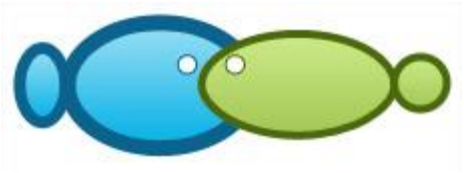

Fisheries-based food security in coastal Semarang, Central Java, Indonesia: assessing availability, accessibility, utilization, stability, and climate change adaptation

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Abstract. Climate change poses significant challenges to coastal fisheries and the food security of communities dependent on them. This study analyses the resilience of fisheries-based food supply chains in a coastal region of Indonesia by examining four key dimensions: availability, accessibility, utilization, and stability, alongside fishermen's adaptive responses to climate change. Data collected from surveys of 103 respondents — including fishers, aquaculture farmers, traders, and local stakeholders — indicate that while fish resource availability remains relatively strong, accessibility and stability are constrained by market dependence, limited infrastructure, and adverse climate impacts. Although awareness of nutritional benefits and proper utilization practices are high, capacity for value-added processing and financial preparedness is low, increasing vulnerability during environmental and economic shocks. Adaptive strategies such as livelihood diversification and improvements in fishing and aquaculture practices have been adopted but are insufficient to fully mitigate risks posed by unpredictable weather and fluctuating market prices. The findings underscore the need for integrated management approaches and targeted support programs to strengthen supply chain resilience, enhance food security, and support sustainable livelihoods for fishing communities. This research contributes to advancing fisheries governance and aligns with global sustainable development goals related to zero hunger and ocean sustainability.

Keywords: adaptation strategies, coastal communities, coastal small-scale fisheries.

Introduction. Coastal fisheries play a crucial role in ensuring food security, livelihoods, and economic stability for millions of people in Indonesia. In Semarang City, Central Java, Indonesia, a major hub within Fisheries Management Area (WPP) 712 (Rizal et al., 2023), the fisheries sector contributes significantly to local nutrition and income generation. However, this region faces mounting pressures from climate change, including rising sea temperatures, tidal flooding, habitat degradation, and unpredictable extreme weather events (Diposaptono et al., 2009; Istiqomah, 2018; Kasfari et al., 2018). Between 2016 and 2019, marine fishery production in Semarang fell dramatically from 352 tons to only 28 tons (Statistics Indonesia, 2018), reflecting the combined impacts of ecosystem degradation, such as mangrove and coral reef loss (Zega et al., 2024), as well as reduced fishing days caused by climatic uncertainty (Báez et al., 2021; Cheung et al., 2021; Mulyasari et al., 2023). These environmental and economic challenges threaten both ecological sustainability and the resilience of fisheries-based food supply chains that coastal communities depend upon.

The vulnerabilities are amplified by rapid urbanization and population growth in Semarang's coastal districts, where demand for fishery products continues to increase (Handayani et al., 2020). Yet, food production in these regions remains highly seasonal and sensitive to climate variability, creating significant risks to food security (Ansar &

Fathurrahman, 2018; Santoso et al., 2021). Areas distant from central markets or major distribution hubs are particularly vulnerable to fluctuating prices and unstable supplies, which exacerbate economic and nutritional insecurities (Rice et al., 2024; Rusmawati et al., 2023). In addition, coastal communities often lack access to financial resources for implementing modern fishing technologies (Hungevu et al., 2025), accurate weather information systems, and limiting their capacity to adapt effectively to climate-induced shocks (Ndimele et al., 2024).

Despite extensive research on coastal resource management and environmental impacts in Indonesia (Hamid et al., 2021; Rizal, 2021; Sidik et al., 2023), studies that integrate fisheries-based food supply chains with climate adaptation strategies remain scarce. Most existing work focuses narrowly on ecological assessments (Sabdono et al., 2021; Tussadiah et al., 2021; Khozanah et al., 2022) or resource mapping (Daris et al., 2022; Hermawan et al., 2021; Fauziyah et al., 2022), without addressing how climate change disrupts interconnected systems of production, distribution, and market access in urban coastal settings. This knowledge gap constrains the development of comprehensive, data-driven policies to strengthen both food security and community resilience under intensifying climate stress.

