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Evaluating the Impact of Climate Change on Sustainable Economic Development: Empirical Research in the Coastal Area of Kien Giang, Vietnam

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Abstract

Alongside the economic growth in various coastal regions, including Kien Giang, the area faces non-traditional security issues, most notably marine environmental pollution due to the impacts of climate change. This study surveyed 130 households in several coastal regions of Kien Giang. It employed a multivariate regression model to assess the implications and quantify climate change's effects on economic activities. The findings indicate that most factors harm the financial activities of households living in these coastal regions of Kien Giang. This paper underscores the significance of addressing the adverse impacts of climate change on local economies. It highlights the urgent need for comprehensive strategies to mitigate these effects, ensuring the sustainable development of coastal communities in Kien Giang.

Keywords: Climate Change, Saltwater Intrusion, Household Income, Kien Giang

INTRODUCTION

Coastal localities play an essential role and position in the country's socio-economic development. Coastal areas include many large cities with quite good infrastructure than inland areas. A critical economic region of the country is receiving substantial investment and growth; rich and diverse resources, an abundant labor source, and a convenient rail, waterway, and road transportation system... are favorable conditions for receiving domestic and foreign investment capital. So, the coastal regions have many advantages for rapid and dynamic economic development. Practice in many countries worldwide has affirmed the role of driving force in promoting the entire economic development of coastal areas.

Kien Giang, a coastal province in southern Vietnam, is grappling with significant challenges due to climate change. With a diverse landscape that includes plains, mangrove forests, and significant islands like Phu Quoc, Kien Giang is highly vulnerable to extreme weather events such as storms, flooding, and saltwater intrusion. The impacts of climate change not only threaten the natural environment but also pose severe risks to the economic development and livelihoods of the local population. Saltwater intrusion is one of the most evident effects of climate change in Kien Giang. As sea levels rise, saltwater penetrates further inland, contaminating freshwater sources and agricultural lands. This has severely affected rice fields and fruit orchards, directly impacting farm productivity and farmers' incomes.

Additionally, water temperature and salinity changes have negatively impacted the province's aquaculture industry, a critical economic sector. Climate change has also increased the frequency and intensity of storms and heavy rains, causing severe flooding. This disrupts production activities and transportation and inflicts significant damage on infrastructure and homes. Coastal areas and islands like Phu Quoc, which rely heavily on tourism, risk losing beaches and coastal ecosystems due to erosion and rising sea levels. To address these challenges, Kien Giang has implemented various measures to adapt to climate change, such as constructing barriers to prevent saltwater intrusion, promoting sustainable agriculture, and protecting mangrove forests. However, given the complexity of climate change, more significant investment is needed in research and the application of new technologies, along with close collaboration between government agencies, local communities, and international partners, to ensure the sustainable development of Kien Giang in the future.

Literature review

Climate change will cause far-reaching socio-economic consequences, affecting major economic sectors such as agriculture, energy, and healthcare and leading to changes in the supply and demand of goods and services of all sectors of the economy to varying degrees. Higher temperatures, rising sea levels, and other climate changes (changes in regional precipitation, water cycles, frequency and intensity of extreme weather events) will also impact aspects of life that are not primarily based on or related to economic activity, for example, human security, health and well-being, culture, human capabilities, and environmental quality (Carleton & Hsiang, 2016). On the other hand, the impacts of climate change are uniform across different territories with different natural and social conditions and adaptation conditions. IPCC (2014) indicates that poorer populations, especially in agricultural societies, are likely to suffer the most. In terms of sectors, agriculture and energy use are two areas with high levels of risk.

In the future, rising sea levels will cause significant losses in public infrastructure and private development, with substantial economic impacts on coastal countries worldwide. However, different coastal environments will face unique hazards due to differences in geology, topography, regional climate, and development patterns. The coast has a variety of landforms such as estuaries, beaches, dunes, low slopes, high cliffs, and steep mountains, and it also has development patterns from low to high density. Coastal areas with lower elevations will be more vulnerable to flooding due to the combined effects of waves, storm surges, storm surges, high tides, and future rising sea levels. On the contrary, areas with higher terrain, such as cliffs, bluffs, and coastal mountains, will risk coastal erosion due to solid wave attacks during high tides or when sea levels rise. Future rising sea levels will lead to two main scenarios: First, low-elevation coastal areas will face more frequent and more severe flooding, followed by permanent inundation and the disappearance of beaches and coastal wetlands. Second, in higher elevations such as cliffs, bluffs, and coastal dunes, waves will impact the base of these features more often, leading to increased erosion rates.

