Scientific
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Adaptation to Climate Change in Aquatic Aquarium in Quang Binh Province, Vietnam

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Abstract

Quang Binh is a locality with a long coastline and a rather large system of rivers and streams, which is very favorable for aquaculture development. However, as a locality subject to many impacts of climate change, the aquaculture sector in Quang Binh province has faced many difficulties in recent years. This study tries to answer the questions of how climate change affects aquaculture farmers in Quang Binh province; what methods do people choose to adapt to climate change and what factors influence people's choice of adaptation methods.

Keywords

Quang Binh Province, Climate Change, Adaptation to Climate Change, Aquaculture, Aquaculture in Quang Binh Province

1. Introduction

Quang Binh has a coastline of more than 116 km, a rather large system of rivers and streams with a density of 0.8 - 1.1 km/km^2, and 5 estuaries with large water surface areas capable of aquaculture. However, the aquaculture industry in Quang Binh province faces many difficulties, of which the biggest difficulty is the change of climate. Over the past years, Quang Binh has suffered many influences from abnormal weather phenomena such as sea level rise, heat, storms, floods, etc., which have devastated the coastal ecosystem, affected and caused many damages to the agricultural sector in general and the aquaculture industry in particular. For example, the October 2020 flood caused the total damage to the aquaculture area to be 3133.9 hectares and 47,845 m^3 of cages damaged by 30% - 100% with a total damage value of 194,330 million VND (Department of Fisheries, 2020; Department of Agriculture and Rural Development of Quang

Binh Province, 2021). Facing that situation, proactively adapting to the adverse effects of climate change is an important and necessary job of aquaculture farmers in Quang Binh province. Facing that situation, proactively adapting to the adverse effects of climate change is an important and necessary job of aquaculture farmers in Quang Binh province. Therefore, in order to find out the current situation of aquaculture people in Quang Binh province, what methods are used to adapt to the impacts of climate change and the factors affecting the choice of these methods, the author conducts a study on the issue of "Adapting to climate change in the aquaculture of fishermen in the coastal area of Quang Binh province".

2. Theory Framework and Research Method

2.1. Theory Framework

- Climate change: There are many concepts of climate change; research approaches the concept of the United Nations Framework Convention: Climate change is caused directly or indirectly by human activities, which alters the composition of the global atmosphere and is due to the natural variability of climate observed over comparable periods. Manifestations of climate change are changes in temperature, erosion, saltwater intrusion and extreme weather events. The cause of climate change is due to two subjective factors and objective factors (Dat & Thu, 2013).

- The objective causes are due to natural variations such as: changes in solar activity, changes in the earth's orbit, changes in the position and size of continents, changes in ocean currents, etc. circulation, the circulation within the atmospheric system. The second cause is anthropogenic resulting from changes in land use and water resources, and an increase in CO_2 and greenhouse gas emissions from human activities.

- Adaptation to climate change: Up to now, there are many different conceptions of climate change adaptation. IPCC conceptual approach study in the third assessment report on Climate Change: Climate change adaptation is the adjustment in natural or human systems in response to real changes (IPCC TAR, 2001).

2.2. Research Method

- *Method of collecting secondary data:* The study collects secondary information from published documents related to climate change and climate change adaptation; reports of the Department of Agriculture and Rural Development of Quang Binh province on the situation of aquaculture and the effects of climate change on aquaculture in Quang Binh province.

- *Method of primary data collection:* Primary data collection through survey by questionnaire. The subjects of the survey are aquaculture households in Quang Binh province.

The sample size is determined by the formula:

$$n = \frac{N}{1 + N(e)^2}$$

With a confidence level of 95% and $P = 0.5$, sample size with an error of ±5%, the study determined the sample to be investigated $n = 395$. The author determined the number of surveyed households to be 400 aquaculture farming households; data collection was conducted randomly at each survey site.

The questionnaire is designed with the following parts: 1) Awareness and attitudes of aquaculture households towards climate change; 2) Impact of climate change and adaptation methods of aquaculture households; 3) Factors affecting the choice of adaptation methods of households; 4) general information about households. The questions in each section are designed in two forms, closed questions and open questions.

3. Research Results and Discussion

3.1. Aquaculture Situation in Quang Binh Province from 2019 to 2021

The situation of aquaculture in Quang Binh province is reflected in Table 1, showing that from 2019 to 2021, the aquaculture production and area have been continuously increasing. The area of cage farming in 2020 increased by 349 hectares compared to 2019, corresponding to a 5.1% increase, and the production increased by 97 tons, corresponding to a 0.7% increase. In 2021, the area of cage farming increased by 229.4 hectares compared to 2020, corresponding to a 3.2% increase, and the production increased by 466.5 tons, corresponding to a 3.5% increase. The production growth rate in 2021/2020 is higher than the production growth rate in 2020/2019 due to the significant impact of the historic flood in October 2020 on aquaculture in Quang Binh province.

