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Studying the Level of Livelihood Vulnerability and the Necessity of the Work Developing a Farmhouse Economic Model to Adapt to Climate Change in the Coastal Area of Ben Tre

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Abstract

Climate change has been causing multifaceted impacts on the natural environment, biodiversity, and the livelihoods and lives of people in coastal areas. Vietnam is a maritime country considered one of the five countries most severely affected by climate change. Among geographical regions, the Mekong Delta (MRD), especially coastal areas, is the most sensitive and vulnerable to the impacts of climate change, directly from sea level rise., saltwater intrusion, changes in hydrological properties in estuaries, and changes in the nature of monsoons and tropical storms... The impact of climate change in recent years has been shown quite clearly in the coastal areas of Ben Tre province. Saltwater intrusion, drought, scarcity of fresh water, flooding due to high tides, and rising sea levels have seriously affected the livelihoods of poor communities living in lowland and coastal areas. This article presents the results of research on the level of livelihood vulnerability and the necessity of choosing appropriate ecological economic models for people in coastal communes of Ben Tre province under the impact of climate change.

Keywords: Climate change, people's livelihoods, vulnerability, ecological economy.

1. Ask a problem

Climate change has been causing multifaceted impacts on the natural environment, biodiversity, and human livelihoods and lives. Vietnam is considered one of the five countries most severely affected by climate change. Among geographical regions, the Mekong Delta (MRD), especially coastal areas, is the most sensitive and vulnerable to the impacts of climate change, most directly on sea level rise, saltwater intrusion, changes in hydrological properties in estuaries, and changes in the nature of monsoons and tropical storms (IPCC, 2017; MONRE et al., 2018). Ben Tre is considered one of the provinces most heavily affected when sea levels rise by 1m by 2100 (Jeremy, 2018).

In recent years, the impact of climate change has been clearly shown in the coastal districts of the province. The situation of saltwater intrusion into the inland fields is becoming more and more complicated, with longer droughts, scarcity of fresh water, flooding due to high tides, and rising sea levels, which have seriously affected the economic development of local social economy, especially the livelihood activities of poor communities living in lowland and coastal areas.

This article presents the results of assessing the level of livelihood vulnerability and the necessity of choosing appropriate ecological economic models for people in three coastal communes: An Thuy (Ba Tri), Thua Duc (Binh Dai), and Thanh Hai (Thanh Phu) in Ben Tre province (Vietnam) under the impact of climate change using a community-based approach.

2. Research area and methods

2.1. Overview of the research area

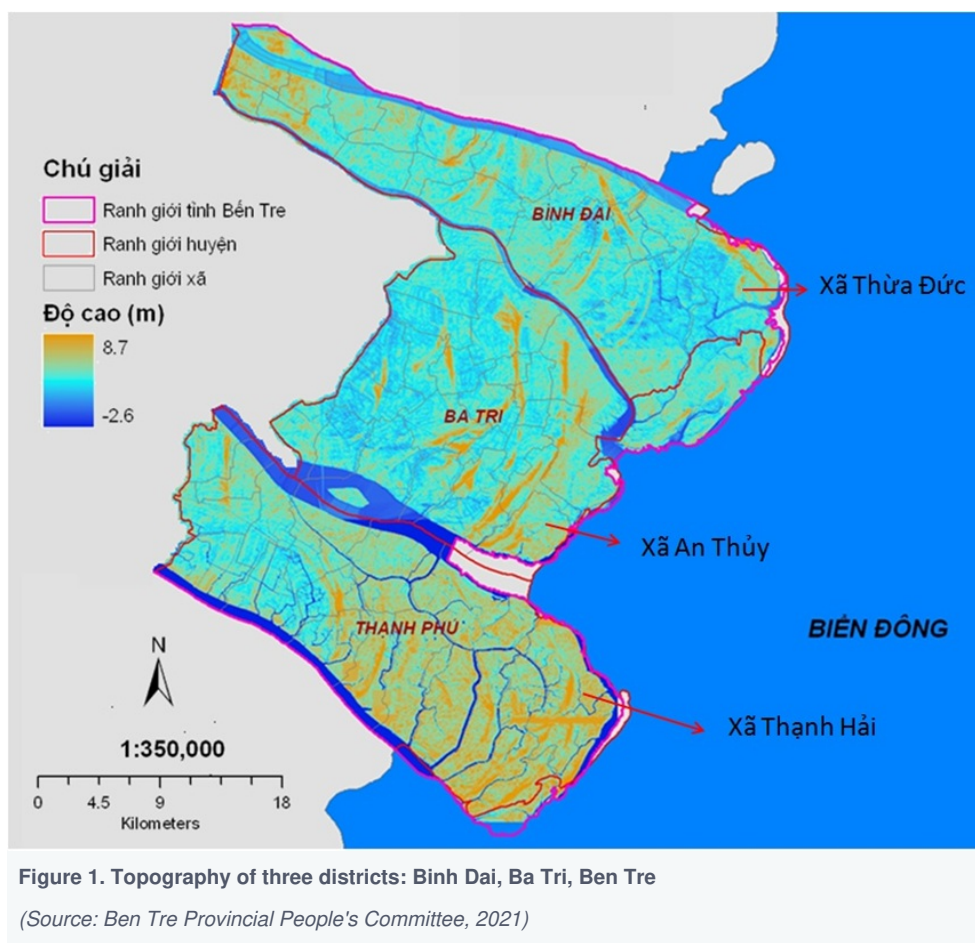
The coastal region of Ben Tre province has three districts, including: Ba Tri, Binh Dai, and Thanh Phu, with 03 Towns and 59 communes with a total natural area of 1,203.5 km². The total population is 447,812 people. As a result of the actual survey, the research team selected 03 typical communes from 03 districts, including:

Thanh Hai commune (Thanh Phu) has 8,196 people and 2,183 households. The natural area is 6,425 hectares, with 6,021 hectares of agricultural land, of which about 900 hectares are mangrove forests, 177 hectares are clam farming areas, and large alluvial areas along the coast.

An Thuy commune (Ba Tri) has 16,891 people with 3,405 households, a natural area of 3,063 hectares, of which over 80 hectares are crop land, about 590.5 hectares are shrimp and clam farming areas. About 43% of the population in the commune specializes in fishing and aquaculture, and about 37% of households grow crops.

Thua Duc commune (Binh Dai) has 8,408 people and a natural area of 6,045 hectares with 3,400 hectares of agricultural

land. Of which, there are more than 1,657 hectares of aquaculture land _about 850 hectares of clam and blood cockle farming, 221.1 hectares of crop land where people grow crops such as watermelon, cassava, peanuts..., about 56%. People live by fishing and aquaculture, and 33% of farming households grow crops.



2.2. Research Methods

This study uses a community-based approach to examine community livelihood vulnerability in the context of climate change. A community-based approach to analyzing the effects of climate change on people's livelihoods, especially farmer economic models, is employed. In the scope of this article, livelihood vulnerability is considered as the vulnerability or ability to cope when affected by extreme weather and climate events that disrupt lives and livelihoods of farming households. At the same time, we propose to choose a more suitable ecological economic model to adapt in the context of climate change.

Through a questionnaire survey of 80 households and group discussions about the seasonal calendar and extreme weather events occurring in the area, the level of vulnerability for each type of livelihood will be built based on people's feedback. From there, the research team proposed choosing a suitable ecological economic model for the people.

3. Research results and discussion

3.1. Seasonal calendar

People's lives in An Thuy, Thua Duc, and Thanh Hai mainly rely on agricultural production: growing crops on sandy land; shrimp and crab farming in mangrove forests; raising clams and blood cockles in tidal areas (mud flats, sand dunes); and fishing in estuary areas. In particular, growing crops, fishing, and raising aquaculture products are the main livelihoods of farmers here, while raising cattle and poultry on a small household scale is also common.

The main crops in the three surveyed communes are watermelon, cassava, and peanuts. Watermelon is usually grown in two seasons, from January to March and from September to November. Peanuts are usually grown from April to August; people often plant beans in rotation with other crops to increase fertility. Much for the land. Cassava is usually planted from April to August or from December to April of the following year. Normally, each crop is spaced 2 weeks to 1 month apart to allow the soil to rest (Table 3.1).