The economic impact of coastal hazards will vary depending on the area's level and type of development, including both public and private development. One of the significant challenges facing protected and highly developed coasts is passive erosion. Passive erosion occurs when beaches are gradually lost due to rising sea levels. In contrast, the beach behind is stabilized by artificial structures such as seawalls, rock revetments, or construction works. This phenomenon is especially worrying in armored coastal areas, where intense development has created tremendous pressure on the natural environment.

A good example is the southern California coast, one of the most developed regions with a length of about 325 km (233 miles). This is where millions of residents and tourists use the beaches every year, creating a significant source of income for the local economy. However, around 38% of this entire coastline is now armored, and with sea levels continuing to rise, the problem of passive erosion and loss of beaches will become increasingly severe. The disappearance of beaches affects recreational activities and tourism and threatens coastal infrastructure and assets (Phillips & Jones, 2006). Coastal protection measures such as the construction of seawalls and rock revetments, although they can temporarily reduce the impact of waves and erosion, lead to the gradual shrinking of beaches, reducing the area's natural sand beach (Defeo et al., 2009). This affects the landscape and coastal ecosystem and causes economic damage as beaches, which are valuable assets, are gradually wiped out. With sea levels expected to continue to rise, highly developed coastal areas such as southern California will face increasingly more significant challenges in protecting their coastlines and sustaining development. The balance between protecting infrastructure, maintaining beaches, and ensuring economic growth will become a complex problem for managers and policymakers in the context of increasing climate change (Griggs, 2005).

Climate change and rising sea levels continue to be pressing issues on the environmental policy agenda, both nationally and globally. However, one of the biggest challenges in assessing the impacts of climate change and sea level rise is the ability to synthesize and simplify complex data (Alves et al., 2020). In particular, moving from complex models of the individual effects to a set of indicators that are easy to understand and can be tailored to each region and industry is essential for informed policy decisions. Currently, many assessment models use physical measures such as the number of people affected, the change in total crop growth, or the number of natural systems changing. These metrics allow researchers and policymakers to specifically and directly assess the impacts that climate change has on natural systems (Pettorelli et al., 2021). For example, the number of people affected can help estimate social impacts, while changes in crop growth provide essential information about food security. However, these assessment methods are mainly developed and widely applied in developed countries with adequate research systems and data.

Meanwhile, developing countries, which lack resources and technology, have only recently begun to access and deploy similar assessment methods. This creates a significant gap in the ability to assess and respond to climate change between developed and developing countries. Bridging this gap requires international cooperation, in which developed countries can support developing countries in building appropriate data systems and assessment models. In this way, the international community can come together to develop more effective solutions to the challenges that climate change and sea level rise bring while ensuring that all countries can protect the environment and maintain sustainable development in the future (Hoegh-Guldberg & Bruno, 2010).

Kien Giang is one of the cities most threatened by climate change, in which saltwater intrusion significantly affects agricultural production. Due to climate change's effects, drought and saltwater intrusion in Kien Giang have become complicated and tend to increase in both level and intensity. Climate change has a severe impact on production, life, and the environment, which is an existential threat to the goal of hunger eradication and poverty reduction, the implementation of the millennium goals, and the sustainable development of the country. Combined with industrialization activities, climate change strongly affects people's economic activities. This study surveys and evaluates the effects of climate change and industrialization on the financial activities of households in Kien Giang to provide implications for reducing economic losses. Economic benefits for families under the influence of climate change and industrialization.

METHODS

The study used a questionnaire survey method for households living in coastal areas of Kien Giang. The questionnaire is designed in two parts, including basic information about the household head and questions for the Linkert scale with factors related to industrialization and climate change. In part two, questions are scored from 1-5, with levels of 1 being strongly disagreed and five being strongly agree. The study uses the OLS regression model to evaluate each factor's impact on households' economic activities in the coastal areas of Kien Giang. The authors distributed 130 ballots and collected 120 cleaned ballots to conduct the research.

The hypothesis: Climate change damages land and household assets

Climate change damages household economies through 02 main channels: (01) Damage to family's farmland and residential land; (02) Damage to household assets (houses, machinery, tools for agricultural production, farming and fishing, etc.).

The research model includes the following factors:

$A6 = C + \beta1*A1 + \beta12*A2 + \beta13*A3 + \beta14*A4 + \beta15*A5$

Which includes:

A6: variable representing climate change that damages household land and assets.