This study aims to comprehensively analyse the resilience of fisheries-based food supply chains in the coastal region of Semarang by focusing on the four key dimensions of food security: availability, accessibility, utilization, and stability. Additionally, this research investigates how local fishers and aquaculture farmers adapt to the ongoing challenges posed by climate change, including environmental variability and economic fluctuations. By integrating social, economic, and environmental perspectives, the study seeks to fill existing knowledge gaps and provide data-driven insights to support sustainable fisheries management and strengthen the food security of coastal communities. Ultimately, the findings will inform policy and program development to enhance adaptive capacity and resilience in the face of intensifying climate pressures.

Material and Method

Description of the study sites. This study was carried out in the coastal region of Semarang City, Central Java, Indonesia, covering six sub-districts: Tugu, Semarang Barat, Semarang Utara, Semarang Timur, Gayamsari, and Genuk. These areas are known for intensive fisheries and aquaculture activities but are increasingly threatened by climate change impacts such as tidal flooding, shoreline erosion, and unpredictable extreme weather events. The research was conducted from June to August 2025, with Figure 1 presenting the map of the study area.

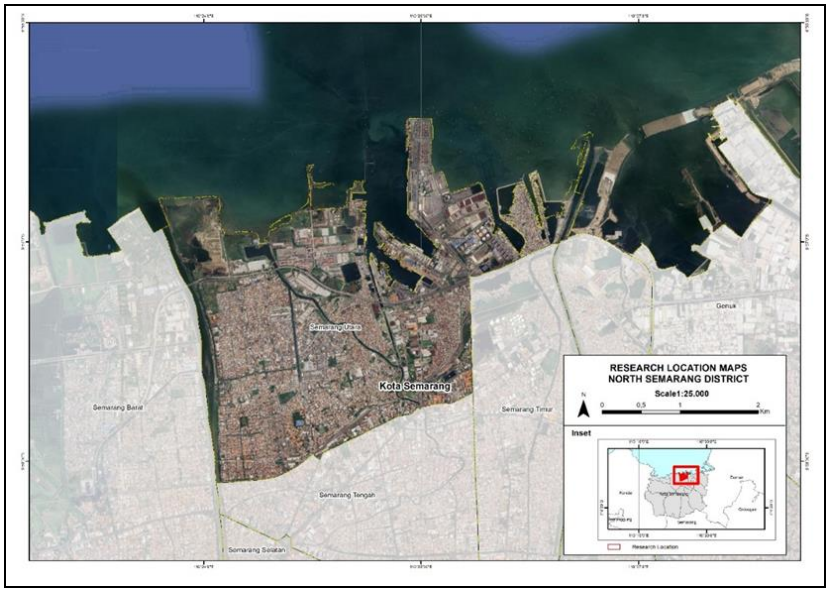

Figure 1. The research location in Semarang, Indonesia (map generated using ArcGIS Pro and Google Earth Engine).

This study employed a mixed-methods approach to comprehensively analyse the resilience of fisheries-based food supply chains and fishermen's adaptive responses to climate change in coastal communities. It is focused on four key dimensions of food security: availability, accessibility, utilization, and stability within the fisheries supply chain.

Data collection. Primary data were collected using a structured questionnaire administered to 103 respondents representing small-scale fishers, aquaculture farmers, traders, processors, and government officials. The questionnaire included: (1) general respondent information: capturing demographic data, type of main business, family size, and years of experience; (2) resilience dimensions: statements rated on a 5-point Likert scale assessing perceptions and conditions related to availability of fishery resources, market accessibility, utilization and nutrition knowledge, and business and price stability; (3) additional closed-ended questions: gathering information on group membership, sales channels, capital sources, training participation, and income sufficiency; (4) catch calendar: monthly details on fish catch types, distance travelled for fishing, and average daily catch; (5) adaptation and mitigation questions: open-ended items investigating observed changes over time, causes, anticipatory and adaptive actions taken, and their perceived effectiveness; (6) regeneration assessment: questions on family participation and the interest of younger generations in continuing fishery activities. Responses to the questionnaire items were measured using a five-point Likert scale, where 1 = strongly disagree (SD), 2 = disagree (D), 3 = neutral (N), 4 = agree (A), and 5 = strongly agree (SA). These abbreviations are used to present the results of the questionnaire.

