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Gender-Differentiated Impacts of Salinity Intrusion on Agricultural Production and Food Security

A Study in the Mekong Delta, Vietnam

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Agricultural production is a major economic sector in Vietnam, and the Mekong Delta is one of the two main rice-producing regions of the country. Yet, climate change, extreme climate events, and recent salinity intrusion are growing concerns for the delta. It is important to control soil salinity through drainage and water management practices to avoid loss of production. This study investigates the gender-differentiated impacts of salinity intrusion on agricultural production and food security and suggests policy interventions for effective adaptation that can contribute to sustainable livelihoods for local farmers. For the study, we surveyed 430 farm households, including 274 male-headed and 156 female-headed households, in three rice-producing provinces in the delta. The survey data are employed to examine how salinity intrusion has influenced rice production, farmers' income, farm households' food expenditure, and their consumption of selected main foods. This study finds that the high yield loss due to salinity leads to a significant reduction of income, food expenditure, and consumption of some main foods. The findings show that training initiatives on salinity intrusion and adaptation have enhanced rice production and incomes of participating farmers. At present, fewer females participate in training. Technical support for farmers, including more effective training initiatives, with flexible schedules, may help to avoid crop loss. Government authorities should also promote research on rice varieties that are well adapted to salinity and local conditions, and these varieties should be introduced in high-saline regions.

Keywords: Agriculture, Farmers, Food security, Mekong Delta, Salinity intrusion, Vietnam

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1. Introduction

The impacts of climate change on agricultural production and rural livelihoods are real and increasing worldwide. Salinity intrusion has had profound impacts on agricultural production and food security. These impacts include a decrease in crop production (Rabbani et al., 2013); a decline in agrobiodiversity, rising food prices, and adverse effects on nutritional status and health (Rahman et al., 2011); soil infertility, and reduced economic opportunities (Lam et al., 2021); and an increase in labor costs, fertilizer and pesticide expenses, and yield and income loss (Khanom, 2016). Such impacts are particularly severe for developing countries and the rural poor. Salinity triggers food insecurity in these countries (Lam et al., 2021). Income loss due to salinity intrusion forces farmers to consume non-sticky and small-grain rice varieties, with reduced nutritional value since they cost less. Lower income also makes rural people limit the use of vegetables, meat, milk, eggs, and fish to reduce family expenses (Rahman et al., 2011).

In the Mekong Delta, Vietnam, agricultural production, including rice production, has been affected substantially by a rise in sea levels and salinity intrusion. The observed salinity is increasing, and salt water increasingly encroaches on rivers and land (Khong et al., 2020). The impacts of salinity intrusion on agricultural production and food security can include yield loss or failure, decreasing quality of agricultural products, farm income loss, and reduction in food expenditure and food consumption (Dam et al., 2019b; Hoque et al., 2013; Khanom, 2016; Miah et al., 2020; Mishra et al., 2016; Nguyen et al., 2017; Phan & Kamoshita, 2020; Tran et al., 2021).

Worldwide, female farmers are involved in activities to adapt to climate change (Carvajal-Escobar et al., 2008). However, female farmers often have limited access to resources that would help them adapt their agricultural production to climate-related risks (Jost et al., 2016). Males and females have been affected differently by environmental stressors in several areas, such as food security, health, education, migration, and access to resources (Chaudhury et al., 2012; Goh, 2012; Huynh & Resurreccion, 2014; Pham et al., 2016). Substantial gender disparities in access to education, credit, land ownership, and off-farm jobs remain in rural areas, with the result that climate change impacts differ for male and female farmers (Bayard et al., 2007; McKinley et al., 2016). The household responsibilities of women exacerbate these differential impacts (Dankelman, 2008). Crop yields may be influenced by the unequal access to agricultural resources between male and female farmers (FAO, 2011).

Women may suffer more food insecurity than men under climate change (Goh, 2012). Because of yield loss from salinity, farmers in Bangladesh could not afford agricultural input costs and family-related expenditures (Khanom, 2016). Males have moved to urban centres or other rural areas with better agricultural job opportunities, while females have stayed and become involved in non-agricultural activities (Lam et al., 2021). According to Goh (2012), these women have had to pawn their crops, borrow money, and sell cloth, utensils and jewellery to buy food. They are forced to consume rotten food and may have difficulties breastfeeding due to malnourishment (Lam et al., 2021).

While gender-differentiated impacts of climate change on agricultural production and food security have been examined in past studies (Arora-Jonsson, 2011; Carr & Thompson, 2014; Goh, 2012; Huynh & Resurreccion, 2014; Pham et al., 2016), there has not been any research on the gender-differentiated impacts of salinity intrusion in the Mekong Delta, the major rice-producing region of Vietnam. This study therefore investigates the different impacts of salinity intrusion on agricultural production and food security for women and men and suggests policy implications for helping both male and female farmers in dealing with salinity intrusion in local areas.

2. Materials and methods

2.1 Research sites and data collection

The Mekong Delta has an important role in producing rice for Vietnam, with 50% of rice production (Wassmann et al., 2004) and 90% of rice exports (Yen et al., 2019) for the country. About 80% of the delta population are involved in rice farming. Yet, the Mekong Delta is also the region most vulnerable to climate change in Southeast Asia (Yusuf & Francisco, 2009). One special feature of the delta is its complex system of canals and rivers (Nguyen et al., 2007). It is also just two meters above sea level (Wassmann et al., 2004). Those features make the delta the region of Vietnam most vulnerable to a rise in sea level and salinity intrusion (Nachmany et al., 2015; Smajgl et al., 2015). The projected sea level rise of one meter by 2100 could inundate more than 30% of the delta. Salinity intrusion has increased in both frequency and magnitude (Nguyen et al., 2019) and has moved further inland (Bergqvist et al., 2012). In addition, the area has experienced severe drought in recent years (Sebastian et al., 2016).