Table 3.1. Crop calendar in 3 research communes													
Some main livelihoods		1	2	3	4	5	6	7	8	9	10	11	12
Plant color	Watermelon	X	X	X						X	X	X	
	Peanut				X	X	X	X					
	Cassava	X	X	X	X	X	X	X	X				X
Raising livestock and poultry	Raising pigs	X	X	X	X	X	X	X	X	X	X	X	X
	Raising cows	X	X	X	X	X	X	X	X	X	X	X	X
	Raising chickens	X	X	X	X	X	X	X	X	X	X	X	X
Aquaculture	White leg shrimp			X	X	X	X	X					
	Extensive black tiger shrimp soup				X	X	X	X	X				
	Intensive black tiger shrimp farming	X	X	X	X	X	X						
	Crab farming	X	X	X	X	X	X	X	X			X	X
	Raising crabs in rotation in shrimp ponds					X	X	X	X	X	X		
	Raising blood cockles	X	X	X	X	X	X	X	X	X	X	X	X
	Clam exploitation				X	X	X	X	X				
Fishing		X	X	X	X	X	X	X	X	X	X	X	X

(Source: Results of in-depth interviews with farming households in 2021)

The main aquatic products in the 3 research communes are black tiger shrimp (with improved extensive farming models, intensive - semi-intensive farming, and shrimp mixed with forests), white-legged shrimp, and clams. Whiteleg shrimp stocking time is from March, and harvesting is in July every year. Intensive and semi-intensive black tiger shrimp are stocked from January and harvested in June, while improved extensive black tiger shrimp are stocked in April and harvested in August every year. Clam seeds are stocked from April to July. Clam seed exploitation time begins in August

every year. Commercial clam farming occurs from September to March of the following year. Blood cockles are widely raised in Thanh Hai and Thua Duc communes. People usually stock cockles in May and harvest them in April of the following year. In addition, crabs are also experimentally raised in the three research communes. Although the number of households raising crabs is not many, many households evaluate it as quite effective. Crabs are raised almost all year round; seeding begins in November, and harvesting is in August of the following year. For crabs rotated in shrimp ponds, the stocking time is from May, and the harvesting is in October every year.

From the summary results of Table 3.1, it shows that the seasonal calendar for each type of livelihood (crop growing, animal husbandry, fishing, and aquaculture) between communes has no difference. The big difference here is that people often have the flexibility to plant crops a few days earlier or later than the seasonal schedule depending on the soil conditions, ecological characteristics of each area, and the production experience of each household, family, and the impacts of annual weather and climate factors, specifically extreme weather events.

3.2. Extreme weather phenomena

The dry season starts from November to April of the following year. During this time, long heat waves often occur from January to April, in which March and April are the months with very high temperatures during the day, and drought and saltwater intrusion peaked, seriously affecting the production activities of people in the region.

Table 3.2. Extreme weather phenomena often appear in the three study communes

Performance event	1	2	3	4	5	6	7	8	9	10	11	12
Dry season	X	X	X	X							X	X
Drought			X	X								
Unseasonal rain	X			X								
Rainy season					X	X	X	X	X	X		
She's limited								X				
Low pressure, storm								X	X	X	X	X
tides	X								X	X	X	X
Landslide								X	X	X	X	X
Tornado								X	X	X	X	

(Source: Results of in-depth interviews with farming households in 2021)

In addition to the long drought during the dry season, the locality also suffers from severe drought. This is a drought that occurs during the rainy season, usually occurring in August every year, when the Southeast monsoon encroaches and repels the West wind carrying moisture, causing continuous droughts, each lasting from 5 to 7 days, sometimes up to 15 days. Droughts can cause river water to dry up, causing a shortage of irrigation water and reducing crop productivity.

However, because drought occurs in the rainy season, this is also a favorable time for people in the commune to harvest crops and prepare the land for the next crop.

Unseasonal rain usually occurs in January or April every year. This is the time when cashew crops are still quite immature or about to be harvested, causing a significant impact on the production activities of crop-growing households. For aquaculture households, it also causes significant losses because the hot weather and off-season rain cause sudden changes in water concentration, making shrimp, clams, and oysters susceptible to shock and death.

The rainy season usually starts from May to October. During this period, tropical depressions and storms often appear in August, September, October, and November, causing heavy rain. High tides occur from September to January of the following year, causing local flooding in some places. Landslides occur frequently, especially in estuaries and coastal areas from August to December every year. Tornadoes occur between August and November every year. All of these extreme weather phenomena combined with strong annual winds cause serious damage to the production activities and daily life of the community here.

3.3. *Extent of damage to livelihoods*

The results of a survey of 80 households in 3 communes of Thua Duc, An Thuy, and Thanh Hai show that the level of vulnerability of all types of livelihoods to the impact of extreme weather and climate factors makes the situation more invasive. Salinity and flooding in the area are becoming more serious, causing difficulties for people's livelihoods (Table 3.3).