Table 1. Aquaculture situation in Quang Binh province from 2019 to 2021.

Productivity and area of farming	Unit	2019	2020	2021	2020/2019		2021/2020	
					±	%	±	%
1. *Farming yield*	*tons*	13,232	13,329.1	13,796	97	0.7	466.5	3.5
Saline water	tons	5096	5125	5289	29	0.6	164.0	3.2
Fresh water	tons	8136	8205	8507	69	0.8	302.5	3.69
2. *Area of open farming*	*hectares*	6820.5	7169.2	7399	349	5.1	229.4	3.2
Saline water	hectares	1534.7	1586.3	1632	52	3.4	46.0	2.9
Fresh water	hectares	5285.8	5582.9	5766	297	5.6	183.4	3.29
3. *Productivity*	*tons/hectares*	1.94	1.86	1.86	−0.08	−4.2	0.01	0.29
Saline water	tons/hectares	3.32	3.23	3.24	−0.09	−2.7	0.01	0.29
Fresh water	tons/hectares	1.54	1.47	1.48	−0.07	−4.5	0.01	0.39

Source: Department of agriculture and rural development of Quang Binh Province and calculations by the author.

The results of Table 1 also show that the structure of aquaculture area in Quang Binh province has a proportion of freshwater aquaculture accounting for over 61% and tends to increase from 2019 to 2021. However, the productivity of saline water aquaculture is higher than that of fresh water aquaculture by 2.1 times.

3.2. Statistical Description of the Results of the Survey on Aquaculture Farming Households

The survey results of 400 aquaculture farming households in 8 administrative units in Quang Binh province are presented in Table 2. The sample distribution was based on the scale of aquaculture farming in each locality. Accordingly, the localities include: Dong Hoi city, Bo Trach district, and Quang Trach district, with 70 households surveyed in each locality; Le Thuy district, Quang Ninh district, and Ba Don town, with 50 households surveyed in each locality; and Minh Hoa district, with only a few aquaculture farming households, so 20 households were surveyed in each locality. The surveyed households had an average age of 37.6 years and 11 years of experience in aquaculture farming, which are considered favorable factors for aquaculture farming. However, the educational level of the households was limited to 9th grade, and only 73% of the households received training, which poses difficulties in applying scientific and technical advances in their farming practices.

The surveyed households had an average farming area of 1.39 hectares per household, with Bo Trach district being the locality with the highest average farming area (1.49 hectares per household) and Minh Hoa district being the locality with the lowest average farming area (1.25 hectares per household). The average production yield of the surveyed households was 1.84 tons per hectare, with Dong Hoi city, Quang Ninh district, and Quang Trach district being the

Table 2. Statistical description of the results of the survey on aquaculture farming households.

Targets	Unit	Total	Investigation site in Quang Binh Province							
			Dong Hoi city	Le Thuy district	Quang Ninh district	Bo Trach district	Quang Trach district	Ba Don town	Tuyen Hoa district	Minh Hoa district
1. Number of households	household	400	70	50	50	70	70	50	20	20
2. Age of household head	age	37.6	35.6	38.2	39.5	38.3	39.2	37.3	35.6	33.5
3. Educational level	class	9	10	9	10	10	8	10	8	8
4. Farming experience	year	11	12	11	12	12	12	10	9	9
5. Training participation	%	73.0	83.2	73.5	75.3	70.2	68.3	69.5	68.8	68.3
6. Farming area	Hectare/household	1.39	1.38	1.3	1.35	1.49	1.43	1.41	1.28	1.25
7. Productivity	Tons/hectares	1.84	1.85	1.84	1.85	1.84	1.85	1.84	1.82	1.82

Source: Author's survey and calculation results, 2021.

localities with the highest production yield.

### 3.3. Current Status of Impacts of Climate Change on Aquaculture in Quang Binh Province

Survey results on the effects of climate change on aquaculture of people in Quang Binh province on the following phenomena:

- *Sea level rise and saline intrusion:* Survey results (Figure 1) show that the degree of impact due to sea level rise and saline intrusion is not large, up to 76.5% are not affected, only 11.5% of households with aquaculture died, 13.5% of households have reduced productivity, and 22.5% of households have slow-growing aquatic products. However, saline intrusion has a great impact on aquaculture due to changes in water environment and slow growth of aquatic products.

- *Severe cold, harmful cold:* Survey results (Figure 2) show that severe cold, harmful cold also causes a lot of damage to farmers. The survey results show that severe cold and harmful cold have a great impact on aquaculture farmers in Quang Binh province, with 58.5% of households having aquaculture died, 36% of households having crops lost and losing crops 67.5% of households have reduced productivity, only 16.5% of households are not affected.