Insert Figure 1 here

To investigate the effects of salinity on farm households in the Delta, we conducted a farm household survey in three coastal provinces: Tien Giang, Ben Tre, and Soc Trang. Rice production in those provinces has been significantly influenced by salinity intrusion (Wassmann et al., 2019). One district and then one commune were selected in each of the provinces for the survey (see Table 1). We selected districts and communes in which rice has been grown in recent years and which have experienced recent severe salinity intrusion. With the support of local authorities, rice farm households within each commune were randomly selected for the survey.

Insert Table 1 here

After being trained, 10 enumerators were sent to the research areas to conduct the rice farm household survey. The survey was conducted in September and October 2020. We interviewed the heads of both male-headed and female-headed farm households. To be eligible to participate in the survey, farm households must have been affected by recent salinity intrusion. Local farmers were invited to meeting rooms in each commune for the interviews. The final sample size was 430 households, including 274 male-headed and 156 female-headed households. The average amount of time for each interview was one hour.

We used a structured questionnaire for the survey. The questionnaire included questions regarding farmers' perception of salinity intrusion, public adaptive measures, individual households' adaptive measures, local supporting activities regarding rice production and adaptation, the characteristics of farm households and rice production, and households' income and expenditure. Three expert interviews were conducted at the early stage to contribute to develop the questionnaire. Ten randomly selected households were interviewed as a pre-test and information from the pre-test was used to refine the questionnaire.

2.2 Theoretical background

While the gender-differentiated impacts of climate change have recently attracted much interest worldwide, a qualitative approach has most frequently been employed to examine these impacts (Abbasi et al., 2019; Acosta et al., 2019; Goodrich et al., 2019; Huynh & Resurreccion, 2014; Pham et al., 2016). There is limited empirical evidence on such impacts. Past studies were often limited in geographic scope and are therefore highly contextual. A limited body of work has only provided a broad overview of gender considerations in the climate change context. It is therefore important to produce sound empirical evidence on these impacts and also with a wide geographic scope (Goh, 2012).

Goh (2012) reviewed the gender-differentiated impacts of climate change related to agricultural production, food security, health, water and energy resources, climate-related migration and conflict, and climate-related natural disasters. This author identifies three main impacts on agricultural production. First, climate variability has decreased agricultural production. This reduction in crop yield may affect women and men differently due to differences in their involvement in farming practices and exposure to climate risks. Goh (2012) found mixed empirical results regarding differences in possession of assets and capital for men and women in relation to climate risks. Second, women may be more affected by climate variability related to time spent on and labour used in agricultural production. Third, differences in access to information and agricultural inputs for men and women may be important regarding mitigating the risks of increased climate variability.

Some studies have found different effects of climate change on agricultural production for men and women. Aryal et al. (2020) and Jordan (2019) found that gender inequality and discrimination made women more vulnerable to climate risks in some developing countries. According to Bayard et al. (2007), increased climate variability exacerbates the differences in access to information and agricultural inputs for men and women. Climate variability may result in climate-induced migration, in which men are more likely to move to less affected areas. In that case, the role of women within a household changes, as they have to undertake both agricultural work and home-related tasks (Goh, 2012).

2.3 Empirical model

While a growing body of literature has focused on the impacts of salinity intrusion on agricultural production and food security (Ahmed & Haider, 2014; Alam et al., 2017; Dam et al., 2019b; Dasgupta et al., 2018; Hoque et al., 2013; Khanom, 2016; Miah et al., 2020; Mukhopadhyay et al., 2021; Nguyen et al., 2017; Phan & Kamoshita, 2020; Tuong et al., 2003), there are limited salinity-related studies that incorporate gender differentiation issues.

Commonly used techniques to estimate the impacts of salinity intrusion on agricultural production and food security include the Cobb-Douglas production function (Ahmed & Haider, 2014), varietal portfolio analysis and yield variance regression (Dam et al., 2019b), and panel regression (Dasgupta et al., 2018). Some studies have approached the topic by using qualitative analysis and case studies. This study uses the Cobb-Douglas production function to estimate the impacts of salinity intrusion, socio-economic characteristics of farm households, and institutional factors on agricultural production and food security. Gender differentiation is also involved in these analyses. The Cobb-Douglas production function is characterized as follows.

$$Ln(Y) = \alpha_0 + \alpha_1 Ln(X_1) + \alpha_2 Ln(X_2) + \cdots + \alpha_n Ln(X_n) + \beta_1 D_1 + \beta_2 D_2 + \cdots + \beta_n D_n$$

where α_0 is the intercept; α_1,… α_n are the estimated coefficients for continuous variables; and β_1,… β_n are the estimated coefficients for dummy variables. Explanatory variables include demographic variables, socio-economic and farming characteristics of farm households, institutional conditions, social capital, and salinity-related variables. We run the regression models for dependent variables that represent agricultural production and food security. They are rice yield, annual farm household income, food expenditure, and the extent of consumption of selected main foods (rice, vegetables, and meat). We employ the rice yield in 2019, the most recent year that salinity intrusion has seriously affected rice production in the research sites. The regression models were run for the whole sample (430 observations) and selected models were run separately for the 274 male-headed households and 156 female-headed households.

We use similar independent variables in the food security models. Additional variables are the percentage of time allocated to farming, livestock production and other jobs, participation in formal institutions, and the extent of the effect of salinity on farm households' total income and total expenses.

