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Factors Affecting Climate-Smart Agriculture Practice Adaptation of Farming Households in Coastal Central Vietnam: The Case of Ninh Thuan Province

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Agriculture is a sector with a long tradition and an important contribution to economic growth in Vietnam, providing food security and generating revenue for the country's exports. However, agricultural activities in Vietnam are significantly affected by climate change. In Vietnam, the central coastal area in general and Ninh Thuan province in particular are the most vulnerable areas to natural disasters. In that context, climate-smart agriculture (CSA) is a good strategy to help local famers coping with climate change while securing food security. This study has two main objectives: to assess farmers' awareness on disasters and to analyze factors affecting the decision to apply CSA practices of farming households in Ninh Thuan. The study conducted focus group discussion, in-depth interview and survey of 436 households in 3 districts of Ninh Thuan to collect data. Research results showed that local farmers have a high awareness of natural disasters trends and impacts on agricultural livelihoods. Facing with disasters in the context of climate change, farming households have applied some models of CSA such as minimal tillage, intercropping, crop rotation, crop transformation, and the use of plant varieties. Binary logit regression analysis indicated that age, education level, household income, membership of local associations, training attendance, and support policies were variables significantly influencing the farmers' decision to apply CSA. Challenges for CSA adoption include lack of capital, information, technical support and land ownership institutions in Vietnam. The study also made recommendations to promote CSA in Vietnam, including reforming the legal system, strengthening agricultural extension services, and providing technical and capital support to farmers.

Keywords: climate-smart agriculture, food security, climate change, extension, resilience, adaptation, farming household, livelihoods

INTRODUCTION

Since the "Open door" *(Doimoi)* policy in 1986 and market-oriented development, Vietnam has experienced rapid economic growth, becoming a middle-income country and one of the fastest-growing economies globally. During this time, Vietnam also turns into a leading emerging market in the region. Gross domestic product (GDP) per capita is currently $2,830 in 2020, with an average

GDP growth rate of 6.2%/year for the past 10 years (International Labor Organization–ILO, 2018; Dat and Thanh, 2019; World Bank, 2019).

During the 1990s, the main driver of GDP growth in Vietnam was increased agricultural productivity (Dinh et al., 2018; Marie and Bienabe 2018). Currently, the agricultural sector contributes 15.2% of export value and 18% of national GDP. It helps Vietnam become the world's leading exporter of essential agricultural products: rice, coffee, pepper, vegetables, and rubber (Dinh et al., 2018). At the same time, Vietnam has also become a country that plays a vital role in ensuring world food security, with the rice export volume of about 4–5 million tons per year (IPSARD, 2016; Hoang and Vu, 2017; Jaffee et al., 2019; World Bank, 2019).

At present, Vietnam's agricultural growth faces severe climate change risks. Vietnam ranks first in terms of serious effects on population and GDP growth among the 84 coastal developing nations (Dung and Phu, 2016; Dinh et al., 2018; Ha et al., 2019). Vietnam has a significant influence on population and GDP growth. In 2014, Maplecroft estimated that Vietnam is among 30 nations globally that are very hazardous and based on the Climate Change Vulnerability Index (CCVI). Extreme weather occurrences, including floods, cold spells in the North and central areas, saltwater incursion in the Mekong Delta, and drought in central highlands, show a wider expression of Vietnam (Pham and Dao, 2016; Simelton et al., 2017; Tran et al., 2019).

To adapt and redirect agricultural growth under the new climate change conditions, the approach of climate-smart agriculture (CSA) was introduced (Kariyasa and Dewi, 2013; Ho and Shimada, 2019). The most widely accepted definition is the United Nations Food and Agricultural Organization (FAO), which defines the CSA as "Agriculture that sustainably raises production, improves resilience (adaptation), decreases or eliminates GHGs (mitigation), and enhances achievement of national food security and development goals." It aims at tackling three main goals: increasing agricultural productivity; adapting and building resilience to climate change; and reducing greenhouse gas emissions (Arslan et al., 2014; Mwangi and Kariuki, 2015; FAO, 2019; M'koumfida et al., 2020; Ankit et al., 2021).

Converting traditional agricultural production toward CSA can be a good solution to help agriculture in Vietnam overcome challenges in the future. Many smart agricultural practices have been implemented in Vietnam to maintain agricultural production in increasing climate risks (Dang et al., 2014; Dung and Phu, 2016; Ha et al., 2019; WHO, 2019). These include intelligent irrigation and water management, better plant varieties, agricultural forestry, crop management, sustainable land management, agricultural waste treatment (apply biogas technology in farming), and agricultural climate information services (Nguyen et al., 2017b, 2018; Shukla et al., 2018; Reardon et al., 2019). However, the level of adoption of CSA technologies is generally still low or moderate. The replication of CSA technologies is limited due to difficulties in inputs, high costs, and lack of investment capital. In addition, the lack of information in local development programs and plans (at the district level) is also a barrier in implementing CSA technologies (IPSARD, 2016; Hoang and Vu, 2017; Hau, 2019; Ho and Shimada, 2019).

In Vietnam, the central coastal region is the most vulnerable area to climate change in the country. Every year, this area is affected by many natural disasters and extreme weather phenomena (Dang et al., 2014; Luu et al., 2016). In the central provinces, Ninh Thuan is assessed as one of the provinces most strongly affected by natural disasters. In which, drought is identified as a form of natural disaster with serious impacts and increasing frequency (Grosjean et al., 2016). In order to cope with adverse weather conditions, it is necessary to transform and develop agriculture in the direction of both increasing incomes, ensuring food security, and adapting and mitigating the impacts of climate change for Ninh Thuan in particular and the central coastal area in general (Hoi et al., 2016; Vietnam Parliament, 2017; World Agroforestry Centre, 2017; Lam et al., 2018).