In-depth interviews complemented the quantitative survey data by providing nuanced insights into local supply chain dynamics, market structures, and community adaptation strategies to climate-related risks. Additionally, direct field observations enriched contextual understanding of fishing and aquaculture practices, transport, and distribution mechanisms in the study area. Secondary data from the Department of Fisheries on production statistics, climate and tidal data from the Meteorological, Climatological, and Geophysical Agency (BMKG), and spatial datasets on administrative boundaries, land use, and coastal vulnerability were incorporated to provide crucial environmental and socio-economic context for the analysis.

Analytical approach. Quantitative data from the structured questionnaires were first analysed by descriptive percentage method to effectively summarize and interpret the responses collected through the structured questionnaire. Each item's response was transformed into a percentage score representing the proportion of respondents endorsing a particular level of agreement or option. This method was applied to each item within the resilience dimensions, which are rooted in the four pillars of food security — availability, accessibility, utilization, and stability — as originally defined by the Food and Agriculture Organization (FAO et al., 2022). The results were then categorized into criteria based on the percentage ranges to facilitate interpretation. Grouping responses this way allowed for clear descriptive interpretation and identification of strengths and weaknesses across the supply chain resilience indicators. This descriptive percentage approach provides an intuitive and straightforward analysis of survey results, helping to highlight prevailing perceptions and conditions among respondents effectively.

Qualitative data from open-ended survey questions, in-depth interviews, and field observations were analysed through thematic content analysis, identifying key themes around observed changes in fisheries, adaptation strategies, barriers faced, and family participation in sustaining fishery livelihoods across generations. This triangulation of qualitative insights with quantitative results enriched the interpretation of social, economic, and environmental influences on resilience.

Results

Respondent characteristics. The respondents in this study consisted of actors within the fisheries supply chain such as fishermen, fish and green mussel farmers, collectors,

fish auction managers, fish processing entrepreneurs from micro, small and medium-sized enterprises (MSMEs), consumers, and government officials. The total number of respondents was 103, each classified by specific categories or characteristics. The survey results showed that most actors involved in the fisheries supply chain were male and actively contributed to fishing or aquaculture activities. Only a small portion of respondents were female, mainly working as collectors, middlemen, and in fish processing businesses. Respondent characteristics based on business type and gender are presented in the Table 1.

Table 1

Respondents by business type and gender

Characteristics	*Number*	*Percentage (%)*
Business type		
Milkfish/another aquaculture	6	5.83
Green mussel farming	4	3.88
Fishermen	80	77.67
Fish processing MSMEs	5	4.85
Collector	2	1.94
Middleman	2	1.94
Fish auction	1	0.97
Government agency	1	0.97
Consumer	2	1.94
Total respondents	103	100
Gender		
Male	94	91.26
Female	9	8.74
Total respondents	103	100

Among the respondents directly involved in fish production activities — namely milkfish farmers, green mussel farmers and fishermen — there were 90 individuals. Their characteristics, including age, education level, years of experience, family size, and classification of fishermen/farmers, are detailed in the Table 2.

Table 2

Characteristics of fish production respondents

Characteristics	*Number*	*Percentage (%)*
Age		
15 - 25 years	1	1.11
26 - 35 years	6	6.67
36 - 45 years	22	24.44
46 - 55 years	39	43.33
56 - 65 years	18	20
> 65 years	4	4.44
Total respondents	90	100
Educational level		
No schooling	14	15.56
Elementary school or equivalent	55	61.11
Junior high school or equivalent	11	12.22
Senior high school or equivalent	10	11.11
Total respondents	90	100
Years of experience		
< 5 years	1	1.11
5 - 10 years	7	7.78
10 - 15 years	4	4.44
> 15 years	78	86.67
Total respondents	90	100
Family size		
≤ 4 members	53	58.89
≥ 5 members	37	41.11
Total respondents	90	100

Classification of fisheries actors		
Fishermen in groups	68	75.56
Independent fishermen	12	13.33
Fish aquaculture farmers	6	6.67
Green mussel aquaculture farmers	4	4.44
Total respondents	90	100

Description of boats and fishing gear. The description of boats includes details on boat size, ownership status, fishing gear used, and fishing distance, as summarized in Table 3.

