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Impacts and adaptation activities in response to climate change by fishery households in Thua Thien Hue Province, Vietnam

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Abstract

Purpose – This study aims to examine the climate change impacts on Phu Thuan's fishery livelihoods, identifying adaptation strategies and policies for resilience. It addresses impacts, demographic factors and sustainable fishery management, aligning with SDGs 1, 13 and 14 for coastal communities.

Design/methodology/approach – This mixed-method study surveys (n = 119) focus groups and meteorological data (1956–2022) to assess climate change impacts in Phu Thuan, Vietnam. Logistic regression and Kruskal–Wallis tests analyze adaptation, complemented by qualitative insights.

Findings – Climate change causes 23.5% severe gear damage and 21% resource depletion in Phu Thuan. Households adapt via 58% fishing reinvestment and 47% seasonal labor; 21% use unsustainable nets. Younger age increases diversification (OR = 1.50, $p < 0.01$) mirroring global constraints.

Research limitations/implications – Sample size (n = 119) and focus on Phu Thuan limit generalizability. Older fishers may underreport impacts. Recent data (2015–2022) may miss historical baselines. Larger and longitudinal studies with marine assessments can enhance findings for scalable climate adaptation strategies.

JEL classification – O13, Q22, Q54, Q57, R58

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Declarations:

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Ethical approval: This research was done in compliance to the recommended Code of Ethical Conduct for Research on Human Subjects. Approval for the research protocol was obtained from the Institutional Review Board (IRB) of Hue University, Vietnam. Permission from all participants was sought and their privacy and identities were preserved when data was being collected and analyzed.

Conflict of interest statement: The authors declare that there is no conflict of interest regarding the publication of this paper.

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Practical implications – Vocational training, fishing ground regulation and gear subsidies mitigate 23.5% gear damage. Community co-management reduces unsustainable practices. Aligned with Vietnam's National Adaptation Plan, these policies enhance economic stability and sustainability for climate-vulnerable coastal communities.

Social implications – Training empowers younger fishers, reducing poverty (SDG 1). Equitable fishing access fosters community cohesion. Adaptation workshops promote sustainable practices, enhancing resilience and social equity in Phu Thuan, supporting inclusive development.

Originality/value – Integrating mixed-method data, this study quantifies Phu Thuan's climate impacts (23.5% gear damage) and adaptations (OR = 1.50, $p < 0.01$). Global comparisons and SDG-aligned policies offer a novel framework for sustainable fishery management in vulnerable coastal communities.

Keywords Climate change, Fishery households, Adaptation response, Coastal area, Vietnam

Paper type Research paper

Introduction

Climate change is a pressing global challenge that profoundly influences the development and sustainability of countries, regions and continents (Barros, 2014). Its effects will be particularly severe in developing countries where millions of people are substantially dependent on natural ecosystems for their livelihood and well–being (Aboye *et al.*, 2023; Weatherdon *et al.*, 2016). In these countries, the areas most vulnerable to its impacts are coastal regions, which face heightened risks from global warming and extreme climatic events (Islam *et al.*, 2019). Similar to agriculture, the fisheries sector is highly vulnerable to these changes due to its dependence on natural and environmental conditions (Brander *et al.*, 2017; Hobday *et al.*, 2018). Climate variability and climate-induced disasters threaten fishers' livelihoods and fishing communities worldwide (Islam *et al.*, 2019; Allison et al, 2009). Fishers are experiencing significant losses and damages due to the changing climate (White *et al.*, 2005). For instance, coastal communities in Bangladesh, the Philippines and Ghana face declining fish stocks and intensified storms, prompting adaptive strategies like livelihood diversification (e.g. small-scale aquaculture in Bangladesh) and community-based resource management (Alam and Mallick, 2022; Alcantara *et al.*, 2023). These cases highlight the need for context-specific policies, informing this study's focus on Phu Thuan.

Vietnam, prone to natural disasters such as storms, floods and coastal erosion, is among the world's most vulnerable to climate change (FAO, 2020; Huynh *et al.*, 2021). With over 3,260 kilometers of coastline accounting for 15% of the country's natural area, Vietnam's coastal regions are home to approximately 25% of the national population across 28 provinces and 125 coastal districts. Of these, 23 provinces include particularly disadvantaged coastal and island communes. These regions are heavily impacted by climate change, as the livelihoods of their populations depend heavily on natural resources (Schleyer-Lindenmann *et al.*, 2022). Vietnam's marine fisheries face intense pressure, with an ecological footprint exceeding the bio-capacity of its coastal ecosystems by an estimated 1.5 times, driven by overfishing, competition from large vessels and environmental degradation (Hoang, 2021; Tran *et al.*, 2021). In Phu Thuan Commune, this overexploitation reduces nearshore fish stocks, exacerbating climate-induced vulnerabilities and limiting adaptive capacity. The impacts of climate change are predicted to amplify further and exacerbate the existing pressures on the coastal regions and communities, threatening sustainable development in terms of livelihoods and natural resources, particularly in the disadvantaged coastal areas (Barros, 2014; Tran *et al.*, 2017).

Marine protected areas (MPAs), such as those in the Tam Giang-Cau Hai lagoon, are critical for conserving marine biodiversity and supporting fishery sustainability in Vietnam. However, restricted access to these areas reduces traditional fishing grounds, pushing fishers

toward unsustainable practices like small-mesh nets, which further deplete resources (Erzini, 2020; Pomeroy *et al.*, 2009; Pham *et al.*, 2023). Thua Thien Hue, a coastal province in Central Vietnam, has 128 kilometers of coastline, with nearly 70% of its population living in rural areas (Badjeck *et al.*, 2010). Among these are 23 particularly disadvantaged coastal and island communes. Fishing and agriculture, traditional livelihoods for most households in these areas, serve as the primary sources of income (Galappaththi *et al.*, 2019). However, these livelihoods are highly precarious due to the increasing frequency and severity of natural disasters, such as storms, floods, droughts, cold spells and tornadoes (Huynh *et al.*, 2021; Hoang *et al.*, 2022). These events are causing severe and escalating impacts on coastal plains and lagoons, particularly in low-lying and disadvantaged areas (Hagedoorn *et al.*, 2021). According to national climate change scenarios and local assessments, Thua Thien Hue is one of the regions most severely affected by climate change and extreme weather. Agriculture and fisheries are identified as the most impacted sectors (Badjeck *et al.*, 2010).

Grounded in the vulnerability framework (Galappaththi *et al.*, 2019), this study investigates the multifaceted impacts of climate change on fishery households in Phu Thuan Commune, Phu Vang District, Thua Thien Hue Province, focusing on disruptions to fishing gear, marine resources, human health and livelihoods. It examines how households adapt through strategies such as livelihood diversification, gear modification and non-fishing activities, while assessing their sustainability. The study addresses three research questions:

RQ1. How does climate change impact fishery livelihoods in Phu Thuan?

RQ2. Which demographic and socioeconomic factors shape household adaptation strategies?