- *Drought:* In recent years, there have been droughts here, but the degree of impact is not large on aquaculture activities, with 71.5% of households not affected, the number of affected households is very low: 11.5% of households have slow-growing aquatic products, 9.5% of households have reduced productivity, 6.35% of households have a changed water environment, 10.2% of households have more diseases and 7.25% of households have dead fish.

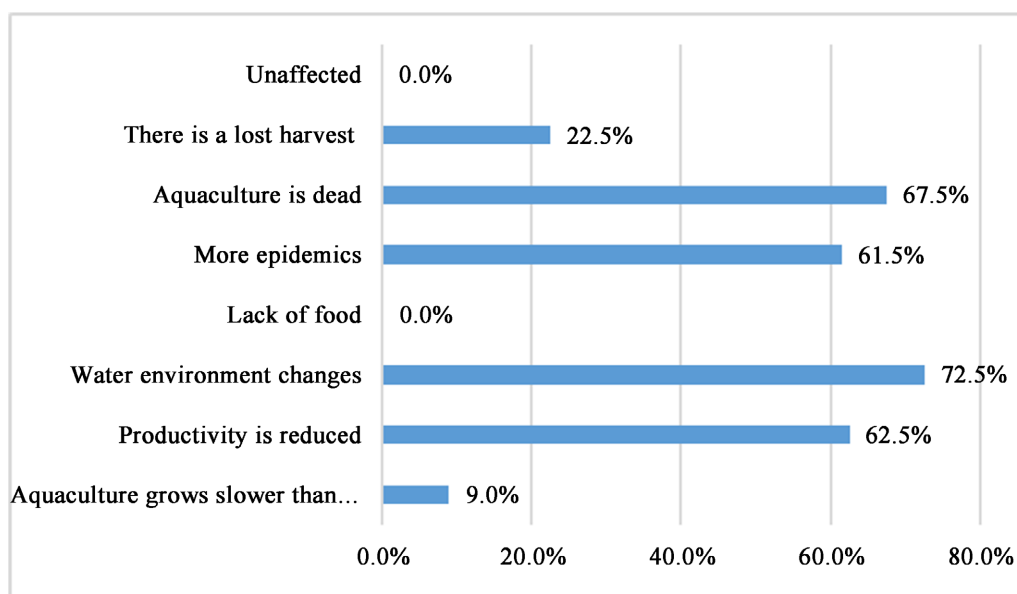- *Hot weather:* Survey results (Figure 3) show that hot weather causes many
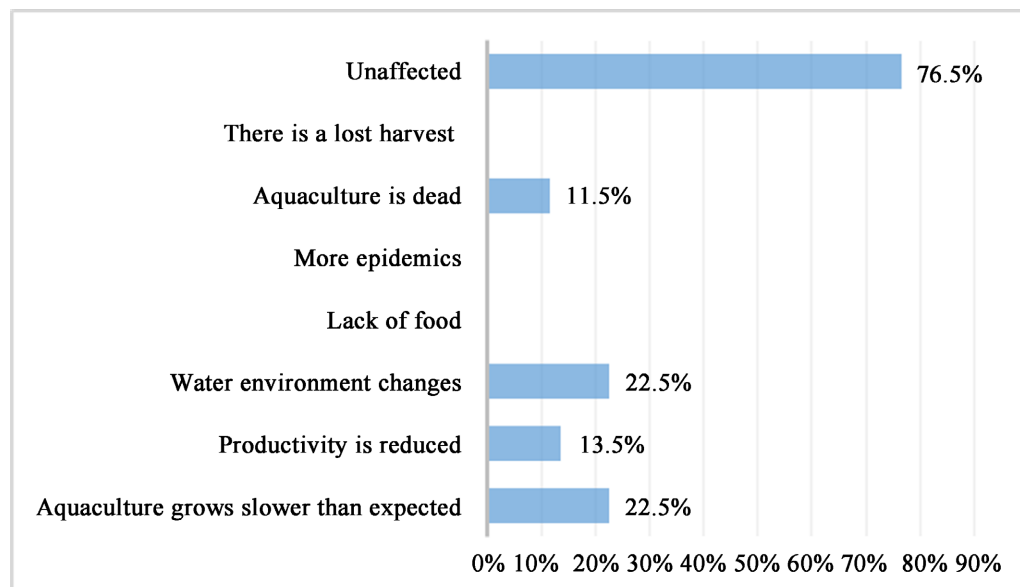
Source: Author's survey and calculation results, 2021.