Independent variables in all regression models include demographic variables (age, gender, level of education), socio-economic characteristics (household size, time allocation for farming, livestock production, and other jobs), farming characteristics (experience, rice farm size, land tenure), institutional support (extension services, credit access, training in salinity adaptation), social capital (formal participation in institutions), and salinity-related variables (distance from rice field to the nearest saltwater prevention sluice, perception of salinity intrusion, yield loss due to salinity in 2019, and the extent of the effect of salinity on farm households' total income and total expenses). Independent variables differ in different regression models. All variables are presented in Table 2.

Insert Table 2 here

Three dummy variables representing institutional conditions were employed. The first is the participation of farm households in extension services. The second is the participation of farm households in training on adaptation to salinity intrusion. The third is farm households' access to formal credit. One dummy variable representing social capital was employed, which is farm households' participation in formal institutions.

Five salinity-related variables were used as proxies for salinity intrusion in the research areas. They are the distance from rice farms to the nearest saltwater prevention sluice, farmers' perceptions of salinity intrusion in local areas, the percentage of rice yield lost due to salinity in 2019, and the extent of the effect of salinity on farm households' total income and on living expenses. Farmers' perceptions on salinity intrusion in local areas were measured by asking farmers how much they agree with five different statements, using a 7-point Likert scale. Those statements are about the frequency, magnitude, and the severity of salinity intrusion in local areas. We took an average of the responses to the five questions as a measure of farmers' perceptions of salinity intrusion. Farm households were also asked to assess how much salinity intrusion has affected their total income and living expenses.

3. Results and discussion

3.1 Farm household characteristics

About 64% of the households in the survey are male-headed, and 36% are female-headed. The average age of household heads is 52, with 18 and 81 as the youngest and oldest. Rice farming has mostly been transferred from parents to their children in a family tradition. There has been limited take-up of education in the research sites, even though public education services have been available. The average education level of household heads is approximately grade 7. Household size ranges from 1 to 11 members, with the mean at 4.2. Since rice cultivation was originally labour-intensive, it has been common to have large households in rural areas. The average rice farming experience of farm households is 29 years. Some farmers have been involved in rice farming since they were very young, and thereby have extensive experience in rice production. While the largest rice farm is about 17 hectares, the typical rice farm is 0.8 hectares on average. Around 30% of rice farm households rent land.

More than 74% of the farm households in the sample have participated in extension services. The most common reasons for not participating in those services were no access or no time. Those services were evaluated as 5 to 7 on a 7-point scale (from 1- little benefit to 7 – much benefit) by over 90% of the farmers interviewed, implying a high level of benefit. In contrast, only about 36% of the households have attended training on adaptation to salinity intrusion.

Although 50% of farm households in the sample have access to both formal and informal credit, according to the experts interviewed, the formal credit is most used. However, farmers claim that the paperwork required and limited support from local authorities make it difficult for them to borrow money from banks.

The mean distance from rice farms to the nearest saltwater prevention sluice is about 4.6 km, with 40 as the maximum distance. Almost all farmers have considered the problem of severe salinity intrusion in their areas. In 2019, some farm households lost their entire rice crop. The average rice yield loss is approximately 48% (compared to the year without salinity intrusion). The extent of the effect of salinity on farm households' total income and living expenses was in turn 5.6 and 5 on the 7-point scale (from 1 – little influence to 7 – much influence), which is considered serious.

We use similar independent variables in the food security models. Additional variables are the percentage of time allocated for farming, livestock and other jobs, participation in formal institutions, and the effect of salinity on farm households' total income and total expenses. The average percentage of time farmers allocate for farming, livestock production and other jobs is about 47%. The maximum is 90%. Around 63% of farmers have joined formal institutions such as the Farmers' Unions, Women's Unions, or Veterans' Associations.

These findings seem to be interrelated. When farmers spend all their time working several jobs, they do not have time to join formal institutions.

3.2 Factors affecting rice production

The rice production regression models were run for the whole sample (n=430) and separately for male-headed (n=274) and female-headed (n=156) households. Overall, similar results were found for the three models. Rice farm size positively affects rice yield per hectare, suggesting possible increasing returns to scale. A larger farm allows farmers to mechanize, which could save time and labour, thereby increasing efficiency and contributing to a higher yield. Farm households who use rented land have lower rice yields. This might be because land ownership is important in providing farmers with legal rights to invest in their land. Farmers may not want to invest in land that belongs to others.

Salinity intrusion has negative impacts on rice yield when modelled for the whole sample and separately for male-headed and female-headed households. If farmers perceive salinity intrusion to be more severe, they harvest less rice. Although farmers' perceptions of salinity intrusion was used as a proxy for salinity intrusion, the results are consistent with the findings of Ahmed and Haider (2014). These authors concluded that rice production and net returns decreased with an increase in soil salinity. Two other studies in Vietnam confirm that saline water intrusion has probably had negative impacts on rice yield (Dam et al., 2019b; Dam et al., 2019a). Dasgupta et al. (2018) find that an increase in soil salinity decreases rice output. Greater distance from the rice farm to the saltwater prevention sluice also lowers rice yield. The rationale is that, if the rice farm is close to a saltwater prevention sluice, farmers have convenient and timely access to irrigation water of suitable quality.