RQ3. What policies can promote resilience and sustainable fishery management in Phu Thuan?

Using a mixed-method approach, this research provides empirical and theoretical insights into social-environmental interactions in coastal communities. It aims to inform culturally sensitive, climate-resilient policies aligned with Sustainable Development Goals (SDGs), particularly SDG 13 (Climate Action), SDG 14 (Life Below Water) and SDG 1 (No Poverty), to foster resilience and sustainable resource management. This intersection highlights the need for integrated approaches that balance ecological sustainability with socioeconomic development in vulnerable coastal communities. The findings aim to guide policies that promote sustainable fishing practices, livelihood diversification and equitable resource access, addressing the socioeconomic and ecological challenges faced by Phu Thuan's fishery households.

Methodology

Study site

Phu Vang District is bounded to the east by the East Vietnam Sea, to the west by Huong Tra District and Hue City, to the north by Quang Dien District and to the south by Phu Loc District. The Phu Vang lowlands have a total area of 28,032 hectares, of which 10,829 hectares are agricultural land, 13,933 hectares are non-agricultural and 3,269 hectares are idle land. The district has a population of 182,336 people, with a population density of 647 per square kilometer (km^2) and a workforce of 85,830 (2023).

Thua Thien Hue is a central coastal province of Vietnam, with 128 km of coastline, the Tam Giang-Cau Hai lagoon, covering 22,000 ha and forest land spanning more than 200,000 ha. The

lagoon extends 70 km and supports over 380,000 people in buffer areas, 45% of whom live in 32 communities in five districts and 236 villages (Pham and Saizen, 2023). These residents, who form a significant portion of the province's total population of 1,090,879, rely on fishing, aquaculture and farming, exploiting the lagoon's natural resources. Phu Thuan Commune, one of eight particularly disadvantaged coastal communes in Phu Vang District, Thua Thien Hue Province frequently experiences natural disasters such as storms, floods, droughts, coastal erosion and epidemics (*Report on the Social Economic Development Plan of Phu Thuan Commune (Hard Copy)*, 2023). Marine fishing is the primary income source for most households in Phu Thuan's fishing hamlets, but overfishing and competition from large vessels exacerbate resource depletion, with nearshore fish stocks declining by approximately 20% over the past decade (Hoang, 2021; Ayad and Lefilef, 2025). MPAs in the Tam Giang-Cau Hai lagoon conserve biodiversity and regulate fishing, yet restricted access limits traditional fishing grounds, pushing fishers toward unsustainable practices like small-mesh nets, which threaten long-term resource sustainability (Erzini, 2020; Pomeroy *et al.*, 2009); Pham *et al.*, 2023).

Methods

This study employed a mixed-method approach, integrating qualitative and quantitative methods to collect and analyze data, as guided by Creswell and Clark (2017). Data collection occurred in Phu Thuan Commune, Phu Vang District, Thua Thien Hue Province(see Figure 1), from November 2023 to April 2024, using document analysis, focus group discussions, key informant interviews and household surveys.

First, document analysis involved reviewing annual reports on the socio-economic development of Thua Thien Hue Province, Phu Vang District and Phu Thuan Commune to contextualize the study site. Meteorological data spanning 1956–2022 were collected from the Hue Meteorological Station to analyze climate change trends. Second, interviews with key informants, including commune leaders and fisher association heads, were conducted. These interviews aimed to understand the local authorities' socioeconomic characteristics, strategies and action plans in response to climate change and extreme events, as well as the challenges and planned measures to support fishery households in securing livelihoods and conserving natural resources. Focus groups discussions were conducted with 12 representatives of local fishery households, selected based on diversity in gender, age and household type as recommended by fishing hamlet leaders. This method provided insights into household perspectives on climate change impacts and adaptive strategies.

Household surveys were administered to 119 fishery households across six hamlets in Phu Thuan Commune (Tan An, Xuan An, Trung An, An Duong 2 and An Duong 3). As described by De Vaus (Thuy *et al.*, 2017), a simple random sampling approach was employed, using the list of fishing households provided by local authorities. If a selected household was inaccessible, the researcher substituted it with the nearest available household based on recommendations from hamlet representatives. This method ensured equal selection probability and represented population heterogeneity, suitable for studying diverse adaptation strategies. To address potential biases, such as incomplete household lists or accessibility issues, hamlet leaders were consulted to verify substitutions, minimizing selection bias. However, the sample size (n = 119) may not fully capture the diversity of Phu Thuan's fishing households, a limitation addressed in the Recommendations section.

Quantitative data, including meteorological records and survey responses, were processed using Microsoft Excel with descriptive statistical analysis conducted to clarify the research aims. To strengthen causal insights, logistic regression analysis was performed using R software to examine relationships between demographic factors (e.g. age, education, number of laborers) and adaptation strategies (e.g. investment in fishing vs non-fishing

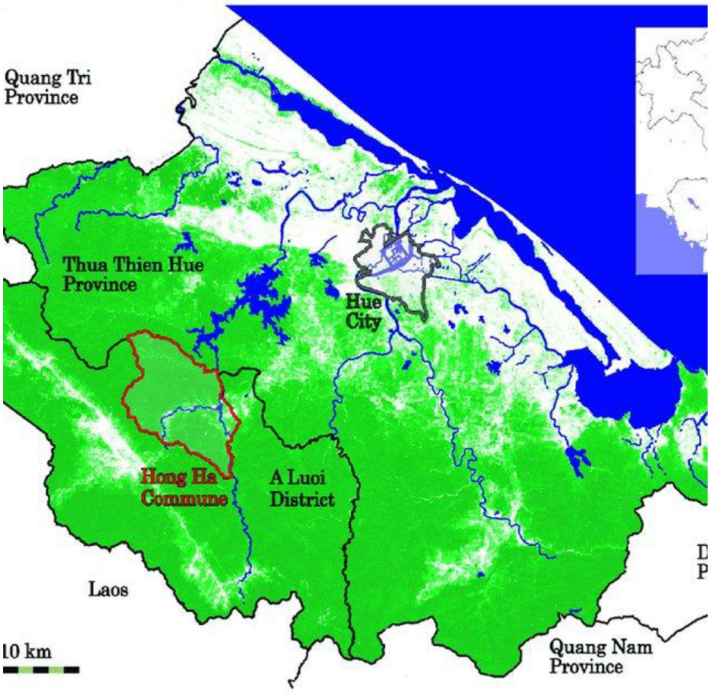

Figure 1. Map of Phu Thuan Commune and Thua Thien Hue Province showing the coastline
Source: Adapted from local government data, 2023

activities). Results, reported as odds ratios and *p*-values, showed younger age increased diversification likelihood (e.g. OR = 1.8, $p < 0.05$). Qualitative data from the focus group and key informant interviews was recorded and organized by session and then used to complement and interpret the quantitative findings presented in the paper.