Figure 1. Effects of sea level rise and saltwater intrusion on aquaculture.
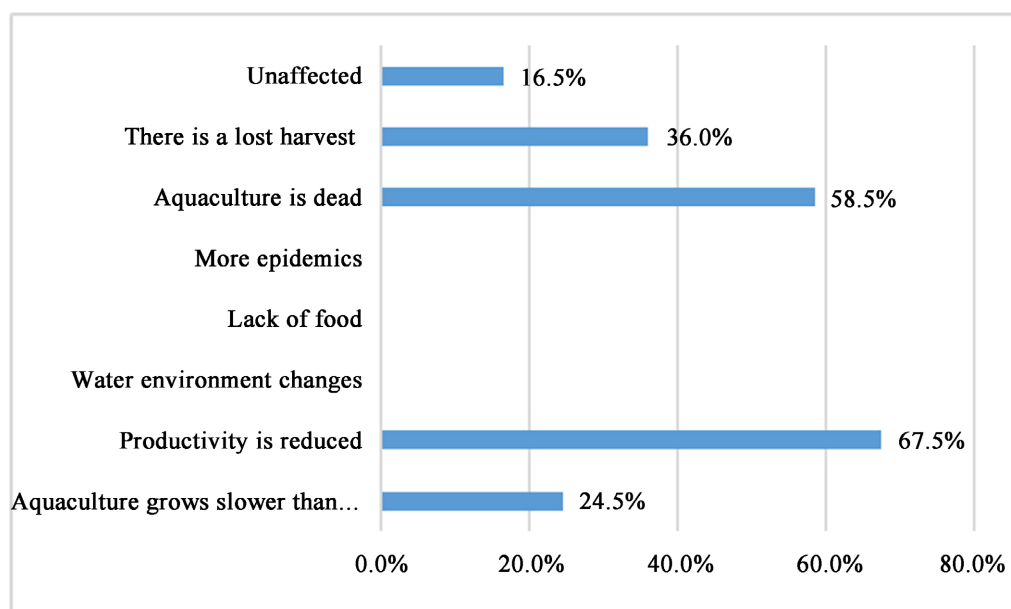
Source: Author's survey and calculation results, 2021.

Figure 2. Effects of severe cold, harmful cold on aquaculture.

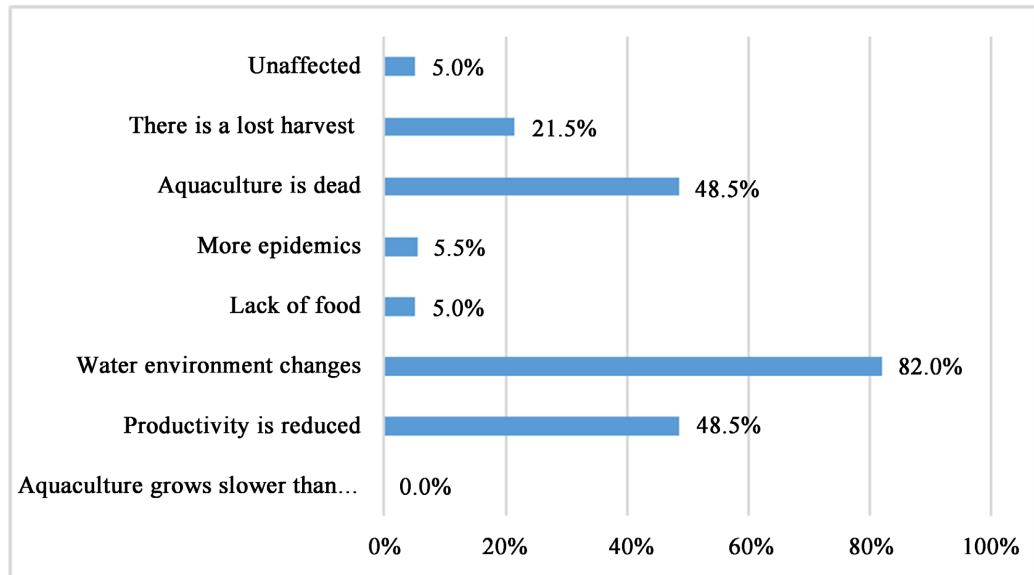Source: Author's survey and calculation results, 2021.

Figure 3. Effects of hot weather on aquaculture.

impacts on their farming. In which, the most affected is the hot weather that changes the water environment (72.5%), the death of farmed aquatic products (67.5%), the yield decrease by 62.5%, and the loss of a crop (22.5%). In addition, hot weather is also a condition for the emergence of diseases on livestock, especially for shrimp species, due to prolonged hot weather, fluctuating water environment, unadapted seed leads to livestock weak, resistance decreases and disease arises, 61.5% of households believe that hot weather increases disease out-

breaks.