Farmers who participated in training on salinity intrusion adaptation had higher yields. This suggests that the training program has some positive, though small, effects (see Table 3). There was a difference in the effect for the full sample, male-headed, and female-headed households. While participation in training on salinity intrusion adaptation is statistically significant for the full sample and the sample of male-headed households, it is not significant for female-headed households. Participation in training on salinity intrusion adaptation was particularly useful in increasing the rice yield of male farmers (see Table 4). This result seems reasonable since 90% of farmers who have used extension services rated them as useful. That this variable is not significant for female-headed households may be linked to the finding that these households have less access to local social activities and extension services. Approximately 39% of female farmers reported that they have not participated in any extension services, compared to 18% of male farmers. Nearly 77% have not attended any training on salinity intrusion adaptation, compared to 57% of male farmers. The most common reasons given by female farmers for not participating in extension services were no access, not enough time, and that their husbands had joined. It appears that such activities were considered the responsibility of husbands, even if the women oversaw the farm. Female farmers may not have time for training because of housework duties. They may also not have enough education to absorb the knowledge. The findings imply that training on salinity intrusion adaptation can be useful, though the data are insufficient to prove that they are equally useful for everyone. Female farmers could benefit from more information on training, flexible training schedules and transport to attend training sessions.

Insert Table 3 here

Insert Table 4 here

3.3 Factors affecting food security

Five regression models are used to investigate the impacts of salinity intrusion on food security. Food security is represented by farm households' income, food expenditure, and the amount of consumption of three main foods: rice, vegetables, and meat. We run all five models for the full sample. Additionally, male-headed, and female-headed households are compared in terms of their differences in food expenditure and amount of meat consumption.

In the farm household income model for the full sample, farmers' perception of the effect of salinity on their household income negatively influences the farm households' income. If these perceptions are reasonable estimates of salinity intrusion, then salinity intrusion has reduced farmers' incomes. Higher yield loss implies lower income. Training on salinity intrusion adaptation positively affects farm households' income. Farmers with more experience in rice cultivation, which may mean more experience in adaptation to salinity intrusion, have higher incomes. An increase in the percentage of time that farmers allocate to farming, livestock production, and other jobs produces a small but significant increase in income.

Insert Table 5 here

The food expenditure model for the whole sample (see Table 6) shows that an increase in rice yield loss reduces a farm household's expenditure on food. Higher income increases expenditure on food. The findings are similar in the model for male-headed households (Table 7). Extreme rice yield loss is associated with lower food expenditure. There are differences between male and female-headed farm households in the food expenditure model. Where the effect of salinity on household income is perceived to be large, this perception is associated with increased food expenditure in the model for female-headed households. It is not significant, though, in the model for male-headed households. It can be inferred from this result that female farmers' involvement in household management means they have had to plan for food expenditure. When female-headed households are aware of serious salinity impacts on farm household income, they were more likely to stock up on food.

Insert Table 6 here

Insert Table 7 here

The rice consumption model for the full sample showed a positive significant relationship between rice consumption and the following explanatory variables: farmers' perception of the effect of salinity on household income, household size, and the percentage of time allocated for farming, livestock production, and other jobs. Farm households who perceived the effect of salinity as large had higher rice consumption. In addition, the impacts of yield loss and household income on rice consumption were negative and significant. That is, while an increase in yield loss reduces farm households' rice consumption, a higher income reduces the households' rice consumption, perhaps because these households consume more meat and vegetables.

Insert Table 8 here

In the vegetable consumption model for the full sample (see Table 9), more vegetable consumption was associated with a perception of a stronger effect of salinity on household income, greater distance from the rice farm to the nearest saltwater prevention sluice, and higher household income. It is reasonable that high income households would increase their consumption of vegetables instead of rice. Rice can be considered as an inferior good. Higher yield loss appears to lead to less vegetable consumption. Possibly greater yield loss forces farmers to balance their living expenses, and vegetables may not be a high priority.

Insert Table 9 here

In the meat consumption model for the full sample (Table 10), higher yield loss leads to a reduction in meat consumption, though income does not have a statistically significant effect. Perhaps yield loss captures the effect of lower income. Unique among the food security models, the gender variable appears statistically significant in the meat consumption regression, with more meat consumption for male-headed households. Yield loss significantly decreases meat consumption in the model for male-headed households while it is not significant in the model for female-headed households (Table 11). Male farmers are more involved in farming activities and off-farm jobs, while female farmers are more involved with housework. Because of their different roles in farming tasks and different levels of access to various resources, female farmers seem not to be affected by yield loss in the meat consumption model.

Insert Table 10 here

Insert Table 11 here

4. Conclusions and policy implications

This study examines how salinity intrusion has influenced farm households in the Mekong Delta in terms of rice production, household income, food expenditure, and consumption of selected main foods, and examines possible gender differentiation. We find that farmers who participate training on salinity intrusion adaptation enhanced their rice production and income. Male farmers participated in these training initiatives more than female farmers. Flexible training schedules may improve access to training for farmers whose time is limited by having off-farm jobs, and female farmers who have family responsibilities. Ensuring training venues are convenient for access could also assist farmers in the research sites who do not have transport means.

It was also revealed that farmers who perceived the effect of salinity intrusion as serious suffered greater rice yield loss. Here farmers' perceptions seem to reflect a high level of salinity intrusion which has motivated farmers to change part of their rice farms to other crops or to find alternative adaptation measures. The involvement of relevant stakeholders (e.g. local authorities, agricultural experts) in identifying potential land use and sustainable use of resources is also required to ensure sustainable development of rice farming in this region.

Protecting rice yields in the Mekong Delta will require controlling soil salinity. Local authorities can provide technical support for farmers to mitigate salinity impacts. They can also promote research to identify or develop and introduce salt-tolerant varieties of rice and make them available to farmers in highly saline regions.

