

Economic Adaptation of Fishermen to Climate Change Impacts in Labuhan Haji District, East Lombok Regency, Indonesia

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DOI: <https://doi.org/10.5281/zenodo.15736618>

Published Date: 25-June-2025

Abstract: This research aims to: (1) Identify the impact of climate change on the economic activities of fishermen in Labuhan Haji District, East Lombok Regency; and (2) to identify the economic adaptation strategies used by fishermen in response to climate change in Labuhan Haji District, East Lombok Regency. A descriptive method was applied, with Labuhan Haji District selected purposively due to its vulnerability to climate hazards, such as increasingly frequent tidal flooding and extreme sea conditions. The study focused on three coastal villages: Labuhan Haji, Kerta Sari, and Surya Wangi. A total of 35 respondents were selected using proportional sampling, comprising 14 fishermen from fishing groups and 21 independent fishermen. The findings reveal that climate change has significantly reduced fishing frequency and catch volumes, thereby decreasing fishermen's income. In response, fishermen employed several adaptation strategies: (1) active strategies, including livelihood diversification beyond the fisheries sector; (2) passive strategies, such as reducing household consumption; and (3) network based strategies, including fishing gear diversification, expanding market access, and obtaining financial support through informal or formal lending.

Keywords: Fishermen, Economic Adaptation, Impact of Climate Change.

I. INTRODUCTION

The fisheries sector is one of the key contributors to Indonesia's economic development. The country's abundant fisheries potential, supported by its archipelagic geography dominated by marine areas, positions the fisheries industry as a main pillar of the national economy. According to Statistics Indonesia [1], the Gross Domestic Product (GDP) of the fisheries sector at current prices increased by 30.88% from IDR 385.9 trillion in 2018 to IDR 505.1 trillion in 2022. This data underscores the prioritization of the fisheries sector in the 2020–2024 National Medium-Term Development Plan, which emphasizes strengthening the economic resilience of coastal communities by optimizing fisheries resource management [6].

West Nusa Tenggara Province (NTB) is among the regions with the highest fisheries production in Indonesia. Within NTB, East Lombok Regency is recognized as a major contributor to the province's fisheries sector, with sustainable fishery potential estimated at 18,242 tons per year and a consistently increasing production trend between 2019 and 2023 [3]. This high productivity presents a significant opportunity for enhancing the economic welfare of coastal communities, especially those whose livelihoods rely heavily on fishing.

Fishing remains the primary occupation for most coastal residents in East Lombok Regency, which hosts the largest number of fishermen in the province 13,393 individuals across coastal sub-districts, including Labuhan Haji District [2]. However, the majority of fishermen face unstable economic conditions, largely due to unpredictable fish catches. These uncertainties are strongly linked to climate change, given the sector's heavy dependence on weather and sea conditions.

Labuhan Haji District is particularly vulnerable to the effects of climate change. Increased occurrences of extreme weather events provide strong evidence that climate disruptions are intensifying. During recent years, average temperatures have reached up to 32°C, leading to drought in several areas. Similarly, extreme rainfall has increased river discharge levels,

causing floods in residential zones. High wind speeds have also triggered sea waves reaching 2.8 meters and currents exceeding 2 m/s, heightening the risk of tidal flooding in coastal villages [4].

Climate change has become a significant barrier to the sustainability of local fisheries. Unstable weather creates operational uncertainty, deterring fishermen from going to sea. Furthermore, changes in oceanic conditions affect fish migration patterns and upwelling zones, reducing catch volumes [7]. These challenges threaten the economic security of fishing households and necessitate the development of appropriate economic adaptation strategies.

Based on the description above, the objectives of this study are: (1) Identify the impact of climate change on the economic activities of fishermen in Labuhan Haji District, East Lombok Regency; and (2) to identify the economic adaptation strategies used by fishermen in response to climate change in Labuhan Haji District, East Lombok Regency.

II. METHODS

This study employed a descriptive method to observe and analyze the current conditions, group characteristics, and ongoing events [8]. The unit of analysis was individual fishermen. Labuhan Haji District was selected purposively as the research location due to its coastal characteristics and high vulnerability to the impacts of climate change, such as tidal flooding and strong sea currents. The specific study sites included three coastal villages: Labuhan Haji, Kerta Sari, and Surya Wangi. Respondents were selected using purposive sampling, focusing on two categories: group fishermen (members of fishing organizations) and non-group fishermen (independent). A total of 35 respondents were selected proportionally, consisting of 14 group fishermen and 21 non-group fishermen. Both qualitative and quantitative data were collected, including primary data (through interviews) and secondary data (from institutional sources). Data analysis was carried out by identifying the main climate change indicators perceived by fishermen and examining the forms of economic adaptation they adopted in response. This qualitative assessment was based on descriptive interpretation of interview responses and field observations.