Results

Descriptive statistics

Table 1 presents the perceived barriers to climate change mitigation among surveyed fishery households. The most commonly cited obstacle (20.7%) is the high cost of action, reflecting concerns about the financial burden of adaptation. A significant portion (19.7%) selected "other" reasons, suggesting diverse and context-specific perceptions not captured by predefined options. In addition, 16.3% believe the impacts of climate change are too severe to mitigate, whereas 15.0% attribute inaction to selfish attitudes among individuals. Notably, insufficient government commitment (14.7%) and general apathy (13.7%) were also cited as key concerns.

These findings underscore a complex mix of economic, institutional and behavioral barriers that limit effective climate action in the region. The prominence of cost-related concerns reflects the financial vulnerability of fishery households, whereas the noted lack of public and policy engagement highlights the need for targeted communication, trust-building and inclusive adaptation policies.

Table 1. Why don't you think things can be done to mitigate climate change

Perceived reasons	N	%
Impacts of climate change are too severe	19	16.3
Requires large cost to take actions	24	20.7
It is committed from government policy to local government	17	14.7
People are selfish to do anything to tackle climate change	18	15.0
No one care	16	13.7
Others	23	19.7

Source(s): Author's work

Figure 2 illustrates that the majority of respondents believe climate change poses a direct threat to local infrastructure, particularly to homes and roads. While a small minority disagreed with this assessment, their rationale remains unclear. This finding signals the urgent need for climate-resilient infrastructure planning, especially in coastal areas exposed to extreme weather events.

Figure 3 shows that cost-related concerns remain the dominant perceived barrier to implementing climate change solutions. Perceived severity of climate impacts ranks second,

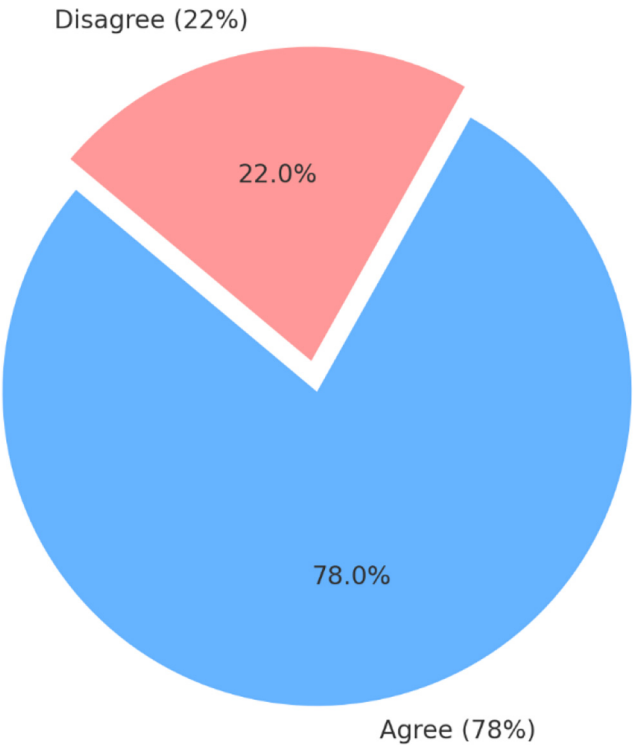

Figure 2. Pie chart showing perceptions of climate change risks to infrastructure among fishery households
Source: Author's work

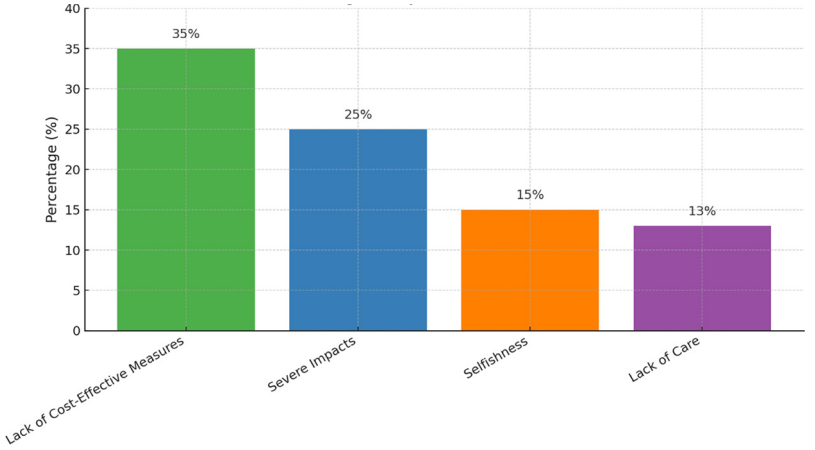

Figure 3. Bar chart showing perceived barriers to climate change solutions among fishery households
Source: Author's work

followed by social and psychological factors such as apathy and selfishness. The relatively lower ranking of institutional issues suggests that while governance matters, the most immediate constraints are economic and attitudinal in nature.

Table 2 presents descriptive statistics summarizing respondents' perceptions of the impacts of climate change on fishery activities, fishing efforts and livelihoods. Most of the mean values fall between 2.87 and 3.11, reflecting a moderate level of agreement across a broad range of climate-related impact statements.

Among the most affected domains, fish availability at fishing grounds (mean = 3.11) and fishing communities (mean = 3.07) stand out, suggesting widespread concern over resource depletion and community-level vulnerability. Perceptions of early rains, heatwaves and shifts in seasonal patterns also scored around 3.0, reflecting uncertainty and disruption in local weather patterns.

The standard deviations, ranging from 1.37 to 1.48, indicate a relatively high variance in perceptions, which may be influenced by differences in geography, household experience or individual adaptation capacity. These results suggest a complex and heterogeneous understanding of climate impacts, particularly in relation to fishing infrastructure, income stability and health outcomes. Logistic regression (see Methodology) indicates younger households perceive greater impacts ($p < 0.05$), informing targeted interventions.

Table 3 highlights the primary sources of financial difficulty reported by fishing households. Natural hazards (26.7%) and disease treatment costs (26.7%) emerged as the leading stressors, followed closely by family expenses (25.0%) and weather-related income loss (21.7%). These underscore the dual burden of environmental and health risks, necessitating policies like subsidized healthcare or sustainable fishing gear.

Figure 4 complements this data by visually illustrating the distribution of financial stressors. Natural disasters and healthcare expenses dominate household concerns, indicating how climate change not only disrupts livelihoods directly but also exacerbates health vulnerabilities. Combined with family expenses and losses from extreme weather, these stressors present substantial obstacles to economic stability and long-term resilience among fishery-dependent populations. This highlights the need for integrated climate and health support systems.