The results of this study also show that the high percentage of rice yield loss due to salinity leads to a significant reduction in household income, food expenditure, and food consumption. The reduction in the consumption of vegetables and meat shown as an effect may have adverse nutritional impacts, increase vulnerability to diseases, and ultimately contribute to food insecurity. Thus, avoiding yield loss due to salinity intrusion may have significant effects on farmer's welfare.

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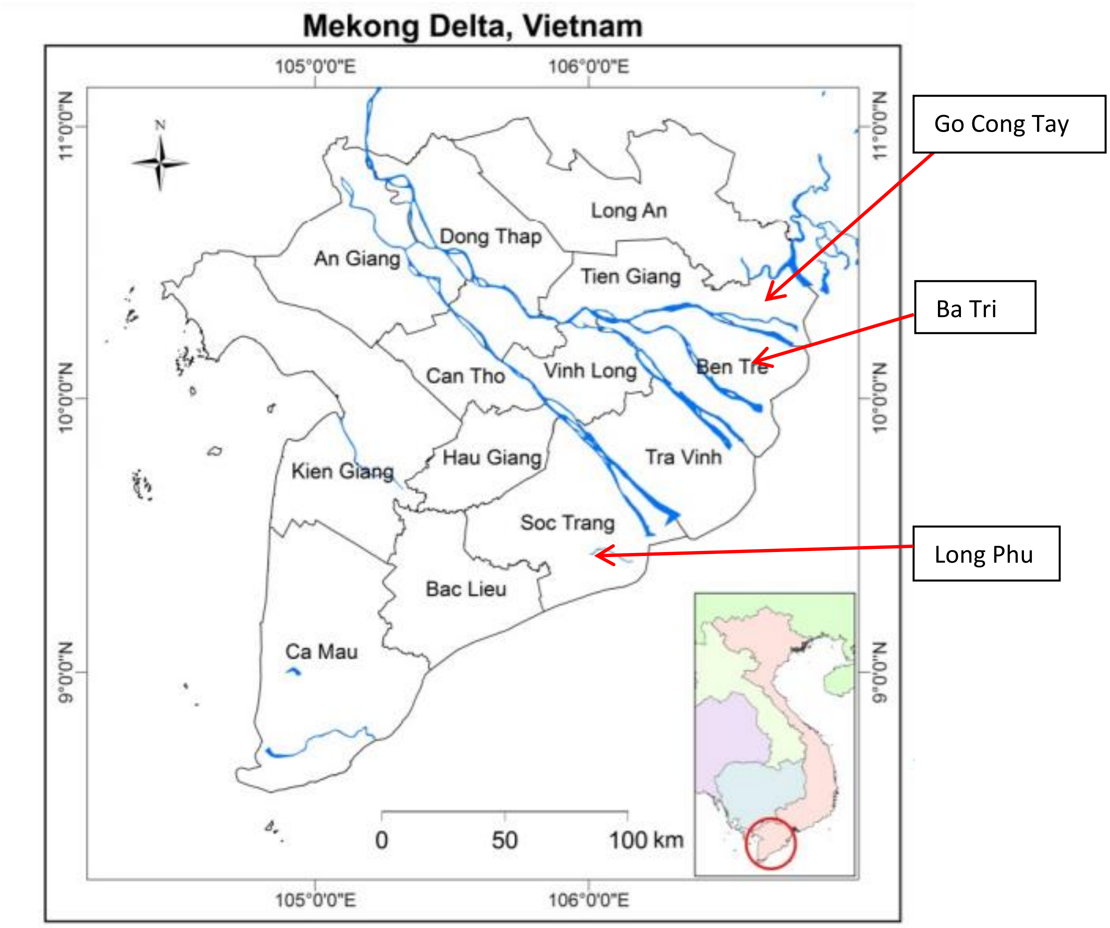
Figure 1. Map of the research areas



Source: https://www.apn-gcr.org/publication/mapping-vulnerability-to-dengue-in-mekong-delta-region-vietnam-from-2002-to-2014-using-geospatial-data-by-water-associated-disease-index-approach/

Table 1. The surveyed areas in the Mekong Delta

Provinces	Districts	Communes
Tien Giang	Go Cong Tay	Dong Thanh
Ben Tre	Ba Tri	An Binh Tay
Soc Trang	Long Phu	Chau Khanh

Table 2. Explanatory and dependent variables used in rice production and food security models (n = 430)

