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Livelihood Vulnerability to Climate Change in Viet Nam: Evidence from Coastal Households, Quang Nam Province

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ABSTRACT

Vietnam, with its twenty-eight coastal provinces, is one of the nations most profoundly affected by the adverse impacts of climate change (CC). These provinces face severe challenges as they contend with the escalating effects of CC, including rising sea levels, typhoons, flooding, and droughts. In this context, this article aims to assess the vulnerability of households' livelihoods in Quang Nam Province by applying the Livelihood Vulnerability Index (LVI) developed by Hahn et al., along with the Intergovernmental Panel on Climate Change framework (LVI-IPCC). The study utilises five sources of household capital—human, social, physical, natural, and financial—to construct its indices. The data for this article is based on a survey of 200 households. The research methodology combines both quantitative and qualitative methods, including questionnaire interviews, in-depth interviews, and focus group discussions. The research period spans from 2021 to 2023. The study results revealed that the household LVI was 0.371, while the LVI-IPCC was 0.086, highlighting the critical need for access to food and clean water, which scored 0.458 and 0.351, respectively. The research underscores how CC significantly affects the livelihoods of coastal communities, particularly in sectors such as fishing, aquaculture, and agriculture. The study concludes that CC poses significant challenges to the livelihoods of coastal communities in Quang Nam Province and that adaptation measures are necessary to support these communities. The research highlights the importance of livelihood diversification, job transformation, and improving knowledge and skills to enhance the resilience of coastal communities to CC.

Keywords: Capital; Climate Change (CC); Livelihood Vulnerability Index (LVI); Viet Nam; Vulnerability

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1. Introduction

NASA's 2024 report highlights that the global mean sea level in 2023 rose by 9.4 cm [+/−1 cm] compared to 1993, marking the highest recorded levels since modern observations began in the nineteenth century [1]. The report also notes that August 2024 became the hottest month globally, culminating in the hottest summer since records began in 1880. The summer months of June, July, and August 2024 were approximately 0.10 °C warmer than any other recorded summer. Furthermore, the summer of 2024 exceeded the average summer temperatures from 1951 to 1980 by 1.25 °C, with August alone being 1.30 °C warmer.

According to the WMO (2024), the average annual global temperature was 1.45 °C [+/−0.12 °C] in 2024, warmer than it was before humans started burning fossil fuels, a process that has more than doubled the rate of sea-level rise) over the past ten years since the first decade of satellite records from 0.21cm per year in the period 1993–2002 to 0.48cm per year in the period 2014–2023 [2]. Since the beginning of the twentieth century, global average sea levels have risen faster than in any previous century in at least the past 3000 years, and the rate of increase is accelerating.

The report by Ripple et al. (2024) argued that the three hottest days ever occurred in July 2024 and that current policies have put us on track for a peak warming of around 2.7 °C by 2100 [3]. Duncan's (2024) research showed that the global average temperature throughout 2024 was 14.98 °C, surpassing 2016, the previous warmest year. The temperature was 1.48 °C higher than in the pre-industrial period of 1850–1900 [4]. New temperature records were set every month from June to December, with July and August 2024 being the hottest.

The most recent report by C3S (2024) acknowledged that the temperature in September 2024 was 1.54 °C higher than in pre-industrial society (before 1700) [5]. The year 2024 was considered the warmest year recorded in history. Extreme rain events are becoming more frequent this month, and warmer atmospheres lead to more intense rainfall. The risk of extreme rain will continue to increase as temperatures rise.

On a global scale, the impacts of CC are intensifying and becoming more severe, and Vietnam is not exempt from its influence.

Vietnam is among the countries most adversely affected by CC. The country has proactively established many policies and programs addressing CC at central, ministerial, and local levels over the last 30 years. The increase in CC events significantly contributes to the heightened vulnerability of livelihoods dependent on natural resources in many coastal communities in Viet Nam.

In the context of increasingly abnormal CC and severe impacts on the livelihoods of coastal people, it is essential to study and assess vulnerabilities and develop strategies to adapt to CC in these communities. There is a need for research on marine livelihoods in the context of CC, from which recommendations and policy solutions based on scientific evidence can be made to build a sustainable livelihood framework for coastal residents.

According to the World Bank's 2010 report on CC in Asian coastal cities, flooding driven by CC has severely affected cities such as Manila, Ho Chi Minh City, and Bangkok [6]. As a result, these cities have incurred billions of dollars in repair expenses, alongside experiencing a 2 to 6 per cent reduction in economic growth over the past three decades, varying by location.

Adger (2000) and Cutter et al. (2003) observed that the characteristics of population structures play a role in determining their effective or ineffective adaptation to CC [7,8]. Moreover, Dulal et al. (2010) revealed that low-income households, constrained by limited financial resources, are less resilient to the impacts of CC [9]. These findings emphasise that LV encapsulates the challenges individuals and systems face in coping with the adverse effects of CC and the broader social context surrounding them [10–12].

From the different theories and dimensions of CC impacts on household livelihoods, the problem analysis framework has gradually developed over the past 15 years.

One is the analytical framework of IPCC (2001) [13]. The IPCC's analytical framework defines LV under CC impacts using three indicator components: *Exposure, adaptation, and sensitivity* [13].

The second framework is the LVI developed by Hahn et al. (2009) based on their analysis in Mozambique [14]. This LVI framework is built upon Chambers and Conway's five capital sources of livelihood (1992) [15]. Hahn et al. also incorporate the IPCC's analysis in their work [14]. The study's findings reveal indicators of social networks and household characteristics that are most vulnerable to the impacts of CC.