Table 3.3. Level of vulnerability of livelihoods in the study area				
Event	Level of damage			
	Salty		Salty, flooded	
	crops	aquaculture	crops	aquaculture
Livestock and plants die	1	3	3	1
Reduce crop and livestock productivity	3	3	3	1
Change the growing season	1	2	1	2
Change livestock and crop breeds	1	2	1	2
Lack of water for living and production	3	1	3	1
The area of cultivated land is shrinking	1	0	3	0
Total	10	11	14	7

(Source: Results of interviews with 80 farming households in 2021)

Results Table 3.3. shows that the livelihood of growing crops is most vulnerable to changes in weather and climate factors. In the dry season, the land is arid, underground water sources for daily life and irrigation are depleted, seriously

affecting the livelihoods and lives of crop-growing households. Some households growing crops reported that due to the hot weather and many frosts, some areas growing crops, due to the lack of water, had leaves yellowing and dying. Where they still survive, fruit and tuber yields are significantly reduced. The difficult problem for crop-growing households here is the serious lack of water for irrigation. Unseasonal rains often alleviate the situation of dry and burning fields, but many families are also worried when heavy rains destroy crops.

According to people, melons, cassava, and peanuts tolerate drought quite well but are poorly tolerant of waterlogging, so crops in the rainy season often yield less than in the dry season. In addition, during the rainy season, combined with high tides and tornadoes, trees are crushed, flooded, and die. Not to mention the situation of pests and diseases that multiply and develop very quickly, causing harm and reducing productivity and product quality. In addition, winds, tornadoes, and high tides have caused many areas of sandy coastal land and river mouths to erode, causing people's cropland area to shrink. In addition, when flooding lasts for a long time, the soil becomes saline, affecting the next year's planting season. Many gardens had to be abandoned or converted to shrimp farming.

For aquaculture households, although the level of injury is somewhat lighter than that of cash crop households, the level of loss is not small. According to survey results of aquaculture households, before 2006, aquaculture activities in the study area were very favorable. However, from 2006 until now, crops have often failed completely. The reason, according to people, is due to erratic changes in weather and climate, making saltwater intrusion and flooding more frequent.

During the dry season, shrimp, blood cockles, and clams in cooperatives in the three research communes died en masse. Due to erratic weather and climate changes, prolonged heat, and sudden temperature changes between day and night, shrimp, clams, and cockles get shocked and die. Some households believe that because the farming density is too high, it leads to the death of shrimp, clams, and oysters. In addition, according to the opinion of clam farmers, water pollution from shrimp pond cleaning activities discharged directly into rivers, canals, and industrial parks also contributes to the deterioration of the living environment of clams and clams, leading to disturbance, shock, and death. Shrimp farming households also admit that due to the lack of infrastructure to serve ponds, most people do not use settling ponds but use water directly from the river. Polluted river water makes shrimp susceptible to disease and die. Some households also believe that white spot and red body shrimp diseases cause mass deaths partly due to the quality of the seed of unknown origin. Most farmers have to buy seeds floating on the market that have not passed quarantine. During the rainy season, strong winds combined with high tides flood the embankments, breaking the shrimp shells and losing everything. Not to mention when storms and tropical depressions disrupt the habitat of shrimp, clams, and oysters, causing serious damage.

As for households that catch seafood, the impact of climate change on their livelihoods is not significant compared to households that grow crops and raise aquaculture products. This profession only stops working when there are storms, tropical depressions, rain, strong winds, and tornadoes. Usually, they go to work all the time.

According to farmer households, in addition to the impacts of changes in weather and climate, the impact of unnatural factors also has a significant impact on the livelihoods of local people (Table 3.4).

Table 3.4. Impact of unnatural factors on community livelihoods

Unnatural elements	Plant color (36 households)	Aquaculture (42 households)	Fishing (6 households)
Lack of production capital	22 61.1%	30 71.4%	4 (66.7%)
Lack of new breeds and pets	14 38.9%	8 19.1%	-
Lack of access to science and technology	21 58.3%	27 64.3%	-
Lack of cooperation between early rows	-	5 11.9%	-
Mangrove forests are destroyed	7 19.4%	5 11.9%	4 (66.7%)
Lack of coordination between government and people	4 11.1%	10 23.8%	-

(Source: Results of interviews with 80 farming households in 2021)

Currently, the problem of climate change is reducing crop productivity, and livestock diseases are becoming complicated, causing heavy losses to farming households. The results of Table 3.4 show that capital and access to science and technology are two issues that people are concerned about and in need of, and they need help from local authorities. Because the general educational level of farming households here is low, their ability to access science and technology is very limited. Besides, most poor households do not have much capital to reinvest in production when crops fail. Most households have to borrow money. When the harvest is good, almost every household wins, but agricultural product prices drop, and the already difficult livelihoods of farming households become even more stagnant when market prices are unstable and prices are forced by traders. In addition, the destruction of mangrove forests is also the cause of saltwater and seawater easily entering fields, causing crop damage. When storms occur, thin forests cannot provide cover, causing landslides, land loss, and severe crop damage.