III. RESULT AND DISCUSSION

Labuhan Haji District is located at the easternmost part of Lombok Island, directly bordering the Alas Strait, which separates it from Sumbawa Island. Covering an area of 49.57 km², the district comprises 12 villages. The region experiences a tropical climate characterized by two distinct seasons: the dry season and the rainy season. Most residents are engaged in the fisheries and agriculture sectors. The fishing communities are distributed across several villages, including Labuhan Haji Village, Kerta Sari Village, and Surya Wangi Sub-district. The community structure includes both group fishermen (organized in formal fishermen's groups) and non-group fishermen (operating independently). According to data from the [3] there are 518 fishermen in the district, consisting of 315 non-group fishermen and 203 group fishermen. Of the 20 registered fishermen's groups in the area, only 15 remain active.

Fishermen's Perceptions of Climate Change

Climate change poses a significant challenge to the productivity of fishermen in the fisheries sector. Their perception of climate change is reflected in observed variations in weather elements such as air temperature, rainfall intensity, and wind patterns between the east and west seasons. The east season generally spans from April to September, while the west season occurs from October to March. Table 1 presents the perceived changes in climate elements as reported by fishermen in Labuhan Haji District.

Table 1. Fishermen's Perceptions of Climate Change

Climate Elements	Conditions of Change	West Season		East Season	
		Σ	%	Σ	%
Air Temperature	Very Hot	0	0.00	15	42.86
	Moderate	22	62.86	20	57.14
	Cold	13	37.14	0	0.00
Rain Intensity	Very Heavy	21	60.00	0	0.00
	Heavy	14	40.00	10	28.57
	Moderate	0	0.00	25	71.43
Wind Speed	Very Strong	27	77.14	0	0.00
	Moderate	8	22.86	15	42.86
	Weak	0	0.00	20	57.14

Source: Processed Primary Data, 2025

Fishermen’s perceptions of climate change were identified through their experience of shifting weather patterns, particularly with respect to air temperature, rainfall intensity, and wind speed. These perceptions varied across the two seasonal periods. A detailed explanation of the perceived changes in each climate element is provided below.

1. Air Temperature

According to fishermen’s experience, during the west monsoon season, air temperature tends to be in a cold to moderate range, causing seawater temperatures to rise. This facilitates fish catches, as fish generally congregate in warmer waters. However, the west monsoon is often accompanied by extreme weather conditions, increasing the risk of going to sea and leading many fishermen to temporarily suspend fishing operations. In contrast, during the east monsoon, fishermen report moderate to high variations in temperature. Although weather is more favorable for fishing activities, the number of fish tends to decrease. Additionally, fish migrate deeper due to colder sea temperatures, making them more difficult to catch. As a result, fishermen are often required to travel farther offshore, requiring greater effort and leading to increased variable fishing costs.

2. Rainfall Intensity

Rainfall during the west monsoon is typically heavy to very heavy. These conditions increase the risk associated with fishing activities and often deter fishermen from going to sea. In contrast, rainfall intensity during the east monsoon tends to be moderate to heavy. In this case, fishermen can still operate, though usually limited to areas close to the shoreline as a precautionary measure in anticipation of sudden heavy rains.

3. Wind Speed

Wind speed is a crucial factor for fishermen in assessing sea wave conditions. During the west monsoon, wind speed can range from moderate to very strong. Many fishermen report that wind conditions can change abruptly while at sea, despite having assessed wind conditions before departure. This unpredictability requires fishermen to exercise greater caution, as sea accidents are more likely during this period. Wind conditions during the east monsoon are generally more stable, with wind speeds ranging from weak to moderate. Consequently, sea waves are not excessively high, and the risks associated with fishing activities are reduced.

Impact of Climate Change

Climate change, as perceived by fishermen through shifts in various weather elements, has had a substantial impact on their fishing activities. This impact is evident in the reduced frequency of fishing trips, primarily due to the uncertainty of weather conditions, which serve as a critical factor in determining fishing operations. Table 2 summarizes the contributing factors to the declining frequency of fishing, along with the perceived levels of impact among fishermen in Labuhan Haji District.