Evaluating household livelihood capacity can be effectively achieved using the five sources of capital—human, financial, natural, social, and material—outlined by Chambers and Conway in 1992 [15]. This approach is both practical and straightforward to apply. According to these two authors, households achieve sustainable livelihoods with clear and concrete indicators of capability, approaches, and activities of capital-based livelihoods [15]. Livelihoods are sustainable when people can cope and recover from shocks, sustain and improve capacity, and have access to capital. The funding suggested by these two authors is currently being utilised by numerous researchers and international organisations, including DFID (1999), FAO and ILO (2009), and UNDP (2017) [16–18].

Shah et al.'s (2013) study in Trinidad and Tobago

employed LVI analysis in combination with IPCC insights, revealing that elements like livelihood strategies, healthcare availability, access to clean water, and land ownership played a key role in influencing households' ability to adapt to CC [19]. Madhuri et al.'s (2014) research in Bihar demonstrated that factors such as education levels, diversification of livelihoods, and the growth of household social networks are closely linked to the capacity to manage the adverse effects of CC [20].

According to Panthi et al. (2016), research in Nepal identified livelihood strategies and access to food resources as the primary factors contributing to people's vulnerability to climate change (CC) [21]. In their analysis of CC's vulnerability to agricultural ecosystems in Ethiopia, Simane et al. (2016) showed that living standards, technology, and infrastructure are essential factors in adapting to CC [22]. In the Ghana study, Adu et al. (2017) also showed that social networks and livelihood strategies are essential indicators that households are vulnerable to adapting to extreme weather [23]. Ding et al. (2018) showed that social and natural capital factors can affect households by reducing their income [24].

Sujakhu et al. (2019), in their assessment of the LVI of indigenous households in Himalayan Nepal, showed that financial resources, household health, and livelihood strategies affect CC adaptation capacity [25]. Research by Majid et al. (2019), combining LVI calculations and geographic information systems (GIS), showed that households with female heads of households lack livelihood diversity, and riverine families are vulnerable to weather changes such as floods [26].

In their study in Bangladesh, Alam et al. (2017) showed that CC significantly affects five-capital sources of households by reducing arable and forest land, pushing many people out of their hometowns to live, and reducing incomes [27]. From there, Alam et al. measured people's awareness of CC and adaptation strategies based on farming time frames, crop changes, and livelihood diversity [27].

In Vietnam, McElwee's research (2010) highlighted that social factors, particularly those related to gender and religious perspectives, demonstrate strong adaptability to CC [28]. This adaptability stems from people's ability to support one another in the aftermath of adverse weather events.

Tran and Vu (2012) provided perspectives on the assessment of CC for coastal livelihoods in Vietnam, in which the two authors emphasise the analysis framework based on the five capital sources of DFID [29].

In their report *Evaluating Evidence: Migration, Environment and CC in Vietnam*, Dang et al. (2016) highlighted that the Mekong Delta region is the most severely impacted by rising sea levels and extreme weather events, such as heavy rains and droughts [30]. The effects of CC complicate people's livelihoods and force some individuals to leave their traditional homes.

In the 2015 special report on *Disaster Risk Management and Extreme Phenomena for CC Adaptation*, IMHEN and UNDP highlighted several typical CC-related challenges, including typhoons, urban flooding, droughts, and saltwater intrusion [31]. The report assessed exposure, adaptation, and vulnerability, revealing the profound effects of CC on the livelihoods of coastal residents. The study also shows that Viet Nam needs to have long-term measures and plans for disaster prevention and adaptation to CC, reflected in the introduction of timely policies from the central to local levels, enhancing knowledge about CC and strengthening the participation role of people in action plans.

Research by Dang and Quyen (2016) on the adaptation of aquaculture communities in the coastal region of Nam Dinh showed that aquacultural farms have brought high incomes to people [32]. However, CC dramatically affects people, especially clam farmers, because the farming environment is most vulnerable to changes in weather, and no valuable measures have been taken to prevent it.

Phung et al. (2019), in their research in the Nga Son and Hau Loc districts of Thanh Hoa province, Viet Nam, showed that residents have not yet adapted effectively to CC [33].

Research by Bui et al. (2021) based on an analysis framework of three sources of capital (financial, human, and social capital) in two coastal provinces of Ninh Thuan and Binh Thuan, Viet Nam, showed that the most prominent manifestation of CC affecting residents' livelihoods is prolonged drought [34]. Since then, many households whose main activity is agriculture have had to switch to other jobs to adapt to the new context.

Studies have shown that Vietnam suffers much damage due to CC; however, the livelihood damage to coastal communities is insignificant. Therefore, vulnerability assessment is scientifically necessary to compare the scope of many countries and suggest policies to adapt to CC. In this context, the evaluation framework of Hahn et al. (2009) ensures the most thorough understanding of livelihood damage and adaptation strategies of households and communities under the impact of CC due to the combination of the five-source funding framework of Chambers and Conway (1992) and the analytical framework of the IPCC [13–15]. This toolkit is currently considered the most potent and complete, covering household resources, and is widely used in the scientific community and international organisations today.

This article systematically assesses the livelihood vulnerability of coastal households due to the impacts of CC over the past ten years (2010–2022) by studying 200 households in 3 communes of Tam Thanh, Tam Phu, and Tam Tien in Quang Nam province. All three communes border each other, bordering the sea, and have very similar socio-economic characteristics.