- ***Heavy rain:*** The survey results on the effects of heavy rain on aquaculture (Figure 4) showed that heavy rain changed the water environment (82.0%), aquatic animals died (48.5%), crop productivity decreased (48.5%) and up to 21.5% of households lost their crops.

- ***Flooding:*** Similar to heavy rain, the survey results on the effects of flooding on aquaculture shown in Figure 5 show that flooding mainly upsets the water environment, leading to the death of livestock, Growth retardation and disease

Source: Author's survey and calculation results, 2021.

Figure 4. Effects of heavy rain on aquaculture.
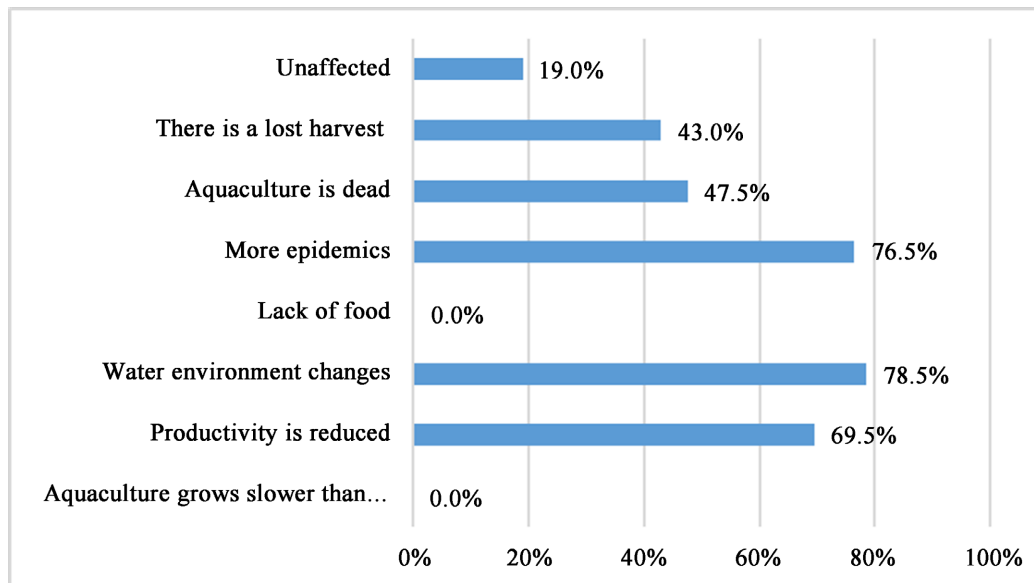
Source: Author's survey and calculation results, 2021.

**Figure 5.** Impact of flooding on aquaculture.

increase, thereby reducing productivity, up to 69.5% of households surveyed had a decrease in farming productivity due to flooding, especially 43.0% of households had crops lost. In reality, the historic flood in 2020 in Quang Binh province caused even greater damage to aquaculture, as shown in Table 3. The total damaged area due to the flood was 6,810.5 hectares, accounting for 95% of the total aquaculture area. Among them, damages exceeding 70% accounted for 38.45%, damages between 30% and 70% accounted for 12.0%, and damages below 30% accounted for 44.6%. Only 5% of the aquaculture area remained unaffected by the flood.

- *Storms:* Every year, Quang Binh province suffers from many storms with strong intensity, which have seriously affected aquaculture in general and people in aquaculture areas in particular. The 2013 storm caused a large loss of aquaculture area in Quang Binh province. The survey results on the impact of storms on aquaculture (Figure 6) showed that the number of households whose productivity

Table 3. Situation of damaged aquaculture area in Quang Binh province due to the flood in October 2020.

Serial	Targets	Unit	Grazing	Damages				No damages
				Total damage	>70%	From 30% to 70%	<30%	
1	Acreage	Ha	7169.2	6810.5	2754.5	858.0	3198.0	358.7
2	Damage ratio/ Grazing area	%	100	95.0	38.4	12.0	44.6	5.0