Table 2. Impact of Climate Change on Fishermen’s Frequency of Going to Sea

Causative factor	Impact of Change	Impact Level	∑	%
Air Temperature Changes	Fish Upwelling Zone Changes	High	16	45.71
		Moderate	14	40.00
		Low	5	14.29
Wind Direction Change	Unstable Ocean Current	High	23	65.71
		Moderate	12	34.29
		Low	0	0.00
Changes in Rainfall Intensity	Difficulty Determining Fishing Spots	High	17	48.57
		Moderate	15	42.86
		Low	3	8.57
Wave Sea Level	High Sea Risk	High	35	100
		Moderate	0	0.00
		Low	0	0.00

Source: Processed Primary Data, 2025

Based on the research findings, four major factors contribute to the decline in fishermen’s sea-going frequency. These factors include: (1) Air temperature changes, which affect the fish upwelling zone; (2) Shifts in wind direction, leading to unstable ocean currents; (3) Changes in rainfall intensity, causing difficulties in identifying optimal fishing locations; (4) Rising sea levels and wave heights, which significantly increase the risk of fishing operations. Each of these elements has directly or indirectly disrupted the sustainability of traditional fishing patterns, reinforcing the vulnerability of fishing communities to the effects of climate change.

1. Air Temperature Changes

Air temperature changes are one of the key factors influencing the reduced frequency of fishing activities in the Labuhan Haji District. As many as 16 fishermen (45.71%) reported that air temperature changes significantly affect the fish upwelling zones, making it difficult for them to identify ideal fishing locations. Meanwhile, 14 fishermen (40%) reported a moderate impact, and 5 fishermen (14.29%) experienced only a minor impact. The variation in impact levels highlights the different references used by fishermen in determining fishing locations. The smaller the perceived impact of temperature changes, the greater the opportunity for fishermen to maintain or increase their fishing activity.

2. Wind Direction Change

Wind direction is a critical determinant in fishermen’s decision making processes regarding when and where to fish. Most fishermen recognize that changes in wind direction currently influence the stability of ocean currents. As presented in Table 2 fishermen (65.71%) reported that wind direction changes have a significant impact on ocean current stability. Meanwhile, 12 fishermen (34.29%) reported a moderate effect. Ocean currents are driven by the horizontal and vertical movement of seawater, which is heavily influenced by wind dynamics. Ocean currents, in turn, affect fish migration patterns. Stronger currents often correlate with greater changes in migration routes. Many fishermen also associate strong ocean currents with increased risks and difficulties when going to sea. Therefore, strong ocean currents are often seen as indicators of hazardous fishing conditions.

3. Changes in Rainfall Intensity

Variations in rainfall intensity often disrupt the frequency of fishing activities. According to the study, such changes make it more challenging for fishermen to determine suitable fishing spots. The impact levels reported by fishermen varied: 17 fishermen (48.57%) experienced a high impact, 15 fishermen (42.86%) reported a moderate impact, and 3 fishermen (8.57%) reported only a low impact. High rainfall intensity conditions often lead to increased sedimentation and turbidity, reducing light penetration in seawater. This limits phytoplankton growth, which is a key food source for fish. As a result, fishermen must search for clearer waters, making it more difficult to locate suitable fishing grounds particularly under unstable weather conditions.

4. Wave Sea Level

Wave sea level were identified as the primary factor contributing to the reduction in fishing frequency. All 35 fishermen (100%) reported that high sea waves significantly increased the risk of going to sea. This condition often forces fishermen to reduce their fishing efforts or temporarily halt operations altogether to avoid accidents. These findings align with previous research by [5], which highlights that extreme wave conditions frequently limit fishermen’s ability to operate safely at sea.