The reality of agricultural production in Ninh Thuan shows that farmers here have applied a number of adaptation measures to the adverse climate such as applying conservation farming techniques, minimal tillage, intercropping, crop rotation, crop transformation, and the use of plant varieties that are resistant to adverse conditions. These models can be viewed as CSA solutions (Quan et al., 2013; Tran, 2013; Nghia et al., 2015; Nguyen et al., 2019).

The main objective of this study is to assess the awareness of farmers about the evolution and impact of natural disasters on agricultural production in Ninh Thuan province. In addition, the study also analyzes the factors affecting the behavior of farmers in applying CSA solutions to adapt to climate change in the locality. Several challenges in the application of CSA at the household and management levels were also identified. From that, the study gives some implications to promote the application of CSA in Ninh Thuan in particular and in Vietnam in general.

STUDY AREA

Ninh Thuan is a province in the South Central Coast region of Vietnam. The province is 350 kilometers far from Ho Chi Minh City, 60 km from Cam Ranh airport (Nha Trang city) and be convenient for socio-economic development exchanges (**Figure 1**). Ninh Thuan's topography gradually lowers from the Northwest to the Southeast, with three types of terrain: mountains accounting for 63.2%, hills and semi-mountains accounting for 14.4%, coastal plains accounting for 22.4% of the natural area of the whole province (Dung and Phu, 2016; Dinh et al., 2018). Ninh Thuan has a typical tropical monsoon climate with characteristics of hot, dry, windy, strong evaporation, the average annual temperature is from 26 and 27°C, the average rainfall is 700–800 mm in Phan Rang and gradually increases to over 1,100 mm in mountainous areas, the air humidity is from 75 to 77%. Large radiant energy 160 Kcl/cm^2 (General Statistical Office, 2017). The weather has two distinct seasons: rainy season from September to November and dry season from December to August next year. Water sources in Ninh Thuan are unevenly distributed, mainly concentrated in the northern and central areas of the province. Groundwater is only one third of the national average (Dang et al., 2018). Total natural area is 335,534 ha, of which land used for agricultural production is 83,618 ha; forestry land 188,997 ha; aquaculture land 2,028 ha; salt production land 3,809 ha; specialized land 19,512 ha; residential land 4,948 ha; land for rivers, streams and specialized water surface 5,262 ha; remaining unused land.

In 2019, the province's population reached 590,467 people, the population density reached 181 people/km². There are 34 ethnic groups in the province, in which, Kinh people have the largest number with 432,399 people, followed by Cham people with 67,274 people, ranked third is Raglay with 58,911 people, Co Ho people with 2,860 people, 1,847 people with Chinese people, and some other ethnic minorities such as Chu Ru, Nung, Tay (Ninh Thuan General Statistic Office–GSO 2020). In 2018, the Gross Domestic Product (GRDP) reached 24,288 billion VND (1.055 billion USD), the GRDP per capita reached 39.7 million VND (equivalent to 1,724 USD), the GRDP growth rate reached 10.25%. Regarding agriculture, Ninh Thuan is famous for products such as: grapes, apples, shrimp seed, this is the locality with the largest scale of grape growing in the country, grown mainly in Ninh Phuoc, Ninh Son, and Ninh Hai districts. In addition, this locality is also a large shrimp breeding center of the country with the production scale in 2019 estimated at 33.9 billion shrimp seed (Nguyen et al., 2019).

Regarding natural disasters and climate change, studies by the Ministry of Natural Resources show that drought is the dominant type of natural disaster, occurs frequently and leaves negative impacts on the environment promote agricultural production in Ninh Thuan in the past, present and future. **Table 1** describes the area of land subject to meteorological drought at different degrees, by district in 2020. The results show that the total area of land in Ninh Thuan with mild to moderate drought is nearly 300,000 ha out of a total of 324,183 ha and distributed in all districts.

METHODOLOGY AND DATA

This study has two main objectives, including (i): to assess farmers' awareness of natural disasters impacts on agricultural activities and CSA practice they apply to adapt with disasters and (ii) to analyze factors affecting the decision to apply CSA models of farming households in Ninh Thuan province.

Toward the above objectives, the study used 3 main methods: Focus group discussion (FGD), survey and in-depth interview (**Figure 2**).

Focus Group Discussion (FGD)

Two FGDs were performed with two groups of key informants. The first FDG was conducted with managers in Ninh Thuan province in March 2021 including the Department of Agriculture and Rural Development, the Department of Natural Resources and Environment, the Department of Planning and Investment, the Office of the Provincial People's Committee and Department of Agricultural Extension of the province. This FDG helps identify natural disaster and climate trends in the province in recent years (2015–2020), impacts of natural disasters, especially on agricultural production, adaptation models that the farmers have applied in drought conditions, CSA application areas, government supports and challenges of management agencies in supporting CSA.

Through the first FDG, we have identified two drought-adapted CSA solutions that are commonly applied by farmers:

(i) Watering crops sparingly, including drip irrigation for fruit trees and perennials (grapefruit, oranges, custards, mangoes), fine-grained sprinkler irrigation techniques for vegetables and crops (purple onions, garlic, peppers, tomatoes, asparagus, aloe vera, peanuts/peanuts, green beans,...), irrigation techniques that combine both drip and spray for grapes, apples, asparagus, and aloe vera, high-altitude rain spray technique for sugarcane and industrial crops.