Table 3

Characteristics of boats and fishing gear

Characteristics	*Number*	*Percentage (%)*
Boat size		
No boat used	2	2.22
< 5 GT	83	92.22
≥ 5 GT	5	5.56
Total respondents	90	100
Boat ownership status		
Owned personally	80	88.89
Rented / borrowed	3	3.33
Owned by individual (captain)	5	5.56
No boat ownership	2	2.22
Total respondents	90	100
Fishing gear used		
Hook and line	3	3.33
Nets	9	10.00
Surrounding net (arad)	53	58.89
Bubu Naga trap	5	5.56
Push net (sodo)	2	2.22
Surrounding net + Bubu Naga trap	1	1.11
Surrounding net + Bubu Apolo trap	1	1.11
Lift net (bagan)	6	6.67
Fixed net cages (keramba jaring tancap)	5	5.56
Fish aggregation devices (rumpon)	5	5.56
Total respondents	90	100
Fishing distance		
< 1 mile	10	11.11
1 – 3 miles	71	78.89
4 – 8 miles	7	7.78
> 8 miles	2	2.22
Total respondents	90	100

Figure 2 illustrates two commonly used fishing gears in the study area: the surrounding net on the left and the trap on the right, both playing key roles in local fisheries practices.

Figure 2. Surrounding net (left), Bubu Naga trap (middle), and Bubu Apolo trap (right).

Among respondents engaged in fish and green mussel aquaculture, 5 respondents constructed fixed net cages (keramba jaring tancap) for milkfish farming, 5 others-built fish aggregation devices (rumpon) for green mussel cultivation, while 1 respondent made a rumpon for marine fish habitat. Figure 3 shows an example of the fixed net cage (keramba jaring tancap) used by several respondents for milkfish aquaculture, reflecting one of the key aquaculture practices in the area.

Figure 3. Fixed net cage (keramba jaring tancap) for milkfish aquaculture.

Seasonal patterns of local fisheries. To better understand the dynamics of fishing activities and how aquaculture might complement existing practices, it is essential to consider the seasonal patterns of capture fisheries, as shown in Table 4.

Table 4

Seasonal fishing calendar in North Semarang

Catch type	*Month*											
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Squid (*Loligo* spp.)			■	■	■	■						
Shrimp (*Penaeus* spp.)	■	■									■	■
Anchovies (*Stolephorus* spp.)				■	■	■						
Acetes shrimp (*Acetes* spp.)	■	■	■	■								■
Blue swimming crab (*Portunus pelagicus*)							■	■	■	■		
Milkfish (*Chanos chanos*)							■	■	■	■	■	
Mullet fish (*Mugil* spp.)				■	■	■					■	
Rabbitfish (*Siganus* spp.)				■	■	■						
Yellow-lined spinefoot (*Siganus javus*)			■	■								
Sea catfish (*Ariidae* spp.)								■	■	■	■	
Barracuda (*Sphyraena* spp.)							■	■	■	■		
Snapper (*Lutjanus* spp.)							■	■	■	■		
Grouper (*Epinephelus* spp.)	■						■	■	■	■		
Mackerel scad (*Decapterus macarellus*)											■	
African pompano (*Alectis ciliaris*)											■	■
Ariid catfish (*Arius* spp.)	■	■						■	■	■	■	■
Gray eel-catfish (*Plotosus canius*)	■	■	■	■				■	■	■	■	■
Salt pottery fish (*Otolithes ruber*)			■	■	■			■	■	■	■	■
Beardless barb (*Cyclocheilichthys* spp.)						■	■	■	■	■	■	■
Mackerel (*Rastrelliger* spp.)	■	■	■	■	■	■						
Green mussel (*Perna viridis*)				■	■	■	■	■	■	■	■	■
Other shells (*Bivalvia* spp.)			■	■	■	■						

Fisheries-based food security dimension. Availability in the fisheries supply chain refers to the extent to which fish and fishery products can be consistently produced, supplied, and distributed to meet community consumption needs. The availability of catch as a food source is greatly influenced by the capacity of fishermen and aquaculture

farmers to produce consistently. To assess the condition of catch availability in the study area, measurements were made using several indicators reflecting the ability of fishermen and farmers to maintain a sustainable supply. These indicators include aspects of catch/harvest production, fishing facilities and infrastructure, and contributions to meeting community needs. The results of the availability dimension indicators are presented in Table 5.