Forms of Adaptation of Fishermen's Economy

The increasingly evident impact of climate change has contributed to greater uncertainty in the fisheries sector. The diverse impacts of climate change represent major challenges for fishermen, prompting the need for Economic Adaptation Strategies as a means to sustain their financial resilience. These strategies include active, passive, and network-based approaches, as shown in the following table:

Table 3. Forms of Fishermen's Economic Adaptation to the Impacts of Climate Change

Forms of Economic Adaptation Strategy	Number of people)	Percentage (%)
Active	21	60.00
Passive	35	100.00
Network	32	91.43

Source: Processed Primary Data, 2025

The data presented in the table above show that the economic adaptation strategies employed by fishermen consist of Active, Passive, and Network-base approaches. The majority of fishermen in Labuhan Haji District reported employing Passive Adaptation Strategies, with all 35 respondents (100%) indicating reliance on this approach. Additionally, 32 fishermen (91.43%) stated that they implemented Network-based Strategies to support their economic resilience. In contrast, only 21 respondents (60%) reported the use of Active Strategies in adapting to the impacts of climate change.

Active Adaptation Strategy

The active adaptation strategy refers to efforts by fishermen to maximize their work potential by engaging in additional income-generating activities outside the fisheries sector. This strategy is typically characterized by business diversification. The implementation details of this strategy in Labuhan Haji District are presented in Table 4 below.

Table 4. Forms of Active Adaptation

Active Adaptation Strategy	Group Fishermen		Non-Group Fishermen		
	Σ	(%)	Σ	(%)	
Construction laborers	4	44.44	4	33.33	
Business Diversification	Farm workers	1	11.11	5	41.67
	Chicken Coop Keeper	2	22.22	3	25.00
	Coconut Pickers	2	22.22	0	00.00

Source: Processed Primary Data, 2025

The findings indicate that fishermen pursued business diversification through jobs such as construction laborers, farm workers, chicken coop keeper, and coconut pickers. construction laborers emerged as the most common alternative occupation among fishermen. A total of 4 fishermen from both group and non-group categories (44.44% and 33.33%, respectively) reported working in construction alongside their primary fishing activity. Additionally, 1 group fisherman (11.11%) and 5 non-group fishermen (41.67%) worked as farm laborers. Employment as chicken coop guards was undertaken by 2 group fishermen (22.22%) and 3 non-group fishermen (25%). coconut pickers was reported only among group fishermen (22.22%).

These diversification efforts were largely supported by the use of social capital, which served as a mechanism for disseminating job information. The fishermen stated that relationships formed between individuals and across communities enabled the sharing of job opportunities. Business diversification has been taking place for the past five years, a period during which fishermen have faced increasingly intense climate related challenges affecting their fishing operations.

Passive Adaptation Strategy

The passive adaptation strategy involves fishermen adapting to climate change by minimizing household expenditures. This strategy is most commonly implemented by fishing communities in Labuhan Haji District, as detailed in Table 5.

Table 5. Forms of Passive Adaptation Carried Out by Fishermen in Labuhan Haji District in 2025.

Passive Adaptation Forms	Group Fishermen		Non-Group Fishermen	
	Σ	(%)	Σ	(%)
Reduce Household Expenditure	14	100	21	100

Source: Processed Primary Data, 2025

The data shows that all surveyed fishermen 14 from group fishermen and 21 from non-group fishermen opted to reduce household expenditure as a primary form of passive adaptation. This response stems from an awareness of economic vulnerability due to climate change, which has disrupted the consistency of income from fishing. This form of adaptation is especially important during periods of reduced income, such as lean fishing seasons. Fishermen often reduce household spending during these periods, particularly during “dead tide” periods or lean seasons when fish availability is minimal. These findings are consistent with the research by [9], which also noted that fishermen reduce consumption expenditures to balance their income and sustain their livelihoods.

Network Adaptation Strategy

The impact of extreme climate change has affected various aspects of fishermen's livelihoods, particularly fishing efforts. This has encouraged fishermen to adopt adaptive strategies, one of which is the "Network Adaptation Strategy". This strategy involves the diversification of fishing gear, expansion of marketing alternatives, and access to financial resources through borrowing. The details of this strategy as applied in the Labuhan Haji District are presented in the following table.

Table 6. Network Adaptation Strategies Carried Out by Fishermen in Labuhan Haji District in 2025

Network Adaptation Strategy		Group Fishermen		Non-Group Fishermen	
		Σ	(%)	Σ	(%)
Diversification of Fishing Gear	Gillnet	14	50.00	12	57.14
	Longline	14	50.00	15	71.42
Expansion of Marketing Alternatives	Direct Selling	8	30.77	0	0
	Selling to Fish Collectors	14	53.85	21	100.00
	Social Media	4	15.38	0	0
Borrow Money	Family	4	21.05	4	19.05
	Other Fishermen Group Members	2	10.53	0	0
	Other Non-group Fishermen	0	0	2	9.52
	Fish Collectors	6	31.58	9	42.86
	Banks	7	36.84	6	28.57

Source: Processed Primary Data, 2025

The network adaptation strategy implemented by fishermen in Labuhan Haji District includes the diversification of fishing gear, expansion of marketing alternatives, and borrowing money. The implementation of this strategy relies on social networks within fishing communities for the exchange of information regarding fishing techniques, marketing practices, and access to capital.