(ii) Solution transforming crop structure from inefficient rice cultivation to upland crops (grapes, green apples, asparagus, aloe vera, green beans, grass for livestock, and fruit trees).

The districts selected for the survey are those with the total planting area of each variety, mainly in Ninh Phuoc, Ninh Son, and Ninh Hai. The communes selected for the survey are also communes with a large area of planting each type of tree introduced by the staff in charge of agriculture. Specifically, the study identified the surveyed communes (Phuoc Son, Phuoc Hau, Phuoc Thuan- Ninh Phuoc district); (Tan Son commune, Lam Son commune, Luong Son commune- Ninh Son district); (Vinh Hai commune, Xuan Hai commune- Ninh Hai district).

The second FDG also took place in January 2020 with the audience representing 20 farmers at the hall/cultural house in Lam Son commune (Ninh Son district). Qualitative data from the participatory farmer FDG provides community-level information on local CSA production and practices, including agricultural production conditions, impacts of natural disasters on agriculture and adaptive practices to response to droughts. This data is the basis for designing the survey questionnaire.

Survey and Sampling

The household samples were selected in two stages. First, we did a household spatial mapping in each sampled commune. Then, in the second stage, we selected households in each village using simple random sampling based on a list of households provided by seven communes' People Committee. According to the GSO of Ninh Thuan General Statistic Office (2020), 10,983 households live in 8 studied communes with about 51,620 people (on average, each household has 4.7 people). The study uses the following formula (Moore 2003) to estimate the number of sampled farming households:

$$n = \frac{N}{1 + Ne^2}$$

n is the sample size, N is the total number of households in the population, e is accepted errors.

With $e = 0.05$ (estimated error is 5%), the estimated sample for reliability was 436. Thus, 436 households were chosen (3.98% of total households) for survey. To ensure the representation, in each commune, researchers selected 3.98% households for the survey. The total number of research samples is therefore allocated as in **Table 2**.

TABLE 1 | Area of meteorological drought by degree of Ninh Thuan province in 2020 (hectare).

No	Districts	Drought level (moisture level in soil)				Total
		No drought (>70%)	Medium (50–70%)	Light (30–50%)	High (<30%)	
1	Ninh Son	16,622.4	9,128.5	75,194.4	–	100,945.3
2	Bac Ai	10,412.1	–	62,257.6	–	72,669.7
3	Ninh Hai	–	6,945.6	15,721.0	–	22,666.6
4	Thuan Bac	–	22,883.3	8,857.4	–	31,740.7
5	Phan Rang	–	–	7,829.9	–	7,829.9
6	Ninh Phuoc	6,176.4	1,750.4	46,399.3	–	54,326.1
7	Thuan Nam	–	180.9	33,824.2	–	34,005.1
	Total	33,210.8	40,888.6	250,083.8	–	324,183.2

TABLE 2 | Sampling in districts of Ninh Thuan.

Commune	Population	Sampled households
Phuoc Son	6,720	57
Phuoc Hau	6,844	58
Phuoc Thuan	5,756	57
Tan Son	4,298	45
Lam Son	5,973	50
Luong Son	6,221	53
Vinh Hai	5,124	60
Xuan Hai	6,684	56
Total	51,620	436

Source: Author's processing from survey data.

The questionnaire is designed to include the following main contents: (i) socio-economic information of the household; (ii) farmers' awareness about the trends and impacts of natural disasters on agricultural production; (iii) information on specific CSA models that farmers have been implementing; (iv) information on barriers and risks in production. The study also examined the information to find out the factors influencing the behavior of the households to adopt CSA practices. The survey data collects information on the livelihood capital of households according to the DIFID framework (1999) including human capital, natural capital, financial capital, physical capital and social capital.

Survey was implemented during April and May, 2021 at the site. Four hundred and thirty six farming households were surveyed (70 households growing rice, 65 households growing green apples, 70 households growing grapes, 136 households growing green asparagus (saving irrigation and traditional irrigation), 95 households growing peanuts (64 households apply traditional irrigation method, 31 households apply economical irrigation method).

In-Depth Interview

We have implemented interviews with farm specialists, officials from the public authorities (department of agriculture at village, district, and provincial levels) and farmers. The authors has met with stakeholders in the field and discussed about CSA implementation with them. Then, critical reviews were done by comparing results of desk studies with information collected from field surveys.

In addition, we have reviewed analytical reports by professionals working in the agriculture field, especially CSA. These report and studies are still limited in quantity in Vietnam, coming from the World Bank (2016, 2019), the Government of Vietnam Government (2017), the Ministry of Health (2019), the Ministry of Agricultural and Rural Development (MARD) (2020), FAO (2016, 2019) and WHO (2019).

Model Analysis of Factors Affecting Households' Decision of Implementing CSA

The study uses a binary logit model to analyze different factors affecting the decision of farmers to apply CSA practices to adverse weather phenomena in agricultural production. The general form of the binary logit model is as follows:

$$P_i = \frac{e^{X\beta}}{1 + e^{X\beta}}$$

In which:

P_i is the probability of occurrence of an event (Yi = 1: event occurs; Yi = 0: event does not occur)
β is the vector of the parameters, and X is the vector of the influencing factors

The coefficient of marginal effect (ME) is a key tool for analyzing binary logit models. The coefficient of marginal influence is determined through the following formula.

$$ME = \frac{\partial \hat{}(X'\beta)}{\partial X} = \hat{}\left(X'\beta\right)\left[1 - \hat{}\left(X'\beta\right)\right]\beta$$

X is the matrix of independent variables in the logit model (influential factors)

β is the matrix of parameters in the logit. model

According to the above model, the decision of farmers to adopt CSA practices is a form of discrete choice (yes or no). Specifically, one (1) represents the households that apply the CSA. Conversely, zero (0) indicates non-CSA households.