Table 5

Availability dimension indicators

Indicator	*Frequency*					*Indicators mean*	*Conversion (%)*	*Category*
	SD (1)	D (2)	N (3)	A (4)	SA (5)			
A1	0	0	3	58	29	4.29		
A2	4	4	5	31	46	4.23		
A3	0	6	0	26	58	4.51		
A4	0	3	9	41	37	4.24		
A5	1	9	12	55	13	3.78		
	Variable average					4.21	84.22	Very high

In the context of fisheries-based food security, accessibility refers to the ability of fishermen and aquaculture farmers to consistently market their catch or harvest. Accessibility encompasses the ease of selling the catch or aquaculture products, buyer options, transportation facilities, and affordability of prices. Table 6 presents the results of the analysis of accessibility indicators within the fisheries supply chain.

Table 6

Accessibility dimension indicators

Indicator	*Frequency*					*Indicators mean*	*Conversion (%)*	*Category*
	SD (1)	*D (2)*	*N (3)*	*A (4)*	*SA (5)*			
B1	1	2	1	46	40	4.36		
B2	0	17	10	31	32	3.87		
B3	20	11	13	35	11	3.07		
B4	8	18	22	29	13	3.23		
B5	5	5	7	35	38	4.07		
	Variable average					*3.72*	*81.33*	*High*

Utilization encompasses knowledge of nutrition, skills in processing, and preserving fishery products. Table 7 presents an analysis of indicators related to utilization and nutrition in the fisheries supply chain. This dimension refers to the optimal use of catches or harvests to meet community nutritional needs.

Table 7

Indicators of utilization and nutrition dimension

Indicator	*Frequency*					*Indicators mean*	*Conversion (%)*	*Category*
	SD (1)	*D (2)*	*N (3)*	*A (4)*	*SA (5)*			
C1	2	11	12	46	19	3.77		
C2	0	0	1	42	47	4.51		
C3	0	0	1	20	69	4.76		
C4	84	4	0	0	2	1.13		
C5	5	5	18	49	13	3.67		
	Variable average					*3.57*	*71.33*	*High*

Stability significantly affects the smooth distribution of fishery products and determines the overall supply chain sustainability. Table 8 presents findings on business and price stability indicators.

Table 8

Indicators of business and price stability

Indicator	*Frequency*					*Indicators mean*	*Conversion (%)*	*Category*
	SD (1)	*D (2)*	*N (3)*	*A (4)*	*SA (5)*			
D1	33	29	8	12	8	2.26		
D2	3	0	8	46	33	4.18		
D3	0	1	0	4	85	4.92		
D4	14	42	10	19	5	2.54		
D5	0	0	4	33	53	4.54		
	Variable average					*3.57*	*73.78*	*High*

Among the four dimensions of fisheries supply chain resilience, availability scored the highest average indicator of 4.21, emphasizing supply availability as the foundational pillar of fisheries resilience. Availability encompasses fish stocks in the sea or aquaculture harvests. Despite seasonal trends showing higher catch volumes during certain months (rainy season), fish stocks remain sufficient outside peak seasons, though in smaller quantities. Availability underpins the other dimensions; without sufficient stock or supply, the supply chain is disrupted.