The paper begins with the methodology and how

livelihood vulnerability indicators are calculated. Next, the Results and Discussion sections present the research data in detail. The division of sections is intended to help readers understand the research context in Quang Nam province and previous studies.

2. Research Methods

(1) Approach: The research uses an integrated, holistic, multidimensional, and interdisciplinary approach to the research problem [35–37]. In particular, research and collect information and data from the central level, the government, ministries, departments, and local leading agencies to study. The research also collects opinions from businesses, households, and people directly related to the topic at the research sites. The investigation also gathers residents' opinions, age groups, education levels, genders, the elderly, children, and the socially disadvantaged. The project ensures that the voices of all research subjects are respected and presented in the report to ensure the representation of the population in the study provinces. The study also uses an interdisciplinary approach. Selected economics, sociology, environment, and anthropology knowledge is thoroughly applied.

(2) Research methods: The study uses quantitative and qualitative research methods. Specifically, the study conducted questionnaire interviews for 200 households. The questionnaire will collect data related to households, sources of capital, and CC over the past 10 years. The study also conducted 20 group discussions with households and officials from local departments. The content of the group discussion is related to consensus, commonalities, and differences in livelihoods in the context of local CC in recent years. The study also conducted 30 in-depth interviews with heads of households and the general population at the study sites.

(3) Sampling: 200 households were selected using a systematic random method. The local authority lists all households in three communes, and the research team uses that to select a sample (see Figure 1 [38]).

In this article, the livelihood of coastal residents is understood as the livelihood of communities living in coastal areas, using resources to participate in coastal regions' economic activities to achieve income goals and improve living standards. Basic coastal livelihood activities include fisheries, aquaculture, and tourism.

The article defines CC based on Vietnam's Law on Hydrometeorology 2015, which describes it as a long-term alteration in climate caused by natural factors and human activities [39]. This is evident in global warming, rising sea levels, and the increasing frequency of extreme hydrometeorological events [39].

The concept of LV is the extent to which people and systems cannot cope with the negative impacts of CC [40].

Figure 1 illustrates the map of the survey areas in Quang Nam Province.

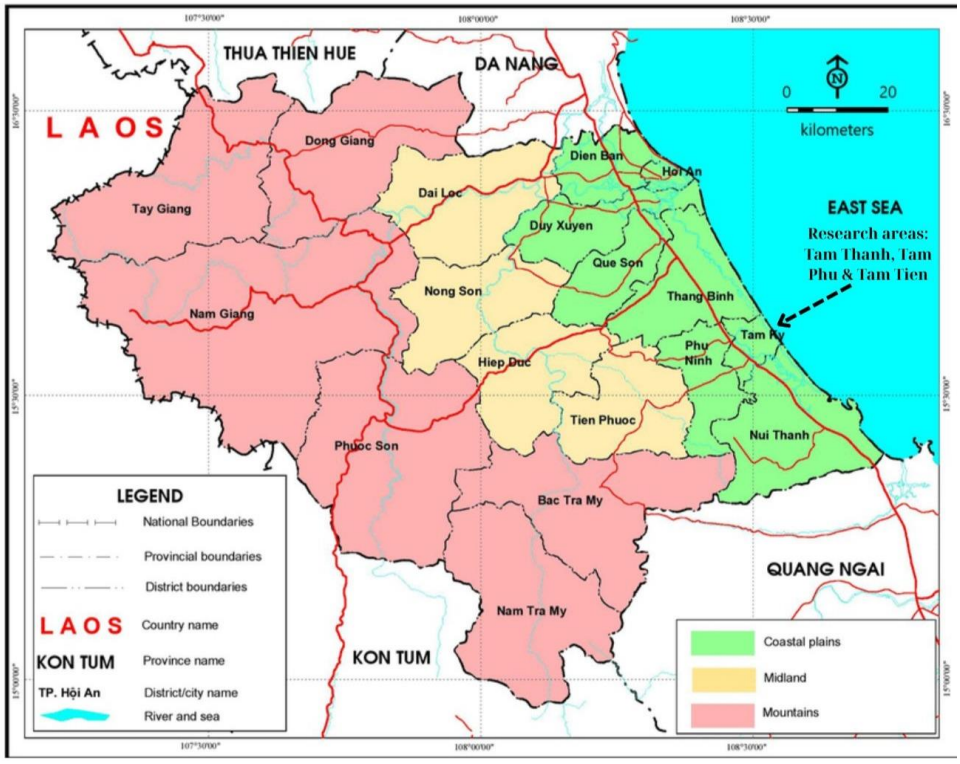

Figure 1. Map of survey areas in Quang Nam Province.

3. LVI and LVI-IPCC Analysis Framework

From the approach and research methods above, the article adopts an extensive assessment of CC based on the LVI methodology of Hahn et al. (2009) and the IPCC approach (2001, LVI-IPCC) [13,14]. It integrates with the perspective of five sources of capital by Chambers and Conway (1992), including financial, human, natural, physical, and social [15]. The LVI is measured from 0 (least vulnerable) to 1 (most vulnerable). The LVI-IPCC is measured from –1 (least vulnerable) to 1 (most vulnerable). This article analyses the LVI and LVI-IPCC according to the formula proposed by Hahn et al. (2009) [14].

The elements used to calculate the LVI include Access to clean water (W), Access to food (F), Healthcare (H), Household profile (SDP), Livelihood strategy (LS), Natural disasters, and CC (NDCV), Physical capital (PC), and Social capital (SC).