Table 2. Descriptive statistics

Statement about the impacts of climate change	N	Min.	Max.	Mean	SD
How would you describe the trend in the average number of fishing caught during last 10 years	119	1	5	3.07	1.394
How would you describe the trend in the average yield of aquaculture during last 10 years	119	1	5	3.07	1.394
To what extent to you agree with the following statements about the impacts of climate change on fishery activities – early rains that are not expected	119	1	5	2.99	1.414
To what extent to you agree with the following statements about the impacts of climate change on fishery activities – waterbody is too hot as a results of heat waves	119	1	5	2.97	1.465
To what extent to you agree with the following statements about the impacts of climate change on fishery activities – shifts in the start or end of rains	119	1	5	3.00	1.431
To what extent to you agree with the following statements about the impacts of climate change on fishery activities – shifts in start and end of dry season	119	1	5	3.06	1.383
In terms of fishing efforts – climate change impact on fishing infrastructure	119	1	5	2.99	1.373
In terms of fishing efforts – climate change impact on fishing gears	119	1	5	2.83	1.385
In terms of fishing efforts – climate change impact on safety of fishing	119	1	5	3.03	1.397
In terms of fishing efforts – climate change impact of fishing communities	119	1	5	3.07	1.475
In terms of fishing efforts – climate change impact on fishing grounds	119	1	5	2.92	1.444
In terms of fishing efforts – climate change impact on fish availability at the fishing ground	119	1	5	3.11	1.420
In terms of livelihood – climate change impact of health status of fishermen	119	1	5	3.00	1.465
In terms of livelihood – climate change impact of household income	119	1	5	2.88	1.436
In terms of livelihood – climate change impact on flux of migrant of fishermen	119	1	5	2.92	1.371
In terms of livelihood – climate change impact on fishers security	119	1	5	2.97	1.369
In terms of livelihood – climate change impact on the cost of fishing gears	119	1	5	2.95	1.429
In terms of livelihood – climate change impact on fishing marketing access	119	1	5	2.99	1.476
To what extent to you agree with the following statements about the impacts of climate change on fishery activities – Shifts in start and end of dry season	119	1	5	2.98	1.408
In terms of fishing efforts – climate change impact on fishing infrastructure	119	1	5	2.87	1.390
In terms of fishing efforts – climate change impact on fishing gears	119	1	5	2.88	1.433
In terms of fishing efforts – climate change impact on fishing gears	119	1	5	3.04	1.421
Valid N (listwise)	119				

Source(s): Author's work

Table 3. What are the reasons for financial difficulties

Reasons for financial difficulties	N	%
Lost due to weather	25	21.6
Natural hazards	32	26.7
Pay for disease treatment	32	26.7
Expense for family	30	25.0

Source(s): Author's work

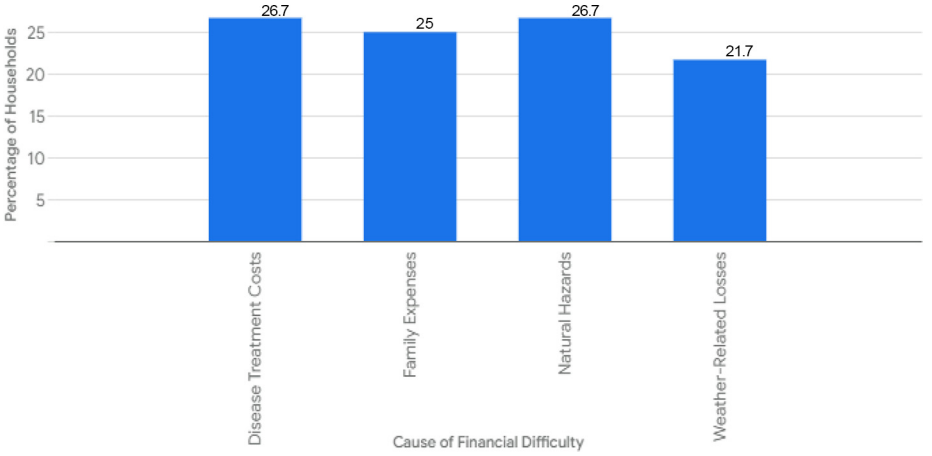

Figure 4. Bar chart showing causes of financial difficulties among fishery households
Source: Author's work

Table 4 presents the financial sources that fishery households rely on to support their fishing activities. The most frequently cited source is borrowing from banks (25.3%), followed by accessing funds, projects or programs (20.3%). Social organizations also play a significant role, providing financial support to 19.3% of households. In contrast, household savings (18.0%) and loans from relatives or friends (17.0%) are somewhat less common.

These findings suggest that while formal financial institutions are a primary avenue for funding, community-based and informal mechanisms remain important – particularly for households with limited access to credit or government programs. The diversity of funding sources underscores the importance of promoting equitable, accessible and sustainable financing mechanisms for small-scale fishery households adapting to climate change.

Figure 5 highlights the diverse range of adaptive responses households employ in response to financial or environmental challenges. The largest group (23.0%) selected "Other" actions, suggesting that adaptation is often context-specific and may involve informal or unrecorded strategies. This is followed closely by households that pursue new employment opportunities (22.7%), seek support through social networks (19.0%), adopt alternative livelihoods (18.0%) or migrate (17.3%).

As illustrated in Figure 6, employment change emerges as the most common proactive adaptation strategy, indicating that fishery households often respond to economic and climate stressors by shifting to more stable or better-paying jobs. While alternative livelihoods and

Table 4. Which financial source do you use for the fishing activities

Financial sources	N	%
Borrow from the bank	30	25.3
Borrow from the social organization	23	19.3
Household financial source	21	18.0
Borrow money from relatives/friends	20	17.1
Borrow from funds, projects, programs	24	20.3

Source(s): Author's work

Table 5. Respond action

Respond action	N	%
Finding the alternative livelihood	21	18.0
Looking for a new job	27	22.7
Migration	20	17.3
Finding the assistance from social networks (family, friends, peer)	22	19.0
Others	28	23.0

Source(s): Author's work

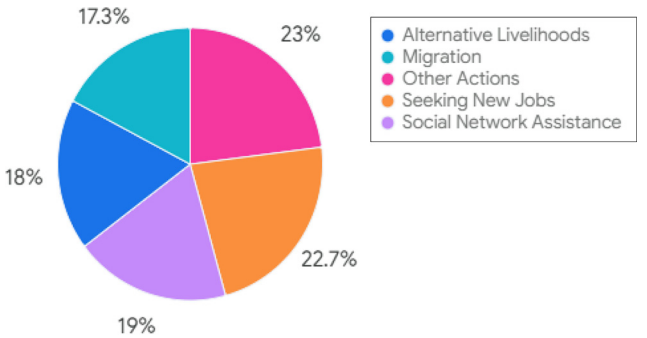

Figure 5. Pie chart showing adaptation strategies to financial and environmental challenges among fishery households
Source: Author's work

reliance on social networks are also employed, they appear to be secondary options. The high proportion of "Other" responses points to the need for more localized research to better understand informal or undocumented adaptive behaviors.

Climate change in the coastal area of Thua Thien Hue

Thua Thien Hue, a highly climate-vulnerable province, faces intensifying natural disasters, including storms, floods, droughts and coastal erosion (Schmidt-Thomé *et al.*, 2015). Meteorological data (1956–2022) reveal significant climate trends impacting fishery households in Phu Thuan Commune.