Discussion

Demographic and socioeconomic characteristics. From the survey of 90 respondents, the age range varied from 20 to 75 years. The majority (95.56 %) were within the productive age group (15 – 65 years), with the youngest respondent aged 20 and the oldest 75 years. Older fishermen often face physical challenges that limit their ability to perform strenuous activities such as catching and hauling fish. This situation may encourage them to retire or switch to less physically demanding occupations, which can indirectly impact fisheries productivity. Regarding education, most respondents (61.11 %) had completed only primary education, while 15.56 % had not attended school. Respondents with junior and senior high school education were nearly similar at 12.22 % and 11.11 %, respectively. Regarding experience, 86.7 % had worked in the fisheries sector for more than 15 years, indicating a highly experienced group, although the number of newcomers was relatively small. Most respondents had family sizes of four members or fewer (58.9 %), while 41.1 % had families with five or more members. The size of household dependents could influence family economic strategies, including decisions about fishing or managing fisheries businesses.

Based on the classification of fisheries actors, 75.56 % of respondents were fishermen affiliated with groups or cooperative units, 13.33 % were independent fishermen, 6.67 % were involved in fish farming (milkfish or other species), and 4.44 % were green mussel farmers. This suggests that fishing remains the primary livelihood, although aquaculture activities are gradually becoming an additional income source in the region.

The demographic profile thus shows that most fisheries actors are within the productive age group, with extensive experience in fishing — over 15 years on average. Such experience implies strong traditional knowledge of fishing grounds, weather patterns, and species behaviour, which is valuable for resource management and adaptation to climate change. However, the aging population raises concerns about the sustainability of the sector, especially as younger generations appear less interested in entering fisheries due to the physically demanding nature of the work, uncertain incomes, and environmental risks such as tidal flooding and coastal abrasion (Power et al., 2014; Suharyanto et al., 2024).

Additionally, low educational attainment—where over 75 % of respondents had only primary or no formal education — may constrain the adoption of modern technologies, financial literacy, and market diversification strategies. Education levels are closely linked to adaptive capacity under changing environmental (Feinstein & Mach, 2020) and market conditions (Mustafazada, 2024). Therefore, targeted capacity-building programs focusing on financial management, sustainable fishing practices, and aquaculture innovations could improve resilience.

Gender disparity also characterizes the sector, with over 90 % of respondents being male. Women were more engaged in post-harvest processing and marketing than in fishing itself. While this reflects common gendered divisions of labour in coastal communities, empowering women through training, credit access, and value-added processing technologies could enhance household incomes and food security.

Fishing operations and gear utilization. Based on the survey results, fishermen in North Semarang are predominantly small-scale operators. Most boats measure less than 5 GT, accounting for 92.22 % of respondents, while only 5.56 % operate boats of 5 – 6 GT, and two respondents do not own boats. Those without boats typically fish nearshore using foam boxes as floating aids. Ownership data show that 88.89 % use personally owned boats, granting autonomy in selecting fishing grounds and trip durations. A small number borrow boats or work as crew members (ABK) under individual owners (juragan), following a 60 : 40 revenue-sharing arrangement after fuel expenses.

The surveyed respondents included 80 fishermen, 5 milkfish farmers, 4 green mussel farmers, and 1 fish farmer cultivating grouper and snapper. The most common gear type was the surrounding net (58.89 %), followed by traps (bubu naga), gillnets, hook-and-line systems, and bagan lift nets. The prevalence of traditional gear highlights both cultural continuity and sustainability challenges. While such gears are low-impact and cost-efficient, they limit catch volumes and economic returns. Introducing selective, eco-friendly gear could improve resource conservation and livelihoods simultaneously (Islam et al., 2018).

Fishing areas and seasonal patterns. Most respondents fish within 1 – 2 miles of the shore (78.89 %), with only 2.22 % operating beyond 8 miles. This nearshore dependence emphasizes their vulnerability to coastal and environmental changes. The seasonal fishing calendar derived from interviews demonstrates distinct temporal patterns, with economically valuable species such as anchovies, sea catfish, barracuda, and gray eel-catfish peaking between March – May and September – November. Consequently, household incomes fluctuate seasonally, increasing vulnerability during lean months (Badjeck et al., 2010; Susilo et al., 2021).

Some species — such as shrimp, mackerel scad, and green mussels — have multiple or extended peak seasons, making them suitable for aquaculture and value-added processing to stabilize income (Gurung et al., 2018; Wang et al., 2024). However, seasonal variability is influenced by monsoons and climate anomalies that may disrupt traditional fishing calendars (Konnov et al., 2022). Adaptive management, including early warning systems and flexible fishing strategies, is therefore crucial.