The detailed components of the five sources of capital are as follows:

+ **Household profile** (**Human capital**): Gender of the household head, education level, and health status.

+ **Financial and natural capital**: Economic activities of the household, diversity of livelihoods, migration patterns, borrowing practices, household income and expenditure, land, and home ownership.

+ **Social capital**: Participation of households in state and civil organisations.

+ **Physical capital**: Resources for fishing, agriculture, livestock raising, transportation, and communication.

+ **Natural disasters and CC**: Impacts such as loss of life and property, temperature fluctuations, and the frequency of storms, tropical depressions, and rainfall over the past decade.

+ **Healthcare**: Access to medical facilities.

+ **Access to food**: Capability to purchase and store food during natural disasters.

+ **Access to clean water**: Water is available for consumption and daily living.

After calculating the values of the main components as suggested by Hahn et al. (2009) [14], the LVI can be given below:

$$LVI_{qn} = \frac{W_{SDP}SDP_{qn} + W_{LS}LS_{qn} + W_{SC}SC_{qn} + W_{H}H_{qn} + W_{F}F_{qn} + W_{W}W_{qn} + W_{PC}PC_{qn} + W_{NDCV}NDCV_{qn}}{W_{SDP} + W_{LS} + W_{SC} + W_{H} + W_{F} + W_{W} + W_{PC} + W_{NDCV}} \quad (1)$$

Specifically, LVI_{qn} denotes the LVI for the study area, Quang Nam Province (qn), along with the weights assigned to the eight primary components. WM_i is defined by the number of subcomponents that comprise each main component of the overall LVI. The weights of each significant component are determined by the number of sub-components that make up each principal component and are included to ensure that all sub-components contribute equally to the overall LVI [14,40].

In addition to the LVI, the LVI-IPCC index is also based on household-level data and components. The LVI-IPCC index structure includes *exposure* (NDCV), *adaptability* (SDP, LS, and SC), and *sensitivity* (H, F, PC, and W). Calculations for the three main components involve:

$$CF_{qn} = \frac{\sum_{i=1}^{n} W_{Mi}M_{qni}}{\sum_{i=1}^{n} W_{Mi}} \quad (2)$$

where CF_{qn} represents one of the three main components contributing to the IPCC framework (exposure, sensitivity, or adaptability) in the study area of Quang Nam province (qn). M_{qni} refers to the main component of the *qn* study area, where *i* indicates the component index. W_{Mi} is the weight assigned to each principal component, and *n* is the number of components within each major category. After calculating each component, to derive the LVI-IPCC value, the three component elements are combined using

$$\text{LVI-IPCC}_{qn} = (e_{qn} - a_{qn}) * S_{qn} \quad (3)$$

where qn is the study area in Quang Nam, *e* is the exposure index (NDCV), *a* is adaptability (SPD, LS, SC), and *S* is the sensitivity index (H, F, PC, and W).

4. Results and Discussions

Based on the above knowledge, the paper divides this main presentation into four parts, presenting the basic characteristics of household livelihoods at the study sites. Then, the authors set the context of household livelihoods in the context of CC in Vietnam and Quang Nam province over the past 10 years. Next, the paper presents five sources of household capital and their roles in coping with CC. The final part of the paper presents LVI and IPCC to assess the vulnerability of household livelihoods in the context of CC.

4.1. Livelihood Characteristics of Coastal Households in Quang Nam Province

Quang Nam is a province located in the centre of Vietnam. The province has two cities, Tam Ky and Hoi An. The total natural area of the province is 1057474 hectares, with a population of nearly 1.5 million. Quang Nam province has a coastline of 125 km. The coast has many beautiful and famous beaches, such as Ha My (Dien Ban), Cua Dai (Hoi An), and Tam Thanh (Tam Ky). Tam Ky City is a developed tourism area with a mural village in Tam

Thanh commune, with paintings of high artistic quality on the walls.

Tam Ky City also has the advantage of being located between Da Nang City, the major economic centre of the Central region, and the service industry development area of Chu Lai and Dung Quat (Quang Ngai province). These districts are areas with geographical locations adjacent to the sea, so every year, there are often many typhoons, tropical depressions, and heavy rains. The provincial report noted an annual average of 8 to 10 storms from August to November each year, combined with heavy rains causing flooding.

For many years, CC has affected two famous beaches in Tam Ky City, including Ha Thanh and Tinh Thuy. These beaches have many tourists, leading to thriving tourism services such as hotels, restaurants, motels, small businesses, car parking, beach tables, and chair rentals. Since then, people have invested in and developed this home accommodation service. The Tam Thanh commune also has three traditional fishing source cooperatives: Tam Thanh, Ngoc Lan, and Cat Trang. In 2020, the Ngoc Lan cooperative had a 3-star One Commune One Product). CC also affected 295 business activities. Most activities are procuring aquatic products, grocery trading, food, cereals, and necessities [42].

Regarding livestock and cultivation, residents of Tam Tien commune also have small-scale livestock activities with 665 buffaloes, 780 cows, 1850 pigs, and 28200 poultry of all kinds. There are also eight nesting establishments in the commune. The total area of arable land annually is about 519.5 hectares, with main products such as rice, peanuts, and vegetables. Among the 200 households surveyed in the Tam Tien commune, the percentage of households with agricultural livelihoods accounted for 15.5%. The number of households with fishery-related livelihood sources accounts for 26.5%. The proportion of households with people working in trade and services accounts for 26%. This rate is close to the proportion of households with people working in the fisheries sector. Among the different types of livelihood, the proportion of households with people working in industrial parks and self-employed workers is very high, accounting for 47.5% and 40%. This figure aligns with the economic development trend in Quang Nam province in recent years, when many industrial parks have been operating. The most notable survey data is that the proportion of households owning boats and boats for fishing is still quite large (accounting for 16%). However, the proportion of households with working people hired by boat owners is small (1.5%).