This study focuses on factors related to economic characteristics, household livelihood assets as independent variables affecting CSA implementation behavior. Accordingly, the dependent variable in this study is the CSA acceptance behavior of households. The explanatory variables are based on 5 livelihood assets of households: human capital, natural capital, financial capital, physical capital, and social capital. These explanatory variables were selected based on secondary data and from the survey. Specifically, they include: age, gender, education level, ethnicity, economic conditions of the household, number of people, family agricultural labor, production experience, size of cultivated land partners/households, access to credit, level of attendance in training courses, membership in local organizations, and support policies.

RESULTS

Socio-Economic Characteristics of the Survey Sample

Survey results show that out of a total of 436 respondents, 56.9% are men, 43.1% are women; 64.1% are Kinh, 35.8% Cham, and other 10.1%. The average age of the household heads is 39 years old (**Table 3**).

On average, each household has 4.7 people with about 2.7 workers/household. The average number of years of schooling of the people is 9.3 years. The high labor rate is also favorable for apple, grape, and asparagus cultivation. These crops are all crops that require a lot of care, so the more family workers can be mobilized, the higher the income for the farmer household will be. The average income of both husband and wife is 12.6 million VND/household/month.

In terms of experience, the number of years of experience in agricultural production is generally 18.1 years. For CSA models alone, the average number of years farmers apply the model is 7.8 years. Of all the practices, rice farming households have the most years of experience with 16.3 years. Next is the grape farming households, which is understandable because vines are quite typical and traditional crops in Ninh Thuan. The remaining crops such as apples and asparagus are not newly grown, but the popularity of farming techniques has only been around 5–7 years. This change is also quite close to the extremes of climate factors occurring in Ninh Thuan from about 2012 up to now.

TABLE 3 | Socio-economic characteristics of the sample.

Indicator	Number	%	Average
Gender			
Male	248	56.9	
Female	188	43.1	
Age			
20–30	46	10.5	39.0
31–40	221	50.8	
41–50	132	30.2	
51–60	22	5.0	
>60	15	3.5	
Minority group			
Kinh	154	54.1	
Cham	236	35.8	
Others	46	10.1	
Average people in household			4.7
Number of people in labor force age			2.7
Education			
Primary	0	0.0	9.0.3
Secondary	168	38.5	
High school	244	56.0	
University	24	5.5	
Years of CSA implementation			
1–5	100	22.9	7.8
6–10	153	35.2	
11–15	112	25.8	
16–20	44	10.0	
>20	27	6.1	
Agricultural land area (*sào* = 1,000 m2)			
<5	122	28.0	5.2
5–10	244	56.0	
1–15	56	12.8	
>15	14	3.2	
Household income			
Very low (poor)	7	1.5	
Low	68	15.6	
Average	265	60.7	
Fairly high	84	19.2	
High	13	3.0	

Source: Author's processing from survey data.

People's Perception of Climate Change and Its Impacts on Livelihood

The first outcome of this study was an assessment of farmers' perceptions of climate-related shocks and their options for adapting to these climate shocks.

Farmers were asked about climate-related shocks that frequently occurred in the past 3 years from 2017 to 2020, focusing on five phenomena: drought, heat, flooding, heavy rain, and storm. The results show that drought is a phenomenon that farmers in Ninh Thuan often suffer and are severely affected (**Figure 3**).

The frequency, extent and intensity of natural disasters in localities in the province are quite consistent, mostly at about 2.5 points on the scale from 0 to 3. The higher the score implying that extreme climate events affect farmers quite severely. Drought and heat are the types of natural disasters that cause the most seriousness according to the subjective assessment of farmers. On a provincial scale, Ninh Phuoc, Ninh Son, and Ninh Hai districts are the areas with more severe climate-related shocks (**Table 4**).

Table 5 below illustrates the observations of surveyed farmers about the impact of different types of disasters on farming