Figure 7 shows a long-term increase in annual average temperature, with stable conditions in the 1950s–1970s giving way to greater variability post-1980. From 2015 to 2022, the average temperature rose by 0.7°C, with 2019 recording a 1°C increase over 2010 (Figure 8). Peak temperatures in June and July approach 30°C, exacerbating heat stress for fishers and marine ecosystems.

Precipitation data (1956–2022) indicate rising variability, with consistent rainfall in earlier decades (1950s–1970s) shifting to pronounced wet-dry fluctuations from the 1980s (Figure 9). Notable peaks in 1999 and 2020 exceeded 5,000 mm and recent years (2015–2022) show more frequent above-average rainfall, particularly in 2020 and 2022. The rainy season (October–December) accounts for over 76% of annual rainfall, causing floods that damage aquaculture, infrastructure and household assets, whereas dry-season water shortages disrupt fishing (Binh *et al.*, 2018; Figure 10).

Sea level rise, though not directly monitored in Thua Thien Hue, is evident in neighboring areas, with Son Tra (Da Nang) and Cua Viet (Quang Tri) recording 7–8 cm increases from 1998 to 2022 (Thuc *et al.*, 2016). In 2020, sea level rise flooded 300 hectares in Thua Thien Hue.

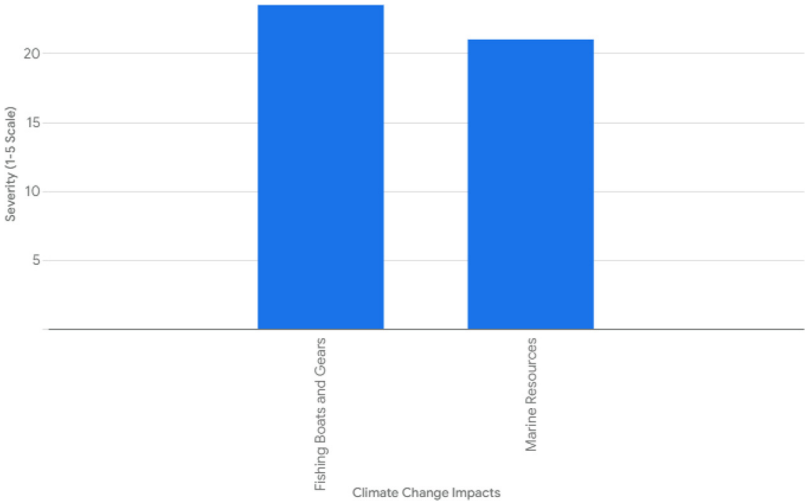

Figure 6. Bar chart showing severity of climate change impacts on fishery activities
Source: Author's work

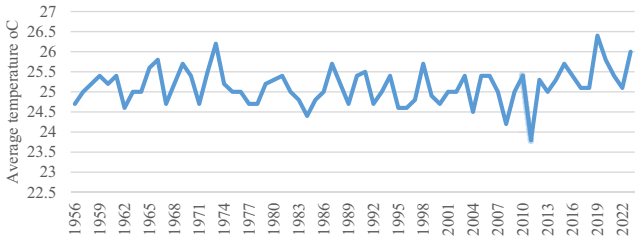

Figure 7. Annually average temperature from 1956 to 2022
Source: Author's work

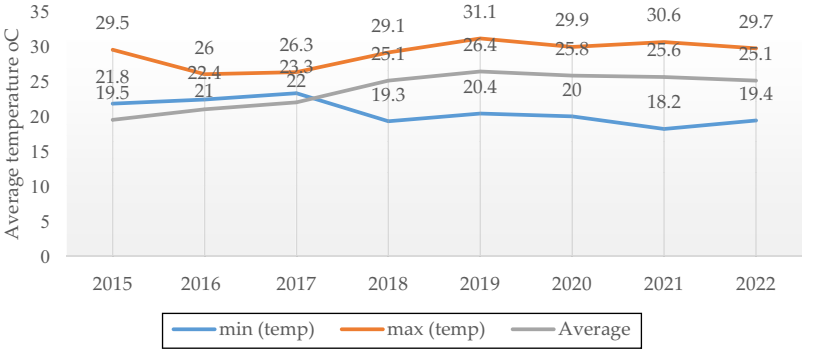

Figure 8. Average minimum and maximum temperature in Thua Thien Hue from 2015 to 2022
Source: Author's work

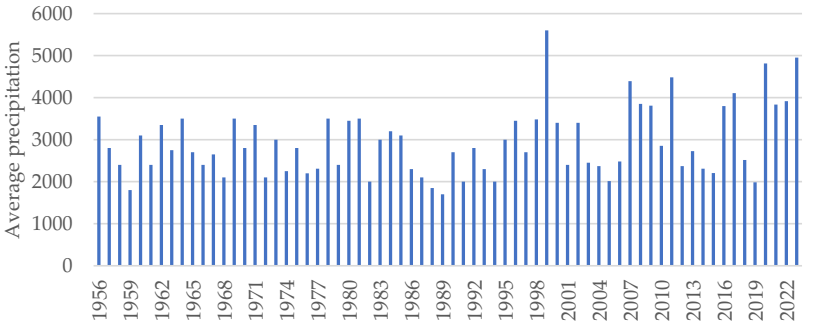

Figure 9. Annually precipitation in Thua Thien Hue 1956–2022
Source: Author's work

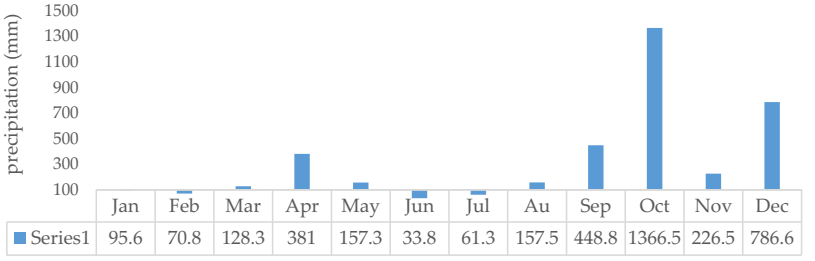

Figure 10. Average precipitation by month in Thua Thien Hue in 2022
Source: Author's work

Projections estimate a 25 cm rise by 2050 and 70 cm by 2100, threatening coastal livelihoods and infrastructure. Phu Vang District, including Phu Thuan, also faces prolonged dry-season droughts (May–August), extended cold spells (October–December) and intensified storms, driven by saltwater intrusion and unpredictable weather patterns (Béné, 2009).