Source: Department of Agriculture and Rural Development of Quang Binh province and calculations by the author.
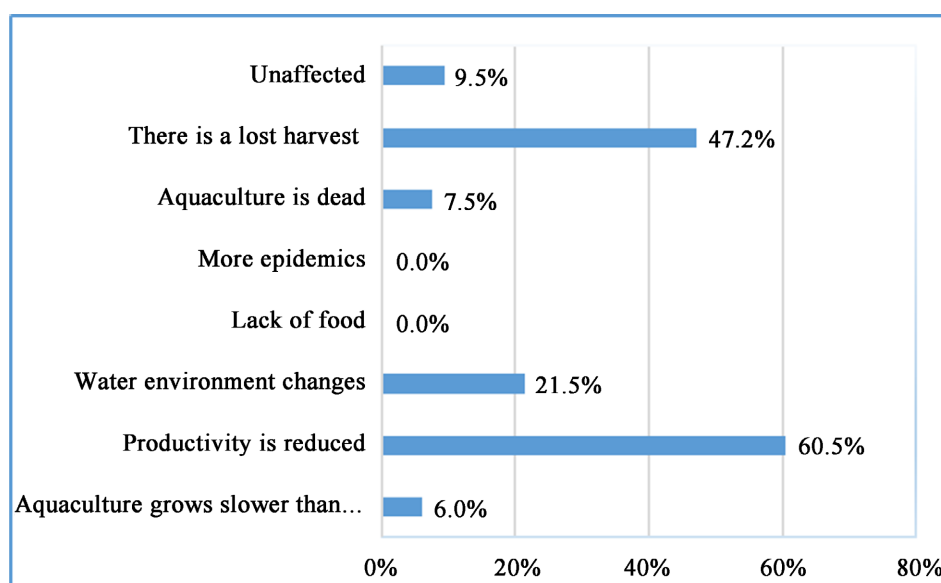
Source: Author's survey and calculation results, 2021.

Figure 6. Impact of typhoons on aquaculture.

decreased due to storms was 60.5%, especially 47.2% of households whose crops were lost.

3.4. Adaptation Methods in Aquaculture in Quang Binh Province

Facing the adverse effects of climate change, aquaculture farmers in Quang Binh province have taken many adaptation measures to ensure stable production and business. The survey results on adaptation methods to climate change (Figure 7) show that aquaculture households apply a variety of methods, specifically:

- *Breeding method:* This is the most widely applied method (46.3%) because the selection of good and suitable breeds is the decisive factor for most of the success of farming; In the current area of Quang Binh province, the seed is also floating from many different sources, especially for shrimp farming. Therefore, in order to choose a good breed, people have to go through their social network relationships.

- *Method of changing farming methods:* This method has the rate of 38.7% of surveyed households applying, the basis for households to apply is through training (21.5%), relationships friendship (30.23%), through mass media (38.9%), and from surrounding farmers (17.4%).

- *Method of investing in more equipment:* This method is also applied by many households, the survey results have 31.5% of households applied. However, the investment in modern farming equipment often requires large capital, so associations have to mobilize from many sources, of which loans from credit institutions meet from 40% to 55%, the rest is borrowing from other sources such as relatives, friends, etc.
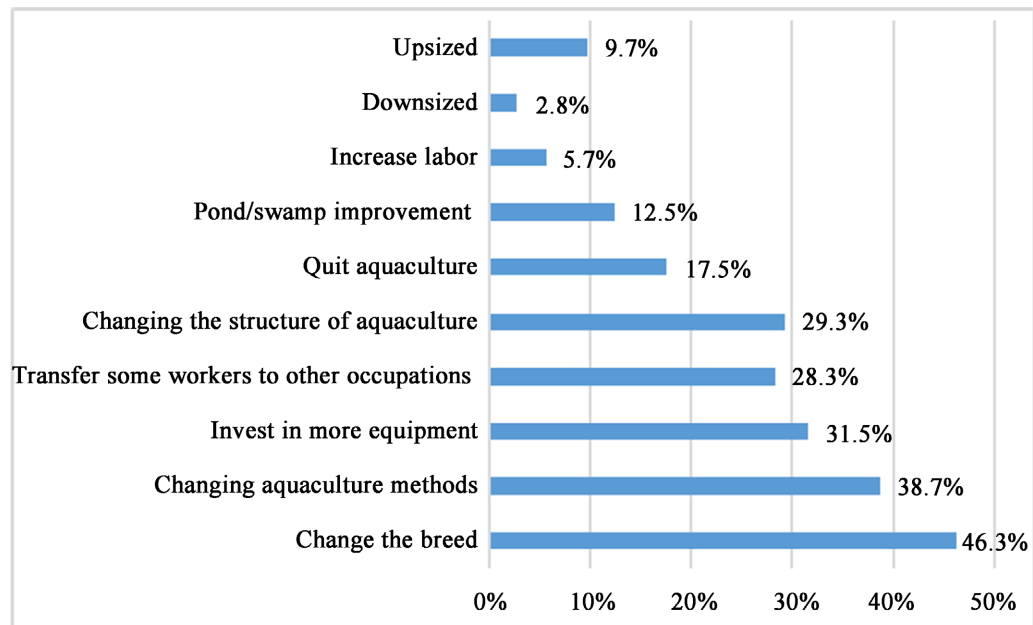
Source: Author's survey and calculation results, 2021.

Figure 7. Climate change adaptation activities of coastal people in aquaculture in Quang Binh province.