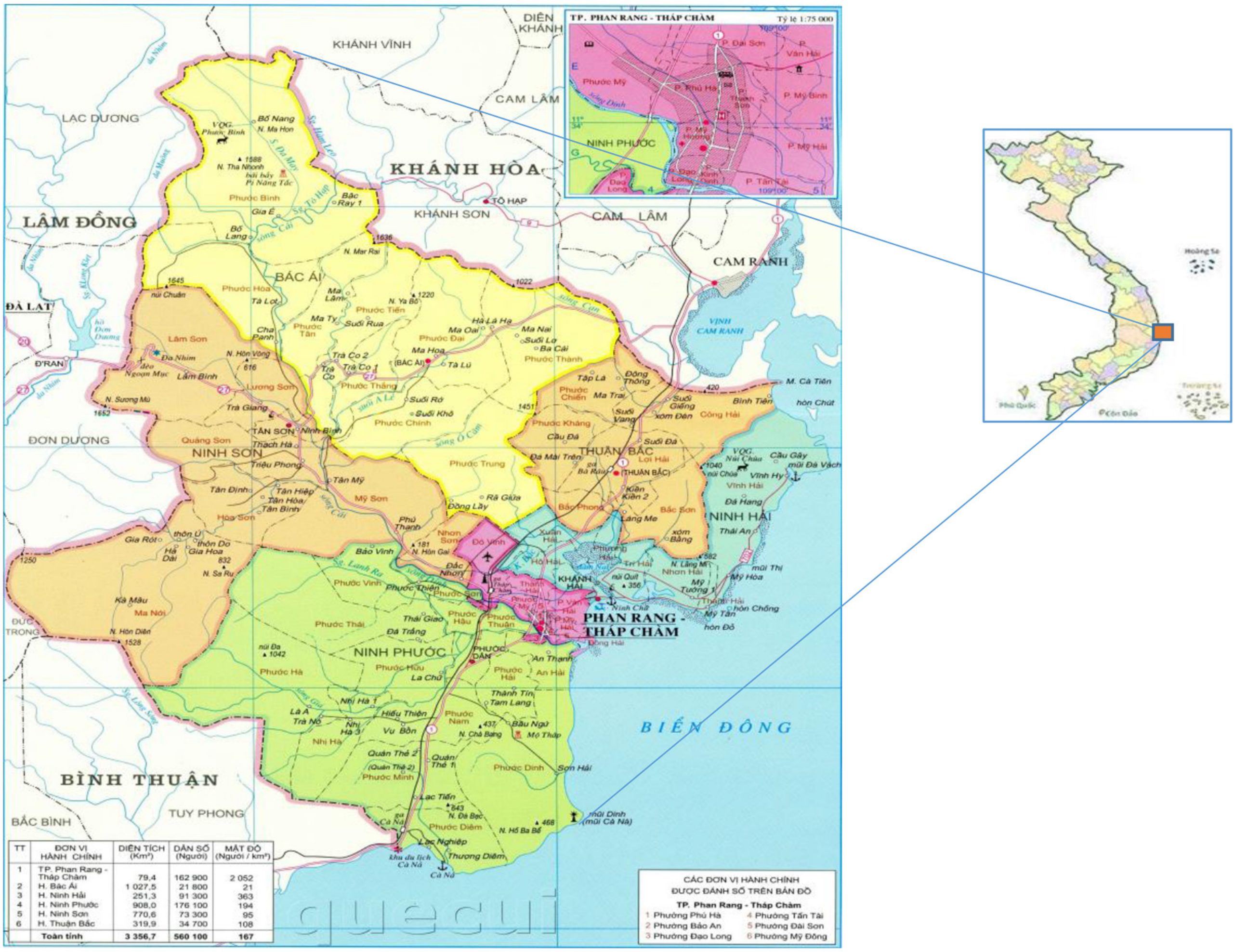

FIGURE 1 | Study area – Ninh Thuan province, Vietnam.

activities. The survey results show that there is a clear consistency and similarity in people's perceptions about the impacts of climate change on agricultural activities. Notably, changes in climatic factors have a very significant effect on planted area (shrinking area) and crop yield.

The survey results also show that people in the districts are also very aware of the local climate conditions and have changed in terms of awareness and production thinking to be able to adapt with adverse weather conditions. Specifically, over 45% of respondents have ever converted at least one farming practice. The solution related to the transformation of crop structure from inefficient rice farming to upland crops is one of the top advantages because rice farming requires huge water consumption. Another response of the majority of farmers with at least 33.9% of respondents saying that they have applied water saving models (drip irrigation, purchased sprinkler) on crops such as grapes, apples, sugarcane, custard-apple, grapefruit, vegetable crops, and livestock grass. At the same time, construction solutions such as digging more wells and ponds to water crops are also solutions that households have to implement to cope with severe drought in recent years. New cultivation techniques such as intercropping legumes with fruit trees and perennials to create moisture-retaining vegetation and improve soil fertility have also been applied (**Table 6**).

In order to reduce risks due to the impact of natural disasters, local authorities have many forecasting, notification and warning systems to the people. Specifically, through newspapers, television and loudspeakers of villages and hamlets; through phone messages, face-to-face meetings at the village, hamlet, and commune levels. **Table 7** shows the choices of farmers to respond to disaster risks and climate change in the future.

On the basis of the impacts of natural disasters, solutions for disaster warning, local government notification systems, and indigenous knowledge of the community have been applied in responding to climate change and increasing adaptive capacity. The results show that seed support is the solution proposed by the majority of local people with 86.7%. Next are solutions for capital support (78.8%) and technical support/agricultural extension (78.3%).