A1: The independent variable represents precipitation

A2: The independent variable represents the temperature

A3: The independent variable represents salinity intrusion

A4: The independent variable represents sea level rise

A5: The independent variable represents storms and floods

RESULTS

Basic statistical results

Primary statistical results on the demographic characteristics of the surveyed target group are shown in Table 1 below. In the 120 survey samples, the number of men reached 52.1%, and women accounted for 47.9% of the individuals surveyed. Regarding the highest level of education that the survey subjects have graduated, the highest proportion is 39.5% for individuals who have graduated from high school. The remaining number is evenly distributed, with 21.8% % graduating from university and 9.3% of respondents graduating from high school/college. The number of people with income from 5 million VND/month to 10 million VND/month accounts for the highest proportion with 47.9%. Ranked second is the number of people with income from 1 million VND/month to 5 million VND. /month with 35.3%. The interviewees were spread evenly between 18 and 71 years old, and the average age of the survey sample was 43.5 years old.

Table 1: Basic statistical results

Variable		proportion (%)
Sex	Male	52.1
	Female	47.9
Education level	Below high school	19.3
	High school	39.5
	Intermediate/College level	19.3
	University	21.8
Average monthly income	Under 1,000,000	3.4
	From over 1,000,000 to 5,000,000	35.3
	From over 5,000,000 to 10,000,000	47.9
	From over 10,000,000 to 15,000,000	10.9
	From over 15,000,000 to 20,000,000	1.7
	Over 20,000,000	0.8

Source: Calculation results of the authors from survey data

Regarding statistical results related to employment and income under the impact of climate change, 47.7% of respondents had to change due to the effects of climate change. Climate change reduces income for 56.6% of respondents, 30% assess that climate change has no impact on income, and 8.3% of respondents have increased revenue due to impacts. Impacts of climate change: 4.1% of respondents had a significant decrease in income due to these impacts.

Model results

Check the reliability of the scale.

Cronbach's alpha coefficients of the scales in Table 2 show that the reliability coefficients are all satisfactory. Cronbach's alpha coefficient was used to eliminate trash variables. Variables with a correlation of less than 0.3 will be eliminated, and the selected scale must have an alpha reliability of 0.60 or higher. After that, variables with factor loadings less than 0.50 in EFA will continue to be eliminated. Therefore, all scales meet reliability requirements (0.6<0.95) and are accepted for inclusion in exploratory factor analysis (EFA) to test convergent validity. The results of scale reliability analysis show that Cronbach's alpha reliability coefficient of all variables in the model is in the range from 0.6 to 0.8, so it is concluded that there are no junk variables in the model. After checking the scale's reliability, the study conducted exploratory factor analysis. The principal component method chosen for factor analysis with Promax rotation is the extraction method.

Table 2. Cronbach's alpha coefficient of observed variables

Code	Variable name	Cronbach's Alpha
A1	Rainfall	0.864
A2	Temperature	0.624
A3	Saline intrusion situation	0.868
A4	Sea level rise	0.905
A5	Storms and floods	0.837
A6	Climate change harms household economies	0.750

Source: Calculation results of the authors from survey data

KMO coefficient and sig coefficient

Exploratory factor analysis for the independent variables shows that the p-value = 0.000 of the Bartlett test allows us to reject hypothesis H0 safely (H0: factor analysis does not fit the data). KMO index = 0.584 shows a high model fit (Table 3).

Table 3: KMO coefficient and Bartlett's Test for factors

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.584
Bartlett's Test of Sphericity	Approx. Chi-Square	3635.638
	df	991
	Sig.	0.000

Source: Calculation results of the authors from survey data

Table 4: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.421	24.436	24.436	3.421	24.436	24.436	3.301	23.582	23.582
2	1.754	12.531	36.968	1.754	12.531	36.968	1.725	12.321	35.904
3	1.580	11.288	48.256	1.580	11.288	48.256	1.515	10.821	46.724
4	1.412	10.089	58.344	1.412	10.089	58.344	1.476	10.544	57.268
5	1.149	8.205	66.549	1.149	8.205	66.549	1.299	9.280	66.549
6	.944	6.744	73.293						
7	.810	5.782	79.075						
8	.688	4.915	83.990						
9	.623	4.451	88.441						
10	.517	3.693	92.135						
11	.439	3.137	95.271						
12	.316	2.258	97.529						
13	.252	1.802	99.331						
14	.094	.669	100.000						
Extraction Method: Principal Component Analysis.									

Source: Calculation results of the authors from survey data

The factor analysis results showed that the variables were extracted into four groups, with the total variance extracted = 66.54% > 50%, and the scale was accepted (Table 4).