The research findings highlight a trend of job transitions among former fishermen shifting to onshore employment in response to changes in the local economic structure, CC, workplace safety concerns, and wage considerations. Overall, the survey results reveal a common characteristic among households in the study areas: livelihood diversity. Within each household, members take on multiple jobs to sustain their livelihoods and support one another.

4.2. Context of CC in Quang Nam Province

Temperature statistics for many years at Tam Ky station show that within 20 years, from 1976 to 1996, the temperature decreased slightly, while in the following 20 years, from 1997 to 2018, the temperature at Tam Ky station increased sharply, an average increase of 0.883 °C/10 years. At Tam Ky Station, the average maximum temperature in the first period, 1979–1998, was 33.7 °C, while in 2009–2018, this temperature increased to 34.4 °C. In Quang Nam, the average temperature increase per decade is about 0.16 °C, higher than the yearly increase of about 0.10 °C nationwide and the global average value (0.12 °C/decade) [43]. The temperature in the latter period in Quang Nam is higher than in the previous period [43].

The impacts of CC can be seen in recent times when the sharp fluctuations of the maximum temperature, the minimum temperature, and the annual temperature range, the aquaculture area tends to decrease sharply from 6733 hectares in 2010 to 6,609 hectares in 2018. The shrimp farming area decreased sharply, specifically in 2017, compared to 2014, when it was 198 hectares. The area of fish farming has a similar situation; from 2010 to 2018, it decreased by 234 hectares. The area of farming other aquatic species tends to increase; from 2010 to 2016, it increased to 320 hectares, but by 2017 it had decreased to 538 hectares. The cause of this fluctuation is that shrimp and fish have limited adaptability and are prone to shock due to changes in temperature and salinity. Therefore, many households have transferred part of the area to other aquaculture. In addition, abnormal temperature increases and decreases are conditions for many diseases in farmed aquatic species [43].

Rainfall from 1976 to 1996 increased quite rapidly, reaching a level of 27.6 mm per year, while in the later period from 1997 to 2018, rainfall decreased by 17.9 mm per year. From 1976 to 2018, rainfall tended to increase [43].

The fluctuating rainfall causes the habitat and adaptability of farmed subjects to change suddenly, leading to shock and mass death, causing fish and shrimp production to fluctuate. From 2010 to 2018, shrimp and fish production increased, but the level increased unevenly over the years. From 2015 to 2016, shrimp production increased by 2833 tons, but from 2017 to 2018, it increased by 7599 tons. Fish production also increased, but the growth slowed down; from 2016 to 2017, it increased by 503 tons, but from 2017 to 2018, it only increased by 303 tons, less than the same period of 200 tons [43].

The sea level rose from before 2000 to 4.6 mm per year and after 2000 to 1.3 mm per year. The average sea

level rise trend in 2021–2025 is 105.09 cm, and the 2026 – 2030 may be up to 106.95 cm in RCP4.5 and RCP8.5 CC scenarios.

Typhoons have occurred in the past ten years, and rainstorms have been erratic. The number of typhoons recorded in the period 1970–2016 shows that, although the frequency of annual typhoons in Quang Nam decreased, the number of super typhoons with winds of 167 km/h or more has tended to increase in recent years with 4/8 storms from super typhoon level or higher from 2006–2016 and in the whole assessment period of 7/35 storms, accounting for 20% [43].

Data compiled by the research team also showed that in the past ten years, Quang Nam Province had 527 people killed, missing, or injured due to natural disasters. 101938 houses were damaged or collapsed. More than 50431 hectares of land for planting trees and aquaculture areas were seriously affected. The number of natural disasters, including typhoons, thunderstorms, cyclones, and high tides, was up to 194 times. In the past ten years, total material losses caused by weather are VND 4358 billion [44].

4.3. Sources of Household Capital

(1) Human Capital. According to the survey in Quang Nam province, female householders account for 18% of the total population. In households, there are an average of 4 demographics per household. The age of the householders at the survey sites is also relatively young, and all are in the working age group. In Quang Nam province, the rate is 75%. The representative health status of households was also quite good, with only 8.7% of householders reporting their health or illness. The education level of the surveyed household group showed that 52% of households had lower secondary education (grades 6–9), followed by upper secondary school (grades 10–12), accounting for 28.17% and 19% of households with primary education (grades 1–5).

The current primary employment survey reveals that 47% of household heads identify themselves as being hired. Hired jobs that do not require high expertise and freelance jobs; 45% of household heads have jobs that trade; 31% of householders work farming and fishing; 19% of household heads work in private manufacturing enterprises; 10% of household heads work in state agencies. However, in in-depth interviews, many heads of households said they had various jobs to earn extra income for their families. For example, in the above presentation on the context of household livelihoods, the livelihood diversity factor is the primary trend of households in the province studied.

(2) Social Capital. Of the 200 samples studied, 90.5% of households participated in or were members of ward and non-provincial associations. Generally, all households are very active in unions, strengthening family relationships. Local associations are legislative associations carried out through the state, such as peasants' associations, women's associations, youth unions, veterans' associations, and fatherland secret forces. Non-local associations are associations and groups based on customs, regulations, and operating principles loosely determined through interviewing people, such as religious associations, hometown councils, business associations, and fisheries associations.