- The method of transferring some laborers of households to other occupations: This method also has a high rate of application by households 28.3% due to the fact that farming requires a lot of energy and technology. The male part of the main labor force and farming does not require too many human resources, so only 2 - 3 people participate in this work, other members find other jobs. In addition, in recent years, due to epidemics, storms and floods, farming has also faced many difficulties, leading to the rate of households transferring less labor to other occupations.

- Method of changing the farming structure: This method has a percentage of households applying 29.3%, because this method is suitable for the climate and weather of each season; make the most of food resources; clean up the environment in order to improve the quality of livestock and increase the value of income for local people.

- The method of abandoning farming: This method has a rate of 17.5% of surveyed households. Households apply this method because due to storms and floods, many households lose nothing, so they no longer have investment capital; besides, many households switch to other fields of investment because aquaculture is no longer economically viable.

- Method of upgrading ponds/lagoons: This method is also applied by many households by 12.5% to ensure the living environment for aquatic products, reduce disease and improve economic efficiency.

Besides the above methods applied by aquaculture households quite highly, there are still some households using other methods such as arranging more workers, reducing scale and increasing scale. However, these methods have a low percentage of households applying them.

3.5. Evaluation of Factors Affecting the Selection of Adaptation Methods to Climate Change in the Aquaculture Sector

To evaluate the factors affecting the selection of climate change adaptation methods in the aquaculture sector in Quang Binh province. The study evaluates through the tested correlation and analysis by logistic regression model between the factors (age, education level, family economic conditions, household size (number of people) working age), participate in training on climate change, learn more production experience, cooperate with other households) with each adaptation method.

The results of the logistic model and the correlation test show that the factors of business cooperation among households, learning from experience, education, participation in training, and economic conditions have an influence on the choice of household. Adaptation methods are as follows:

- Breed change method: The results of logistic regression test on factors related to the method of changing aquaculture varieties are shown in Table 4 as follows: with $p < 0.05$ significance level, there are 11.8% of variation in breed is related to variables: education, business cooperation with other households,

learning more experience from others.

- Method of changing farming methods: Results of Chi-Square testing the relationship between changing farming methods and factors: education, age, economic status, cooperation between households, participation training, learning more experience shows that, with the significance level $p < 0.05$, the factor of learning more experience and participating in training has an influence on the choice of adaptation method to change farming methods (Table 5). The other factors, although there is a difference, are not statistically significant.

- Method of investing in more farming equipment: The test results shown in Table 6 show that, with the significance level $p < 0.05$. There is a correlation

Table 4. Logistic regression on factors related to the method of breeding variety.

Variable	β	Standard Error (S.E.)	Statistical significance level
Education	0.436	0.214	0.041
Have business cooperation with other households	1.104	0.531	0.037
Learn more from other people's experiences	0.799	0.555	0.148
Nagelke R Square = 0.118, $p = 0.015$			

Source: Author's survey and calculation results, 2021.

Table 5. The relationship between the method of changing farming methods and the factors of learning more experience, participating in training.

Variable		Change of farming method (%)	Statistical significance level
Learn to get more experience	Yes	168	0.041
	No	32	
Join the training	Yes	172	0.03
	No	28	

Source: Author's survey and calculation results, 2021.

Table 6. Correlation between economic conditions, business cooperation with other households and the method of "Investing in more farming equipment".

Variable		Change of farming method (%)	Statistical significance level
Family economic conditions	Medium	37.6	0.03
	Wealthier	62.4	
Doing business with other households	Yes	66.5	0.01
	No	33.5	

Source: Author's survey and calculation results, 2021.

between the investment in additional farming equipment and the family's economic condition and the cooperation with other households.

- *Method of transferring some household's laborers to another occupation:* Table 7 shows the results of logistic regression testing on factors related to the method of transferring some household's laborers to another occupation. After removing a number of variables that are not statistically significant, the results show that with the significance level of $p < 0.05$, 33.7% of the household's labor shift to another occupation is related to the variables: income from farming activities, the number of laborers in working age of the household. Specifically: The transfer of labor of the household to another occupation has a negative relationship with the income variable from farming activities, has a positive relationship with the variable of labor in the working age of the household, for example: group having less income from farming will have a higher rate of labor transfer of households to other occupations, and households with more people of working age will have a higher rate of labor transfer to other occupations.

- *Method of changing farming structure:* Table 8 shows the results of logistic regression test on factors related to the method of changing farming structure, after removing some variables that are not statistically significant, the results show that with the significance level of $p < 0.05$, 22.4% of the change in farming structure is related to the variables: Training participation and age. Specifically, the younger age group, the higher the rate of change in farming structure, the training group is often equipped with more knowledge, so they also apply this method more.