Periods of overlapping peak seasons also raise overfishing concerns, especially for species with slow reproduction. Management measures such as seasonal closures (Islam et al., 2021), gear restrictions (Carvalho & Humphries, 2022), and catch quotas (Lawson & Smith, 2023) could help balance resource use and sustainability. Moreover, policy interventions supporting alternative livelihoods — like seaweed farming (Putri et al., 2025) and coastal tourism (Kabil et al., 2021) — as well as investments in storage and cold-chain facilities (Tang & Ho Thi, 2024), could enhance income stability. Training on adaptive fishing and climate-resilient livelihoods (Khan & Sano, 2025) remains essential.

Fisheries-based food security dimension. Table 5 indicates that resource availability falls into the very high category (84.22 %, average index 4.21). Respondents reported year-round harvests (Indicator A1: 4.29), suggesting stable fish stocks, though monsoonal transitions occasionally reduce productivity. Weather disruptions (A2: 4.23) remain significant external risks, while production equipment availability (A3: 4.51) strongly supports fishing efficiency. Most catches are sold via intermediaries (A4: 4.24), easing market access but limiting price autonomy. Local consumption remains inconsistent (A5: 3.78) due to priority sales to middlemen. These results imply that although production tools and resource potential are strong, dependence on intermediaries and exposure to climatic risks create vulnerabilities. Adaptive management integrating climate-resilient practices (Awazi, 2025), diversified marketing

channels (Nicolosi et al., 2021), and community-based distribution (Garcia-Lorenzo et al., 2021) could enhance equity and resilience. Strengthening local value chains (Sobariah & Herlambang, 2025) and promoting cooperative business models (Ankrah Twumasi et al., 2021) are also critical for improving fishermen's bargaining positions and food security.

Perceptions of accessibility were high (81.33 %, index 3.72). Most fishermen sell to middlemen or local markets (B1: 4.36), facilitating fast distribution but creating dependency. Prices are often determined by buyers (B2: 3.87), while alternative market channels remain scarce (B3: 3.07). Information on prices is mostly informal (B4: 3.23), and transportation capacity is generally good (B5: 4.07). While local market reach is strong, overreliance on middlemen and limited formal information networks weaken bargaining power. Market diversification (Nicolosi et al., 2021), digital and cooperative-based information systems (Yomungga & Kubelaborbir, 2024), and direct-to-consumer sales models (Advani et al., 2024) could increase autonomy and income stability while creating a more equitable seafood supply chain.

Respondents displayed high awareness of fish utilization and nutrition (71.33 %, index 3.57). Most families regularly consume their catch (C1: 3.77), reinforcing food security. Awareness of fish's nutritional value is high (C2: 4.51), as is preservation knowledge (C3: 4.76). However, participation in fish processing training is extremely low (C4: 1.13), limiting opportunities for value-added products. Most catches are consumed locally (C5: 3.67).

Business and price stability were rated high (73.78 %, index 3.57). Most fishermen cannot work during adverse weather (D1: 2.26), confirming climate vulnerability. Weather conditions directly affect production and income (D2: 4.18), though post-monsoon periods offer better catches. Price drops during peak seasons (D3: 4.92) create financial stress, while lack of savings (D4: 2.54) exposes families to shocks. Many rely on formal or informal loans from middlemen. A strong desire for resilience-building support (D5: 4.54) was evident. These findings underscore the need for financial literacy, access to microfinance, and risk management tailored to fishing livelihoods. Training in business planning, cooperative savings, and market timing could reduce vulnerability and dependence on informal credit systems. Although nutritional awareness is strong, limited access to processing and training hinders value chain upgrading. Enhancing training programs on processing, packaging, and marketing could foster value addition, reduce losses, and strengthen household food security (Fadila et al., 2022; Mariana et al., 2024). Community-based processing initiatives may further stimulate local entrepreneurship and resilience.