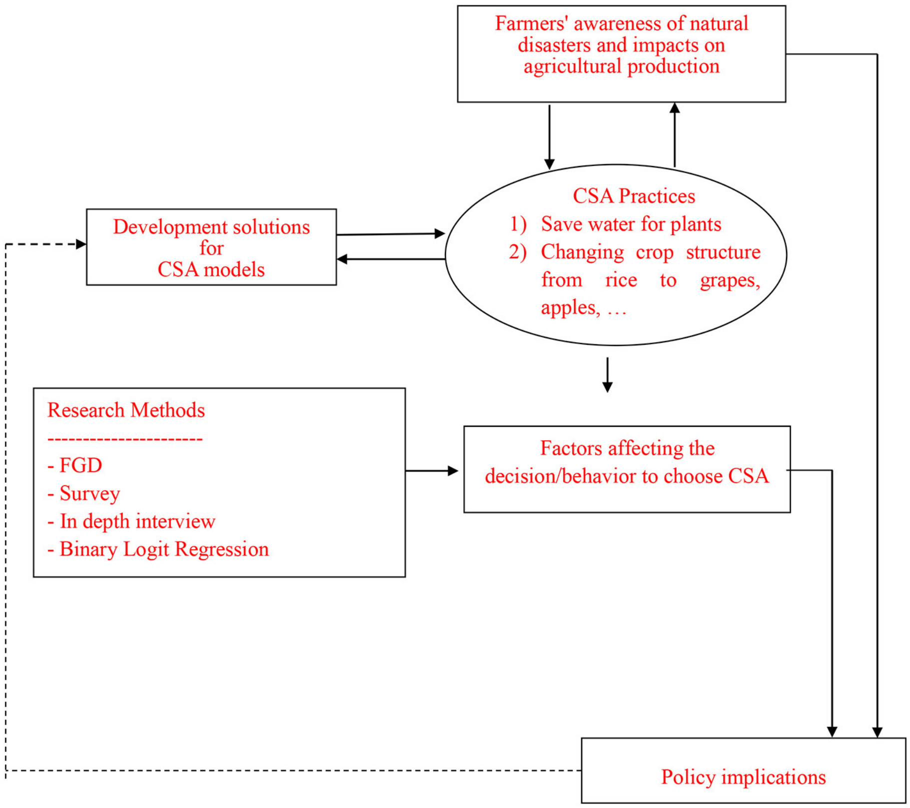

FIGURE 2 | Analytical framework of the study.

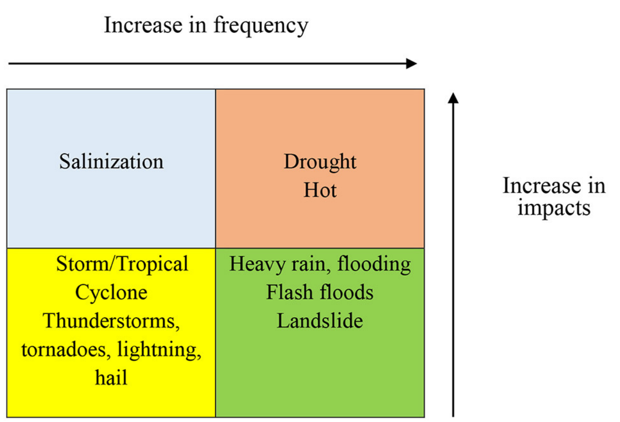

FIGURE 3 | Summary of natural disasters and pressure on agricultural production in Ninh Thuan.

Analysis of Factors Affecting the Behavior of Households in Choosing the CSA Model

The relationship socio-economic factors of household and decision to apply CSA practices to adapt weather conditions in agricultural production has been studied. We used the binary logit regression model with maximum likelihood estimation. Accordingly, the decision to apply or not to apply CSA model is a discrete dependent variable that takes two values: 0 and 1. There are 13 explanatory variables included in the model (**Table 8**). After checking for multicollinearity, there are no variables with VIF > 10, so the included variables are suitable.

The results of regression of factors affecting the behavior of farmers choosing to apply CSA are presented in **Table 9**.

Regression results (**Table 9**) show that variables including gender, ethnicity, number of family members, agricultural worker of family and agricultural production experience have $p > 0.05$, so the they do not significantly affect the decision to implement CSA of farming households.

Meanwhile, the variables of age, education, income, credit access, training attendance, and support policies all have $p < 0.05$, meaning that they have significant influence on the decision to apply CSA models. In addition, the variables of farmland size, member in local association can also be considered to have an influence on the decision of the CSA model by household (with 10% significance level).

The regression coefficient B of the independent variables has a positive sign, therefore, when the variables include access to credit, attendance at training and support policies, it will increase the probability of decision making to apply CSA models.

In addition, the value of Exp(B) shows the degree of impact of significant variables on the potential to apply the CSA model.

TABLE 4 | Awareness of natural disasters by farmers in Ninh Thuan.

Disaster	% household			Frequency			Average severity		
	Ninh Phuoc	Ninh Son	Ninh Hai	Ninh Phuoc	Ninh Son	Ninh Hai	Ninh Phuoc	Ninh Son	Ninh Hai
Drought	73.3	51.4	49.5	1.90	1.77	1.68	2.49	2.58	2.38
Hot	39.9	34.9	21.3	1.53	1.43	1.42	2.57	2.60	2.65
Heavy rain	24.7	16.1	16.3	1.04	1.03	1.01	1.30	1.09	1.4
Storm	11.3	23.3	19.2	1.00	1.00	1.03	1.00	1.01	1.00
Flood	17.7	16.3	23.2	1.03	1.05	1.00	1.30	1.34	1.40

Source: Author's processing from survey data.

TABLE 5 | The impact of climate change crop production and adaptation measures by farmers' perceptions (% households).

Impacts	Ninh Phuoc	Ninh Son	Ninh Hai
Impact on the farming sector	**78.1**	**67.7**	**68.5**
Lower productivity	60.1	48.5	61.3
More likely to lose crops	50.7	37.8	46.5
More diseases and pests	25.6	38.9	28.9
Exacerbation of drought stress	27.1	26.9	22.2
Cultivated area is shrinking	57.8	49.7	45.5
Adaptive solutions	**50.7**	**49.7**	**44.8**
Plant cover crops/cover crops to improve soil nutrition and retain soil moisture	16.7	19.7	11.8
Efficient management and use of water resources	40.8	35.2	33.9
Management of input chemicals (fertilizers, pesticides)	11.2	21.0	15.9
Structural transformation/crop diversification	48.6	57.8	46.0
Use adaptive/tolerant varieties	20.7	29.8	18.9
Construction solutions (digging wells, reservoirs,...)	11.9	20.1	15.9
Other (seasonal adjustment, land cover, crop rotation, intercropping)	6.9	4.7	3.2

Source: Author's processing from survey data.