Due to harsh weather, constant drought, and salinity, crops fail. Finding plant varieties with high salt tolerance is the dream of local growers. For aquaculture households, they are counting on departments and scientists to find out the cause of the mass deaths of shrimp, clams, and oysters.

As for fishing households, they believe that the destruction of mangrove forests to build shrimp farms is the cause of erratic weather changes, polluted water sources, and depleted aquatic resources, affecting their fishing activities. Previously, the mangrove forests here were very thick. In recent years, the forests have been cut down indiscriminately, causing fish and shrimp to lose their place of residence.

3.5. General perception

Through the survey results of 80 farming households in the three communes of Thua Duc, An Thuy, and Thanh Hai, it

shows that the seasonal calendar is always flexibly changed by local people according to their own experience. However, due to erratic changes in weather and climate combined with extreme weather phenomena, it has seriously affected people's livelihoods. In particular, the livelihood of growing crops is considered to be the profession most severely damaged by erratic changes in weather and climate. People who grow crops not only suffer from crop failures but also lose arable land due to river and coastal landslides. Land that is heavily saline cannot be cultivated and must be abandoned or converted to shrimp farming.

Aquaculture is a livelihood that is assessed to have a high level of vulnerability after growing crops, and erratic weather changes cause mass deaths of shrimp, clams, and shellfish, causing headaches for people. Besides weather changes, the polluted water environment is believed by many farmers to be the main cause of mass shrimp deaths. These damages have lasted for many years, making the lives of households involved in clam and oyster farming difficult. Many households have lost production capital, are in debt, and their livelihoods are gradually coming to a standstill.

4. Main farming household livelihood models

The main livelihood models in a year are household production and business models where people spend the most time in a year to generate income.

Some main livelihoods		total income	Spend	Save	Income per hectare	Evaluate
Plant color	Watermelon/Peanuts/Cassava	65,478	51,387	14,091	26,290	T
Raising livestock and poultry	Raising pigs/chickens and ducks	439,267	397,600	41,667	7,409	K
Livestock + crops		140,667	94,333	46,333	17,409	T
Aquaculture	White leg shrimp	721,659	492,235	229,424	106,675	TB
	Extensive black tiger shrimp soup	66,786	46,879	19,907	5,901	TB
	Shrimp, crab + forest farming	139,737	101,1139	38,598	19,017	T
	Aquaculture + salt making	25,900	22,125	3,775	13,169	K
	Raising blood cockles/clams	116,659	84,214	32,286	56,971	TB
Fishing near shore		298,645	235,267	63,348		TB
Offshore fishing		3,282,000	1,958,000	1,324,000		TB

(Ranking rating according to 5 criteria: 1. Urgency, 2. Stability, 3. Integration, 4. Feasibility (cost), 5. Sustainability; In which: T: Good; K: good, TB: average)

Based on the criteria, use data to collect information on income and expenditure from livelihood models over the past year. Through analysis based on household net income value and combined with environmental sustainable development criteria such as high adaptation to climate change in coastal areas, evaluate the sustainability and effectiveness of the models.

* Shrimp/crab intercropping forest model: Planting forests combined with intercropping shrimp/crab farming is a quite good model, bringing stable income, low risk, and environmental friendliness. This model supports sustainable aquaculture development by combining aquaculture with afforestation. In the context of increasingly polluted water resources causing aquaculture to face many disadvantages, sustainable and environmentally friendly aquaculture is a goal that needs to be developed and aimed for in the future. In addition to aquatic species raised in ponds, tiger shrimp and crabs are also released into the natural environment around people's aquaculture areas. Planted and protected mangrove forests contribute to preventing landslides, regulating the climate, protecting the environment for a large area, and are also the habitat for the development of aquatic species.