In Quang Nam province, the majority of residents practice Buddhism. In addition, most people who fish at sea have distinct beliefs, such as worshipping whales.

Thus, the study results show that quite a few households are participating in oriental associations rather than non-local associations. The survey results on the social capital of households also show a social network of households in daily life and the ability to cope partially with negative phenomena and risks caused by weather.

(3) Natural capital. The section on livelihood characteristics of coastal families in the study area highlights that Quang Nam province residents enjoy convenient access to the abundant resources of the East Sea (Bien Dong). This proximity provides them access to ecosystems that are rich in biodiversity.

The proportion of households using tap water for eating and drinking in Quang Nam province is 20.5%, and the proportion of households using tap water for household activities is 16%. For natural sources (well water, rainwater) for household activities, this rate in Quang Nam province is 86%, and for feeding and drinking, it is 80%. The research team's survey shows many inhabitants have ponds, lakes, canals, and rivers. However, very few residents use these natural water sources for their family's living, eating, and drinking. The study also found that only 0.7% of households said they lacked drinking water in the past 12 months. However, up to 6.8% of households reported alum-contaminated and salinised water in Quang Nam province.

Of the natural sources of capital for coastal residents, land ownership and arable area in crop and aquaculture are the most important in livelihood activity. At the survey site in Quang Nam province, the average aquaculture household has an area of 3,200 m^2. The average household area of arable land is 540 m^2.

(4) Physical capital. Housing is considered the most essential facility for households, a haven when there are negative weather phenomena, such as typhoons, tornadoes, and heavy rain. At the survey sites in Quang Nam province, semi-permanent houses are the primary type. This rate is up to 88%. The percentage of households with rudimentary and temporary houses is 11%. Thus, it can be said that households first need to have a solid place to live in coastal areas to ensure sustainable livelihoods in the context of CC, “settle down to lose their jobs" or according to the policy of the Government of Vietnam, localities and people need to adhere to the motto "four in place" and "three readies." In

particular, solid houses are essential materials in place to be ready to respond to natural disasters caused by weather.

At the survey sites, motorbikes are the most important means of transportation for nearly any household, accounting for 87.7%. Other necessities of household life include televisions (87%) and smartphones (80.2%). The proportion of households with nearshore and offshore fishing vessels and boats was 12.5%.

(5) Financial resources. Statistics over the past ten years show that Quang Nam province has a high multidimensional poverty rate (9.1%) (General Statistics Office of Vietnam, 2011–2020) [45]. According to the survey sample, the proportion of households with per capita income in Group 1 (the lowest income) is 1.8 million per person per month. The per capita income in Group 5 (the group with the highest income) is 4.1 million per person per month, 2.27 times higher than in Group 1. Households in Quang Nam province have made great efforts to meet the criteria of escaping poverty according to national standards: rural area income is VND 1500000/person/month, and urban area is VND 2000000/person/month (Note: One US dollar is equal to VND 24000).

From the survey of financial capital in households in Quang Nam province, over the years, household incomes have increased significantly, the lives of many coastal residents have improved greatly, and the poverty rate has decreased considerably. The changing factors are mainly due to significant economic decisions in coastal areas by the Party and Government of Vietnam that have helped people have more stable jobs and high incomes. Coastal communities now have many employment options instead of simply sticking to the sea as before. The topic in the previous sections identifies the seaside community's diversity of livelihoods.

4.4. Livelihood Vulnerability Due to CC to Households in Quang Nam Province

Over the past decade, CC has severely affected coastal households in Quang Nam Province. The region has experienced the highest losses in terms of human lives (527), housing (101938), and the overall monetary value of damages (4358 billion VND) with 196 natural disasters over the last ten years (2010–2019, **Table 1**).

Table 1. Damage caused by CC in Quang Nam Province from 2010 to 2019.

CC Significantly Impacts	Quang Nam
Human injured, missing, or dead	527
Housing damage	101938
Damage to rice fields and fisheries (Ha)	50431
Number of natural disasters	194
Total value caused by natural disasters in VND billion	4358

Note: The author synthesised data from the Steering Committee for Natural Disaster Prevention and Control and Search and Rescue of Quang Nam Province from 2010 to 2020.

Survey results from 200 households in Quang Nam Province reveal that recent CC has significantly affected many families' livelihoods and well-being. Household perceptions further highlight this reality, with 80.7% citing noticeable temperature changes, such as increased sunshine and unusual heat. Household feedback and the provincial Department of Natural Resources and Environment report echo this concern. Additionally, 64.3% of households across surveyed provinces reported an increase in erratic rainfall compared to the past, leading to heightened shrimp diseases or crop damage during harvest seasons.

Based on the methodology of Hahn et al. (2009) and IPCC (2001) and integrated with the perspective of the five sources of capital of Chambers and Conway (1992), we carried out an extensive assessment of LV under the impact of CC of households in Quang Nam Province [13–15].

The research findings reveal that Quang Nam Province has a significantly high LVI, recorded at 0.371, based on the evaluation of various component indicators (**Table 2**).

Table 2. Component values of LV due to CC impacts in Quang Nam Province.