Variables	Descriptive	%	Mean	St.dev	Min.	Max.
Dependent variables						
Yield_2019	Yield of rice in 2019 (ton/ha)		0.465	0.212	0.146	1.100
Income	Total income of household (million/VND/year)		157.991	128.611	2	1176.6
Expenditure_food	Food expenditure (million VND/year)		35.786	20.685	2.4	180
Consum_rice	Consumption for rice (kg/month)		38.501	16.977	7	120
Consum_vegetable	Consumption for vegetables (kg/month)		26.215	16.187	2	90
Consum_meat	Consumption for meat (kg/month)		22.423	10.984	2	60
Demographics						
Age	Age of respondent		52.598	11.534	18	81
Gender	Gender of respondent		0.637	0.481	0	1
	1 = Male	63.72				
	0 = Female	36.28				
Education	Number of years of schooling of respondent		7.377	3.892	0	18
Socio-economic characteristics						
Hhsize	Number of household members		4.226	1.592	1	11
Farm_livestock_other time allocation	Percentage of time allocation for farming, livestock and other jobs		46.709	18.372	0	90
Farming characteristics						
Experience	Number of year farm household has been growing rice		28.840	13.085	2	66
Rice_farm_size	Rice farm land owned (ha)		0.766	1.132	0.1	16.9
Land tenure	The state of using rented land		0.302	0.460	0	1
	1 = Using rented land	30.23				
	0 = Not using rented land	69.77				
Institutional conditions						
Extension	Attending extension services		0.744	0.437	0	1
	1 = Yes	74.42				
	0 = No	25.58				
Credit	Accessing credit		0.493	0.501	0	1
	1 = Yes	49.30				
	0 = No	50.70				
Training_salinity	Attending training of responding to salinity intrusion		0.358	0.480	0	1
	1 = Yes	35.81				
	0 = No	64.19				
Social capital						
Formal_institutions	Attending formal institutions		0.630	0.483	0	1
	1 = Yes	63.02				
	0 = No	36.98				
Salinity degree						
Distance	Distance from respondent's rice farm to the nearest saltwater prevention sluice (km). It is a proxy variable of salinity degree.		4.607	5.612	0.04	40
Per_salinity	Respondent was asked to identify the extent they agree with the 5 corresponding statements about perception on salinity intrusion based on seven-point Likert scale (from 1—strongly disagree to 7—strongly agree) (taking the average)		6.136	0.810	1.6	7
Loss_yield	Percentage of yield lost due to salinity in 2019 (%)		48.280	20.559	0	100
Influence_salinity_total income	The extent of influence of salinity on farm household's total income (1-7 scale)		5.627	1.248	1	7
Influence_salinity_total expenses	The extent of influence of salinity on farm household's total expenses (food, medicines, electricity, esential goods...) (1-7 scale)		5.093	1.292	1	7

Note: Percentage in the case of dummy variables; Mean and Standard deviation in the case of continuous variables

Table 3. Cobb-Douglas model of the factors affecting rice production (n = 430)

Variables	Coefficients	Robust Std. err	P > t	Marginal effects	VIF
Constant	1.1497	0.5094	0.025		
Log(Age)	*-0.2517	0.1328	0.059	-0.0022	1.83
Gender	*0.0983	0.0552	0.075	0.0457	1.14
Log(Education)	0.0022	0.0031	0.472	0.0001	1.04
Log(Experience)	-0.0274	0.0515	0.595	-0.0004	1.89
Log(Rice_farm_size)	***0.1390	0.0266	0.000	0.0844	1.19
Land tenure	***-0.1907	0.0547	0.001	-0.0889	1.12
Extension	0.0274	0.0515	0.688	0.0127	1.24
Credit	0.0352	0.0452	0.436	0.0164	1.04
Training_salinity	*0.0936	0.0497	0.060	0.0435	1.18
Log(Distance)	***-0.1591	0.0213	0.000	-0.0161	1.14
Log(Per_salinity)	***-0.4395	0.1155	0.000	-0.0333	1.04
Number of observations	430				
F(11, 418)	17.25				
Prob > F	0.0000				
R-squared	0.2917				
White's test for HET H_0: Homoskedasticity					
Chi2(72)	86.13				
Prob > chi2	0.1225				

Note: *, **, *** indicate significance at 10%, 5%, and 1%, respectively

Table 4. Cobb-Douglas model of the factors affecting male and female farmers' rice production

Variables	Male (n = 274)					Female (n = 156)				
	Coefficients	Robust Std. err	P > t	Marginal effects	VIF	Coefficients	Robust Std. err	P > t	Marginal effects	VIF
Constant	0.6510	0.4824	0.178			2.4699	1.1901			
Log(Age)	-0.1562	0.1386	0.261	-0.0014	1.88	-0.3925	0.2575	0.130	-0.0033	1.78
Log(Education)	0.0037	0.0037	0.316	0.0002	1.03	0.0026	0.0039	0.506	0.0002	1.08
Log(Experience)	-0.0431	0.0556	0.439	-0.0007	1.89	0.0051	0.0865	0.953	0.0001	1.90
Log(Rice_farm_size)	***0.1372	0.0285	0.000	0.0753	1.19	***0.1538	0.0545	0.006	0.1183	1.15
Land tenure	*-0.0867	0.0501	0.085	-0.0421	1.14	***-0.4046	0.1199	0.001	-0.1733	1.16
Extension	0.0757	0.0657	0.250	0.0368	1.17	-0.0452	0.0957	0.638	-0.0194	1.23
Credit	0.0325	0.0465	0.486	0.0158	1.05	0.1105	0.0983	0.263	0.0473	1.12
Training_salinity	***0.1491	0.0494	0.003	0.0724	1.16	-0.1095	0.1101	0.322	-0.0469	1.22
Log(Distance)	***-0.1493	0.0261	0.000	-0.0177	1.20	***-0.1758	0.0377	0.000	-0.0137	1.13
Log(Per_salinity)	***-0.3495	0.1030	0.001	-0.0277	1.05	**-0.8419	0.3213	0.010	-0.0587	1.18
Number of observations	274					Number of observations	156			
F(10, 263)	14.79					F(10, 145)	5.83			
Prob > F	0.0000					Prob > F	0.0000			
R-squared	0.3308					R-squared	0.2822			
White's test for HET H_0: Homoskedasticity						White's test for HET H_0: Homoskedasticity				
Chi2(61)	64.53					Chi2(61)	71.45			
Prob > chi2	0.3544					Prob > chi2	0.1695			

Note: *, **, *** indicate significance at 10%, 5%, and 1%, respectively

Table 5. Regression model of the factors affecting farm households' income (n = 430)