* Model of growing crops on sand dune land: Year-round, this model brings stable income, and the lack of fresh water and saltwater intrusion is no longer a concern for people. Because highland areas are less affected, choosing good crop varieties will bring high efficiency. The crop rotation model in agricultural cultivation should be encouraged to be replicated because of the superiority of this model in improving soil and avoiding the spread of diseases on crops, especially for the livelihood of children in coastal communes of the province.

For example, planting melons covered with tarpaulin helps save irrigation water; on the other hand, it limits weeds, prevents soil erosion, and helps prevent pests. The model of growing watermelons covered with tarpaulin is favored by farmers because of its economic efficiency and suitability for the local land.

* Livestock and crop farming model: This is a method to diversify livelihoods and increase income for coastal people by taking advantage of the existing facilities in each family and applying new production methods such as improved production techniques. The goal is to create a mixed garden, including a special garden (growing coconuts), interspersed with elephant grass, raise cows and goats on the shore, and raise fish in the pond (catfish, grass-fed fish...). This is actually the garden and barn pond model (VAC). Although this model is not new, it is a model that demonstrates the superiority of a self-sufficient micro-ecology and is very suitable in the current practical situation. The superiority of this model lies in its ability to withstand and recover quickly in the context of climate change, and it is easy to apply at the household level, bringing a direct impact to people's lives. Furthermore, applying this model is not difficult, mainly involving the use of folk experience/indigenous knowledge. The model has high flexibility through the restructuring of livestock and crops in accordance with climate change. It can be said that VAC is a sustainable livelihood model, ensuring environmental friendliness and diversification of agricultural products, and it is capable of being replicated in all regions.

From there, it is seen that the livelihood models of the people here are essentially household production and business models where people spend the most time in a year generating income. Among them, the models considered to be the most effective (Rated Good) always have a combination of three elements: economic, social, and environmental. These models create profits, aim at the quality of life of environmentally friendly communities, and if these three factors reach a state of balance, sustainability will be satisfied.

5. Propose solutions

- Change crop structure appropriately. Change and adjust production practices such as planting, sowing, and harvesting time to suit the local practical situation and adapt to the impacts of climate change and sea level rise.
- Organize tour programs to showcase sustainable livelihood models with high economic efficiency in localities across the country to help people have the opportunity to learn, exchange, and share experiences in farming. Agriculture: mangrove co-management model; clam and cockle farming cooperative model; protected area co-management model; sustainable seafood community model; community ecotourism model; VAC model... Field trip programs are valuable knowledge that helps people easily absorb and grasp information, stimulating exploration, learning, and experimental research, thereby applying it to local practical situations.
- The Women's Union, Farmers' Union, Youth Union, and Veterans' Association are organizations that play a leading role, able to support, guide, and advise people to develop all creative potential and innovations. Folk knowledge and experience/indigenous knowledge, combined with science and technology, enhance the exchange and sharing of production experiences among farming households to enhance people's ability to proactively adapt and respond to emergencies, including erratic changes in weather and climate.

6. Conclusion

Through the survey results of 3 communes (Thua Duc, An Thuy, and Thanh Hai) in 3 coastal districts of the Province, it shows that coastal resources are being exploited and used quite a lot by people, especially in Ba Tri district, where most people gather. The city is densely populated with many types of livelihoods, and coastal ecosystems such as mangrove forests have been severely damaged. In Binh Dai district, although coastal resources are being exploited, the possibility of partially restoring the mangrove ecosystem, sand dunes, and river estuaries is possible because the population pressure here is not high.. Thanh Phu is considered the district with the least damaged coastal natural resources, so the ability to preserve and conserve is considered the highest.

In the context of climate change in Ben Tre, the primary livelihood models are vulnerable to its impact, particularly those relying on ecological systems. Recognizing this, the integration of Agriculture 4.0, especially the application of Aquaponics, emerges as a pivotal strategy. Climate change poses a significant threat to local ecosystems, making it imperative to develop sustainable and environmentally-friendly economic models geared towards a green economy. Among these emerging models, Aquaponics stands out as an innovative approach. By combining aquaculture and hydroponics, it creates a symbiotic system where fish waste provides nutrients for plants, and plants help purify the water. This not only enhances resource efficiency but also reduces emissions, aligning with the global trend towards eco-friendly practices.

In the pursuit of a green economy, prioritizing eco-friendly economic models becomes paramount. These models not only prove efficient in resource utilization but also strive for low emissions, contributing to social equity. Thus, opting for such ecological economic models not only represents a global trend but also aligns with the national strategy for sustainable and green growth.

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