., & Renn, O. (2024). Participation in Energy Transitions: A Comparison of Policy Styles. *Energy Research & Social Science, 118,* Article ID: 103743. https://doi.org/10.1016/j.erss.2024.103743

Sady, M. (2024). The Role of Stakeholders in Sustainable Development. In A. Kuźniarska, K. Mania, & M. Jedynak (Eds.), *Organizing Sustainable Development* (pp. 203-217). Routledge. https://doi.org/10.4324/9781003379409-19

Saye, W. A. (2024). Poverty Measurements in the Small-Scale Fishery of Liberia: A Step Towards Poverty Eradication. *International Journal of Fisheries and Aquatic Studies, 12,* 73-83. https://doi.org/10.22271/fish.2024.v12.i4a.2946

Smith, G., Chowenga, M., & Karsters, J. (2023). Local Knowledge Matters: Understanding the Decision-Making Processes of Communities under Climate Change in Suriname. *Frontiers in Climate, 5,* Article 1294271. https://doi.org/10.3389/fclim.2023.1294271

South, L., Saffo, D., Vitek, O., & Dunne, C. (2024). Effective Use of Likert Scales in Visualization Evaluations: A Systematic Review. *Computer Graphics Forum, 41,* 43-55. https://doi.org/10.31219/osf.io/6f3zs

Suratman, M. N. (2021). *Mangrove as a Natural Barrier to Environmental Risks and Coastal Protection.* Springer. https://doi.org/10.1007/978-981-16-2494-0

Taoreed, A. A. (2024). *The BALM Framework of Clinical Excellence: An Adoptable Model for Sub-Saharan Africa.* https://www.researchgate.net/publication/372707850_The_BALM_framework_of_clinical_excellence_an_adoptable_model_for_sub-Saharan_Africa

Togbah, C. F. (2024). *An Analysis of Liberia's Vulnerability to Climate Change in the Context of Least Developed Countries (LDCs).*

Townhill, B., Harrod, O., Painting, S., Acheampong, E., Bell, J., Nyarko, B. K. et al. (2023). Climate Change Risk and Adaptation for Fisher Communities in Ghana. *Journal of Coastal Conservation, 27,* Article No. 45. https://doi.org/10.1007/s11852-023-00967-7

Ullah, H., Wahab, M. A., Rahman, M. J., Al Mamun, S. N., Kumar, U., Rahman, M. A. et al. (2023). Local Ecological Knowledge Can Support Improved Management of Small-Scale Fisheries in the Bay of Bengal. *Frontiers in Marine Science, 10,* Article 974591. https://doi.org/10.3389/fmars.2023.974591

USAID (2020). *Regional Development.*

Villasante, S., Macho, G., Silva, M. R. O., Lopes, P. F. M., Pita, P., Simón, A. et al. (2022). Resilience and Social Adaptation to Climate Change Impacts in Small-Scale Fisheries. *Frontiers in Marine Science, 9,* Article 802762. https://doi.org/10.3389/fmars.2022.802762

Wang, B., Hua, L., Mei, H., Wu, X., Kang, Y., & Zhao, N. (2024). Impact of Climate Change on the Dynamic Processes of Marine Environment and Feedback Mechanisms: An Overview. *Archives of Computational Methods in Engineering, 31,* 3377-3408. https://doi.org/10.1007/s11831-024-10072-z

Werners, S. E., Sparkes, E., Totin, E., Abel, N., Bhadwal, S., Butler, J. R. A. et al. (2021). Advancing Climate Resilient Development Pathways since the IPCC's Fifth Assessment Report. *Environmental Science & Policy, 126,* 168-176. https://doi.org/10.1016/j.envsci.2021.09.017

World Bank (2024). *Climate Risk Country Profile.* ResearchGate.

Wuokolo, J. D. (2023). *Perception of Climate Change and Barriers to Strategic Adaptation for Smallholder Farming in Todee District, Liberia.* Ph.D. Thesis, Chulalongkorn University. https://www.researchgate.net/publication/367392196_Perception_Of_Climate_Change_And_Barriers_To_Strategic_Adaptation_For_Smallholder_Farming_in_Todee_District_Liberia

Yanou, M. P., Ros-Tonen, M. A. F., Reed, J., Moombe, K., & Sunderland, T. (2023). Inte-

grating Local and Scientific Knowledge: The Need for Decolonising Knowledge for Conservation and Natural Resource Management. *Heliyon, 9,* e21785. https://doi.org/10.1016/j.heliyon.2023.e21785