Variables	Coefficients	Robust Std. err	P > t	Marginal effects	VIF
Constant	3.9217	0.8640	0.000		
Log(Influence_salinity_total income)	**-0.2583	0.1227	0.036	-7.2512	1.09
Log(Yield_loss)	***-0.0429	0.0145	0.003	-0.1404	1.08
Extension	-0.0186	0.1004	0.853	-2.9386	1.26
Formal_institutions	0.0487	0.0847	0.565	7.6942	1.10
Training_salinity	***0.3168	0.0960	0.001	50.0515	1.21
Log(Experience)	***0.2286	0.0818	0.005	1.2523	1.86
Log(Rice_farmsize)	-0.0064	0.0477	0.893	-1.3201	1.15
Log(Distance)	**-0.0794	0.0404	0.050	-2.7229	1.14
Log(Age)	-0.2619	0.2420	0.280	-0.7867	1.88
Gender	0.1463	0.0920	0.113	23.1141	1.17
Log(Education)	-0.0072	0.0060	0.225	-0.1542	1.05
Log(Hhsize)	***1.0257	0.1136	0.000	38.3501	1.09
Log(Farm_livestock_other time allocation)	***0.0392	0.0141	0.006	0.1326	1.05
Number of observations	430				
F(13, 419)	13.50				
Prob > F	0.0000				
R-squared	0.2922				
White's test for HET H_0: Homoskedasticity					
Chi2(100)	94.64				
Prob > chi2	0.6326				

Note: *, **, *** indicate significance at 10%, 5%, and 1%, respectively

Table 6. Regression model of the factors affecting farmers' food expenditure (n = 430)

Variables	Coefficients	Robust Std. err	P > t	Marginal effects	VIF
Constant	4.1636	0.5129	0.000		
Log(Influence_salinity_total amounts)	0.1296	0.1165	0.267	0.8241	1.39
Log(Influence_salinity_total expenses)	-0.0361	0.0943	0.702	-0.2537	1.38
Log(Yield_loss)	**-0.0216	0.0099	0.030	-0.0160	1.08
Log(Distance)	0.0233	0.0233	0.317	0.1810	1.11
Log(Age)	***-0.5519	0.1125	0.000	-0.3755	1.07
Gender	0.0302	0.0556	0.587	1.0807	1.09
Log(Education)	-0.0015	0.0078	0.844	-0.0073	1.03
Log(Hhsize)	***0.5222	0.0780	0.000	4.4225	1.34
Log(Farm_livestock_other time allocation)	0.0034	0.0057	0.550	0.0026	1.05
Log(Income)	***0.1210	0.0359	0.001	0.0274	1.35
Number of observations	430				
F(10, 419)	23.62				
Prob > F	0.0000				
R-squared	0.2792				
White's test for HET H_0: Homoskedasticity					
Chi2(64)	38.28				
Prob > chi2	0.9956				

Note: *, **, *** indicate significance at 10%, 5%, and 1%, respectively

Table 7. Regression model of the factors affecting male and female farmers' food expenditure

Variables	Male (n = 274)					Female (n = 156)				
	Coefficients	Robust Std. err	P > t	Marginal effects	VIF	Coefficients	Robust Std. err	P > t	Marginal effects	VIF
Constant	4.1030	0.6322	0.000			3.5961	0.9778	0.000		
Log(Influence_salinity_total income)	0.0724	0.1522	0.635	0.4801	1.30	*0.2940	0.1724	0.090	1.7351	1.63
Log(Influence_salinity_total expenses)	-0.0201	0.1274	0.875	-0.1476	1.28	-0.1329	0.1314	0.314	-0.8636	1.62
Log(Yield_loss)	*-0.0182	0.0109	0.095	-0.0138	1.12	-0.0279	0.1047	0.790	-0.0197	1.12
Log(Distance)	*0.0540	0.0298	0.071	0.4845	1.14	-0.0164	0.0366	0.655	-0.1017	1.07
Log(Age)	***-0.5778	0.1341	0.000	-0.3975	1.03	**-0.4144	0.2004	0.040	-0.2763	1.18
Log(Education)	0.0111	0.0091	0.223	0.0514	1.02	-0.0075	0.0094	0.428	-0.0400	1.06
Log(Hhsize)	***0.4134	0.1043	0.000	3.5130	1.27	***0.6736	0.1133	0.000	5.6684	1.54
Log(Farm_livestock_other time allocation)	0.0595	0.0396	0.134	0.0443	1.02	0.0031	0.0058	0.594	0.0025	1.08
Log(Income)	***0.1508	0.0425	0.000	0.0316	1.27	0.0707	0.0564	0.212	0.0190	1.43
Number of observations	274					Number of observations	156			
F(9, 264)	11.74					F(9, 146)	14.24			
Prob > F	0.0000					Prob > F	0.0000			
R-squared	0.2298					R-squared	0.3851			
White's test for HET H_0: Homoskedasticity						White's test for HET H_0: Homoskedasticity				
Chi2(54)	26.54					Chi2(54)	61.98			
Prob > chi2	0.9994					Prob > chi2	0.2128			

Note: *, **, *** indicate significance at 10%, 5%, and 1%, respectively

Table 8. Regression model of the factors affecting farmers' rice consumption (n = 430)

Variables	Coefficients	Robust Std. err	P > t	Marginal effects	VIF
Constant	2.6413	0.3370	0.000		
Log(Influence_salinity_total income)	*0.1346	0.0704	0.057	0.9208	1.39
Log(Influence_salinity_total expenses)	0.0421	0.0661	0.524	0.3183	1.38
Log(Yield_loss)	*-0.0125	0.0067	0.063	-0.0100	1.08
Log(Distance)	0.0217	0.0175	0.215	0.1813	1.11
Log(Age)	0.0083	0.0765	0.914	0.0061	1.07
Gender	0.0223	0.0417	0.593	0.8586	1.09
Log(Education)	-0.0067	0.0063	0.292	-0.0350	1.03
Log(Hhsize)	***0.5954	0.0528	0.000	5.4250	1.34
Log(Farm_livestock_other time allocation)	**0.0121	0.0052	0.021	0.0100	1.05
Log(Income)	**-0.0538	0.0228	0.019	-0.0131	1.35
Number of observations	430				
F(10, 419)	16.66				
Prob > F	0.0000				
R-squared	0.2570				
White's test for HET H_0: Homoskedasticity					
Chi2(64)	72.97				
Prob > chi2	0.2069				