Focus group discussions (Table 6) reveal fishers' perceptions of declining rainfall, hotter and more humid conditions and unpredictable storms and thunderstorms. While storm frequency has decreased, their intensity has risen, with two major storms in 2022 severely impacting Thua Thien Hue's coast. Sudden thunderstorms pose risks to fishers' safety and equipment, despite improved weather forecasting access (Allison *et al.*, 2009). These climatic shifts reduce fishing seasons, damage gear and strain marine resources, underscoring the need for climate-resilient policies, such as enhanced early warning systems and sustainable fishery management, to support SDG 13 (Climate Action) and SDG 14 (Life Below Water).

Impact of climate change on fishing activities

A survey of 119 fishery households in Phu Thuan Commune assessed climate change impacts on various livelihood aspects using a 1–5 scale (1 = no impact, 5 = very severe). Quantitative analysis reveals severe effects on fishing boats and gear, human health and marine resources, with lesser impacts on infrastructure, housing and food security (Figure 11).

Fishing boats and gear face the most severe impacts, with 23.5% of respondents rating effects as nearly very severe. Focus group discussions confirmed that unpredictable storms and thunderstorms since 2016 have caused significant gear damage, with local leaders reporting widespread boat losses during floods and storms. Human health is similarly affected (23.5% rated severe), driven by heat stress and thunderstorm risks. A fisher noted, "We used to fish for hours at sea, but now heat forces us to stop early." Marine resources are also heavily impacted (21% rated severe), with focus groups reporting declining fish stocks and disappearing local species due to climate change and pollution (Elum and Snijder, 2023). Infrastructure, housing and food security face moderate impacts (rated not severe), though cumulative effects threaten household stability.

Nearly 90% of surveyed fishers reported reduced catches and income, driven by shorter fishing seasons, off-season rains and rising temperatures. Communication between boats and the mainland is unstable during disasters, exacerbating livelihood challenges. These findings highlight the need for policies promoting resilient fishing gear, early warning systems and sustainable marine resource management, aligning with SDG 13 (Climate Action) and SDG 14 (Life Below Water).

Table 6. The manifestation of the climatic phenomenon in Thua Thien Hue Province

Climatic	Manifestation
Rainfall	Rain is getting less and less and mainly concentrates from September to December yearly. In 2019, there was not even rain in the summer. The rainy season also has less rain than the previous year. In 2020, heavy rain and floods were severe
Temperature	The temperature is also quite erratic; some months are freezing, and others are hot and muggy. Temperatures are increasing compared to before, especially in the dry season
Storm	Storms tend to occur less frequently than before but are more intense and dangerous. Major storms such as Katsana (2009), Nockte (2016), and Storms No. 10 and No. 12 (2017) caused heavy damage to people, boats, roads and sea erosion
Thunderstorms	Thunderstorms at sea occur more erratically than before, causing risks to life and danger to people when fishing at sea
Erosion	Sea erosion occurs every year and dramatically affects households living along the coast

Source(s): In-depth interview and focus group discussion with the leaders of fishery association, local authorities and fishery households, 2024

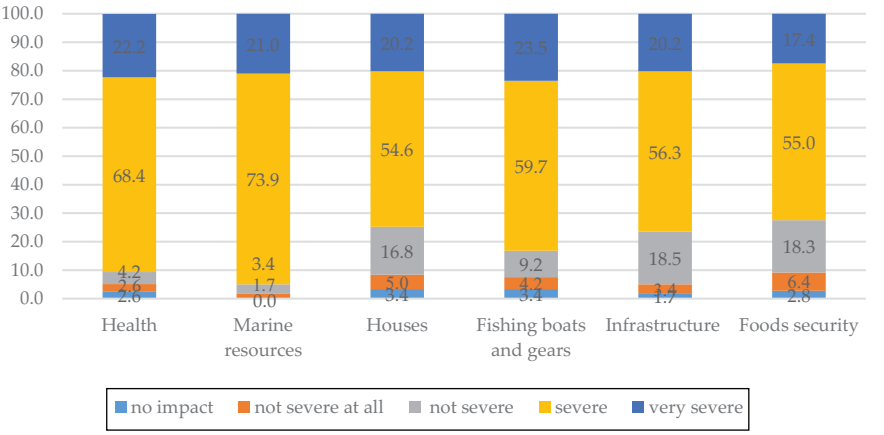

Figure 11. Climate change impacts to fishers' households
Source: Author's work

Livelihood adaption response of fishery households

Fishery households in Phu Thuan Commune employ diverse strategies to sustain livelihoods amid climate change and natural disaster risks (Table 7). Survey data from 119 households reveal that 21% sold larger vessels due to insufficient income, whereas 58% invested in fishing operations by purchasing gear, refurbishing boats, or adjusting fishing methods and timing. Field observations indicate a shift toward unsustainable practices, such as small-mesh nets, electric fishing devices and LED lights for squid in restricted zones (5–10 nautical miles), to offset declining catches. Fishers acknowledge these methods harm fish stocks but cite competition from over 100 large-powered boats from provinces like Quang Ngai and Binh Dinh, which encroach on Thuan An Sea fishing grounds, reducing nearshore resources and threatening safety (Hoang, 2021).

Non-fishing activities supplement income for some households. Locally, 7% engage in farming or livestock raising, 6% run small-scale retail and 11% work as hired labor for construction or larger boats. Limited agricultural land restricts farming to small gardens for household use, and low local demand limits retail income. Non-local options are more common, with 47% pursuing seasonal labor elsewhere, 10.1% sending family members to

Table 7. Adaptation activities in response to climate change

No.	Adaptation activities	No. of HH $n = 119$	%
1	Selling assets (boats)	34	28.6
2	Investment in fishing activities	96	80.6
3	Investment in aquaculture	2	1.7
4	Investment in agriculture	4	3.3
5	Small business	47	39.4
6	Looking for a full-time job (work as hired labor within the local area)	41	34.4
7	Looking for a part-time job (seasonal labor outside the local area)	56	47.0
8	Migrant	12	10.1
9	Nothing	9	7.5

Source(s): Field survey, 2024

urban or international labor markets and 4% working in major cities. Seasonal labor is preferred for its higher income and flexibility with fishing schedules. Approximately 7.5% of households report no specific adaptation activities, whereas 80% combine fishing and non-fishing strategies to diversify income.

These findings align with studies on climate-affected coastal communities in Vietnam and globally (Badjeck *et al.*, 2010; Pham and Saizen, 2023; Alam and Mallick, 2022). Small-scale non-fishing activities, such as trading or services, remain supplementary due to their seasonal nature. Policies promoting sustainable fishing practices, equitable access to fishing grounds and vocational training for alternative livelihoods could enhance resilience, supporting SDG 1 (No Poverty) and SDG 14 (Life Below Water).

Factors influencing the livelihood adaptation of fishery households

To examine how demographic and socioeconomic factors influence livelihood adaptation, 119 fishery households in Phu Thuan Commune were categorized into four groups: Group 1 (investing in fishing activities), Group 2 (investing in both fishing and non-fishing activities), Group 3 (investing in non-fishing activities) and Group 4 (no additional investment). Kruskal–Wallis tests reveal significant differences across groups for age, number of laborers, fishing experience, equipment ownership and social support access ($p < 0.05$ to $p < 0.001$; Table 8).