TABLE 6 | Changes in field/garden management practices under drought conditions in the period 2017–2020 in Ninh Thuan.

Criteria	2017	2020	*p*
Crop conversion (% of households)	50.6	67.3	0.00
Increase the amount of input chemicals used (% of households)	89.9	70.1	0.02
Digging wells and ponds to store water (% of households)	30.0	43.0	0.07
Applying economical irrigation techniques	26.7	37.8	0.03
Percentage of arable land of each household that is fully irrigated according to needs	67.0	65.6	0.08
Percentage of crops irrigated	20.9	23.7	0.00

Source: Author's processing from survey data.

TABLE 7 | Choice of local people on solutions to respond to climate change/natural risks.

	Building warehouses and storage yards for post-harvest	Invest in production infrastructure	Technical support/agricultural extension	Capital support	Seed support	Support stabilizing output markets
Select (%)	70.5	59.8	78.3	78.8	86.7	63.7
Not select (%)	29.5	40.2	21.7	21.2	13.3	36.3

Source: Author's processing from survey data.

TABLE 8 | The explanatory variables in the binary logit model.

Variable	Symbol	Unit	Average (n = 436)	Std Dev
Age of respondents	AGE	year	39.6	8.73
Gender	GENDER	1 = male, 0= female	0.45	0.49
Education level	EDU	1 = Primary; 2 = Secondary; 3 = High school, 4 = University	2.6	0.75
Ethnic group	ETH	1 = Kinh, 2 = Cham, 3 = Others	1.49	0.67
Income	INCOME	1 = very low, 2 = low, 3 = average, 4 = fairly high, 5 = high	2.63	0.88
Members in household	MEMBERP	person	4.70	1.65
Agricultural labor in household	AGRILABOR	person	2.57	1.14
Agricultural production experience	EXP	year	18.1	10.5
Crop area/household	AREA	*Sao* (1,000 m2)	5.2	2.71
Credit access	CREDIT	1 = yes	0.47	0.49
Training participation	TRANING	1 = yes	0.55	0.49
Member in local associations	MEMBER	1 = yes	0.54	0.49
Support policy	SUPPORT	1 = yes	0.57	0.49

Source: Author's processing from survey data.

Thus, there are three important factors that positively affect the probability of applying CSA models of households, including access to credit, attendance at training, and support policies. In addition, the two variables of the size of the arable land of each household and the economic conditions of the household are also factors that significantly affect the ability to apply CSA models.

TABLE 9 | Results of binary logit regression.

	B	S.E.	Wald	*df*	Sig.	Exp (B)
Age	−0.037**	0.029	1.655	1	0.043	0.964
Gender	0.161	0.252	0.408	1	0.523	1.174
EDU	0.447**	0.169	7.019	1	0.038	1.564
ETH	−0.174	0.181	0.932	1	0.334	0.840
Income	0.327**	0.142	5.313	1	0.021	1.387
Person	0.009	0.107	0.008	1	0.931	1.009
Agrilabor	0.267	0.151	3.111	1	0.678	1.305
Exp	0.020	0.023	0.725	1	0.395	1.020
Area	0.128*	0.047	7.320	1	0.071	1.137
Credit	1.563**	0.249	39.430	1	0.018	4.775
Traning	1.193**	0.242	24.205	1	0.043	3.295
Member	0.516*	0.243	4.513	1	0.064	1.675
Support	1.423**	0.256	31.018	1	0.036	4.151
Constant	−4.491	1.117	16.169	1	0.000	0.011

*(**Significant at 5% level, *Significant at 10% level).*
Source: Author's processing from survey data.

DISCUSSIONS

In general, the survey results on farmers' perceptions of climate change show that people are aware of and have experienced changes in weather and climate factors in the area. These changes cause the impact to be considered moderately severe. At the same time, there are also significant similarities between awareness and actions to cope and adapt to these disadvantages. If compared with the actual statistics of Ninh Thuan province on the area of crop structure conversion from rice to upland crops and the actual crop area with economical irrigation, it can be seen that shows the correlation between changes in climate factors and adaptation actions of households.

Although, farmers are aware of the impacts of adverse weather conditions on crops and have made positive changes in the field to better adapt, but this rate is still limited. Changing crop types is a popular practice among farmers in the hope of greater efficiency. There are 67.3% of the households surveyed have had at least one farming change in the last 3 years. That positive shift also seems to come with farmers using less chemicals for the farming process. Measures to store and save water for crop irrigation tend to increase reflecting the harshness of natural conditions. The crop area that is supplied with the necessary amount of water for growth and development tends to decrease slightly. Most crops are still irrigated according to traditional methods and with a focus on a few staple crops.