Note: *, **, *** indicate significance at 10%, 5%, and 1%, respectively

Table 9. Regression model of the factors affecting farmers' vegetable consumption (n = 430)

Variables	Coefficients	Robust Std. err	P > t	Marginal effects	VIF
Constant	0.4934	0.5822	0.397		
Log(Influence_salinity_total income)	**0.3561	0.1419	0.012	1.6587	1.39
Log(Influence_salinity_total expenses)	0.0222	0.1095	0.839	0.1143	1.38
Log(Yield_loss)	***-0.0416	0.0111	0.000	-0.0226	1.08
Log(Distance)	***0.1210	0.0269	0.000	0.6885	1.11
Log(Age)	**0.2729	0.1287	0.035	0.1360	1.07
Gender	0.0198	0.0624	0.752	0.5191	1.09
Log(Education)	0.0029	0.0080	0.718	0.0103	1.03
Log(Hhsize)	***0.3382	0.0805	0.000	2.0982	1.34
Log(Farm_livestock_other time allocation)	-0.0129	0.0095	0.177	-0.0072	1.05
Log(Income)	***0.0999	0.0377	0.008	0.0166	1.35
Number of observations	430				
F(10, 419)	7.30				
Prob > F	0.0000				
R-squared	0.1592				
White's test for HET H_0: Homoskedasticity					
Chi2(64)	67.16				
Prob > chi2	0.3693				

Note: *, **, *** indicate significance at 10%, 5%, and 1%, respectively

Table 10. Regression model of the factors affecting farmers' meat consumption (n = 430)

Variables	Coefficients	Robust Std. err	P > t	Marginal effects	VIF
Constant	1.9806	0.4738	0.000		
Log(Influence_salinity_total income)	0.1085	0.1015	0.285	0.4323	1.39
Log(Influence_salinity_total expenditure)	0.1460	0.0932	0.118	0.6428	1.38
Log(Yield_loss)	***-0.0352	0.0077	0.000	-0.0163	1.08
Log(Distance)	**0.0509	0.0216	0.019	0.2477	1.11
Log(Age)	-0.0396	0.0993	0.691	-0.0169	1.07
Gender	**0.1098	0.0543	0.044	2.4621	1.09
Log(Education)	-0.0010	0.0068	0.881	-0.0030	1.03
Log(Hhsize)	***0.4631	0.0657	0.000	2.4575	1.34
Log(Farm_livestock_other time allocation)	-0.0016	0.0105	0.879	-0.0008	1.05
Log(Income)	0.0275	0.0290	0.343	0.0039	1.35
Number of observations	430				
F(10, 419)	10.50				
Prob > F	0.0000				
R-squared	0.1966				
White's test for HET H_0: Homoskedasticity					
Chi2(64)	54.28				
Prob > chi2	0.8017				

Note: *, **, *** indicate significance at 10%, 5%, and 1%, respectively

Table 11. Regression model of the factors affecting male and female farmers' meat consumption

Variables	Male (n = 274)					Female (n = 156)				
	Coefficients	**Robust Std. err**	**P > t**	**Marginal effects**	**VIF**	**Coefficients**	**Robust Std. err**	**P > t**	**Marginal effects**	**VIF**
Constant	2.2441	0.5849	0.000			2.0566	0.9317	0.029		
Log(Influence_salinity_total income)	-0.0001	0.1075	0.999	-0.0004	1.30	0.2795	0.1845	0.132	1.0283	1.63
Log(Influence_salinity_total expenditure)	0.1005	0.1086	0.356	0.4637	1.28	0.1995	0.1732	0.251	0.8082	1.62
Log(Yield_loss)	***-0.0305	0.0068	0.000	-0.0146	1.12	-0.0506	0.1177	0.668	-0.0223	1.12
Log(Distance)	0.0346	0.0242	0.155	0.1951	1.14	*0.0767	0.0410	0.064	0.2964	1.07
Log(Age)	0.0263	0.1042	0.801	0.0114	1.03	-0.1591	0.2091	0.448	-0.0661	1.18
Log(Education)	0.0009	0.0070	0.894	0.0026	1.02	-0.0033	0.0099	0.745	-0.0110	1.06
Log(Hhsize)	***0.4377	0.0791	0.000	2.3369	1.27	***0.4614	0.1122	0.000	2.4205	1.54
Log(Farm_livestock_other time allocation)	-0.0270	0.0590	0.647	-0.0126	1.02	-0.0003	0.0097	0.973	-0.0002	1.08
Log(Income)	0.0203	0.0334	0.544	0.0027	1.27	0.0366	0.0539	0.498	0.0061	1.43
Number of observations	274					Number of observations	156			
F(9, 264)	5.55					F(9, 146)	6.53			
Prob > F	0.0000					Prob > F	0.0000			
R-squared	0.1314					R-squared	0.2643			
White's test for HET H_0: Homoskedasticity						White's test for HET H_0: Homoskedasticity				
Chi2(54)	52.52					Chi2(54)	43.57			
Prob > chi2	0.5318					Prob > chi2	0.8440			

Note: *, **, *** indicate significance at 10%, 5%, and 1%, respectively