1. Diversification of Fishing Gear

Fishermen reported using both gillnets and longlines as part of this adaptation. All 14 Group Fishermen (50%) used both types of gear gillnets and longlines demonstrating a balanced approach to fishing practices. Conversely, among non-group fishermen, longlines were more prevalent, with 15 individuals (71.42%) using them, while only 12 (57.14%) used gillnets. This suggests that diversification of fishing gear is a strategic adaptation for improving catch efficiency under changing environmental conditions.

2. Expansion of Marketing Alternatives

Marketing adaptation was observed in three main forms: selling directly to consumers, selling through fish collectors, and and selling via social media. Among group fishermen, 8 individuals (30.77%) sold their own catch directly to consumers, 14 (53.85%) sold to fish collectors, and 4 (15.38%) utilized social media platforms. In contrast, non-group fishermen sold their catch exclusively to fish collectors. This shows that Group Fishermen tend to be more advanced in using digital technologies to market their products, likely due to access to smartphones and better digital literacy.

3. Borrowing Money

Access to financial resources was another aspect of network adaptation. The research findings reveal a distinct difference in loan source preferences between group fishermen and non-group fishermen. Among group fishermen, the primary source of loans was formal financial institutions, particularly banks. This is supported by data showing that 7 fishermen (36.84%) reported receiving loans from banks. Conversely, borrowing from fellow group members was the least preferred option, with only 2 fishermen (10.53%) utilizing this source. In contrast, non-group fishermen most commonly borrowed from fish collectors, with 9 individuals (42.86%) reporting this as their main loan source. The least preferred option in this group was borrowing from other non-group fishermen, reported by only 2 respondents (9.52%). These findings suggest that group fishermen are more inclined to utilize formal credit institutions such as banks, likely due to better access to information, networks, and institutional support. In contrast, non-group fishermen tend to rely on informal lenders, particularly fish collectors, due to limited access to formal credit channels and a lack of information regarding institutional financing opportunities.

IV. CONCLUSION AND RECOMMENDATION

Conclusion

Based on the observations and findings of this study, the following conclusions can be drawn:

1. Climate change, particularly in the Labuhan Haji District, has significantly reduced fishing frequency, leading to a decrease in fish catches and the income of fishermen. This is largely due to increasingly unpredictable weather patterns, which hinder fishermen's ability to safely determine optimal fishing times and locations. Additionally, heightened sea risk and erratic rainfall have added further uncertainty, weakening the stability of fisheries based livelihoods. These conditions compel fishermen to adopt various economic adaptation strategies to maintain household income and economic resilience.
2. Fishermen's economic adaptation strategies in Labuhan Haji District consist of three main forms: Active Adaptation, Passive Adaptation, and Network Adaptation. Active adaptation involves diversifying income sources through non-fishing jobs such as construction laborers, farm workers, chicken coop keeper, and coconut pickers. Passive adaptation is implemented through household cost reduction and savings during periods of limited fishing activity. Network adaptation includes diversifying fishing gear (e.g., gillnets and longlines), expansion of marketing alternatives (direct selling, selling to fish collectors, and via social media), and accessing credit through loans from banks, families, peers, or fish collectors. These adaptation strategies collectively help fishermen cope with the adverse effects of climate change and ensure economic sustainability despite declining fisheries productivity.

Recommendations

Based on the conclusions above, the following recommendations are proposed:

1. The local government should organize a Fishermen's Climate Field School in collaboration with NTB Agency for Meteorology, Climatology, and Geophysics (BMKG) and the East Lombok Marine and Fisheries Service. This program should be held regularly to improve fishermen's knowledge of climate risks and reduce the hazards associated with going to sea under extreme weather conditions.
2. A structured training program should be developed to support the implementation of economic adaptation strategies among fishermen. This initiative should focus on building capacity in digital marketing, alternative income generation, and financial literacy, thereby strengthening the fishermen's economic resilience in the face of climate change.

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