Younger household heads (mean age ~45 years) and spouses in Group 1 prioritize fishing investments, whereas older heads in Group 4 (mean age 60.8 years, spouse 59.6 years) often forgo adaptation ($p < 0.001$). Education levels, typically elementary to middle school, limit access to stable non-fishing jobs ($p < 0.05$). Focus groups noted that early school dropout (age 15–16) restricts fishers to low-paying labor, with Groups 2 and 3 relying on seasonal work. Households with more laborers (mean 2.7 in Groups 2 and 3 vs 2.3 in Group 1) diversify into non-fishing activities ($p < 0.01$). For example, a fisher shared, "My son and I fish, my wife sells fish, and our daughter works in the South for extra income."

Longer fishing experience ($p < 0.01$) correlates with non-fishing activities or inaction (Group 4), as older fishers' health declines, whereas less experienced fishers (Group 1) focus on fishing. Households with more equipment (e.g. boats, nets) invest in fishing or diversify (Groups 1 and 2; $p < 0.001$), unlike those with limited gear (Groups 3 and 4). Access to social

Table 8. The difference between groups in climate change adaptation responses

Households characteristics	Group 1 Invest in Fishery ($n = 33$)	Group 2 Invest in both fishery and non-fishery activities ($n = 27$)	Group 3 Invest in non-fishery activities ($n = 34$)	Group 4 None investment ($n = 25$)
Age (year)***	51.4 (32–65)	51.9 (30–65)	55.3 (36–65)	60.8 (45–65)
Education level	2.2 (1–4)	2.4 (1–4)	2.3 (1–4)	2.3 (2–4)
Age of wife/husband***	50.2 (30–65)	50.2 (31–65)	53.6 (25–65)	59.6 (46–65)
Education of wife/husband	2 (1–4)	2.2 (1–4)	2.1 (1–4)	1.9 (1–3)
Number of members (person)	4.8 (2–8)	4.8 (3–8)	4.9 (2–9)	3.9 (2–8)
Labors (person)**	2.3 (1–6)	2.7 (2–7)	2.7 (2–5)	2.1 (2–3)
Year experience (years)***	32.4 (10–55)	319 (10–50)	35.8 (15–50)	43.4 (25–51)
Fishing gears and equipment***	2.4 (1–4)	2.6 (1–5)	1.8 (1–4)	1.3 (1–3)
*Access to social support resources**	3.2 (1–4)	3.7 (2–4)	3.4 (0–4)	3.2 (0–4)

Note(s): *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$
Source(s): Field survey, 2024

support ($p < 0.05$), including relatives and organizations, boosts diversification (Groups 2 and 3), whereas Group 1 relies on fishing networks.

Local authorities provide technical support (e.g. flood control, boat anchoring guidance), but fishers prioritize livelihood-focused policies, such as job training, external employment information and fishing ground management to ensure safety and sustainability. These align with SDG 1 (No Poverty) and SDG 14 (Life Below Water), emphasizing equitable resource access and economic resilience.

Discussion

Meteorological data (1956–2022) from Thua Thien Hue Province reveal rising temperatures, extended heatwaves, irregular rainfall and intensified storms and floods, severely impacting fishery households in Phu Thuan Commune (Thuc *et al.*, 2016; Figures 7–10). Fishers report unpredictable weather shortening fishing seasons and increasing offshore risks, underscoring the vulnerability of traditional livelihoods to climate change (Tran *et al.*, 2019; Weatherdon *et al.*, 2016). This study identifies five critical impact areas: fishing equipment, human health, marine resources, infrastructure and food security, with the first three experiencing the most severe effects (Figure 11).

Fishing boats and gear are highly vulnerable, with 23.5% of 119 surveyed households reporting near-very-severe damage from storms and floods, escalating repair costs and constraining operations. Human health is similarly affected (23.5% rated severe), with heat stress and thunderstorm risks reducing fishing hours and increasing injury incidents (Hoang *et al.*, 2022). Marine resources face significant declines, with 21% of respondents noting reduced fish stocks and disappearing species, driven by climate change, pollution and competition from large vessels (Elum and Snijder, 2023). Infrastructure and food security experience moderate impacts, but cumulative effects threaten household stability, with 90% of fishers reporting income losses.

Adaptation strategies vary (Table 7). While 58% of households invest in fishing (e.g. gear upgrades, adjusted methods), many adopt unsustainable practices like small-mesh nets, risking long-term marine ecosystems (Pham and Saizen, 2023). Non-fishing activities, including seasonal labor (47%), farming (7%), retail (6%) and urban/international migration (10.1%), provide supplementary income, but their small-scale, unstable nature limits effectiveness. Notably, 7.5% of households lack adaptation measures, highlighting vulnerability (Table 5).

Kruskal–Wallis tests (Table 8) reveal demographic influences on adaptation ($p < 0.05$ to $p < 0.001$). Younger households with more laborers and equipment diversify into fishing and non-fishing activities, whereas older, labor-scarce households (mean age 60.8 years) remain passive. Low education (elementary to middle school) restricts access to stable jobs, forcing reliance on low-wage labor (Alam and Mallick, 2022). These findings align with global coastal communities, where resource constraints drive similar adaptations (Tran *et al.*, 2019).

Policies promoting sustainable fishing practices, vocational training and equitable fishing ground access are critical to enhance resilience, aligning with SDG 1 (No Poverty), SDG 13 (Climate Action) and SDG 14 (Life Below Water). Local authorities' technical measures (e.g. flood control) must shift toward livelihood-focused support, such as job creation and resource management, to address fishers' needs and ensure sustainable development.

Figure 12 presents a graphical abstract summarizing the study's findings on climate change impacts, adaptation strategies and policy solutions for fishery households in Phu Thuan Commune, aligning with SDGs 1, 13 and 14.