Farmers' age and education significantly affect the application of CSA in agricultural production in Ninh Thuan and this result is consistent with the study of Nhhemachena and Hassan (2017). Age and production experience can negatively influence the decision to adopt new technology because older farmers are often more risk averse than younger farmers and are therefore less likely to adopt the technology. The study showed that ethnic minorities are less likely to invest in climate change adaptation measures. Educational attainment is proved to increase the probability of CSA application. Evidence from previous studies shows a positive influence of the education level of the household head on the decision to adapt to climate change. Household characteristics used to explain adaptation decisions include economic conditions, number of people, number of employees, size of arable land and income. In this study, household economic status (e.g., income and poverty level) and resources (e.g., land size) also influence the application of CSA models (Tran et al., 2019). Meanwhile, household size and number of employees are found to have a positive effect as the chances of obtaining information increase with the number of household members (Deressa et al., 2008). Level of attendance at training, training and membership in a socio-political organization are found to have a positive impact on adaptation decisions (Salvini et al., 2016). It is considered a kind of social capital for farmers and as a member of this organization, the head of household may have more opportunities to learn new farming methods than other members. Access to credit and support policies are the basis and motivation for farmers to boldly invest and pursue their livelihood goals.

Regarding the challenges promoting the application of CSA in Vietnam, through in-depth interviews with managers and farmers, the study identified the following challenges:

Firstly, the level of investment in agriculture and rural areas is still limited and scattered, not commensurate with the potential and contribution of the industry to the national economy, so the rural technical infrastructure is still very poor and inadequate, not meeting development requirements, especially technical infrastructure directly serving CSA. For example, Vietnam's irrigation system is judged to be inefficient, with no water quality measurement system and no flow control system; water productivity is low (World Bank, 2016). Agricultural support services are also underdeveloped, especially in post-harvest preservation and logistics. The processing industries of agricultural products have not yet developed. Most of them are small-scale, with outdated technology that leads to low quality of agricultural products when exported with small added value. Supporting the connection to form a chain of production—distribution of key agricultural products is still facing many difficulties. The agricultural product trading system only focuses on traditional or highly profitable industries such as rice, rubber, coffee, pepper, and cashew. Although "agricultural product exchanges" have been established, their activities are still limited and not substantial.

Secondly, regarding climate data, in many provinces, long-term data on climate and disaster risk are lacking. In some places, data is very difficult to access, especially for managers and farm households. Climate data and models are developed at the national level, but when translated into local data, they are general and difficult to interpret for local managers. In addition, localities also do not have parts to build climate models and long-term climate forecasts for localities, making it difficult to transfer data from central to local levels. Due to the lack of information on the potential impacts of climate change on agricultural activities in the future, it is difficult for local managers to plan management and support farmers in CSA implementation.

Moreover, although the agricultural extension system in Vietnam is well-invested and quite effective, it still faces many limitations. The information guidance is traditionally carried out (from the central to the grassroots level) rather than encouraging participation. There has been a shortage of exchange, experience sharing among farmers, and field training. However, innovations in agricultural consulting services such as providing information based on farmers' needs can significantly impact.

Restrictions in land policy are also significant barriers to the development and replication of CSA in Vietnam. Unsecured land tenure impedes large investments in agriculture. According to the Constitution, the land is owned by the Government and managed by the Government. Land use rights are granted to individuals for a specific period and can be canceled in land acquisition projects. In addition, the Government's tight control in land use is also a factor limiting the ability of households to diversify crops. The land-use policy is mainly formulated to protect the rice land. Although since 2015, the Government has granted farmers and local authorities more flexibility in converting rice land to land for other agricultural products or adopting crop rotation. However, this policy still limits the ability to alter land use to more economical forms of production, such as growing fruit trees.

CONCLUSIONS AND RECOMMENDATIONS

This study showed that local farmers in Ninh Thuan have a high awareness of natural disasters trends and impacts on agricultural livelihoods. Facing with disasters in the context of climate change, farming households have applied some models of CSA such as minimal tillage, intercropping, crop rotation, crop transformation and the use of plant varieties. Binary logit regression analysis indicated that age, education level, household income, membership of local associations, training attendance, and support policies were the variables that significantly influenced the decision to apply CSA of farmers. Challenges for CSA adoption include lack of capital, information, technical support and land ownership institutions. From the results, the article proposes some recommendations to promote and replicate CSA models in Ninh Thuan and Vietnam, as follow:

Firstly, raising awareness for all social classes from managers, the business community and people about the role of CSA production development; bringing CSA development to integrate into socio-economic development policies and strategies from national to local and sectoral levels.

Secondly, establishing and strengthening institutions, supporting the development of a network of suppliers of "inputs" and services in agriculture such as repair of agricultural machinery and equipment, efficient use of raw, environmentally friendly; providing and maintaining climate-appropriate genetic resources; giving financial support, setting up linkage and harmonization between finance for climate change and traditional agricultural finance through promoting the public-private partnership model in agriculture.

Thirdly, continuing to implement experimental models and focus on deploying CSA models in selected areas, applying science and technology in line with reality; restructuring forms of agricultural production organization in rural areas, develop individual households into small enterprises or household associations under the management of a large enterprise; building a value chain, from manufacturers to supermarkets to be the outlets for products.

Fourthly, training human resources for CSA development such as technical staff, managers for the DARD, agencies under the Department and localities, agricultural enterprises; and strengthening the capacity of researchers and technology experts in high technology in agriculture.

Lastly, improving CSA international collaboration. Many foreign organizations have in recent times supported the implementation of CSA by Vietnam. Therefore, Vietnam should enhance the investment climate and encourage greater involvement from international organizations and foreign industries to make the CSA more effective. This would mean that Vietnam will benefit from these changes.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

DD and TT developed the theory, supervised the findings of this work, and performed the computations. LH verified the analytical methods. All authors discussed the results and contributed to the final manuscript.

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