Component Values	Quang Nam
Household profile	0.356
Livelihood strategy	0.094
Social capital	0.305
Physical and natural capital	0.393
Healthcare	0.209
Access to food	0.458
Access to water	0.351
Natural disasters and CC	0.551
LVI	0.371

When analysing LV in more detail, natural disasters significantly influence the LVI index, scoring 0.551. This index aligns with the recent CC findings in Quang Nam Province [43]. Additionally, food accessibility poses a considerable challenge for the residents of Quang Nam amidst CC, with a value of 0.458. Consequently, the increasing frequency of severe weather events, such as storms, cyclones, floods, heavy rainfall, and droughts, has dramatically disrupted the livelihoods of coastal communities. Households relying solely on fishing or aquaculture are typically more vulnerable in the face of CC than those with various income sources (See more in **Figure 2**).

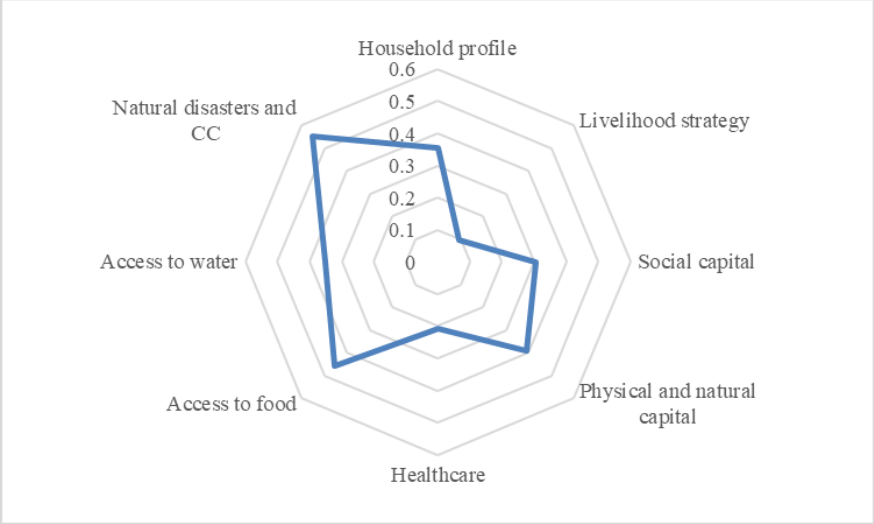

Figure 2. Components of the LVI in Quang Nam Province.

Table 3. Index of LVI-IPCC due to CC.

Values	Quang Nam
Adaptability	0.287
Sensitivity	0.326
Exposure	0.551
LVI-IPCC	0.086

The LVI-IPCC's approach also found that households' resilience to CC in Quang Nam Province is quite good, which is reflected in the adaptation value of households of 0.287. **Table 3** also shows a sensitivity value of 0.326. The highest value affecting the LVI-IPCC index is the Exposure value, with 0.551. The results show that the LVI-IPCC of households in Quang Nam province is very high, 0.086 (**Table 3**).

Figure 3 further shows each component's LVI-IPCC model for households in Quang Nam Province according to the LVI-IPCC method.

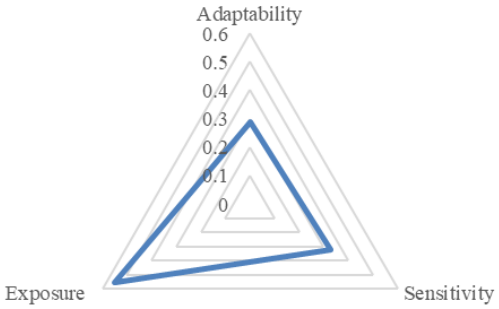

Figure 3. LVI-IPCC Due to CC.

Thus, CC in the past ten years has affected some capital sources of households in Quang Nam Province in very different directions:

Erratic weather patterns have significantly affected *human capital*, disrupting jobs for 58.3% of household members and leading to job losses for 22.5%. Additionally, changing weather conditions have increased the likelihood of illness among household members, with 7.3%

experiencing adverse effects on their health.

Regarding *social capital*, various channels, including government agencies, newspapers, radio, and television, inform nearly all households (91.7%) about upcoming adverse weather events. However, government support is generally limited, primarily focusing on poor and near-poor households (40%) regarding finance and food. At the same time, families and businesses urgently require local government assistance to secure bank loans, restart production, sustain business operations, and generate employment opportunities for local workers. The survey results reveal that approximately 61.50% of households and neighbours support one another in times of need, such as illness or home repairs (**Table 4**).

Table 4. Impacts of CC on household capital sources.

Capitals and CC	Variables	Percent (%)
Human capital	Work interruptions	51.40
	Job loss	59.30
	Diseases' effects on human health	18.20
	Families injured, missing, or dead	86.70
Social capital	Warnings from all levels of government	36
	Disaster support	40
	Households visiting neighbours when they are sick	48
	Households helping others repair houses	58
	Households helping each other at work	68.50
	Households receiving help from neighbours when sick	61.50
	Households receiving help from neighbours when repairing their houses	60.30
	Households lending money to neighbours when needed	13.90
	Households receiving help from neighbours when lending money	27.30
Natural capital	Erosion and landslides in the community	10.40
	Water sources for households used in food and daily life are contaminated with salinity	15
	Land subsidence	60.70
	Landslides in travel places	10.40
	Lack of domestic water	21.10
	Households' business land area reduced	28.60
	Lack of water to irrigate crops	34.80
	Forest land area reduced	36.40
Physical capital	Loss of business capital	28.60
	Damage to the house	68
	Change of residence	39.30
Financial capital	Diseases caused by farmed aquatic animals	35.10
	Loss of crops due to rain, storms, and floods	52.80
	Erratic sun and rain are causing shrimp to suffer from temperature shock	4.20
	More pests than ever before	51.20
	Crop yield reduced	54
	Sick and dead cattle and poultry	9.20
	Flooded and waterlogged crops	12.70
Natural disasters	High temperature, abnormally hot	40.50
	More storms	46.20
	Weighty rain	50.30
	Drought increasing	40.20
	More flooding	39.70
	Unusually high tides	49.50
	Lower temperature, colder	27.20
	More thunders	46.20