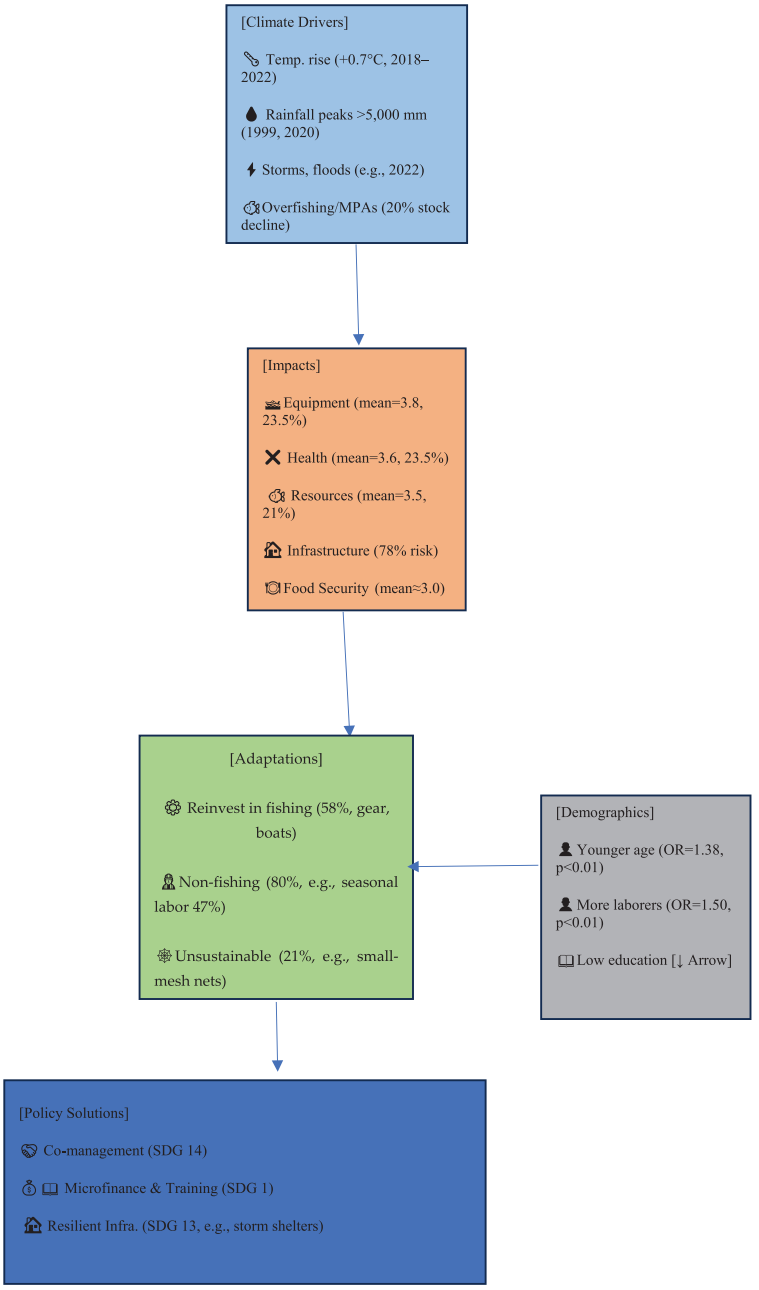

Figure 12. Graphical abstract: Climate change impacts, adaptations and policy solutions for fishery households in Phu Thuan
Source: Author's work

Recommendations

This study highlights severe climate change impacts on fishery households in Phu Thuan Commune, including gear damage (23.5%), marine resource depletion (21%) and income losses (90%) (Figure 11). Methodological limitations require attention to strengthen future research. The sample size (n = 119) may not fully capture Phu Thuan's diverse fishery households, potentially underestimating impacts like marine resource decline (21%). A larger, stratified sample could enhance statistical power and validate findings across socioeconomic groups. The focus on Phu Thuan limits generalizability, as Thua Thien Hue's coastal communities vary in ecological conditions (e.g. lagoon vs open sea) and socioeconomic factors (e.g. market access). Demographic characteristics, such as age (mean 60.8 years in Group 4), low education (elementary to middle school) and fishing experience, shape perceptions (Table 8). Older fishers may underreport impacts due to adaptation fatigue or limited exposure to recent resource trends, introducing bias. Reliance on recent meteorological data (2015–2022) overlooks historical baselines, which could contextualize long-term resource declines. Subjective perceptions, influenced by recent extreme weather (e.g. 2020 floods; Figure 9), may prioritize short-term concerns. Future studies should employ longitudinal data, objective marine stock assessments and mixed-method approaches to triangulate fishers' perceptions with ecological data, ensuring robust findings.

To enhance resilience, local authorities should implement livelihood-focused policies tailored to Phu Thuan's needs. First, establish vocational training and job placement programs to address low education levels, enabling fishers to transition to stable non-fishing roles, such as aquaculture, eco-tourism, or coastal infrastructure maintenance. These programs could target younger fishers (mean age ~45 years in Group 1), who show adaptability (Table 8). Second, enforce regulations on fishing grounds to limit encroachment by large vessels from provinces like Quang Ngai, which exacerbate nearshore resource depletion (Hoang, 2021). Equitable access to fishing zones would support small-scale fishers and conserve marine ecosystems. Third, provide subsidies for climate-resilient fishing gear (e.g. storm-resistant nets) and early warning systems to mitigate gear damage (23.5%) and safety risks from thunderstorms (Figure 11). These measures align with SDG 1 (No Poverty) by reducing economic vulnerability, SDG 13 (Climate Action) by enhancing adaptive capacity and SDG 14 (Life Below Water) by promoting sustainable fisheries.

Community-based initiatives are critical. Cooperative resource management groups could empower fishers to monitor marine stocks and adopt sustainable practices, reducing reliance on small-mesh nets (Pham and Saizen, 2023). Climate adaptation workshops, co-designed with fishers, could raise awareness of environmental protection and alternative livelihoods, supporting the 7.5% of households without adaptation strategies (Table 5). Nationally, Vietnam's climate resilience strategies, such as the National Adaptation Plan and Fisheries Development Strategy 2030, should prioritize disadvantaged coastal communes like Phu Thuan. Funding for gear subsidies and training could be channeled through these programs, fostering economic stability, resource conservation and community empowerment for sustainable development in a changing climate.

Conclusions

This study demonstrates that climate change severely impacts fishery households in Phu Thuan Commune, with 23.5% reporting near-very-severe damage to fishing gear, 21% noting marine resource depletion and 90% experiencing income losses (Figure 11). Adaptation strategies, including gear upgrades (58%), seasonal labor (47%) and migration (10.1%), are constrained by limited resources, low education and labor scarcity (Tables 7, 8). While fishers proactively

adapt, unsustainable practices like small-mesh nets and competition from large vessels threaten marine ecosystems (Pham and Saizen, 2023).

The effectiveness of adaptations depends on household resources – labor, equipment and social support (Hoa and Hà, 2015). Younger, labor-rich households diversify livelihoods, whereas older households (mean age 60.8 years) remain passive (Table 8). Local authorities' technical support (e.g. flood control) falls short of fishers' needs for stable income and safety (Thi Lan Huong *et al.*, 2017). To enhance resilience, policies should prioritize:

- vocational training to improve job access, addressing low education levels;
- subsidies for resilient gear and early warning systems to reduce losses (23.5% gear damage);
- regulated fishing grounds to curb external vessel intrusion, protecting nearshore resources; and
- community-based education on sustainable fishing and climate change, boosting awareness (Nguyen *et al.*, 2014).

These measures align with SDG 1 (No Poverty), SDG 13 (Climate Action) and SDG 14 (Life Below Water), fostering economic stability and marine sustainability. Fishing supports livelihoods and Vietnam's coastal security, necessitating national strategies to ensure safe, sustainable practices. Future research should explore longitudinal impacts and scalable solutions across Thua Thien Hue, amplifying fishers' resilience in a changing climate.

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