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Adaptation to climate change. Fishermen and aquaculture farmers depend heavily on natural conditions and must undertake mitigation and adaptation actions to address changes. Interviews show that all respondents experienced changes in catch or harvest due to unpredictable weather patterns over the past 2 – 3 years, reducing fishing frequency. Rough seas and strong winds deter fishermen from going out. Respondents have access to weather information from the Meteorology, Climatology, and Geophysical Agency of Indonesia (BMKG) to monitor conditions and help prevent damage from adverse weather. BMKG support is delivered by tools such as the 'Info BMKG' application, which plays a critical role in monitoring conditions and preventing damage from adverse weather. Recent research analysing the app using the Delone and McLean (2003) model highlights that information quality and early warning system success factors significantly

influence users' intention to use and satisfaction, underscoring its importance for enhancing disaster preparedness and response in Indonesia (Siswanto et al., 2024). For cage aquaculture farmers, strong waves damage cages, threatening harvest success (Zhang et al., 2021). Besides weather, increasing use of fish aggregation devices (rumpon) adversely affects fishermen due to gear entanglement, halting activities. Predators like barracudas invading cage aquaculture during breeding stages also reduce harvests. Adaptation involves repairing boats, engines, and gear during high-wave breaks. Some seek casual labour for supplementary income or switch to green mussel aquaculture during slow fishing seasons.

The findings from this study align closely with previous research by Rahman et al. (2022) emphasizing the critical role of climate change adaptation in strengthening household food security among fishing communities. Evidence shows that fishermen employ multiple adaptation strategies, ranging from adjusting fishing locations and schedules to adopting new technologies such as fish-finding tools and modifying fishing gear to cope with changing weather patterns. This study highlights that adaptation efforts are positively influenced by asset ownership, social and financial capital, access to climate information, and heightened awareness of climate change risks. Conversely, factors such as older fishing vessels and the necessity for secondary income outside the fisheries sector can hinder adaptation capacity.

Most importantly, these studies confirm that adaptation intensity has a direct and significant impact on household food security, measured through indicators such as the food insecurity experience scale (FIES) and the food consumption score (FCS). Enhanced adaptation not only improves household resilience but also strengthens food security outcomes, particularly when supported by targeted interventions. Policy recommendations emerging from this study include providing subsidies for modernizing fishing vessels and equipment, improving access to microfinance institutions, strengthening fisheries extension services through training and support programs, and expanding access to timely and accurate climate information. These measures would collectively build the adaptive capacity of fishing communities, mitigate the risks posed by extreme weather events, and sustain local food security in the face of climate variability.

Conclusions. This study highlights that the fisheries-based food supply chain in the coastal region of Semarang maintains a relatively strong resource availability supported by adequate production tools and experienced small-scale fishers. However, significant challenges persist in terms of market accessibility, price and business stability, and adaptive capacity to climate change impacts. The heavy dependence on middlemen, limited alternative buyers, and restricted access to formal price information reduce fishermen's bargaining power, while low participation in fish processing training constrains value addition and income diversification. Adaptive strategies such as livelihood diversification and improved fishing practices have been adopted yet remain insufficient to fully offset climate and economic risks. These findings imply that targeted interventions focusing on market diversification, capacity building in processing and financial management, cooperative strengthening, and infrastructure improvements are essential for enhancing community resilience and ensuring food security. The promotion of aquaculture as a supplementary livelihood also offers a promising pathway to sustainable fisheries management and stable food supply in this vulnerable coastal setting.

Despite its comprehensive approach, this study has limitations including its focus on only six sub-districts within Semarang, which may limit the generalizability of findings to other coastal regions with different socio-ecological contexts. Additionally, the predominance of self-reported survey data may be subject to biases inherent in respondent perceptions. Future research should expand to comparative studies across diverse coastal fisheries regions to better capture spatial variations in resilience and adaptation. Longitudinal studies tracking the efficacy of implemented adaptation and support programs over time would provide deeper insights into the dynamics of fisheries-based food security under climate change. Furthermore, exploring gender-specific roles

and barriers in the fisheries supply chain would enrich understanding and inform more inclusive policy designs. Integrating emerging technologies and market innovations into fisheries resilience assessments also presents a valuable avenue for future investigation.

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Conflict of Interest. The authors declare that there is no conflict of interest.

Data Availability. The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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