Regarding *natural capital*, 71.10% of households have reported experiencing problems related to bank erosion and landslides along rivers, canals, and coastlines. Many households also complained about losing their forest land due to CC (36.40%) (**Table 4**). In an interview with the leaders of the Tam Tien commune, Mr Le Xuan Uy argues that "*in Tam Tien commune, Quang Nam province, Typhoon No. 9 (Typhoon Molave, in 2020), has caused 1.5km of coastline to be eroded, completely breaking*". In Tam Thanh commune, Mr. Nguyen Thanh Binh, chairman of the commune, said that "*the natural area of the commune in 1998 was 630 hectares, now it is only 570 hectares, a decrease of 60 hectares due to heavy rainstorms, sea level rise, leading to coastal breakage*" [42]. Additionally, nearly 15% of households believe the water used for daily activities is salty [42].

Regarding *financial resources*, disruptions and losses in employment, as previously mentioned, have significantly

impacted household incomes. CC has also adversely affected fishery and aquaculture activities in many households, with unusual weather patterns leading to increased quantity (39.30%) (See **Table 4**).

Comparing the research results on households in Quang Nam province, Vietnam, and other regions worldwide, Quang Nam province has a reasonably high LVI. For example, the LVI results in Mabote and Moma Mozambique districts are 0.316 and 0.326, respectively [14]. Narayanpur and Bihpur districts, India, also have LVI of 0.34, respectively [20]. The same is true for the LVI-IPP index. Two Mozambique districts are –0.074 and 0.005, respectively. Two other relatively high regions are Narayanpur and Bihpur, India, which have only 0.07 and 0.06. In Vietnam, Tran et al. (2022) in the study at Can Tho City and Tra Vinh Province, Mekong Delta, showed that LVI was 0.338 and 0.406, and the LVI-IPCC was 0.012 and 0.039, respectively [46].

Consequently, the adverse effects of CC in coastal provinces have profoundly affected the livelihoods of many coastal communities. In Quang Nam Province, erratic rains and typhoons have disrupted nearshore fishing, shrimp farming, and rice crops.

5. Conclusion

Vietnam is significantly impacted by CC, posing numerous challenges, difficulties, and some advantages for the livelihoods of its coastal residents. Since implementing the Doi Moi policy in 1986, the Party and Government of Vietnam have significantly evolved their approach to addressing livelihoods and CC. Their focus has shifted from merely *responding*, *preventing*, and *building resilience* to now including *adaptation* to CC, demonstrating a strong commitment to ensuring no one is left behind.

The survey findings reveal that households in Quang Nam Province rely on a mix of livelihood activities, including farming, aquaculture, and nearshore and offshore fishing. Fishing remains a dominant livelihood in the studied areas, although most fishing activities are small-scale and nearshore. The number of households employing workers in the fishing industry has significantly declined. Many residents have shifted from sea-based occupations to pursue other jobs inland or in distant locations. Despite their coastal setting, farming and animal husbandry are still prevalent, though typically on a small scale.

Over the years, Vietnam's marine economic policies introduced by the Party and Government have facilitated families in transitioning to safer and more fitting careers. An increasing number of household members now work in factories and industrial zones. Research indicates that livelihood diversification has become a popular trend among families. Individuals often take on multiple jobs to support their lives and complement one another. Depending on weather changes, a single person might have various roles. However, over the past decade, CC has negatively affected Quang Nam Province, adversely affecting its communities' livelihoods.

The research results showed that the LVI of households was 0.371 and an LVI-IPCC of 0.086. CC has had very negative impacts on household livelihoods, with increasingly intense storms and storm surges causing erosion in coastal areas, significantly affecting the livelihoods of coastal communities, particularly families in fishing, aquaculture, and agriculture.

Policy Implications: The study results show a need for integrated policies focusing on some of the most important points of capital sources to help coastal households strengthen their capacity to respond to and adapt to CC and ensure sustainable livelihoods for people at the community level. Increase resilience at all levels to minimise the adverse effects of extreme weather and limit vulnerability. In particular, policies focus on knowledge and skills for fishermen and women to transform jobs, improve livelihood diversification, and enhance the resilience of coastal communities to CC. Policies also advance household financial loans after significant typhoons, strengthen dikes and fishing boat mooring areas, and actively plant coastal forests to avoid erosion.

Limitations: This study only focuses on the livelihood vulnerability of households in Quang Nam province, which mainly focuses on the vulnerability of capital sources; therefore, it is not comprehensive for the Central region and many other regions in Vietnam.

Author Contributions

Conceptualization, N. B. N.; methodology, N. B. N.; software, N. B. N.; validation, N. B. N.; formal analysis, N. B. N.; investigation, N. B. N. and H. L. T. T.; resources, N. B. N.; data curation, N. B. N.; writing—original draft preparation, N. B. N.; writing—review and editing, H. L. T. T.; visualization, N. B. N.; supervision, H. L. T. T.; project administration, H. L. T. T.; funding acquisition, H. L. T. T.. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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