Table 7. Logistic regression—Factors related to adaptation mode "transfer some labor of the household to another occupation".

Variable	β	Standard Error (S.E.)	Statistical significance level
Income from farming activities	−0.596	0.130	0.000
Number of employees in working age of the household	0.803	0.321	0.011
Nagelke R Square = 0.337, $p = 0.00$			

Source: Author's survey and calculation results, 2021.

Table 8. Logistic regression—Factors related to adaptation mode "change in farming structure".

Variable	β	Standard Error (S.E.)	Statistical significance level
Join the training	2.597	0.773	0.001
age	−0.053	0.026	0.038
Nagelke R Square = 0.224, $p = 0.00$			

Source: Author's survey and calculation results, 2021.

Table 9. Relationship between independent variables and the method of "abandon farming".

Variable		Qquit job (Ratio %)	Statistical significance level
Education	primary school secondary school	62	0.04
	High school	38	
Economic status	Medium	78	0.00
	Wealthier	22	
Age group	≤30	0	0.094
	31 - 40	35	
	41 - 50	22	
	≥51	43	
Do you have business cooperation with other households?	Yes	24	0.00
	No	76	
Did you attend training on climate change?	Joined	26	0.00
	Not participate	74	
Did you learn more from the past 5 years?	Yes	23	0.00
	No	77	

Source: Author's survey and calculation results, 2021.

- *The method of abandoning farming:* Table 9 shows the test results between the above factors and the method of "abandoning farming" also show that, in the group that quit farming, the group with lower education has a higher rate of abandonment; the group with average economic conditions give up more than the group with good economic conditions; The abandonment of farming was not statistically significant with age. In addition, we see that learning from experience and business cooperation play an important role in climate change adaptation in the aquaculture sector. With the significance level, $p < 0.05$, it shows that the group that has learned more business experience and the group that cooperates with other households has a lower rate of abandoning farming. The group that had participated in climate change training also had a lower rate of abandonment than the group that had never attended.

4. Conclusion

Research results based on surveys and assessments of people show that manifestations of climate change such as saltwater intrusion, drought, heavy rain, floods, severe cold and storms, all affect activities. The production activities of people are at different levels and all cause difficulties for production activities and affect productivity, growth and production output. The aquaculture sector is one of

the most affected and affected sectors in Quang Binh province, in which, storms and floods have the greatest impact, followed by severe cold, damaging cold, heavy rain and hot sun, which also have a large degree of influence; The phenomenon of sea level rise, salinity intrusion and drought have not had a great impact. In order to adapt to climate change to ensure and improve the efficiency of production and business, aquaculture households in Quang Binh province have had many adaptation methods, in which the method of changing varieties is the people's choice. The most commonly used methods, followed by the methods used quite a lot, such as: changing farming methods, investing in new equipment, transferring some of the household's labor to another occupation, changing the farming structure, and quit farming. Other methods such as arranging more workers, reducing the scale and increasing the scale have a low percentage of households applying to adapt to climate change.

On the study of factors related to the selection of adaptation methods, the results show that the adaptation measures of households are based on reasonable consideration of factors on household resources such as: material conditions, education, age, and family size…

In general, in aquaculture, people in Quang Binh province have many adaptation methods to the impacts of climate change. However, adaptation is still mainly spontaneity of households, lack of synchronization and increasingly unpredictable weather changes, so productivity and efficiency are unstable and not as expected. Therefore, in order to enhance the effectiveness of adaptation to climate changes in agricultural production in Quang Binh province in general and in aquaculture in particular, the following issues are recommended:

- The State in the process of formulating and implementing strategies, master plans and plans for industrial development, agriculture, transport, urban development, resource and land use, etc., should pay attention to the limitation, the causes of climate change. Programs to respond to climate change need to be synchronous among ministries—sectors and local authorities, and at the same time must take into account regional and local factors. At the same time, it is necessary to attract the participation of the community in responding to climate change.

- The local government of Quang Binh province should effectively promote the role and responsibility of the local government in the programs to respond to climate change in the area, specifically: continuing to research and apply advanced Ministry of science and technology in aquaculture; promoting the development of agriculture in general and aquaculture in particular in the direction of high technology; raising awareness, propagating and disseminating information to the people about climate change, causes and impacts of climate change on production and business. It is necessary to have policies for people to borrow capital to ensure investment capital for production and increase income.

- For aquaculture people, it is necessary to raise awareness and find appropri-

ate adaptation measures to climate change; actively participate in training courses to improve knowledge on climate change and farming techniques, especially for new varieties that are able to adapt well to the local climate situation; strengthen and expand the community network and social relationships in order to learn and share knowledge and experiences with the community, especially those who are new to applying adaptation measures.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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