Regression model results

The study uses econometric regression results to identify factor variables that are statistically significant in explaining changes in willingness to pay at the α=5% significance level. The hypothesis to test the significance of the variable is given as follows:

$$\begin{cases} H0: \beta = 0, variable\ is\ not\ statistically\ significant \\ H1: \beta \neq 0, statistically\ significant\ variable \end{cases}$$

If P-value< α: refuse H_0, statistically significant variable

If P-value> α: accept H_0, the variable is not statistically significant.

The regression model produces Sig results. F = 0.000, which means that hypothesis H1 is statistically significant: climate change will damage household land and assets. The model has an R coefficient of 0.577, equivalent to the model being important at the 57.7% level, which is within the acceptable level of an OLS regression model.

Table 5: Model summary[b]

Model	R	R Square	Adjusted R Square	Std.Erro of the Estimate	Durbin-Watson
1	.577[a]	.333	.303	.46263	1.894

a. Independent variable: A5TB, A3TB, A1TB, A4TB, A2TB

b. Dependent variable: A612TB

Source: Calculation results of the authors from survey data

Assuming that climate change negatively impacts household economies, the results from equation (3) indicate that statistically significant climate change factors positively affect household production activities. Among the independent variables in the model, two statistically significant factors are A3 – Saltwater Intrusion and A5 – Storms and Flooding, with P-values of 0.00 and 0.005, respectively. The coefficient for A3 is 0.359, indicating that for every 1-point increase in the impact of saltwater intrusion, household land and assets suffer an additional 0.359 points of damage. Similarly, the coefficient for A5 is 0.366, meaning that for every 1-point increase in the impact of storms and flooding, household land and assets experience an additional 0.366 points of impact on a scale of 5 (Table 6).

These results highlight the significant negative influence climate-related factors, particularly saltwater intrusion and extreme weather events, have on household property and assets, emphasizing the need for targeted measures to mitigate these impacts.

CONCLUSION

In Kien Giang, the two most significant negative impacts of climate change on household assets and land are saltwater intrusion and storms or flooding in the surveyed areas. Regarding saltwater intrusion, the surveyed areas are scattered along coastal regions, where the scale, severity, and frequency of saltwater intrusion have heavily impacted these regions, particularly in agricultural production. Although major storms or floods are less frequently recorded in Kien Giang, rapid urbanization has increased urban flooding following heavy rains, making these two impacts more evident to the local population. These effects have also negatively influenced household incomes, with nearly half of the respondents reporting a need to change their agricultural practices or shift from agriculture to industrial services due to the impacts of climate change. Most residents believe climate change has reduced their income, not only because they can no longer farm as they used to but also due to the damage to their assets and land.

Based on the viewpoints of the 12th National Congress and the 10-year review of the implementation of Central Resolution 4 of the 10th Central Committee on Vietnam's Marine Strategy to 2020, the 8th Plenary Session of the 12th Central Committee (October 2018) adopted the "Strategy for Sustainable Development of Vietnam's Marine Economy to 2030, with a Vision to 2045." This strategy emphasizes that "Vietnam must become a strong maritime nation, thriving from the sea, developing sustainably, prosperously, securely, and safely; sustainable marine economic development must be closely linked with ensuring national defense and security."

A significant new focus of the 8th Central Committee's session on the marine strategy is the goal of sustainable marine economic development. This is particularly important for the national economy, contributing to the nation's strength in the long-term and immediate struggle to protect sovereignty over its seas and islands.

As a coastal city, Kien Giang has a relatively strong marine economy. According to data from the General Statistics Office, the scale of Kien Giang's marine economy accounts for 2.49% of the overall economy. This underscores the city's significant role in contributing to the national marine economy and its potential for further development in line with Vietnam's broader strategic goals. To mitigate the impacts of climate change, it is crucial to raise awareness about marine environments and implement institutional and policy solutions to develop the coastal economy in seaside cities. In facing these challenges, Kien Giang needs a sustainable development strategy focused on enhancing its resilience to climate change. Key measures include investing in green infrastructure, improving disaster risk management and forecasting systems, and implementing efforts to protect and restore coastal ecosystems. These actions are essential for the city to overcome the adverse effects of climate change. By integrating economic development with environmental protection, Kien Giang can maintain its position as one of the leading financial centers in northern

Vietnam while ensuring future sustainable growth. Balancing economic progress with ecological conservation will help the city address current climate challenges and secure its long-term prosperity and stability.

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